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IBM System Storage Tape Library Guide for Open Systems

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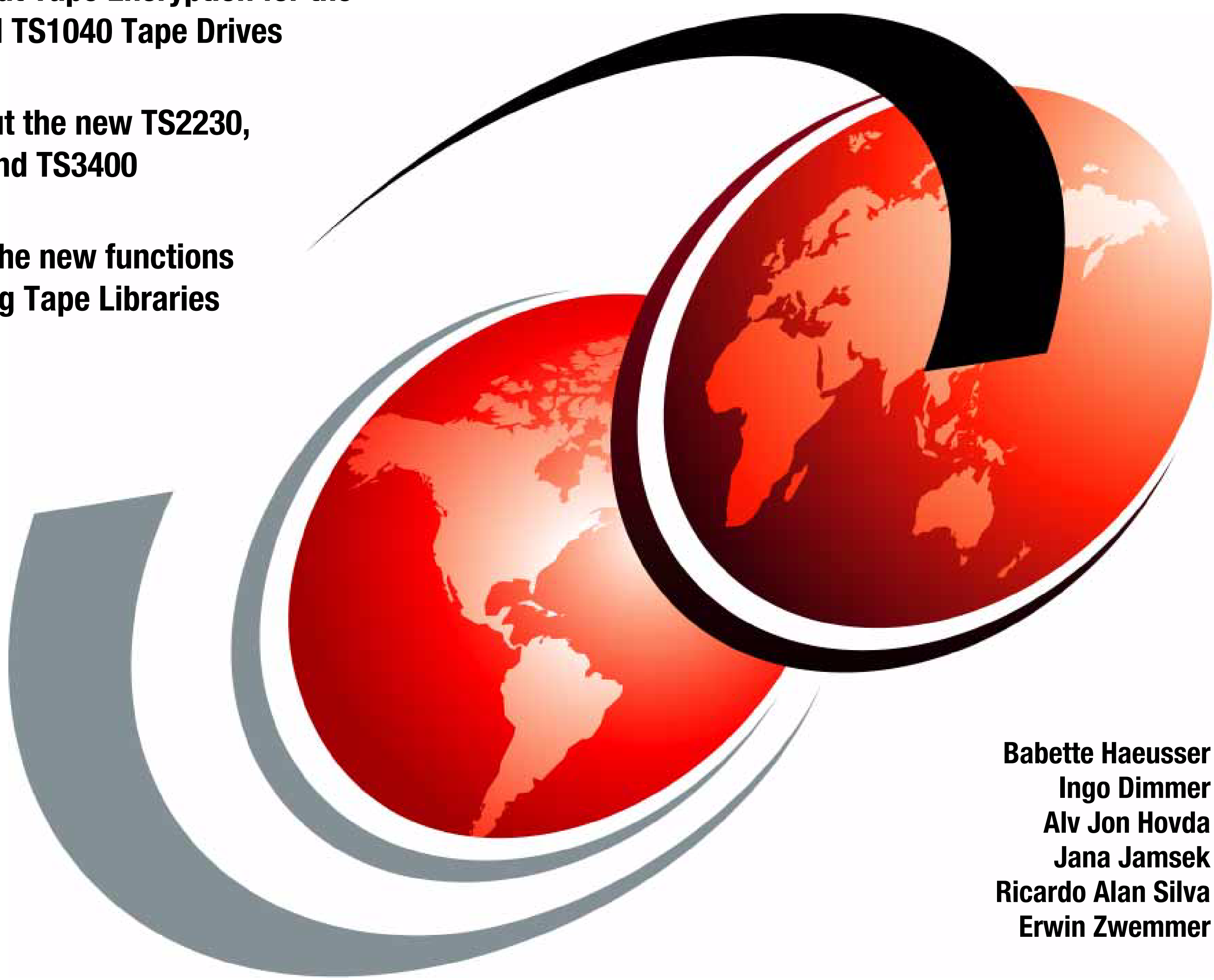

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IBM System Storage Tape Library Guide for Open Systems

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Note: Before using this information and the product it supports, read the information in “Notices” on page xiii.

Sixth Edition (October 2007)

This edition applies to those versions of the IBM TSxxxx tape drive and tape library products current at the time of publishing. For reference purposes, it also contains information about tape drives and libraries that have been withdrawn from marketing.

Contents

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Preface

This IBM® Redbooks® publication presents a general introduction to Linear Tape-Open (LTO) technology and the implementation of corresponding IBM products. It describes both general LTO technology specifications and specific details of the unique design of IBM Ultrium tape drives and libraries. This sixth edition of the book includes information about the fourth-generation Ultrium drive including Tape Encryption and about the recently announced IBM System Storage™ TS3100, TS3200, TS3310, and TS3400 Tape Libraries. You will find technical information about each of the IBM tape products for Open Systems, including general sections about SCSI and Fibre Channel connections, multi-path architecture configurations, and IBM System Storage TS3500 features, such as the Advanced Library Management System (ALMS) and virtual I/O. The book also includes a detailed discussion of tools and techniques for Library Management.

This book is intended for anyone who wants to understand more about the general LTO technology specification and its evolution, as well as the IBM implementation of that specification and other IBM Tape products. It is suitable for IBM clients, IBM Business Partners, IBM specialist sales representatives, and technical specialists. If you do not have a background in computer tape storage products, you might need to reference other sources of information. In the interest of being concise, topics that are generally understood are not covered in detail.

The team that wrote this IBM Redbooks publication

This book was produced by a team of specialists from around the world working at the International Technical Support Organization, San Jose Center.

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Summary of changes

This section describes the technical changes made in this edition of the book and in previous editions. This edition might also include minor corrections and editorial changes that are not identified.

Summary of Changes
for SG24-5946-05
for IBM System Storage Tape Library Guide for Open Systems
as created or updated on October 30, 2007.

October 2007, Sixth Edition

This revision reflects the addition, deletion, or modification of new and changed information described below.

New information

- TS2230 Tape Drive
- TS2340 Tape Drive
- IBM Linear Tape-Open Ultrium 4 Tape Drive
- IBM System Storage TS3400 Tape Library
- Tape Encryption

Changed information

- IBM TS3310 Tape Library
- IBM TS3500 Tape Library

April 2007, Fifth Edition

This revision reflects the addition, deletion, or modification of new and changed information described below.

New information

- IBM TS3100 Tape Library
- IBM TS3200 Tape Library
- IBM TS3310 Tape Library
- Library Management

Changed information

- IBM TS1020 Tape Drive
- IBM TS1120 Tape Drive
- IBM TS3500 Tape Library

September 2005, Fourth Edition

This revision reflects the addition, deletion, or modification of new and changed information described below.

New information

- WORM media for Ultrium 3 drives
- Ultrium 3 drives and libraries
- Virtual I/O for IBM TotalStorage 3584 Tape Library

June 2004, Third Edition

This revision reflects the addition, deletion, or modification of new and changed information described below.

New information

- Description of WORM technology
- New models IBM TotalStorage 3581 2U Tape Autoloader L28 and F28
- New frames and features for the IBM TotalStorage 3584 Tape Library, including support for IBM TotalStorage 3592 Tape Drive with WORM media
- Advanced Library Management System (ALMS) for the IBM TotalStorage 3584 Tape Library

Part 1

Open Systems Tape Basics

In this part, we discuss Open Systems tape technologies and introduce the IBM tape drives that can be installed inside IBM tape libraries for Open System hosts.

1

Tape technology perspective

Tape systems traditionally have been associated with the mainframe computer market, because they have represented an essential element in mainframe systems architectures since the early 1950s as a cost-effective way to store large amounts of data. The mid-range and client/server computer market has, in contrast, made very limited use of tape technology until quite recently.

Over the past few years, however, the growth in the demand for data storage and reliable backup and archiving solutions has greatly increased the need to provide manageable and cost-effective tape library products. The value of using tape for backup purposes has only gradually become obvious and important in these environments.

In this chapter, we will review the history of tape technology, including technologies, formats, and standards that you will see for tape products in today's market. We discuss a number of products from non-IBM vendors and, although we have reviewed the material carefully, we remind you that the vendors of those products are the definitive source of information.

1.1 Tape products and technologies

Two basic tape technologies have been utilized. Until the middle of the 1980s, all computer tape systems utilized linear recording technology, a technology that uses a stationary head writing data in a longitudinal way. (See Figure 1-3 on page 6 for an example of longitudinal technology.)

In the middle of the 1980s, helical tape technology (which had been developed for video applications) became available for computer data storage. This technology uses heads rotating on a drum and writing data in an angle. Helical tape systems found natural applications in backing up magnetic disk systems where their cost advantages substantially outweighed their operational disadvantages. (See Figure 1-4 on page 7 for an example of helical-scan technology.)

1.1.1 Helical versus longitudinal

The first computer tape systems used linear recording technology. This technology provides excellent data integrity, rapid access to data records, and reasonable storage density.

The first implementation of linear recording technology used magnetic tapes on open reels. Later, the tape was protected inside cartridges, using one or two reels. Linear technology drives write each data track on the entire length of the tape. Data is first written onto a track along the entire length of the tape, and when the end is reached, the heads are repositioned to record a new track again, along the entire length of the tape, now travelling in the opposite direction. This continues back and forth until the tape is full. On linear drives, the tape is guided around a static head.

On helical scan systems, by contrast, the tape is wrapped around a rotating drum containing read/write heads. Due to the more complicated path, mechanical stress is placed on the tape. When contrasted with linear tape systems, helical tape systems have higher density (and, therefore, lower media cost), but lower data transfer rates (due to the smaller number of active read/write heads), less effective access to random data records, increased maintenance requirements, and reduced data integrity.

Both linear and helical tape systems have advanced substantially over the past decade. Linear systems have improved significantly in the areas of storage density (and, therefore, cost) and operational convenience (with a variety of removable cartridge systems, such as 3590, QIC, DLT, and now LTO replacing reel-to-reel systems). Helical systems have improved in the areas of transfer rate and data integrity with the implementation of both channel and error correction coding technologies.

Over the past few years, one of the most significant advances in tape technology for computer applications has been the maturation of serpentine linear recording systems which, for the first time, has permitted linear recording systems to provide recording density that is comparable with that of helical systems. The first commercially successful serpentine linear tape system for professional applications was DLT. Another important improvement is the use of servo tracks, first introduced by IBM on the Magstar® 3590 tape. Servo tracks on the tape cartridge are recorded at the time of manufacture. These tracks enable the tape drive to position the read/write head accurately with respect to the media while the tape is in motion.

Most linear media is manufactured using metal particle (MP) technology. As with most tape products, metal particle media comprises several layers: a substrate that provides the base for other layers, the magnetic layer where data is stored, and a back coat that controls the media’s frictional characteristics.

The most advanced implementations of 8 mm format (VXA and AIT) use Advanced Metal Evaporative (AME) media. The AME magnetic layer is 100% cobalt and is a much thinner, pure magnetic layer that contains no binders or lubricants. These qualities give AME tapes greater potential data density so that more information can be stored on less tape surface.

We think that the fundamental difference between linear recording and helical scan technologies is so important that it is worthwhile to summarize all of the available current technologies (see Table 1-1).

Table 1-1 Tape technology overview

Name	Recording technology	Media width	Type
1/2-inch reels	Linear	1/2 inch	Single hub
QIC	Linear	1/4 inch and 8 mm	Dual hub
DDS/DAT	Helical-scan	4 mm	Dual hub
8 mm	Helical-scan	8 mm	Dual hub
Mammoth	Helical-scan	8 mm	Dual hub
AIT	Helical-scan	8 mm	Dual hub
VXA	Helical-scan	8 mm	Dual hub
DLT/SDLT	Linear	1/2 inch	Single hub
IBM 3480/90	Linear	1/2 inch	Single hub
IBM Magstar MP 3570	Linear	8 mm	Dual hub
IBM 3590	Linear	1/2 inch	Single hub
STK 9840, 9940	Linear	1/2 inch	Dual hub
LTO Ultrium	Linear	1/2 inch	Single hub

1.1.2 Tape reels (1/2-inch)

The first data backup device (and the ancestor of magnetic tape devices with a 1/2-inch-wide tape format) used magnetic tape reels, shown in Figure 1-1. Reel tapes have been around for many years. They can support densities from 800 bpi to 6250 bpi (bits per inch) and were manufactured and sold in many different lengths and brands. The most common densities used were 1600 and 6250 bpi, but most of these devices have since been replaced.

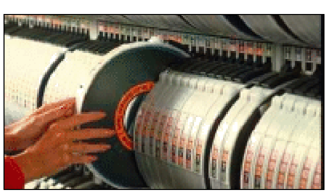


Figure 1-1 Tape reels, 1/2-inch

1.1.3 Quarter-inch tape

The quarter-inch tape cartridge (QIC) was first introduced in 1972 by the 3M company as a means to store data from telecommunications and data acquisition applications. As time passed, the comparatively inexpensive QIC drive became an accepted data storage system, especially for standalone PCs.

A QIC cartridge (shown in Figure 1-2) looks much like an audio tape cassette with two reels inside, one with tape and the other for take-up. The reels are driven by a belt built into the cartridge. A metal rod, known as a *capstan*, projects from the drive motor and pinches the tape against a rubber drive wheel.

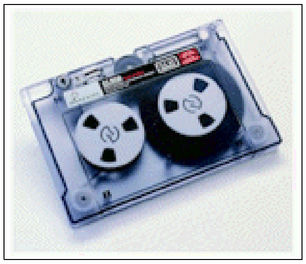


Figure 1-2   QIC cartridge

The QIC format employs a linear (or longitudinal) recording technique in which data is written to parallel tracks that run along the length of the tape. The number of tracks is the principal determinant of capacity. The cartridges come in two varieties, DC600 cartridge and DC2000 mini-cartridge, the latter being the more popular. The encoding method used is either Modified Frequency Modulation (MFM) or Run Length Limited (RLL) and is similar to the way a hard drive encodes data.

QIC uses a linear read/write head similar to those found in domestic cassette recorders (Figure 1-3). The head contains a single write head flanked on either side by a read head, which allows the tape drive to verify data just written when the tape is running in either direction. If the data just written is verified by the read head, the buffer is flushed out and new data is acquired from the system memory.

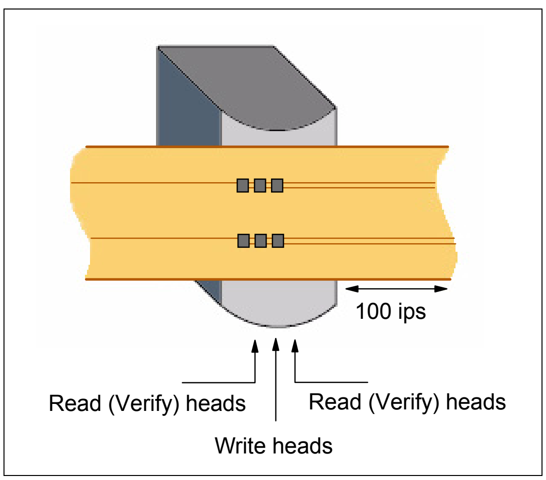


Figure 1-3   QIC head diagram

QIC standards

As the QIC standards of the time failed to keep up with the storage media explosion of the mid-1990s, the QIC cartridge underwent an evolution that increased capacities by both lengthening and widening the tape. The Sony-inspired move to a wider format tape was a noteworthy development.

One of the drawbacks with QIC is incompatibility. The format has suffered from an overabundance of standards over the years, there are more than 120 currently, and not all QIC drives are compatible with all standards.

Tandberg Data manufactures QIC drives with its Scalable Linear Recording (SLR) technology. Their most recent drive, the SLR140, provides 70 GB (native) and 100 GB (with 2:1 compression) capacity on a single data cartridge. The maximum data transfer rates are 6 MB/s uncompressed and 12 MB/s (with 2:1 compression).

1.1.4 Digital Data Standard (4 mm)

The Digital Audio Tape (DAT) standard was created in 1987 and, as its name implies, was originally conceived as a CD-quality audio format offering three hours of digital sound on a single tape. The Digital Data Standard (DDS) is based on DAT and uses a similar technology. The cartridge design is common, but different tape formulations have been developed. In 1988, Sony and Hewlett-Packard (HP) defined the DDS standard, transforming the format into a format that could be used for digital data storage.

DAT technology is a 4 mm tape that uses helical scan recording technology. This is the same type of recording as that used in videocassette recorders and is inherently slower than the linear type. The tape in a helical scan system is pulled from a two-reel cartridge and wrapped around a cylindrical drum containing two read heads and two write heads, arranged alternately. The read heads verify the data written by the write heads. The cylinder head is tilted slightly in relation to the tape and spins at 2,000 revolutions per minute. The tape moves in the opposite direction to the cylindrical spin, at less than one inch per second, but because it is recording more than one line at a time it has an effective speed of 150 inches per second. (Refer to Figure 1-4.)

Short diagonal tracks, about eight times longer than the width, are written across the width of the tape. These tracks each contain about 128 KB of data and an error correction code.

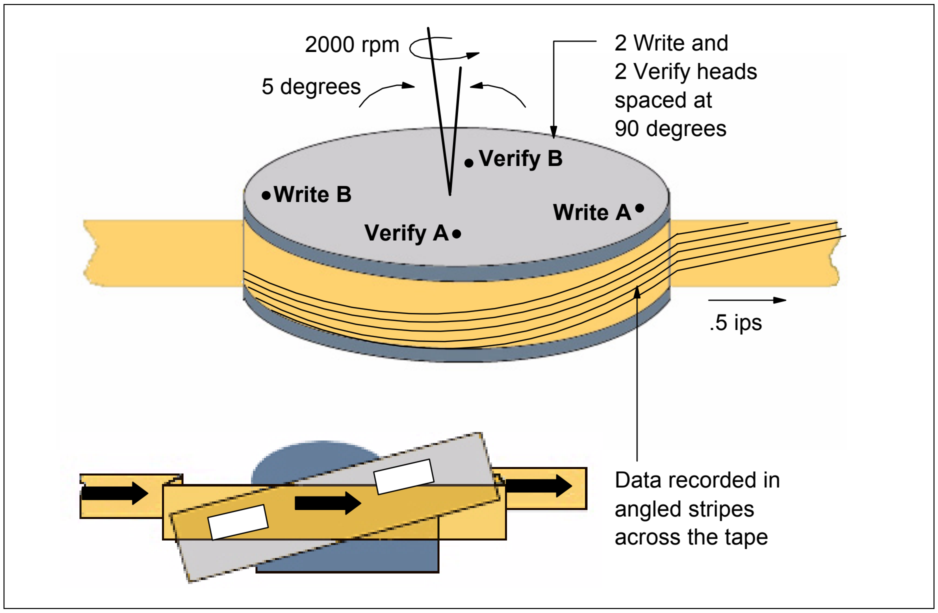


Figure 1-4 Helical-scan recording diagram

A read head verifies the data. If errors are present the data is rewritten; otherwise, the controller buffer is flushed ready for the next segment. The second write head writes data at a 40-degree angle to the first one.

Even though the first and second writes overlap, they are magnetically encoded with different polarities so that they are read only by the correct read head. The “criss-cross” pattern packs more data onto the tape, enabling helical scan systems to achieve very high data densities. A directory of files is stored in a partition at the front of the tape.

Just as with linear recording, the performance would be greatly improved if additional read/write heads were added, but this is difficult with helical scan devices because of the design of the rotating head. The fact that the heads can only be added in pairs makes it difficult to fit the wiring inside a single cylinder, and this limits the potential performance of helical scan devices. Because of the wide wrap angle of the tape and the consequent degree of physical contact, both the head and the media are prone to wear and tear.

Table 1-2 shows the various DDS standards, all of which are backward-compatible.

Table 1-2 DDS standards

Standard	Capacity	Maximum data transmission rate
DDS	2 GB	0.55 MB/s
DDS-1	2/4 GB	0.55/1.1 MB/s
DDS-2	4/8 GB	0.55/1.1 MB/s
DDS-3	12/24 GB	1.1/2.2 MB/s
DDS-4	20/40 GB	2.4/4.8 MB/s
DAT72 DDS-5	36/72 GB	3.0/6.0 MB/s

1.1.5 The 8 mm format

Designed for the video industry, 8 mm tape technology was created to transfer high-quality color images to tape for storage and retrieval and now has been adopted by the computer industry. Similar to DAT, but with greater capacities, 8 mm drives are also based on the helical scan technology. A drawback to the helical scan system is the complicated tape path. Because the tape must be pulled from a cartridge and wrapped tightly round the spinning read/write cylinder (Figure 1-5), a great deal of stress is placed on the tape.

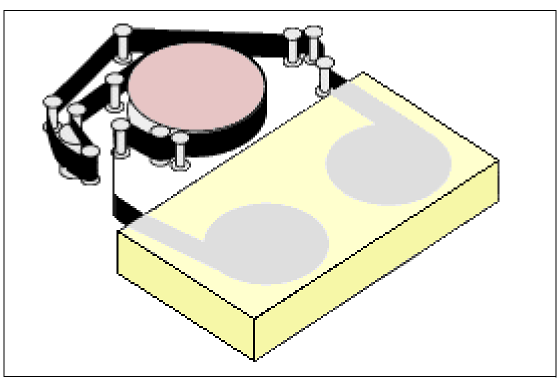


Figure 1-5 An 8 mm tape path

There are two major protocols that use different compression algorithms and drive technologies, but the basic function is the same. Exabyte Corporation sponsors standard 8 mm and VXA formats, while Seagate and Sony represent a new 8 mm technology known as Advanced Intelligent Tape (AIT).

Mammoth tape format

This SCSI-based 8 mm tape technology is designed for Open Systems applications. It is a proprietary implementation of the 8 mm original format available since 1987 and uses Advanced Metal Evaporative (AME) media. This media has a coating over the recording surface that seals and protects the recording surface.

The Exabyte Mammoth drives have a 5.25-inch form factor. The first generation provided 20 GB (native) and 40 GB (with 2:1 compression) capacity on a single 8 mm data cartridge. The maximum data transfer rates were 3 MB/s uncompressed and 6 MB/s (with 2:1 compression).

With the Mammoth-2 technology, the capacity and data rate have been increased to 60 GB (120 GB with 2:1 compression) and 12 MB/s uncompressed (24 MB/s with 2:1 compression). Mammoth-2 drives are read compatible with the previous models.

VXA tape format

This is an 8 mm tape technology designed for Open Systems applications. It is a proprietary implementation of an 8 mm packet format available since 2001 and uses Advanced Metal Evaporative (AME) media. This media has a coating over the recording surface that seals and protects the recording surface.

The Exabyte VXA drives have a 5.25-inch form factor. The first generation provided 32 GB (native) and 64 GB (with 2:1 compression) capacity on a single 8 mm data cartridge. The maximum data transfer rates were 3 MB/s uncompressed and 6 MB/s (with 2:1 compression).

With the VXA-2 technology, the capacity and data rate have been increased to 80 GB (160 GB with 2:1 compression) and 6 MB/s uncompressed (12 MB/s with 2:1 compression). VXA-2 drives are read compatible with the previous model.

With the VXA-3 technology, the capacity and data rate have been increased to 160 GB (320 GB with 2:1 compression) and 12 MB/s uncompressed (24 MB/s with 2:1 compression). VXA-3 drives are read compatible with the previous model.

Advanced Intelligent Tape (AIT) format

The AIT format was developed by Sony. Available in a 3.5-inch form factor, Sony AIT-1 drives and media provide 25 GB (native) and 50 GB (with 2:1 compression) capacity on a single 8 mm data cartridge. The maximum data transfer rate is 3 MB/s native.

Sony's latest AIT-4 format, made available in 2004, has capacity and performance of 100 GB (200 GB with 2:1 compression) and 12 MB/s native. AIT-4 drives are backward-read/write compatible with AIT-3, and backward-read compatible with AIT-2 and AIT-1.

AIT drives feature an Auto Tracking Following (ATF) system, which provides a closed-loop, self-adjusting path for tape tracking. This servo tracking system adjusts for tape flutter, so that data tracks can be written much closer together for high-density recording. AIT uses the Adaptive Lossless Data Compression technology (ALDC) compression algorithm. The 8 mm original format has various drive generations, and all are backward-compatible (Table 1-3 on page 10).

Table 1-3 Standards for 8 mm

Standard	Capacity	Maximum data transmission rate (compressed)
Original 8 mm	3.5/7 GB	0.53 MB/s
Original 8 mm	5/10 GB	1 MB/s
Original 8 mm	7/14 GB	1 MB/s
Original 8 mm	7/14 GB	2 MB/s
Mammoth	20/40 GB	6 MB/s
Mammoth-2	60/120 GB	24 MB/s
VXA-1	32/64 GB	6 MB/s
VXA-2	80/160 GB	12 MB/s
VXA-3	160/320 GB	24 MB/s
AIT-1	25/50 GB	6 MB/s
AIT-2	50/100 GB	12 MB/s
AIT-3	100/200 GB	24 MB/s
AIT-4	200/520 GB	48 MB/s

1.1.6 Digital Linear Tape (DLT)

DLT drives appeared in 1985 when Digital Equipment Corporation needed a backup system for their MicroVAX systems.

The system uses a square cartridge that contains tape media but no take-up reel. The take-up reel was built into the drive itself. This design eliminated the additional space typically associated with cassette and cartridge drives, such as QIC or 8 mm. The drive itself had to be made larger than most to accommodate the internal take-up reel. Called the TK50, the new tape drive was capable of storing 94 MB per cartridge.

Using a ferrite read/write head, the TK50 recorded data in linear blocks along 22 tracks. Its read/write head actually contained two sets of read/write elements. One set was used when reading and writing forward, and the other set was used when reading and writing backward.

The TK50 started recording at the beginning of the tape, recording on one track. When it reached the end, the system recorded back to the beginning along a new track. After every two tracks that were written, the system moved the head up the width of one track and began the process again. The read-after-write capability of the system ensured basic data accuracy. The drive fit into a full-height, 5.25 inch drive bay.

In 1987, Digital released the TK70. This tape drive offered 294 MB of storage on the same square tape cartridge, a threefold improvement over the TK50. Digital accomplished this by increasing the number of tracks to 48 and by increasing density on the same 1/2-inch tape.

In 1989, Digital introduced the TF85, the first true DLT system. The TF85 (later called the DLT 260) incorporated a new feature that enabled the system to pack 2.6 GB onto a 1,200-foot tape (CompacTape III, now known as DLTtape III).

The DLT Tape Head Guide Assembly was incorporated for the first time in the TF85 drive. Six precision rollers provided long tape life. The six-roller head guide assembly gave the TF85 a much shorter tape path than helical-scan systems (Figure 1-6 on page 11).

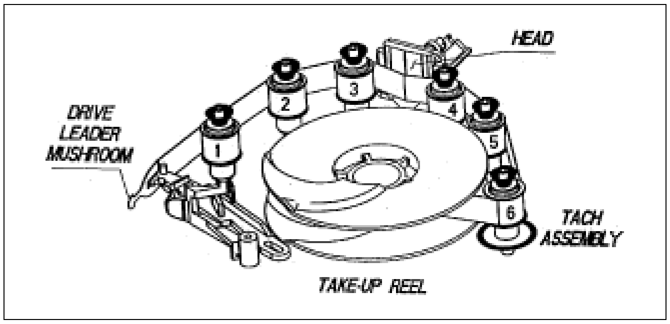


Figure 1-6 DLT tape path mechanism

The read/write head was equipped with an additional write element. The elements now were arranged in a write/read/write pattern. This pattern enabled the TF85 to read after writing on two channels and in both forward and reverse directions. This is the multi-channel serpentine recording depicted in Figure 1-7.

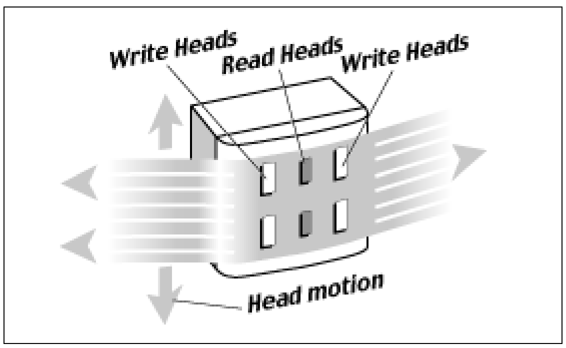


Figure 1-7 DLT 2000 recording head design

Two years later, Digital introduced the TZ87, now known as the DLT 2000 tape drive. This system offered 10 GB of native capacity on a single CompacTape III cartridge (shown in Figure 1-8) and now known as DLTtape III, 2 MB of read/write data cache memory, and a data transfer rate of 1.25 MB/s. This was the first generation of DLT.

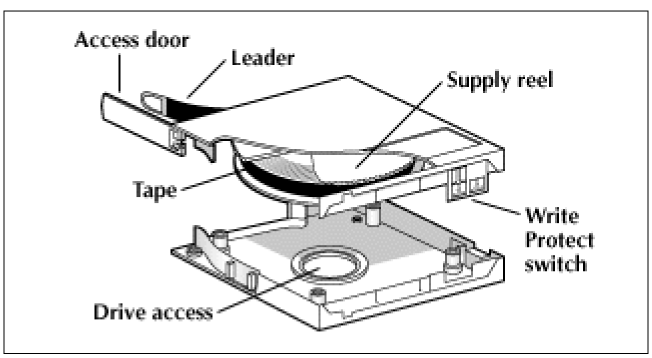


Figure 1-8 DLT cartridge

In 1994, Quantum acquired the Storage division of Digital Equipment Corporation (DEC). In late 1994, Quantum released the DLT 4000. By increasing real density (bits per inch) from 62,500 to 82,000, and tape length by 600 additional feet (DLTtape IV), the capacity of the DLT 4000 grew up to 20 GB (40 GB compressed) on a single 1/2-inch DLTtape IV cartridge. The new DLTtape system provided data transfer at 1.5 MB/s (3 MB/s compressed) and was fully read/write compatible with previous generations of DLTtape drives.

DLT 2000 and DLT 4000 drives write data on two channels simultaneously in linear tracks that run the length of the tape, as shown in Figure 1-9.

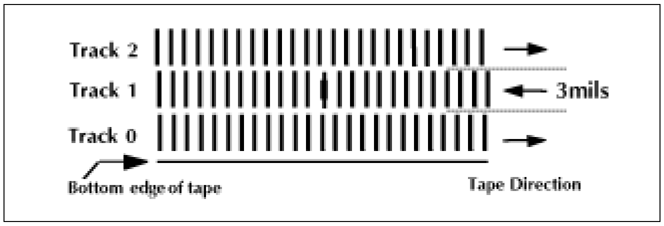


Figure 1-9 DLT 2000/4000 linear recording format

The DLT 7000 appeared in 1996. This drive offered a total storage capacity of 35 GB native, 70 GB compressed on the 1,800 foot DLTtape IV cartridge. The DLT 7000 incorporated a 4-channel head that gives the drive a transfer rate of 5 MB/s of data in native mode (Figure 1-10).

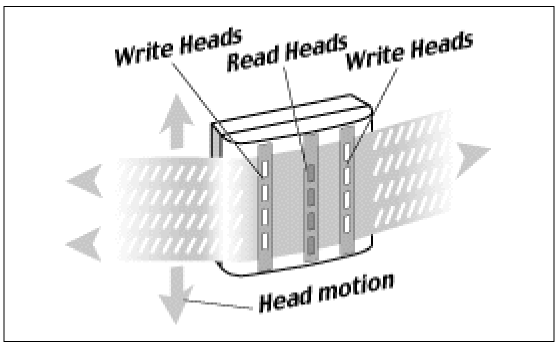


Figure 1-10 DLT 7000/8000 tape head

Quantum's latest DLT product is their DLT 8000 drive. This tape drive features a native transfer rate of up to 6 MB/s, with a native capacity of 40 GB. The DLT 7000/8000 drives incorporate the Symmetric Phase Recording technology that writes data in an angled pattern (Figure 1-11).

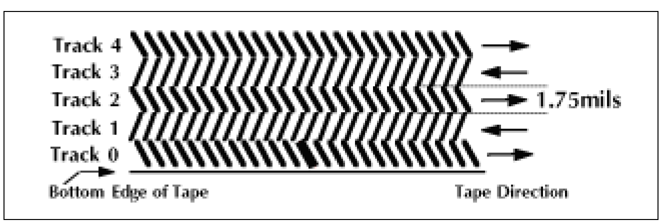


Figure 1-11 Symmetric Phase Recording technology

The DLT standard has various generations of tape drives, all of which are backward-compatible. We have summarized the specifications in Table 1-4 on page 13.

Table 1-4 DLT drive standards

DLT drive generation	Capacity	Maximum data transmission rate
DLT2000	10/20 GB	1.25 MB/s
DLT2000XT	15/30 GB	1.25 MB/s
DLT4000	20/40 GB	1.5 MB/s
DLT7000	35/70 GB	5 MB/s
DLT8000	40/80 GB	6 MB/s

1.1.7 SuperDLT (SDLT)

SuperDLT (SDLT) is a new format specification designed by Quantum Corporation as an evolution of the DLT standard. It uses Laser Guided Magnetic Recording (LGMR) technology. This technology includes the Pivoting Optical Servo (POS). This optically assisted servo system is implemented on the unused reverse side of the media and uses a laser to read the servo guide. SDLT uses 100% of the media for data recording.

SDLT uses Advanced Metal Powder (AMP) media containing embedded information for the Pivoting Optical Servo system.

The recording mechanism is made of Magneto-Resistive Cluster (MRC) heads, a cluster of small magneto-resistive tape heads.

The first SDLT drive, the SDLT 220, was introduced in late 2000. It provides a capacity of 110 GB (native) and 220 GB (with 2:1 compression). The native data transfer rate is 11 MB/s. This first drive was not backward read compatible with earlier models. In 2001, Quantum released a version of the SDLT 220 drive that was backward read compatible with the DLTtape IV cartridge.

Quantum's second SDLT 320 drive became available in 2002. It increased the native capacity to 160 GB (320 GB with 2:1 compression) and the native transfer rate to 16 MB/s. (32 MB/s with 2:1 compression). The SDLT 320 is backward read compatible with DLTtape IV cartridges and uses Super DLTtape I media.

The SDLT 600 is the third generation of Quantum's SDLT product range. It provides a capacity of 300 GB (native) and 600 GB (with 2:1 compression) and the native transfer rate increased to 36 MB/s (72 MB/s with 2:1 compression). The SDLT660 comes with an LVD 160 SCSI or with a 2 GB Fibre Channel interface. The SDLT 600 is backward compatible with the SDLT 320 and the DLT VS 160.

The media format compatibility includes:

- Super DLTtape II (read/write) 300 GB native capacity
- Super DLTtape I (read only) 160 GB native capacity
- DLTtape VS1 (read only) 80 GB native capacity

1.1.8 IBM 3480

The second generation of IBM magnetic tapes and the first one to use an enclosed cartridge containing 1/2-inch tape, the IBM 3480, was announced on March 22, 1984. The tape was stored in a now-familiar cartridge, which was smaller, much more robust, and easier to handle than tape reels. The cartridge capacity was 200 MB, and the channel data rate was 3 MB/s, writing 18 tracks in one direction.

1.1.9 IBM 3490

The 3490 replaced the 3480 tape technology, using the same tape cartridge media. The IBM 3490E, with a tape capacity of 800 MB uncompacted (2.4 GB compacted) and a channel data rate of 3 MB/s, increased the capacity of the 3480 fourfold by using a double-length tape and by writing data in both directions: 18 tracks to the end of tape, and 18 tracks back to the start of the tape.

During this second generation, several steps were taken to automate tape processing and to reduce or eliminate human intervention. Automatic cartridge loaders and automated tape libraries, such as the StorageTek™ Silos and the IBM 3495 and 3494 libraries, were introduced to reduce or eliminate the need for tape operators. Software packages, such as CA-1, TLMS, and the DFSMS™ Removable Media Manager (DFSMSrmm™), were implemented to manage the tape volumes automatically.

The IBM 3490 and compatible drives were probably the first family of tape products that was mostly used with automatic tape libraries rather than being installed as stand-alone drives operated manually.

Applications still used tapes directly, and the Improved Data Recording Capability (IDRC), which compacts the data, reduced the number of tape volumes used.

Magnetic disks were now widely used for online data, and these second-generation tape systems therefore became primarily a medium for backup and were introduced as an archive medium. The process of archiving was also automated with products, such as Hierarchical Storage Manager (HSM) and DFSMShsm™ (a component of DFSMS/MVS™) using tape as the lowest level in a storage hierarchy. Of course, tape was still used as an interchange medium, but networks were also used for that purpose.

1.1.10 IBM 3590

The IBM TotalStorage Drive 3590 was previously called the IBM Magstar 3590. The IBM Magstar tape technology was first introduced in July 1995. The original cartridge maintained the external form factor of the 3490 (Figure 1-12), had a capacity of 10 GB uncompacted (30 GB compressed), and the data rate was 9 MB/s. Later drive models and new media increased these figures. The data format is incompatible with the 3490.

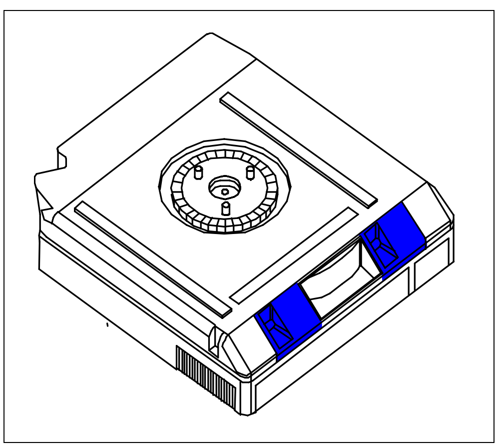


Figure 1-12 Magstar 3590 tape cartridge

The 3590 drive (Figure 1-13 on page 15) incorporates a new longitudinal technology, Serpentine Interleaved Longitudinal Recording. Data is written in each direction in turn, and to increase capacity further by providing multiple sets of tracks in parallel, the concept of *head* *indexing* is introduced. The entire set of heads is slightly shifted after one pass, and all subsequent passes (for a total of eight) are used to write data tracks adjacent to the existing ones. This means a significant improvement in the tape capacity and transfer rates without changing the tape speed (2 m/s) and media length (600 m). The 3590 drive uses a buffer and compresses the data before it writes the data to tape. In addition, the drive can complete a stop-start cycle in approximately 100 ms. The performance is significantly improved for both start-stop and streaming applications.

With the IBM TotalStorage 3590 Model H and the Extended Length Cartridges made available in 2002, the capacity and data rate increased to 60 GB (180 GB assuming 3:1 compression) and 14 MB/s native respectively, while maintaining backward compatibility for reading with the base models.

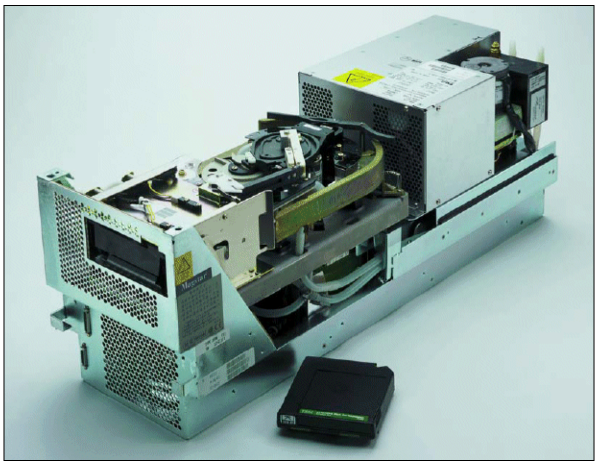


Figure 1-13 Magstar 3590 tape drive

This design incorporates innovations, such as servo tracks on the tape to guide the read/write heads along the data tracks and the implementation of an improved error correcting code (ECC). A portion of the tape within each cartridge is reserved for statistical information; it is continually updated after each read or write, providing statistics that you can use to obtain drive and media information and identify problems with a particular tape or drive as early as possible.

Technology

The IBM 3590 provides high capacity, performance, reliability, and a wide range of host connectivity. This technology exploits a fourth generation magneto resistive (MR) head, a 16 MB buffer, predictive failure analysis, and state-of-the-art electronic packaging.

While reading or writing 16 tracks at a time, the 3590 models use serpentine, interleaved, longitudinal recording technology for a total of four, eight, or twelve round trips from the physical beginning to the physical end of the tape and back again. The tape read/write head indexes, or moves vertically, when it completes each round trip so that the recorded tracks are interleaved across the width of the tape.

Figure 1-14 on page 16 shows the recording element of the IBM TotalStorage Enterprise 3590 tape drives. It also shows the way in which the read/write heads are moved over the width of the tape medium.

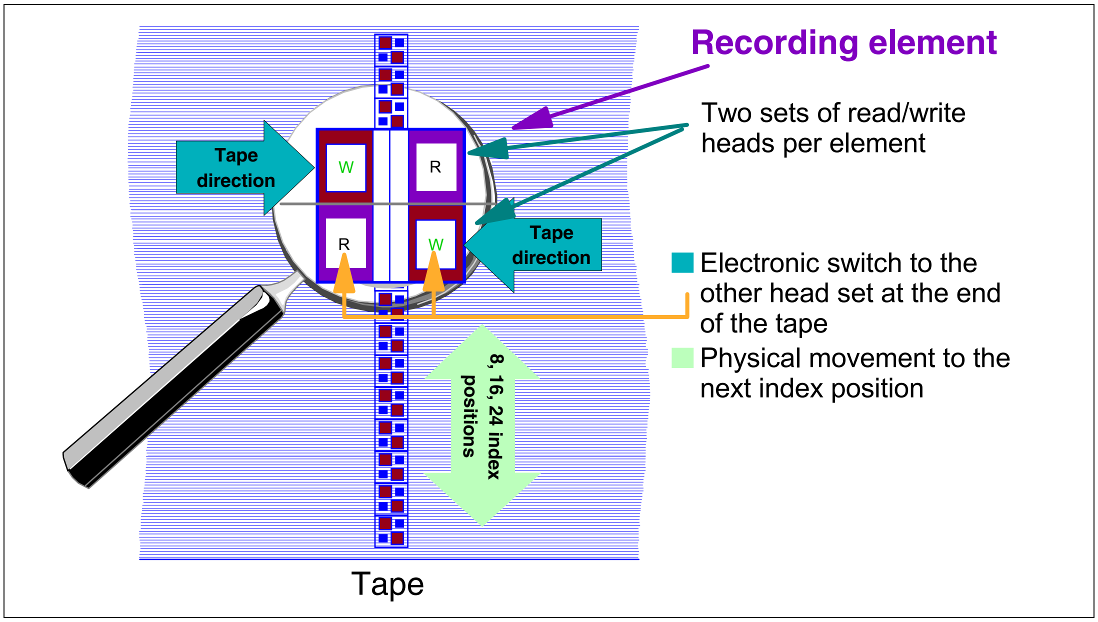


Figure 1-14 IBM 3590 recording

The 3590 tape drives use a metal particle medium in the tape cartridge that can store 10, 20, 30, 40, or 60 GB of uncompacted data, depending on the cartridge type and the drive model. The integrated control unit uses a compaction algorithm that can increase the storage capacity of these cartridges. Assuming a compression ratio of three to one (3:1), the cartridge capacity increases to 60 GB on E models and to 90 GB on H models.

The 3590E and 3590H models have a 14 MB/s device data rate, and 3590B models have a 9 MB/s device data rate. With data compression, the 3590 tape drive can more effectively use the full capability of the Ultra™ SCSI data rate, the Enterprise Systems Connection (ESCON®) data rate, or the Fibre Connection (FICON®) data rate. The Ultra/wide SCSI data rate is up to 40 MB per second and the Fibre Channel data rate is up to 100 MB per second.

High-speed data access

The 3590 longitudinal serpentine recording technique allows for high performance read operations. The 3590 Model E tape drive makes eight round-trip passes over the tape, where the Model H tape drive makes 12 passes. If a required block of data is, logically, one-eighth or one-twelfth of the way along the length of the tape, the read head only needs to index upward by one position to access this data. This requires no tape movement.

Unlike any previous tape product, the IBM Magstar 3590 tape subsystem uses a volume control region, inaccessible to user applications, to locate data on the tape. When a read request takes place, the tape drive uses a high-speed block search to position the tape directly at the required data block. It indexes the head to the correct set of tracks to allow for high-speed access to blocks or files. The tape drive performs this work while it is logically disconnected from the channel. This enables the channel to do other work.

This facility allows for access speeds that are significantly faster than previous generations of tape technology. The 3590 can search for data at up to 332 MB/s, compared to the 3490 rate.

Data integrity with the 3590 tape system

A unique feature of the IBM TotalStorage Enterprise 3590 Tape System is the way data is *striped* horizontally and vertically (Figure 1-15 on page 17). If a media error occurs, even one that covers several tracks, the error correction code can reconstruct the data for the application. The 3590 E and H tape drives have enhanced error correction code for improved data reliability compared to the Model B drives.

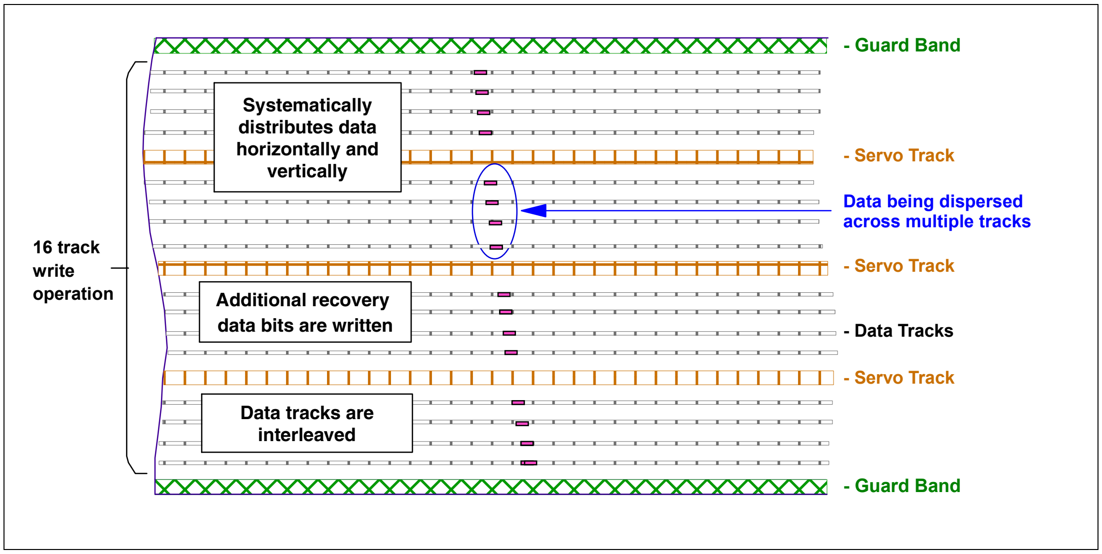


Figure 1-15 IBM TotalStorage 3590 tape data integrity

Considering the way the 3590 tape drive writes data onto the tape, we achieve RAID-like tape storage:

- Multiple write elements are used for improved performance.
- Data is spread across multiple tracks to achieve improved availability.
- Recovery bits are written for improved error recovery.

Metal particle media

A chromium dioxide medium was used in the IBM 3480 and 3490 cartridges. The IBM 3590 High Performance Tape Cartridge uses a metal particle medium, which has a significantly increased coercivity and therefore permits a much higher data recording density in comparison with chromium dioxide media. The linear density is proportional to the medium's coercivity, and therefore the linear density of the IBM 3590 tape is approximately three times that of the IBM 3480 and 3490. The track density is also improved approximately fourfold. Advances in the metal particle coatings and media binders afford reliability and magnetic stability equal or superior to chrome media.

1.1.11 IBM 3592

Introduced in October 2003, the 3592-J1A Tape Drive is a high-performance tape drive that you can install in the IBM System Storage TS3500 Tape Library (previously known as the IBM TotalStorage 3584 Tape Library), as well as in the IBM TotalStorage 3494 Tape Library and StorageTek 9310 Powderhorn™ Tape Library, or the 3592-J1A Tape Drive can reside in a stand-alone rack. It has a 2 GB Fibre Channel attachment and a native data rate of up to 40 MB/s.

The 3592-J1A Tape Drive has 300 GB of native capacity in a half-inch format tape cartridge. It is also, by design, a foundation for future generations of this new tape drive family based on the concept of media reuse. This design helps protect the client's investment in tape cartridges.

In October 2005, the second generation of the 3592 drive, the IBM System Storage TS1120 Tape Drive Model E05, was introduced. The IBM 3592-E05 has the same physical measurements as the 3592-J1A Tape Drive but the capacity increased 1.6 times from 300 GB to 500 GB native capacity on one cartridge. It has a 4 GB Fibre Channel attachment and a native data rate of up to 100 MB/s.

Figure 1-16 shows the new TS1120 Tape Drive, the IBM 3592-E05. The white spot on the right bottom is the fiducial.

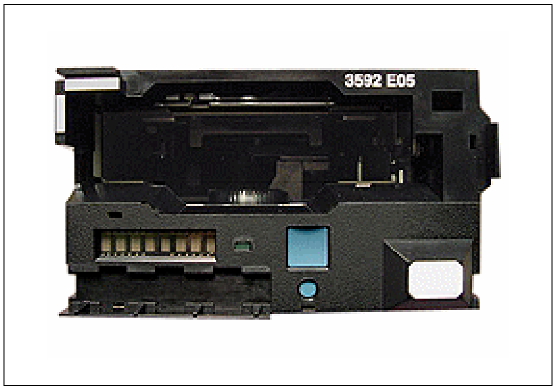


Figure 1-16 IBM System Storage TS1120 Tape Drive Model E05

For more specifications regarding the 3595 J1A Tape Drive and TS1120 Tape Drive, see 2.5, “IBM 3592 Tape Drive Model J1A” on page 81 and 2.6, “IBM System Storage TS1120 Tape Drive” on page 90.

1.2 Technology

In the following sections, we summarize the various tape technologies including tape libraries.

1.2.1 STK 9840

Introduced in late 1998, the STK T9840 Tape Drive (dubbed “Eagle”) is based on linear technology and targeted at the high-end, enterprise server market. The dual-hub cartridge (shown in Figure 1-17 on page 19) has a native capacity of 20 GB and a maximum data rate of 10 MB/s with 9840A. To maintain compatibility with existing enterprise system automation products (mainly the STK silos), the cartridge maintains the external form factor of the 3490/3590 cartridge.

In 2001, StorageTek introduced a second-generation 9840 drive, the T9840B, which increased the data rate to 19 MB/s and provided the same capacity as T9840A. The latest T9840 drive, introduced in 2003, is the T9840C, which doubled the capacity to 40 GB and increased the data rate to 30 MB/s.

Data on all 9840 drives is written 16 tracks at a time in a total of 18 passes, for a total of 288 tracks. In addition to the data tracks, the tape contains five bands of five servo tracks each (25 tracks total) that are pre-written on the tape.

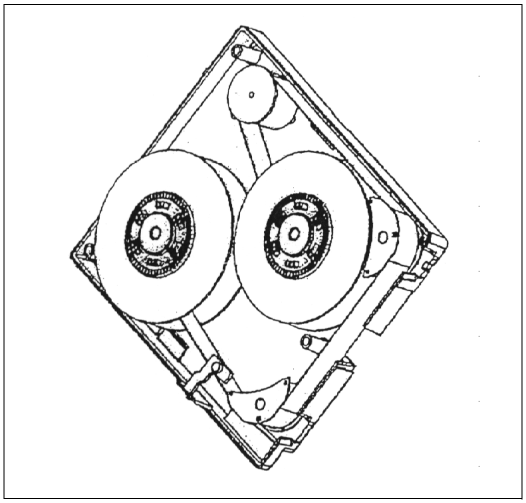


Figure 1-17 STK 9840 tape cartridge

1.2.2 STK 9940

The STK T9940 is based on T9840 technology. The biggest differences between these two drives are the data cartridge and the loader mechanism for the cartridge. The T9940 cartridge has the same form factor and dimensions as the T9840 cartridge, but the T9940 cartridge contains a single reel of media, and the tape path, take-up reel, and tape guidance system are located inside the drive. The first-generation T9940A drive has a capacity of 60 GB (native) and 120 GB (with 2:1 compression). The native data transfer rate is 10 MB/s.

The StorageTek T9940B format, made available at the end of 2002, increased the capacity and data transfer rate of the prior generation to 200 GB (400 GB with 2:1 compression) and 30 MB/s native. the T9940B drive is backward read compatible with the T9940A model.

StorageTek has been acquired by Sun™ Microsystems.

1.2.3 LTO Ultrium

The Linear Tape-Open (LTO) standard was released as a joint initiative of IBM, Hewlett-Packard, and Seagate Technology. As result of this initiative, two LTO formats (Ultrium and Accelis) were defined. The consortium now consists of IBM, Hewlett-Packard, and Quantum/Certance.

The consortium of these companies is known as the Technology Provider Companies. The new technology specifications are detailed at an LTO Web site:

`http://www.lto-technology.com`

The IBM LTO Ultrium 1 drive provides a single-media capacity of up to 100 GB (200 GB with 2:1 compression) data storage per cartridge and a sustained data rate of up to 15 MB/s (uncompressed). IBM LTO Ultrium 2 doubled the media capacity to 200 GB (400 GB with 2:1 compression) data storage per cartridge and more than doubled the sustained data rate to 35 MB/s (uncompressed). IBM LTO Ultrium 3 doubled the capacity to 400 GB (800 GB with 2:1 compression) and more than doubled the sustained data rate to 80 MB/s (uncompressed).

For a detailed description of the LTO Ultrium tape format specification, see 2.1.2, “LTO standards” on page 30.

For a detailed description of the IBM LTO Ultrium drive, see 2.1.5, “IBM LTO Ultrium common subassembly” on page 48.

1.2.4 LTO WORM

The IBM Ultrium WORM cartridges were designed for applications such as archiving and data retention, as well as those applications requiring an audit trail. The IBM Ultrium 3 and Ultrium 4 tape drives provide WORM support for these types of applications. The IBM Ultrium WORM cartridges work with the IBM System Storage LTO Ultrium tape drive to help prevent the alteration or deletion of user data. In addition, IBM has taken several steps to reduce the possibility of tampering with the information:

- The bottom of the cartridge is molded in a different color than rewritable cartridges.
- The special cartridge memory helps protect the WORM nature of the media.
- A unique format is factory-written on each WORM cartridge.

New models of the 3589 are now available. To order the IBM TotalStorage Ultrium WORM Data Cartridges, see Table A-1 on page 395. The Ultrium 400 GB WORM format, based on LTO specifications, provides a tape cartridge capacity up to 400 GB native physical capacity (800 GB with 2:1 compression). You can use these cartridges in IBM TotalStorage Ultrium 3 Tape Drives, the third generation LTO Ultrium tape drive in the IBM TotalStorage LTO Ultrium family of products. The WORM 800 GB data cartridge provides a capacity up to 800 GB native physical (1600 GB with 2:1 compression). The 800 GB WORM can only be used in the IBM Ultrium 4 tape drives.

For currently installed 358*x* products with IBM TotalStorage LTO Ultrium 3 Tape Drives, you might need a drive microcode and library firmware update. However, no hardware additions or features are necessary to enable this LTO WORM capability.

1.2.5 Libraries

System administrators are clamoring for technologies that enable them to efficiently and economically manage the explosive growth in stored data. As the amount of data increases, the backup process takes longer and longer.

The solution to this problem is to use a device that integrates the tape drive with some level of automation. The challenge is to choose the right solution in terms of size and automation level.

System administrators industry-wide have recognized the need for automating the backup-and-restore process to the extent that it requires little or no human intervention. This has become known as *lights-out backup*. This process can be done off-shift or concurrently with other applications during normal operations. Multi-drive tape libraries are the only available technology to offer both the reliability and low cost to make lights-out backup practical.

The hardware options for automation are autoloaders and a range of multi-drive automated tape libraries. We distinguish among them in the following descriptions.

Autoloaders

Autoloaders have one tape drive and clients typically use autoloaders to access a small number of tapes once a day. Most autoloaders are designed for purely sequential operations. These units place no emphasis on performance.

Automated tape libraries

Automated tape libraries have one or more tape drives, but clients typically use them with at least two tape drives. All tape cartridges are accessible to all drives, therefore making concurrent reading and writing operations possible.

You can increase throughput by adding additional drives. Libraries can exchange tapes in a few seconds, substantially improving file-restore response times. Tape libraries are mandatory for lights-out operations and other higher performance tape storage applications. Tape libraries also offer the security of knowing that other drives take over if one fails.

Multi-drive automated tape libraries and ultra-scalable tape libraries combined with storage-management software, including concurrent backup, archive, and HSM, offer the most robust solution to manage and protect huge amounts of corporate data. Automated tape libraries allow random access to large numbers of tape cartridges and concurrent use of two or more drives, rather than manually loading one tape after another or using a single-drive sequential autoloader.

Enterprise tape libraries

Enterprise tape libraries are automated tape libraries that provide enhanced levels of automation, scalability, reliability, availability, and serviceability. They typically have the capacity to house dozens of drives and hundreds of tapes. Equipped with high-performance robotic mechanisms, barcode scanners, and support for cartridge I/O ports, these libraries often offer redundant components and a high degree of flexibility through a modular design. Certain models add support for multiple SCSI, FC-AL, FCP, and ESCON or FICON connections to allow connection to more than one host platform. The top of the line of the enterprise tape library products, such as the IBM TotalStorage Enterprise Tape Library 3494 and the IBM TotalStorage UltraScalable Tape Library 3584, are designed to be shared between two or more heterogeneous host systems. All the hosts have access to the control functions of the tape library robotics. Simply put, the library is shared in a physical way, with each system thinking it really owns the entire library.

1.3 SAN technologies

A Storage Area Network (SAN) is a high-speed network that enables the establishment of direct connections between storage devices and processors (servers) within the distance supported by Fibre Channel. View the SAN as an extension to the storage bus concept that enables storage devices and servers to be interconnected using elements similar to Local Area Networks (LANs) and Wide Area Networks (WANs): routers, hubs, switches, directors, and gateways. You can share a SAN between servers or dedicate a SAN to one server. A SAN can be local or extended over geographical distances.

1.3.1 Tiered overview

In today's SAN environment, the storage devices in the bottom tier are centralized and interconnected, which represents, in effect, a move back to the central storage model of the host or mainframe.

Figure 1-18 on page 22 shows a tiered overview of a SAN connecting multiple servers to multiple storage systems.

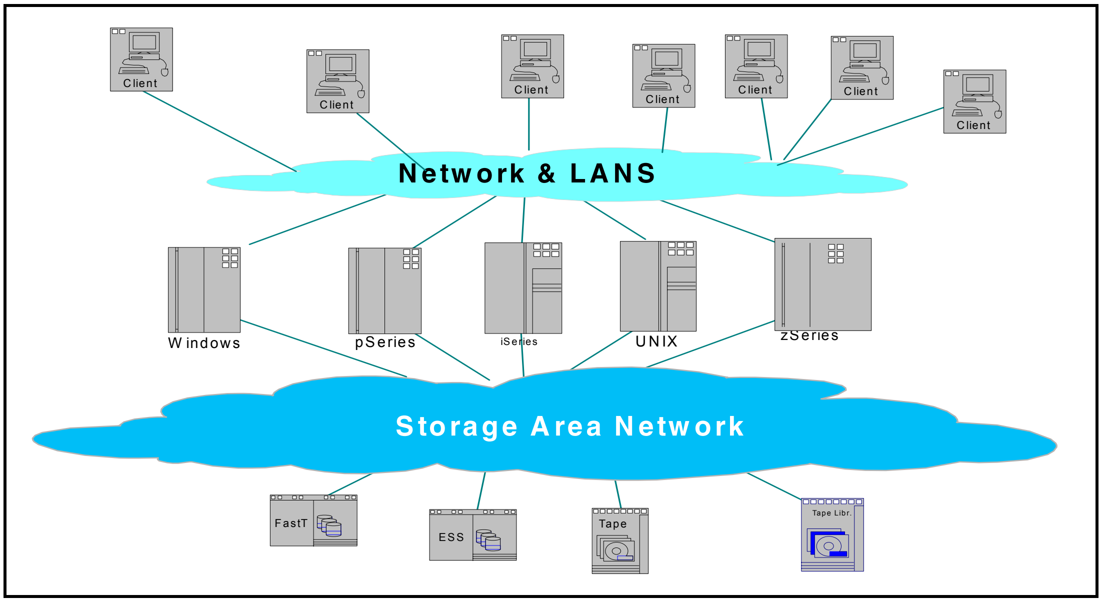


Figure 1-18 Overview of a SAN

A SAN facilitates direct, high-speed data transfers between servers and storage devices, potentially in any of the following ways:

- Server to storage: This is the traditional model of interaction with storage devices. The advantage is that the same storage device can be accessed serially or concurrently by multiple servers.
- Server to server: A client can use a SAN for high-speed, high-volume communications between servers.
- Storage to storage: This outboard data movement capability enables the movement of data without server intervention, thereby freeing up server processor cycles for other activities such as application processing. Examples include a disk device backing up its data to a tape device without server intervention or a remote device mirroring across the SAN.

1.3.2 Tape solutions in a SAN environment

Connectivity to tape is essential for most backup processes. However, manual tape operations and tape handling are expensive. Studies show that automation of tape processing saves money and increases reliability. Enterprises have long had to utilize staff to remove these tapes, transport them to a storage site, and then return them to the tape drive for mounting when necessary. Client tape planning initiatives are directed at more efficient utilization of drives and libraries, as well as minimization of manual labor associated with tape processing.

The biggest challenges with SCSI tape implementations are the limited cable length and the limited possibilities to share drives between several systems. For LVD SCSI, the total cable length is limited to 25 m (82 ft.) using point-to-point interconnection (such as one host connected to only one tape drive). With multi-drop interconnection (one host connected to more than one tape drive on the same SCSI bus), the total cable length is 12 m (39 ft.) for LVD SCSI and 25 m (82 ft.) for High Voltage Differential (HVD) SCSI. Most SCSI tape drives currently have only one SCSI port and therefore can only be attached on one SCSI bus. This severely limits the number of hosts that can physically allocate the drive without recabling.

SANs enable greater connectivity of the tape libraries and tape drives, as well as tape sharing, which we discuss later in this chapter. With Fibre Channel, the distance between the server (or *data point*) and the connected tape node can be up to 10 km. Fibre Channel enables multiple host scenarios without recabling.

If software to manage tape-drive sharing is unavailable, we have to isolate (or *zone*) the drives to unique hosts using functions commonly available on SAN gateways or switches. With the proper management software, each drive can talk to each host, and connections can be dynamic without recabling.

Backup solutions can utilize SAN technology in a number of ways to reduce the costs of their implementation and at the same time increase their performance.

Sharing tape devices on a SAN environment

The tape world has three distinct means of sharing:

- Library sharing
- Drive sharing
- Media sharing

Library sharing

Library sharing occurs when multiple servers attached to a tape library share both the library and the robotics. Tape drives within the library might or might not be shared (*pooled*) among the attached servers. Tape library sharing is a prerequisite for tape-drive sharing.

Drive sharing

The sharing of one or more tape drives among multiple servers is called *drive sharing*. To share drives between heterogeneous applications within a tape library, the tape library must provide multiple paths to the robotics and also must have the capability to define the library's drives and slots as multiple logical libraries. The server attached to each partition has no knowledge of any drives or slots outside the partition.

Media sharing

Media sharing today is possible only in a homogeneous environment between servers that use the same backup server and the same library to back up their data. For systems that are not backed up by the same backup server, it is only possible to share a tape scratch pool.

Figure 1-19 on page 24 shows the multi-path architecture of the 3584 LTO tape library. Every drive can have a path defined to the SCSI Medium Changer (SMC).

The library on the left has been partitioned into three logical libraries. In the AIX and Windows® partitions, only the first drive has a defined library control path.

The iSeries is unique in that every IOP/IOA must have a library control path defined. That is true for V5R1. When you install V5R2, one FC adapter can support up 16 LUNs. The System i attached to the library on the left has two SCSI buses and, therefore, two library control paths defined. These three servers share the IBM 3584 but not the drives.

The library on the right has not been partitioned and has only one logical library. Every System i SCSI bus has a library control path defined to allow control of the TS3500 robotics.

The System i servers attached to the right library also share the library even though it has not been partitioned. Through Backup Recovery Media Services (BRMS), the System i servers share the library and media; they are not performing tape-drive pooling.

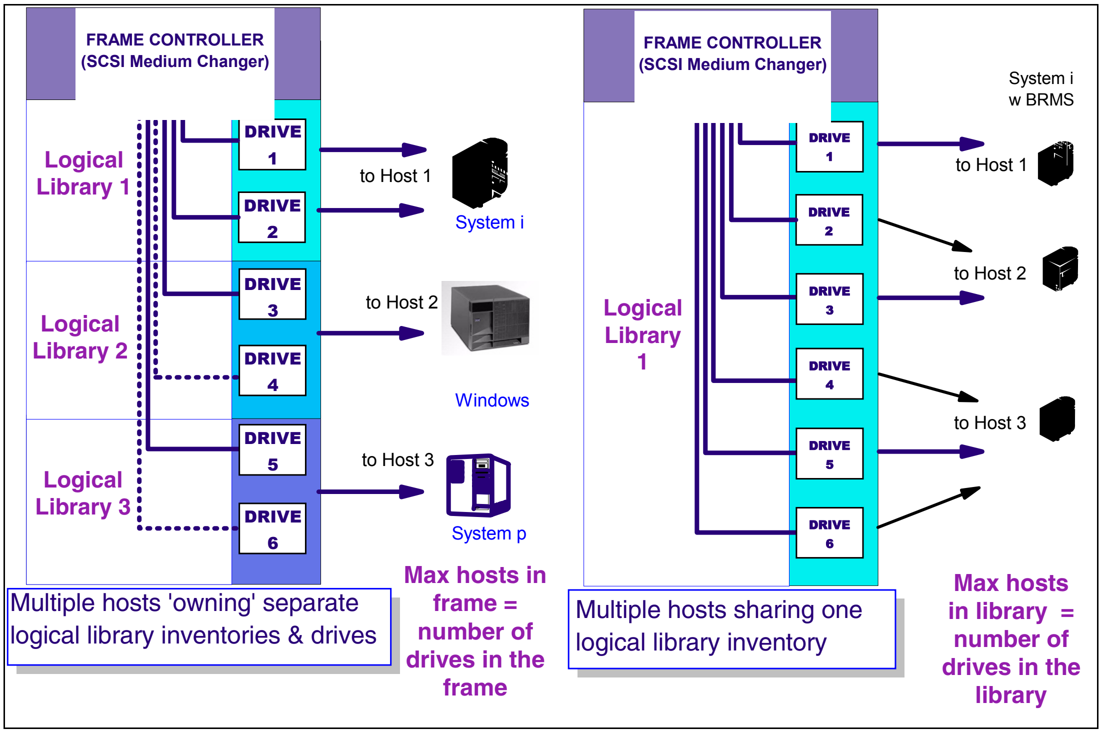


Figure 1-19 IBM 3584 multi-path architecture

IBM LTO in SAN environment

The IBM LTO Ultrium 2 and 3 Tape Drives are available with a Fibre Channel interface for either point-to-point or Fibre Channel-Arbitrated Loop (FC-AL) attachment. These options remove the need to use a SAN data gateway. The device can be attached directly to SAN switches or FC-AL hubs.

In each case, the server requires a supported Fibre Channel host bus adapter (HBA).

Backup software for SAN environments

Implementing backup solutions in a SAN topology requires software developed to enable sharing tape drives at a logical level. The major benefits of this software are:

- Direct connection of the tape drive to the server for high speed
- Sharing the drive with another server to save money

All you need is the proper traffic control feature at a software level.

The development of backup software solutions supporting tape-sharing on SAN is an ongoing process, and many of the back-up software vendors have already delivered products or plan to deliver such a product. IBM has made tape-sharing available for IBM Tivoli Storage Manager since Version 3.7 (October 1999).

Using electronic vaulting for disaster recovery

Another important aspect of using tape in a SAN is the opportunity to exploit tape connectivity for disaster recovery enhancements. Today, most enterprises take their tape backups off-site for disaster recovery. The tape is actually created in a locally attached tape library, then ejected from the library, and finally removed to an off-site location. All of this requires manual intervention and is error-prone. A major reason for failed recoveries is a misplaced tape or tapes.

Fibre Channel SANs enable the backup server to create tapes easily and safely in a remotely attached tape library. This is called *electronic vaulting*. It removes all of the manual effort, because the tape is already off-site and prevents a major cause of disaster-recovery failure. Currently, most enterprises staff tape operations to handle the tapes as they come and go from off-site storage. Fibre Channel allows for greater distances, so it becomes much easier to put a remote tape library at another location to create the backup tape copy. With this method, outlined in Figure 1-20, no manual handling is necessary.

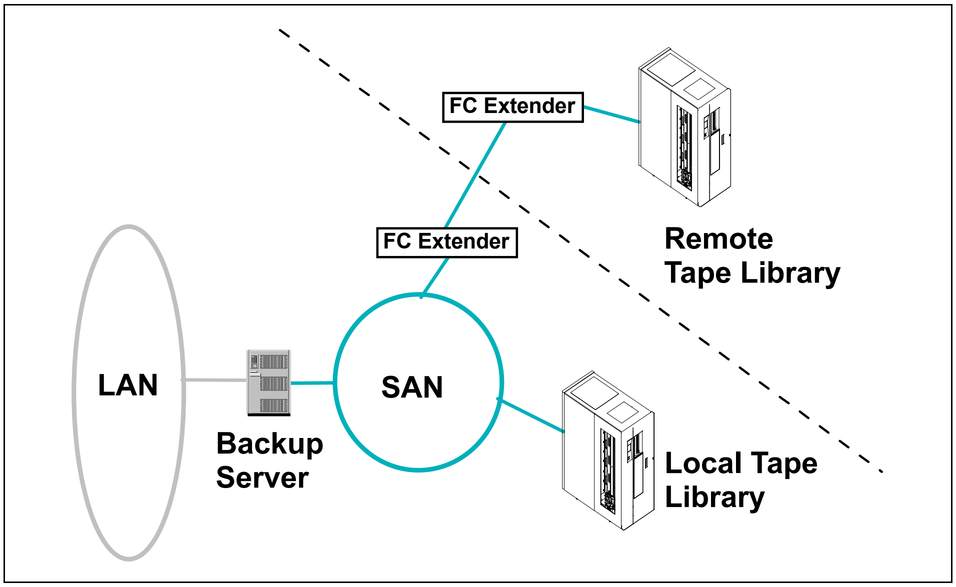


Figure 1-20 Electronic vaulting

LAN-free backup

SAN technology provides an alternative path for data movement between the backup client and the server. Shared storage resources, such as disk and tape, are accessible to both the client and the server through the SAN. Data movement is offloaded from the LAN and from the server processor and allows for greater scalability. LAN-free backups decrease the load on the LAN.

Managed System for SAN is a feature of IBM Tivoli Storage Manager that enables LAN-free data movement. The Tivoli Storage Manager client data moves directly to and from a storage device attached to a SAN. A Tivoli Storage Manager Storage Agent is installed on the client machine and shares storage resources with the Tivoli Storage Manager server. The Storage Agent can write directly to storage media in a format that is consistent with that used by the server. The Tivoli Storage Manager server or servers control the storage devices and keep track of the data that the client has stored. Tivoli Storage Manager continues to use a LAN connection to exchange control information, such as policy information and data about the backed up objects. Using the SAN for client data movement decreases the load on the Tivoli Storage Manager server and allows the server to support a greater number of simultaneous client connections. See Figure 1-21 on page 26.

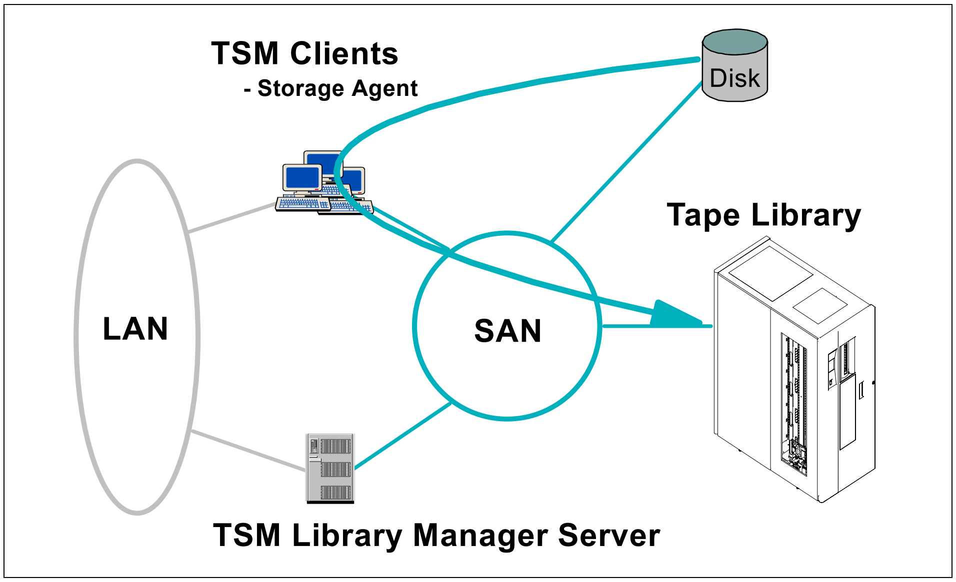


Figure 1-21 Tivoli Storage Manager LAN-free backup

The Storage Agent communicates with the server via the LAN to obtain and store database information and to coordinate device and volume access. The server determines whether the client is requesting access to storage for which the client has a defined SAN path. If a SAN path is defined, the client (by means of the Storage Agent) transfers data on that path. If a failure occurs on the SAN path, failover occurs and the client uses its LAN connection to the Tivoli Storage Manager server and moves the client data over the LAN.

2

Overview of IBM tape technology

The Linear Tape-Open (LTO) program was conceived as a joint initiative of IBM, Hewlett-Packard, and Seagate Technology. In 1997, the three technology provider companies set out to enable the development of best-of-breed tape storage products by consolidating state-of-the-art technologies from numerous sources. In November of that year, they produced a joint press release about LTO. The three technology provider companies for LTO are Hewlett-Packard (HP), IBM Corporation, and Certance LLC[1].

In the tape storage industry, the member companies saw a common set of problems affecting clients in the midrange and network server areas. Multiple tape options are available, each offering certain strengths in terms of capacity, performance, data integrity, reliability, and cost, but no single option appears to meet all of these client needs effectively. The LTO technology objective, therefore, was to establish new open-format specifications for high-capacity, high-performance tape storage products for use in the midrange and network server computing environments and to enable superior tape product options.

We discuss the LTO format specifications in general terms, including first, second, third, and fourth generation Ultrium. The documented LTO specification includes all of this information: information referring to the data cartridge, the format in which data is written, elements of the drive specification relating to that format, and the compression algorithm description. This kind of information is applicable to all LTO manufacturers' product offerings to ensure cartridge interchangeability.

Information in this chapter that relates to the LTO Ultrium drive relates to the IBM LTO Ultrium drive. It might differ from information from other manufacturers in regard to such features as data rate and reliability.

In this chapter, we also present the IBM 3592 technology, introduced by IBM in October 2003.

[1] Seagate RRS became Certance and is now owned by Quantum.

2.1 The LTO organization

The two principal Web sites for marketing, technical, and licensing details for the Linear Tape-Open program are:

http://www.lto-technology.com
http://www.ultrium.com

2.1.1 Overview

Two LTO formats (Ultrium and Accelis) were originally introduced in 1997, and licenses for the new technology were made available. Since then, the Accelis format has not been actively pursued by manufacturers because it is apparent that the Ultrium format meets market needs. The three LTO sponsoring companies also took steps to protect client investment by providing a six-generation roadmap, shown in Figure 2-1, and establishing an infrastructure to enable compatibility between products. At the time of writing this book, four generations were available.

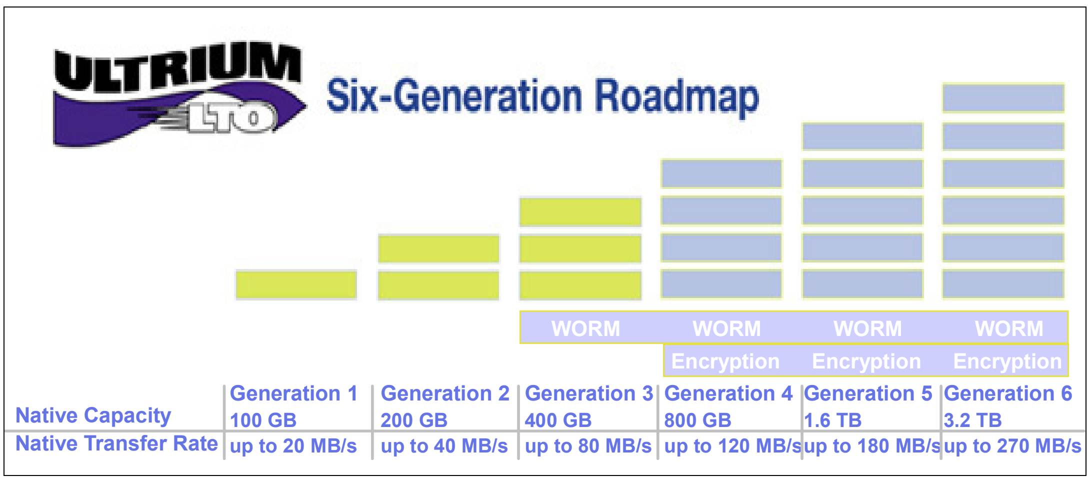


Figure 2-1 LTO Ultrium roadmap

Important: Hewlett-Packard, IBM, and Certance reserve the right to change the information in this migration path without notice.

The LTO Ultrium compatibility investment protection is provided based on the following principles:

- An Ultrium drive is expected to read data from a cartridge in its own generation and at least the two prior generations.
- An Ultrium drive is expected to write data to a cartridge in its own generation and to a cartridge from the immediately prior generation in the prior generation format.

Compatibility among the available Ultrium 1, Ultrium 2, Ultrium 3, and Ultrium 4 media is discussed in 2.4.1, “IBM Ultrium 1, 2, 3, and 4 compatibility” on page 69.

The three technology provider companies (HP, IBM, and Certance) have all made significant contributions of time and expertise to the definition of the LTO format specifications. All have deep knowledge of client needs and have provided expert knowledge and engineering skill in the critical areas of magnetic recording technology, mechanism design, media materials, and cartridge design. This cooperative process has created stronger LTO format definitions than any of the individual companies would have developed working alone.

Open licensing and manufacture

To answer industry calls for open tape format specifications, LTO format specifications have been made available to all who want to participate through standard licensing provisions. More than 25 companies, including HP, IBM, and Certance, have become LTO technology licensees. The licensees include an impressive array of worldwide storage industry leaders, such as:

- Accutronics Incorporated
- ADIC
- Advanced Research Corporation
- Alps Electric Company Limited
- Certance
- EDP/Colorflex
- EMag Solutions
- EMTEC Magnetics GmbH
- Exabyte Corporation
- Fuji Photo Film Company Limited
- Fujitsu Limited/FCPA Intellistor
- Hewlett-Packard Company
- Hi/fn
- IBM Corporation
- Imation Corporation
- M4 Data Limited
- Matsushita Electric Industry
- Maxwell
- Mitsumi Electric Company Limited
- Mountain Engineering II Incorporated
- NEC Corporation
- Otari Incorporated
- Ontrack Data International
- Overland Data, Incorporated
- Phillips Semiconductor Gratkorn
- Plasmon IDE Incorporated
- Quantegy Incorporated
- Sony Corporation
- Tandberg Data
- TDK Corporation
- Verbatim Corporation

In attracting these other industry-leading companies, LTO program technology and LTO specified products (tape drives and tape storage cartridges) can reach the market from multiple manufacturers, not just the technology provider companies. This is critical to meeting an open market objective and is accomplished through open licensing of the technology.

License packages

Three combinations of packages are available for potential licensees:

- *Ultrium Specification Document* provides the opportunity to review the Ultrium format specification with a minimal investment and is suitable for those companies interested in a feasibility investigation.
- *Ultrium Tape Cartridge License Package* is for those companies interested only in designing Ultrium tape cartridges.

- *Ultrium Tape Mechanism License Package* enables the licensee to design Ultrium tape drive mechanisms.

Each license package contains one or all of the following types of documents:

- *Format specification documentation*, which provides the technical information about the format necessary to develop mechanisms and cartridges that interchange between products of the same format
- *License documentation*, which provides additional technical information about tolerance interdependencies and interchange verification testing, and also presents a conceptual overview of the design
- The *trademark style guide*, which describes the use of the Ultrium trademarks and logos (Figure 2-2)

Figure 2-2 LTO trademarks

Compliance verification

The technical strategy for accomplishing format compliance verification among the licensees has been defined, and an independent Compliance Verification Entity (CVE) has been selected. In an effort to promote interchangeability of tape cartridges, a third-party verification test company has been enlisted to perform specification compliance verification testing. These tests will be required annually for all companies that use the logo.

The objective of the compliance testing is to test only the ability to produce, read or write Ultrium cartridges that meet the format specifications. It is not an objective of this format compliance testing to evaluate Ultrium drive quality, mean time before failure (MTBF), physical form factor, or other parameters not directly related to the LTO program formats and interchangeability. LTO program licensees have wide latitude to establish their own mechanical, electrical, and logical designs to meet the format specifications. These factors will not be tested as part of the compliance verification process.

For more details about the packages, documentation, or licensing, refer to the LTO Web site:

http://www.lto-technology.com

2.1.2 LTO standards

LTO technology was originally developed for two open tape format specifications: Accelis and Ultrium. The Accelis format (fast-access) is not being developed, because the Ultrium format provides adequate fast-access performance.

LTO core technology

Multi-channel linear serpentine recording is at the core of the LTO formats. It enables an optimum balance of reliability and data integrity, performance, and high capacity. In the LTO recording format, data is written in tracks that run down the length of the tape.

The Ultrium format records either 384 (Ultrium 1), 512 (Ultrium 2), or 704 (Ultrium 3) tracks across the half-inch tape width. This linear recording format has a *serpentine* characteristic. The drive mechanism makes multiple passes from the beginning of the tape to the end of the tape and back to read or write the full capacity of the cartridge. In the Ultrium 1 format, the 384 tracks are split into four bands of 96 tracks each. In Ultrium 2 format, the 512 tracks are split into four bands of 128 tracks each. In Ultrium 3 format, the 704 tracks are split into four bands of 176 tracks each. In Ultrium 4 format, the 896 tracks are split into four bands of 224 tracks each.

Data is written to the innermost bands first to provide protection to the data recorded earliest in the process, by writing it in the center, which is the most physically stable area on the tape. Data is also verified as it is written. On pass one of a round-trip down the length of the tape and back, eight tracks are read or written, concurrently. At the end of the tape, pass two of the round-trip starts. The read/write heads are indexed and positioned over eight new tracks, and the tape reverses direction back toward the beginning of the tape to complete the round-trip. For the next round-trip, the heads are again indexed to a new position over a new group of eight tracks. With Ultrium 3 and 4, 16 tracks are read/written on each pass of a round-trip.

Because track densities are high, and because the tape is subject to some lateral movement as it is moved, it is critical for performance and data integrity that the read/write heads are always positioned precisely over the correct tracks. This is accomplished through a technique called *timing-based servo*. This technique makes it possible to use high track densities, now and in the future, without changing the format of the media, and it provides the ability to read data, even with media imperfections.

In the LTO system, electronic signals are generated through the real-time reading of servo data bands that are prerecorded on the LTO tape. These signals enable the servo system to dynamically control the positioning of the read/write heads across the width of the tape. Similar magnetically based, track-following servo systems are proven in tens of thousands of tape drives in use today, such as the IBM TotalStorage 3590 Tape Drive (IBM 3590) and IBM TotalStorage 3592 Tape Drive (IBM 3592).

The LTO formats also utilize advanced error correction codes for data integrity. These systems are designed to automatically correct most cross-track errors and provide data correction even if a full track is lost. Data is further protected by the demarcation of bad areas of the tape (for example, where servo signals are unreliable) and through dynamically rewriting bad blocks. Cartridge memory is embedded in the LTO cartridges. A non-contacting radio frequency module, with non-volatile memory capacity of 4096 bytes for Ultrium 3 and 8192 bytes for Ultrium 4, provides for storage and retrieval.

Ultrium tape formats

Figure 2-3 and Figure 2-4 on page 32 show the IBM Ultrium cartridges, which you can distinguish by color: The first generation IBM cartridge is black, the second generation (Ultrium 2) cartridge is purple, the third generation (Ultrium 3) is slate blue, and the fourth generation (Ultrium 4) is green. The third generation IBM WORM cartridge is a two-tone cartridge with a slate-blue top and a platinum (silver) bottom and the fourth generation WORM cartridge is a two-tone cartridge with a green top and a platinum (silver) bottom.

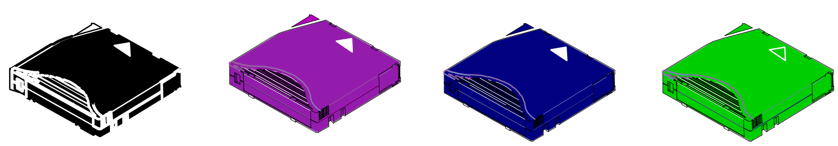


Figure 2-3 IBM LTO Ultrium 1, Ultrium 2, Ultrium 3, and Ultrium 4 tape cartridges

The Ultrium tape format specification is the implementation of LTO optimized for high capacity and performance with outstanding reliability, in either a stand-alone or an automated environment. The Ultrium cartridge uses a larger single-reel design (Figure 2-3 and Figure 2-4 on page 32) and 1/2-inch tape to provide ultra-high storage capacity. The tape is extracted from the cartridge by the tape drive through a leader pin and wound onto a take-up reel contained within the drive itself. This design is focused on client requirements for very high capacity and performance, and is ideally suited for backup, restore, and archive applications. Ultrium drive technology is intended to meet the needs of the enterprise on a roadmap, or migration path, that extends well into the future. The Ultrium tape format establishes a new benchmark for large volume backup and archive.

WORM tape format

Beginning with LTO Ultrium format generation 3, Write Once Read Many (WORM) functionality provides for non-erasable, non-rewritable operation with tape media and is designed for long-term, tamper-resistant record retention. LTO4 drives provide the same WORM capability.

The format specification for WORM for LTO Ultrium generation 3 and 4 includes low-level encoding in the Cartridge Memory (CM) and also is mastered into the servo pattern as part of the manufacturing process. This encoding is designed to prevent tampering.

Data can be appended at the end of a WORM cartridge to which data was previously written allowing the full use of the high-capacity tape media.

LTO Ultrium format generation 3 non-WORM and WORM as well as LTO4 drives can coexist.

Figure 2-4 IBM LTO Ultrium 3 WORM tape cartridges

Interleaved recording

The LTO drive uses an interleaved, serpentine, longitudinal recording format. The first set of 8 or 16 data tracks is written from near the physical beginning of the tape to near the physical end of the tape. The head then repositions to the next set of tracks for the return. This process continues until all tracks are written and the tape is full.

The format of the recording of the data and servo tracks is defined as part of the LTO specification in order to meet the requirement for interchange among different manufacturers' implementations.

Servo tracks

Servo tracks (also called *servo bands*) enable accurate positioning of the tape drive head over the data track, ensuring that the head does not stray onto an adjacent track. They are necessary to support high-data densities on the tape where the tracks are very close together. The servo bands are written when the cartridge is manufactured, before the cartridge is usable for data storage and retrieval. If the servo bands are erased, the tape becomes unusable.

Servo tracks are similar to lane markings on a multi-lane highway. Imagine how difficult it would be to drive on the highway without any lane markings. Lane markings help by positioning you on the lane, just as servo tracks support the drive recording head to position it on the data tracks. See Figure 2-5.

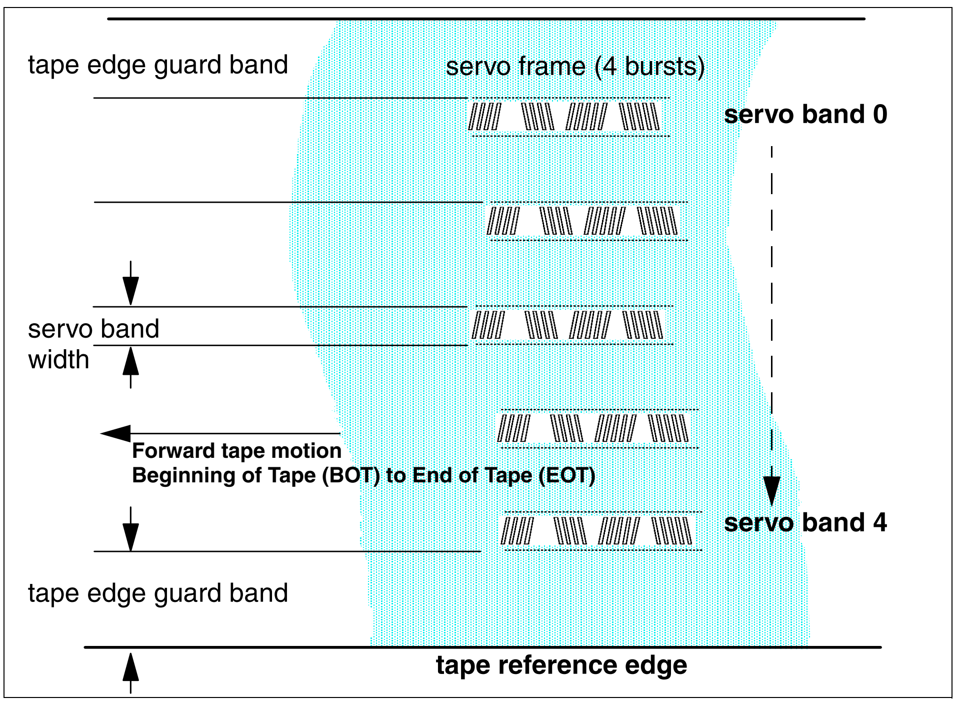


Figure 2-5 Servo band position and nomenclature

As shown in Figure 2-5, five servo bands, numbered 0 through 4, make up the servo tracking mechanism on the LTO Ultrium tape. They are each located at specific distances from the tape reference edge[2]. Within the servo bands are *servo stripes*, groups of which make up *servo bursts*. Four servo bursts make up a servo frame; the first two bursts (as written in the forward tape-motion direction) contain five servo stripes, and the second two bursts contain four servo stripes.

[2] The reference edge of the tape is the bottom edge when viewing the recording side of the tape with the hub of the tape to the observer's right, as shown in Figure 2-5.

Track following

Each pair of servo bursts is at an angle to each other, and the servo heads move such that they keep a constant value for the distance between the bursts. In this way, the servo is able to follow a straight line within the servo band; any small deviation away from the correct path causes a variation (plus or minus) in the gap between the bursts (see Figure 2-6). Provided that the servo head element follows a straight line along the servo band, then the distance “x” shown in the figure remains constant. IBM LTO drives use two servo bands simultaneously during write operations to provide two sources of servo information, and therefore increased accuracy.

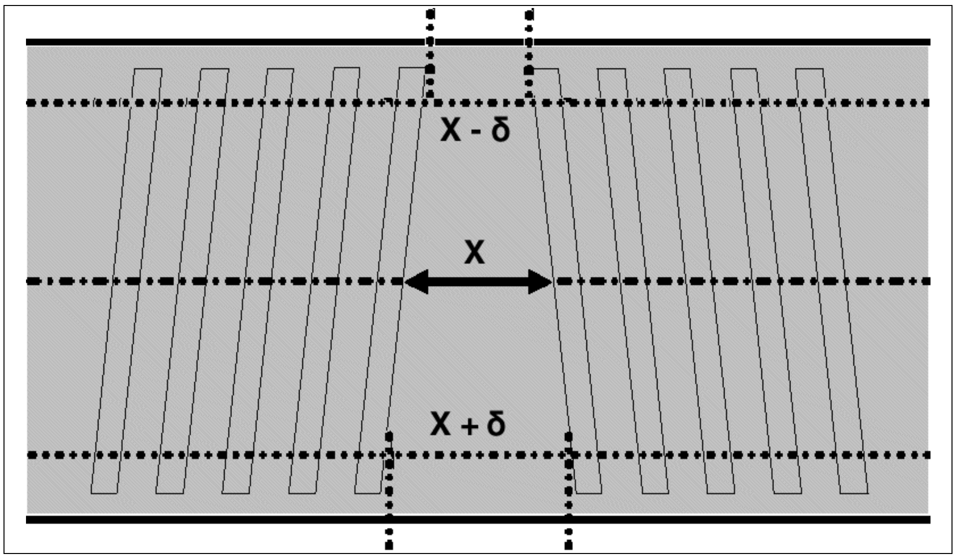


Figure 2-6 Magnified servo band showing a pair of servo bursts

The format specifies six nominal servo positions for Ultrium 1, eight servo positions for Ultrium 2, and eleven servo positions for Ultrium 3 within each servo band. In addition, the servo head is made up of two servo head elements to address a single servo band. This means that, using the two elements, the servo head is able to reposition within the servo band for the six (Ultrium 1) or eight (Ultrium 2) forward and reverse data wraps within each data band (Figure 2-9 on page 37). The distance between each servo position corresponds to the distance apart that the data tracks are written. For further information about the drive head and elements, see “Drive head” on page 49 and Figure 2-20 on page 49.

This technology can be extremely fine-tuned and is capable of supporting very high track densities using the same servo tracks, because the Ultrium 1 and Ultrium 2 six/eight nominal positions are basically definitions of six/eight different “x distances” between servo bursts (see Figure 2-6) and not a fixed servo track. By defining additional “x distance” positions, it is possible to increase the number of tracks on an LTO Ultrium while still using the same technology. With this technology, LTO is also able to satisfy the compatibility aspects as described in 2.1, “The LTO organization” on page 28. The Ultrium 2 drives have to use the six defined “x distances” on the Server tracks to read and write in Ultrium 1 Format.

With Ultrium 3 the concept is still the same, but increasing the number of servo positions to eleven. Compatibility with the previous generations is achieved by using their six/eight servo positions. See “Data tracks” on page 35 also for further details.

Longitudinal positioning

The LTO servo band is designed not only for track following, but also for recording the longitudinal position (LPOS). The absolute location down the length of the tape and the manufacturer data are recorded in LPOS *words* approximately every quarter-inch (.7 cm) along the tape. The LPOS word consists of symbols constructed from bit sequences (ones and zeros); these bits are encoded within the servo frames. See Figure 2-7.

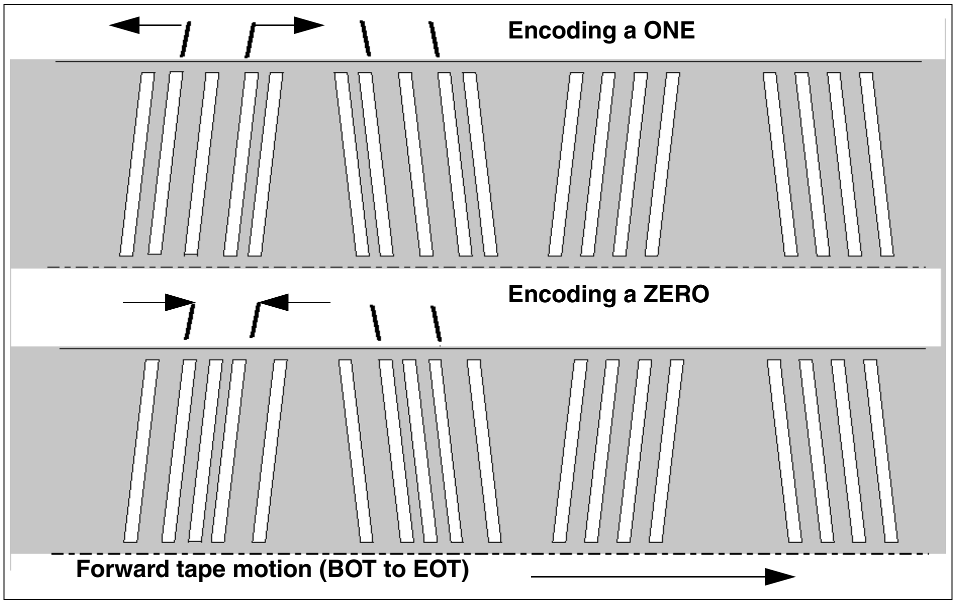


Figure 2-7 Encoding bits using the servo stripes within the servo bursts

Each servo frame encodes one bit using the first pair of servo bursts. When servo stripes 2 and 3 (out of the five) are shifted inward (see Figure 2-7), this encodes a zero; when servo stripes 2 and 3 are shifted outward, this encodes a one. The LPOS word contains 36 bits and therefore has a length of 36 servo frames.

Each of the 5 servo bands on the tape can be uniquely identified by the relative positions of the frames down the tape, in adjacent servo bands. The offset of the frames between servo band *n* and servo band *n+1* are specific to each servo band (0 and 1, 1 and 2, 2 and 3, or 3 and 4). Therefore, the drive can move the head directly from the physical beginning of the tape to a specific logical position for reading or writing.

Data tracks

The area between adjacent servo bands is a *data band*. There are four data bands numbered 2, 0, 1, and 3, where data band number 2 is nearest to the reference edge of the tape and data band 3 is farthest away, as in Figure 2-8 on page 36. The data bands are written in sequence beginning with 0 (in the center of the tape) and ending with 3.

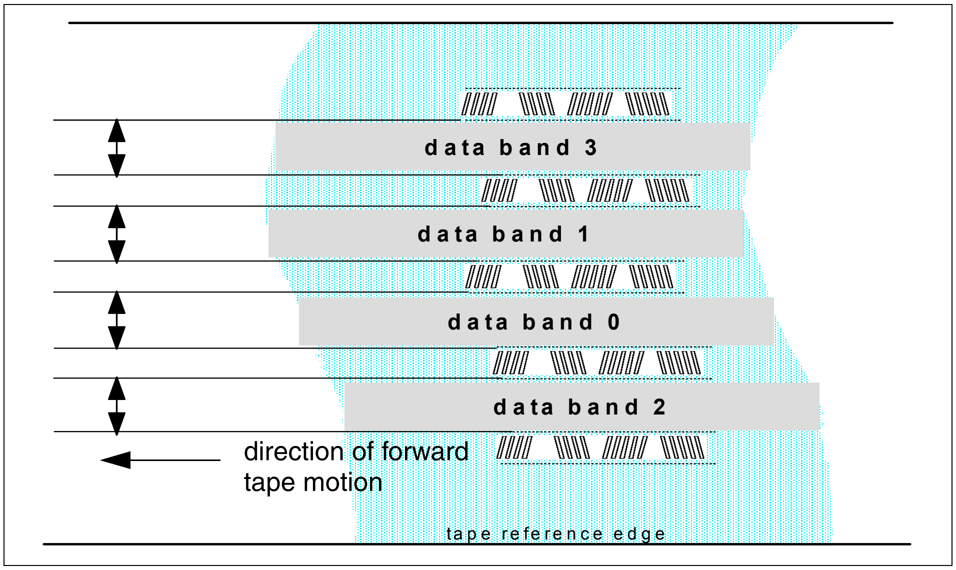


Figure 2-8 Four data bands written between the servo tracks

Each data band consists of numbers of tracks that are recorded eight tracks at a time (for Ultrium 1 and Ultrium 2) from one end of the tape to the other. For Ultrium 3 and Ultrium 4, the tracks are recorded 16 tracks at a time. The process is like this:

1. The head is positioned over data band 0, and the first set of eight (16) tracks is written from the physical beginning of the tape (BOT) to the physical end of the tape (EOT).
2. The head physically repositions (using a different servo position within the same servo bands) and switches electronically[3] to a second set of eight (16) write elements in order to write eight (16) tracks in the reverse direction back to the physical beginning of the tape.
3. The head physically repositions again, and, switching back to the first set of write elements, writes another set of tracks to the physical end of the tape.
4. The head continues to switch and index in this manner until all the tracks are written and the head is back at the physical beginning of the tape (Ultrium 1 and 2), or at the end of the tape for Ultrium 3.
5. The head moves to data band 1 to continue writing the data.

For Ultrium 1, 96 data tracks (8 tracks times 6 forward and backward writes) coexist in one data band. For Ultrium 2, there are 128 data tracks in one data band (8 tracks times 8 forward and backward writes), and for Ultrium 3 there are 176 tracks in one data band (16 tracks times 6+5 forward or backward writes). For Ultrium 4, 224 data tracks (16 tracks times 14 forward and backward writes) are in one data band.

A group of tracks recorded concurrently in the physical forward or the physical backward direction is called a *wrap*. Wraps recorded while the tape is moving from BOT to EOT are *forward wraps*; wraps recorded while the tape is moving from EOT to BOT are *reverse wraps*. The wraps are recorded in a serpentine fashion, as described: a forward wrap, then a reverse wrap. They are numbered sequentially in the order that they are processed, starting with wrap 0. Therefore, for Ultrium 1 six forward wraps and six reverse wraps make up a data band. For Ultrium 2, eight forward and eight reverse wraps make up a data band. The individual tracks within a wrap are interleaved with tracks from other wraps; in other words, adjacent tracks are not part of the same wrap. (See Figure 2-9 on page 37.)

[3] See “Drive head” on page 49 for more information about electronic head switching.

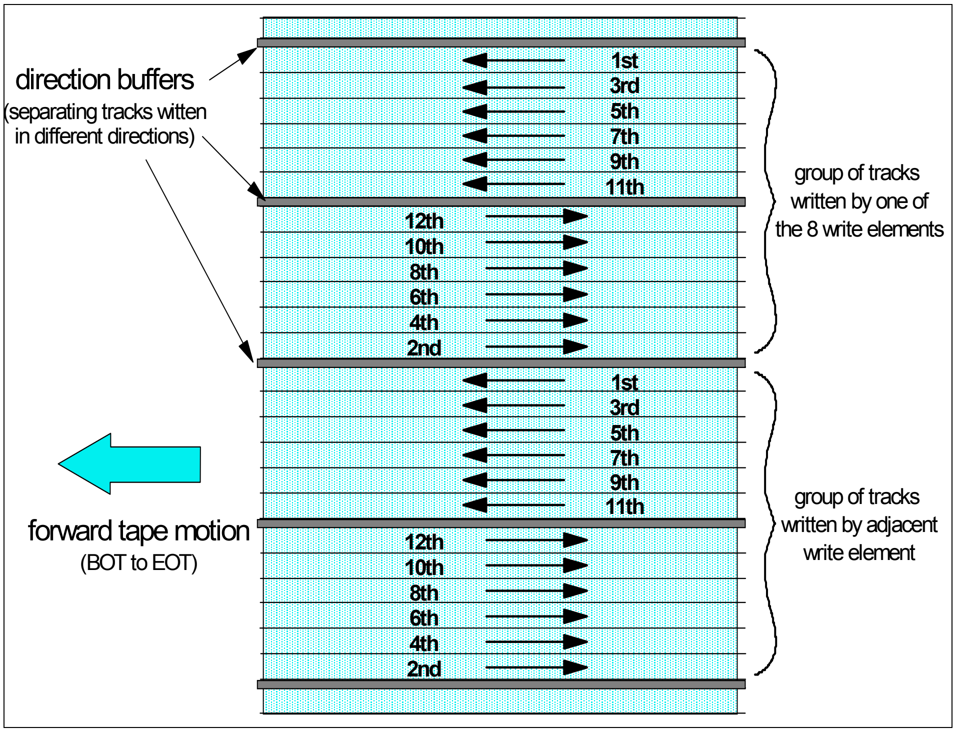


Figure 2-9 Portion of data band showing Ultrium 1 track-writing sequence

This figure expands on Figure 2-8 on page 36 to illustrate the sequence in which the tracks are written. One data band is magnified[4] to show an area written by two adjacent write head elements (from the total of eight); this is one quarter of the width of the data band. You can see that the tracks are written in an inward spiral (serpentine) manner; the first and second tracks are farthest away from one another while the 11th and 12th tracks are adjacent to one another. In Ultrium 2, there will be 16 serpentine tracks for each of the 8 write elements.

Ultrium 3 is conceptually the same, but technically different. Within each data band, there are 16 write elements that will write a total of 11 serpentine tracks. For example, in data bands 0 and 2, there are six forward wraps but only five reverse wraps. The data bands 1 and 3 are complementary to this and will contain five forward wraps and six reverse wraps. Thus with Ultrium 3, the read/write head is moved from data band 0 to data band 1 while the tape is at the EOT position.

The space between tracks written in opposing directions is called a *direction buffer*. This space is designed to minimize magnetic interference between tracks written in opposite directions (cross-track interference).

Read/verify elements are built into the tape head in the drive. The data is written by the write elements and then immediately passes the read/verify elements and is checked for errors. If any errors are found, the block of data is rewritten farther down the tape.

The total number of data tracks across the width of the tape is 384 for Ultrium 1, numbered 0 through 383. For Ultrium 2, 512 tracks are used, for Ultrium 3 there is a total of 704 tracks, and for Ultrium 4, there are 896 tracks. Track numbering is unrelated to the sequence in which the tracks are written: data track 383/511/703 is the closest to the reference edge of the tape, and data track 0 is farthest away.

[4] Refer to "Drive head" on page 49 and Figure 2-20 on page 49 to see the structure of the eight-element head.

Backwards compatibility

The LTO standard specifies a backwards compatibility of writing one generation backwards and reading two generations backwards. To make this possible, LTO uses a technique called *shingling*. When using shingling, a write track might overlap the bottom of a previously written track. LTO Generation 2 uses shingling when writing data to an LTO Generation 2 Cartridge. The very first two passes write to the tape in the normal way. The following passes can partially overwrite previously written data tracks. The IBM LTO Generation 2 write head width is that of the LTO Generation 1. Therefore, the LTO Generation 2 drives can write an LTO1 cartridge in full track width, and when writing to an LTO2 cartridge it uses the shingling write function. To read the residual LTO generation 2 data tracks, the read head must of course be narrower than the LTO generation 1 read head (Figure 2-10).

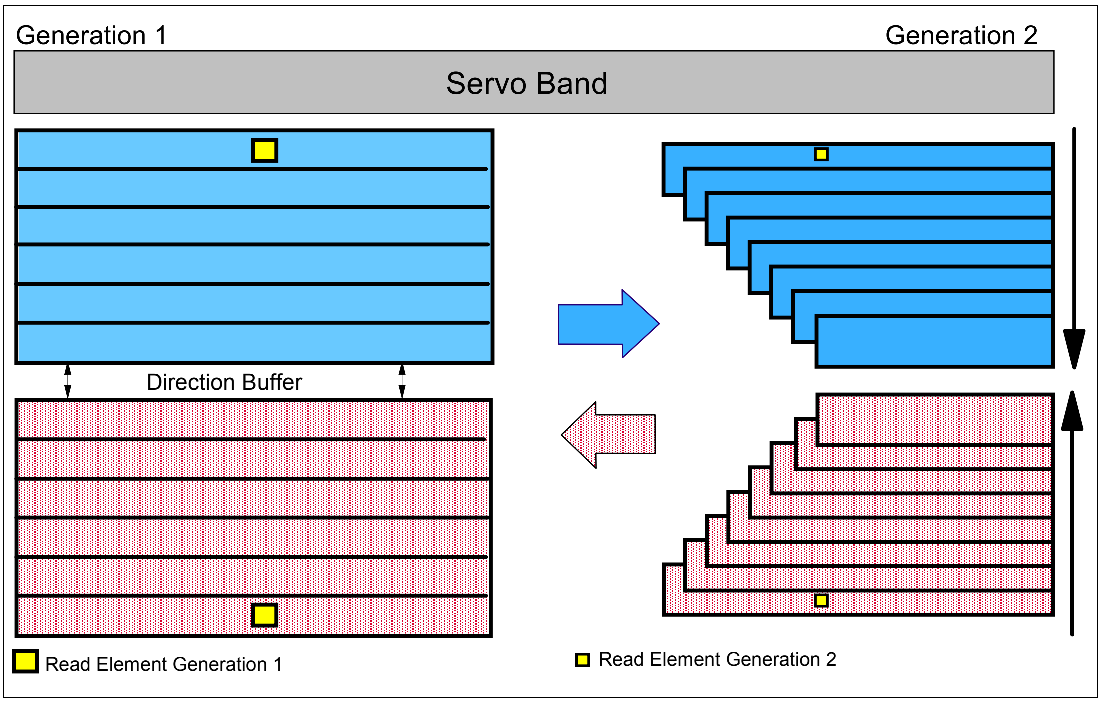


Figure 2-10 Shingling: Writing to tape generation 1 versus generation 2

Again, LTO Generation 3 and 4 are conceptually the same, but technically different. The Ultrium 3 and 4 data is written 16 tracks at a time utilizing the shingling technique. To achieve compatibility, the write heads of LTO3 drives are equal to the residual track width of the Generation 2 format, and the spacing between alternate (every second) Generation 3 write heads is the same as between the Generation 2 write heads. Thus, Generation 3 data is written using the shingling method, but Generation 2 data is written using only every second write head and writing the full Generation 2 data width. Generation 1 data can similarly be read by every other read head.

Linear density

The linear density for LTO1 is 4880 bits per mm. The linear density was improved for LTO2 to 7398 bits per mm and for LTO3 to 9638 bits per mm.

Both LTO1 and LTO2 cartridges are of the same length, 610 m (2000 feet). To achieve the required doubling of capacity, the LTO3 tape is slightly longer, 680 m (2231 feet) and LTO4 is 864 m (2703 feet).

2.1.3 Data compression

The LTO Consortium created a superior data compression technique known as *LTO Data Compression (LTO-DC)*. Though an excellent data compression algorithm, adaptive lossless data compression (ALDC) already existed, and it is not optimized for incompressible data such as encrypted or previously compressed data. For incompressible data, it is usually best not to apply any data compression algorithm, but rather to simply pass the input data directly out to the compressed data stream (pass-through). Given the variations in data, there are times when ALDC is desirable and times when a simple pass-through is better. For instance, if using ALDC-based data compression, it is best if all segments of incompressible data are recorded without expansion by using a pass-through technique instead. Figure 2-11 is a block diagram illustration of the LTO-DC data compression technique using the two schemes.

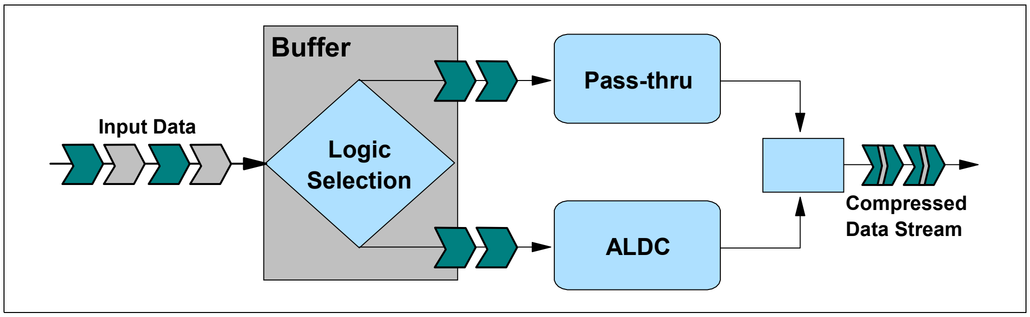


Figure 2-11 LTO-DC block diagram

Note that no standardization of when to scheme swap when compressing data was specified by LTO-DC. LTO-DC was approved by ECMA as the Streaming Lossless Data Compression (SLDC) standard, as explained at:

http://www.ecma-international.org/publications/standards/ECMA-321.htm

Note: The LTO compression technique is called SLDC.

Because no standardization is specified, all vendor implementations might do scheme swapping differently. What is specified and tested is that the resultant compressed data stream is decompressible by the defined set of LTO-DC rules. This enables interchange between drives from the different vendors. Each vendor's Ultrium drive has been shown to be able to read and decompress the LTO-DC streams of the others.

Embedded codewords

LTO-DC uses embedded codewords to enable swapping between the two schemes. ALDC is referred to as Scheme 1, and pass-through is referred to as Scheme 2. Both methods are used. However, only one is used to output any given data byte, though different bytes in a record might be output in different schemes. Therefore, if a given record begins with compressible data it can be output in Scheme 1, and if the nature of the data changes inside of the record and it becomes incompressible (as embedded control data or an array of incompressible data), a scheme swap can be performed to allow outputting the incompressible data in Scheme 2. Similarly, a scheme swap can be performed to revert to Scheme 1 if the data becomes compressible again. A scheme swap is denoted in the compressed data stream via one of four embedded codewords.

As an example, one 13-bit codeword basically means all following data is to be decompressed as Scheme 1 until another scheme swapping codeword is encountered. Embedded codewords are also used to delineate record boundaries and filemarks. Having record boundaries demarked within the output compressed data stream, rather than by pointers maintained in a separate directory table, has a number of advantages. First, from a storage point of view, it is more efficient because it enables greater capacity. Second, the insertion of these codewords enables higher-speed data streaming because they can be managed by the compression engine without microprocessor involvement. Both of these features are especially useful for small records. Typically, backup applications will send 512-byte, 4-KB, 32-KB, or 256-KB records to a backup tape drive. For small records such as 512 bytes, the improved format efficiency of the embedded control is substantial. By reducing required microprocessor involvement, it allows superior transfer rates to the drives. This is why LTO tape drives offer high capacity tape backup, as well as drive transfer rates far better than other midrange backup tape drives and are superior even to some more expensive, high-end tape drives.

The ability to swap between ALDC and a pass-through mode gives a tape drive the power to automatically adapt to the incoming data stream.

Note: The IBM 3592 Tape Drive uses the same compression technique: SLDC.

2.1.4 Tape cartridge

The Ultrium cartridge is a single-reel cartridge. This means that the whole tape is wrapped around a single reel when the cartridge is not loaded in a drive. During the loading process, the threader of the drive catches the leader pin of the tape and threads it through the drive and the machine reel. During the read/write process, the tape is stored on the machine reel and the cartridge.

Two views of the tape cartridge are shown in Figure 2-12 and Figure 2-13 on page 41.

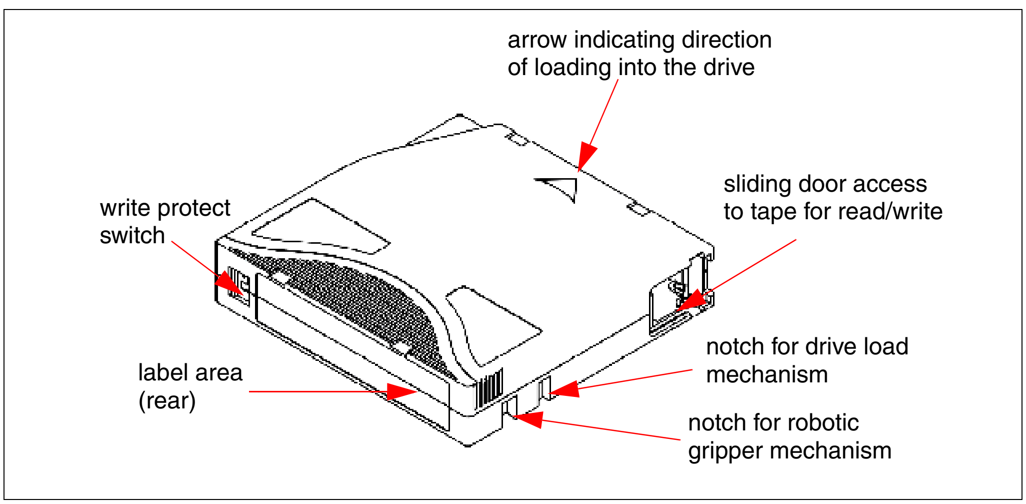


Figure 2-12   Ultrium cartridge view from top and rear

The cartridge is approximately 10.2 cm long, 10.5 cm wide, and 2.2 cm high (approximately 4 x 4.16 x 0.87 inches). The cartridge contains 12.6 mm (1/2-inch), metal-particle tape with a high density recording area. The Ultrium 1 specification describes four types of cartridges, each with a different tape length and, therefore, capacity. At this time, only one cartridge type is generally available, with a tape length of 610 m (2000 feet) providing 100 GB of native data and 200 GB of compressed data (assuming 2:1 compression). There is only one standard Ultrium 2 cartridge type and therefore only one tape length of 610 m (2000 feet). The native capacity of the Ultrium 2 cartridge is 200 GB (400 GB compressed assuming 2:1 compression).

With Ultrium 3 and 4, there are both regular rewritable tapes and Write Once Read Many (WORM) tapes. To achieve the 400 GB (LTO3) or 800 GB (LTO4) native data, this tape is slightly longer at 680 m (2231 feet).

Figure 2-13 shows several of the components of the cartridge.

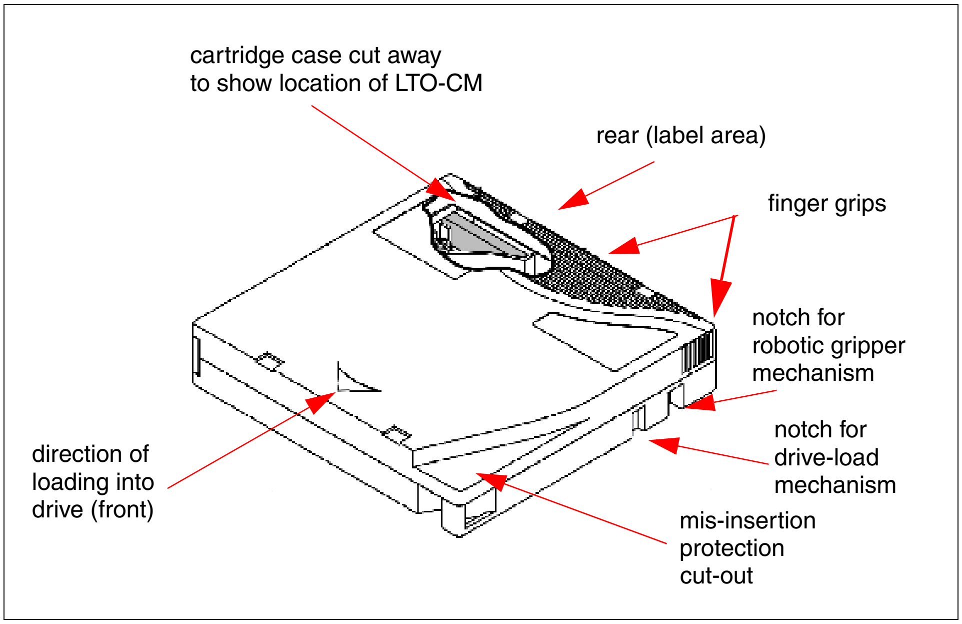


Figure 2-13 Ultrium cartridge view from top and front

The labeled parts are:

- Grips: Molded areas on the cartridge casing designed as finger grips for manual loading.
- Label area: Located at the designated area at the rear of the cartridge where the adhesive barcode label is applied.
- Sliding door: Cartridge door (shown in Figure 2-12 on page 40) that protects the tape from contamination whenever the cartridge is out of the drive. Behind the door, the tape is threaded onto a leader pin (shown in detail in Figure 2-14 on page 42), which is used to pull the tape from the cartridge for use. A locking mechanism prevents the media from unwinding when the cartridge is not located in the drive.
- Notches: Two sets of molded notches in the cartridge casing are located on the sides near the rear. The first pair enables the robotic gripper to pull the cartridge out of the drive mouth after the cartridge has been unloaded; the second pair enables the drive to grip the cartridge and pull it into the loading position inside the drive.
- Mis-insertion protection: A cut-out in the front side of the cartridge casing that prevents the cartridge from being inserted into the drive in the wrong orientation. This feature prevents the use of unsuitable cartridges of similar, but not identical, construction.

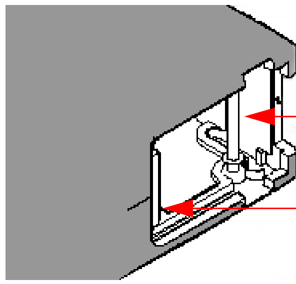


Figure 2-14 Leader pin attached to the tape medium

The various cartridges are color-coded for easy visual distinction (see also “Ultrium tape formats” on page 31):

- LTO1 cartridges have an all black casing.
- LTO2 cartridges have an all purple casing.
- LTO3 cartridges have an all slate-blue casing.
- LTO4 cartridges have an all green casing.
- LTO3 WORM cartridges have a two-tone casing with a blue top and a platinum bottom.
- LTO4 WORM cartridges have a two-tone casing with a green top and a platinum bottom.

Even though the servo tracks are similar on Ultrium 1 and Ultrium 2 cartridges, Ultrium 2 cartridges are required with an Ultrium 2 drive to achieve Ultrium 2 capability. Similarly, an Ultrium 3 cartridge is required to achieve Ultrium 3 capacity, and an Ultrium 4 cartridge is required to achieve Ultrium 4 capacity. See 2.4.1, “IBM Ultrium 1, 2, 3, and 4 compatibility” on page 69 for more about media compatibility among the generations.

Metal particle medium

The metal particle tape medium consists of a transparent polyethylene base material with two coatings. On one side, the base has two fine coats of a strong yet flexible ferromagnetic material, dispersed in a suitable binder; this is the surface on which the data is written. The back surface is coated with a non-ferromagnetic conductive coating.

Metal particle media have high coercivity, which is a measure of their ability to retain their magnetic properties after the data is written to the tape; this is one of the factors in enabling a potentially longer shelf life than other media.

Cartridge memory (LTO-CM)

Information about the cartridge and the tape is written to the LTO-CM, which is a serial Electronically Erasable Programmable Read-Only Memory (EEPROM) with both read-only and rewritable areas. It is housed inside the cartridge casing at the left rear (label side) corner as illustrated in Figure 2-13 on page 41, which shows the interior of the cartridge casing.

The LTO-CM has a capacity of 4096 bytes for Ultrium 3 or 8192 bytes with Ultrium 4. It is used to hold information about that specific cartridge, the media in that cartridge, and the data on the media. A copy of this information is also kept in the first data set within the user data area and is given the data set number zero.

Communication between the drive and the LTO-CM uses a contactless low-level radio frequency (RF) field generated (in the IBM implementation) by the drive. The LTO-CM is non-volatile storage updated using the RF field; it requires no additional power source. This type of technology has an expected shelf life of more than 30 years.

There are a number of distinct data fields within the LTO-CM, shown in Table 2-1. The fields align to 32-byte boundaries, because this is the defined block access size.

Table 2-1 Data fields stored in the LTO-CM

LTO-CM information	Read/write
LTO-CM manufacturer's data	Read-only
Tape label[a]	
Media manufacturer information	
Initialization data[b]	Restricted write capability
Cartridge status and tape alert flags	Read or write
Usage information	
Tape write pass	
Tape directory	
End-of-data information	
Mechanism-related	
Application-specific data[c]	
Vendor-unique data	

a. This field contains information about the tape, including a 10-byte field with the tape serial number; it is a read-only area and does not contain the volume label, which can be changed if the tape is reinitialized.
b. This is a restricted-write field that is updated with changes when the tape is reinitialized.
c. This is a field for application data (such as the volume label) to be stored in the CM. However, currently there is no SCSI function available to support writing to that area.

Although transparent to the user, keeping this type of information enhances the efficiency of the drive and the cartridge. Data and block locations are stored in memory; for example, the end-of-data location is stored, so that when the tape is next loaded, the drive can use the fast locate function to move directly to the recording area and begin recording. Storing data about the age of the cartridge, how many times it has been loaded, and how many errors it has accumulated aids in determining the reliability of the cartridge. It is of particular value if this data is stored with the cartridge itself, so that whenever it is mounted on any host system, the history is accessible.

This is not the first tape product where information has been kept on the cartridge; however, previously it has been written onto the tape medium itself in a non-user-accessible portion of the tape before the BOT marker, for example, as in the IBM 3590 Tape Drive.

Barcode label

Each data and cleaning cartridge processed by an Ultrium tape library needs to have a barcode label. (This is mandatory for libraries that have an installed barcode reader.)

The label, as shown in Figure 2-15 on page 44, contains a human-readable volume serial number or volume label and the corresponding machine-readable barcode.

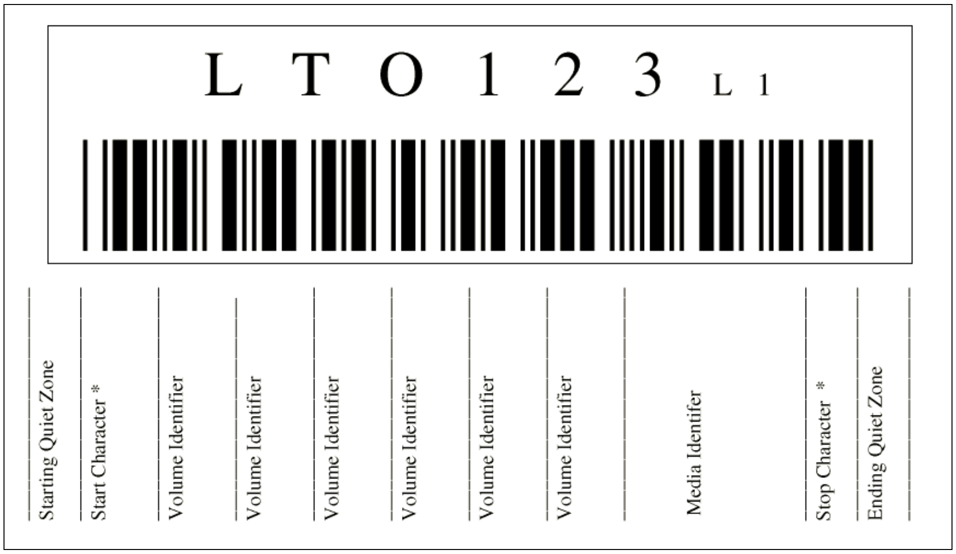


Figure 2-15 Barcode label example

The barcode format is:

- Quiet zones (at each end of the barcode).
- A start character (indicating the beginning of the label).
- A six-character volume label.
- A two-character cartridge media-type identifier (L1, L2, L3, or L4), which identifies the cartridge as an LTO cartridge ("L") and indicates the LTO generation: 1, 2, 3, or 4. Other identifiers are also specified by the LTO standard; thus, the LTO3 WORM cartridge is identified by LT and the LTO4 WORM cartridge is identified by LU.
- A stop character (indicating the end of the label).

When read by the library's barcode reader, the barcode identifies the cartridge's volume label to the tape library. The barcode volume label also indicates to the library whether the cartridge is a data, cleaning, or diagnostic cartridge.

Tape cartridges are often supplied with the labels already attached, or you can attach a label yourself. Operators must handle the cartridges and barcode labels in accordance with the instructions in the operator guides supplied with the products. You must ensure that labels are removed cleanly, reapplied carefully, in good condition, and not obscured or damaged. The Ultrium cartridge features a recessed area for the label (see Figure 2-12 on page 40). The label must be applied only in the recessed label area; if it extends outside of the area it can cause loading problems in the drive.

Volume label format

The LTO cartridge label uses the Uniform Symbol Specification-39 barcode symbols. A description and a definition are available from the Automatic Identification Manufacturers (AIM) specification document *Uniform Symbol Specification-39* and *ANSI MH10.8M-1993 ANSI Barcode Specification.*

A cartridge's volume label consists of exactly six characters, starting from the left. Except for cleaning and diagnostic cartridges, these six characters are limited to the following ASCII characters:

- Uppercase A-Z (ASCII character code: 41h-5Ah)
- 0-9 (ASCII character code: 30h-39h)

The volume label must consist of exactly six, all uppercase alphabetical, all numeric, or alphanumeric characters, such as ABCGVE, 123621, or F8H5N9. It cannot consist of fewer than six characters.

A volume label format of CLN*Unn* represents a universal cleaning cartridge. A volume label of the form CLN*vnn* is used for a unique cleaning cartridge, where *v* is an alphanumeric identifier that represents the vendor of a drive-unique cleaning cartridge. (An IBM-unique cleaner cartridge uses the label format CLN*Inn*.) This identifier is logged in the vendor information pages in the Ultrium tape drive.

A volume label of the form DG(space)*vnn* is used for diagnostic and service cartridges. The drive uses the *v* to determine whether the drive-unique diagnostic cartridge is loaded. The *nn* represents a specific cartridge and is logged in the vendor information pages in the Ultrium tape drive.

The internal and external labels on a cartridge do not need to match; this means that the volume label on the barcode label does not need to match the volume label recorded on the tape in the tape label area when it is initialized. However, it is generally preferable for them to match to avoid confusion.

You will find more detailed information in the LTO Label Specification at:

`http://www.ibm.com/servers/storage/media/lto/index.html`

Ordering barcode labels

For ordering barcode labels, see Appendix A, “IBM LTO Ultrium and 3592 media” on page 393.

Write protect switch

The write protect switch is located at the front of the cartridge to the left of the barcode label (see Figure 2-12 on page 40). The position of the write-protect switch on the tape cartridge determines whether you can write to the tape; you cannot write to the tape when the switch is pushed to the right. When the write protect switch is set to inhibit writing, a visual lock mark, such as a padlock, is visible.

In most cases, backup and recovery host application software is used to achieve the most benefit from using an LTO system. It is better to rely on the host application software to write protect your cartridges rather than manually setting the write protect switch. This enables the host software to identify a cartridge that no longer contains current data and is eligible to become a scratch cartridge. If the switch is set and the host application sets the cartridge to scratch status, the tape drive will not be able to write new data to the tape.

Cleaning the cartridge

Cartridges that are physically dirty on the outside of the casing can reduce the reliability of an Ultrium tape library as well as cause the loss of recorded data. If dirt appears on the cartridge, you can wipe the outside surfaces with a lint-free cloth, which can be lightly moistened with the manufacturer’s recommended tape unit cleaner or equivalent.

When cleaning a tape cartridge, do not allow anything wet (including the cleaning fluid) to contact the tape inside the casing. Make sure that all cartridge surfaces are dry before the cartridge is inserted into a drive.

Cartridge life

The magnetic tape inside the cartridge is made of highly durable materials. However, the tape wears after repeated cycles. Eventually, such wear can cause an increase in tape errors, records of which are stored in the LTO-CM. This means that cartridge performance can be tracked and monitored, enabling predictive failure analysis and enhancing data integrity. This tracking is done automatically, and the drive issues a message when errors on the tape exceed a certain threshold.

The IBM Ultrium Data Cartridge has a usable life of 5000 load and unload cycles in a typical office computer environment.

The data recorded on the cartridge has an archive storage life of 30 years minimum with less than 5% loss in demagnetization, when the cartridge is stored at 16° C (60° F) to 25° C (77° F), 20% to 50% non-condensing humidity, and wet bulb temperature of 26° C (79° F) maximum.

Cleaning cartridge

To support client and application requirements and expectations for cleaning, each LTO drive vendor used to provide its own cleaning cartridge specifically for its Ultrium drives. To avoid potential interoperability problems, the LTO consortium decided to introduce a universal cleaning cartridge. IBM offers only the universal cleaning cartridge.

The IBM Ultrium LTO tape drive was intentionally designed to be self-monitoring and self-cleaning. Therefore, the IBM recommendation is not to manually clean the tape drive, but rather to use the automatic cleaning function provided with the library or by your application.

Each drive determines when it needs to be cleaned and alerts the library or your application.

In order to prevent recontamination of drive surfaces, you are limited to using a specific cleaner cartridge a maximum of 50 times.

Cartridge handling

Tape cartridges are tough packages made of inexpensive materials capable of storing tremendous amounts of data and approaching data densities of hard disks. They can survive for years in library environments where they are being gripped, poked, loaded, and unloaded. But we recommend treating tape cartridges in a similar fashion to hard disk drives. Here are several suggestions to protect your data on tape cartridges.

Ensure that proper procedures are in place to cover media handling, and make sure that anyone who handles cartridges has been trained in those procedures.

Media shipping and handling: Procedures

Ship cartridges in their original packaging or, preferably, ship and store in jewel cases. Use only recommended shipping cases that securely hold the cartridges in their jewel cases for transportation. Turtle Cases from Perm-A-Store, shown in Figure 2-16 on page 47, have been tested and found to be satisfactory. Turtle Cases are available at:

http://www.turtlecase.com

Figure 2-16 Turtle case

Never ship a cartridge in a commercial shipping envelope without boxing or packaging. If shipping in cardboard or similar boxes:

- Double-box the cartridges with padding between the boxes, as shown in Figure 2-17.
- Pack snugly so cartridges do not rattle around.
- If possible, place cartridges in polyethylene plastic wrap or bags to help seal out dust, moisture, and other contaminants.

Figure 2-17 Double box

Media shipping and handling: Inspecting

If you receive media, inspect it before use:

- Inspect packaging for evidence of potential rough handling.
- Inspect cartridge for damage before using and storing.
- Check leader pin for correct seating.
- When there is evidence of poor handling or shipping, ensure that the cartridge leader pin (Figure 2-18 on page 48) is undamaged before inserting the cartridge in a drive or library, because a bad cartridge can damage a drive.

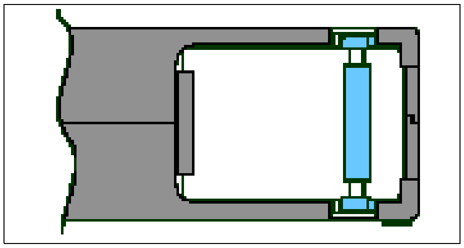


Figure 2-18 Correct leader pin placement

If the pin is loose or bent, look for cartridge damage and use the IBM Leader Pin Re-Attachment Kit, part number 08L9129, to correctly seat the pin.

Shipping summary

Important considerations include:

- Package appropriately for shipping.
- Inspect for damage or rough handling and take appropriate action.
- Do not put damaged media in drives or libraries; use data recovery services.
- For specific media types, check your product's Planning and Operator Guide.
- With simple care and handling, you can get the most out of your tape media.

2.1.5 IBM LTO Ultrium common subassembly

Certain elements of the Ultrium drive design are covered by the LTO format specification, such as anything related to writing the specified data format that enables tape interchange. However, there is no strict LTO definition in terms of how the drive module is constructed, so in this area, manufacturer's drives might differ from each other in performance and specification, such as the data rate or quality design points. This section therefore relates specifically to the IBM LTO implementation. However, we emphasize again that the IBM LTO Ultrium cartridges are compatible with those of all other licensed manufacturers.

The IBM LTO Ultrium common subassembly drive (Figure 2-19) is a high-performance, high-capacity tape drive. The drive records data using the specified linear serpentine recording format on 1/2-inch tape housed within the LTO Ultrium cartridge. The data tracks are located using preformatted servo tracks, as outlined in "Servo tracks" on page 33.

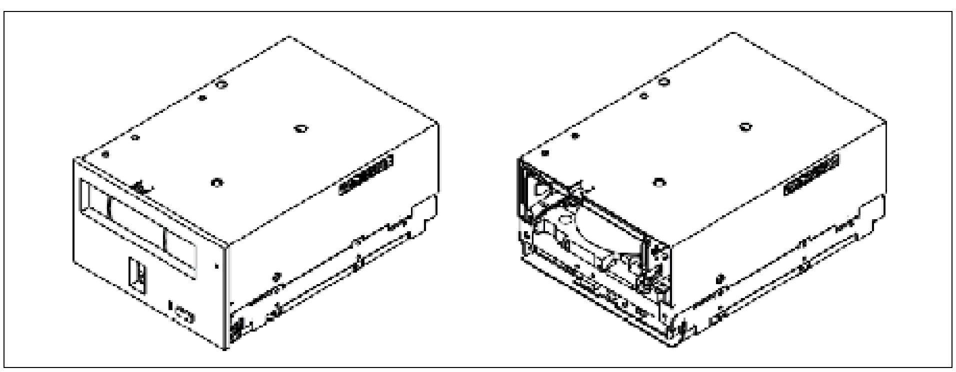


Figure 2-19 IBM LTO Ultrium common subassembly

The original basic unit was the first-generation IBM LTO series of products. Subsequent generations of IBM LTO exploit extensive reuse, making the IBM Ultrium drives very reliable. Especially in LTO3, there have been a number of reliability improvements to tape path and internal tape handling. These units are a common subassembly and so do not have an IBM machine type. The subassembly is not available for clients to purchase directly, but only as a part number used in the assembly of other IBM machine types. The subassembly does not have its own power supply but is powered by the library, frame, or casing into which it is integrated.

The IBM machine types that integrate the subassembly are described in 2.4.6, “The IBM LTO Ultrium family of tape drives and libraries” on page 77 and in more detail in later chapters. The subassembly is sold on the other equipment manufacture (OEM) market to other LTO library manufacturers. The common subassembly is a single field-replaceable unit (FRU); that is, if it fails, the whole unit is replaced and no parts or subassemblies within the unit are replaced when the drive is maintained by an IBM service support representative (SSR).

Drive head

When the cartridge is inserted into the drive, a threading mechanism pulls the leader pin and attached tape (see Figure 2-14 on page 42) out of the cartridge, across the read/write head, and onto a nonremovable take-up (machine) reel. The head can then read or write data from or to the tape.

In generations 1 and 2, the drive has a 2 x 8 element head, reading or writing data eight tracks at a time (see Figure 2-20). The head is sized to cover the width of a data recording band (approximately a quarter of the tape width; see Figure 2-8 on page 36). Unlike the IBM 3590, for example, it does not cover the whole width of the tape.

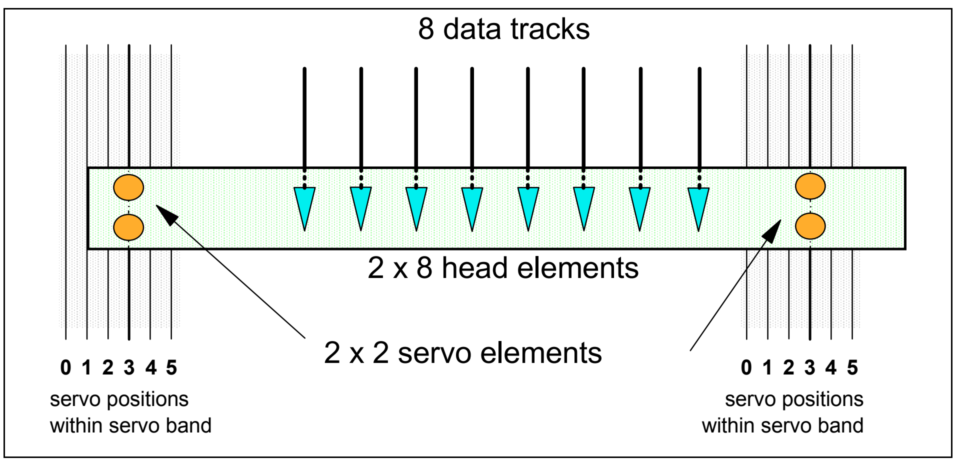


Figure 2-20 Generation 1 and 2: One of eight element heads shown, with servo elements

The write elements are immediately followed by read/verify elements, so there are in fact two sets of eight head elements (eight write elements and eight read elements) to allow the tape to write in the forward and reverse directions down the length of the tape. The head switches electronically from one set to another as the tape changes direction, as in Figure 2-21 on page 50, which shows two enlarged pairs of head elements and the direction indicators. Two sets of heads (read/write (r/w) and write/read (w/r)) are required because the tape is written and read in both directions.

The LTO3 and LTO4 drive has a 2 x 16 element head, reading or writing data at 16 tracks at a time. Conceptually, they are similar to the 8 element head, except they have elements of a smaller size. The 16 r-w heads are side by side similar to the sum of r-w and w-r heads in Figure 2-21 on page 50. The corresponding 16th w-r head element (for writing the reverse wrap) is located immediately face-to-face with the r-w element. Thus, only every second r-w head corresponds to the LTO1 or LTO2 formats. Note that LTO4 drives cannot read LTO1 cartridges.

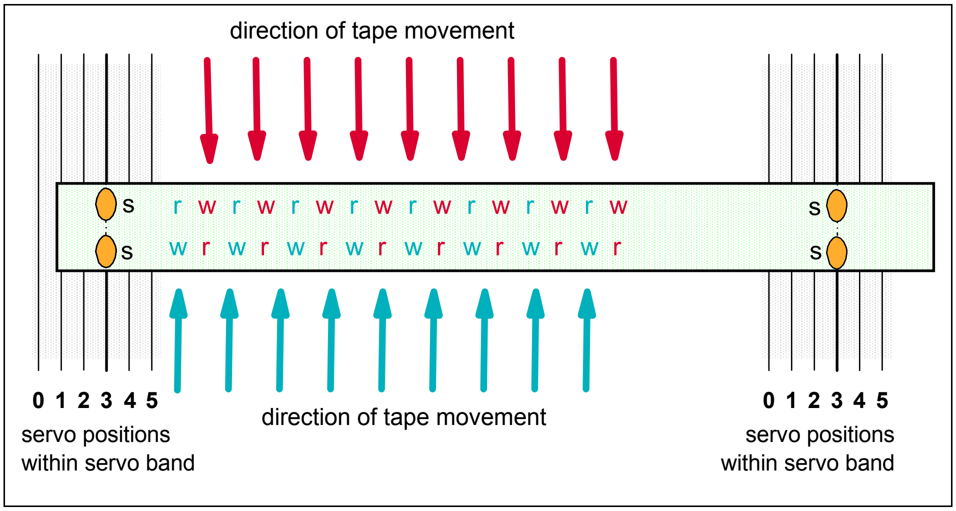


Figure 2-21 Conceptual allocation of read and write heads for forward and reverse wrap

We explain the mechanism for writing data in "Data tracks" on page 35.

Four servo elements are used: two for each set of read/write elements. The head actually uses both servo tracks at each edge of the data band it writes for increased accuracy in track-following, so there are two servo elements at each end of the head. As an example, Figure 2-20 on page 49 shows a diagram of the top servo element 1 following servo position 3, used for the sixth wrap (a reverse wrap) in a data band. Note that the diagram is not to scale. If you need more information about this topic, an animated conceptual explanation is in the LTO Ultrium technology primers on the LTO Web site at:

http://www.lto-technology.com/newsite/html/about_tech.html

Note that the animation is designed to provide a basic understanding of LTO technology and does not provide the same level of detail outlined here. Nor does it detail the actual implementation in the IBM Ultrium drives.

Data compression

As described in 2.1.3, "Data compression" on page 39, data compression implementation can differ from vendor to vendor. However, they all conform to the basic rules, and the data written can be read by any other vendor's tape reader.

One implementation appears to only perform scheme swapping on a record basis. For example, if the compressed data stream output for a given record is larger for Scheme 1 than for Scheme 2, the entire record is output in Scheme 2. A second implementation seems to react to data on an ongoing basis so that if the drive perceives that the nature of the data in a record has changed from compressible to incompressible, then a Scheme 2 swap is enabled and the incompressible data from there on is output in Scheme 2. This is not always advantageous because the incompressible data might again transition to compressible even before that scheme swap occurs. Each scheme swap codeword output is 13 bits long. Therefore, to swap to a scheme and swap back costs 26 bits. The compression gain following the first scheme swap might benefit more than 26 bits over the previous scheme; if so, the swap was well-advised. If not, the scheme swap actually increased the size of the output compressed data stream and reduced the compression rather than increase it. This can occur if data compressibility is inferred by having the data compression engine observe how data that has already been output from the compression engine was compressed, that is, only by viewing data in the past.

The only way to adapt via scheme swapping within records, without being susceptible to inadvertent data expansion, is to use the IBM-patented scheme swapping technique. This method is preferred, because it effectively looks at data ahead, rather than behind. In the IBM implementation, a scheme swap is not automatically generated unless there appears to be more compression gain within the look ahead buffer than it costs to scheme swap, and then swap back. This is advantageous because small bursts of compressible data within an otherwise incompressible file might not make it worthwhile to scheme swap. If a scheme swap is optimal, the IBM implementation puts the scheme swap out where the change in data compressibility occurs, giving maximum advantage. For more information, see the white paper at:

http://www.ibm.com/servers/storage/tape/whitepapers/pdf/whitepaper_compression.pdf

This paper shows how the IBM LTO-DC embodiment achieved superior data compression to another vendor's LTO drives by performing scheme swapping simultaneously with changes in the compressibility of the data, enabled by effectively looking 64 bytes ahead in the input data stream.

The LTO consortium decided, as many other vendors also do in the open environment, to indicate characteristics of LTO products for both native data and when assuming a data compression ratio of 2:1. For enterprise-related (mainframe) tape products, IBM and other manufacturers assume a compression ratio of 3:1, even though the IBM LTO and IBM 3592 use the same compression algorithm (SLDC). In any case, remember that the real compression reached by the drive depends on the nature of the data and that you need to base all sizings on the native value.

Interfaces

The IBM LTO Ultrium drive is available with a choice of the following interfaces:

- Small Computer System Interface (SCSI):
  - Low Voltage Differential (LVD)
  - High Voltage Differential (HVD (LTO1 and 2 only)
- Fibre Channel (FC)
- Serial-Attached SCSI (SAS)

When ordering an IBM product offering, you choose the drive interface. You cannot change the interface on the drive; if you want a different interface, you must replace the drive assembly.

Historically, SCSI connections were used for attachment of tape drives and libraries to Open Systems. Fibre Channel connections using SANs are becoming increasingly common.

SCSI single-ended

This was the most common form of SCSI signaling. Many removable drives, scanners, and almost all 50-pin SCSI devices fit into this category. Often you do not see "SE" or "single-ended" written on the documentation; if a device does not specifically say LVD, Ultra2 Wide, differential, or a similar definition, it is probably single-ended. Typically, single-ended devices support a total bus length of 1.5 meters (5 ft.) or less.

IBM high-performance SCSI tape drives (IBM 3590, IBM 3570, and LTO Ultrium drives) are all differential-attached drives, not single-ended.

SCSI differential (HVD)

HVD (often referred to as just *differential*) uses differential signaling. The idea behind differential signals is that each bus signal is carried on a pair of wires. The first wire of the pair carries the same type of signal as single-ended SCSI. However, the second wire of the pair carries its logical inversion. The receiver of the signals takes the difference of the pair (therefore, the name), which makes it less susceptible to noise and capable of supporting greater cable lengths. HVD and single-ended SCSI are completely incompatible with each other.

In general, IBM HVD tape devices support an overall bus length of 25 m (82 ft.), using point-to-point or multi-drop interconnection (*daisy-chaining*). For each daisy-chain device, you have to reduce the maximum cable length by 0.5 m (1.6 ft.).

SCSI differential (LVD)

This newer differential interface implementation, LVD, uses less power than the HVD differential interface and allows the higher speeds of Ultra-2 SCSI. LVD requires 3.3 V dc instead of 5 V dc for HVD.

LVD is sometimes referred to as Ultra-2 Wide SCSI, which is a general marketing term for 16-bit Fast-40 or 80 MB/s. Only LVD and HVD can potentially run in Ultra-2 Wide mode and only LVD in current commercially available products.

IBM LVD tape devices support a bus length of 25 m (82 ft.) point-to-point, and 12 m (39 ft.) using multi-drop interconnection (daisy-chaining). For each daisy-chain device, you have to reduce the maximum cable length by 0.5 m (1.6 ft.).

The terms “fast”, “wide”, and “ultra” indicate characteristics that are separate from those implied by differential, single-ended, and high or low voltage. Table 2-2 shows the SCSI terms used to describe different host and device adapters and what they imply in terms of bus width and speed.

Table 2-2 SCSI terms and characteristics

SCSI term	Bus width (bits)	Speed (MB/s)	Maximum length	Maximum number of devices
SCSI	8	5	6 m	7
Fast SCSI	8	10	3 m	7
Fast Wide SCSI	16	20	3 m	15
Ultra (Wide) SCSI HVD	16	40	25 m	15
Ultra (Wide) SCSI 2 LVD	16	80	25 m/12 m	15
Ultra 160 SCSI LVD	16	160	12 m	15

Note that a faster bus does not imply that an attached device will support that data rate, but that multiple devices can operate on the bus at that maximum speed. For a detailed table of SCSI terms and related specifications, refer to the SCSI Trade Association Web site at:

http://www.scsita.org/terms/scsiterms.html

To ensure best performance, if possible, avoid daisy-chaining.

Serial-Attached SCSI

Serial-Attached SCSI (SAS) was introduced because parallel SCSI has a maximum bandwidth of 320 MB/s. There was a need for a faster interface to attach tapes and disks on a host bus adapter (HBA). Parallel SCSI started in the beginning of the IBM 360 Mainframe period back in the early sixties. That IBM 360 mainframe was able to communicate with more devices using the same I/O bus. This I/O bus was known later as the OEM channel, and IBM wanted to make this OEM channel the Industrial Standard for parallel devices. IBM went to the American National Standards Institute (ANSI), but ANSI refused because it was not standardized enough. In 1981, Adaptec designed a standardized bus that ANSI approved. From that time forward, it was called Small Computer System Interface (SCSI).

SCSI was designed in the first place to attach hard disks on a I/O bus but over the years all types of devices could connect to the SCSI bus, such as tape drives, scanners, plotters, printers, and optical devices. Over the years, the bandwidth increased from 5 MB/s up to 320 MB/s, better known as Ultra320 SCSI.

In 2003, the SCSI bus speed was increased up to 640 MB/s but that never became a new standard for the SCSI speed. One problem when the SCSI speed increases is a phenomenon called *clock skew*. Clock skew is a phenomenon in synchronous circuits in which the clock signal (sent from the clock circuit) arrives at different components at different times. This is typically due to two causes. The first is material variability, which causes a signal to travel faster or slower than expected. The second is distance: The further a signal has to travel the longer it takes to arrive; therefore, signals arrive at different points at different times. As the clock rate of a circuit increases, timing becomes more critical and there is less variation that can be tolerated while still functioning properly.

The industry was looking for a new, faster interface and a serial version of SCSI was designed and approved in 2002 by the SCSI Trade Association and by the International Committee for Information Technology Standards. In 2005, the first devices came on the market with a SAS interface. The first generation of SAS has a native speed of 3 GB/s, and future generations will be at 6 GB/s and 12 GB/s.

One of the benefits of SAS is that it can communicate with Advanced Technology Attachment (ATA) devices. SAS has a point-to-point architecture and a bandwidth of 300 MB/s. Because of its point-to-point architecture, more devices can be handled in the same time on the bus with an maximum of 128 targets. Another advantage of SAS is that the connection cables between the HBA and the devices are much thinner and thus more scalable. SAS devices do not need external terminators. The I/O bus is electronically terminated.

The total cable length from the device to the HBA is limited to 5.5 m (18.04 ft.). The total cable length in an LVD configuration is 25 m (82 ft.) when a point-to-point connection is used or 12.5 m (39 ft.) when a multi-drop-connection is used.

Figure 2-22 on page 54 shows you an IBM SAS HBA, part number 25R8060.

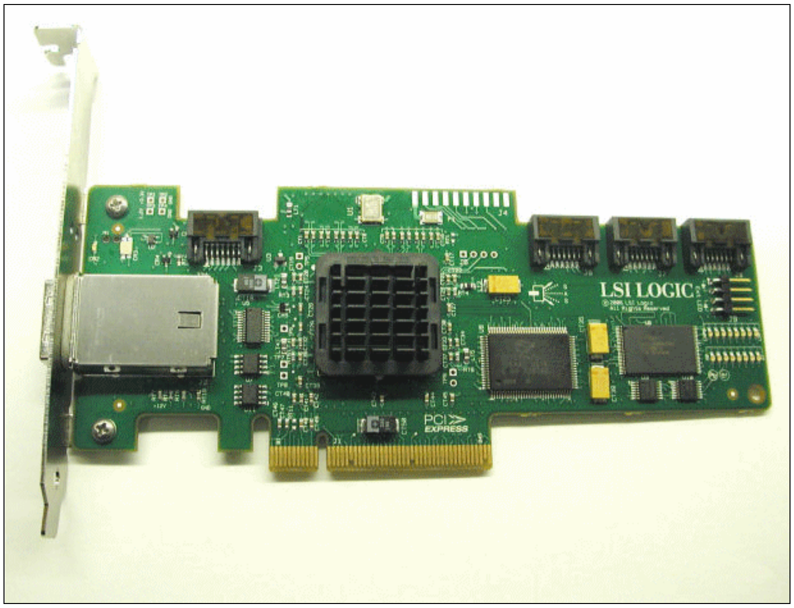


Figure 2-22 SAS HBA with IBM part number 25R8060

The PCI small form factor IBM SAS HBA Controller is based on the LSI 1068E SAS processor. It can handle medium to large capacity server storage applications by connecting an 8 lane PCI-Express adapter with one external x4 Small Form Factor Committee (SFF)-8088 connector and four x1 internal 7 pin connectors.

Two connecting interfaces are used for connecting the external devices: SFF-8088 and SFF-8470. Figure 2-23 shows an SFF-8088 connector.

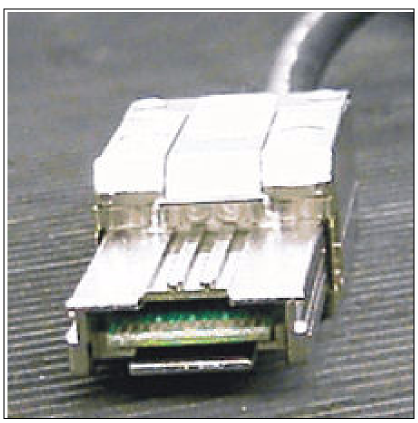


Figure 2-23 SFF-8088 connector

All IBM SAS tape drives have an SFF-8088 interface. SAS cables are available in several lengths with a maximum length of 5.5 m (18.04 feet) and in any combination of the SFF-8470 and SFF-8088 connectors.

Figure 2-24 on page 55 shows the SFF-8470 connector.

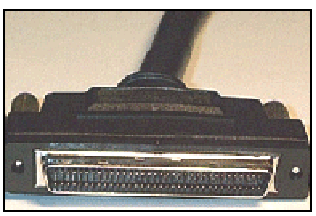
Figure 2-24 SFF-8470 connector

At the time of writing this publication, IBM SAS Tape Drives only support a point-to-point connection, and there is no support to connect the SAS Tape Drive on an Expander Box. Two IBM LTO tape drives are available with the SAS interface:

- IBM LTO Ultrium 3 Half-High Tape Drive
- IBM LTO Ultrium 4 Full-High Tape Drive

Connector types

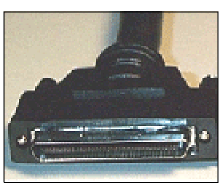
When ordering cables, pay careful attention to the type of connector on both the cable and device, so that everything correctly plug ins together. These are the major connector types.



SCSI HD68

The HD68 connector is the normal 68-pin SCSI connector. All IBM LTO SCSI drives, except the drives in the 3584, have an HD68 connector. Before June 12, 2001, all LTO tape drives in the IBM 3584 used HD68 connectors.

Figure 2-25 HD68 connector



SCSI VHDCI

The Very High Density connector (VHDCI) is a mini-SCSI connector, about half the width of the HD68 connector. The IBM LTO drives in the IBM 3584 have a VHDCI connector.

Figure 2-26 VHDCI connector

FC SC

The duplex SC connector is a low-loss, push/pull fitting connector. The two fibers each have their own part of the connector. The connector is keyed to ensure correct polarization (transmit to receive and vice versa) when connected. Most 1 Gb SAN devices, including IBM Ultrium 1 FC drives, use SC connectors.

FC LC

Connectors that plug into SFF or SFP devices are called *LC connectors*. There is also a duplex version used so that the transmit and receive are connected in one step. The primary advantage of these LC connectors compared to SC connectors is that the LC connectors use a smaller form factor. Therefore, manufacturers of Fibre Channel components can provide more connections in the same amount of space.

Most 2 Gbit SAN devices, including IBM Ultrium 2 and 3 FC drives, use LC connectors.

Available interfaces for IBM Ultrium 1

IBM Ultrium 1 drives offer these connection types:

- Ultra2/Wide LVD SCSI using HD68 connector
- Ultra/Wide HVD SCSI using HD68 connector
- FC-AL, 1 Gbit using SC connector
- SCSI drives installed in the 3584 use VHDCI connector

Available interfaces for IBM Ultrium 2

IBM Ultrium 2 drives offer these connection types:

- Ultra 160 LVD SCSI using HD68 connector
- Ultra/Wide HVD SCSI using HD68 connector
- Switched fabric 2 Gbit using LC connector
- SCSI drives installed in the TS3500 use VHDCI connectors

The drive can work in fabric or FC-AL mode. Per the SNIA standard, it tries first to connect as FC_AL, and if this fails, it tries to log on as a fabric device. It does an autosensing on the speed and connects with either 1 Gbit or with 2 Gbit.

With the IBM 3584, you have the capability to set the FC port speed and the FC protocol mode.

Available interfaces for IBM Ultrium 3

IBM Ultrium 3 drives offer these connection types:

- Ultra 160 LVD SCSI using HD68 connector
- 3 Gbps SAS
- Switched fabric 2 or 4 Gbit using LC connector
- SCSI drives installed in the 3584 use the VHDCI connector

The drive can work in fabric or FC-AL mode. Per the SNIA standard, it tries first to connect as FC_AL, and if this fails, it tries to log in as a fabric device. It does an autosensing on the speed and connects with either 1 Gbit, 2 Gbit, or with 4 Gbit.

Available interfaces for IBM Ultrium 4

IBM Ultrium 4 drives offer these connection types:

- Ultra160 SCSI LVD using HD68 connector
- 3 Gbps dual port SAS
- 4 Gbps native Fibre Channel

The drive can work in fabric or FC-AL mode. Per the SNIA standard, it tries first to connect as FC_AL, and if this fails, it tries to log in as a fabric device. It does an autosensing on the speed and connects with either 1 Gbit, 2 Gbit, or with 4 Gbit.

2.2 Tape Encryption overview

Data is one of the most highly valued resources in a competitive business environment. Protecting this data, controlling access to it, and verifying its authenticity while maintaining its availability are priorities in our security-conscious world. Tape Encryption is a process that answers many of these needs.

The IBM System Storage TS1120 (3592-E05) and TS1040 (3588-F4A) Tape Drives are capable of encrypting data as it is written to tape. The TS1120 supports any type of IBM

TotalStorage Enterprise Tape Cartridge, including WORM cartridges, and the TS1040 supports IBM Ultrium 4 Data Cartridges for data encryption, including WORM cartridges. Encryption is performed at full line speed in the tape drive after compression. (Compression is more efficiently done before encryption). The encryption process is less than one percent of the performance impact on the read/write throughput.

Encryption for the TS1120 Tape Drive is available at no charge. The TS1120 can be installed in the TS3400 and TS3500 Tape Libraries.

For the TS1040, the Application-Managed Encryption method is available at no charge. However, a billable Feature Code must be installed, FC5900 or, for the TS3500, FC1604, to support Transparent LTO Encryption. You must also order FC9900 (Encryption Configuration). Supported Tape Libraries for the TS1040 Tape Drive are: TS3100, TS3200, TS3310, and TS3500.

Encryption adds significant strength to the security of your stored data without the processing overhead and the performance degradation associated with encryption performed on the server or the expense of a dedicated appliance.

Note: TS1120 drives produced before September 8, 2006, do not have the encryption capability. However, there is a chargeable upgrade available (FC5592) to upgrade the TS1120. This encryption capability includes drive hardware, as well as microcode additions and changes.

Encryption keys are used to encrypt data when data is being written and decrypt the data when being read from data cartridge. The IBM Encryption Key Manager (EKM) is the component that assists the TS1120 and the TS1040 in generating, protecting, storing, and maintaining encryption keys. EKM R2 must be used when using a TS1040 Tape Drive in a tape library or as a stand-alone tape drive (TS2340 Tape Drive).

The EKM is installed on a server in the network and communicates through TCP/IP with the tape library or the tape drive.The EKM operates on z/OS®, i5/OS®, AIX, Linux®, HP-UX, SUN Solaris™, and Windows. EKM is capable of serving numerous IBM encrypting tape drives, regardless of where those tape drives reside.

EKM is part of the IBM Java™ environment and uses the IBM Java Security components for its cryptographic capabilities. EKM and three other main components, shown in Figure 2-27 on page 58, control Tape Encryption.

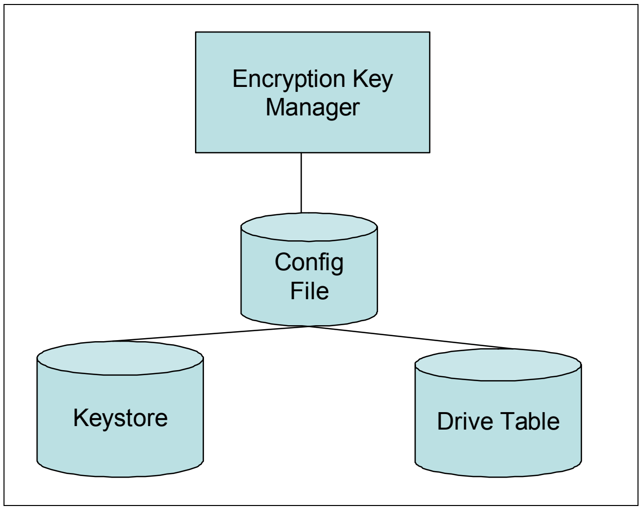


Figure 2-27 Encryption main components

These components are:

- Encryption Key Manager

  The EKM obtains encryption keys and manages their transfer to and from the tape devices.

- Configuration file

  The configuration file records the keystore location and defines EKM behavior. The EKM configuration file allows you to tailor the behavior of EKM to meet the needs of your organization.

- Java security keystore

  The keystore is defined as part of the Java Cryptography Extension (JCE) and is an element of the Java Security components, which are, in turn, part of the Java runtime environment. A *keystore* holds the certificates and keys (or pointers to the certificates and keys) used by EKM to perform cryptographic operations. EKM supports several types of Java keystores offering different operational characteristics to meet your needs.

- Tape drive table

  The tape drive table is used by EKM to keep track of the tape devices it supports. The tape drive table is a non-editable, binary file whose location is specified in the configuration file.

Important: Due to the critical nature of keys in your keystore, we highly recommend that you back up your keystore on a regular basis so that you can recover it as needed and be able to read the data cartridges that were encrypted using the certificate with that drive or library. *Do not encrypt your backups*.

The EKM is a process awaiting a key generation or key retrieval request that a tape drive or library sends over a TCP/IP communication path between the EKM and the tape library or tape drive. When a tape drive writes encrypted data, it first requests an encryption key from the EKM. Upon receipt of the request, EKM generates an Advanced Encryption Standard (AES) key and sends it to the tape drive.

An AES encryption key is typically a random string of bits generated specifically to scramble and unscramble data. Encryption keys are created using algorithms designed to ensure that each key is unique and unpredictable. The longer the key string, the harder it is to break the encryption code. TS1120 and TS1040 Tape Drive encryption uses 256-bit AES algorithm keys to encrypt data.

2.2.1 Encryption methods

The encryption methods for the TS1120 and the TS1040 Tape Drive are slightly different. In the following sections, we explain those differences.

Symmetric key encryption

Encryption of data using a symmetric key and algorithm is sometimes called *private key encryption* or *secret key*, which is not to be confused with the private key in an asymmetric key system. In a symmetric key system, the cipher key that is used for encrypting data is the same as the cipher key used for decryption.

The encryption and decryption ciphers can be related by a simple transform on the key, or the encryption key and the decryption key can be identical. In the IBM Tape Encryption solution, the same encryption key is used for both encryption of data and decryption of data; this key is protected by an asymmetric key algorithm and never available in the clear.

Symmetric key encryption is several orders of magnitude faster than asymmetric key encryption; in addition, the comparable key sizes for symmetric key as opposed to asymmetric key are an order of magnitude different. A 128-bit secret key is considered safe, while Rivest-Shamir-Adleman (RSA) suggests a 1024-bit key length. The IBM Tape Encryption solution utilizes an AES algorithm with a key length of 256 bits. The AES algorithm is based on the Rijndael algorithm. AES is an accepted standard that supports a subset of the key sizes and block sizes that the Rijndael algorithms support.

Secret key algorithms can be architected to support encryption one bit at a time, or by specified blocks of bits. The AES standard supports 128-bit block sizes and key sizes of 128, 192, and 256. The IBM Tape Encryption solution uses an AES-256 bit key. Other well-known symmetric key examples include Twofish, Blowfish, Serpent, Cast5, DES, TDES, and IDEA.

Figure 2-28 on page 60 shows the process of symmetric encryption data flow.

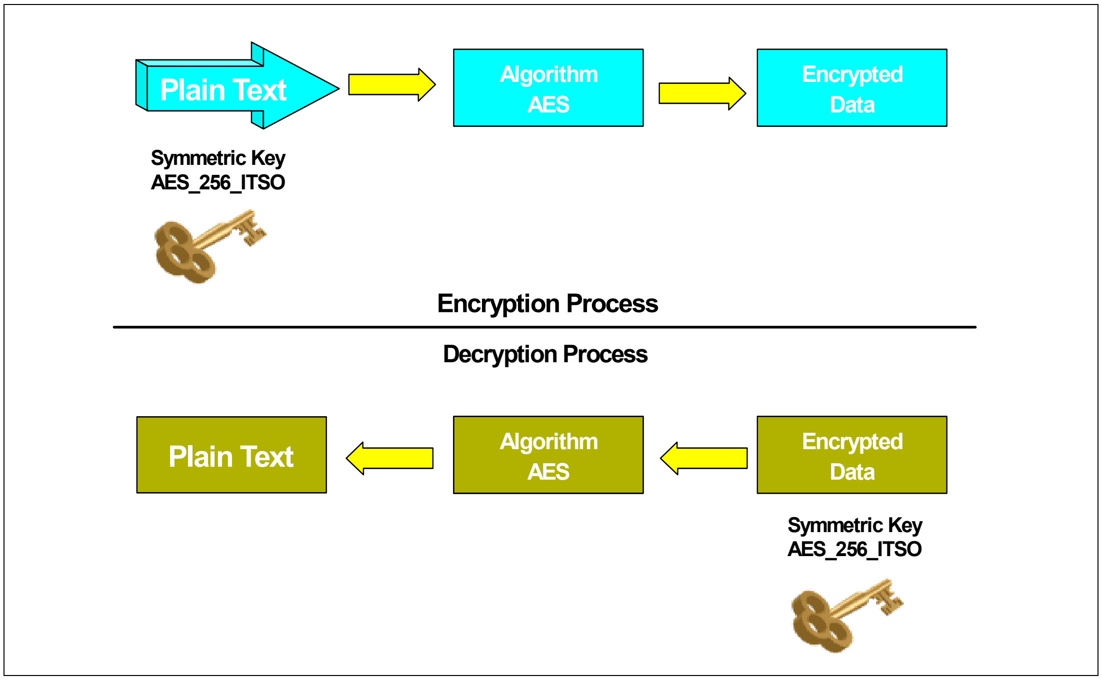


Figure 2-28 Symmetric key encryption data flow

Asymmetric key encryption

Another important method of encryption that is widely used today is referred to as *public/private key encryption* or *asymmetric encryption*. Using this encryption methodology, ciphers are generated in pairs. The first key is used to encrypt the data, and the second key is used to decrypt the data.

This technique was pioneered in the 1970s and represented a significant breakthrough in cryptography. The Rivest-Shamir-Adleman (RSA) algorithm is the most widely used public key technique. The power of this approach is a public key, which is used to encrypt the data. This public key can be widely shared, and anyone who wants to send secure data to an organization can use its public key. The receiving organization then uses its private key to decrypt the data; this makes public/private key very useful for sharing information between organizations. This methodology is widely used on the Internet today to secure transactions, including Secure Sockets Layer (SSL).

Asymmetric key encryption is much slower and more computationally intensive than symmetric key encryption. The advantage of asymmetric key encryption is the ability to share secret data without sharing the same encryption key. Figure 2-29 on page 61 shows an encryption and decryption data path when using public key encryption algorithms. In the diagram, the plain text is enciphered using the public key and an RSA encryption algorithm, which yields the encrypted data. Starting with the enciphered text, a private key is used, with the RSA algorithm to decrypt the data back to plain text.

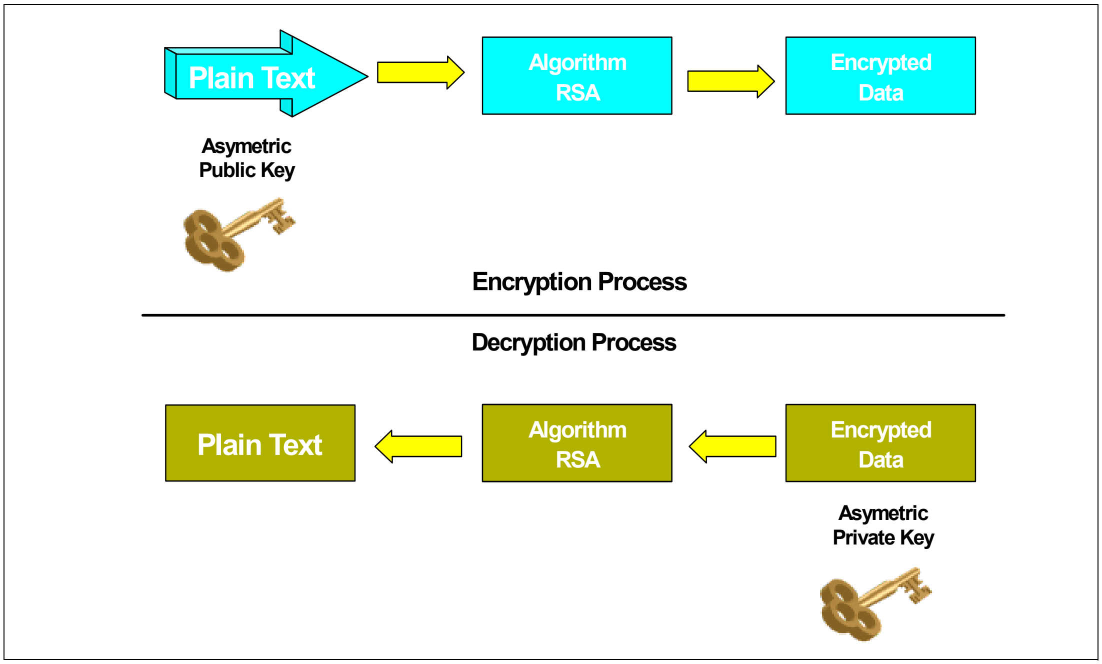


Figure 2-29 Asymmetric key encryption data flow

Managing encryption

There are three methods of encryption management from which to choose. These methods differ in where you choose to locate your EKM application. Your operating environment determines which is the best for you, with the result that key management and the encryption policy engine can be located in any one of the following environmental layers.

Application-Managed Tape Encryption (AME)

This method is best where operating environments run an application already capable of generating and managing encryption policies and keys, such as Tivoli Storage Manager (TSM). Policies specifying when encryption is to be used are defined through the application interface. The policies and keys pass through the data path between the application layer and the TS1120 and TS1040 Tape Drives. Encryption is the result of interaction between the application and the encryption-enabled tape drive, and is transparent to the system and library layers. Because the application manages the encryption keys, volumes written and encrypted using the application method can only be read using the Application-Managed Encryption method.

System-Managed Tape Encryption (SME)

This method can be used for Open Systems operating environments where no application capable of key management runs. Encryption policies specifying when to use encryption are set up through each instance of the IBM device driver. Key generation and management is performed by the Encryption Key Manager (EKM), a Java application running on the host or externally on another host. Policy controls and keys pass through the data path between the system layer and the TS1120 and TS1040 Tape Drives. Encryption is transparent to the applications. System-Managed Tape Encryption and Library-Managed Tape Encryption are transparent to one another. In other words, a tape encrypted using System-Managed Encryption can be decrypted using Library-Managed Encryption, and vice versa, provided they both have access to the same EKM keystore.

Library-Managed Tape Encryption (LME)

This method is supported on the following IBM Tape Libraries:

- TS3100 with the TS1040 Tape Drive
- TS3200 with the TS1040 Tape Drive
- TS3310 with the TS1040 Tape Drive
- TS3400 with the TS1120 Tape Drive
- TS3500 with the TS1040 and the TS1120 Tape Drive. Both tape drives can be installed in the TS3500, but they cannot be intermixed within the same logical library.

Key generation and management are performed by EKM, a Java application running on a library-attached host. The keys pass through the library-to-drive interface; therefore, encryption is transparent to the applications. Library-Managed Encryption, when used with certain applications, such as Symantec Netbackup, includes support for an internal label option. When the internal label option is configured, the TS1120 and TS1040 Tape Drives automatically derive the encryption policy and key information from the metadata written on the tape volume by the application.

System-Managed Tape Encryption and Library-Managed Tape Encryption are transparent to one another. In other words, a tape encrypted using System-Managed Encryption can be decrypted using Library-Managed Encryption, and vice versa, provided they both have access to the same EKM keystore and both use AIX and the Atape device driver. Otherwise, this might not be feasible.

2.2.2 TS1120 Tape Encryption

The TS1120 Tape Drive uses an AES encryption key, which is a random string of bits generated specifically to scramble and unscramble data. Encryption keys are created using algorithms designed to ensure that each key is unique and unpredictable. The longer the key string, the harder it is to break the encryption code. TS1120 Tape Drive encryption uses 256-bit AES algorithm keys to encrypt data.

Two types of encryption algorithms are used by EKM for encryption on the TS1120 Tape Drive:

- **Symmetric algorithms**. Symmetric, or secret key encryption, uses a single key for both encryption and decryption. Symmetric key encryption is generally used for encrypting large amounts of data in an efficient manner.
- **Asymmetric algorithms.** Asymmetric encryption uses a pair of keys. Data encrypted using one key can only be decrypted using the other key in the asymmetric key pair.

When an asymmetric, or public/private key pair, is generated, the public key is typically used to encrypt, and the private key is typically used to decrypt. TS1120 Tape Drive encryption uses both types: symmetric encryption for high-speed encryption of user or host data, and asymmetric encryption (which is necessarily slower) for protecting the symmetric key used to encrypt the data (key wrapping). We show the TS1120 Tape Encryption process flow in Figure 2-30 on page 63.

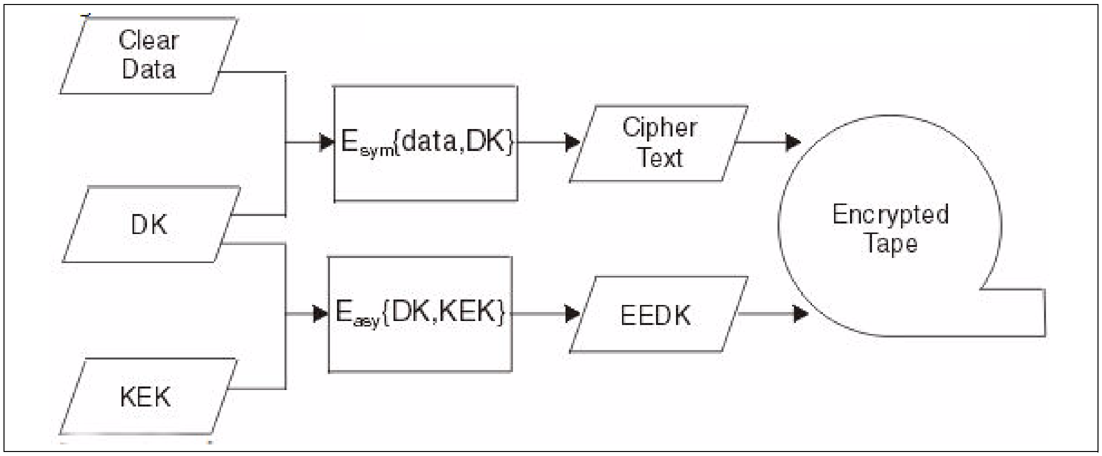


Figure 2-30 Tape Encryption process flow of the TS1120 Tape Drive

When unencrypted data (*clear text*) is sent to the TS1120 Tape Drive for encryption, it is converted to ciphertext (encrypted data) through AES encryption, a symmetric (or secret) key type of encryption requiring a symmetric Data Key (DK), and is then written to tape. The 256-bit AES Data Key is also encrypted, or wrapped, using the public key from an asymmetric Key Encrypting Key (KEK) pair to create an Externally Encrypted Data Key (EEDK).

This EEDK is written to the cartridge memory and to three additional places on the 3592 Tape Cartridge. The tape cartridge now has both the encrypted data and the means to decrypt it for anyone who holds the private KEK. The DK can also be wrapped a second time, using the public key of another party, to create an additional EEDK. Both EEDKs can be stored on the tape cartridge. In this way, the tape cartridge can be shipped to a business partner holding the corresponding private key that would allow the DK to be unwrapped and the tape decrypted on a different TS1120 Tape Drive.

In the Figure 2-31 on page 64 and Figure 2-32 on page 65, we explain the Tape Encryption and decryption processes in a more detailed way. We start first with the encryption process.

Figure 2-31 on page 64 describes the flow of encrypted data to tape, and how keys are communicated to the tape drive and then stored on the data cartridge. In our example, we assume that an EKM is running on one server and that the tape library and tape drives are connected to another server.

We assume that a *certificate*, which is a way to bind public key information with an identity, from a Business Partner had been imported into this keystore. It has only a public key associated with it; the Business Partner has the corresponding private key.

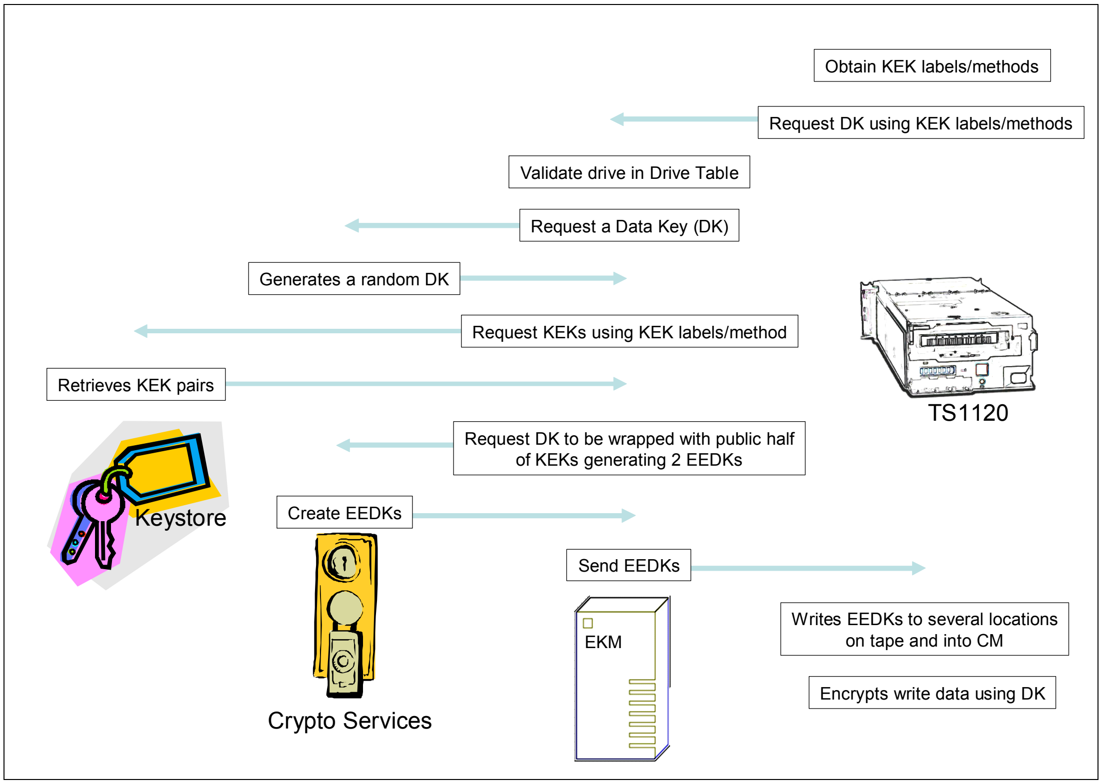


Figure 2-31 Encryption process TS1120

Now, our abstract server sends a write request to the drive. Our drive is encryption-capable, and the host has requested encryption. As part of this initial write, the drive obtains two Key Encrypting Key (KEK) labels from the host or a proxy, which are aliases for two Rivest-Shamir-Adleman (RSA) algorithm KEKs. The drive requests that the EKM send it a data key (DK) and encrypt the DK using the public KEKs aliased by the two KEK labels.

The EKM validates that the drive is in its list of valid drives. After validation, the EKM obtains a random DK from cryptographic services. EKM then retrieves the public halves of the KEKs aliased by the two KEK labels. The EKM then requests that cryptographic services create two encrypted instances of the DK using the public halves of the KEKs, therefore, creating two Externally Encrypted Data Keys (EEDKs).

The EKM sends both EEDKs to the tape drive. The drive stores the EEDKs to several locations on the tape and in the cartridge memory. The EKM also sends the DK to the drive in a secure manner. The drive uses the separately secured DK to encrypt the data.

Figure 2-32 on page 65 is the decryption data path. In this example, we decrypt data that was encrypted at another site, as outlined in Figure 2-31. For the decryption process, the tape has two EEDKs stored in its cartridge memory. We call these EEDK1 and EEDK2.

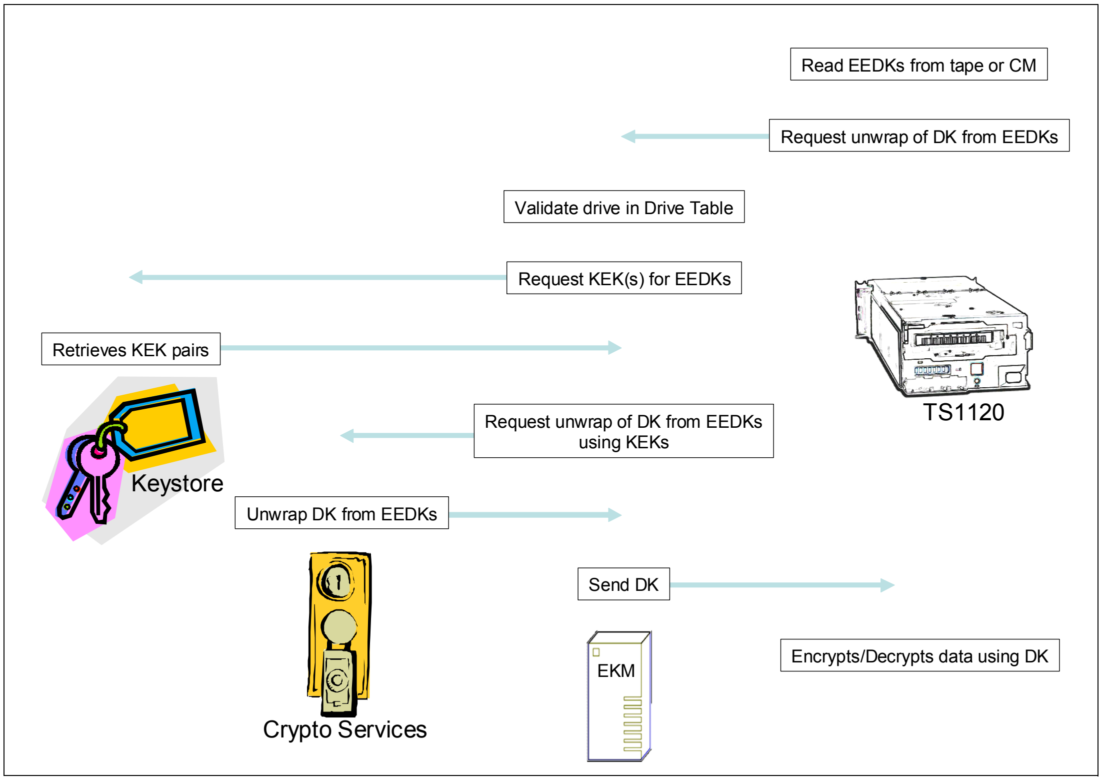


Figure 2-32 Decryption process TS1120

An encrypted tape is mounted for a read or a write append. The two EEDKs are read from the tape. The drive asks the EKM to decrypt the DK from the EEDKs. The EKM validates that the drive is in its list of valid drives. After validation, the EKM requests the keystore to provide the private halves of each KEK used to create the EEDKs. The KEK label associated with EEDK1 cannot be found in the keystore, but the HASH of the public key for EEDK2 is found in the keystore.

The EKM asks cryptographic services to decrypt the DK from EEDK2 using the private half of the KEK associated with EEDK2. The EKM then sends the DK to the drive in a secure manner. The drive either decrypts the data for a read operation or uses the DK to encrypt data for a write-append.

2.2.3 TS1040 Tape Encryption

The TS1040 Tape Encryption differs from the TS1120 Tape Encryption. The TS1040 cannot store a wrapped form of the symmetric encryption key on the tape cartridge like the TS1120. The symmetric encryption key is stored in the keystore attached to the EKM. An associated Key Identifier or alias maps to the Data Key in the keystore. This alias is stored with each block of data on the tape. AES 256-bit encryption is used, like the TS1120, to encrypt and decrypt the data on the data cartridge.

Write Request

The process for a Write Request to the TS1040 with encryption includes these steps:

1. The TS1040 tape drive receives a mount request for write with Beginning Of Tape (BOT) with encryption.
2. The TS1040 initiates a session with the EKM. The TS1040 communicates through the library using TCP/IP. The TS1040 requests a data key and passes an optional key label.

3. The EKM authenticates the TS1040 in its drive table.
4. The EKM retrieves a pre-generated AES-256 Data Key from the TS1040.
5. The EKM sends a data key and key identifier to the TS1040 in a secure manner.
6. The TS1040 receives the key structures and embeds the key identifier in the data and encrypts and writes the data to the tape.

Read or Write-Append Request

When an encrypted cartridge is mounted in the TS1040 in response to a specific mount request, the following steps are taken:

1. The TS1040 receives a mount request for a read or an append operation.
2. The TS1040 begins reading and finds an encrypted record. The key identifier is retrieved.
3. The TS1040 initiates a session with the EKM. The TS1040 communicates through the library using TCP/IP. The key identifier is passed for decryption.
4. The EKM authenticates the TS1040 in the drive table.
5. The EKM retrieves the pre-generated data key referenced by the key identifier.
6. The EKM passes the data key to the TS1040 in a secure manner.
7. The TS1040 reads the data from or write-appends data to the data cartridge.

2.3 IBM System Storage TS1030 Tape Drive

The TS1030 LTO Tape Drive drive offers high capacity, performance, and technology designed for the midrange Open Systems environment. The TS1030 LTO Tape Drive has a 4 Gbit Fibre Channel interface for either point-to-point or Fibre Channel-Arbitrated Loop attachment.

The native data transfer rate is 80 MB/s, and it uses the IBM TotalStorage LTO Ultrium 400 GB data cartridge, which provides up to 800 GB of storage with 2:1 compression.

The TS1030 LTO Tape Drive uses the new dual-stage 16 head actuator for a more precise head alignment to help support higher track density, improved data integrity, a new independent tape loader, and threader motors with positive pin retention. The new pin retention mechanism prevents loose tape wraps and stretching or breaking the tape. Also, the tape loader and threader motors are designed to help improve the reliability of loading and unloading a cartridge and to help retain the pin even if the tension drops. The TS1030 LTO Tape Drive has a 128 MB internal buffer.

We describe highlights of the TS1030 LTO Tape Drive in the following sections.

Dynamic braking

The TS1030 LTO Tape Drive uses dynamic braking. In the event of a power failure, reel motors are designed to maintain tension and gradually decelerate instead of stopping abruptly, reducing the potential for tape breakage, stretching, or loose tape wraps during a sudden powerdown.

Servo and track layout technology

The TS1030 LTO Tape Drive uses 704 data tracks to read and write to tape. The high bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

Surface Control Guiding Mechanism

The Surface Control Guiding Mechanism is designed to guide the tape along the tape path in the TS1030 LTO Tape Drive. This method uses the surface of the tape, rather than the edges, to control tape motion. This helps to reduce tape damage (especially to the edges of the tape) and tape debris, which comes from the damaged edges and can accumulate in the head area.

Magneto Resistive (MR) head design

This design uses a flat lap head technology in MR heads for Ultrium 3 that helps to minimize the contact, debris accumulation, and wear on the tape as it moves over the read/write heads.

Dynamic Amplitude Asymmetry Compensation

This design helps to dynamically optimize readback signals for linear readback response from magneto resistive read head transducers.

2.4 IBM System Storage TS1040 Tape Drive

The TS1040 LTO Tape Drive offers high capacity, performance, and technology designed for the midrange Open Systems environment. The TS1040 LTO Tape Drive has a 4 Gbit Fibre Channel interface for either point-to-point or Fibre Channel-Arbitrated Loop attachment, a Ultra160 LVD SCSI attachment, or a 3 Gbps dual-ported SAS interface.

The TS1040 is the first tape drive within the IBM LTO tape family that supports Tape Encryption. Tape Encryption is supported on the SAS and Fibre Channel tape drives. The Ultra160 LVD SCSI interface does not support Tape Encryption.

AME is available at no charge. For SME and LME, Feature Codes 5900 or 1604 (Transparent LTO Encryption) and FC9900 (Encryption Configuration) must be ordered if you are planning to implement Tape Encryption in your environment. If you want to learn more about Tape Encryption, we recommend that you read the following interesting topic, 2.2, “Tape Encryption overview” on page 56.

The internal read/write buffer increased to 256 MB, and the total amount of data tracks is 896.

The native storage capacity is 800 GB and 1600 GB with a 2:1 compression. Table 2-3 shows the native data transfer rate when a different generation data cartridge is processed.

Table 2-3 Native data transfer rate with different media

	Generation 4 media	Generation 3 media	Generation 2 media
Supported methods of operating	Read/write	Read/write	Read only
Native data rate **SCSI** (MB/s)	120	80	35
Native date rate **SAS** (MB/s)	120	80	35
Native data rate **Fibre Channel** (MB/s)	120	80	35

Basic points to consider

The Ultrium 4 drive can operate either as an NL port (FCAL support, or connection to an FL port on a fabric) or as an N port ((supporting direct connection to an F port (for example, a McData switch), also known as point-to-point to a fabric)). The Ultrium 4 drive auto-configures to either an N or an NL port depending on whether it sees a loop or an F-port connection when the drive boots unless it has been set to force an explicit setting of these configurations. The drive can be forced to an explicit setting by serial port (LDI/ADI) and library port (LUN1) commands, which write the VPD. The Ultrium 4 drive will attempt to connect at 4 Gb, but will auto-negotiate down to 2 Gb or 1 Gb if the system or switch to which it is connected cannot support 4 Gb.

SAS drives will auto-negotiate speed. The SAS drives are dual-ported and use the SAS Drive Plug Connector, which supplies power to the drive.

Speed matching

To improve the performance of the LTO4 tape drive, the tape drive uses a technique called *speed matching* to dynamically adjust its native (uncompressed) data rate to the slower rate of the server's HBA. The LTO4 tape drive is negotiating with the server's HBA to set up a speed with the best performance. Six speeds are available when reading or writing the prior generation of data cartridges. Native rates are:

- Generation 2: 30, 26, 22, 19, and 15 MB/s
- Generation 3: 30, 40, 50, 60, 70, or 80 MB/s
- Generation 4: 30, 48, 66, 84, 103, or 120 MB/s

If the server is between two of the native rates, the drive calculates the appropriate data rate at which to operate. Speed matching reduces back hitching. *Back hitching* is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is usually the result of a mismatch between the data rates of the connected server and the tape drive.

Channel calibration

The performance of the LTO4 tape drive is further optimized by a feature called *channel calibration.* Channel calibration is the process by which the drive automatically customizes each read/write data channel to compensate for variations in the recording channel's transfer function, the media, and characteristics of the drive head.

Sleep mode

To save energy, the LTO4 tape drives use a feature called *sleep mode*. To enter sleep mode, the LTO4 tape drive must be inactive for a minimum of 30 seconds. The LTO4 tape drive goes out of this sleeping mode again after receiving a SCSI command, a command across the Library/Drive interface (LDI or RS-422), or on a load or unload request. When in sleep mode, the drive response time to commands that do not require media motion increases by up to ten microseconds. Commands that require media motion might be delayed an additional 100 milliseconds, because the tape must be retensioned.

Customer Centric Statistical Analysis Reporting System

Customer Centric Statistical Analysis Reporting System (ccSARS) provides information reflecting the current and overall health of the drive and any media recently used within the TS1040. The ccSARS can be used either directly by the host or a subsystem to monitor the systemic operational characteristics of the TS1040 and media. At the time of writing this publication, the only library that is able to be incorporated with ccSARS is the TS3500 Tape Library.

2.4.1 IBM Ultrium 1, 2, 3, and 4 compatibility

Table 2-4 shows the compatibility among the four generations of LTO data cartridges. The following rules describe the compatibility between the different generations LTO cartridges:

- Data cartridges one generation prior are Read/Write compatible.
- Data cartridges two generations prior are Read only.
- Data cartridges three generations prior are not supported.

However, the Ultrium 4 drive only allows an Ultrium 3 cartridge to be written at the LTO Generation 3 operating point (400 GB). More specifically, the Ultrium 4 drive does not allow an Ultrium 3 cartridge (400 GB) to be reformatted to the Ultrium 4 format (800 GB). This is generally true when a data cartridge is used in a higher generation Ultrium tape drive.

Table 2-4, Figure 2-33 on page 70, and Figure 2-34 on page 71 provide a overview of the compatibility of the four generations of data cartridges.

Table 2-4 shows the read/write compatibility among the four generations of data cartridges.

Table 2-4 *Ultrium data cartridge compatibility*

IBM Ultrium Tape Drive	**IBM TotalStorage LTO Ultrium Data Cartridge**			
	800 GB (Ultrium 4)	**400 GB (Ultrium 3)**	**200 GB (Ultrium 2)**	**100 GB (Ultrium 1)**
Ultrium 4	Read/write	Read/write	Read only	
Ultrium 3		Read/write	Read/write	Read only
Ultrium 2			Read/write	Read/write
Ultrium 1				Read/write

Figure 2-33 on page 70 shows the read/write compatibility and the native sustained data rate and the native physical data cartridge capacity. The different generations of data cartridges can be recognized quickly by the color or barcode label. The color represents the following generation LTO data cartridges:

- Black LTO1 data cartridge
- Purple LTO2 data cartridge
- Slate Blue LTO3 data cartridge
- Green LTO4 data cartridge

Every data cartridge has an external label, and the generation shows on the right side of the label: L1 for the first generation, L2 for the second generation, L3 for the third generation, and L4 for the fourth generation. WORM data cartridges use LT for identification.

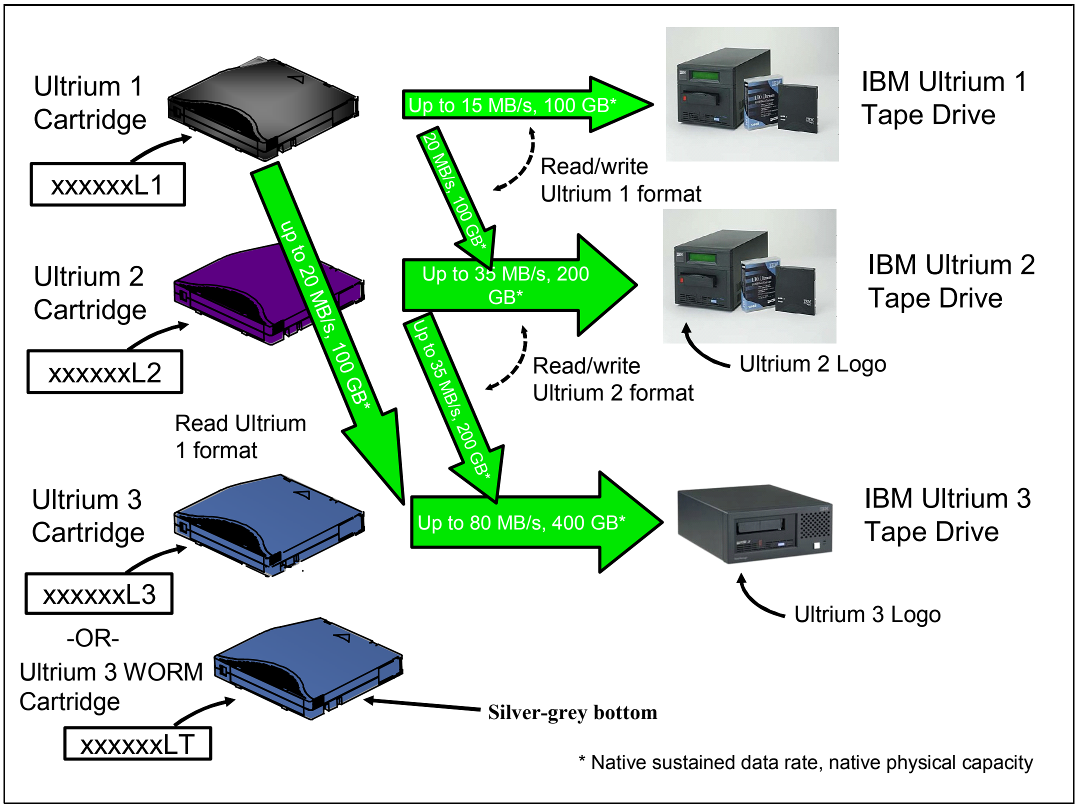


Figure 2-33 IBM Ultrium 1, 2, and 3 compatibility

Figure 2-34 on page 71 shows the compatibility between Ultrium 2, 3, and 4 data cartridges.

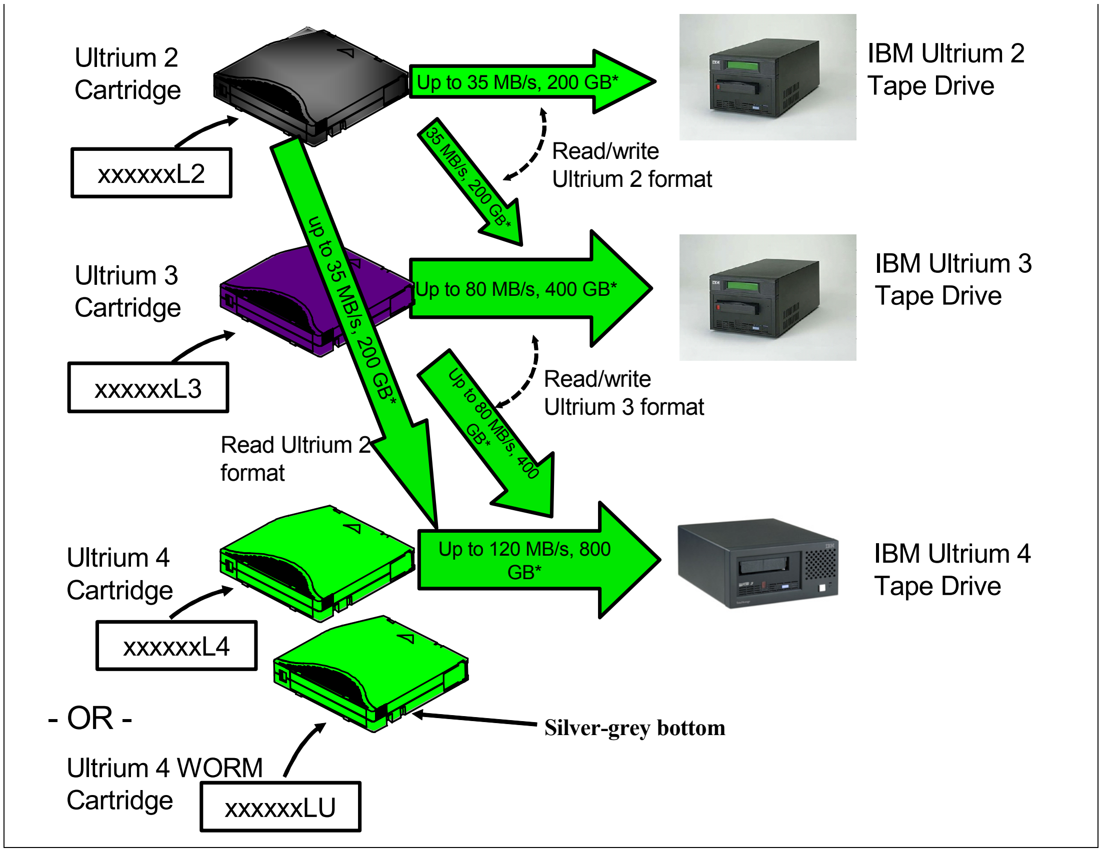


Figure 2-34 IBM 2, 3, and 4 compatibility

2.4.2 LTO performance

IBM LTO drives provide high performance and will continue to improve with each new generation of products. If you run applications that are highly dependent on tape-processing speed, you can exploit the significant performance provided by the Ultrium tape drives.

IBM LTO Ultrium drives provide efficient tape operations and relief to users who have difficulty completing tape activities in the time available. If you have limited system backup windows, or if you have large amounts of disk data to back up, Ultrium tape drives are ideal.

By using the built-in data-compression capability of the Ultrium drive, you can potentially achieve greater data rates than the uncompressed data rate. However, the actual throughput is a function of many components, such as the host system processor, disk data rate, block size, data compression ratio, SCSI bus capabilities, and system or application software. Installing multiple tape drives in general (or more than two in the case of IBM LTO) on a single SCSI bus can adversely affect data transfer rates.

IBM Ultrium 1

The IBM LTO Ultrium 1 Tape Drive has these performance characteristics:

- 15 MB/s native sustained data transfer rate
- 30 MB/s sustained data transfer rate at 2:1 compression
- 60 MB/s maximum sustained data rate (at maximum compression)
- 100 MB/s burst data transfer rate for Fibre Channel

- 80 MB/s burst data transfer rate for Ultra2 SCSI LVD drives
- 40 MB/s burst data transfer rate for Ultra SCSI HVD drives
- 20 s nominal load-to-ready time
- 18 s nominal unload time
- 73 s average search time to first byte of data
- 110 s maximum rewind time
- 4 m/s read/write speed
- 6 m/s search/rewind speed
- 32 MB buffer

IBM Ultrium 2

The IBM LTO Ultrium 2 drives provide more than twice the performance of IBM Ultrium 1 with sustained data rates of 35 MB/s native and 70 MB/s with 2:1 compression. IBM Ultrium 2 has faster load and unload time, faster data access time, faster rewind time, and faster cartridge fill time compared with IBM Ultrium 1. The Ultrium 2 drive provides speed matching with five speeds for the Ultrium 2 cartridge. The Ultrium 2 drive also reads and writes to an Ultrium 1 cartridge at a higher speed than the Ultrium 1 drive.

The IBM LTO Ultrium 2 Tape Drive has these performance characteristics:

- 35 MB/s native sustained data transfer rate
- 70 MB/s sustained data transfer rate at 2:1 compression
- 110 MB/s maximum sustained data rate (at maximum compression)
- 200 MB/s burst data transfer rate for Fibre Channel
- 160 MB/s burst data transfer rate for Ultra 160 SCSI LVD drives
- 40 MB/s burst data transfer rate for Ultra SCSI HVD drives
- 15 s nominal load-to-ready time
- 15 s nominal unload time
- 49 s average search time to first byte of data
- 80 s maximum rewind time
- 6.2 m/s read/write speed
- 8 m/s search/rewind speed
- 64 MB buffer

IBM Ultrium 3

The IBM LTO Ultrium 3 drives offer more than double the performance of IBM Ultrium 2 with sustained data rates of 80 MB/s native and 160 MB/s with 2:1 compression. IBM Ultrium 3 provides speed matching with five speeds for both Ultrium 3 and Ultrium 2 cartridges and reads and writes an Ultrium 2 cartridge at the speed of the Ultrium 2 drive.

The IBM LTO Ultrium 3 Tape Drive has these performance characteristics:

- 80 MB/s native sustained data transfer rate
- 160 MB/s sustained data transfer rate at 2:1 compression
- Over 200 MB/s maximum sustained data rate (at maximum compression)
- 200 MB/s burst data transfer rate for Fibre Channel
- 160 MB/s burst data transfer rate for Ultra 160 SCSI LVD drives
- 15 s nominal load-to-ready time
- 15 s nominal unload time
- 54 s average search time to first byte of data
- 88 s maximum rewind time
- 6.2 m/s read/write speed
- 8 m/s search/rewind speed
- 128 MB buffer

IBM Ultrium 4

The IBM LTO Ultrium 4 tape drive has these performance characteristics:

- 120 MB/s native sustained data transfer rate
- Sustained data transfer rate at 2:1 compression:
  - For SCSI: 140 MB/s
  - For SAS: 240 MB/s
  - For FC: 240 MB/s
- 12 s nominal load-to-ready time
- 17 s nominal unload time
- 57 s average search time to first byte of data
- 54 s average rewind time
- 8 m/s read/write speed
- 8m/s rewind speed
- 256 MB buffer

Partial Response Maximum Likelihood (PRML)

The IBM patented linear tape implementation of a Partial Response Maximum Likelihood (PRML) channel technology increases linear densities up to 33% and consequently data throughput. The key to PRML's space-saving capability is that on a read-back operation, the magnetic flux transitions are sampled and the sampling feeds logic algorithms that reconstruct the user's data stream, rather than using the flux transitions themselves. The previous method of data encoding was Run Length Limited (RLL) encoding, also patented by IBM for use in earlier tape drives. Figure 2-35 compares both methods.

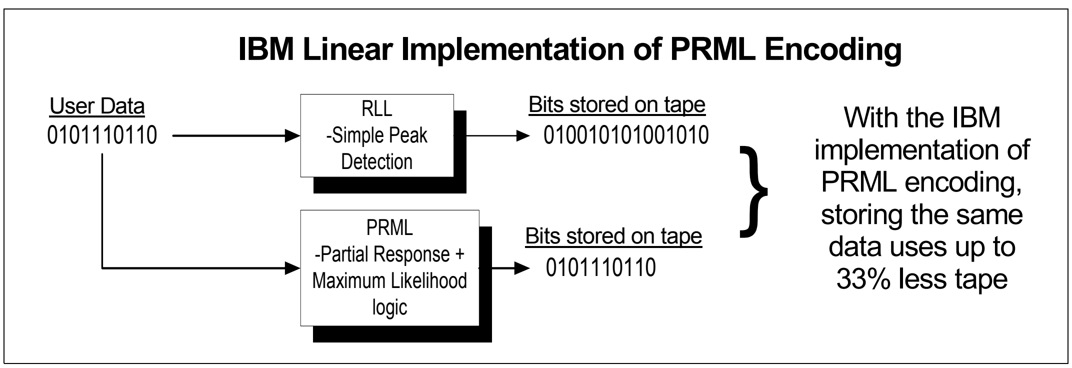


Figure 2-35 IBM linear implementation of PRML encoding

2.4.3 Operating the Ultrium drive

The IBM subassembly itself has a simple status LED indicator, an unload push button, and a single-character display (see Figure 2-36).

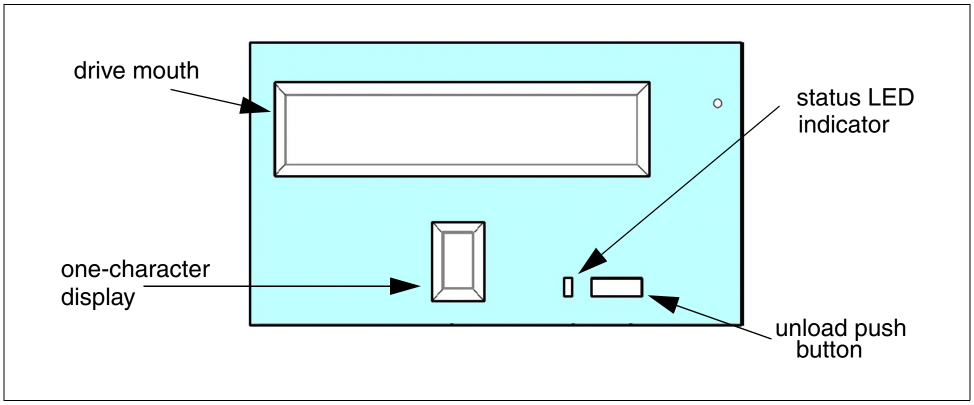


Figure 2-36 Front of subassembly showing Operator Panel indicators

The status LED indicator uses color and lighting to indicate that:

- The tape is in motion for reading or writing.
- The drive is rewinding, locating, or unloading the cartridge.
- The drive is in maintenance mode.
- A failure occurred and the drive or media requires service.
- A microcode update is occurring.

The unload push button enables the operator to:

- Unload a cartridge
- Enter maintenance mode and execute maintenance operations
- Force a drive dump operation

The single-character display indicates errors and communicates messages, such as requests for cleaner tapes. The operator uses the single-character display for diagnostic and maintenance functions.

2.4.4 Reliability

The IBM LTO Ultrium tape format differs from earlier IBM products. Reliability and availability features include:

- Data integrity

  The drive performs a read after write for verification. Incorrectly written data, such as the result of a tape defect, is automatically rewritten by the drive in a new location. Data rewritten as the result of media defects is not counted against the drive error performance.

  The drive never records incorrect data to the tape media without posting an error condition.

- Power loss

  No recorded data is lost as a result of normal or abnormal power loss while the drive is reading or writing data. If power is lost while writing data, only the data block currently being written might be in error. Any previously written data is not destroyed.

- Error correction

  Data integrity features include two levels of error correction that can provide recovery from longitudinal media scratches.

- Integrated head cleaner

  The head of the drive must be kept clean to prevent errors caused by contamination. During the load process, a brush integrated into the drive mechanism cleans the head before it is used with the tape. This keeps the head and media free of debris on a continuing basis and is designed to require fewer drive-cleaning operations.

- Surface control guiding

  The Surface Control Guiding Mechanism, which is patented by IBM, guides the tape along the tape path using the surface of the tape rather than the edges to control tape motion. Using grooved rollers (see Figure 2-37), an air cushion builds between the tape and the rollers that keeps the tape in the right position. This results in less tape damage (especially to the edges of the tape) and less debris from damaged edges that can accumulate in the head area, and this helps minimize the chance of physical damage to the tape media.

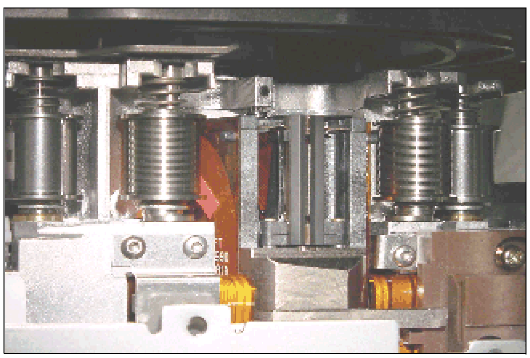


Figure 2-37 Surface control guiding

- Flat lap head

  The flat lap head, which is shown in Figure 2-38, improves contact between the read and write recording elements and the tape, giving higher quality recording and readback of data.

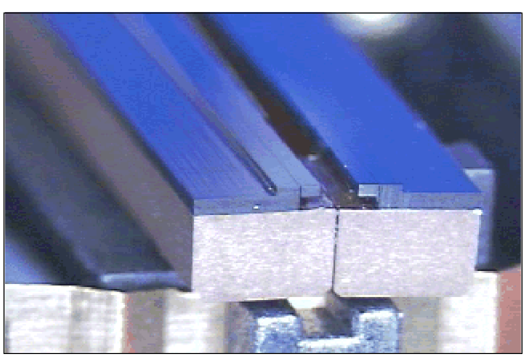


Figure 2-38 Flat lap head

Surface control guiding and the flat lap head are designed to help minimize debris generated as the tape moves through its path, resulting in increased reliability in reading and writing data. This also potentially increases the life expectancy of the media by not using the edges of the tape to guide it over the read/write head. Historically, this also was a major source of debris on the tape path.

- Statistical Analysis and Reporting System

  Statistical Analysis and Reporting System (SARS) is another IBM exclusive. Only IBM LTO drives provide this level of preventive diagnostic reporting. The Ultrium drive uses this reporting system to assist in isolating failures between media and hardware. SARS uses the cartridge performance history saved in the CM module and the drive performance history kept in the drive flash EEPROM to determine the most likely cause of failure. It then can cause the drive to request a cleaner tape, to mark the media as degraded, and to indicate that the hardware has degraded. SARS reports the results of its analysis in the form of a Tape Alert if necessary (see Figure 2-39).

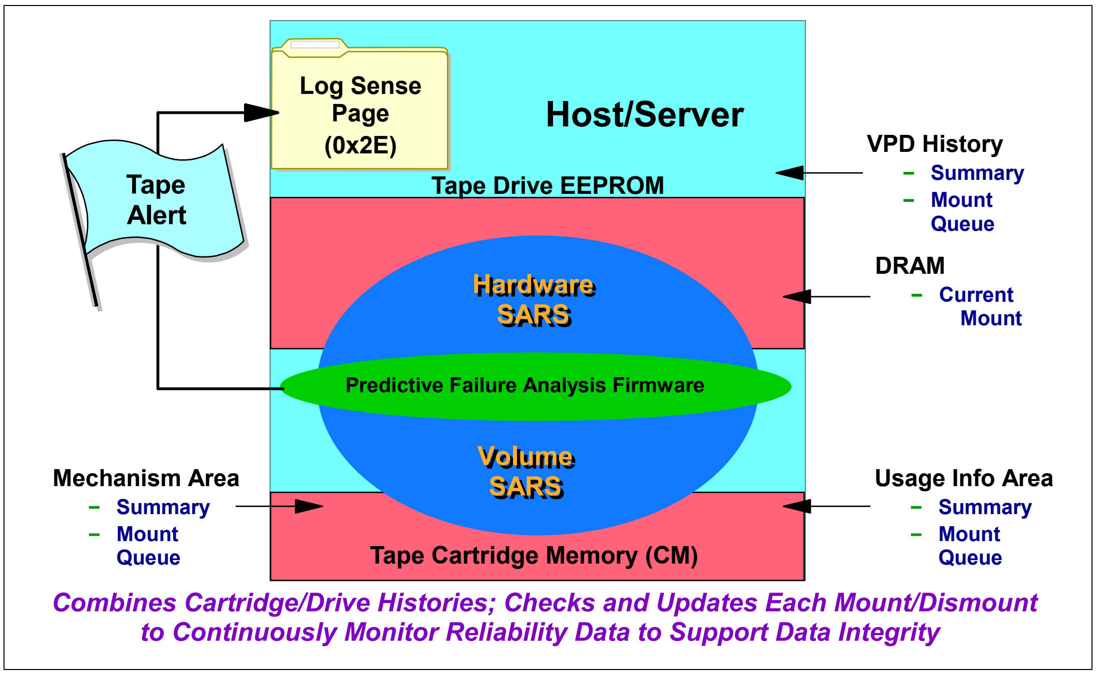


Figure 2-39 Statistical Analysis and Reporting System

2.4.5 Cleaning the drive

In addition to the integrated head-cleaning mechanism, IBM recommends that you clean the drive regularly, with automatic cleaning enabled where supported in the libraries. The automatic cleaning prevents drive shutdowns because of improper maintenance or contaminants that cause the drive to fail.

In the unusual event that the drive head becomes clogged, it *might* be necessary to use the specially labeled IBM LTO Ultrium cleaning cartridge supplied with each Ultrium tape drive product. The cleaning cartridge is good for 50 cleaning operations. If cleaning proves necessary, the LTO-CM memory in a cleaning cartridge is used to track the number of times that the cartridge has been used. After the cartridge has been used 50 times, the drive marks the cleaning cartridge as expired. This also protects you from accidentally reinserting a cleaning cartridge that has been used 50 times.

Note: The use of cleaning cartridges other than when automatically required (that is, a manual or user-initiated cleaning) is unnecessary. Using cleaning cartridges other than when automatically required is discouraged for normal operation of Ultrium tape drives.

2.4.6 The IBM LTO Ultrium family of tape drives and libraries

The IBM Ultrium family of tape drives and libraries (pictured in Figure 2-40) comprises five different product offerings, ranging from a stand-alone unit to a highly scalable automated library.

Figure 2-40 The IBM Ultrium family of tape drives and libraries

They are all based on a common tape drive subassembly packaged in different robotic and stand-alone environments. The tape drives and libraries shown in Figure 2-40 are:

- The *IBM TotalStorage 3580 Tape Drive* is a stand-alone desktop single-drive unit without an autoloader. You mount tapes manually one at a time.
- The *IBM TotalStorage 3581 Tape Autoloader* is also a single-drive unit, but it has a seven-cartridge or eight-cartridge autoloader within the device. It is either a stand-alone desktop, an external 2U stand-alone, or a rack-mountable unit. This unit is no longer available (as of October 1, 2004), and the existing units only support LTO1 or LTO2 drives.
- The *IBM TotalStorage 3581 2U Tape Autoloader* is a desktop or rack-mountable unit that comes equipped with a robotic interface that moves tape cartridges to and from the drive and an eight-cartridge carousel. It occupies two units of the rack when it is rack-mounted.
- The *IBM TotalStorage 3582 Tape Library* is a small robotic library, accommodating one to two drives and providing space for up to 23 Ultrium cartridges. The IBM 3582 can be stand-alone or, with an optional feature, housed in a rack.
- The *IBM TotalStorage 3583 Tape Library* is a small robotic library, accommodating from one to six drives and providing space for up to 72 Ultrium cartridges. The IBM 3583 can be stand-alone or, with an optional feature, housed in a rack.
- The *IBM System Storage TS3500 Tape Library* (previously known as IBM TotalStorage 3584 Tape Library) is a larger modular enterprise class library with the potential to house a maximum of 192 IBM LTO or IBM 3592 tape drives in as many as 16 frames. There is a

trade-off between cartridge capacity and installed drives: a fully configured library with 192 drives and a cartridge I/O station has a cartridge capacity of 6201; in a minimal drive configuration, the cartridge capacity can reach a maximum of 6887.

Note: The IBM 3580 Tape Drive and the IBM 3581, 3582, and 3583 Tape Libraries have been withdrawn from Marketing.

Replacement tape drives and tape libraries are available. We show them in Figure 2-41.

Figure 2-41 IBM 3580 Tape Drive, TS3100, TS3200, and TS3310 Tape LIbraries

The tape drives and libraries shown on the left side of Figure 2-41 are (listed from top to bottom):

- The *IBM System Storage TS2340 Tape Drive* is an external stand-alone or rack-mountable (optional) unit and is the entry point for the family of IBM Ultrium Tape products. It features the LTO4 Tape Drive.
- The *IBM System Storage TS3100 Tape Library* is a desktop or rack-mountable single drive unit that can hold up to 24 cartridges. A robotic system moves the cartridges to and from the drive. When it is mounted in a rack, it occupies two units of the rack.
- The *IBM System Storage TS3200 Tape Library* is a desktop or rack-mountable single or dual drive unit that can hold up to 48 cartridges. It has a three slot I/O station that must be shared when logical libraries are configured. When it is mounted in a rack, it occupies four units of the rack.
- The *IBM System Storage TS3310 Tape Library* is highly modular and vertically expandable. The smallest configuration includes a base module with one to two LTO3 or LTO4 tape drives, 12 TB of native tape storage (30 slots), and 6 I/O slots. This will be

upgradeable in the future to a fully configured rack-mounted library 41U high with up to 18 LTO3 or LTO4 tape drives, over 320 TB of native tape storage (402 slots), and up to 48 I/O slots.

On the right side of Figure 2-41 on page 78, you see (from top to bottom):

- The *IBM System Storage TS2230 Tape Drive* is an external stand-alone or rack-mountable unit and is the entry point to the family of IBM Linear Tape-Open (LTO) Ultrium Tape products. It features the LTO3 Half-High Tape Drive.
- The *IBM System Storage TS3400 Tape Library* is a tape library based on the TS1120 Tape Drive. The TS3400 provides 18 storage slots, including a three slot I/O station. The total native capacity is 12.6 TB.

2.4.7 Multi-path architecture

The patented multi-path architecture was introduced with the IBM Magstar MP 3575 library. It provides a way to share a tape library among a number of servers without the need to implement application software to control and serialize tape drives and media. It is presently implemented in the IBM TS3100, TS3200, TS3310, TS3400, 3582, 3583, TS3500, and 3584 libraries.

Multi-path architecture is an IBM unique feature. The IBM TS3100, TS3200, TS3310, TS3400, TS3310, 3582, 3583, TS3500, and 3584 LTO libraries feature the second generation of the architecture. It uses the SCSI-3 Move Media command set that is featured in midrange and open libraries. The key benefit is that multi-path architecture removes the need for a dedicated server plus middleware to control the use of a library by many different hosts utilizing different operating systems, because each drive has its own path to the control unit.

Conventional tape libraries use a dedicated host port to communicate with the library, for example, for sending mount request commands. IBM LTO tape libraries use the same path to communicate with both the drives and the library controller, as shown in Figure 2-42. This is not one dedicated path, but it might be any path to any tape drive.

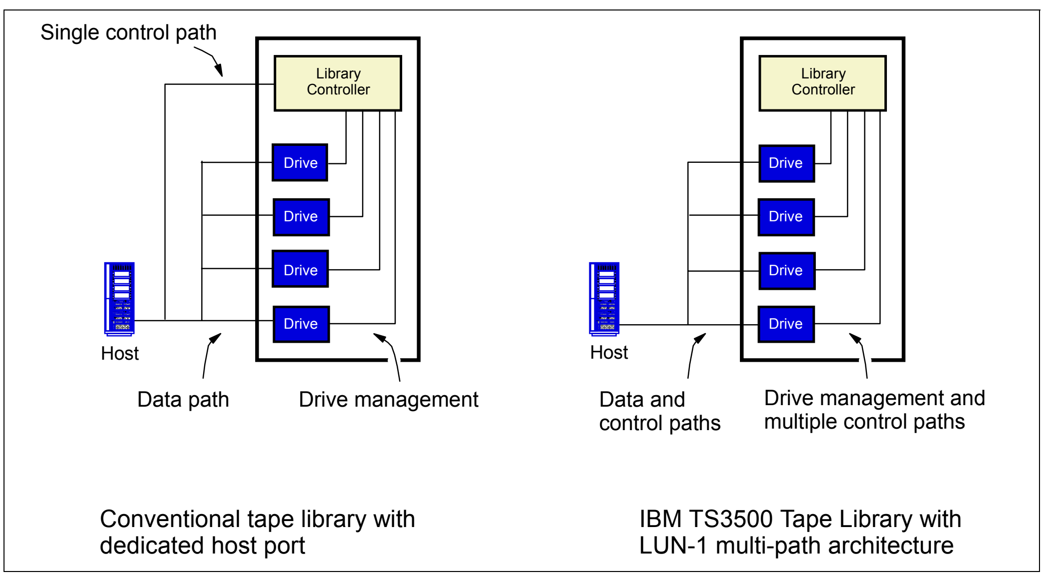


Figure 2-42 Conventional tape library versus multi-path architecture

For conventional tape libraries, the control path is a single point of failure. In contrast, the IBM LTO tape libraries offer as many control paths as there are drives installed in the library, so in the event of individual control path failure, you can communicate with your library over different, redundant control paths. As shown in Figure 2-43, if one path to a drive is broken because of a defective switch port, cable, or HBA, communication to the library controller can still occur using one of the other available paths. In conjunction with automatic control path failover, this constitutes a unique high-availability option.

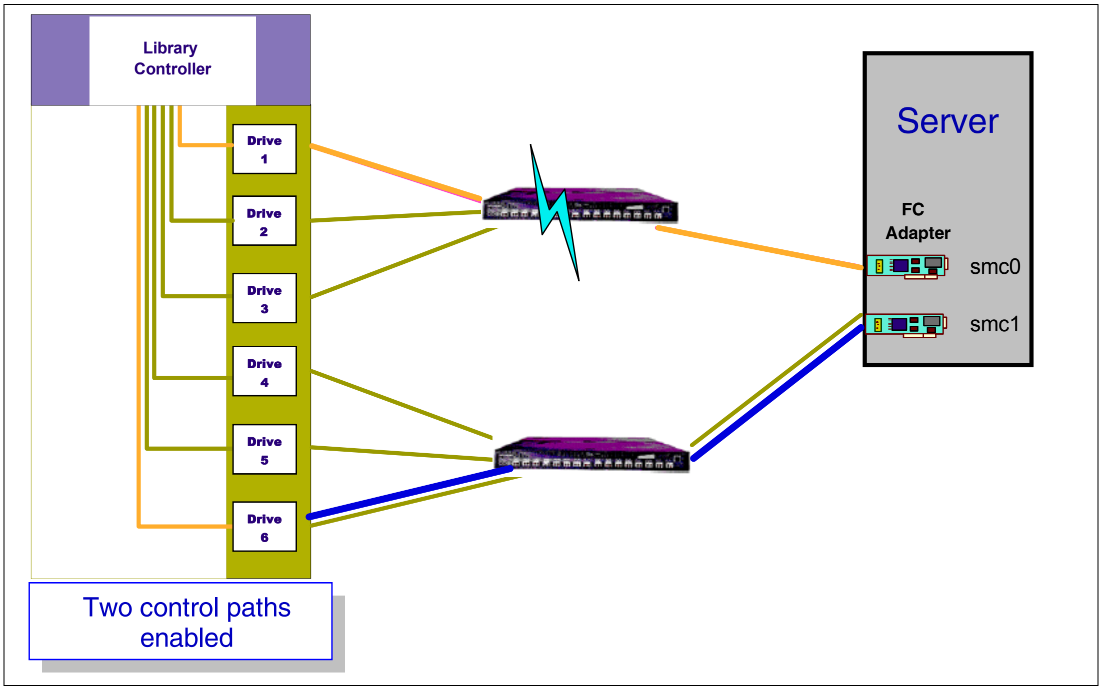


Figure 2-43 Redundant control paths to the library controller

As well as the redundant control path, multi-path architecture offers the additional benefit of built-in partitioning. With the partitioning feature of the IBM LTO libraries, you can divide the physical library into several smaller logical libraries, which are independent from each other. The maximum number of logical libraries varies by model type. A logical library must contain at least one tape drive and cartridge cell and can comprise more than one tape drive sharing the same cartridge cells.

Multiple heterogeneous hosts can share the library with this partitioning option. Each logical library has its own drives, cartridges, and control paths. Because of barriers between the logical libraries, cartridges cannot be moved from one logical library to another. Figure 2-44 on page 81 shows three logical libraries with two drives each and several cartridge storage slots dedicated to each of the heterogeneous servers.

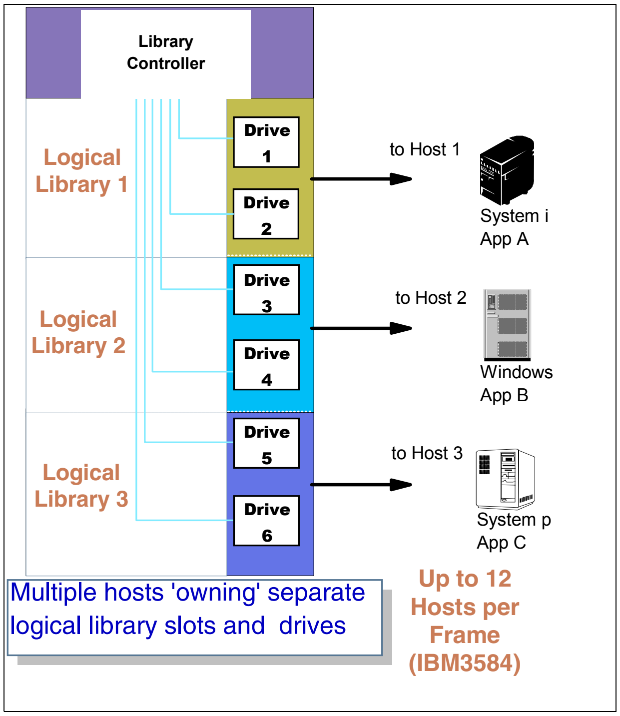


Figure 2-44 IBM LTO tape library partitioned into three logical libraries

2.4.8 Next generation multi-path architecture

The Advanced Library Management System (ALMS) is an optional extension to the IBM patented multi-path architecture. The multi-path architecture itself virtualized the library accessor. This enabled a library to be partitioned into multiple logical libraries and allowed a single library accessor to be used by multiple host computers in a transparent manner. The ALMS virtualizes the SCSI element address for storage slots, I/O slots, and drives. ALMS provides enhanced automation functionality, such as dynamic partitioning, including storage slot pooling and flexible drive assignment. Tape drives can be assigned to any logical library and to multiple logical libraries using a Web browser-based user interface. Logical libraries can be added, deleted, or easily changed non-disruptively. Storage capacity can be changed without any impact to host applications.

ALMS is a feature with the IBM TS3500 Tape Library and is described in detail in 9.5, “ALMS” on page 262.

2.5 IBM 3592 Tape Drive Model J1A

Introduced in October 2003, the 3592-J1A Tape Drive is a high-performance tape drive that can be installed in the IBM System Storage TS3500 Tape Library, as well as in the IBM TotalStorage 3494 Tape Library and StorageTek 9310 Powderhorn Tape Library, or reside in a stand-alone rack.

It has 300 GB of native capacity in a half-inch format tape cartridge and a native data rate of up to 40 MB/s. It is also, by design, a foundation for future generations of this new tape drive family based on the concept of media reuse. This design helps protect the client’s investment in tape cartridges. Figure 2-45 on page 82 shows the IBM 3592-J1A Tape Drive.

Figure 2-45   IBM 3592 Tape Drive Model J1A

The 3592-J1A Tape Drive is significantly lighter and more compact than its predecessor, the IBM 3590. The 3592-J1A Tape Drive and canister weigh only 5.7 kg (12.6 lb) as compared to IBM 3590’s 40 kg (88.2 lb). The drive itself has a smaller form factor, which allows two 3592-J1A Tape Drives in canisters to be placed in the same IBM TotalStorage 3494 Tape Library automation space as one IBM 3590 drive. Figure 2-46 shows the potential benefits of the smaller-scale 3592-J1A Tape Drive compared to the IBM 3590.

Figure 2-46   The IBM 3590 and IBM 3592 Tape Drive Model J1A

For its high capacity capability, the 3592-J1A Tape Drive uses the IBM TotalStorage Tape 3599 Media, which provides a native cartridge capacity of up to 300 GB.

The 3599 media models include:

- R/W 300 GB Data Cartridge
- R/W Economy 60 GB Data Cartridge
- WORM 300 GB Data Cartridge
- WORM Economy 60 GB Data Cartridge

The 3592-J1A Tape Drive is designed to meet the needs of tape clients across a broad range of computing environments, including IBM System z™, System i, System p™, System x™, IBM eServer zSeries®, iSeries, pSeries®, and xSeries®, and S/390®, AS/400, RS/6000®, Sun Solaris, and Hewlett Packard servers, as well as Intel®-compatible servers running Microsoft® Windows and Linux. In addition, the 3592 can be integrated into the IBM

TotalStorage 3494 Tape Library and StorageTek 9310 Powderhorn Tape Library or reside in a stand-alone rack.

2.5.1 IBM 3592 Tape Drive Model J1A technical features

The 3592 Model J1A Tape Drive exploits a number of technologies to provide improved speed, capacity, and reliability.

Interleaved recording

The 3592-J1A Tape Drive and recording technology offer many similarities with the technology introduced in 2.3, "IBM System Storage TS1030 Tape Drive" on page 66.

The 3592-J1A Tape Drive uses the same interleaved recording technique described in "Interleaved recording" on page 32. The descriptions for servo tracks, track following, and longitudinal positioning also apply.

Feeds, speeds, and speed matching

The 3592 Model J1A Tape Drive has a high-technology design that increases the maximum native data rate to up to 40 MB/s (nearly three times the 14 MB/s data rate of the 3590 E or H models, and over four times the 9 MB/s data rate of the 3590 B models). This is achieved by moving the tape over an eight-track read/write head at a maximum read/write speed of 4.74 m/s. Beyond this maximum read/write speed, the IBM 3592 Model J1A Tape Drive has an 8 m/s high speed locate mode to enable fast rewinds and longitudinal seeks and can read/write at lower speeds when it is advantageous to do so.

The 3592-J1A Tape Drive uses the proven Digital speed matching technology shipped in IBM LTO2 tape drives (see "Speed matching" on page 68) to monitor the effective (after data compression) host data rate and to switch to lower the read/write speed to keep pace with the host. Digital speed matching has two important effects, both of which are beneficial to the client. First, it helps dramatically reduce the number of back hitches required to read or write a tape when the drive is attached to a system that does not have an effective data rate high enough to stream the drive at its maximum native data rate. Digital speed matching helps significantly reduce the stress on the tape that can result from constant backhitching. Second, it helps reduce the time required to reposition, or *backhitch*, the tape. In a non-synchronizing environment, in which backup and restore functions are streamed, the backhitch time is hidden by the DRAM buffer. Therefore, reducing the backhitch time generally does not improve performance. However, in other environments where backhitching cannot be hidden by the 128 MB DRAM buffer, such as when executing read error recovery procedures or when the drive is forced to empty its buffer to tape in certain writing situations, reducing the backhitch time helps improve performance.

Cartridge Memory (CM)

Contained within the cartridge is the Cartridge Memory (CM), a passive, contactless silicon storage device (4096 bytes) that is physically a part of the cartridge. The CM is used to hold information about that specific cartridge, the media in the cartridge, and the data on the media. It is designed to support the High Resolution Tape directory feature. The CM is located in the left-rear corner of the cartridge and is mounted at an angle similar to LTO to allow the ability of interfacing to the CM from the rear of the cartridge by a picker or other device. Communication between the drive and the CM is performed via a non-contact passive radio frequency interface that eliminates the need for physical connections to the cartridge for power or signals.

Virtual backhitch (non-volatile caching)

As other modern tape drives do, the 3592-J1A Tape Drive stages write data through an intermediate DRAM buffer on its way to tape. This buffer is volatile in that it will not retain what is stored in it if power is lost. For streamed writes (or reads), this buffer yields considerably improved performance. When a pre-3592 drive is performing a streamed write to tape and the buffer empties, or if a synchronizing command is received that forces the buffer to be written to tape, the streamed writing will cease for want of data. Any non-immediate write-type command (for example, how filemarks are typically written by most mainframe applications) is considered a synchronizing command. Non-immediate write-type commands require the drive to store data to tape before returning Command Complete (with good status) in response to that command. This by definition forces all the data in the volatile buffer to be written to tape.

When streaming writes cease, a pre-3592 tape drive halts the tape and repositions it upstream of where writing ended. This allows subsequently received data to be written immediately following the previously written data in order to eliminate the waste of the considerable length of tape from the point at which good status is returned to the host to the point at which the host has subsequently sent enough data to resume writing. For example, if tape is streaming at 4.74 m/s when the buffered data falls below the threshold, an entire meter of tape can pass unwritten in about 210 milliseconds. Substantial lengths of unwritten tape can significantly reduce capacity. Heretofore, a backhitch has been used by typical tape drives to eliminate this capacity loss following a synchronizing write to tape.

Non-volatile caching (NVC) is an 3592-J1A Tape Drive feature that can help greatly improve write performance through backhitch reduction. This system temporarily reserves portions of physical tape for cache areas. Data received from the host is written to the volatile buffer as usual, and also to nonvolatile tape cache areas, with the exception that no backhitch is typically necessary when writing temporary copies to cache areas of tape. This temporary capacity loss is easily recouped. The data is written to temporary cache areas and is not released in the volatile buffer, but instead it accumulates. This accumulation typically continues until the buffer is nearly full. At this time, the accumulated data in the buffer is rewritten via a streamed write to the standard area of tape. When the rewrite is complete, the temporary cache areas of tape are released so that they can be overwritten. Writing temporary copies to the cache areas of tape without backhitching until the buffer is nearly full, and then streaming a rewrite of the data to the standard area of tape, can help significantly improve the average write throughput to tape.

Capacity scaling and segmentation

The 3592-J1A Tape Drive supports scaling and segmentation modes on the 300 GB R/W (JA) cartridge to enable clients to trade off capacity for improved access times. While 256 settings of capacity are supported on the 3592-J1A Tape Drive, only two primary settings are recommended for use and fully certified:

- 300 GB default mode
- 60 GB fast access mode

> **Important:** We recommend that you check with your backup software provider to confirm that the software supports scaling and segmentation.

Capacity scaling of the tape medium is the action of modifying internal formatting indicators in the medium (and in the cartridge memory (CM) chip) so that the normal serpentine track format is altered to limit the recorded portion of the tape to a specified fraction of the linear dimension of the medium (Figure 2-47 on page 85). This action is normally accomplished by the drive responding to a command, in this case, a Mode Select command. It pertains only to the currently loaded cartridge; it is not persistent.

The consequences of capacity scaling a tape to a percentage value, 20% for example, is that the maximum number of recordable gigabytes is reduced to 20% of the normal value, and the average time to locate a random record on a full tape starting from load point is (very roughly) 20% of the time to locate a random record from load point for a full, unscaled tape. In comparison, the average time to locate a random record on an unscaled (serpentine) tape that has only been filled to 20% capacity is nearly the same as the average time to locate a random record on an unscaled tape that has been filled to 100%. Scaling cuts the access time proportionately, and it also introduces normal end-of-tape programmatic warnings when approaching the scaled capacity limit in the same sense that those indicators are returned at end of tape when unscaled.

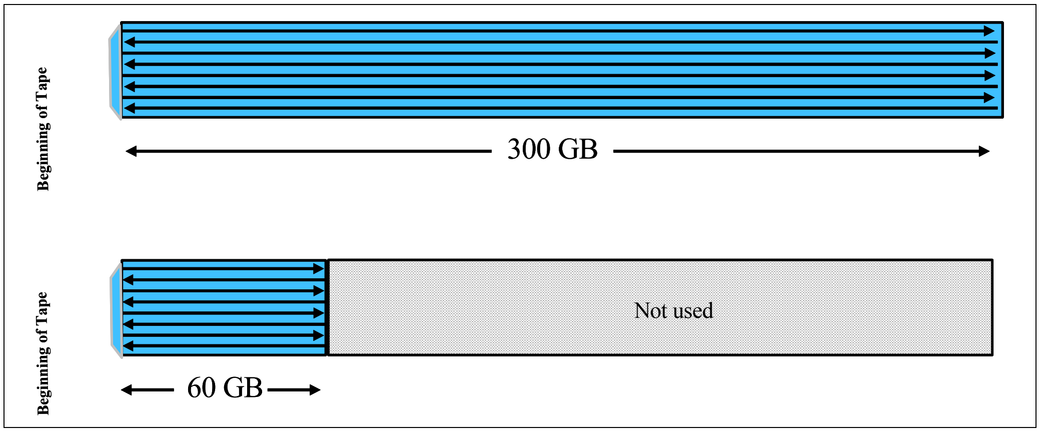


Figure 2-47 A 300 GB tape scaled by 20% to 60 GB

Segmentation involves the 3592-J1A Tape Drive dividing the tape longitudinally into segments. The first segment has a native capacity of 60 GB and spans approximately the first 158 meters of tape. Remaining segments total the remaining native capacity of 240 GB to logical EOT. The drive automatically keeps writing from segment 1 on into segment 2 seamlessly; that is, the tape appears as a single logical partition to the host system (shown in Figure 2-48). Segmentation offers high-performance random access in the first segment (first 60 GB), as if it were a scaled cartridge, while still providing an additional 200 GB capacity. However, if fewer than 60 GB are written to the media, the user experiences greatly improved locate performance, because accesses are restricted to the first 158 m of tape.

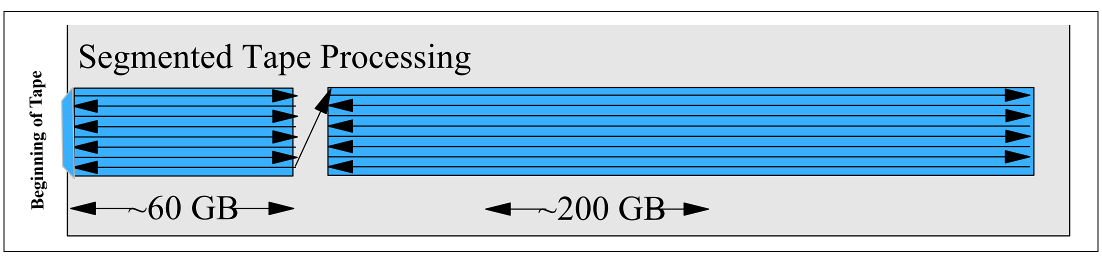


Figure 2-48 Segmented tape processing

Channel calibration

The *channel calibration* feature is designed to allow for customization of each read/write data channel for optimum performance. The customization can enable compensation for variations in the recording channel transfer function, media characteristics, and read/write head characteristics. The 3592-J1A Tape Drive is designed to automatically perform recalibration in the field if it detects degraded performance.

2.5.2 IBM 3592-J1A Tape Drive attachment types

The 3592-J1A Tape Drive provides as standard two switched fabric 2-Gbps Fibre Channel attachments for attachment to multiple servers or a single server with redundancy. It can also attach to the 3592 Model J70 controller or the 3590 Model A60 controller for attachment to ESCON or FICON channels on System z or zSeries servers. The IBM 3592 will attempt to connect at 2 Gbps (FC-2) but will auto-negotiate down to 1 Gbps (FC-1) if the system or switch to which it is connected cannot support 2 Gb/s.

The 3592-J1A Tape Drive can operate either as an NL port (FCAL support) or as an N port (supporting direct connection to a McDATA switch, also known as *point-to-point*). The 3592-J1A Tape Drive will auto-negotiate to either the N or NL port depending on whether it sees a loop or a point-to-point connection when the drive boots, unless it has been set to force an explicit setting of these configurations. Regardless of whether the 3592-J1A Tape Drive connects as an NL port or an N port, it auto-negotiates to be a public device (attached to a switch) or a private device (attached to another N port, that is, directly to a host). If a library drive is replaced, an IBM SSR might select for the replacement unit to automatically inherit the configuration attributes of the failed unit. This way, a user can avoid having to reconfigure the zoning in the switches. Alternatively, the panels can be used to change these fields directly at any time.

For a detailed description of Fibre Channel attachment planning, refer to *IBM TotalStorage Enterprise Tape System 3592 Introduction and Planning Guide*, GA32-0464.

For the latest information about applications and their levels that support 3592 tape drives, refer to the Independent Software Vendor (ISV) matrixes on:

http://www.ibm.com/servers/storage/tape/compatibility/pdf/3592_isv_matrix.pdf

You can find a list of host bus adapters (HBAs) supported for the 3592 drive at:

http://knowledge.storage.ibm.com/servers/storage/support/hbasearch/interop/hbaSearch.do

IBM 3592 cartridge and media

Clients are faced with the need to cost-effectively store more digital information than ever before, often to meet growing regulatory and legal requirements. The 3592-J1A Tape Drive can help meet these needs with the addition of lower capacity, less expensive cartridges and WORM cartridges. Together, these capabilities expand the range of client data workloads that can be addressed with the 3592-J1A Tape Drive. The Economy cartridge can help lower the cartridge cost for clients with smaller capacity needs and provide faster access to data. The WORM cartridges provide non-erasable, non-rewritable storage media. Clients with regulatory or legal requirements to store electronic records for long periods of time might be able to use the IBM 3592-J1A Tape Drive to provide cost-effective storage.

The 3592 cartridges have a form factor similar to the 3590 tape cartridge. They are supported in the IBM TotalStorage 3494 Tape Library, IBM System Storage TS3500, IBM TotalStorage 3584 Tape Library, and StorageTek ACS automation environments. (However, the tape must be relabeled; see “Compatibility: The need to replace the external label” on page 89.) These new capabilities are standard on all IBM 3592-J1A Tape Drives, enhancing its ability to meet a wide variety of tape storage needs with a single type of tape drive across a broad range of tape subsystems and servers. With an update to the installed tape drive, controller, or library microcode firmware, installed IBM 3592-J1A Tape Drives can also support these capabilities.

The cartridge contains half-inch tape media with a new dual-coated, advanced-particle media. This is a new media with improved real density capabilities that differs from the tape media in any previously shipped cartridge.

The new IBM 3592 cartridge was designed to have the strength and durability of an enterprise cartridge. Enhanced assembly strengthens the cartridge at critical points and helps make the IBM 3592 cartridge less susceptible to damage (for example, if dropped). The tape is pulled from the cartridge by means of a leader pin rather than a leader block as in the 3590. A sliding door covers the area formerly occupied by the leader block in a 3590 cartridge. A locking mechanism prevents the media from unwinding when the cartridge is not located within a drive. A special mechanical design provision prevents the 3592 cartridge types from being loaded into IBM 3590 or 3490 drives; if inadvertently loaded into a 3590, the cartridge present sensor will not change state and the drive will not attempt to load. If a 3590 cartridge is loaded to an 3592-J1A, the door opening hook on the 3592-J1A Tape Drive will stop the cartridge and prevent full insertion; therefore, it does not attempt to load.

Media types

The 3592 J1A Tape Drive uses four media cartridge types: JA, JJ, JW, and JR. All four cartridge types contain the same dual-coated advanced particle media. The media is housed in a 3592 cartridge shell, which is close to but not identical to current 3590 cartridges in size and shape. The only externally visible difference among the four cartridge types is the color of certain parts of the cartridge. Table 2-5 shows the four media types and characteristics.

Table 2-5 IBM 3592 media types

Type	Media identifier letters	Length	Capacity	Comments	DFSMS media type
ETC	JA	609 m	300 GB	R/W tape	MEDIA5
EETC	JJ	246 m	60 GB	Economy R/W tape	MEDIA7
EWTC	JW	609 m	300 GB	WORM tape	MEDIA6
EEWTC	JR	246 m	60 GB	Economy WORM tape	MEDIA8
ETC - Enterprise tape cartridge EETC - Enterprise economy tape cartridge EWTC - Enterprise WORM tape cartridge EEWTC - Enterprise economy WORM tape cartridge					

Note: There are two additional capacities available optionally with the JA type cartridge when it is ordered as "Labelled and Initialized". The capability exists to prescale the cartridges to 60 GB fast access and 260 GB fast access and capacity. Refer to "Capacity scaling and segmentation" on page 84 for further information.

Figure 2-49 on page 88 shows the four new media types. The WORM cartridges pictured on the left have a platinum color shell and the R/W cartridges on the right have a black shell. The write protect tab, door, and label for the full length cartridges (both WORM and R/W) are dark blue. The write protect tab, door, and label for the Economy (Short Length) cartridges are light blue.

Figure 2-49 IBM T3592 WORM and R/W cartridges

You can order IBM 3592 tape media in three ways:

- Order features from IBM that are available only with the initial hardware order.

  300 GB R/W Data Cartridges only without labeling or initialization.
- Order the IBM 3592 product offering (using the new IBM Model type 3599).
- Contact the IBM MEDIA business supplies or a third-party supplier using the IBM part number descriptions.

Table 2-6, “3599 media” on page 88 lists the 12 models.

Table 2-6 3599 media

Model	Description	Feature code
3599-021	3592 Tape Cartridge (WORM 300 GB) with Labelling and Initialization (20-pack)	FC2120
3599-022	3592 Tape Cartridge (WORM 300 GB) with Volume serial labels only (20-pack)	FC2220
3599-023	3592 Tape Cartridge (WORM 300 GB) without Labelling or Initialization (20-pack)	FC2320
3599-E21	3592 Tape Cartridge (Economy WORM 60 GB) with Labelling and Initialization (20-pack)	FC3120
3599-E22	3592 Tape Cartridge (Economy WORM 60 GB) with Volume serial labels only (20-pack)	FC3220
3599-E23	3592 Tape Cartridge (Economy WORM 60 GB) without Labelling or Initialization (20-pack)	FC3320
3599-011	3592 Tape Cartridge (R/W 300 GB) with Labelling and Initialization and Optional Scaling (see Note 1) (20-pack)	FC1020
3599-012	3592 Tape Cartridge (R/W 300 GB) with Volume serial labels only (20-pack)	FC2020
3599-013	3592 Tape Cartridge (R/W 300 GB) without Labelling or Initialization (20-pack)	FC3020

Model	Description	Feature code
3599-E11	3592 Tape Cartridge (Economy R/W 60 GB) with Labelling and Initialization (20-pack)	FC1120
3599-E12	3592 Tape Cartridge (Economy R/W 60 GB) with Volume serial labels only (20-pack)	FC1220
3599-E13	3592 Tape Cartridge (Economy R/W 60 GB) without Labelling or Initialization (20-pack)	FC320
Note 1: The Model 3599-011 cartridge can be ordered with the following optional features: FC9060 Fast Access: This feature scales a 300 GB data cartridge to 60 GB fast access. FC9062 Fast Access + Capacity: This feature provides for a single partition of 260 GB capacity with the first 60 GB having record access characteristics (equivalent to those of the 60 GB scaled format or the 60 GB Economy cartridge) plus an additional 200 GB of capacity.		

Labels

The new cartridges use a new media label to describe the cartridge type, as shown in Figure 2-50, the “JA” example. In tape libraries, the library vision system identifies the types of cartridges during an inventory operation. The vision system reads a volume serial number (VOLSER), which appears on the label on the edge of the cartridge. The VOLSER contains from one to six characters, which are left-aligned on the label. If fewer than six characters are used, spaces are added. The media type is indicated by the seventh and eighth characters.

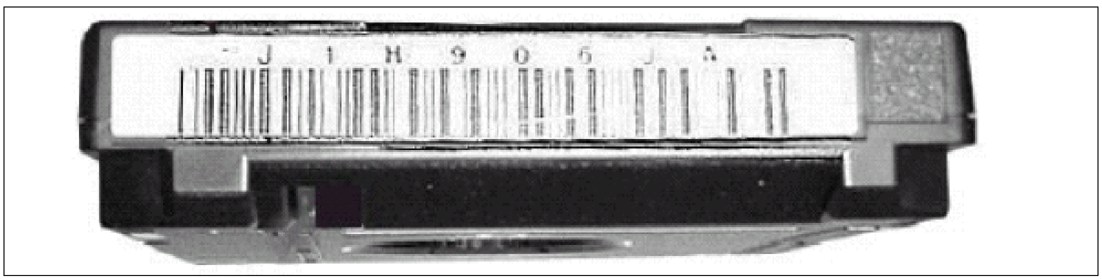


Figure 2-50 View of the IBM 3592 cartridge label

Cleaning cartridges

There is a cleaning cartridge designed specifically for the IBM 3592-J1A Tape Drive. As with the data cartridges, the 3592 cleaning cartridges are not interchangeable with 3590 cleaning cartridges, so you must have both types of cleaning cartridges if you have both types of drives in your environment. The cleaning cartridge also contains a cartridge memory (CM) device, which automatically tracks the number of times it has been used. You must replace cleaning cartridges after 50 uses. The physical characteristics of the 3592 cleaning cartridge distinguish it from the 3592 data cartridges: The product label on the top of the cartridge is white, with the word `cleaning` printed on it. In place of the write-protect switch, there is a non-moveable light gray block. The cartridge door is also light gray. If you order cleaning cartridges with pre-attached labels, the first three characters of the volume serial number (VOLSER) are `CLN`.

Compatibility: The need to replace the external label

An IBM 3592 cartridge cannot be moved into an IBM 3584 from a StorageTek ACS without you relabeling the cartridge. The ACS labels are unreadable in the IBM 3584, because they consist of two labels pasted together.

Also, you cannot move IBM 3592 cartridges into or from a StorageTek ACS or IBM 3494 without changing the exterior labels.

When cartridges labeled with the standard media identification characters (JA, JJ, JR, or JW) or new cartridges are requested for temporary (or permanent) entry in an ACS, you must apply a new VOLSER label.

For IBM 3592 cartridges to be associated with different emulated drive types within an ACS, the standard media identification characters (JA, JJ, JR, or JW) must be replaced as indicated in Table 2-7.

Table 2-7 Media identification characters for 3592 cartridges in ACS

Emulated drive type	Data cartridge media identifier	Cleaner cartridge media identifier
4480	No label	No label
4490	E or no label	E or no label
9490	E or no label	E or no label
SD-3	A, B, or C	D
9840	R	U
9940	P	W

IBM 3592 cartridges without the standard media identification characters (old style 6-character labels) are usable in IBM TotalStorage 3494 Tape Libraries. The VOLSER range table is used by the 3494 to determine the media type.

A seventh media type character on these cartridges will not work for the 3592 cartridge in an IBM TotalStorage 3494 Tape Library, because the only seventh characters recognized by the IBM 3494 are 1, E, J, and K, which equate to 3490 and 3590 media. Any other seventh characters cause the cartridge to be ejected with an invalid media type. To include a media type in the barcode label for the IBM 3592-J1A Tape Drive in an IBM TotalStorage 3494 Tape Library, the media type must be two characters long, integral with the VOLSER barcode, code 3 of 9, and JA, JJ, JR, or JW.

2.6 IBM System Storage TS1120 Tape Drive

Introduced in October 2005, the IBM System Storage TS1120 Tape Drive (Figure 2-51 on page 91) is the second generation of a new family of tape products that are designed to meet the growing needs of both new and existing IBM tape clients across a wide range of environments. The TS1120 Tape Drive is the follow-on to the IBM 3592 Tape Drive Model J1A and the highly successful 3590 Enterprise Tape Drive. The TS1120 Tape Drive can be installed in the IBM System Storage TS3500 or IBM TotalStorage 3584 Tape Library, IBM System Storage 3400 Tape Library, the IBM TotalStorage 3494 Tape Library, and in a StorageTek 9310 Powderhorn. It has 500 GB or 700 GB, when using the extended data cartridge, of native capacity in a half-inch format tape cartridge and has a native data rate of up to 100 MB/s. By its design, it is also the foundation for future generations, and it helps to protect the client investment of tape cartridges.

All TS1120 Tape Drives produced after 8 September 2006 are Tape Encryption capable. All three encryption methods are supported and are available at no charge:

- Application-Managed Encryption
- System-Managed Encryption
- Library-Managed Encryption

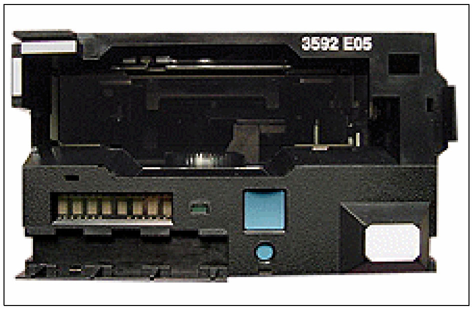


Figure 2-51 IBM System Storage TS1120 Tape Drive

With its higher performance, greater capacity, and smaller size, as compared to a 3590 Tape Drive, the use of the TS1120 Tape Drive can help save costs as you reduce your number of tape drives and cartridges and the associated floor space.

Highlights of the TS1120 Tape Drive are:

- Up to 100 MB/s native data rate, over 2.5 times the 40 MB/s of the 3592 Model J1A, and over seven times the 14 MB/s of the 3590 E or H Models
- Up to 700 GB native cartridge capacity, a 1.6 times increase over the 3592 Model J1A, and a five times increase over the 60 GB for the 3590 H Models
- A larger, 512 MB internal buffer
- Dual-ported switched fabric 4-Gbps Fibre Channel attachments
- Small form factor that allows you to double the drives in a single 3494 frame, as compared to the 3590 Tape Drive
- High reliability and availability design
- Additional performance and access improvements over the 3592-J1A

The TS1120 Tape Drive is supported in a wide range of environments, including selected IBM System i and iSeries, AS/400, System p and pSeries, RS/6000, System x and xSeries, System z, IBM mainframe Linux, Sun, and Hewlett-Packard servers, as well as Intel-compatible servers running Linux, Microsoft Windows 2000 Server, or Windows Server® 2003. Attachment to ESCON or FICON channels on IBM mainframe servers requires a tape controller.

The 3599 media models include:

- R/W 700 GB Data Cartridge
- R/W 500 GB Data Cartridge
- R/W 100 GB Data Cartridge
- WORM 700 GB
- WORM 500 GB
- WORM Economy 100 GB

2.6.1 IBM System Storage TS1120 Tape Drive enhancements

In this section, we summarize the highlights of the TS1120 Tape Drive.

Performance

The IBM TS1120 Tape Drive uses a design that increases the native data rate to 100 MB/s versus the 40 MB/s data rate of the 3592 Tape Drive Model J1A. With compression and a 32 K block size, the TS1120 Tape Drive can offer up to 1.6 times the data rate of the 3592 Model

J1A Tape Drive. The TS1120 Tape Drive is designed to offer improved access characteristics in load/ready time, search velocity, and rewind time versus the 3590. The TS1120 Tape Drive has other enhancements designed to help aid small file and Hierarchical Storage Manager performance.

Capacity scaling

The TS1120 Tape Drive is designed to support capacity scaling of an individual tape cartridge to 100 GB. Capacity scaling allows the utilized length of tape to be logically shortened, allowing improved data access times in a trade-off for reduced capacity. The tapes can subsequently be scaled back to full capacity as needed. Multiple scale settings are supported on the TS1120 Tape Drive, including a 100 GB, 20 percent-scaled JA cartridge.

The TS1120 Tape Drive allows an application to issue a command to scale the IBM TotalStorage Tape Data Cartridge 3592 to 100 GB. Clients can exploit the capacity scaling capability of the TS1120 Tape Drive.

Cartridges pre-scaled for 100 GB capacity are also available for order with the 3599 Models E11, E21, 011, and 021. These pre-scaled cartridges can be ordered (and labeled) for a specific VOLSER range. This allows capacity scaling to be exploited by an application that permits media pools to be defined by the VOLSER range. See also “Capacity scaling and segmentation” on page 84.

Statistical Analysis and Recording System

The TS1120 Tape Drive uses Statistical Analysis and Recording System to assist in isolating failures between media and hardware. It is designed to use the cartridge performance history saved in the cartridge and drive performance history kept in the drive to determine the likely cause of failure. It is designed to cause the drive to mark the media as degraded and to indicate that the hardware has degraded.

High-availability data path failover

High-availability data path failover is available with the AIX, Linux, Solaris, and Windows IBM tape device drivers. The failover mechanism is designed to enable you to configure multiple redundant paths in a SAN environment with the TS1120 Tape Drive. In the event of a path or component failure, the failover mechanism is designed to automatically enable error recovery to retry the current operation using an alternate, preconfigured path without stopping the current job in progress. This supports flexibility in SAN configuration, availability, and management.

Dynamic load balancing

A function in the AIX, Linux, and Solaris IBM tape device drivers, *dynamic load balancing*, is also available for the TS1120 Drives used in a SAN environment. The dynamic load balancing support is designed to improve resources for devices that have physical connections to multiple HBAs in the same machine. When an application opens a device that has multiple HBA paths configured, the device driver determines which path has the HBA with the lowest usage and assigns that path to the application. The device driver is designed to dynamically track the usage on each HBA as applications open and close devices and balance the number of applications using each HBA in the machine. This can help optimize HBA resources, and it improves overall performance.

Channel calibration

The channel calibration feature is designed to allow for customization of each read/write data channel for optimum performance. The customization can enable compensation for variations in the recording channel transfer function, media characteristics, and read/write head characteristics. The TS1120 Tape Drive is designed to automatically perform recalibration in the field if it detects degraded performance.

Digital speed matching

The TS1120 Tape Drive is designed to dynamically perform digital speed matching to adjust the drive's native data rate to the net host data rate (after data compressibility has been factored out). This is designed to help allow slower hosts to stream the tape drive. The TS1120 Tape Drive has six speed matching levels compared to the four offered in the IBM 3592-J1A Tape Drive.

Redundant power

N+1 power supplies offer redundant power. The TS1120 Tape Drive incorporates *n*+1 power supplies when it is installed in an automation frame. This is designed to help increase drive availability in the event of a power supply failure.

Streaming Lossless Data Compression (SLDC) algorithm

SLDC is an implementation of a Lempel-Ziv class 1 (LZ-1) data compression algorithm. It is an extension to Adaptive Lossless Data Compression (ALDC) and is designed to offer an improvement over previous IBM lossless compression algorithms.

2.6.2 IBM System Storage TS1120 Tape Drive attachment

The TS1120 Tape Drive (IBM 3592-E05) has a dual-ported 4 Gbps native switched fabric Fibre Channel interface. This offers attachment flexibility in an Open Systems environment. The drive can be directly attached to Open Systems servers with Fibre Channel, or to ESCON or FICON servers with the 3592 J70 Controller or 3494 Virtual Tape Server Models B10 or B20. The TS1120 Tape Drive is supported in a wide range of environments, including selected IBM mainframe, System i, iSeries, AS/400, System p, pSeries, RS/6000, System x, xSeries, Sun, and Hewlett-Packard servers, as well as Intel-compatible servers running Microsoft Windows and Linux. The TS1120 Tape Drive can also attach to System z and zSeries servers with FCP channels and Linux.

Multiple Fibre Channel ports

The TS1120 Tape Drive has two independent Fibre Channel interfaces, or ports. Both ports run the SCSI protocol with Fibre Channel tape support. Two ports allow concurrent attachment of two independent Fibre Channel configurations to each drive. One or both ports can be attached to a variety of Open Systems servers, switches, hubs, and directors.

The TS1120 Tape Drive supports industry standard shortwave LC-Duplex fiber-optic cables. This allows cable lengths of up to 500 m (1640 ft.) with 50 micron core fiber.

Supported topologies

The TS1120 Tape Drive supports switched fabric and point-to-point loop topologies.

Switched fabric

Two or more Fibre Channel endpoints interconnect through a switch. The Fibre Channel architecture supports up to 256 ports through each switch. Switches include a function called *Zoning*. This function allows the user to partition the switch ports into port groups. It then assigns group access to other groups. This prevents group interferences. Switched fabrics allow all of its ports simultaneous use of the full Fibre Channel architecture bandwidth.

Point-to-point loop

Point-to-point loop is similar to point-to-point topology. Both have two Fibre Channel end points connected together. The difference is in the protocol. Therefore, when only two Fibre Channel endpoints connect together, either protocol is usable. Both endpoints must, however, use the same protocol. The TS1020 Tape Drive supports point-to-point loop. SAN Data Gateway will utilize either protocol. Most Fibre Channel adapters default to the loop protocol when not directly connected to a fabric.

Address assignments

The TS1120 Tape Drive must have a Fibre Channel address to communicate over the Fibre Channel interface. The TS1120 Tape Drive allows both hard and soft addressing. Most Fibre Channel hosts (initiators) support hard addressing and do not support soft addressing. See your device driver documentation for more information. Selecting the hard addressing option enables you to also select the drive's arbitrated loop physical address (AL_PA), the higher the number, the lower the priority. Most hosts will attempt the lowest AL_PA number (highest priority).

The drive must have a higher AL_PA (lower priority). Multiple drives connected in an arbitrated loop require the drive closest to the host to have a lower AL_PA number (higher priority) than the next drive. Follow this protocol throughout the loop. The soft address feature allows the drive to arbitrate the AL_PA number with other Fibre Channel devices. When sharing a drive between different systems, take caution to keep both hosts from attempting to use the drive at the same time.

Fibre Channel Worldwide ID

Each Fibre Channel card on the TS1120 Tape Drive has four names (Node 0, Node 1, Port 0, and Port 1) that are hard-coded into the electronics of the card by IBM manufacturing. These names are similar to a serial number and are unique throughout the world.

2.6.3 Media supplies

For clients who order media using the 3599 Tape Media method, IBM TotalStorage Enterprise Tape Media 3599 provides the ability to order unlabeled, pre-labeled, initialized, and bulk-packaged tape data cartridges in a wide variety of combinations and cleaning cartridges for the TS1120 Tape Drive.

In addition to the 300 GB, 500 GB, and 700 GB Data type cartridges, three more cartridge types are available: 60 GB (E1 format)/100 GB (E2 format) Economy cartridges, 60 GB (E1)/100 GB (E2) WORM cartridges, and 300 GB (E1)/500 GB (E2) WORM cartridges.

Segmentation and capacity scaling options are also available on the 300 GB Data cartridge for a 60 GB Fast Access capability or as a 260 GB segmented tape with 60 GB of fast access and 200 GB of additional capacity.

The 3599 Tape Media method of ordering uses model numbers to identify the cartridge types, and feature code combinations are used to specify the quantities, labeling, and initialization options.

For a complete list of all orderable media supplies, see Appendix A, "IBM LTO Ultrium and 3592 media" on page 393.

2.6.4 IBM 3592 WORM

The IBM TotalStorage WORM data cartridges are designed to provide non-alterable, non-rewritable tape media for long-term records retention. WORM characteristics include:

- WORM cartridges are available in four sizes: 60 GB, 300 GB, and 500 and 700 GB native capacity.
- WORM and standard tape cartridges can be intermixed within the same IBM TotalStorage 3494 Tape Library, IBM System Storage TS3500 Tape Library, or StorageTek Automated Cartridge System (ACS) solutions.
- When the drive senses that a cartridge is a WORM cartridge, the microcode prohibits changing or altering user data already written on the tape. The microcode keeps track of the last appendable point on the tape by means of an overwrite-protection pointer stored in the CM.
- Each WORM cartridge is identified using a Unique Cartridge Identifier (UCID).
- Non-reversible screws are used to secure the media housing.
- In general, overwrites are prevented, with exceptions; see “Drive operation to prevent overwrite.”

Basic WORM

The WORM microcode enables a standard IBM 3592-J1A Tape drive or TS120 Tape Drive to support both the standard 3592 R/W cartridges and IBM 3592 WORM cartridges. The WORM cartridge is geometrically identical to a R/W cartridge and uses the same rewritable media formulation. However, the servo format mastered onto the tape at manufacturing is different for WORM cartridge types. The WORM aspect comes not from any inherent irreversible media characteristic (such as permanent WORM on optical media: CD-R or ablative optical WORM), but rather by the way the WORM microcode handles a WORM cartridge. The WORM microcode will not allow overwrite or erase previously written client data, such as records or filemarks (except for certain agreed-upon cases detailed in “Drive operation to prevent overwrite”).

Unique cartridge identifier

Each IBM 3592 WORM cartridge is identifiable via a unique cartridge identifier (UCID). The intent of the UCID is that it is constructed in a way to guarantee that it is unique, worldwide. This identifier is derived from a concatenation of the 4 byte unique CM serial number of the CM chip in the 3592 WORM cartridge and the 8 byte unique tape serial number created from information mastered into the timing-based servo (TBS) at the time of cartridge manufacture. The parts of UCID that come from this serial number are written to a locked part of the CM. This additional level of security supports legal audit requirements. Furthermore, the UCID enables unique tracking of cartridges and can be the differentiating factor to other WORM tape providers.

Drive operation to prevent overwrite

A WORM compatible drive handles a WORM cartridge differently than R/W cartridges. In general, it responds to a subset of the SCSI commands that work on a R/W cartridge. For example, an erase command is rejected with the appropriate error posted. Additionally, it rejects certain command sequences of otherwise valid commands. For example, if a cartridge is not empty, a rewind followed by a write command is rejected with the appropriate error posted. In general, the drive prevents overwrite. There are, however, exceptions to this that the drive has to support to be flexible and “application software transparent.” Specifically, the drive has to support some overwrite cases.

WORM permits overwrite for the following scenarios:

- Allows extending files.
- Allows appending files.
- Allows relabeling a new scratch tape; overwrite VOL1 record if no subsequent records on tape.
- Relies on known header/trailer constructs.
- SARS data can be written and updated on WORM tapes, because the SARS data is not in the user area of the tape.

Final destruction of WORM cartridges

A standard WORM cartridge (types JW and JR) cannot be reused after data has been written to it, so when it is no longer of use, you must destroy it. If the WORM cartridge has sensitive data, it must be bulk-erased (which erases everything on the tape including the mastered servo pattern, rendering it useless), before it is sent to the landfill or incinerator.

Part 2

IBM Open System Tape Libraries

In this part, we introduce the current IBM tape library models for installation of LTO tape drives.

3

IBM System Storage TS2230 Tape Drive

The IBM System Storage TS2230 Tape Drive (3580 Models H3L and H3S) is an external stand-alone or rack-mountable unit and is the entry point to the family of IBM Linear Tape-Open (LTO) Ultrium Tape products. The IBM System Storage TS2230 Tape Drive is designed for backup and restore of midrange Open Systems applications. The IBM System Storage TS2230 Tape Drive incorporates the IBM System Storage Ultrium 3 Half-High T880V Tape Drive, which has a native physical capacity of 400 GB or 800 GB with 2:1 compression.

Additional important features of the TS2230 include:

- The TS2230 is the first member of the IBM LTO Tape Family that uses the new Half-High LTO3 Tape Drive. It has the same characteristics of the Full-High tape drive except the native transfer rate which is 60 MB/s compared to 80 MB/s for the Full-High LTO3 drive.
- The IBM System Storage TS2230 Model H3L Tape Drive is available with a Low Voltage Differential (LVD) Small Computer System Interface (SCSI). The IBM System Storage TS2230 Model H3S Tape Drive comes with a Serial-Attached SCSI (SAS) interface.
- It can be installed in an industry standard 19 inch rack using an optional rack mount kit.
- On the front side of the IBM System Storage TS2230 are four Light Emitting Diodes (LED)s indicating the status and errors for the tape drive.
- In addition to the LTO data cartridges, Write Once Read Many (WORM) cartridges are supported and recognized when loaded.
- The TS2230 is a customer-replaceable unit (CRU). In the case that the IBM System Storage TS2230 Tape drive has a failure, IBM provides you with a replacement. Products that are repaired by replacing them are called *CRUs*.

3.1 TS2230 description

The TS2230 can be attached to IBM System i, IBM System p, IBM System x, Microsoft Windows, Hewlett-Packard (HP) UNIX® (HP-UX), Sun Solaris, UNIX, Linux, and PC servers. To determine the latest update of supported servers, visit the Web at:

http://www-03.ibm.com/servers/storage/tape/compatibility/pdf/

> **Note:** For the remainder of this chapter, we will use the term TS2230 as an abbreviation for the IBM System Storage TS2230 Tape Drive.

Two models are available for the TS2230 Tape Drive:

- The *TS2230 Tape Drive Model H3L* has a SCSI Ultra160 LVD physical interface, which has a native data transfer rate of up to 60 MB/s. The physical interface is a high-density, 68-pin, D-shell receptacle connector (HD68).
- The *TS2230 Model Tape Drive H3S* has a SAS interface, which has a native data transfer rate of up to 3 Gbs. The TS2230 SAS Tape Drive has an SFF-8088 interface.

The TS2230 uses the IBM TotalStorage LTO Ultrium 3 400 GB Data Cartridge and can write up to 400 GB or 800 GB using a compression ratio of 2:1. The TS2230 can read and write Ultrium 3 and Ultrium 2 cartridges and can read Ultrium 1 cartridges.

Figure 3-1 shows the front view of the TS2230.

Figure 3-1 Front view of the TS2230

3.2 Highlights of the Half-High Ultrium 3 Tape Drive

In this section, we describe some of the highlights of the Half-High Ultrium 3 Tape Drive. The TS2230 came available at the end of 2006 and might be an ideal tape drive for small clients who want to have a reliable tape drive with LTO technology.

3.2.1 Servo and track layout technology

There are 704 data tracks used to read and write data to the data cartridge. These tracks are grouped in five servo bands as explained in “Servo tracks” on page 33. The high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

3.2.2 Magneto resistive head design

Magneto resistive (MR) head design using flat lap head technology in MR heads for Ultrium 3 helps minimize contact, debris accumulation, and wear on the tape as it moves over the read/write heads.

3.2.3 Surface Control Guiding Mechanism

The IBM patented Surface Control Guiding Mechanism is designed to guide the tape along the tape path in the TS2230 Tape Drive. This method uses the surface of the tape, rather than the edges, to control tape motion. This helps reduce tape damage (especially to the edges of the tape) and tape debris, which comes from the damaged edges and can accumulate in the head area.

3.2.4 Dynamic speed matching

The Ultrium 3 Half-High Tape Drive is designed to perform *dynamic speed matching* (at one of four speeds of 30, 40, 50, or 60 MB/s) to adjust the tape drive's native data rate as closely as possible to the net host data rate (after data compressibility has been factored out). This helps the number of backhitch repositions and improves throughput performance. Back hitching is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is usually the result of a mismatch between the data rates of the connected server and the tape drive.

3.2.5 Power management

The Ultrium 3 Half-High Tape Drive power management function is designed to control the drive electronics to be either completely turned off or stay in a low-power mode when the circuit functions are not needed for drive operations.

3.2.6 Statistical Analysis and Reporting System (SARS)

The Ultrium 3 Half-High Tape Drive uses SARS to help isolate failures between media and hardware. The SARS uses the data cartridge performance history saved in the Cartridge Memory (CM) module and the drive performance history kept in the drive flash Electronically Erasable Programmable Read-Only Memory (EEPROM) to help determine the likely cause of the failure. SARS can cause the drive to request a cleaning tape, to mark the media as degraded, and to indicate that the hardware has degraded. When a drive dump is taken from the drive, the Support Center can determine if the failure is in the Tape Drive itself or on the Data Cartridge.

3.3 LTO3 Data Cartridges

When processing the Ultrium 3 tape cartridge, the Ultrium 3 Tape Drive uses a linear, serpentine recording format. The Ultrium 3 drive reads and writes data on 704 tracks, sixteen tracks at a time. The first set of tracks is written from near the beginning of the tape to near the end of the tape. The head then repositions to the next set of tracks for the return pass. This process continues until all tracks are written and the cartridge is full, or until all data is written.

To ensure that your IBM Ultrium Tape Drive conforms to the IBM specifications for reliability, use only IBM LTO Ultrium tape cartridges. The IBM TotalStorage LTO Ultrium 400 GB Data Cartridge cannot be interchanged with the media used in other IBM non-LTO Ultrium tape products.

You can identify the various generations of IBM TotalStorage Ultrium data cartridges by their color. See Table 3-1.

Table 3-1 Data Cartridge identification by case and color

Data Cartridges	Case color
Ultrium 3 WORM	Slate blue top, platinum (silver gray bottom)
Ultrium 3	Slate Blue
Ultrium 2	Purple
Ultrium 1	Black

All three generations contain 1/2 inch, dual-coated, metal-particle tape. The native data capacity of Ultrium Data Cartridges is listed in Table 3-2.

Table 3-2 Native capacity

Data Cartridge	Native data capacity
Ultrium Worm	400 GB (800 GB at 2:1 compression)
Ultrium 3	400 GB (800 GB at 2:1 compression)
Ultrium 2	200 GB (400 GB at 2:1 compression)
Ultrium 1	100 GB (200 GB at 2:1 compression)

3.3.1 Cartridge compatibility

Table 3-3 shows the compatibility among the three types of Ultrium cartridges.

Table 3-3 Ultrium Data Cartridge compatibility with Ultrium 3 tape drive

	IBM Total Storage LTO Ultrium Data Cartridges		
IBM Ultrium Tape Drive	400 GB (Ultrium 3) 400 GB WORM	200 GB (Ultrium 2)	100 GB (Ultrium 1)
Ultrium 3	Read/Write	Read/Write	Read only

3.3.2 Cleaning cartridge

A specially labeled IBM LTO Ultrium Cleaning Cartridge cleans the drive in your library. One cleaning cartridge is included within the shipping package of the TS2230.

You must clean the drive head whenever the Clean LED is ON. We do not recommend that you clean the drive head on a periodic basis; only when the drive requests to be cleaned. The drive performs the cleaning automatically in less than two minutes, then ejects the cartridge.

The drive will automatically eject an expired cleaning cartridge. The IBM TotalStorage LTO Ultrium Cleaning Cartridge is valid for 50 uses and the Cartridge Memory (CM) chip will track the numbers of the cleaning cycles of the cleaning cartridge.

3.3.3 Cartridge Memory chip (LTO-CM)

All generations of the IBM LTO Ultrium Data Cartridges include a Linear Tape-Open Cartridge Memory (LTO-CM) chip that contains information about the cartridge and the tape (such as the name of the manufacturer that created the tape), as well as statistical information about the cartridge's use.

The LTO-CM enhances the efficiency of the cartridge. For example, the LTO-CM stores the end-of-data location, which the next time this cartridge is inserted and the Write command is issued enables the drive to quickly locate the next available recording area and begin recording.

The LTO-CM also helps determine the reliability of the cartridge by storing data about its age, how many times it has been loaded, and how many errors it has accumulated. Whenever a tape cartridge is unloaded, the tape drive writes any pertinent information to the cartridge memory. The storage capacity of the LTO-CM is 4096 bytes.

3.4 TS2230 setup

The following sections provide an introduction to the necessary steps to implement and operate the TS2230. We describe a practical example of how to install your TS2230 and give you background information about the steps you perform. For a more detailed description, refer to the *IBM System Storage TS2230 Tape Drive Setup, Operator and Service Guide,* GC27-2099.

After unpacking and installing the TS2230, a few steps need to be done to connect it to your server. First, we will show you how to attach your TS2230, which host bus adapters (HBAs) are supported, where you can find your device drivers, and how to install the latest firmware on your TS2230. We start with the physical attachment.

3.4.1 Physical attachment

The TS2230 is available with a SCSI Ultra Fast/Wide 160 LVD interface or with a SAS interface.

Serial Attached SCSI (SAS)

The SAS interface is new in the IBM Ultrium Tape Drive family and the TS2230 comes with two SFF-8088 interfaces on the back of the drive. For a more detailed description of SAS, see "Serial-Attached SCSI" on page 53.

At the time of writing this book, two HBAs are supported:

- LSI Logic SAS3800X
- IBM SAS HBA Controller model 25R8060

The physical interface on the TS2230 is a dual-port SFF-8088, and only a point-to-point connection to the server's HBA is supported. There is no support (yet) for connecting to Expander Boxes. No terminator is needed, because the SCSI bus is automatically terminated. The SAS TS2340 has two SFF-8088 ports so the TS2340 can be connected to two different servers.

SCSI Interface

An LVD SCSI bus supports a length of 25 meters (82 ft.) point-to-point and 12 meters (39 ft.) using multi-drop interconnection (*daisy-chaining*). For each daisy-chained device, the maximum cable length must be reduced by 0.5 meters (1.6 ft.).

The Ultrium 3 drive uses shielded, HD68, 68-pin connectors and can attach directly to a 2-byte-wide SCSI cable.

The Ultrium 3 LTO drive provides a sustained native data transfer of 60 MB/s and can store up to 400 GB of uncompressed information on a single data cartridge.

Note: A faster bus does not imply that an attached device will support that data rate, but that multiple devices can operate on the bus at the maximum speed. To ensure the best performance, if possible, avoid daisy-chaining.

To connect your TS2230 to your server, make sure that the installed SCSI HBA is supported. To find out if your HBA is supported, visit this Web site and select the TS2230:

`http://www-03.ibm.com/servers/storage/tape/resource-library.html#interoperability`

If the HBA is supported, you can connect your TS2230 to the HBA of the server. Figure 3-2 shows you the interoperability of all IBM tape drives and tape libraries.

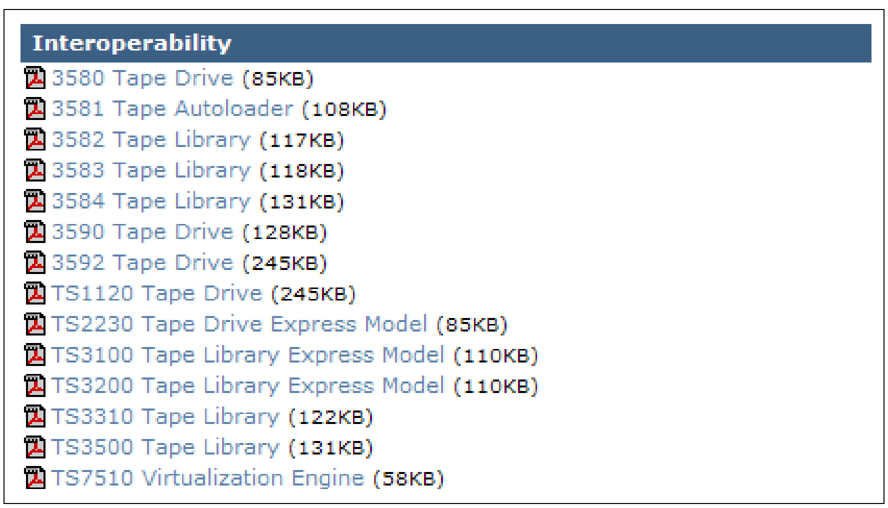


Figure 3-2 Interoperability window

By selecting the TS2230 Tape Drive Express Model, a document opens. Within this document, search for `Operating System` and a list of all supported SCSI LVD HBAs appears. *Note that whenever a SCSI LVD HBA is used to connect the TS2230 to a host that is not in the list, no support can be given in case of a problem.* This operability list contains all HBAs that are tested in our test center in Tucson.

Note: SCSI adapters, which are part of the server's system board, are not supported.

When connecting the TS2230 to the HBA of the server, make sure that the TS2230 has a unique SCSI ID on the SCSI bus. The SCSI ID switch is located on the rear side of the TS2230. Use a small object to change the switch. The range of SCSI IDs is 0 through 15. Generally, the SCSI ID for the HBA is set to 7. Figure 3-3 on page 105 shows the rear view of the TS2230.

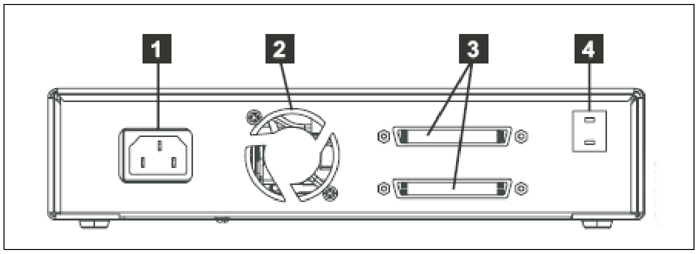


Figure 3-3 Rear view of the TS2230

The numbers in Figure 3-3 represent:

1. Power connector
2. Air vents for fan
3. SCSI connector
4. SCSI ID switch

The IBM TS2230 can be attached as the only the tape drive on the HBA or can be daisy-chained with other SCSI LVD devices. We recommend that you do not use daisy-chaining because of performance reasons and also because the total length of the SCSI cable is limited to 12 m (39 ft.), instead of 25 m (82 ft.) when using a point-to-point connection. The more devices you connect to the HBA, the smaller the actual bandwidth is for each connected device.

An LVD SCSI terminator must be installed on the last device of the SCSI bus. The LVD terminator is delivered with the TS2230.

Do not mix Low Voltage Differential (LVD) and High Voltage Differential (HVD) SCSI host adapters, tape drives, or terminators on the same bus, because they can become damaged.

Figure 3-4 shows a point-to-point configuration.

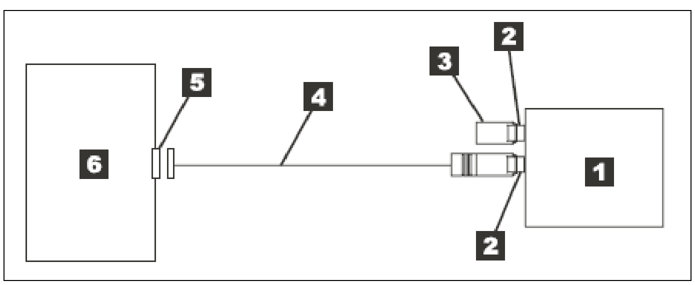


Figure 3-4 TS2230 in a point-to-point configuration

The numbers in Figure 3-4 represent:

1. TS2230
2. SCSI connectors
3. SCSI LVD terminator
4. SCSI cable
5. SCSI HBA
6. Server

Figure 3-5 on page 106 shows a daisy-chained configuration with two TS2230 drives.

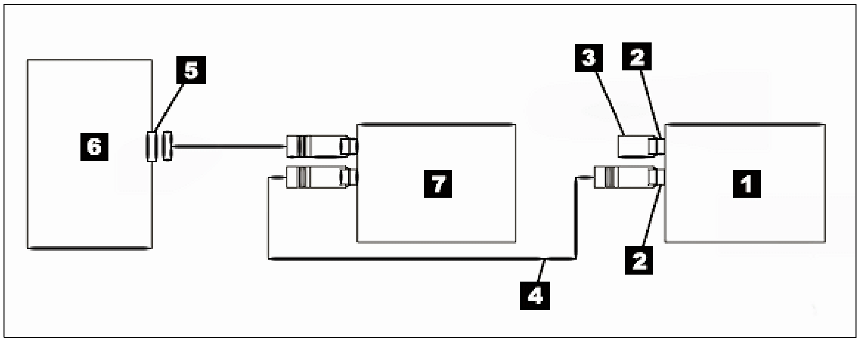


Figure 3-5 A daisy-chained configuration with two TS2230s

The numbers in Figure 3-5 represent:

1. TS2230
2. SCSI connectors
3. SCSI LVD terminator
4. SCSI cable
5. SCSI HBA
6. Server
7. TS2230

In this example, we used two TS2230s, but it can be any other LVD tape drive. The last TS2230 must have a SCSI LVD terminator installed. Otherwise, the SCSI bus is open, which can result in unpredictable errors.

For maximum performance, the quantity of tape drives that can be attached to one SCSI bus is limited. It is based on the type of bus that you have and the amount of data compression achieved. Ultra SCSI buses have a bandwidth of 40 MB per second; Ultra2 SCSI buses have a bandwidth of 80 MB per second; Ultra160 SCSI buses have a bandwidth of 160 MB per second. The tape drive is capable of data transfer rates of up to 60 MB per second with no compression. For maximum performance, we recommend that you attach only one tape drive to an Ultra SCSI bus, an Ultra2 SCSI bus, or an Ultra160 SCSI bus.

Data transfer protocol time-outs for tape and disk drives are dissimilar. For that reason, we strongly recommend that you avoid running tape and disk drives on the same host bus adapter. A configuration with tape and disk on a single host bus adapter gives a slow and unreliable performance.

Note: Do not intermix LVD and HVD devices and HBAs on the same SCSI bus, because damage can occur on the devices.

3.4.2 Installing the SCSI device drivers

The next step is to install the device driver. For information about how to install the device driver on various platforms, refer to:

- *Implementing IBM TAPE in Unix Systems,* SG24-6502
- *Implementing IBM Tape in Linux and Windows,* SG24-6268
- *IBM Ultrium Device Drivers Installation and User's Guide,* GA32-0430

All publications are available and can be downloaded from the Web.

3.5 Firmware

At installation time, verify that the most current firmware is installed. Because the TS2230 does not have a display to show the firmware level, we recommend that you use an IBM tool called the IBM Total Storage Diagnostic Tool (ITDT). ITDT scans the SCSI bus for any attached tape drive and will reflect the firmware of the tape drive.

This tool can also be used for testing the drive and collecting a drive dump for error analyses by the IBM Support Centers. The big advantage of using ITDT is that it is device driver independent. Whatever device driver is installed (IBM or non-IBM device drivers), the TS2230 can be tested, the firmware can be updated, or a drive dump can be made.

At the time of writing, ITDT is supported for the following operating systems:

- Microsoft Windows 2000 Server with SP4 (32-bit IX86)
- Microsoft Windows Server 2003 (32-bit IX86)
- AIX 5L™ 5.2 and 5.3 (64-bit System p)
- Linux systems with Kernel 2.4 and 2.6, glibc 2.2.5 and later (32-bit IX86)
- Linux systems with Kernel 2.4 and 2.6, glibc 2.2.5 and later (64-bit System p)
- i5/OS 5.3 (System i)
- Solaris Version 9 and 10 (64-bit SPARC) and HP-UX Version 11.*xx* (PA-RISC and Itanium®)

ITDT can be downloaded from this Web site:

`ftp://index.storsys.ibm.com/358x/tools/`

In the readme file, you will find installation instructions, as well instructions how to use ITDT.

The latest firmware of the TS2230 can be found on the following Web site:

`http://www-03.ibm.com/servers/storage/tape/lto/`

Another possibility to download the latest firmware is from this FTP Web site:

`ftp://index.storsys.ibm.com/358x/3580`

3.6 Physical specifications

The TS2230 is small-sized with the following specifications:

Width	25 cm (9.85 in.)
Depth	27.5 cm (10.8 in.)
Height	6 cm (2.36 in.)
Maximum weight	4.08 kg (9.03 lbs)

3.7 Feature codes

Table 3-4 on page 108 shows all feature codes and part numbers for the TS2230.

Table 3-4 Feature codes and part numbers for the TS2230

IBM Service part number	Client feature code	High volume part number	Product description
N/A	5402	N/A	2 m SAS/Mini-SAS Cable (from HBA with SFF-8470 to drive with SFF-8088)
N/A	5406	N/A	5.5 m SAS/Mini-SAS Cable (from HBA with SFF-8470 to drive with SFF-8088)
N/A	5502	N/A	2 m Mini-SAS/ Mini-SAS Cable (from HBA with SFF-8088 to drive with SFF-8088)
N/A	5506	N/A	5.5 m Mini-SAS/ Mini-SAS Cable (from HBA with SFF-8088 to drive with SFF-8088)
23R3841	5602	23R7133	VHDCI/HD 68 SCSI cable, 2.5 m (8.2 ft.)
23R3594	5604	23R7134	VHDCI/HD 68 SCSI cable, 4.5 m (14.8 ft.)
23R3593	5610	23R7135	VHDCI/HD 68 SCSI cable, 10 m (32 ft.)
35L1782	N/A	N/A	SCSI Y-cable
23R5841	N/A	N/A	SCSI LVD terminator
23R5840	N/A	N/A	SCSI LVD wrap plug
N/A	7003	96P1565	19 inch rack mount kit

Note: High Volume part numbers can be ordered using the High Volume Channel ordering system.

4

IBM System Storage TS2340 Tape Drive

The IBM System Storage TS2340 Tape Drive (3580 Model X43) is an external stand-alone or rack-mountable (optional) unit and is the entry point for the family of IBM Ultrium Tape products. The TS2340 Tape Drive is designed for backup and restore by midrange Open Systems applications. The TS2340 Tape Drive incorporates the Linear Tape-Open (LTO) IBM System Storage Ultrium 4 Full-High Tape Drive, which writes cartridges with a native physical capacity of 800 GB.

With an optional rack mount kit, the TS2340 can be installed in an industry standard 19 inch rack.

The TS2340 Tape Drive is available in two models determined by the attachment interfaces. The TS2340 Tape Drive Model L43 uses a Small Computer Systems Interface (SCSI) Ultra160 Low Voltage Differential (LVD) attachment, and Model S43 uses a 3 Gbps Serial-Attached SCSI (SAS) interface for connecting to the Open Systems servers. The TS2340 Model S43 has two SFF-8088 interfaces for connecting to Open Systems servers.

Write Once Read Many (WORM) cartridges are supported and recognized when loaded.

The TS2340 Tape Drive Model S43 is encryption-capable and supports Application-Managed Encryption (AME). The TS2340 Tape Drive is using the T10 encryption method. Encryption is only supported with the LTO Ultrium 4 Data Cartridge.

The TS2340 is customer-replaceable unit (CRU). In case the TS2340 has a failure, IBM provides you a replacement.

For error codes and messages, there is a Single Character Display (SCD) at the front of the TS2340 Tape Drive.

4.1 TS2340 description

The TS2340 Tape Drive can be attached to IBM System i, IBM System p, IBM System x, Microsoft Windows, Hewlett-Packard (HP) UNIX (HP-UX), Sun Solaris, UNIX, Linux, and PC servers. To determine the latest supported servers, visit the Web at:

http://www-03.ibm.com/servers/storage/tape/compatibility/pdf/

Two models are available for the TS2340 Tape Drive:

- The *TS2340 Tape Drive Model L43* has a SCSI Ultra160 LVD physical interface, which has a native data transfer rate of up to 120 Mb/s. The physical interface is a high-density, 68-pin, D-shell receptacle connector (HD68).
- The *TS2340 Model Tape Drive S43* has a SAS interface, which has a native data transfer rate of up to 3 Gbs. The TS2340 SAS Tape Drive has a dual-port SFF-8088 interface.

The TS2340 Tape Drive uses the IBM TotalStorage LTO Ultrium 4 800 GB Data Cartridge and can write up to 800 GB or 1600 GB using a compression ratio of 2:1. The TS2340 Tape Drive can read and write Ultrium 4 cartridges, read and write Ultrium 3 cartridges, and can read Ultrium 2 cartridges. Ultrium 1 cartridges cannot be used in the TS2340 Tape Drive. For Tape Encryption, only the LTO Ultrium 4 Data Cartridge is supported.

Figure 4-1 shows the front view of the TS2340 Tape Drive.

Figure 4-1 TS2340

For the remainder of this chapter, we will use the term TS2340 as a abbreviation for IBM System Storage TS2340 Tape Drive.

4.2 Physical attachment

We will give a short overview and the specifications for the physical attachment interfaces:

- SCSI Ultra160 LVD
- The newly announced SAS 3 Gbps

4.2.1 SCSI interface

To communicate with a server, the TS2340 Tape Drive uses an Ultra160 LVD SCSI interface. The SCSI interface has a native data transfer rate of up to 120 Mb/s.

IBM LVD tape devices support a bus length of 25 meters (82 ft.) point-to-point and 12 meters (39 ft.) using multi-drop interconnection (daisy-chaining). For each daisy-chained device, the maximum cable length must be reduced by 0.5 meters (1.6 ft.).

The TS2340 Ultra160 LVD Tape Drive drive uses shielded, HD68, 68-pin connectors and can attach directly to a 2-byte-wide SCSI cable.

The TS2340 Tape Drive provides a sustained native data transfer of 120 MB/s and can store up to 800 GB of uncompressed information on a single data cartridge.

Note: A faster bus does not imply that an attached device will support that data rate, but that multiple devices can operate on the bus at the maximum speed. To ensure best performance, if possible, avoid daisy-chaining.

4.2.2 Serial Attached SCSI (SAS)

The SAS interface is new in the IBM Ultrium Tape Drives family and the TS2340 comes with two SFF-8088 interfaces on the back of the drive. For a more detailed description of SAS, see "Serial-Attached SCSI" on page 53.

At the time of writing, two HBAs were supported:

- LSI Logic SAS3800X
- IBM SAS HBA Controller model 25R8060

The physical interface on the TS2340 is a dual-port SFF-8088, and only a point-to-point connection to the server's HBA is supported. There is no support (yet) for connecting to Expander Boxes. No terminator is needed, because the SCSI bus is automatically terminated. The SAS TS2340 has two SFF-8088 ports so the TS2340 can be connected to two different servers.

Figure 4-2 shows the back side of the TS2340 with two SFF-8088 interfaces.

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Figure 4-2 Back side of the TS2340

4.3 LTO data cartridges

The Ultrium 4 Data Cartridge has a native capacity of 800 GB and uses a linear, serpentine recording format. The TS2340 Tape Drive reads and writes data on 896 tracks, sixteen tracks at a time. The Cartridge Memory (CM) of the data cartridges has been doubled in comparison with the Ultrium 3 cartridge. The storage capacity of the Ultrium 4 data cartridge CM is 8160 bytes. LTO Generations 1, 2, and 3 have an LTO-CM of 4096 bytes.

The outside of the Ultrium 4 cartridges is green, and the cartridge has a nominal life of 20000 load and unload cycles.

In Table 4-1, we show you the compatibility of the Ultrium 4 Data Cartridge and the generations. Ultrium 1 Data Cartridges are not supported.

Table 4-1 Ultrium compatibility among the generations

IBM Ultrium Tape Drive	**IBM TotalStorage LTO Ultrium Data Cartridge**			
	800 GB (Ultrium 4)	400 GB (ultrium 3)	200 GB (Ultrium 2)	100 GB (Ultrium 1)
Ultrium 4	Read/Write	Read/Write	Read only	N/A
Ultrium 3	N/A	Read/Write	Read/Write	Read only
Ultrium 2	N/A	N/A	Read/Write	Read/Write
Ultrium 1	N/A	N/A	N/A	Read/Write

The generations of IBM TotalStorage data cartridges can be identified by color:

- The Ultrium 4 Data Cartridge is green.
- The Ultrium 3 Data Cartridge is slate blue.
- The Ultrium 2 Data Cartridge is purple.
- The Ultrium 1 data Cartridge is black.

4.4 Highlights of the TS1040 Tape Drive

The IBM System Storage TS2340 Tape Drive uses the IBM System Storage TS1040 LTO Ultrium 4 Tape Drive. For the remainder of this chapter, we will use the term LTO as a generic term for different generations of the LTO Ultrium tape drives. As the specific reference to the IBM System Storage TS1040 LTO Ultrium 4 Tape Drive, we use the term LTO4.

4.4.1 Speed matching

To improve the performance of the LTO4 Tape Drive, the tape drive uses a technique called *speed matching* to dynamically adjust its native (uncompressed) data rate to the slower rate of the server's host bus adapter (HBA). The LTO4 Tape Drive is negotiating with the server's HBA, setting up a speed with the best performance. Six speeds are available when reading or writing the generation 3 or generation 4 cartridge format. Native rates are as follows:

- Generation 3: 30, 40, 50, 60, 70, or 80 MB/s
- Generation 4: 30, 48, 66, 84, 103, or 120 MB/s

If the server is between two of the native rates, the drive calculates the appropriate data rate at which to operate. Speed matching reduces back hitching. Back hitching is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is usually the result of a mismatch between the data rates of the connected server and the tape drive.

4.4.2 Channel calibration

The performance of the LTO4 tape drive is further optimized by a feature called *channel calibration.* Channel calibration is the process in which the drive automatically customizes each Read/Write data channel to compensate for variations in the recording channel's transfer function, the media, and the characteristics of the drive head.

4.4.3 Sleep mode

To save energy, the LTO4 tape drives use a feature called *sleep mode*. To enter sleep mode, the LTO4 tape drive must be inactive for a minimum of 30 seconds. The LTO4 tape drive will go out of this sleeping mode again after receiving a SCSI command, a command across the Library/Drive interface (LDI or RS-422), or on a load or unload request. When in sleep mode, the drive response time to commands that do not require media motion increases by up to ten microseconds. Commands that require media motion might be delayed an additional 100 milliseconds, because the tape must be retensioned.

4.4.4 Data Encryption

When the IBM System Storage TS2340 is ordered with the SAS interface, then the LTO4 tape drive is capable of supporting AME. At the time of writing this chapter, the only application that supports AME is Tivoli Storage Manager. Tivoli Storage Manager provides the key for the encryption, the data is encrypted and transferred to the LTO4 tape drive. Encryption is only supported for LTO4 data cartridges.

4.5 IBM System Storage TS2340 setup

The following steps provide an introduction to the necessary steps to implement and operate the IBM TS2340 tape drive. For a more detailed description, refer to the *IBM System Storage Tape Drive Setup, Operator and Service Guide,* GC27-2103.

After unpacking and installing the TS2340, you need to perform a few steps to connect it to the host.

First, we set up a TS2340 with a SCSI interface, and then we show you which steps to do when setting up the TS2340 with a SAS interface.

4.5.1 SCSI interface

To connect your TS2340 to your server, make sure that the installed SCSI HBA is supported. To find out if your HBA is supported, visit this Web site and and select the TS2340:

http://www-03.ibm.com/servers/storage/tape/resource-library.html#interoperability

If the HBA is supported, you can connect your TS2340 to the HBA of the server.

> **Note:** SCSI adapters, which are part of the server's system board, are not supported.

When connecting the TS2340 to the HBA of the server, make sure that the TS2340 has a unique SCSI ID on the SCSI bus. There is a SCSI ID switch located on the rear side of the TS2340. Use a small object to change the switch. The range of SCSI IDs is 0 through 15. Generally, the SCSI ID for the HBA is set to 7. See Figure 4-3 on page 114.

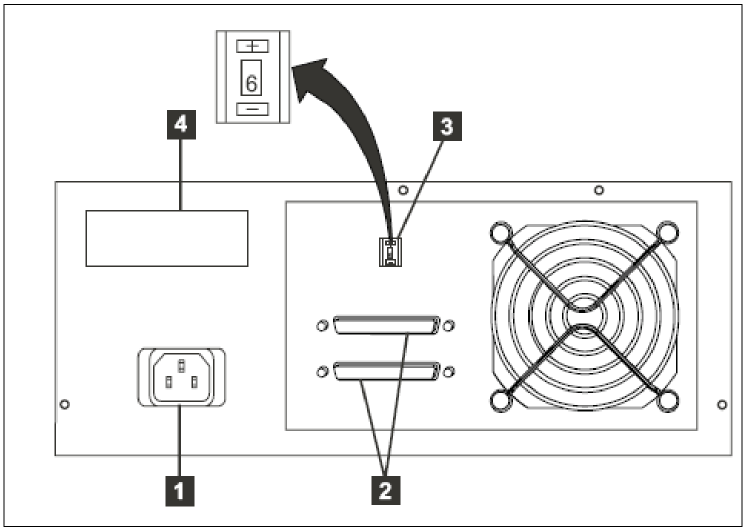

Figure 4-3 The rear view of the TS2340

The numbers in Figure 4-3 represent:

1. Power receptacle
2. SCSI connectors
3. SCSI address switch
4. Serial number label

The IBM TS2340 can be attached as the only tape drive on the HBA or can be daisy-chained with other SCSI LVD devices. We recommend that you do not use daisy-chaining because of performance reasons, and also the total length of the SCSI cable is limited to 12 m (39 ft.) instead of 25 m (82 ft.) when using a point-to-point connection. If you connect more devices to the HBA, the smaller the actual bandwidth is for each connected device.

On the last device of the SCSI bus, an LVD SCSI terminator must be installed. The LVD terminator is delivered with the TS2340.

Do not mix Low Voltage Differential (LVD) and High Voltage Differential (HVD) SCSI host adapters, tape drives, or terminators on the same bus, because they can become damaged.

Figure 4-4 shows a point-to-point configuration.

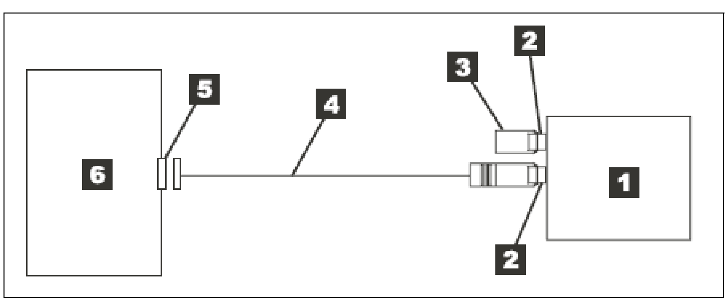

Figure 4-4 TS2340 connected as a point-to-point to the server

The numbers in figure 4-3 represent:

1. TS2340
2. SCSI connectors
3. SCSI LVD terminator

4. SCSI cable
5. SCSI HBA
6. Server

Figure 4-5 shows a TS2340 in a daisy chain configuration.

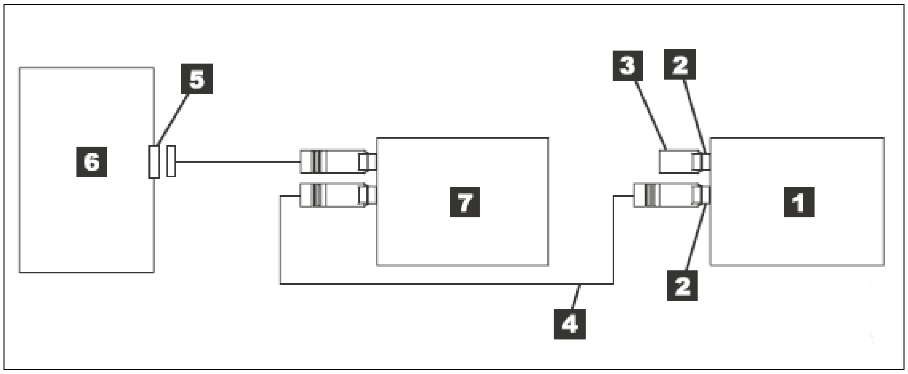

Figure 4-5 Two TS2340s connected in a daisy-chain configuration

The numbers in Figure 4-5 represent:

1. TS2340
2. SCSI connectors
3. Terminator
4. SCSI bus cable
5. SCSI HBA
6. Server
7. TS2340

In this example, we used two TS2340s, but it can be any other LVD tape drive. The last TS2340 must have an LVD terminator installed; otherwise, the SCSI bus is open and that can result in unpredictable errors.

For maximum performance, the quantity of tape drives that can be attached to one SCSI bus is limited, and is based on the type of bus that you have and the amount of data compression achieved. Ultra SCSI buses have a bandwidth of 40 MB per second; Ultra2 SCSI buses have a bandwidth of 80 MB per second; Ultra160 SCSI buses have a bandwidth of 160 MB per second. The tape drive is capable of data transfer rates of up to 80 MB per second with no compression. For maximum performance, we recommend that you attach only one tape drive to an Ultra SCSI bus, an Ultra2 SCSI bus, or an Ultra160 SCSI bus.

Data transfer protocol time-outs for tape and disk drives are dissimilar. For that reason, we strongly recommend that you avoid running tape and disk drives on the same host bus adapter. A configuration with tape and disk on a single host bus adapter gives a slow and unreliable performance.

Note: Do not intermix LVD and HVD devices and HBAs on the same SCSI bus. Damage can occur, because LVD and HVD SCSI devices use different voltages.

4.5.2 SAS interface

Connecting the TS2340 to the HBA of the server is a straightforward exercise. The SAS interface of the TS2340 is always an SFF-8088 and the only supported HBAs in your server are:

- LSI Logic SAS3800
- IBM SAS HBA Controller model 25R8060

Connect one end of the SAS cable to the TS2340 and the other end of the cable to the HBA of the server. The only consideration is the physical connector on the cable. We included a list of all the available features; see 4.7, “Feature codes” on page 118. Figure 4-6 shows the connection to one server’s HBA.

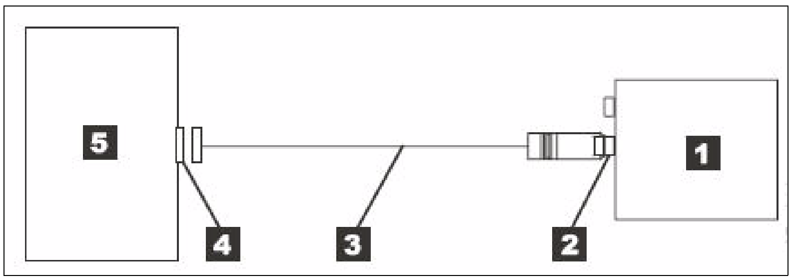

Figure 4-6 Point-to-point connection to one server

The numbers in Figure 4-6 represent:

1. TS2340
2. SAS connector
3. SAS cable
4. HBA of the server
5. Server

The TS2340 has two SAS connectors, so two servers can be connected to the TS2340. Figure 4-7 shows a configuration where the TS2340 is connected to two servers. Daisy-chaining is not allowed, because each SAS port of the TS2340 needs a dedicated HBA.

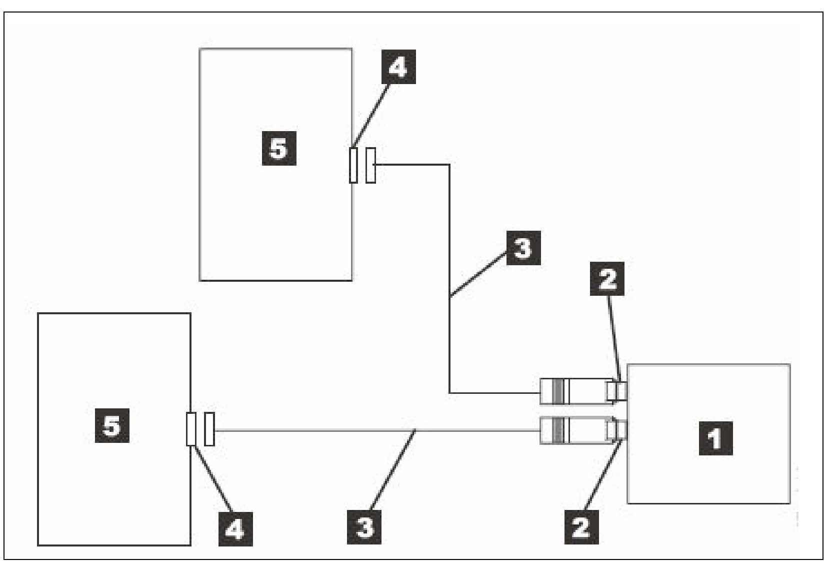

Figure 4-7 TS2340 connected to two servers

The numbers in Figure 4-7 on page 116 represent:

1. TS2340
2. SAS interface
3. SAS cable
4. HBA of the server
5. Server

4.5.3 Installing the SCSI device drivers

To communicate with the TS2340, the appropriate device driver must be installed on your server. Depending on your host operating system, the latest device driver must be installed on your server. Visit the Web site:

http://www-03.ibm.com/servers/storage/tape/lto/

Here, you can download the latest device driver for your operating system.

Another way to get the latest device driver is to visit this Web site:

ftp://index.storsys.ibm.com/devdrvr

Choose your operating system and download the device driver.

Information about how to install the device driver is described step-by-step in the following IBM publications:

- *Implementing IBM TAPE in Unix Systems,* SG24-6502
- *Implementing IBM Tape in Linux and Windows,* SG24-6268
- *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430

All publications are available and can be downloaded from the Web.

4.5.4 Firmware

At installation time, verify that the most current firmware is installed. Because the TS2340 does not have a display to show the firmware level, we recommend that you use an IBM tool called the IBM Total Storage Diagnostic Tool (ITDT). ITDT scans the SCSI bus for any attached tape drive and will reflect the firmware of the tape drive.

This tool can also be used for testing the drive and collecting a drive dump for error analysis by the IBM Support Centers. The advantage of using ITDT is that it works independently of the device driver. Whatever device driver is installed, whether IBM or non-IBM device drivers, the TS2300 can be tested, the firmware can be updated, or a drive dump can be performed.

At the time of writing, ITDT is supported for the following operating systems: Microsoft Windows 2000 Server with SP4 (32-bit IX86, Microsoft Windows Server 2003 (32-bit IX86), AIX 5L 5.2 and 5.3 (64-bit pSeries, Linux systems with Kernel 2.4 and 2.6, glibc 2.2.5 and later (32-bit IX86), Linux systems with Kernel 2.4 and 2.6, glibc 2.2.5 and later (64-bit pSeries), Solaris Version 9 and 10 (64-bit SPARC), HP-UX Version 11.*xx* (PA-Risc and Itanium), and i5/OS V5.3 (iSeries). The ITDT can be downloaded from this Web site:

ftp://index.storsys.ibm.com/358x/tools/

In the readme file, there are installation instructions, as well as instructions to use ITDT.

The latest firmware of the TS2340 can be found on the following Web site:

http://www-03.ibm.com/servers/storage/tape/lto/

Another possibility to download the latest firmware is an FTP Web site:

ftp://index.storsys.ibm.com/358x/3580

4.6 Physical specifications

The TS2340 is a small-sized tape drive with the following specifications:

Width	25.02 cm (9.85 in.)
Length	29.21 cm (11.5 in.)
Height	12.06 cm (4.75 in.)
Weight	6.45 kg (14.2 lbs.)

4.7 Feature codes

In this section, we summarize the feature codes for both TS2340 models. Table 4-2 lists the feature codes and part numbers for SCSI attachment.

Table 4-2 Feature code and part numbers

IBM Service part number	Client feature code	High Volume part number	Product description
23R3841	5602	23R7133	VHDCI/HD 68 SCSI cable, 2.5 m (8.2 ft.)
23R3594	5604	23R7134	VHDCI/HD 68 SCSI cable, 4.5 m (14.8 ft.)
23R3593	5610	23R7135	VHDCI/HD 68 SCSI cable, 10 m (32 ft.)
35L1782	N/A	N/A	SCSI Y-cable
23R5841	N/A	N/A	SCSI LVD terminator
23R5840	N/A	N/A	SCSI LVD wrap plug
N/A	7003	96P1565	19 inch rack mount kit

Table 4-3 lists the feature code and part numbers for SAS attachment.

Table 4-3 SAS feature codes

Feature Code/HVEC	Description	Description
5402 95P4711	2 m SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5406 95P4712	5.5 m SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5502 95P4713	2 m Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5506 95P4714	5.5 m Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
8405 95P4278	Ultrium 4 Data Cartridges (5-pack)	This feature provides five unlabeled 800 GB data cartridges only with ordering the TS2340.

5

IBM System Storage TS3100 Tape Library

The TS3100 Tape Library (Machine Type 3573, Model L2U) is a single or dual drive entry level desktop or a rack-mounted unit (requiring two rack units of an industry standard 19-inch rack) that can operate in random or sequential mode. The robotics inside the library move the cartridges to and from the tape drive permitting unattended backup. Two removable magazines can store a total of 24 cartridges. A single dedicated mail slot (I/O station) is available for importing and exporting cartridges.

The following IBM Ultrium Tape Drives are available for the TS3100 Tape Library:

- The IBM Ultrium 4 Low Voltage Differential (LVD) SCSI Tape Drive
- The IBM Ultrium 4 Fibre Channel (FC) Tape Drive
- The IBM Ultrium 4 Serial Attached SCSI (SAS) Tape Drive
- The IBM Ultrium 3 Half-High LVD SCSI Tape Drive
- The IBM Ultrium 3 Half-High SAS Tape Drive
- The IBM Ultrium 3 Full-High LVD SCSI Tape Drive
- The IBM Ultrium 3 Full-High FC Tape Drive

Up to two IBM Ultrium 3 Half-High Tape Drives or one IBM Ultrium 3 or 4 Full-High Tape Drive can be installed in the TS3100 Tape Library.

Tape Encryption is supported on the IBM Ultrium LTO4 Tape Drive with the SAS and Fibre Channel interface. At the time of writing this publication, the TS3100 supported Application-Managed Encryption and System-Managed Encryption.

The TS3100 Tape Library has four indicator LEDs and one Liquid Crystal Display (LCD) on the front. The LEDs can be used to indicate Ready/Activity, Use Cleaning Tape, Media Attention, and Error.

Standard features are a barcode reader and a remote management unit (RMU). We use the terms *RMU* and *Web interface* interchangeably throughout the following chapters.

New in 2007, the TS3100 is now Simple Network Management Protocol (SNMP) capable.

5.1 Description

Designed for tape automation, the TS3100 Tape Library can be attached to IBM System i or i5, iSeries, AS/400, IBM System p or p5, pSeries, RS/6000, IBM z or z9™, xSeries, Hewlett-Packard (HP), Sun, UNIX, and PC servers. To determine the latest supported servers, visit the Web at:

http://www-03.ibm.com/systems/storage/tape/

The IBM Ultrium 4 LTO Tape Drive with a Fibre Channel or a SAS interface is encryption capable. The IBM LTO4 Tape Drive supports Application-Managed Encryption (AME), System-Managed Encryption (SME), and Library-Managed Encryption (LME). At the time of writing, the only supported encryption methods are AME and SME.

Depending on what IBM Ultrium Tape Drive is installed in the TS3100 Tape Library, the following Data Cartridges can be used:

- The TS3100 Tape Library uses the IBM TotalStorage LTO Ultrium 400 GB Data Cartridge or the 400 GB WORM cartridge when the IBM Ultrium 3 Tape Drive is installed. The Ultrium 3 Tape Drive has the capability of writing up to 400 GB native capacity and up to 800 GB with 2:1 compression. IBM Ultrium 3 Tape Drives can read and write LTO Ultrium 2 Data Cartridges and read LTO1 data cartridges.
- The TS3100 Tape Library uses the IBM TotalStorage LTO Ultrium 800 GB Data Cartridge or 800 GB WORM Cartridge when the IBM Ultrium 4 Tape Drive is installed. The Ultrium 4 Tape Drive has the capability of writing up to 800 GB native capacity and up to 1600 GB with 2:1 compression. IBM Ultrium 4 Tape Drives can read and write LTO Ultrium 3 Data Cartridges, can read Ultrium 2 Data Cartridges, and does not support Ultrium 1 Data Cartridges.

The library capacity is 24 tape cartridges, providing a media capacity of up to 9.6 TB (19.2 TB with 2:1 compression) data storage per TS3100.

Seven models are available for the TS3100 Tape Library:

- The *3573-L4S* comes with an IBM Ultrium 4 LVD SCSI Tape Drive. The Ultrium 4 LVD SCSI drive has an LVD Ultra 160 SCSI interface that can be connected to LVD fast/wide adapters. The Ultrium 4 Tape Drive provides a sustained native data transfer rate of 120 MB/s.
- The *3573-F4S* comes with an Ultrium 4 Tape Drive with a 4 Gbps Fibre Channel interface. The Ultrium 4 Tape Drive provides a sustained native data transfer rate of 120 MB/s.
- The *3573-S4S* comes with a SAS Ultrium 4 Tape Drive that has a SAS interface, which has a native data transfer rate of up to 3 Gbs. The SAS Ultrium 4 Tape Drive comes with an SFF-8088 interface. The Ultrium 4 Tape Drive provides a sustained native data transfer rate of 120 MB/s.
- The *3573-L32* comes with a Half-High Ultrium 3 LVD SCSI Tape Drive. The Ultrium 3 LVD SCSI Tape Drive has an LVD Ultra 160 SCSI interface. The Half-High Ultrium 3 Tape Drive provides a sustained native data transfer rate of 60 MB/s.
- The *3573-S32* comes with a Half-High Ultrium 3 SAS Tape Drive. The Half-High Ultrium 3 Tape Drive has a maximum native data transfer rate of up to 60 MB/s.
- The *3573-F3S* comes with a Full-High Ultrium 3 native switched 4 Gbps Fibre Channel Tape Drive. The Full-High Ultrium 3 Tape Drive has a maximum native data transfer rate of up to 80 MB/s.
- The *3573-L3S* comes with a Full-High Ultrium 3 LVD SCSI Tape Drive. The Full-High Ultrium 3 Tape Drive has a maximum native data transfer rate of up to 80 MB/s.

Figure 5-1 shows the front view of the TS3100 Tape Library. On the left and right sides, you see the cartridge magazines. The I/O slot is accessible from the lower left.

Figure 5-1 IBM System Storage TS3100 Tape Library

5.2 Components

The IBM TS3100 Tape Library has an improved robotic system that moves along an axis from front to back between the two cartridge magazines. This limited movement provides robust robotics. The standard barcode reader is installed on the picker.

Figure 5-2 shows the top view of the TS3100 Tape Library. The right side of the image is the rear of the library and the left side is the front of the TS3100 Tape Library. The TS3100 Tape Library is a modular system, allowing the client to change parts easily.

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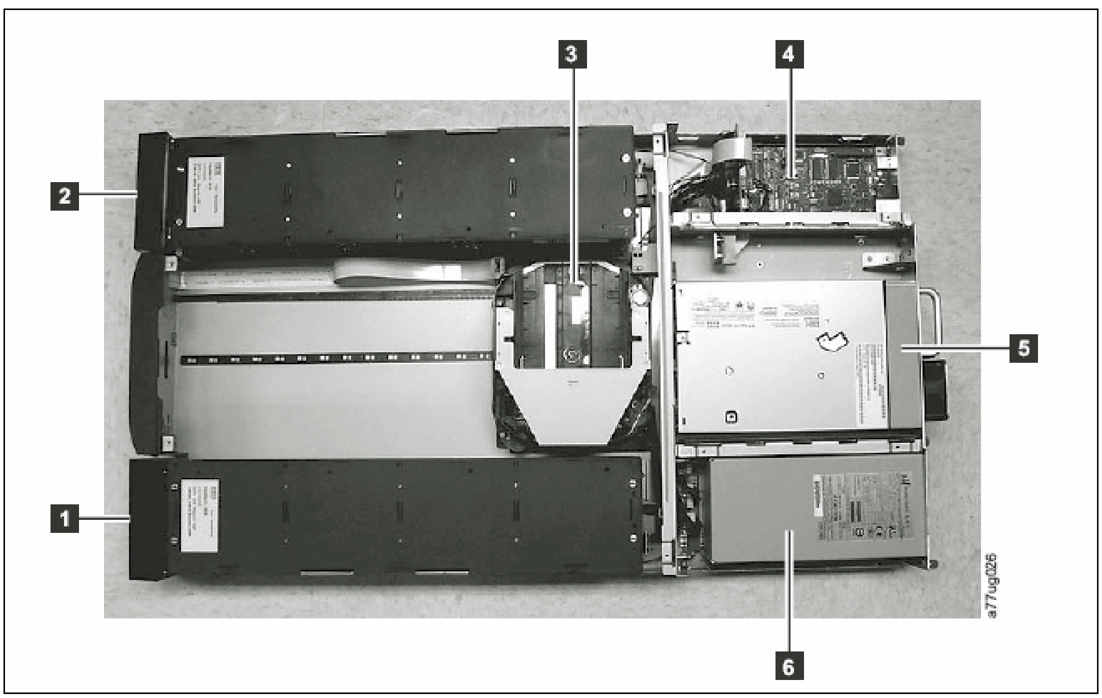


Figure 5-2 Internal top view of the tape library

The components shown in Figure 5-2 are:

1. Right cartridge magazine. This magazine can hold up to twelve cartridges.

2. Left cartridge magazine. This magazine can hold up to 12 cartridges and houses the I/O station.
3. Accessor. This component contains the library robot and the barcode reader. The accessor moves cartridges to and from the:
   - I/O station
   - Storage slots
   - Tape drive
4. Library control card. This component is a customer-replaceable unit (CRU) and stores the user configuration information or vital product data (VPD). The RMU is embedded in this card.
5. Tape drive sled. This library supports the Ultrium 3 or Ultrium 4 tape drive. The tape drive in the library is packaged in a container called a *drive sled*. The drive sled is a CRU, and it is designed for easy removal and replacement.
6. Power supply. The power supply is a CRU. No redundant power is available.

5.2.1 Robotics

The IBM TS3100 Tape Library uses a new independent tape loader, threader motors, and a positive pin retention. These are designed to help improve the reliability of loading and unloading a cartridge and to retain the pin even if tension is dropped. An independent loader motor coupled with the positive pin retention is designed to thread the tape with a higher level of reliability.

5.2.2 Barcode reader

The barcode reader is an integral part of the library accessor, and it does not affect the slot capacity. The barcode reader provides inventory feedback to the host application, Operator Control Panel display, and Web User Interface by reading cartridge barcode labels. The library stores the customized inventory data in memory.

5.2.3 Remote management

The Remote Management Unit (RMU) provides remote management to the library over a network. This function is imbedded in the Library Control Card. The library can be attached to the network using the 10/100 MB Ethernet port. The Ethernet connection is located on the back of the library.

When the IP address is set on the library using the Operator Control Panel (OCP), the library can be monitored and controlled remotely. Entering the IP address in a browser opens a graphical representation of the library. Service actions, such as upgrading the library and drive firmware, can be done by using the remote management facility. Figure 5-3 on page 125 shows the home page of the Web User Interface.

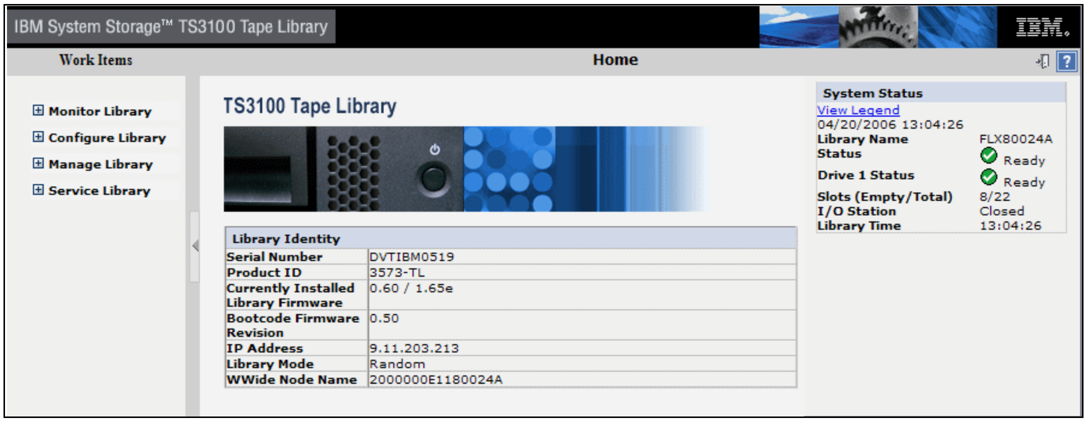


Figure 5-3 Welcome window of the Web User Interface

5.3 Cartridge storage

The IBM TS3100 Tape Library has two removable magazines in the library. The total number of cartridges is 24. The right magazine and the left cartridges magazine can hold up to 12 cartridges per magazine.

The native maximum storage capacity is 19.2 TB with the IBM Ultrium 4 Tape Drive and 9.6 TB with the IBM Ultrium 3 Tape Drive installed. The Input/Output station (or “mail slot”) is part of the left magazine. The magazines can be released using the Operator Panel or the Web User Interface. Magazine access is password-protected.

Figure 5-4 shows the right magazine.

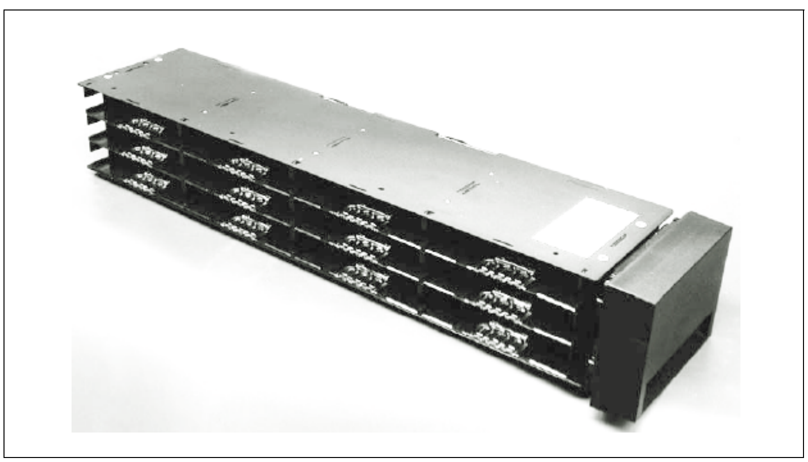
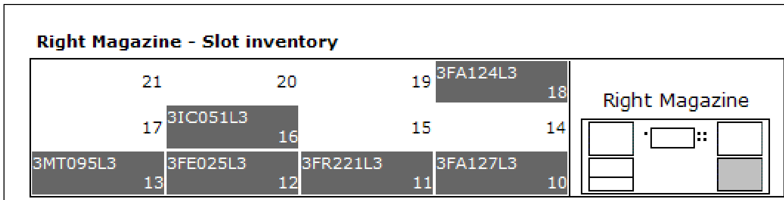


Figure 5-4 Right magazine

When the magazines are filled with cartridges, you can use the Web User Interface to see which cartridges are stored in which storage slot location as demonstrated in Figure 5-5 on page 126.

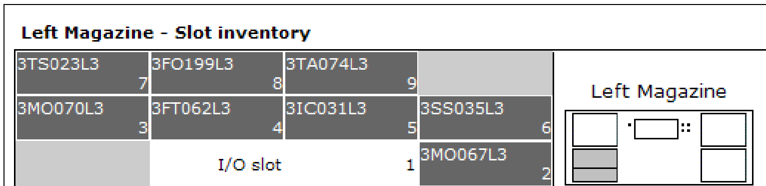


⊟ Cartridge details for Right Magazine

Slot #	Attn	Status	In Drive	Label	Media Loads	Comment
11		Full		3FR221L3		
12		Full		3FE025L3		
13		Full		3MT095L3		
14		Empty		------------		
15		Empty		------------		
16		Full		3IC051L3	35	
17		Empty		------------		
18		Full		3FA124L3		
19		Empty		------------		
20		Empty		------------		
21		Empty		------------		
22		Empty		------------		

Figure 5-5 Inventory of the right magazine using the Web User Interface

Part of the left magazine is the I/O station. You can use the Web User Interface to show an inventory of the magazine as shown in Figure 5-6.



⊟ Cartridge details for Left Magazine

Slot #	Attn	Status	In Drive	Label	Media Loads	Comment
I/O slot	Closed	Empty		------------		
1		Empty		------------		
2		Full		3MO067L3		
3		Full		3MO070L3		
4		Full		3FT062L3		
5		Full		3IC031L3		
6		Full		3SS035L3		
7		Full		3TS023L3		
8		Full		3FO199L3		
9		Full		3TA074L3		
10		Full		3FA127L3		

Figure 5-6 Inventory of the left magazine using the Web User Interface

Figure 5-7 on page 127 shows the left magazine with the I/O station on the left side.

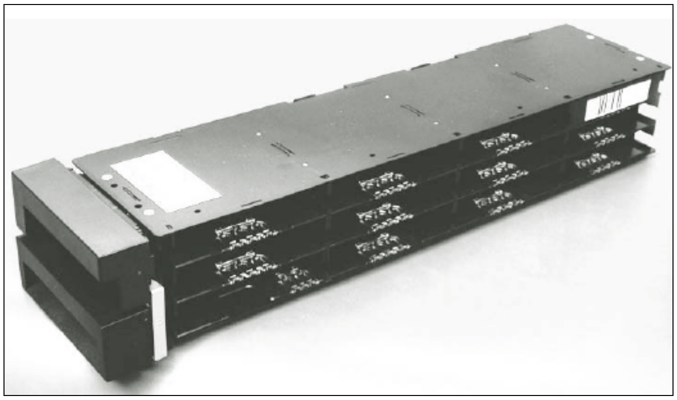


Figure 5-7 Left magazine

The I/O station is part of the left magazine. In Figure 5-8, you can see the left magazine with the I/O slot opened. You can open the I/O station using the OCP or the Control Menu from the Web user Interface. Magazine access is password-protected.

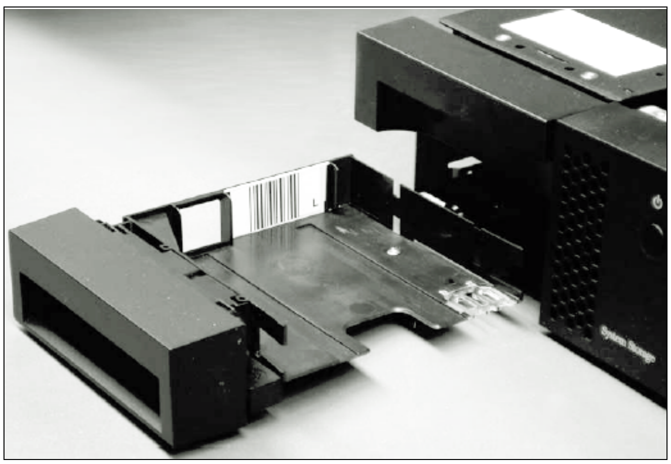


Figure 5-8 I/O station in the left magazine

5.4 IBM Ultrium LTO4 Tape Drive

Each IBM Ultrium 4 Tape Drive contains the electronics and logic for reading and writing data, controlling the tape drive, managing the data buffer, and handling error recovery procedures. Because of its special design as a CRU, the drive can easily be replaced if necessary. Figure 5-9 on page 128 shows the Ultrium 4 drive sled with a SCSI interface. The same drive sled can also contain the 4 Gbps Fibre Channel drive or the SAS drive.

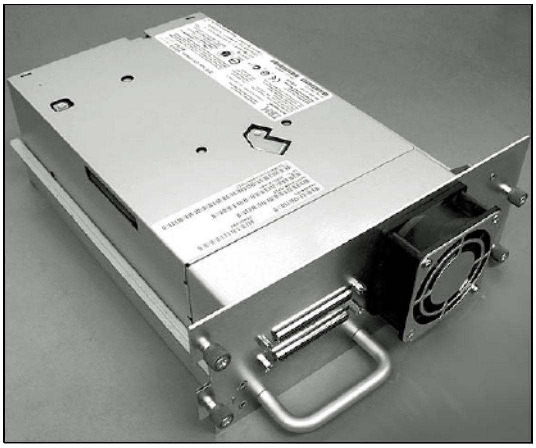


Figure 5-9 Library drive sled with an Ultrium 4 SCSI Tape Drive

5.4.1 Speed matching

To improve the performance of the LTO4 Tape Drive, the Tape drive uses a technique called *speed matching* to dynamically adjust its native (uncompressed) data rate to the slower rate of the server's host bus adapter (HBA). The LTO4 Tape Drive is negotiating with the server's HBA, setting up a speed with the best performance. Six speeds are available when reading or writing the generation 3 or generation 4 cartridge format. Native rates are:

- Generation 3: 30, 40, 50, 60, 70, or 80 MB/s
- Generation 4: 30, 48, 66, 84, 103, or 120 MB/s

If the server is between two of the native rates, the drive calculates the appropriate data rate at which to operate. Speed matching reduces back hitching. Back hitching is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is usually the result of a mismatch between the data rates of the connected server and the tape drive.

5.4.2 Channel calibration

The channel calibration feature of the Ultrium 4 Tape Drive customizes each Read/Write data channel for optimum performance. The customization enables compensation for variations in the recording channel transfer function, media characteristics, and Read/Write head characteristics.

5.4.3 Sleep mode

To save energy, the LTO4 tape drives use a feature called *sleep mode*. To enter sleep mode, the LTO4 tape drive must be inactive for a minimum of 30 seconds. The LTO4 tape drive will go out of this sleeping mode again after receiving a SCSI command, a command across the Library/Drive interface (LDI or RS-422), or on a load or unload request. When in sleep mode, the drive response time to commands that do not require media motion increases by up to ten microseconds. Commands that require media motion might be delayed an additional 100 milliseconds, because the tape must be retensioned.

5.4.4 Power management

The Ultrium 4 Tape Drive's power management function controls the drive's electronics so that part of the electronics completely turn *off* when circuit functions are not needed for the drive's operation.

5.5 IBM Ultrium LTO3 Tape Drive

In this section, we summarize the IBM Ultrium LTO3 Half-High and Full-High Tape Drives.

5.5.1 Servo and track layout technology

There are 704 data tracks used to read and write data to the data cartridge. These tracks are grouped in five Servo bands.The high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

5.5.2 Magneto resistive head design

Magneto resistive (MR) head design, which uses flat lap head technology in the MR heads for Ultrium 3, helps minimize contact, debris accumulation, and wear on the tape as it moves over the Read/Write heads.

5.5.3 Surface Control Guiding Mechanism

The IBM patented Surface Control Guiding Mechanism is designed to guide the tape along the tape path in the TS2300 Tape Drive. This method uses the surface of the tape, rather than the edges, to control tape motion. This helps reduce the tape damage (especially to the edges of the tape) and tape debris, which comes from the damaged edges and can accumulate in the head area.

5.5.4 Dynamic speed matching

The Ultrium 3 Tape drive is designed to perform *dynamic speed matching* (at one of four speeds of 30, 40, 50, or 60 MB/s) to adjust the tape drive's native data rate as closely as possible to the net host data rate (after data compressibility has been factored out). This helps the number of backhitch repositions and improves throughput performance. Back hitching is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is usually the result of a mismatch between the data rates of the connected server and the tape drive.

5.5.5 Power management

The Ultrium 3 Tape Drive power management function is designed to control the drive electronics to be either completely turned off or to stay in a low-power mode when the circuit functions are not needed for drive operations.

5.5.6 Statistical Analysis and Reporting System (SARS)

The Ultrium 3 Tape Drive uses SARS to help isolate failures between media and hardware. The SARS uses the data cartridge performance history saved in the Cartridge Memory module and the drive performance history kept in the drive flash Electronically Erasable Programmable Read-Only Memory (EEPROM) to help determine the likely cause of the failure. SARS can cause the drive to request a cleaning tape, to mark the media as degraded, and to indicate that the hardware has degraded. When a drive dump is taken from the drive, the Support Center can determine if the failure is in the Tape Drive itself or on the data cartridge.

5.6 Physical attachments

The IBM TS3100 Tape Library is available with three interfaces:

- SCSI Ultra Fast/Wide 160 LVD
- 4 Gbps Native Fibre Channel
- SAS 3 Gbps

5.6.1 SCSI Ultra Fast/Wide 160 LVD

IBM LVD tape devices support a bus length of 25 m (82 ft.) point-to-point and 12 m (39 ft.) using multi-drop interconnection (daisy-chaining). For each daisy-chained device, the maximum cable length must be reduced by 0.5 ms (1.6 ft.).

The Ultrium 3 drive uses shielded, HD68, 68-pin connectors and can attach directly to a 2-byte-wide SCSI cable.

The Ultrium 3 LTO drive provides a sustained native data transfer of 80 MB/s and can store up to 400 GB of uncompressed information on a single data cartridge.

> **Note:** A faster bus does not imply that an attached device will support that data rate, but that multiple devices can operate on the bus at the maximum speed. To ensure the best performance, if possible, avoid daisy-chaining.

5.6.2 Fibre Channel interface

Ultrium 3 and 4 Fibre Channel tape drives use LC duplex fiber optic cables. The maximum distances that the library supports on a Fibre Channel link is determined by the link speed, the type of fiber (50-micron or 62.5-micron), and the device to which the library is attached.

If the library attaches to an HBA, refer to the distances that are supported by the HBA. If the library attaches to a switch, the supported distances are:

- For a 50-micron cable:
  - 1 Gbit link speed = up to 500 m (1640 ft.)
  - 2 Gbit link speed = up to 300 m (984 ft.)
  - 4 Gbit link speed = up to 150 m (492 ft.)
- For a 62.5-micron cable:
  - 1 Gbit link speed = 175 m (574 ft.)
  - 2 Gbit speed link = 150 m (492 ft.)
  - 4 Gbit speed link = 70 m (230 ft.)

The 4 Gbps Native Fibre Channel drive port can be configured in the following methods:

- LN Port: (default setting) An automatic configuration that tries arbitrated loop first, then switched fabric
- L Port: Arbitrated loop
- N Port: Point-to-point protocol in a switched fabric topology

5.6.3 SAS interface

The SAS interface is new in the IBM Ultrium Tape Drive family and the IBM Ultrium 4 SAS Full-High Tape Drive comes with two SFF-8088 interfaces on the back of the tape drive. The IBM Ultrium 3 SAS Half-High Tape Drive comes with one SAS interface on the back of the drive. For a more detailed description of SAS, see “Serial-Attached SCSI” on page 53.

At the time of writing, two HBAs were supported:

- LSI Logic SAS3800X
- IBM SAS HBA Controller model 25R8060

Figure 5-10 shows the back side of the SAS Full-High Tape Drive with two SFF-8088 interfaces.

Figure 5-10 the back side of the SAS Full-High Tape Drive

Figure 5-11show the back side of the SAS Half-High Tape Drive with one SFF-8088 interface

Figure 5-11 Back side of the SAS Half-High Tape Drive

No terminator is needed, because the SCSI bus is automatically terminated.

5.6.4 Persistent binding

When you boot a server, it discovers devices and assigns them SCSI target and LUN IDs. It is possible for these SCSI assignments to change between reboots. Certain operating systems do not guarantee that devices are always allocated the same SCSI target ID after rebooting. Also, some software depends on this association, so you do not want it to change. Persistent binding addresses the issue of SCSI ID assignment.

Persistent binding is an HBA function that allows a subset of discovered targets to be bound between a server and device. Implemented by a worldwide node name (WWNN) or worldwide port name (WWPN), persistent binding causes a tape drive's worldwide name (WWN) to be bound to a specific SCSI target ID.

After a configuration has been set, it survives reboots and any hardware configuration changes because the information is preserved. If a drive needs to be replaced, the new drive assumes the WWNN of the old drive because the WWNN for the drive is location-dependent within the library. Because the WWNN does not change, persistent binding does not need to be changed, which causes an outage.

You can find additional information about persistent binding in *Implementing IBM Tape in UNIX Systems*, SG24-6502, and *Implementing IBM Tape in Linux and Windows*, SG24-6268.

5.6.5 Encryption

The LTO Ultrium 4 Tape Drive supports host Application-Managed Encryption (AME) and System-Managed Encryption (SME), using T10 encryption methods, for SAS and Fibre Channel drives only. Data encryption is supported with LTO Ultrium 4 Data Cartridges only. Encryption is also supported for library firmware version 1.95 and higher.

The encryption-enabled drive contains the necessary hardware and firmware to encrypt and decrypt host tape application data. Encryption policy and encryption keys are provided by the host application or host server. A drive digital certificate is installed at manufacturing time. Each drive receives a unique serial number and certificate. The T10 application might validate each drive instance by checking the drive's digital certificate. AME is supported on AIX, Windows 2000 Server, Linux, and Solaris. Encryption requires the latest device drivers that are available on the ftp download site:

ftp://ftp.software.ibm.com/storage/devdrvr/

The LTO Ultrium 4 encryption environment can be complex and requires knowledge beyond that of a product-trained IBM service support representative (SSR). In the Tape Storage environment, the Encryption function on tape drives (desktop, stand-alone, and within libraries) is configured and managed by the client. In certain instances, SSRs will be required to enable encryption at a hardware level when service access or service password controlled access is required.

Tape Encryption is available at no charge for AME. Feature Code (FC) 1604 (for the TS3500 Tape Library) or FC5900 (for all other tape libraries) and FC9900 must be ordered when you are planning to work with SME.

Note: The optional Transparent Encryption Key feature enabling SME and Library-Managed Encryption (LME) is not available on TS3200 and TS3100 models purchased through High Volume (HVEC) channels.

5.7 LTO data cartridges

When processing the Ultrium Tape Cartridge, the Ultrium Tape Drive uses a linear, serpentine recording format. The Ultrium 3 drive reads and writes data on 704 tracks, sixteen tracks at a time, and the Ultrium 4 drive writes data on 896 tracks. The first set of tracks is written from near the beginning of the tape to near the end of the tape. The head then repositions to the next set of tracks for the return pass. This process continues until all tracks are written and the cartridge is full, or until all data is written.

To ensure that your IBM Ultrium Tape Drive conforms to the IBM specifications for reliability, use only IBM LTO Ultrium tape cartridges. The IBM TotalStorage LTO Ultrium 400 GB and 800 GB Data Cartridge cannot be interchanged with the media used in other IBM non-LTO Ultrium tape products.

You can identify the various generations of IBM TotalStorage Ultrium data cartridges by their colors. See Table 5-1.

Table 5-1 Data cartridge identification by case color

Data cartridge	Case color
Ultrium 4 WORM	Slate green top, platinum (silver gray bottom)
Ultrium 3 WORM	Slate blue top, platinum (silver gray bottom)
Ultrium 4	Green
Ultrium 3	Slate blue
Ultrium 2	Purple
Ultrium 1	Black

The native data capacity of Ultrium data cartridges is listed in Table 5-2.

Table 5-2 Native capacity

Data cartridge	Native data capacity
Ultrium 4 WORM	800 GB (1600 GB at 2:1 compression)
Ultrium 3 WORM	400 GB (800 GB at 2:1 compression)
Ultrium 4	800 GB (1600 GB at 2:1 compression)
Ultrium 3	400 GB (800 GB at 2:1 compression)
Ultrium 2	200 GB (400 GB at 2:1 compression)
Ultrium 1	100 GB (200 GB at 2:1 compression)

5.7.1 Cartridge compatibility

Table 5-3 shows the compatibility among the four types of Ultrium cartridges.

Table 5-3 *Ultrium data cartridge compatibility*

IBM Ultrium Tape Drive	IBM TotalStorage LTO Ultrium Data Cartridge			
	800 GB (Ultrium 4)	400 GB (ultrium 3)	200 GB (Ultrium 2)	100 GB (Ultrium 1)
Ultrium 4	Read/Write	Read/Write	Read only	N/A
Ultrium 3	N/A	Read/Write	Read/Write	Read only
Ultrium 2	N/A	N/A	Read/Write	Read/Write
Ultrium 1	N/A	N/A	N/A	Read/Write

5.7.2 Write Once Read Many (WORM)

Certain records retention and data security applications require a Write Once Read Many (WORM) method for storing data on tape. To meet this data storage requirement, a new WORM feature is available on IBM LTO Ultrium generation 3 drives. You can enable the WORM feature by upgrading to WORM-capable drive firmware and using a special WORM tape cartridge.

The IBM Ultrium LTO4 Tape Drive uses the LTO4 WORM cartridges and gives full support for the use of WORM data cartridges.

WORM Media

A specially formatted WORM tape cartridge is required, because standard Read/Write media are incompatible with the WORM feature. Each WORM cartridge has a unique, worldwide cartridge identifier (WWCID), which comprises the unique Cartridge Memory (CM) chip serial number and the unique tape media serial number.

Data security on WORM media

Certain built-in security measures help ensure that the data written on a WORM cartridge does not become compromised, for example:

- The format of an IBM Ultrium 3 and Ultrium 4 400 GB and 800 GB WORM Tape Cartridge is unlike that of standard Read/Write media. This unique format prevents a drive that lacks WORM-capable firmware from writing on a WORM tape cartridge.
- When the drive senses a WORM cartridge, the firmware prohibits changing or altering user data already written on the tape. The firmware keeps track of the last appendable point on the tape.

5.7.3 Cleaning cartridge

A specially labeled IBM LTO Universal Ultrium Cleaning Cartridge will clean the drive in your library. One cleaning cartridge ships with the IBM TS3100 Tape Library.

The drive itself determines when a head needs cleaning and communicates this to the library. When the cleaning is finished, the drive ejects the cartridge and the picker takes the cartridge and places it back in any storage slot. To remove a cleaning cartridge, export it from the library.

The IBM Cleaning Cartridges are valid for 50 uses. The cartridge’s LTO-CM chip tracks the number of times that the cartridge is used.

5.7.4 Cartridge Memory chip (LTO-CM)

All generations of the IBM LTO Ultrium Data Cartridges include a Linear Tape-Open Cartridge Memory (LTO-CM) chip that contains information about the cartridge and the tape (such as the name of the manufacturer that created the tape), as well as statistical information about the cartridge’s use.

The LTO-CM enhances the efficiency of the cartridge. For example, the LTO-CM stores the end-of-data location that the next time this cartridge is inserted and the Write command is issued enables the drive to quickly locate the next available recording area and begin recording.

The LTO-CM also helps determine the reliability of the cartridge by storing data about its age, how many times it has been loaded, and how many errors it has accumulated. Whenever a tape cartridge is unloaded, the tape drive writes any pertinent information to the cartridge memory. The storage capacity of the LTO-CM is 4096 bytes for Ultrium 3 and 8192 bytes for Ultrium 4.

5.8 IBM TS3100 Tape Library setup

The following section provides an introduction to the necessary steps to implement, manage, and operate the IBM TS3100 Tape Library. For a more detailed description, refer to the *IBM System Storage TS3100 Tape Library and TS3200 Tape Library: Setup, Operator, and Service Guide*, GA35-0545.

After unpacking and installing the IBM TS3100 Tape Library, you must perform a few steps to connect it to a host.

5.8.1 User interfaces

There are two ways to configure the library: using the Operator Control Panel (OCP) and the Web User Interface. *You use the OCP and the Web User Interface to complete the installation of the IBM TS3100 Tape Library.* The OCP is located on the front panel of the library and the Web User Interface is accessed via the Web browser.

The Operator Control Panel interface

The Operator Control Panel operates in one of two modes:

- User Interaction mode: This mode is employed when you press buttons on the Operator Control Panel.
- System Driven mode: This is the normal mode of operation. In this mode, the OCP displays the status associated with the actions that were caused by commands issued via the drive's internal (drive to library) serial interface.

When you press and release an OCP button, the OCP automatically transitions to User Interaction mode. User Interaction mode will continue until three minutes after you stop pressing buttons or until the requested accessor action stops, whichever is longer. At this time, the OCP returns to System Driven mode.

If necessary, the Operator Control Panel automatically transitions to the System Driven mode. When this occurs, the library must remember what you were doing before the display mode changed. Therefore, the next button pressed only transitions the OCP to the User Interaction mode from the System Driven mode. In the case of the activated user security feature, the User Interaction mode is restricted to Login and Monitor menu items, until a user logs in with a correct password.

Web User Interface

You can perform many of the same operations performed from the Operator Control Panel remotely using the Web User Interface. The Web User Interface lets you monitor and control your library from any terminal connected to your network or through the World Wide Web.

The Web User Interface hosts a dedicated, protected Internet site that displays a graphical representation of your library. After establishing a connection to the library, open any HTML browser and enter the IP address of the library. To configure the Web User Interface, you must set the IP address.

5.8.2 Configuring the IBM TS3100 Tape Library

One of the benefits of the IBM TS3100 Tape Library is the standard Remote Management Unit (RMU). You can configure and monitor the IBM TS3100 Tape Library remotely, as well as update the firmware of the library and the drive remotely. RMU uses an Ethernet connection to access the IBM TS3100 Tape Library. For the initial setup, you can use the default configuration, which is:

- Dynamic Host Configuration Protocol (DHCP): **On**
- Network Address: **0.0.0.0**
- Drive ID:
  - **4** for a SCSI Drive
  - **4** for a Fibre Channel Drive
- Library mode: **Random**

Making a direct connection to the IBM TS3100 Tape Library might require a crossover Ethernet cable.

Figure 5-12 shows the Library Mode menu and the configuration options.

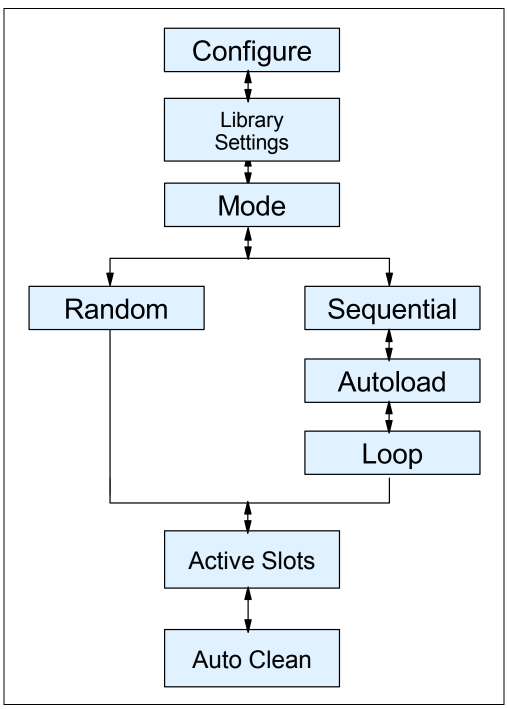


Figure 5-12 Configure: Library Settings

From the Mode menu, you select the Library Mode. Two library modes are available for the IBM TS3100 Tape Library:

1. In *Random* mode, the library allows the server's (host's) application software to select any data cartridge in any order.
2. In *Sequential* mode, the library's firmware predefines the selection of the cartridges. After initialization, the firmware causes the library to select the first available cartridge found (counting from 1 through 22) for loading into the drive. In Figure 5-12, you find the tree structure of the Library mode menu.

In combination with Sequential mode, you can turn on two additional modes:

Autoload Sequential mode with autoload mode ON loads the first cartridge automatically if the library powers ON with an empty drive.

Loop Sequential mode with loop mode ON loads the cartridge in slot 1 after the cartridge in slot 22 has been filled and sent back to its home slot. This allows endless backup operations without user interaction.

You also define the number of *Active Slots* you want to assign in your library. Slots can be reserved so that they are invisible to the host. It might be necessary to set the number of active slots in order to match the number of available slots to the Independent Software Vendor (ISV) software licensing.

Note: When the IBM TS3100 Tape Library is connected to a System i, you must IPL the input/output adapter (IOA); otherwise, System i will not recognize the new mode.

You can connect the library to the host after setting up the library mode. Here are several considerations before you connect the library to the host. Two host connections are available: SCSI and the Fibre Channel connection.

5.8.3 SCSI Host Bus Adapter (HBA) support

For SCSI hosts, verify that the HBA of your server is supported. Check the IBM Interoperability Matrix, which you can find at:

`http://www-03.ibm.com/servers/storage/tape/resource-library.html#interoperability`

Select **TS3100 Tape Library** as shown in Figure 5-13.

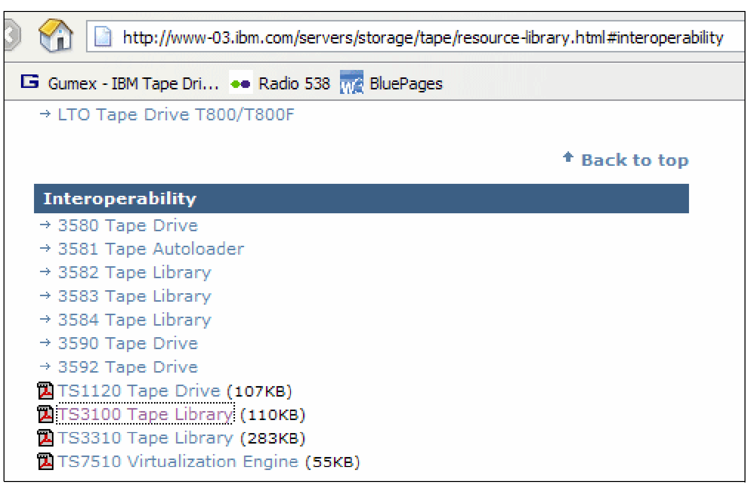


Figure 5-13 Interoperability Web site

The library uses a single SCSI or Loop ID per drive and dual logical unit numbers (LUNs) to control the tape drive (LUN 0) and library accessor (LUN 1). The library requires a host bus adapter (HBA) that supports LUN scanning. If it is not enabled, your host system will not scan beyond LUN 0 and will fail to discover the library. It will only see the tape drive.

Note: Some HBAs, such as RAID controllers, do not support LUN scanning.

If you daisy-chain the IBM TS3100 Tape Library, the last device on the bus must have a SCSI terminator installed. The IBM Ultrium 3 LVD tape device supports a bus length of 25 m (82 ft.) point-to-point and 12 m (39 ft.) using a multi-drop interconnection. For each daisy-chained device, you must reduce the maximum cable length by 0.5 m (1.6 ft.).

5.8.4 Fibre Channel (FC)

Make sure that the FC HBA of your server is supported. Check the IBM HBA Support Web site at:

http://www-03.ibm.com/servers/storage/support/config/hba/index.wss

Select **TS3100 (3573) with Ultrium 3 FCP drives**, as shown in Figure 5-14.

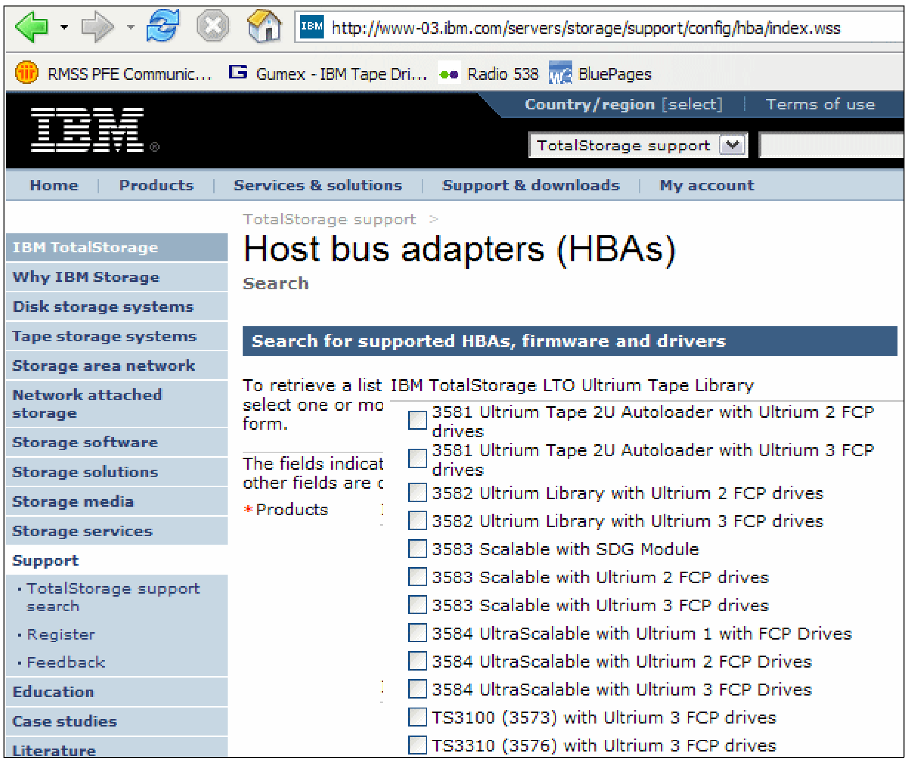


Figure 5-14 Fibre Channel HBA Support Web site

Another way to find out if your Fibre Channel Tape Drive is supported is to visit this Web site:

http://www-03.ibm.com/systems/storage/tape/ts3100/index.html

Figure 5-15 on page 139 shows the link to the IBM Technical Support Web site. Click **System Storage Interoperation Center** and follow the instructions.

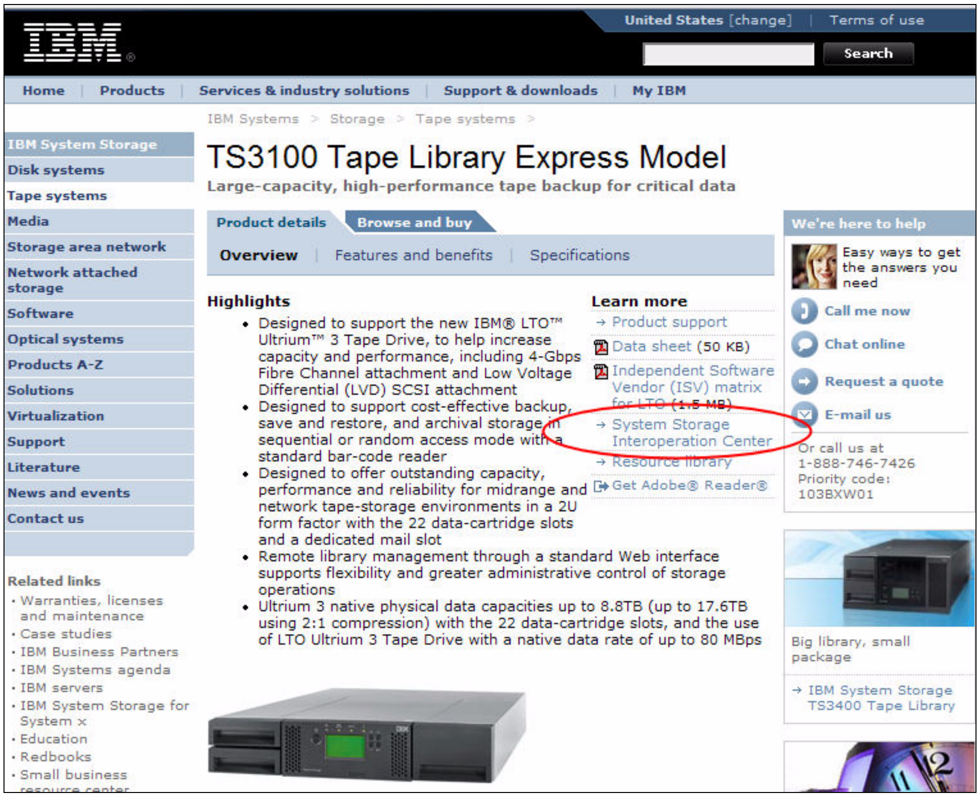


Figure 5-15 System Storage Interoperation Center TS3100

5.8.5 Serial Attached SCSI (SAS)

At the time of writing this book, there was no information available on the Web. Two HBAs however are supported:

- LSI Logic SAS3800X
- IBM SAS HBA Controller model 25R8060

5.8.6 Firmware

At installation time, verify that the most current firmware is installed for both the library and the tape drive. The IBM TS3100 Tape Library is designed as a Customer Setup Machine (CSU), and it is the customer's responsibility to have the current firmware. Determine the current level of firmware available from IBM Technical Support Web sites:

http://www.ibm.com/storage/lto

ftp://index.storsys.ibm.com

The preferred way to update the drive firmware is to use the Web User Interface to update the library and the drive firmware. The RMU or Web User Interface comes standard with the IBM TS3100 Tape Library. This provides a much simpler method for System i clients to update firmware than was previously available. The Field Microcode Replacement (FMR) function is not supported on the IBM TS3100 Tape Library.

An alternative way to update the drive firmware is to use the IBM Total Storage Diagnostic Tool (ITDT). This tool is supported on Windows, AIX, Sun, and Linux servers. You can download this tool from this IBM Web site:

`http://www-03.ibm.com/servers/storage/support/`

To locate the tool, search on *ITDT*.

The ITDT supports both SCSI and Fibre Channel drives. The ITDT does not use any installed device driver and is therefore also an excellent tool to use to test the drives. After the IBM TS3100 is connected to the host and the ITDT is started from a command prompt, the tool scans the bus, and it finds and displays all IBM LTO devices. You can also use tapeutil via the SCSI interface.

Using the ITDT, you can force dumps on a drive and have the output sent to an IBM Support Center for further analysis.

5.8.7 Cartridge magazines

The IBM TS3100 Tape Library has two removable magazines in the library. Magazine access can be password-protected. For safety reasons, the accessor motion stops when a magazine is removed.

You can release the magazines using the Operator Control Panel or the Web User Interface. In case the Operator Control Panel or Web User Interface-initiated process fails or the library no longer has power, a manual emergency release is available.

The I/O station is part of the left magazine. To open the I/O station, grasp the lower handle of the left magazine and gently pull the I/O station open. To close the I/O station, gently push it back into the left magazine.

Inserting cartridges into the IBM TS3100 Tape Library

The last task is now to insert cartridges into the IBM TS3100 Tape Library:

1. Unlock the cartridge magazines using the OCP or the Web User Interface.
2. Remove both magazines from the library.
3. Insert cartridges in the magazine. Do not store in the I/O station.
4. Insert cartridges in any slot of the right magazine.
5. Put both magazines back into the library.

5.9 Physical specifications

The TS3100 Tape Library is a medium-sized tape library with the following dimensions:

- Width: 44.74 cm (17.6 in.)
- Depth: 74 cm (29.1 in.)
- High: 8.76 cm (3.4 in.)
- Weight: With one drive and without media 15.59 kg (34.37 lbs.)

5.10 Feature codes

The IBM TS3100 Tape Library can be ordered with the optional features listed in Table 5-4 on page 141.

Table 5-4 Optional features

Feature code	Description
5096	LC-SC Fibre Channel Cable Interposer
5602	2.5 m VHDCI/HD68 SCSI Cable
5604	4.5 m VHDCI/HD68 SCSI Cable
5610	10 m VHDCI/HD68 SCSI Cable
5900	Transparent LTO Encryption. This feature provides license keys to enable SME and LME
6005	5 m LC/LC Fibre Cable
6013	13 m LC/LC Fibre Cable
6025	25 m LC/LC Fibre Cable
7002	Rack Mount Kit with Power Cord
8002	Universal Cleaning Cartridge
8043	Ultrium 3 LVD SCSI Tape Drive
8044	Ultrium 3 4 Gbps Fibre Channel Tape Drive
8046	Ultrium 3 Half-High LVD SCSI Tape Drive
8047	Ultrium 3 Half-High SAS Tape Drive
8106	Right Side Magazine Set
8143	Ultrium 4 Full-High LVD SCSI Tape Drive
8144	Ultrium 4 Full-High Fibre Channel Tape Drive
8145	Ultrium 4 Full-High SAS Tape Drive
8305	Data Cartridges (GEN3) 5-pack
8405	Data Cartridges (GEN4) 5 -pack
9848	Additional Rack to PDU Line Cord
9900	Encryption Configuration. This feature should be ordered when encryption will be used in the library. It includes publication updates with information about enabling and configuring the library to support encryption. This feature also provides an Encryption Key Manager (EKM) publication.

Table 5-5 lists the feature codes available for SAS attachment.

Table 5-5 SAS Feature Codes

Feature code/HVEC	Description	
5402	2 m SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5406	5.5 m SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5500	Mini-SAS/550x 4x Interposer	This feature provides a 1x4 interposer with mini-SAS/550x connections for connecting the library and drives.
5502	2 m Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5506	5.5 m Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
8405	Ultrium 4 Data Cartridges (5-pack)	This feature provides five unlabeled 800 GB data cartridges only with ordering the TS2340.

6

IBM System Storage TS3200 Tape Library

The IBM System Storage TS3200 Tape Library (Machine Type 3573 Model L4U) is a midrange level desktop or a rack-mounted unit (requiring four rack units of an industry standard 19 inch rack). The IBM TS3200 Tape Library operates in random or sequential mode. You can partition the IBM TS3200 Tape Library into a maximum of four logical libraries when four drives are installed. A mixture of a SCSI drive, a Fibre Channel drive, and a Serial Attached SCSI (SAS) drive is supported when the IBM TS3200 Tape Library is partitioned (but not within the same logical library).

The IBM TS3200 Tape Library supports both data path and control path failover when you install Feature Code (FC) 1682. The robotics inside the library move the cartridges from and to the drives so unattended backups can take place. The four standard removable magazines can store a total of 48 cartridges. The IBM TS3200 Tape Library comes with three I/O slots for importing and exporting cartridges.

The following IBM Ultrium Tape Drives are available for the TS3200 Tape Library:

- The IBM Ultrium 4 Low Voltage Differential (LVD) SCSI Tape Drive
- The IBM Ultrium 4 Fibre Channel (FC) Tape Drive
- The IBM Ultrium 4 Serial Attached SCSI (SAS) Tape Drive
- The IBM Ultrium 3 Half-High LVD SCSI Tape Drive
- The IBM Ultrium 3 Half-High SAS Tape Drive
- The IBM Ultrium 3 Full-High LVD SCSI Tape Drive
- The IBM Ultrium 3 Full-High FC Tape Drive

Up to four IBM Ultrium 3 Half-High Tape Drives or two IBM Ultrium 3 or 4 Full-High Tape Drives can be installed in the TS3200 Tape Library.

Tape Encryption is supported on the IBM Ultrium LTO4 Tape Drive with the SAS and Fibre Channel interface.

Standard features are a barcode reader and a remote management unit (RMU).

New in 2007, the TS3200 now supports Simple Network Management Protocol (SNMP).

6.1 TS2300 Tape Library description

Designed for tape automation, you can attach the TS3200 Tape Library to IBM System i or i5, iSeries, AS/400, IBM System p or p5, pSeries, RS/6000, IBM z or z9, xSeries, Hewlett-Packard (HP), Sun, UNIX, and PC servers. To determine the currently supported servers, visit the Web at:

http://www.ibm.com/storage/lto

This Web site shows you product details, and you can refer to the Interoperability Matrix.

The library capacity is 48 tape cartridges, providing a maximum native media capacity of up to 38.4 TB (76.8 TB with 2:1 compression) data storage per unit.

Depending on what IBM Ultrium Tape Drive is installed in the TS3200 Tape Library, you can use the following data cartridges:

- The TS3200 Tape Library uses the IBM TotalStorage LTO Ultrium 400 GB Data Cartridge when the IBM Ultrium 3 Tape Drive is installed. The Ultrium 3 Tape Drive has the capability of writing up to 400 GB native capacity and up to 800 GB with 2:1 compression. IBM Ultrium 3 Tape Drives can read and write LTO Ultrium 2 Data Cartridges and read LTO1 data cartridges.
- The TS3200 Tape Library uses the IBM TotalStorage LTO Ultrium 800 GB Data Cartridge when the IBM Ultrium 4 Tape Drive is installed. The Ultrium 4 Tape Drive has the capability of writing up to 800 GB native capacity and up to 1600 GB with 2:1 compression. IBM Ultrium 4 Tape Drives can read and write LTO Ultrium 3 Data Cartridges, can read Ultrium 2 Data Cartridges, and does not support Ultrium 1 Data Cartridges.

Seven models are available for the TS3200 Tape Library:

- The *3573-L4S* comes with an IBM Ultrium 4 LVD SCSI Tape Drive. The Ultrium 4 LVD SCSI drive has an LVD Ultra 160 SCSI interface that can be connected to LVD fast/wide adapters. The Ultrium 4 Tape Drive has a native data transfer rate of 120 MB/s.
- The *3573-F4S* comes with an Ultrium 4 Tape Drive with a 4 Gbps Fibre Channel interface. The Ultrium 4 Tape Drive provides a sustained native data transfer rate of 120 MB/s.
- The *3573-S4S* comes with a SAS Ultrium 4 Tape Drive that has a SAS interface, which has a native data transfer rate of up to 3 Gbps. The SAS Ultrium 4 Tape Drive comes with an SFF-8088 interface. The Ultrium 4 Tape Drive provides a sustained native data transfer rate of 120 MB/s.
- The *3573-L32* comes with a Half-High Ultrium 3 LVD SCSI Tape Drive. This Ultrium 3 LVD SCSI Tape Drive has an LVD Ultra 160 SCSI interface. The Half-High Ultrium 3 Tape Drive provides a sustained native data transfer rate of 60 MB/s.
- The *3573-S32* comes with a Half-High Ultrium 3 SAS Tape Drive. The Half-High Ultrium 3 Tape Drive has a native data transfer rate of up to 60 MB/s.
- The *3573-F3H* comes with a Full-High Ultrium 3 LVD SCSI Drive. The Full-High Ultrium 3 Tape Drive has a native data rate of up to 80 MB/s.
- The *3573-L3H* comes with a Full-High Ultrium 3 4 Gbps Fibre Channel Tape Drive. The Full-High Ultrium 3 Tape Drive has a native data rate of 80 MB/s.

Figure 6-2 on page 146 shows the front view of the TS3200 Tape Library with the cartridge magazines on the left and on the right sides.

Figure 6-1 IBM System Storage TS3200 Tape Library

6.2 Components

The TS3200 Tape Library has an improved robotic system that moves in the center of the unit. The standard barcode reader is on the picker, and the improved accessor makes the robotics extremely robust. Three I/O slots for importing and exporting cartridges are part of the lower left magazine.

This is a list of the primary components of the IBM TS3200 Tape Library:

- Two cartridge magazines are on the right side, and two cartridge magazines are on the left side. The I/O slots are part of the lower left magazine.
- Accessor

  This component contains the library robot and the barcode reader. The accessor moves cartridges to and from the:

  - I/O slots
  - Storage slots
  - Tape drives
- Library control card

  This component is a customer replaceable unit (CRU) and stores the user configuration information or vital product data (VPD). The Remote Management Unit (RMU) is embedded on this card also.
- Tape drive sled

  This library supports the Ultrium 3 and Ultrium 4 tape drives. The tape drive in the library is packaged in a container called the *drive sled*. The drive sled is a CRU, and it is designed for easy removal and replacement.
- Power supply

  The power supply is a CRU.

6.2.1 Robotics

The TS3200 Tape Library uses a new independent tape loader, threader motors, and a positive pin retention. These are designed to help improve the reliability of loading and unloading a cartridge and to retain the pin even if tension is dropped. An independent loader motor coupled with the positive pin retention is designed to thread the tape with a high level of reliability.

6.2.2 Barcode reader

The barcode reader is an integral part of the library accessor. The barcode reader provides inventory feedback to the host application, Operator Control Panel (OCP) display, and Web User Interface by reading cartridge barcode labels. The library stores the customized inventory data in memory.

6.2.3 Remote Management Unit

The Remote Management Unit (RMU) provides remote management to the library over a network. This function is imbedded in the Library Control Card. The library can be attached to the network using the 10/100 MB Ethernet port. The 10/100 MB Ethernet port can be in auto-negotiated or fixed mode for a 10 MB connection and use half and full duplex for the 100 MB connection. The Ethernet connection is located on the back side of the library.

When the IP address is set on the library using the OCP, you can monitor and control the library remotely. Entering the IP address in a browser opens a graphical representation of the library. You can perform service actions, such as upgrading the library and drive firmware, by using the remote management facility.

Figure 6-2 shows the Home page of the IBM TS3200 Tape Library Web User Interface. The graphical representation is processed on the Library Control Card.

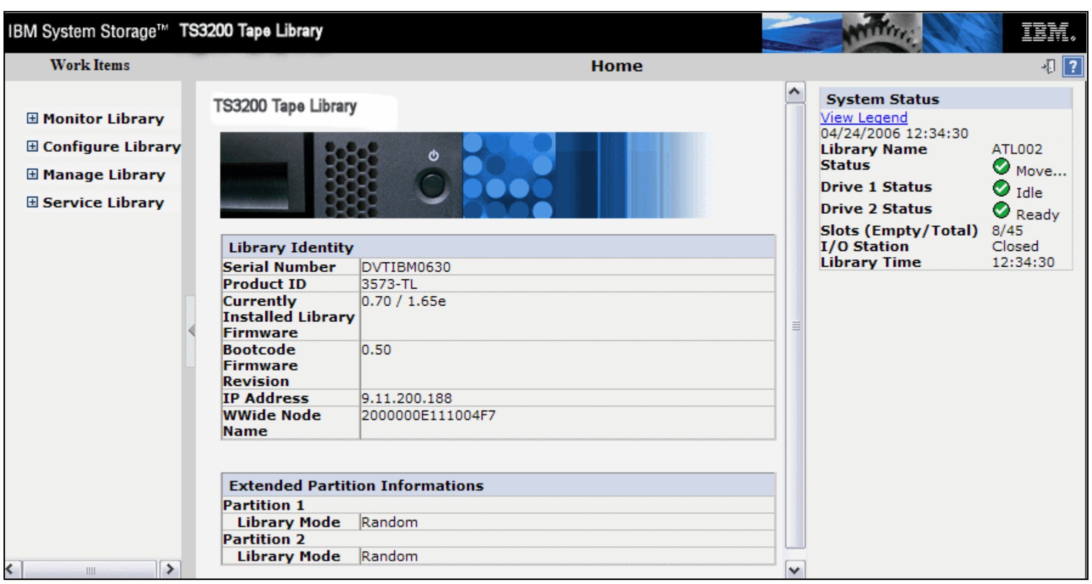


Figure 6-2 Home page of the IBM TS3200 Tape Library Web User Interface

6.3 Control and data path failover and load balancing

The TS3200 Tape Library can use path failover to help enhance availability. This optional feature provides automatic control path failover to a preconfigured redundant control path in the event that a host adapter or control path drive is lost. This works without stopping the current job in progress. AIX, SuSE Linux, Red Hat Linux, Solaris, HP-UX, and Windows for Fibre Channel attachments when you use the IBM tape device driver all support this function.

Figure 6-3 summarizes control path and data path failover with the TS3200.

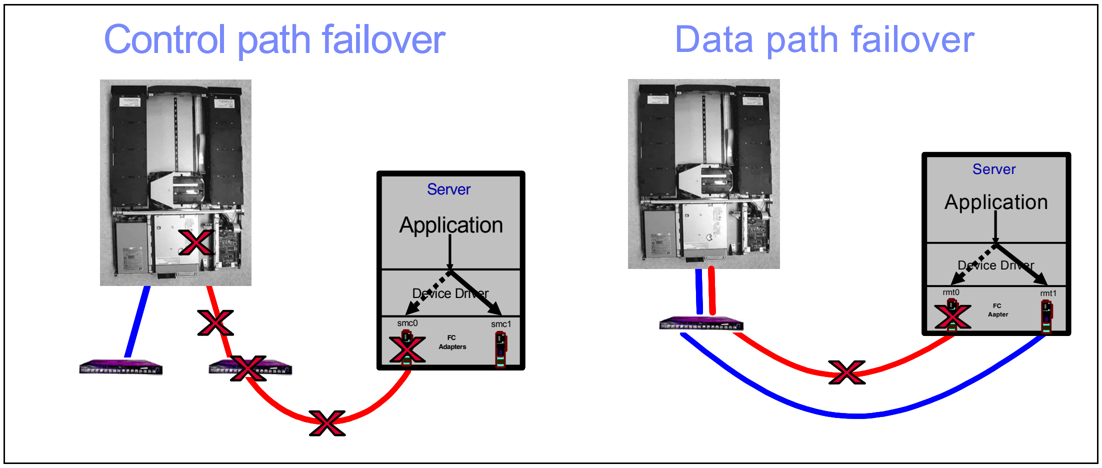


Figure 6-3 Control path and data path failover

As shown on the right side of Figure 6-3, data path failover and load balancing support native Fibre Channel Ultrium 3 and Ultrium 4 Tape Drives in the Tape Library using the IBM tape device driver for AIX, SuSE Linux, Red Hat Linux, Solaris, and Windows. *Data path failover* is designed to provide a failover mechanism in the IBM device driver, which enables you to configure multiple redundant paths in a SAN environment. In the event of a path or component failure, the failover mechanism is designed to automatically provide error recovery to retry the current operation using an alternate, preconfigured path without stopping the current job in progress. This allows you flexibility in SAN configuration, availability, and management.

When accessing a tape drive device that has been configured with alternate pathing across multiple host ports, the IBM device driver is designed to automatically select a path through the host bus adapter (HBA) that has the fewest open tape devices, and assign that path to the application. This autonomic self-optimizing capability is called *load balancing*. The dynamic load balancing support is designed to optimize resources for devices that have physical connections to multiple HBAs in the same machine. The device driver is designed to dynamically track the usage on each HBA as applications open and close devices, and the device driver balances the number of applications using each HBA in the machine.

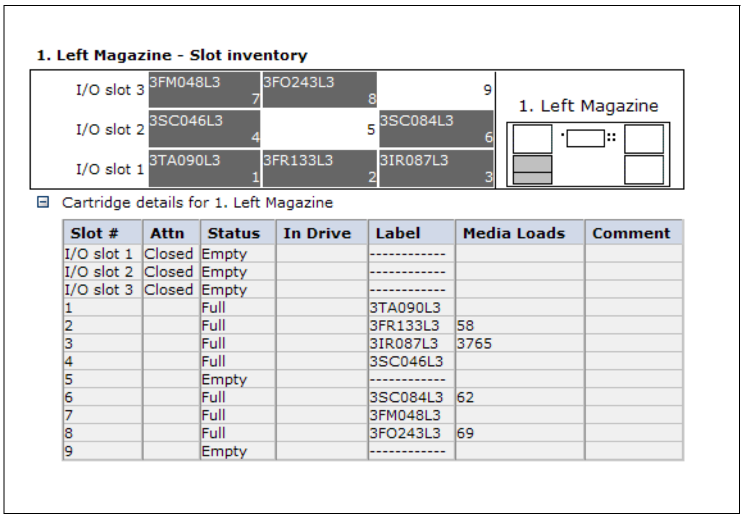
This can help optimize HBA resources and improve overall performance. Further, data path failover provides autonomic self-healing capabilities similar to control path failover. Data path failover is designed to fail over to an alternate data path in the event of a failure in the primary host-side path. Data path failover and load balancing for Ultrium 3 Tape Drives require the optional path failover FC1682.

You use the OCP to install the FC1682 code, which you must also install on the attached server. See the *IBM Ultrium Device Drivers Installation and User's Guide,* GA32-0430, for instructions how to install the Data path failover license key.

6.4 Cartridge storage

The IBM TS3200 Tape Library has four removable magazines in the library. The total number of storage cartridges is 48. The native maximum storage capacity is 38.4 TB, when using the Ultrium 4 data cartridges, and the maximum compressed capacity is 76.8 TB using 2:1 compression. The three Input/Output slots are part of the lower left magazine. Use the OCP or the Web User Interface to release the magazines. Magazine access is password-protected.

When the IBM TS3200 Tape Library fills up with cartridges, use the Web User Interface to show the inventory of each magazine. Figure 6-4 shows the inventory of the lower left cartridge magazine that is filled with seven cartridges. Note the three slot I/O station on the left.



Slot #	Attn	Status	In Drive	Label	Media Loads	Comment
I/O slot 1	Closed	Empty		------------		
I/O slot 2	Closed	Empty		------------		
I/O slot 3	Closed	Empty		------------		
1		Full		3TA090L3		
2		Full		3FR133L3	58	
3		Full		3IR087L3	3765	
4		Full		3SC046L3		
5		Empty		------------		
6		Full		3SC084L3	62	
7		Full		3FM048L3		
8		Full		3FO243L3	69	
9		Empty		------------		

Figure 6-4 Lower left magazine: IBM TS3200 Tape Library

6.5 IBM LTO Ultrium 4 Tape Drive

Each IBM Ultrium 4 Tape Drive contains the electronics and logic for reading and writing data, controlling the tape drive, managing the data buffer, and error recovery procedures. Because of its special design as a CRU, you can easily replace the drive if needed.

Figure 6-5 on page 149 shows the Ultrium 4 Tape drive sled with a SCSI interface. A similar drive sled is also used for the 4 GB Fibre Channel (FC) drive and the SAS drive.

6.5.1 Speed matching

To improve the performance of the LTO4 Tape Drive, the Tape drive uses a technique called *speed matching* to dynamically adjust its native (uncompressed) data rate to the slower rate of the server's HBA. The LTO4 Tape Drive is negotiating with the server's HBA, setting up a speed with the best performance. Six speeds are available when reading or writing the generation 3 or generation 4 cartridge format. Native rates are:

- Generation 3: 30, 40, 50, 60, 70, or 80 MB/s
- Generation 4: 30, 48, 66, 84, 103, or 120 MB/s

If the server is between two of the native rates, the drive calculates the appropriate data rate at which to operate. Speed matching reduces back hitching. Back hitching is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is usually the result of a mismatch between the data rates of the connected server and the tape drive.

6.5.2 Channel calibration

The channel calibration feature of the Ultrium 4 Tape Drive customizes each Read/Write data channel for optimum performance. The customization enables compensation for variations in the recording channel transfer function, media characteristics, and Read/Write head characteristics.

6.5.3 Sleep mode

To save energy, the LTO4 tape drives use a feature called *sleep mode*. To enter sleep mode, the LTO4 tape drive must be inactive for a minimum of 30 seconds. The LTO4 tape drive will go out of this sleeping mode again after receiving a SCSI command, a command across the Library/Drive interface (LDI or RS-422), or on a load or unload request. When in sleep mode, the drive response time to commands that do not require media motion increases by up to ten microseconds. Commands that require media motion might be delayed an additional 100 milliseconds, because the tape must be retensioned.

6.5.4 Power management

The Ultrium 4 Tape Drive's power management function controls the drive's electronics so that part of the electronics completely turn *off* when circuit functions are not needed for the drive's operation.

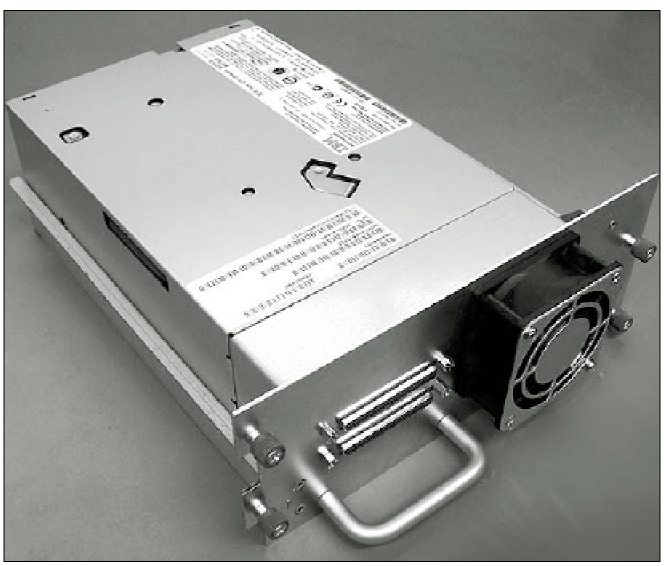


Figure 6-5 Ultrium Drive Sled

6.6 IBM Ultrium LTO3 Tape Drive

In this section, we summarize the IBM Ultrium LTO3 Half-High and Full-High tape drives.

6.6.1 Servo and track layout technology

There are 704 data tracks used to read and write data to the data cartridge. These tracks are grouped in five Servo bands.The high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

6.6.2 Magneto resistive head design

Magneto resistive (MR) head design, which uses flat lap head technology in MR heads for Ultrium 3, helps minimize contact, debris accumulation, and wear on the tape as it moves over the Read/Write heads.

6.6.3 Surface Control Guiding Mechanism

The IBM patented Surface Control Guiding Mechanism is designed to guide the tape along the tape path in the TS2300 Tape Drive. This method uses the surface of the tape, rather than the edges, to control tape motion. This helps reduce the tape damage (especially to the edges of the tape) and tape debris, which comes from the damaged edges and can accumulate in the head area.

6.6.4 Dynamic speed matching

The Ultrium 3 Tape Drive is designed to perform *dynamic speed matching* (at one of four speeds of 30, 40, 50, or 60 MB/s) to adjust the tape drive's native data rate as closely as possible to the net host data rate (after data compressibility has been factored out). This helps the number of backhitch repositions and improves throughput performance. Back hitching is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is usually the result of a mismatch between the data rates of the connected server and the tape drive.

6.6.5 Power management

The Ultrium 3 Ultrium Tape Drive power management function is designed to control the drive electronics to be either completely turned off or stay in a low-power mode when the circuit functions are not needed for drive operations.

Figure 6-6 on page 151 shows the interior of the TS3200 with four Ultrium 3 Half-High drives installed.

Figure 6-6 Interior of the TS3200 with four Ultrium 3 Half-High drives installed

Figure 6-7 shows the back side of the TS3200. In the upper two positions are SAS tape drives and in the lower two positions are LVD Ultra160 tape drives.

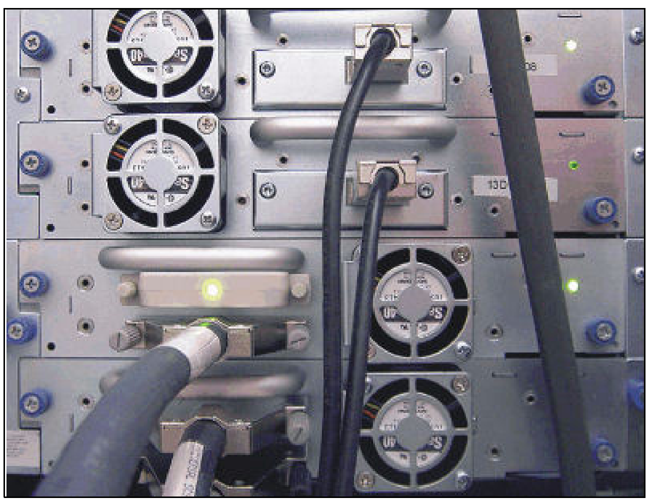


Figure 6-7 Back side of the TS3200

6.7 Physical attachments

The IBM TS3200 Tape Library is available with three interfaces:

- SCSI Ultra Fast/Wide 160 LVD
- Native Fibre Channel 4 Gbps
- SAS 3 Gbps

6.7.1 SCSI Ultra Fast/Wide 160 LVD

IBM LVD tape devices support a bus length of 25 m (82 ft.) point-to-point and 12 m (39 ft.) using a multi-drop interconnection (daisy-chaining). For each daisy-chained device, you must reduce the maximum cable length by 0.5 meters (1.6 ft.).

The Ultrium 3 drive uses shielded, VHDCI, 68-pin connectors and can attach directly to a 2-byte-wide SCSI cable.

The Ultrium 3 LTO drive provides a sustained native data transfer of 80 MB/s and can store up to 400 GB of uncompressed information on a single data cartridge.

Note: A faster bus does not imply that an attached device will support that data rate, but that multiple devices can operate on the bus at the maximum speed. To ensure the best performance, if possible, avoid daisy-chaining.

6.7.2 Native Fibre Channel 4 Gbps

Ultrium 3 and 4 Fibre Channel tape drives use LC duplex fiber optic cables. The maximum distances that the library supports on a Fibre Channel link is determined by the link speed, the type of fiber (50-micron or 62.5-micron), and the device to which the library is attached.

If the library attaches to a HBA, refer to the distances that are supported by the HBA. If the library attaches to a switch, the supported distances are:

- For a 50-micron cable:
  - 1 Gbit link speed = up to 500 m (1640 ft.)
  - 2 Gbit link speed = up to 300 m (984 ft.)
  - 4 Gbit link speed = up to 150 m (492 ft.)
- For a 62.5-micron cable:

  1 Gbit link speed = 175 m (574 ft.)
  2 Gbit speed link = 150 m (492 ft.)
  4 Gbit speed link = 70 m (230 ft.)

You can configure the 4 GB Native Fibre Channel drive port in the following methods:

- LN Port: (default setting) An automatic configuration that tries arbitrated loop first, then switched fabric
- L Port: Arbitrated loop
- N Port: Point-to-point protocol in a switched fabric topology

6.7.3 Serial Attached SCSI (SAS)

The SAS interface is new in the IBM Ultrium Tape Drive family and the IBM Ultrium 4 SAS Full-High Tape Drive comes with two SFF-8088 interfaces on the back of the tape drive. The IBM Ultrium 3 SAS Half-High Tape Drive comes with one SAS interface on the back of the drive. For a more detailed description of SAS, see “Serial-Attached SCSI” on page 53.

At the time of writing, two HBAs were supported:

- LSI Logic SAS3800X
- IBM SAS HBA Controller model 25R8060

Figure 6-8 on page 153 shows the back side of the SAS Full-High Tape Drive with two SFF-8088 interfaces.

Figure 6-8 Back side of the Full-High SAS Tape Drive

Figure 6-9 shows the back side of the SAS Half-High Tape Drive with one SFF-8088 interface.

Figure 6-9 Back side of the Half-High SAS Tape Drive

No terminator is needed, because the SCSI bus is automatically terminated.

6.7.4 Persistent binding

When a server boots up, it discovers devices and assigns SCSI target and LUN IDs. It is possible for these SCSI assignments to change between boots. Certain operating systems do not guarantee that devices are always allocated the same SCSI target ID after rebooting. Also, certain software depends on this association, so you do not want it to change. Persistent binding addresses the issue of SCSI ID assignment.

Persistent binding is an HBA function that allows a subset of discovered targets to be bound between a server and device. Implemented by a worldwide node name (WWNN) or worldwide port name (WWPN), persistent binding causes a tape drive's worldwide name (WWN) to be bound to a specific SCSI target ID.

After a configuration is set, it survives reboots and any hardware configuration changes, because the information is preserved. If a drive needs to be replaced, the new drive assumes the WWNN of the old drive because the WWNN for the drive is location-dependent within the library. Because the WWNN does not change, you do not need to change persistent binding, which causes an outage.

You can find additional information about persistent binding in *Implementing IBM Tape in UNIX Systems*, SG24-6502, and *Implementing IBM Tape in Linux and Windows*, SG24-6268.

6.7.5 Encryption

The LTO Ultrium 4 Tape Drive supports host Application-Managed Encryption (AME) and System-Managed Encryption (SME) using the T10 encryption method for SAS and Fibre Channel drives only. Tape Encryption is supported with LTO Ultrium 4 Data Cartridges only. Encryption is also supported for library firmware version 1.95 and higher.

The encryption-enabled drive contains the necessary hardware and firmware to encrypt and decrypt host tape application data. Encryption policy and encryption keys are provided by the host application or host server. A drive digital certificate is installed at manufacturing time. Encryption requires the latest device drivers that are available on the ftp download site:

ftp://ftp.software.ibm.com/storage/devdrvr/

The LTO Ultrium 4 encryption environment can be complex and requires knowledge beyond that of a product trained IBM service support representative (SSR). In the Tape Storage environment, the Encryption function on tape drives (desktop, stand-alone, and within libraries) is configured and managed by the client. In certain instances, IBM SSRs will be required to enable encryption at a hardware level when service access or service password controlled access is required.

Tape Encryption is available at no charge for AME. Feature Codes 5900 and 9900 must be ordered when you are planning to work with SME.

Note: The optional Transparent Encryption Key feature enabling System-Managed Encryption and Library-Managed Encryption is not available on TS3200 and TS3100 models purchased through High Volume (HVEC) channels.

6.8 LTO data cartridges

When processing the Ultrium 3 tape cartridge, the Ultrium 3 Tape Drive use a linear, serpentine recording format. The Ultrium 3 drive reads and writes data on 704 tracks and the Ultrium 4 drive reads and writes data on 896 tracks, sixteen tracks at a time. The Ultrium drive writes the first set of tracks from near the beginning of the tape to near the end of the tape. The head then repositions to the next set of tracks for the return pass. This process continues until it has written all tracks and the cartridge is full, or until all data is written.

To ensure that your IBM Ultrium Tape Drive conforms to IBM specifications for reliability, use only IBM LTO Ultrium tape cartridges. The IBM TotalStorage LTO Ultrium 400 GB Data Cartridge cannot be interchanged with the media used in other IBM non-LTO Ultrium tape products.

Identify the various generations of IBM TotalStorage Ultrium data cartridges by their color. See Table 6-1.

Table 6-1 Data cartridge colors for identification purposes

Data cartridge	Case color
Ultrium 4 WORM	Green top, platinum (silver gray) bottom
Ultrium 3 WORM	Blue top, platinum (silver gray) bottom
Ultrium 4	Green
Ultrium 3	Blue
Ultrium 2	Purple
Ultrium 1	Black

All four generations contain 1/2-inch, dual-coated, metal-particle tape. The native data capacity of Ultrium data cartridges is listed in Table 6-2 on page 155.

Table 6-2 Native capacity

Data cartridge	Native data capacity
Ultrium 4 WORM	800 GB (1600 GB at 2:1 compression)
Ultrium 3 WORM	400 GB (800 GB at 2:1 compression)
Ultrium 4	800 GB (1600 GB at 2:1 compression)
Ultrium 3	400 GB (800 GB at 2:1 compression)
Ultrium 2	200 GB (400 GB at 2:1 compression)
Ultrium 1	100 GB (200 GB at 2:1 compression)

6.8.1 Cartridge compatibility

Table 6-3 shows the compatibility of the four generations of Ultrium Data Cartridges.

Table 6-3 *Ultrium data cartridge compatibility*

IBM Ultrium Tape Drive	IBM TotalStorage LTO Ultrium Data Cartridge			
	800 GB (Ultrium 4)	400 GB (ultrium 3)	200 GB (Ultrium 2)	100 GB (Ultrium 1)
Ultrium 4	Read/Write	Read/Write	Read only	N/A
Ultrium 3	N/A	Read/Write	Read/Write	Read only
Ultrium 2	N/A	N/A	Read/Write	Read/Write
Ultrium 1	N/A	N/A	N/A	Read/Write

6.8.2 Write Once Read Many (WORM)

Certain records retention and data security applications require a Write Once Read Many (WORM) method to store data on tape. To meet this data storage requirement, a new WORM feature is available on IBM LTO Ultrium generation 3 drives. You can enable the WORM feature by upgrading to WORM-capable drive firmware and using a special WORM tape cartridge.

No physical hardware changes are required to make Ultrium 3 drives compatible with the WORM feature; however, you must install appropriate WORM-capable drive firmware.

WORM Media

Because standard Read/Write media is incompatible with the WORM feature, a specially formatted WORM tape cartridge is required with the worldwide cartridge identifier (WWCID), which comprises the unique Cartridge Memory (CM) chip serial number and the unique tape media serial number.

Data security on WORM media

Certain built-in security measures help ensure that the data written on a WORM cartridge does not become compromised, for example:

- The format of an LTO3 400 GB WORM or an LTO4 800 GB Tape Cartridge is unlike that of standard Read/Write media. This unique format prevents a drive that lacks WORM-capable firmware from writing on a WORM tape cartridge.

- When the drive senses a WORM cartridge, the firmware prohibits changing or altering user data already written on the tape. The firmware keeps track of the last appendable point on the tape.

6.8.3 Cartridge Memory chip (LTO-CM)

All generations of the IBM LTO Ultrium Data Cartridges include a Linear Tape-Open Cartridge Memory (LTO-CM) chip that contains information about the cartridge and the tape (such as the name of the manufacturer that created the tape), as well as statistical information about the cartridge's use.

The LTO-CM enhances the efficiency of the cartridge. For example, the LTO-CM stores the end-of-data location that enables the drive to quickly locate the next available recording area and begin recording the next time this cartridge is inserted and the Write command is issued.

The LTO-CM also aids in determining the reliability of the cartridge by storing data about its age, how many times it has been loaded, and how many errors it has accumulated. Whenever a tape cartridge is unloaded, the tape drive writes any pertinent information to the cartridge memory. The storage capacity of the LTO-CM is 4096 bytes for Ultrium 3 Data Cartridges and 8192 bytes for Ultrium 4 Data Cartridges.

6.8.4 Cleaning cartridge

A specially labeled IBM LTO Ultrium Cleaning Cartridge cleans the drive in your library. One ships with the IBM TS3200 Tape Library.

The drive itself determines when to clean a head and communicates this to the library. When the cleaning finishes, the drive ejects the cartridge and then takes the cartridge to place it back in its designated cleaning slot.

To remove a cleaning cartridge from its designated cleaning slot, export it from the library.

IBM Cleaning Cartridges are valid for 50 uses. The cartridge's LTO-CM chip tracks the number of times that the cartridge is used.

6.9 IBM TS3200 Tape Library setup

The following section provides you a global overview of the steps to implement, manage, and operate the IBM TS3200 Tape Library. We give you hints and tips. For a detailed description, follow the *IBM System Storage TS3100 Tape Library and TS3200 Tape Library Setup, Operator, and Service Guide,* GA32-0545.

After unpacking and installing the IBM TS3200 Tape Library, you must perform a few steps to connect it to a host.

6.9.1 User interfaces

There are two ways to configure the library: using the OCP and the Web User Interface. To complete the installation of the IBM TS3200 Tape Library, you use both the OCP and the Web User Interface. The OCP is located on the front panel of the library, and you access the Web User Interface via the Web browser. The Ethernet connection is located on the back of the IBM TS3200 Library.

Operator Control Panel interface

The Operator Control Panel operates in two modes:

- *User Interaction mode*: Employ this mode when a user presses buttons on the Operator Control Panel.
- *System Driven mode*: This is the normal mode of operation. In this mode, the OCP displays status associated with the actions that were caused by commands issued via the drive's internal (drive to library) serial interface.

When you press and release an OCP button, the OCP automatically transitions to User Interaction mode. User Interaction mode continues until three minutes after you stop pressing buttons, or the requested accessor action stops, whichever is longer. At which time, the OCP returns to System Driven mode.

If necessary, the Operator Control Panel automatically transitions to the System Driven mode. When this occurs, the library must remember what you were doing before the display mode changed. Therefore, the next button pressed only transitions the OCP to the User Interaction mode from the System Driven mode. In cases where you have the user security feature activated, the User Interaction mode is restricted to Login and Monitor menu items, until a user logs in with a correct password.

Web User Interface

You can perform many of the same operations from the Operator Control Panel or remotely using the Web User Interface. The Web User Interface lets you monitor and control your library from any terminal connected to your network or through the Web.

The Web User Interface hosts a dedicated, protected Internet site that displays a graphical representation of your library. After establishing a connection to the library, open any HTML browser and enter the IP address of the library. To configure the Web User Interface, you must set the IP address.

6.9.2 Configuring the IBM TS3200 Tape Library

One of the benefits of the IBM TS3200 Tape Library is the standard Remote Management Unit (RMU). The IBM TS3200 Tape Library can be configured and monitored, and the firmware of the library and the drive can be updated remotely. To access the IBM TS3200 Tape Library, RMU uses an Ethernet connection. For the initial setup, you can use the default configuration, which is:

- Dynamic Host Configuration Protocol (DHCP): **On**
- Network Address: **0.0.0.0**
- Drive ID:
  - **4** for the first SCSI drive or Fibre Channel drive
  - **5** for the second SCSI drive or Fibre Channel drive
- Library mode: **Random**

Making a direct connection to the IBM TS3200 Tape Library might require a crossover Ethernet cable.

Figure 5-12 on page 136 shows the Library Mode menu and the process flow to configure the TS3100 and is also valid for configuration of the TS3200 with one logical library.

Figure 6-10 on page 158 shows the Library Mode menu and the process flow for configuring the TS3200 with two logical libraries.

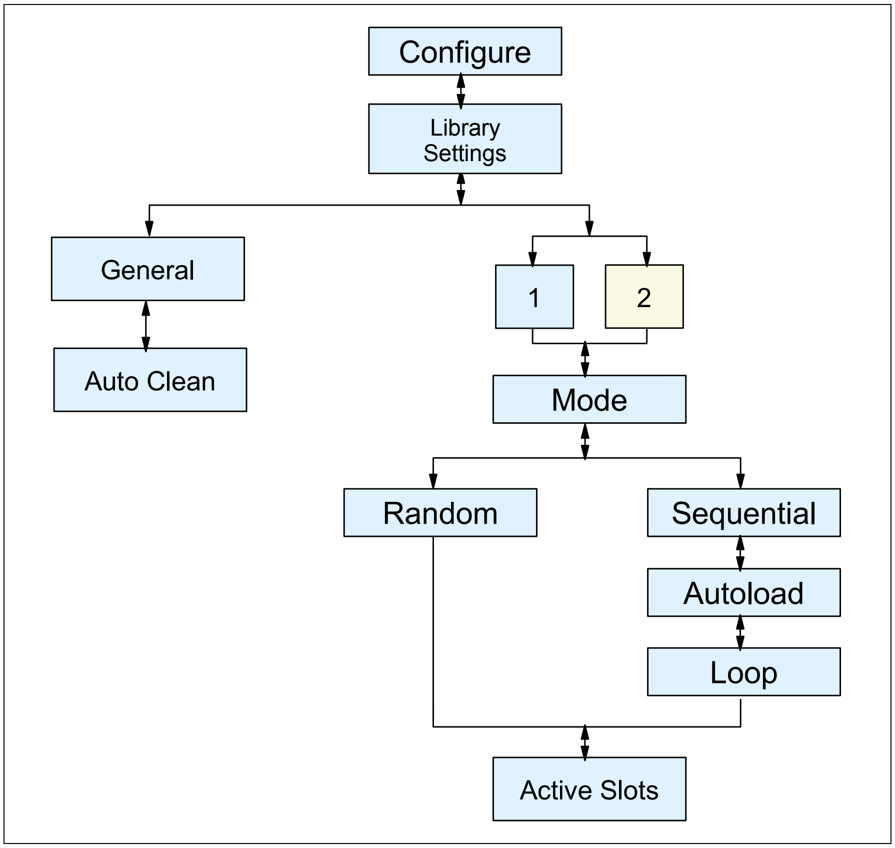


Figure 6-10 Library Mode menu for the IBM TS3200 Tape Library

From the Mode menu, you select the Library Mode for each of the logical libraries. Two library modes are available for the IBM TS3200 Tape Library:

- In *Random* mode, the library allows the server's (host's) application software to select any data cartridge in any order.
- In *Sequential* mode, the library's firmware predefines the selection of the cartridges. After initialization, the firmware causes the library to select the first available cartridge found (counting from 1) for loading into the drive. In Figure 6-10, you find the tree structure of the Library mode menu.

  In combination with Sequential mode, you can turn on two additional modes:

  Autoload Sequential mode with autoload mode ON loads the first cartridge automatically if the library powers on with an empty drive.

  Loop Sequential mode with loop mode ON loads the cartridge in slot 1 after the cartridge in the highest numerical slot has been filled and sent back to its home slot. This allows endless backup operations without user interaction.

You also define the number of *Active Slots* you want to assign in your library. You can reserve slots, so that they are invisible to the host. It might be necessary to set the number of active slots in order to match the number of available slots to the Independent Software Vendor (ISV) software licensing.

Note: When the IBM TS3200 Tape Library is connected to a System i, you must do an IPL on the I/O Adapter (IOA). Otherwise, System i does not recognize the new mode.

Partitioning the IBM TS3200 Tape Library

You can partition the IBM TS3200 Tape Library into a maximum of four logical libraries. A mixture of a SCSI drive, a Fibre Channel drive, or a SAS drive is allowed. All three types of attachment can be intermixed within the same logical library.

When there are four drives installed, and partitioning is set up for 4 logical libraries, then each logical library is assigned one magazine and the I/O slots are shared among the four logical libraries. If installed, the cleaning cartridge is also shared among the four logical libraries.

For detailed instructions about partitioning the IBM TS3200 Tape Library, see the *IBM System Storage TS3100 Tape Library and TS3200 Tape Library Setup, Operator, and Service Guide,* GA32-0545.

6.9.3 Host Bus Adapter (HBA) support

HBA support is available for SCSI attachment and for Fibre Channel attachment.

SCSI hosts

Before connecting the IBM TS3200 Tape Library to your host, make sure the installed HBA in your server is supported.

Note: SCSI adapters, which are part of the server's system board, are not supported.

Check the IBM Interoperability Matrix on the Web:

http://www-03.ibm.com/servers/storage/tape/resource-library.html#interoperability

- The library uses a single SCSI or Loop ID per drive and dual logical unit numbers (LUNs) to control the tape drive (LUN 0) and library accessor (LUN 1). The library requires an HBA that supports LUN scanning. If it is not enabled, your host system will not scan beyond LUN 0 and will fail to discover the library. It will only see the tape drive.

If the IBM TS3200 Tape Library is daisy-chained, the last device on the bus must have a SCSI terminator installed. The IBM Ultrium 3 LVD tape device supports a bus length of 25 m (82 ft.) point-to-point and 12 m (39 ft.) using a multi-drop interconnection. For each daisy-chained device, the maximum cable length must be reduced by 0.5 m (1.6 ft.).

Note: Some HBAs, such as RAID controllers, do not support LUN scanning.

6.9.4 Fibre Channel

If you want to connect the IBM TS3200 Tape Library to a Fibre Channel HBA, check the following Web site to see if the installed HBA in your server is supported:

http://www-03.ibm.com/systems/storage/tape/ts3200/index.html

Figure 6-11 on page 160 shows the IBM Technical Support Web site. To determine which HBA is supported, click **System Storage Interoperation Center** and follow the instructions.

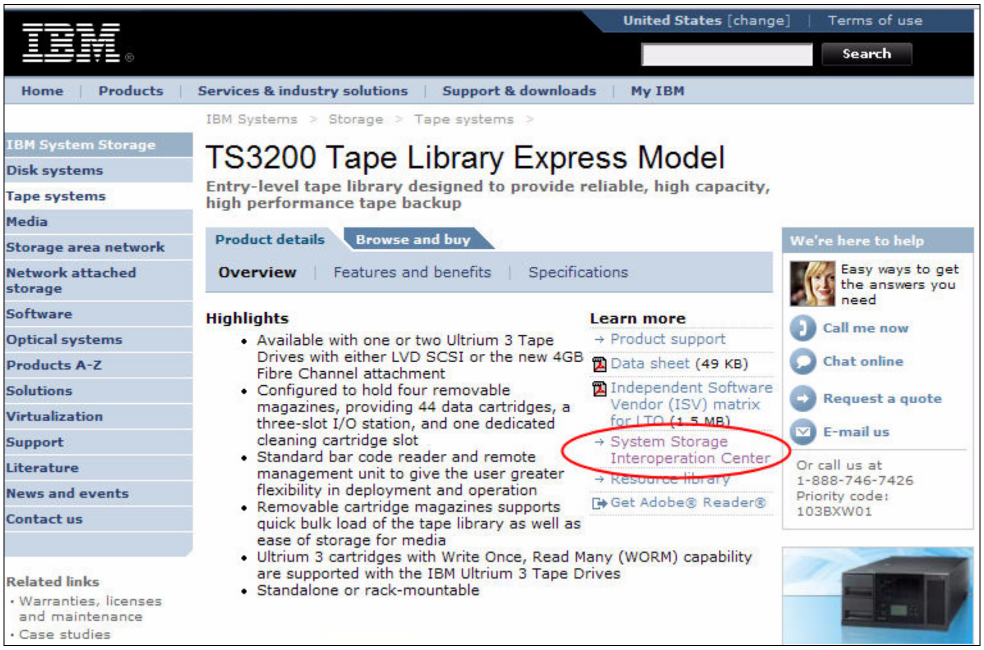


Figure 6-11   System Storage Interoperation Center

6.9.5 Firmware

At installation time, make sure that the actual firmware for the library and the drives is installed on your IBM TS3200 Tape Library. The IBM TS3200 Tape Library is designed as a Customer Setup Machine (CSU), and it is the customer's responsibility to have the current firmware installed. Determine the current level of firmware available from these IBM Technical Support Web sites:

http://www.ibm.com/storage/lto
ftp://index.storsys.ibm.com

The preferred way to update the firmware of the IBM TS3200 Tape Libraries is to use the Web User Interface for the library firmware and for the drives.

The RMU or Web User Interface comes standard with the IBM TS3200 Tape Library. This provides a much simpler method for System i clients to update firmware than was previously available. The Field Microcode Replacement (FMR) function is not supported on the IBM TS3200 Tape Library.

The IBM Total Storage Diagnostic Tool (ITDT) is an alternate way to update the drive firmware, take a dump of a drive, and to test the drive and library. This tool is supported on servers running Windows, AIX, Sun, and Linux. You can download this tool from this IBM Web site:

http://www-03.ibm.com/servers/storage/support/

To locate the tool, search on *ITDT*.

Both SCSI and Fibre Channel drives are supported. ITDT does not use any installed device driver and is therefore also an excellent tool for testing the drives. After the IBM TS3200 Tape Library is connected to the host and ITDT is started from a command prompt, the tool scans the bus, and it finds and displays all IBM LTO devices. Using tapeutil via the SCSI interface is also supported.

Using ITDT, you can force dumps on a drive and have the output sent to an IBM Support Center for further analysis.

6.9.6 Cartridge magazines

The IBM TS3200 Tape Library has four removable magazines. Magazine access can be password-protected. For safety reasons, the accessor motion stops when a magazine is removed or inserted.

Figure 6-12 shows the four removable magazines.

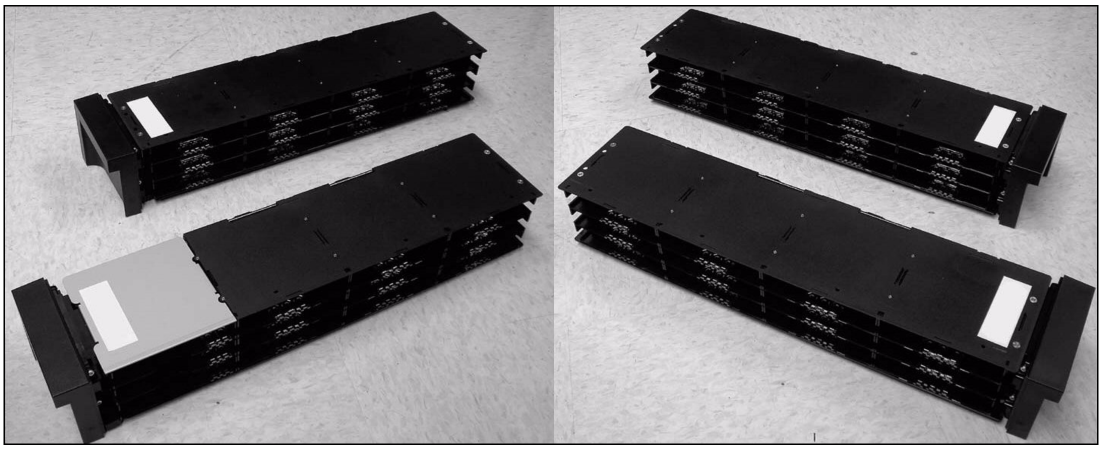


Figure 6-12 Left and right cartridge magazines of the TS3200 Tape Library

The magazines can be released using the OCP or the Web User Interface. In case the OCP or Web User Interface-initiated process has failed or the library no longer has power, a manual emergency release is available.

The I/O (Input/Output) station is part of the lower left magazine. To open the I/O station, grasp the lower handle of the lower left magazine and gently pull the I/O station open. To close the I/O station, gently push it back into the left magazine.

Figure 6-13 on page 162 shows the back side of the I/O station with the finger holes that allow you to push the cartridges out of the I/O station.

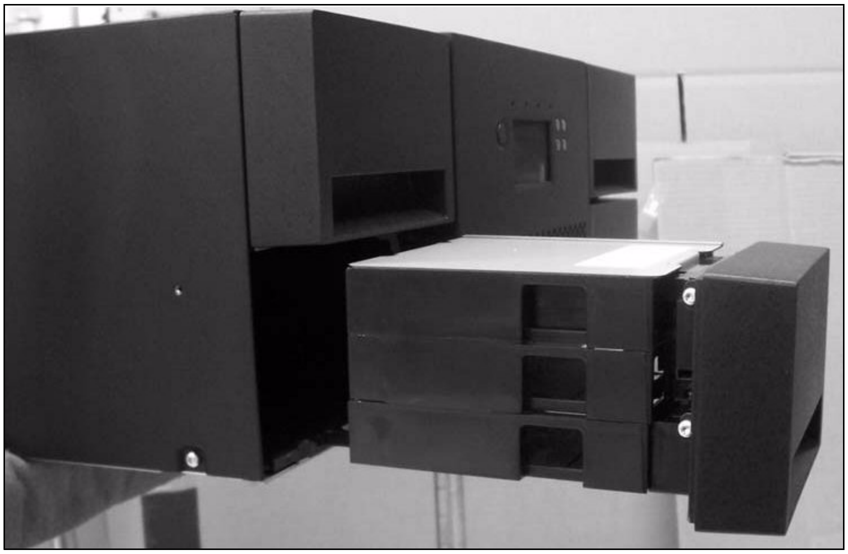


Figure 6-13 TS3200 I/O station in the lower left magazine

Inserting cartridges into the IBM TS3200 Tape Library

To insert cartridges into the IBM TS3200 Tape Library, follow these steps:

1. Unlock the cartridge magazines using the OCP or the Web User Interface.
2. Remove all magazines from the library.
3. Insert cartridges in the magazine. Do not store in the I/O slots or in the dedicated cleaning cartridge slot.
4. Insert the cleaning cartridge in the dedicated cleaning cartridge slot, which is the top slot of the back column of the lower left magazine. See Figure 6-6 on page 151 for the correct location.
5. Put all magazines back into the library.

6.9.7 Physical dimensions

The TS3200 Tape Library is a medium-sized library with the following dimensions:

- Width: Rack mount 44.75 cm (17.6 in.), stand-alone 44.75 cm (17.6 in.)
- Depth: Rack mount 74 cm (29.13 in.), stand-alone 81 cm (31.9 in.)
- Height: Rack mount 17.52 cm (6.9 in.), stand-alone 18.52 cm (7.3 in.)
- Weight with one drive and without media: 21.32 kg (47 lbs.)

6.9.8 Element addressing

To manipulate the media within the IBM TS3200 Tape Library, the host must reference each movement with a source and target destination. This is done using *element addressing*, which specifies which slots are used as target and destination.

6.10 Feature codes

You can order the IBM TS3200 Tape Library with the features shown in Table 6-4 on page 163. Refer to the product publications for detailed information.

Table 6-4 Features for the IBM TS3200 Tape Library

Feature code	Description
1682	Path Failover
1901	Additional Power Supply
5096	LC-SC Fibre Cable Interposer
5602	2.5 m VHDCI/HD68 SCSI Cable
5604	4.5 m VHDCI/HD68 SCSI Cable
5610	10 m VHDCI/HD68 SCSI Cable
5900	Transparent LTO Encryption. This feature provides license keys to enable SME and LME.
6005	5 m LC/LC Fibre Cable
6013	13 m LC/LC Fibre Cable
6025	25 m LC/LC Fibre Cable
7002	Rack Mount Kit with Power Cord
8002	Universal Cleaning Cartridge
8043	Ultrium 3 LVD SCSI Drive Sled
8044	Ultrium 3 4 GB Fibre Drive Sled
8046	Ultrium 3 Half-High LVD SCSI Tape Drive
8047	Ultrium 3 Half-High SAS Tape Drive
8143	Ultrium 4 Full-High LVD SCSI Tape Drive
8144	Ultrium 4 Full-High Fibre Channel Tape Drive
8145	Ultrium 4 Full-High SAS Tape Drive
8106	Right Side Magazine Set
8305	Data Cartridge (GEN3) 5-pack
9848	Additional Rack to PDU Line Cord
9900	Encryption Configuration. This feature must be ordered when encryption will be used in the library. It includes publication updates with information about enabling and configuring the library to support encryption. This feature also provides an Encryption Key Manager (EKM) publication.

Table 6-5 on page 164 lists the feature codes for SAS attachment.

Table 6-5 SAS feature Codes

Feature Code/HVEC	Description	
5402	2 m SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5406	5.5 m SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5500	Mini-SAS/550x 4x Interposer	This feature provides a 1x4 interposer with mini-SAS/550x connections for connecting the library and drives.
5502	2 m Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5506	5.5 m Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
8405	Ultrium 4 Data Cartridges (5-pack)	This feature provides five unlabeled 800 GB data cartridges only with ordering the TS2340.

7

IBM System Storage TS3310 Tape Library

The TS3310 Tape Library is a highly expandable Ultrium LTO library that allows you to start small with a 5U base unit available in desktop or rack-mounted configurations. Over time, as your need for tape backup expands, you can add additional 9U expansion modules, each of which contains space for additional cartridges, tape drives, and a redundant power supply. The entire system grows vertically. Currently, available configurations include the 5U base library module alone or with up to four 9U modules.

The TS3310 Tape Library offers a broad range of configuration possibilities. The smallest configuration includes a base unit with one to two LTO3 or LTO4 tape drives, 24 TB of native tape storage (30 slots), and 6 I/O slots. This will be upgradable to a fully configured rack-mounted library 41U high with up to 18 LTO3 or LTO4 tape drives, over 321.6 TB of native tape storage, and up to 54 I/O slots.

The new Serial Attached SCSI (SAS) IBM Ultrium 4 Tape Drive is also supported in the TS3310.

The IBM Ultrium LTO4 Fibre Channel and Serial Attached SCSI (SAS) tape drives are encryption capable and support Application-Managed Encryption (AME), System-Managed Encryption (SME), and Library-Managed Encryption (LME).

7.1 Product description

The IBM System Storage TS3310 Tape Library (TS3100 Tape Library) is a highly modular, vertically scalable library design offering:

- A 5U desktop or rack-mounted base module providing up to two IBM Ultrium 3 Tape Drives or two IBM Ultrium 4 Tape Drives, 30 storage slots, and six I/O slots.
- Up to four 9U expansion modules can be installed in each one providing up to 4 IBM Ultrium 3 Tape Drives or IBM Ultrium 4 Tape Drives and 92 storage slots, 12 of which you can optionally configure as I/O slots.
- IBM Ultrium 3 Tape Drive support, both SCSI Ultra160 Low Voltage Differential (LVD) and 4 Gbps native switch fabric Fibre Channel drives are supported and can be mixed in a physical library.
- IBM Ultrium 4 Tape Drive support 4 Gbps Fibre Channel and 3Gpbs SAS, which can be mixed in the physical library.
- Remote management is supported through a Web interface. Local management is done through a color touch panel.
- IBM patented Multi-Path Architecture with logical library support to share the library between multiple homogeneous or heterogeneous systems or applications.
- Support for a wide range of systems including System p, pSeries, System x, xSeries, System i, AS/400, RS/6000, Intel, Hewlett-Packard (HP), and Sun.
- Native SMI-S Support.
- A barcode reader.

Optionally, you can install the following features:

- Path failover for both control paths and data paths
- Capacity on Demand (COD) to non-disruptively provide extra capacity
- Redundant power supplies for each module
- Rack mounting

A fully expanded TS3310 Tape Library today occupies 41U of rack space and a potential maximum of 402 storage slots (160.8 TB of storage on Ultrium 3 media at native capacity, 169.6 TB at 2:1 compression, and 321.6 of storage on Ultrium 4 media at native capacity, 643.2 TB at 2:1 compression).

All configurations require one TS3310 Tape Library Model L5B base module. Expansion is provided through the addition of TS3310 Tape Library Model E9U expansion modules.

The TS3310 Tape Library supports all three encryption methods:

- Application-Managed Encryption is available at no charge
- Library-Managed Encryption is available with Feature Code 5900 and 9900
- System-Managed Encryption is available with Feature Code 5900 and 9900

7.1.1 TS3310 Tape Library Model L5B (Machine type 3576)

The base module, which you can see in Figure 7-1 on page 167, offers as standard:

- A Library Control Module (LCM) with remote management interface
- 30 Storage Slots
- Six I/O slots (configurable as storage slots if the library is expanded)

- A color touch-sensitive window Operator Panel for local management
- Cartridge handling robotics
- IBM patented Multi-Path Architecture with logical library support to allow the control of the library by one or multiple systems through multiple paths
- Native SMI-S 1.1 support
- Up to two Ultrium 3 or Ultrium 4 Tape Drives
- A power distribution unit (PDU). A second PDU is optionally available for redundancy.
- Path failover for data path and control paths can be enabled through a chargeable license.
- Licensing to enable the use of up to 82 storage slots (additional storage slots beyond the 30 present in the base module require an expansion module)

You can install the base module, shown in Figure 7-1, as a desktop, deskside, or frame-mounted device.

Figure 7-1 Front view of TS3310 Tape Library Model L5B

7.1.2 TS3310 Tape Library Model E9U (Machine type 3576)

You can stack an expansion module above or below the base module (seen in Figure 7-2 on page 168). This has the following features:

- There are 80 storage slots and 12 I/O slots. The I/O slots can be configured to be storage slots.
- Up to four Ultrium 3 or Ultrium 4 Tape Drives.
- A Power Distribution Unit (PDU). A second optional PDU is available for redundancy.
- There are 46 of the total slots in the first expansion module, which are immediately usable (owing to the licensing which was provided with the base module). The rest can be non-disruptively enabled by installing a license for Capacity Expansion (Feature Code 1682). Subsequent expansion modules require Capacity Expansion features to enable the use of storage slots in increments of 46.
- A 5U base module and one 9U expansion module can be installed as either a deskside device or in a rack. If two 9U expansion modules are installed, they must be rack-mounted.

Figure 7-2 Front of TS3310 Tape Library 41U

7.2 Library expansion

As we described earlier, the base library can be “scaled up” with the addition of expansion modules. Regardless of the number of expansion modules, the TS3310 Tape Library uses a single robust “flow through” design robotic system to access all drives and media. It never requires complex pass-through ports or elevator systems. This removes the need for expensive duplication of robotics and control electronics with each library expansion. It also results in more reliable operations.

Expansion modules can be implemented above or below the base module and approximately 2.5 hours are required from start to finish. When multiple expansion modules are used, they can be installed around the base module if desired.

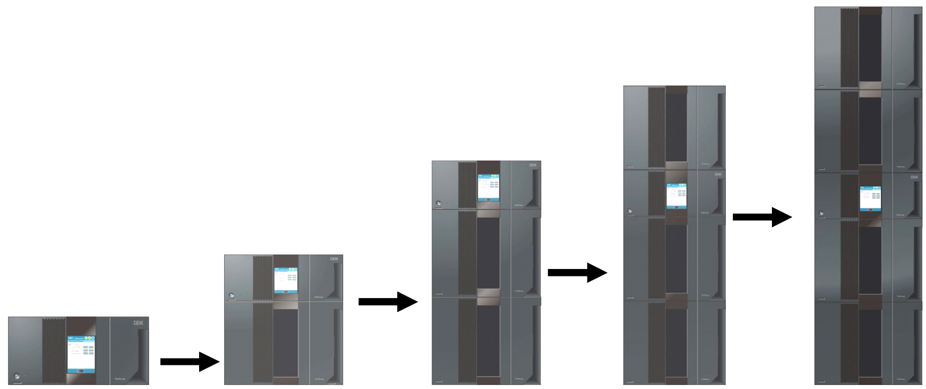


Figure 7-3 TS3310 expansion path

The addition of each expansion module provides a total of 92 storage slots, which are enabled through the use of “Capacity on Demand” licenses. Note that the base module ships with licensing for 82 slots. This effectively means that when you add the first expansion module, half the slots are immediately available without the requirement to acquire additional licenses.

You can configure the I/O slots in each module as a group to operate as I/O slots or storage slots (at least one group must operate as I/O slots). This provides a high degree of flexibility. In a library configuration of one L5B base unit and one 9EU expansion unit, for example, there are three possible combinations:

- A total of 6 I/O slots (all in the base module)
- A total of 12 I/O slots (using the slots in the expansion module)
- A total of 18 I/O slots (using the slots in the base module and the expansion module)

Expansion of the TS3310 Tape Library is very granular and highly configurable. Table 7-1 demonstrates the many configuration options available as the base module expands.

Table 7-1 Library configurations showing I/O slots, storage slots, and drive combinations

Library configuration	Number of available I/O station slots*	Number of accessible storage slots	Total slots**	Number of Expansion License Keys
5U library (control module)	6	30	36	No license key required
14U library (control module + 9U expansion module)	6/12/18	76/70/ 64	82	No license key
	6/12/18	122/116/110	128	One license key required to enable the full capacity of a 14U library

Library configuration	Number of available I/O station slots*	Number of accessible storage slots	Total slots**	Number of Expansion License Keys
23U library (control module + 2 9U expansion modules)	6/12/18/24/30	122/116/110/104/98	128	No license key
	6/12/18/24/30	168/162/156/150/144	174	Each license key enables full capacity of one 9U expansion module
	6/12/18/24/30	212/206/200/194/188	218	Two license keys required to enable the full capacity of a 23U library
32U library (control module + 3 9U expansion modules	6/12/18/24/30/36	168/162/156/150 144/138	174	No license key
	6/12/18/24/30/36	212/206/200/194 188/182	218	Each license key enables full capacity of one 9U expansion module
	6/12/18/24/30/36	260/254/248/242 236/230	266	Two license keys enable an additional 46 slots on each of two 9U expansion modules
	6/12/18/24/30/36	304/298/292/286 280/274	310	Three license keys required to enable the full capacity of a 32U library

Library configuration	**Number of available I/O station slots***	**Number of accessible storage slots**	**Total slots****	**Number of Expansion License Keys**
41U library (control module + 4 9U expansion modules)	6/12/18/24/30/36/42	212/206/200/194 188/182/176	218	No license key
	6/12/18/24/30/36/42	260/254/248/242 236/230/224	266	Each license key enables full capacity of one 9U expansion module
	6/12/18/24/30/36/42	304/298/292/286 280/274/268	310	Two license keys enable an additional 46 slots on each of two 9U expansion modules
	6/12/18/24/30/36/42	352/346/340/334 328/322/316	358	License keys enable an additional 46 slots on each of three 9U expansion modules
	6/12/18/24/30/36/42	394/388/382/376 370/364/358	402	Four license keys required to enable the full capacity of a 41U library
*The I/O station in the 9U expansion module contains 12 slots that can be configured as either I/O or storage slots. If the 9U expansion module I/O slots are configured as I/O, the control module slots can be configured as storage slots. **The number of available I/O and storage slots listed in the table above are adjusted for the unusable slots in each configuration that are not accessible due to space restrictions which limit the movement of the picker.				

7.3 Front panel components

Figure 7-4 on page 172 shows the front panel components of the TS3310.

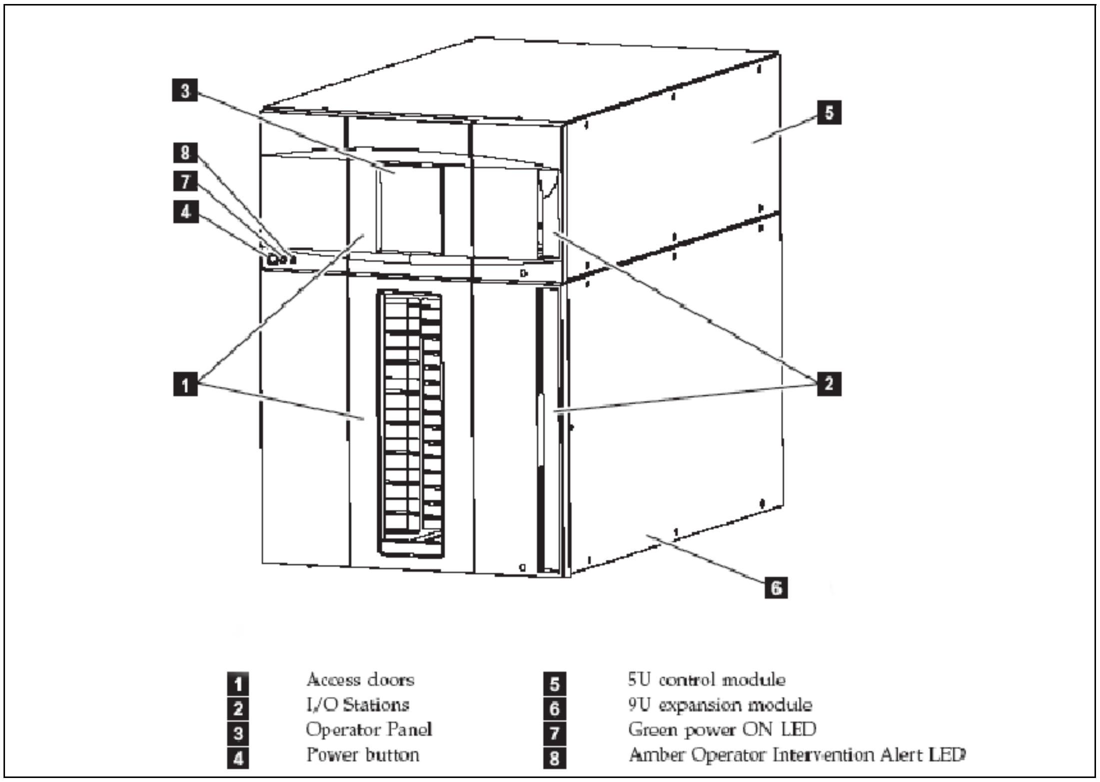


Figure 7-4 Elements visible in the front view of a 14U library configuration

All library configurations include the base module. The base module contains the robotics, library control blade (LCB), and touch-sensitive display. The base module also contains an I/O station, fixed storage slots, one or two tape drives, and one or two power supplies.

7.3.1 Expansion module

Like the control module, the expansion module also provides fixed storage slots, tape drive slots, and power supply slots. The I/O station in an expansion module can be configured as storage. If an expansion module contains only cartridges, all power is derived from the control module.

7.3.2 I/O station

I/O stations are located on the front panel of the library and enable inserting and removing cartridges without interrupting normal library operations. A base module I/O station has a capacity of six cartridges. A 9U expansion module I/O station has a capacity of 12 cartridges.

When an operator places cartridges in the I/O station, the Operator Panel prompts to request Logical Library assignment. The operator must respond to this prompt within two minutes; otherwise, the library assigns the tapes instead to the physical library from which the host application will not have access. All cartridges in the I/O station are assigned as a group. That is, if an operator had cartridges for several logical libraries, the cartridges must be sorted into separate groups prior to being placed in the I/O station.

After an I/O station slot is assigned to a logical library, only that logical library can access that slot. The I/O station is shared among all logical libraries, but the I/O station slots are owned by one logical library at a time. In a 5U library, the six I/O station slots cannot be configured as storage.

7.3.3 Access door

Each base module and expansion module has a door on the front panel that allows access to the internal components of the library. This door is locked by the I/O station. To open the access door, you must first open the I/O station.

> **Note:** When any access door is opened, all in-progress motion commands stop, the picker lowers to the bottom of the library, and the library is taken offline (the library must be put back online manually). When the access door is closed, the library returns any media in the picker to its original storage slot.

7.3.4 Operator Panel

The Operator Panel is the touch-sensitive display device located on the access door of the control module. Library operations and service functions are performed from this display. The Web User Interface offers some of the same functionality as the Operator Panel via a Web browser, which enables remote access to the library. For more information on the Operator Panel and the Web User Interface, refer to 7.7, “Library Management” on page 178.

7.3.5 Power button

Pressing the Power button on the front panel of a control module turns the picker and Operator Panel ON or OFF; however, power is still applied to the power supplies. The Power button is used during library shutdown and to manually reboot the library.

7.3.6 Front panel LEDs

Two LEDs are located on the front of the library to the right of the Power button. The color indicates the problem area:

Green Power on LED. When lit, this LED indicates that the library power is ON.

Amber Operator Intervention Alert LED. When lit, this LED indicates that library, drives, or media Operator Interventions exist. To access the Operator Intervention, select **Tools** → **Operator Intervention** from the Operator Panel.

7.4 Rear panel components

Figure 7-5 on page 174 shows the rear view of a 14U (one base module and one expansion module) library and its main components.

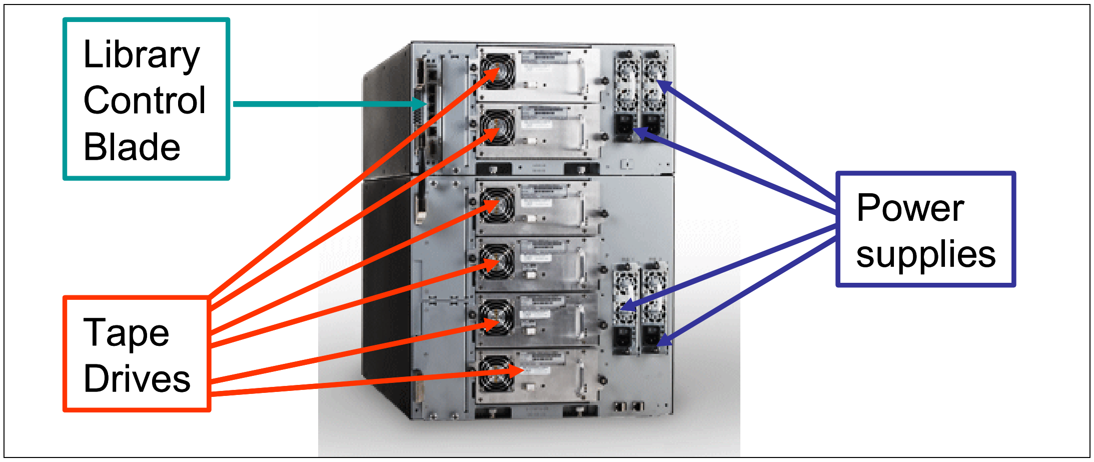


Figure 7-5 Rear panel view of 14U library

7.4.1 Library Control Blade (LCB)

The Library Control Blade manages the entire library, including the Operator Panel and picker, and is responsible for running system tests to ensure that the library functions properly. The LCB houses the Compact Flash Card, which stores vital product data (VPD), such as library settings, the serial number, and so forth. The LCB indicates status with three light emitting diodes (LEDs).

The LCB LEDs indicate status by the rate at which they blink. The color of the LED identifies the area of the component being reported:

- **Green**: Processor Status:

Solid ON	Processor not operating.
Solid ON for three seconds, then blinks twice	LCB firmware is downloading.
One blink per second	Normal: Processor operating.
Ten blinks per second	Identify mode.
Solid OFF	Processor not operating.

- **Amber:** Health Status:

One blink per second	Main processor not operating.
Solid OFF	Normal: Blade operational.

- **Blue:** Power Control Status:

Solid ON	Swap mode: LCB is powered down and can be removed.
One blink per ten seconds	Normal: LCB on.
Solid OFF	LCB not receiving power.

It is the combination of these LEDs and respective specific timing of their being ON that indicates a good or faulty status of the LCB. All three LEDs on solid ON for more than twenty minutes indicate a bad or corrupted compact flash.

7.4.2 Tape drives

The library supports Ultrium 3 SCSI and Fibre Channel tape drives and Ultrium 4 SAS and Fibre Channel tape drives. Tape drives are hot-addable (library power remains ON and operations of the installed tape drives are still active). Drives can be removed and installed without tools. The drive sled itself is a customer-replaceable unit (CRU).

SCSI tape drives are attached directly to a host. Fibre Channel tape drives can be directly attached to a host or a Storage Area Network (SAN). At the time of writing this book, SAS tape drives only supported a point-to-point connection from the tape drive to the server's HBA. Drives mounted in sleds are installed into tape drive slots in the rear of the library. If a tape drive slot is empty, a metal plate covers the empty drive slots to prevent debris from entering the library.

Figure 7-6 shows the back side of the SAS tape drive with two SFF-8088 interfaces.

Figure 7-6 The back side of the SAS tape drive

7.4.3 Power supply

The library supports single and redundant power configurations. A single power configuration has a power supply installed in the left slot of each library module. A redundant power configuration has power supplies installed in both slots of each library module. When using two power supplies in a single module, the power load is spread evenly over both power supplies. If one of the power supplies fails, the power load will be drawn entirely from the functioning supply.

The single configuration has a single AC line input and a single DC power supply. The optional redundant configuration has dual AC line input and dual DC power supplies. A power supply can be hot-swapped if the library has a redundant power supply. A redundant power supply can be hot-added. A power switch is located on every power supply on a control module and an expansion module. This switch is used to remove all power from the library for emergency and service situations. Except in emergency situations, use the shutdown procedure before switching off the power switch.

The power system of the library contains the following components:

- Power supply
- AC power cord

The power supply has three LEDs that provide status information. These LEDs, located to the right of the power switch, are green, amber, and blue in color.

- Green indicates a good AC or DC status.
- Amber indicates a degraded status.
- Blue indicates a fault status.

7.5 Interior components

Storage columns and the robotic system are located within the body of the library.

7.5.1 Storage columns

Storage columns within the library store cartridges while they are not loaded into a drive. The library contains six storage columns. One of those six columns is the I/O station.

7.5.2 Robotic system

The robotic system includes the Y-axis assembly that houses the Y motor, the picker which is attached to the carrier, and the barcode scanner. The climber moves the robotic system within the library. The picker (robotic arm) has fingers that enable it to grab tape cartridges and move them to and from the I/O station, storage slots, and drives. The barcode scanner reads each cartridge barcode label and the fiducial labels that identify the types of cartridge magazines and tape drives installed in the library.

7.6 Optional features

The TS3310 Tape Library is highly configurable, and enhanced functionality is available through the provision of optional features.

7.6.1 Ultrium 3 Tape Drives

This library supports the Ultrium 3 Tape Drive. Each tape drive in the library is packaged in a container called a *drive sled*. The drive is a CRU, and it is designed for quick removal and replacement in the library. The IBM Ultrium 3 Tape Drive supports LVD Ultra160 or Fibre Channel interfaces. It features two HD68 connectors or one LC Fibre Channel connector (FC8042 for Fibre Channel or FC8037 for SCSI).

> **Note:** LTO-3 SCSI and Fibre Channel drives are allowed in the same physical library, but not in the same logical library.

Speed matching

To improve system performance, the Ultrium 3 Tape Drive uses a technique called *speed matching* to dynamically adjust its native (uncompressed) data rate to the slower data rate of the attached server.

Channel calibration

The channel calibration feature of the Ultrium 3 Tape Drive customizes each Read/Write data channel for optimum performance. The customization enables compensation for variations in the recording channel transfer function, media characteristics, and Read/Write head characteristics.

Power management

The Ultrium 3 Tape Drive's power management function controls the drive's electronics so that part of the electronics completely turn OFF when circuit functions are not needed for the drive's operation.

7.6.2 Ultrium 4 Tape Drives

This library supports the Ultrium 4 Tape Drive. Each tape drive in the library is packaged in a container called a *drive sled*. The drive is a CRU, and it is designed for quick removal and replacement in the library. The IBM Ultrium 4 Tape Drive supports SAS or Fibre Channel interfaces.

7.6.3 Speed matching

To improve the performance of the LTO4 Tape Drive, the tape drive uses a technique called *speed matching* to dynamically adjust its native (uncompressed) data rate to the slower rate of the server's host bus adapter (HBA). The LTO4 Tape Drive is negotiating with the server's HBA, setting up a speed with the best performance. Six speeds are available when reading or writing the generation 3 or generation 4 cartridge format. Native rates are:

- Generation 3: 30, 40, 50, 60, 70, or 80 MB/s
- Generation 4: 30, 48, 66, 84, 103, or 120 MB/s

If the server is between two of the native rates, the drive calculates the appropriate data rate at which to operate. Speed matching reduces back hitching. Back hitching is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is usually the result of a mismatch between the data rates of the connected server and the tape drive.

7.6.4 Channel Calibration

The performance of the LTO4 tape drive is further optimized by a feature called *channel calibration.* Channel calibration is the process in which the drive automatically customizes each Read/Write data channel to compensate for variations in the recording channel's transfer function, the media, the characteristics of the drive head, and so forth.

7.6.5 Sleep mode

To save energy, the LTO4 tape drives use a feature called *sleep mode*. To enter sleep mode, the LTO4 tape drive must be inactive for a minimum of 30 seconds. The LTO4 tape drive will go out of this sleeping mode again after receiving a SCSI command, a command across the Library/Drive interface (LDI or RS-422), or on a load or unload request. When in sleep mode, the drive response time to commands that do not require media motion increases by up to ten microseconds. Commands that require media motion might be delayed an additional 100 milliseconds, because the tape must be retensioned.

7.6.6 Redundant power supply

You can hot swap the optional redundant configuration power supplies (FC1900) without interrupting library operation. Each supply in a control module and expansion module includes its own input AC line cord. During redundant operation, each supply carries one-half the power load. If a line cord or power supply fails, the second supply sources the complete power load. Optionally, you can install a single power supply and line cord if redundant power is not required. The second power supply slot is physically covered in this configuration. The library can be upgraded to redundant power at a later time.

7.6.7 Feature licenses

A feature license controls the setting of feature-enabled flags that are based on a user input key and the library serial number that is stored in the library vital product data (VPD). A unique key exists for each library based on an encryption of the chassis serial number and a feature code. After a feature is enabled, it cannot be disabled. The library's serial number can only be assigned at the factory. The library uses feature licenses to enable the Capacity On Demand feature and the Path Failover feature.

Capacity expansion (FC1640)

At any time, the Capacity Expansion feature (FC1640) allows you to enable the unused storage slots within a library via a firmware license key. You can see the library's current configuration from the Operator Panel via the Capacity View home window and from the Web User Interface via **Monitor System** → **System Summary**.

Path failover (FC1682)

The Path failover feature includes the license keys for activating control path failover and data path failover.

Control path failover

A *control path* is a logical path into the library through which a server sends standard SCSI Medium Changer commands to control the logical library. Additional control paths reduce the possibility that failure in one control path will cause the entire library to be unavailable. Use of the control path failover feature further reduces that possibility.

Data path failover

Data path failover is designed to provide a failover mechanism in the IBM device driver, which enables you to configure multiple redundant paths in a SAN environment. In the event of a path or component failure, the failover mechanism is designed to automatically provide error recovery to retry the current operation using an alternate, pre-configured path without stopping the current job in progress. This allows you flexibility in SAN configuration, availability, and management.

The control path failover license key can be installed by using the Operator Panel: Select **Setup** → **License**. Or, you can use the Web User Interface: **Manage Library** → **Setting** → **Feature Licenses.**

Data path failover (DPF) requires a minimum of two paths from the host to a specific tape drive. It allows the IBM device driver to automatically fail over to a redundant path if there is a failure of a host bus adapter (HBA) or a SAN device between the host and the tape drive.

The DPF registration ID is not installed on the library. When needed, it is entered at the host.

For more information about installing the license key on the host, refer to *IBM Ultrium Device Driver Installation and User's Guide,* GA32-0430.

Tip: The Control Path Failover key is five digits and the Data Path Failover key is sixteen digits.

7.7 Library Management

The library has two interfaces for management:

- The Operator Panel for local management
- A Web User Interface (UI) for remote management

The Operator Panel is located on the front door of the control module (CM) and allows operators to work locally on the library using the touch panel. The Web UI allows users to view and perform several library functions from remote sites and is best viewed using Internet Explorer® 4.0 or higher.

The library is also SMI-S 1.1 compliant. This allows Storage Resource Management Applications, such as the IBM Total Productivity Center, to manage the library (along with other SMI-S compliant devices, for example, SAN switches and disk arrays) from a single location.

7.7.1 Operator Panel

The Operator Panel is physically attached to the front door of the base module. The user interface appears on the touch-sensitive LCD display of the Operator Panel for executing basic library management functions. Audible feedback, such as key click sounds, are generated when you touch a button on the touch-sensitive display.

To access the menus, you must first log in using the keyboard display, which appears when you touch the panel.

Note: To use the touch-sensitive display effectively, tap lightly to make your selections.

The first display shown is the welcome window (Figure 7-7). The welcome window provides tabular data about the capacity of the various areas of the library. Use this window to see a quick summary of the capacity of the library.

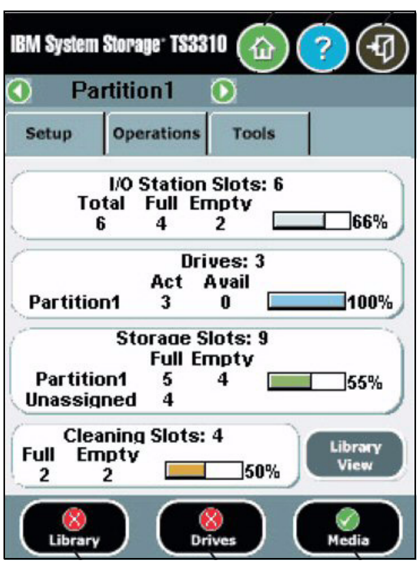


Figure 7-7 Operator Panel welcome window

System summary and subsystem status

You can gauge the health of the library by three subsystem status buttons located at the bottom of the home page. These buttons provide easy access to the health of the library for faster recovery if problems occur. You can select the buttons to view detailed information about the library and gain access to library subsystems. The three subsystems are:

Library	Opens a library menu selection window and then opens the operator interventions for the library.
Drives	Opens the operator intervention window for drives.
Media	Opens the operator intervention window for media.

Each button has three states indicated by color. The three states are:

- Good: Green
- Degraded: Yellow (An operator intervention has been created.)
- Investigate: Red (An operator intervention has been created; however, the library might still be operational.)

If users have access to more than one logical library, they can navigate to other logical libraries using arrows next to the logical library name at the top of the window. If an administrative user is logged in, a view of the physical library appears. If a user is logged in, the first logical library to which that user has access, in alphabetical order, appears.

Menus Available from the Operator Panel

The following three menus organize commands into logical groups:

- The **Setup menu** consists of commands that you can use to set up and configure various aspects of the library, including logical libraries' connectivity, network, physical library, users, date and time, licenses, and Simple Network Management Protocol (SNMP) trap registration.
- The **Operations menu** consists of commands that enable you to change the library's mode of operations, insert and remove cartridges, load and unload drives, move media, and shutdown and restart the library.
- The **Tools menu** consists of commands that you can use to maintain your library, such as viewing operator interventions, capturing the library snapshot, identifying ports, and updating firmware using a Field Microcode Replacement (FMR) cartridge.

Figure 7-8 on page 181 shows a menu tree showing all functions available from the Operator Panel interface.

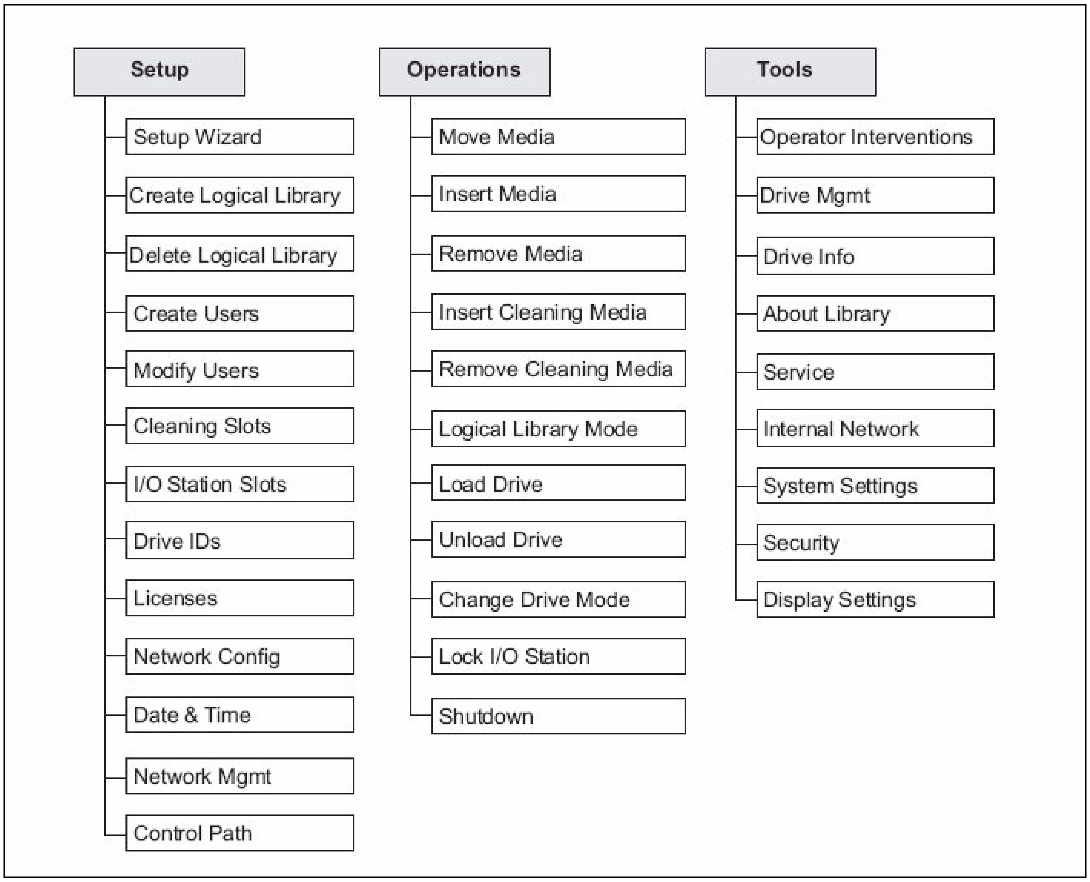


Figure 7-8 Operator Panel menu tree

7.7.2 Web User Interface

The Web User Interface (Web UI) is accessible from a Web browser and is best viewed using Internet Explorer 4.0 or higher. To manage the library using the Web UI, you must set up the initial network configuration of the library from the Operator Panel touch-sensitive display.

Logging in to the Web User Interface

To log in, you need the initial login information:

User: `admin`
Password: `secure`

> **Note:** Before exiting the Web UI, you must log out by clicking **LOGOUT** in the upper right corner of any Web UI interface window. Failure to log out can cause problems with your library.

Lightweight Directory Access Protocol Support (LDAP)

LDAP is the industry standard Internet protocol that provides centralized user account management. Enabling LDAP allows existing user accounts residing on an LDAP server to be integrated into the library's current user account management subsystem.

Administrative users can configure and enable LDAP. When LDAP is enabled, users can log on to the TS3310 using either LDAP or local authentication. Figure 7-9 on page 182 shows the IBM TS3310 Sign On window.

Figure 7-9 IBM TS3310 Sign On window

Menus available from the Web User Interface

Figure 7-10 lists the panels available from the Web User Interface.

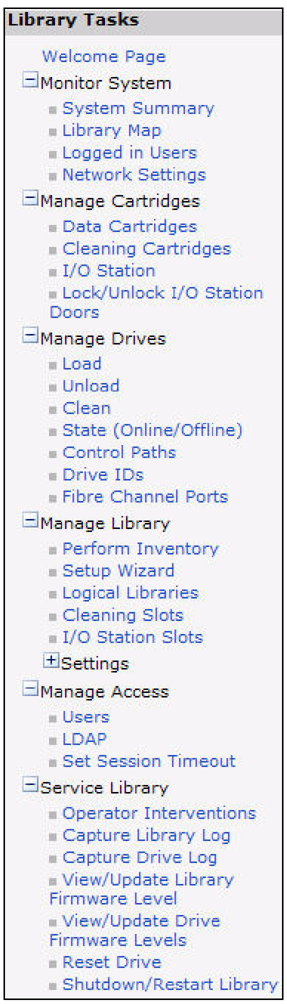


Figure 7-10 Web User Interface menu

Under **Settings**, additional important features are available, which include:

- Feature licenses
- Date and time
- E-mail notifications
- Outgoing server Simple Mail Transfer Protocol (SMTP) configuration
- Contact information
- Network
- SNMP
- SNMP traps
- Save and restore configuration

User privileges

User privilege levels are manually assigned to user accounts created within the library. Controlling access to windows and operations within the library preserves the integrity of the library and the data that is stored within the library.

There are two types of user privileges in the library:

- **Administrative users** are allowed access to the entire physical library and all of its logical libraries. One and only one administrator user must be assigned the login name `admin`.
- **Users** are allowed to operate a logical library, but not perform actions that affect the physical library.

User privileges include:

- A screen saver is invoked after ten minutes of inactivity on the Operator Panel. The Web User Interface (UI) does not use a screen saver. The User, Administrative user, or Service user, who is inactive between 10 and 30 minutes, returns to the last accessed window when activating the display again.
- Any logged in User, Administrative user, or Service user, who is inactive for more than 30 minutes, is logged out.
- Up to eighteen Users and one Administrative user can be logged in at one time on the Web UI. Only one user (Administrative or Service) can be logged in at one time on the Operator Panel. One Administrative user can disconnect another Administrative user.
- Any user can be logged in to only one interface at a time.
- When a Service user logs in, all other Users and Administrative users are logged out and notified that they cannot perform actions on the library. A message is posted that Service is logged in and no other users can access the library until after Service has logged out.

7.7.3 Native SMI-S support

Storage Management Initiative Specification (SMI-S) compliance is discussed in greater detail in “IBM tape libraries and SMI-S” on page 288. To summarize, the TS3310 Tape Library conforms to SMI-S 1.1 via an agent that is embedded within the library. SMI-S 1.1 conformance means that the TS3310 Tape Library adheres to the Storage Management Initiative Specification Version 1.1 defined by the Storage Network Interface Association (SNIA).

The purpose of the standard management interface is to allow multiple storage management devices (for example, SMI-S compliant tape libraries, disk arrays, and SAN switches) from many vendors to all be managed from a single Storage Resource Management Application, such as IBM Total Productivity Center.

In practice, the following type of information is visible:

Library Status, number of drives, number of changers, number of cartridges, number of slots, model, vendor, description, owner, contact, firmware version, element manager, lock present, locked state, and security breach state

Drive Status, needs cleaning, number of mounts, worldwide node name (WWNN)/ worldwide port name (WWPN), firmware version, and location

Changer Status, media-flip supported, WWNN/WWPN, and firmware version

I/O Port Extended state and location

Cartridge Label, capacity, type, whether cleaner media, whether dual-sided, location, and media description

In addition, you can start the native management tool, which in the case of the TS3310 Tape Library means the Web interface, from the Total Productivity Center.

7.7.4 Encryption

The TS3310 library supports host Application-Managed Encryption (AME), System-Managed Encryption (SME), and Library-Managed Encryption (LME) for SAS and Fibre Channel drives only. Data encryption is supported with LTO Ultrium 4 Data Cartridges only.

Application-Managed Encryption is available at no charge and at the time of writing this publication, Tivoli Storage Manager (TSM) was the only application that supports AME.

System-Managed Encryption and Library-Managed Encryption both need feature code 5900 and feature code 9900. FC5900 is a Transparent LTO Encryption Feature which provides a license key to enable SME and LME. FC9900 is a feature that must be ordered when encryption will be used in the TS3310. It includes publication updates with information about enabling and configuring the TS3310 to support Encryption. This feature also provides Encryption Key Manager (EKM) publications.

Before setting up Tape Encryption on the TS3310, you must already have installed your EKM on a server in your network. An EKM is needed when SME or LME will be configured.

Encryption can be set up for each logical library. For configuring encryption, log in to the TS3310 by using the Web User Interface and then select **Manage Library** → **Logical Library** and select the logical library you want to modify. After selecting the logical library, in **Modify Encryption Method,** select your preferred method and click **OK**. Figure 7-11 on page 185shows the types of encryption methods you can select.

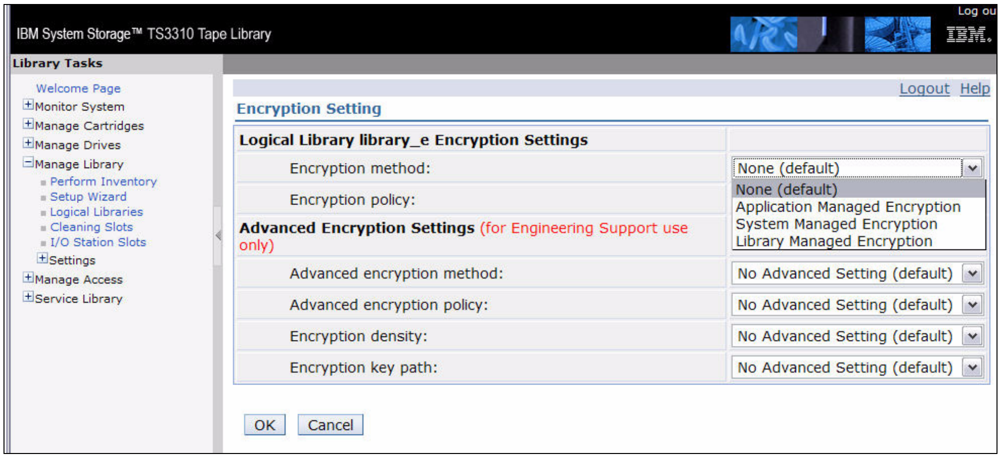


Figure 7-11 Selection Encryption method

Four options are available:

None No encryption is used on partition two

Application Managed Encryption
For encryption in operating environments that run an application capable of generating and managing encryption policies and keys. If you select Application Managed Encryption, no further configuration steps are necessary. At the time of writing the publication, the only application-managed capable application was Tivoli Storage Manager.

System Managed Encryption
For encryption in operating environments where no application is capable of key management runs, and encryption is set up implicitly through each instance of the IBM device driver.

Library Managed Encryption
For transparent encryption by the TS3310 Tape Library tape drive.

There is also an **Engineering Use Only** option available. This option is only for IBM Support personnel (under the direction of the drive development team) to provide a solution to an unforeseen problem or to support a unique configuration. These options are not intended for use by the client without the guidance of IBM Support.

For more detailed instruction about how to set up encryption on the TS3400, read the *IBM System Storage Tape Library Planning and Operator Guide*, GC27-2107.

Encryption requires the latest device drivers, which are available on the ftp download Web site:

ftp://ftp.software.ibm.com/storage/devdrvr/

7.8 Multi-path architecture

Multi-path architecture allows multiple systems to share the library's robotics without middleware or a dedicated server (host) acting as a Library Manager. The library is controlled through the same physical connection as that used for the tape drives. Multi-path architecture allows additional control paths and data paths to be configured for any one logical library.

This has a number of benefits:

- Eliminates the need for a separate dedicated control path to the library, removing a single point of failure.
- Allows for control path failover. If one control path is lost, for example, due to tape drive hardware failure, the library can still be operated through a different path without the need for manual intervention.
- Allows for data path failover. For example, if access to a drive via one HBA is lost, then a separate path can be used without the need for manual intervention.
- Allows the library to be partitioned into multiple logical libraries. Each system connected to the library (through the tape drives) considers that it has access to an entire library (rather than merely part of a physical library) and is unaware that the robotics are actually shared.

The Multi-Path Architecture is compliant with SCSI and Fibre Channel interfaces.

The library is certified for SAN solutions, such as LAN-free backup.

7.8.1 Using multiple logical libraries for library sharing

Multiple logical libraries are an effective way for the library to simultaneously back up and restore data from heterogeneous applications. For example, the library can be partitioned so that it processes:

- Commands from Application 1 (about Department X) in Logical Library A
- Commands from Application 2 (about Department Y) in Logical Library B
- Commands from Application 3 (about Department Z) in Logical Library C

In this configuration, the storage slots and drives in each logical library are dedicated to that library and are not shared among other libraries. Commands issued by the applications travel to the library through three unique control paths. Thus, the data processing for:

- Department X is confined to the storage slots and drives in Logical Library A
- Department Y is confined to the storage slots and drives in Logical Library B
- Department Z is confined to the storage slots and drives in Logical Library C

7.8.2 Using multiple control paths

In addition to creating multiple logical libraries, any logical library can be configured to have more than one control path. When configuring additional control paths, additional library sharing configurations and availability options are made possible. Access to the logical library is on a first-come, first-served basis and each control path for a logical library can accept commands while the library is in use by another control path. By default, a logical library can communicate with the server only through the first LUN-1-enabled drive that is installed in the partition. Note that Microsoft Windows 2000 Removable Storage Manager and Microsoft Windows 2003 Removable Storage Manager (RSM™) do not support multiple control paths within a logical library. We recommend that you disable RSM to use this feature.

To add or remove additional control paths, use the Operator Panel or the Web User Interface. For a particular logical library, you can enable as many control paths as there are drives in that logical library.

7.8.3 Using multiple control paths for control path failover

Command failures and time-outs are costly. You want your library to run smoothly and efficiently. To ensure continued processing, the library offers an optional control path failover feature that enables the host device driver to resend the command to an alternate control path for the same logical library. With control path failover installed, the alternate control path can include another HBA, SAN, or library control path drive. The device driver initiates error recovery and continues the operation on the alternate control path without interrupting the application. AIX, Red Hat Linux, SuSe Linux, Solaris, HP-UX, and Windows hosts are currently supported for this feature. The control path failover feature can be installed by the client.

Note: The control path failover feature is activated by a license key.

For more information about using the control path failover feature, see the *IBM Ultrium Device Drivers Installation and User's Guide,* GA32-0430.

7.8.4 Using multiple data paths for data path failover

Data path failover and load balancing exclusively support native Fibre Channel Ultrium 3 and Ultrium 4 Tape Drives in the library using the IBM device driver for AIX and Linux. Data path failover is designed to provide a failover mechanism in the IBM device driver, which enables multiple redundant paths to be configured in a SAN environment. In the event of a path or component failure, the failover mechanism is designed to automatically provide error recovery to retry the current operation using an alternate, preconfigured path without stopping the current job in progress. This allows flexibility in SAN configuration, availability, and management.

When accessing a tape drive device that has been configured with alternate paths across multiple host ports, the IBM device driver automatically selects a path through the host bus adapter (HBA) that has the fewest open tape devices and assigns that path to the application. This autonomic self-optimizing capability is called *load balancing*.

The dynamic load balancing support is designed to optimize resources for devices that have physical connections to multiple HBAs in the same machine. The device driver is designed to dynamically track the usage on each HBA as applications open and close devices and balance the number of applications using each HBA in the machine. This can help optimize resources and improve overall performance.

Furthermore, data path failover provides autonomic self-healing capabilities similar to control path failover, with transparent failover to an alternate data path in the event of a failure in the primary host-side path. Data path failover and load balancing for Ultrium 3 and Ultrium 4 Tape Drives require an optional feature, Data Path Failover Feature Code 1682. This is activated by installing a license key on the host.

7.9 Setup

The TS3310 Tape Library is a customer setup product (CSU). For detailed information about setup, refer to the *IBM System Storage TS3310 Tape Library Setup and Operator Guide*, GA32-0477. These steps are necessary to configure a newly installed library. Each step is explained in detail in the Setup and Operator Guide:

1. Log in to the Operator Panel.
2. Access the Setup Wizard.
3. Ensure that all hardware is installed.
4. Set up the library network configuration.
5. Enter license keys.
6. Assign cleaning cartridge slots.

7. Assign I/O station slots.
8. Assign logical libraries.
9. Set the date and time.
10. Import cleaning cartridges.
11. Populate your library with data cartridges.
12. Register for My Support.

The first time you turn on your library there is no need to log in. The Setup Wizard appears on the Operator Panel and guides you through the setup. The Setup Wizard times out after one hour. If this happens, you will be able to log back in to the library with the default Admin account. In addition, certain default configurations settings are made if you have not already specified them:

- Network settings will be DHCP-enabled.
- I/O station slots: **6**
- Cleaning cartridge slots: **1**
- Logical libraries: **1**

You can restart the Setup Wizard at any time after you log in.

7.10 Working with logical libraries

Logical libraries are virtual sections within a library that present the appearance of multiple, separate libraries for purposes of file management, access by multiple users, or dedication to one or more host applications. By default, the library has one logical library, which includes all of the library's resources.

There are two ways to create logical libraries:

- *Automatically* where the library divides the available resources equally among the number of logical libraries chosen.
- *Manually* where an administrative user assigns the number of slots per logical library. You can only do this through the Web User Interface.

> **Note:** When changing the logical library mode from online to offline, all host application commands in progress at the start of the mode change are completed.

Administrative users can create, modify, delete, and control access to all logical libraries. Users can be given access to only certain logical libraries and denied access to others. At a minimum, a logical library consists of one tape drive and one slot. The tape drive or slot cannot be shared with another logical library (an exception to the sharing restrictions are cleaning cartridges, which can be shared among all logical libraries). I/O station slots and cleaning slots are shared among all logical libraries. Each logical library is specific to a tape drive interface, for example, SCSI or Fibre Channel. Mixed media are allowed within logical libraries. For example, a logical library can contain LTO2 and LTO3 tape cartridges.

Automatically creating logical libraries

When the library automatically creates logical libraries, the available resources are divided equally among the number of logical libraries created. Prior to creating logical libraries, you must first designate the desired number of cleaning slots and I/O slots (if an expansion module is present). This is necessary because the Automatic Create Logical Library function divides all available storage slots among the chosen number of logical libraries.

From the Operator Panel, all remaining available resources are divided among the number of automatically created logical libraries. Use the Web UI to manually create logical libraries.

> **Note:** On the Web UI, all logical libraries must be deleted for the Automatic button to appear. If the Automatic button does not appear, delete all existing logical libraries.

Manually creating logical libraries

Every logical library must have at least one drive and one storage slot assigned to it. For example, if the library has two tape drives and 12 slots available, the maximum number of logical libraries that you can create is two. Up to 12 slots can be allocated between the two logical libraries in any configuration.

If the library has only one logical library with all resources assigned to it, that logical library must be deleted before reallocating resources to a new logical library.

You might need to provide information for the following fields:

- **Emulation Type** emulates the logical library.
- **Logical Library Name** can be up to a maximum of 12 alphanumeric characters.
- **Media Barcode Format** defaults to the last eight characters.
- **Automatic Drive Cleaning** is enabled by default and requires at least one cleaning cartridge and a communication interface to the tape drive with the ability of the tape drive to indicate that cleaning is needed.
- **Number of Slots** is the number of tape cartridge slots that are to be allocated to the new logical library.

Deleting logical libraries

A logical library can be deleted when it is no longer needed. After a logical library is deleted, its resources become unassigned and can be used to create additional logical libraries or added to existing logical libraries.

Changing logical library access

An administrative user can control which logical libraries a specified user can access. Do this by modifying a user’s account. To change logical library access, you must provide the following information:

- Password: This is a unique string of alphanumeric characters that can be viewed and modified by the Administrator.
- Privilege level: This is the level of library functions to which a user is assigned access.

Changing logical library modes

By default, the library has one logical library enabled. The logical library mode must be changed in order to modify the logical library or library. There are two logical library modes:

- Online: The normal operating condition for a logical library. In this mode, the robotics are enabled and all host application commands are processed.
- Offline: The logical library does not process any host application commands. If a logical library is taken offline, the physical library and other logical libraries are not affected.

You can take the physical library or any of its logical libraries online or offline. Certain operations require that the logical library is offline. Administrative users can take a logical library offline rather than the entire library in order to minimize disruption of library operations.

Administrative users must manually change the logical library mode to online or offline from the Operator Panel or the Web UI.

Details about changing logical library modes include:

- The default logical library mode is online.
- When you access these windows, only logical libraries accessible by the user appear.

When you are changing logical library mode, be aware of the following information:

- The Online/Offline button toggles between states.
- If a logical library is in use, the Online/Office button is grayed out.
- Set the button to read Online to take either the physical library or a logical library, depending on the current view, to an online state, which is the normal operating condition. In this mode, the robotics are enabled and all host commands are processed.
- Set the button to read Offline to take either the physical library or a logical library, depending on the current view, to an offline state. If only the physical library is taken offline, logical libraries will not process robotics commands, even though they are online. If only a logical library is taken offline, neither the physical library nor the other logical libraries are affected.

7.11 Operating procedures

For a full description of all operating procedures, refer to the *TS3310 Tape Library Setup and Operator Guide*, GA32-0477. This section discusses:

- Upgrading firmware
- Understanding cartridge assignment in libraries (loading and unloading cartridges)
- Using cleaning cartridges

7.11.1 Upgrading firmware

The following sections give you information about upgrading library and drive firmware.

Note: When updating firmware:

- Ensure all host applications are varied offline.
- Do not power off the drive until the update is complete, or the firmware can be corrupted.

Updating library firmware

Updating library firmware must be performed by Administrative users from the Web UI.

To update library firmware:

Download the latest level of library firmware to your host computer from this Web site:

http://www-1.ibm.com/servers/storage/tape/lto/

From the Web UI, select **Service Library** → **Update Library Firmware**.

Browse to the file on your computer, select the .tgz file that was downloaded from the IBM Web site, then click **Update Library Firmware**. The Web UI indicates when the operation completes. This means that the firmware file has been successfully moved from the host computer to the library.

Wait for the library to reboot before resuming normal library operations. It will be several minutes before the library reboots.

Important: After the update process starts, you must wait until the library reboots. Do not attempt to interrupt the process in any way, or the upgrade will not be successful.

Updating the library firmware takes approximately 30 minutes.

Updating drive firmware

The best way to update drive firmware is to use the driver's application interface, SCSI or Fibre Channel.

There are tools readily available to facilitate this process. The recommended tool, the IBM TotalStorage Tape Diagnostic Tool (ITDT), is available on the IBM Web site and requires no special device drivers. To download ITDT and instructions for using the tool, visit:

http://www-03.ibm.com/servers/storage/support/

ITDT is available for multiple platforms. Other tools, such as ntutil and TapeUTIL, can also be used for drive firmware updates. The library also supports drive firmware update by creating and using an Field Microcode Replacement (FMR) cartridge.

The recommended method to update drive firmware is:

1. Download the latest drive firmware to your host computer from this Web site:

   http://www-1.ibm.com/servers/storage/tape/lto/

2. Update all SCSI and Fibre Channel drives in the library by using ITDT.

Important: Be careful to select the correct firmware. There is different firmware to use for Fibre Channel drives, SCSI drives, and SAS drives.

Using ITDT to update drive firmware

A newly designed tool, ITDT, has multiple functional capabilities and is a quick, convenient, and efficient method for drive firmware updates. As a note, drive dump retrievals can be performed by the tool as well.

Here are several of the capabilities of this tool:

- Firmware update capability via SCSI to all IBM LTO Tape Drive products.
- The tool does not require any special device drivers.
- The tool is available for most major platforms (Windows, AIX, SUN, Linux, and NetWare).
- The tool is capable of uploading drive dump files.
- The tool's primary function is to thoroughly test a drive. However, if the library is online to the server or host where the tool resides, ITDT communicates with the drive through the library to load and unload a test cartridge, thereby exercising some library functions.
- The tool scans the SCSI bus to find and display for selection all IBM LTO devices. The tool does not display or allow for selection any non-IBM device.
- Each function has a Help selection that explains the required syntax, as well as a brief explanation of the particular function.
- A readme text file is posted with the .exe for a thorough explanation of initial tool download information from the Web, as well as an explanation of tool capabilities.

- The tool is currently a command line tool that you start by simply typing the executable name, `itdt`, from the directory where the tool is located.

Other methods for updating drive firmware

The procedure varies when updating drive firmware by using the SCSI or Fibre Channel SAS, depending on whether you use an IBM tape device driver or a non-IBM tape device driver (such as a driver from Sun, Hewlett-Packard, or Microsoft).

If using an IBM tape device driver, you can update drive firmware using the tapeutil or ntutil tools. These are explained in the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430.

> **Note:** Using the Web User Interface takes about 30 minutes to update 18 drives. The mechanism for updating the drives has been improved.

7.11.2 Understanding cartridge assignment in the library

When a cleaning data cartridge is placed in the I/O station, the library scans the I/O station, then a window displays asking the operator to assign the cartridge to "System" or to a logical library. Cleaning cartridges are assigned to "System" which makes them available to all drives regardless of the logical library to which the drive is assigned. Data cartridges are assigned to a logical library, which restricts them from being accessed by another logical library. A drive FMR cartridge placed in the I/O station for drive firmware update must also be assigned as a SYSTEM cartridge when the assignment window is presented after the I/O station door is closed. Selecting CANCEL or allowing the assignment window to time out will default all newly discovered cartridges in the I/O station to SYSTEM cartridges.

After a cartridge is assigned to "System" or to a logical library, the cartridge must be physically exported from the library to the I/O station, then moved to a different slot in the I/O station before it can be reassigned to a new destination within the library. If the cartridge is left in the same I/O station slot, the library will retain the same assignment, even if the I/O station door is opened and closed.

Cartridges that are placed in the I/O station *before* the library is powered ON will not have an initial assignment. To "force" an assignment window for newly discovered cartridges, the I/O station must be opened and then closed. Shuffling of the cartridges to different I/O station slots is not necessary. Cartridges that are assigned prior to power OFF and remaining in the same I/O station slots retain their original assignment.

7.11.3 Using cleaning cartridges

During the setup of the library, between one and four slots are assigned as cleaning slots. All cleaning cartridges must have "CLNXXX" as part of their barcode in order for the library's barcode scanner to recognize it as a cleaning cartridge.

Drives can either be cleaned by the library automatically as required or by an application. If using automatic library cleaning, the cleaning cartridge must be imported as follows:

- From the Operator Panel: **Operations** → **Import Cleaning Media**
- From the Web User Interface: **Manage Cartridges** → **Cleaning Cartridges**

If using an application to initiate tape drive cleaning, use the application itself to import the cleaning cartridge correctly. In Tivoli Storage Manager, you use a command similar to the following command when you have a single cleaning cartridge in one of the I/O ports:

```
checkin libvolume <library name> search=bulk status=cleaner checklabel=barcode
cleanings=10
```

Note the “cleanings” option. Check the documentation that came with your cleaning cartridge to determine the number of times this cartridge can be used.

> **Note:** Do not manually initiate drive cleaning unless requested by support engineers. LTO drives are self-cleaning and will require infrequent cleaning using cleaning cartridges.

After a cleaning cartridge expires, it is necessary to remove the cartridge from the library. If the library uses automatic cleaning, do this:

- From the Operator Panel: **Operations** → **Export Cleaning Media**
- From the Web User Interface: **Manage Cartridges** → **Cleaning Cartridges**

If the application controls drive cleaning, use the application’s own commands to eject the tape. In Tivoli Storage Manager, you enter the following command:

```
checkout libvol <library name> <label> remove=yes checklabel=no
```

7.12 Supported environments

For a current list of supported server platforms, operating systems, host bus adapters, SCSI adapters, and SAN switches, refer to the following Web site:

http://www.ibm.com/servers/storage/tape/lto

Locate the **TS3310** → **Product Details** → **Interoperability Matrix**.

The list of supported environments constantly changes. The details provided are current as of September 2007 but will rapidly become out of date. They are provided merely as an indication of the breadth of current support.

7.12.1 Supported server platforms

The TS3310 is supported on the following servers:

- Hewlett-Packard servers
- IBM System i, iSeries, and AS/400
- IBM System p, pSeries, and RS/6000
- IBM System z Linux and zSeries Linux
- IBM System x and Intel-based servers
- SUN servers

7.12.2 Supported operating systems

The TS3310 Tape Library is supported on the following operating systems at the minimum levels indicated:

- OS/400® V5R2 or later.
- i5/OS, V5R3, or later.
- AIX 5L V5.1, V5.2, V5.3, or later.

- Sun Solaris 9 and 10.
- Microsoft Windows 2000 (build 2195 or later).
- Microsoft Windows 2003 (build 3790 or later).
- HP-UX 11.0, HP-UX 11.11, and HP-UX 11.23PI. HP-UX patches can be required.
- Linux distributions:
  - Red Hat Enterprise Linux Version 4
  - SUSE Linux Enterprise Server 9
  - Asianux 2.0

7.12.3 Supported storage software

For a current list of host software versions and release levels that support the TS3310 Tape Library, refer to the following Web site and view the Interoperability Matrix:

http://www-03.ibm.com/servers/storage/tape/lto/lto_isv.html

The following Storage Software products support the TSM3310 Tape Library at the time of writing. However, we urge you to refer to the previous Web site to confirm supported levels, platforms, and prerequisites:

- BakBone Software: Netvault
- CommVault Systems: Galaxy
- CA: BrightStor ARCserve Backup
- EMC: Networker
- HP: OpenView Storage Data Protector 5.1 and 5.5
- IBM: BRMS
- IBM: Tivoli Storage Manager
- Symantec: Backup Exec
- Symantec: NetBackup

Tivoli Storage Manager and other offerings provide storage and tape management software for the TS3310. Tivoli Storage Manager supports the base unit from Version 5.2.7 and 5.3.2.

7.13 Specifications

This section provides details of the physical specifications and the operating environment for the TS3310 Tape Library.

7.13.1 Timings

The following timings are approximate and provided as merely indicative values:

To perform an inventory of a 5U library	1 minute
To perform an inventory of a 14U library	4 minutes
To mount a cartridge in a 5U library	15 seconds
To mount a cartridge in a 14U library	18 seconds
To unmount a cartridge in a 5U library	30 seconds
To unmount a cartridge in a 14U library	35 seconds

7.13.2 Physical specifications

Physical specifications are provided for both the L5B module stand-alone and the 14U library configuration.

Model L5B

A 5U library configuration has the following physical specifications:

- Width: 443.2 mm (17.45 in.)
- Depth: 801.4 mm (31.55 in.)
- Height: 219.7 mm (8.65 in.)
- Weight: 38.6 kg (85 lbs.).
- Maximum configuration: Two drives and two power supplies

Model L5B plus E9U

A 14U library configuration has the following physical specifications:

- Width: 443.2 mm (17.45 in.)
- Depth: 801.4 mm (31.55 in.)
- Height: 620.8 mm (24.44 in.)
- Weight: 88.5 kg (195 lbs.)
- Maximum configuration: Six drives and four power supplies

7.13.3 Operating environment

This list details the supported operating environment for all library configurations:

- Temperature: 10 - 38 degrees C (50 - 110 degrees F)
- Relative Humidity: 20 - 80 percent
- Maximum Wet Bulb (Caloric Value): 26 degrees C, 79 degrees F
- Electrical Power: 0.2 kVA
- Capacity of Exhaust: 54 cfm for 5U, 148 cfm for 9U
- Caloric Value: 0.68 kBTU/hr.
- Sound Power Level (LwAd): 6.2 Bels idle, 6.7 Bels operating
- Leakage current: 0.75 mA at 212 Vac per power supply

7.14 Feature codes

Table 7-2 identifies the model numbers and feature codes associated with the TS3310 Tape library. Table 7-3 on page 196 identifies the SAS feature codes.

Table 7-2 Machine type, model numbers, and feature codes

Description	Machine	Model	Feature	Comment
TS3310 Tape Library	3576 3576	L5B E9U	N/A	Base module Expansion module
Transparent LTO Encryption	N/A	N/A	5900	required for SME and LME
LTO Ultrium 3 Fibre Drive (4 Gb)	N/A	N/A	8042	LC interface. Cable required. See below.
LTO Ultrium 3 LVD Ultra-160 Drive	N/A	N/A	8037	HD68 interface. Cable required. See below.
LTO Ultrium 4 SAS Drive	N/A	N/A	8139	SFF-8088 interface

Description	Machine	Model	Feature	Comment
LTO4 Ultrium Fibre Channel drive	N/A	N/A	8142	Fibre Channel interface
Redundant Power Supply	N/A	N/A	1900	Optional. Each module shipped with one PDU, supports two.
Path Failover	N/A	N/A	1682	Optional
Capacity Expansion	N/A	N/A	1640	Optional
Rack mount kit	N/A	N/A	8006	Optional for 5U and 14U libraries. Required for larger libraries.
Encryption configuration	N/A	N/A	9900	Documentation for encryption
Library and Drive code update	N/A	N/A	0500	Optional. IBM will upgrade firmware as required.

Table 7-3 SAS feature Codes

Feature Code/HVEC	Description	Comments
5402	2 m SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5406	5.5 m SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5500	Mini-SAS/550x 4x Interposer	This feature provides a 1x4 interposer with mini-SAS/550x connections for connecting the library and the drives.
5502	2 m Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.

Feature Code/HVEC	Description	Comments
5506	5.5 m Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a mini-SAS (SFF-8088) connector on one end and a mini-SAS (SFF-8088) connector on the other end.
8405	Ultrium 4 Data Cartridges (5-pack)	This feature provides five unlabeled 800 GB data cartridges only with ordering the TS2340.

Power cords

The following power cord features are available:

- 9800 9-foot (2.8 m) Power Cord, 125 V, 15 A U.S./Canada
- 9820 9-foot (2.8 m) Power Cord, 250 V, 16 A (AC) France, Germany
- 9821 9-foot (2.8 m) Power Cord, 250 V, 11 A Denmark
- 9825 9-foot (2.8 m) Power Cord, 250 V, 13 A UK, China
- 9827 9-foot (2.8 m) Power Cord, 250 V, 6-16 A Israel
- 9828 9-foot (2.8 m) Power Cord, 255 V, 10 A Switzerland
- 9829 9-foot (2.8 m) Power Cord, 250 V, 16 A South Africa
- 9830 9-foot (2.8 m) Power Cord, 250 V, 10 and 16 A Italy
- 9831 9-foot (2.8 m) Power Cord, 250 V, 10 A Australia
- 9833 9-foot (2.8 m) Power Cord, 250 V, 15 A U.S./Canada
- 9834 9-foot (2.8 m) Power Cord, 250 V, 10 A Uruguay
- 9835 9-foot (2.8 m) Power Cord, 125 V, 15 A Taiwan
- 9840 9-foot (2.8 m) Power Cord, 250 V, 10 A China (PRC)
- 9841 9-foot (2.8 m) Power Cord, 250 V, 10 A Taiwan
- 9842 9-foot (2.8 m) Power Cord, 125 V, 12 A Japan
- 9843 9-foot (2.8 m) Power Cord, 250 V, 12 A Japan
- 9844 9-foot (2.8 m) Power Cord, 250 V, 12 A Korea
- 9845 9-foot (2.8 m) Power Cord, 250 V, 10 A India
- 9846 9-foot (2.8 m) Power Cord, 125 V, 10 A Brazil
- 9847 9-foot (2.8 m) Power Cord, 250 V, 10 A Brazil
- 9848 Rack to PDU Line Cord, 110 V, 10 A
- 9986 6-foot (1.8 m) Power Cord, 125 V, 15 A Chicago U.S./Canada

Fibre Channel cables

The LTO3 Fibre Channel tape drive has an LC connector. A cable will be required to connect this either directly to a system HBA or a switch. These feature codes are available:

- FC6005: 5 m LC-LC Fibre Channel Cable
- FC6013: 13 m LC-LC Fibre Channel Cable
- FC6025: 25 m LC-LC Fibre Channel Cable
- FC5096: Interposer SC-LC Fibre

SCSI cables

One differential terminator and 0.4 meter drive-to-drive cable are included with each SCSI tape drive. The IBM LTO Ultrium 3 LVD SCSI Tape Drive comes with an HD68 connector for SCSI attachment.

Features for specifying SCSI cables and their respective lengths are:

- FC5602: 2.5 meters
- FC5604: 4.5 meters
- FC5610: 10 meters

These cables have a VHDCI connector on one end and an HD68 connector on the other end.

7.15 Publications

The following publications are included with the Model L5B hardware:

- *IBM System Storage TS3310 Tape Library Setup and Operator Guide*, GA32-0477
- *IBM System Storage TS3310 Tape Library Maintenance Information for IBM Service Personnel,* GA32-0478
- *IBM System Storage TS3310 Tape Library SCSI Reference,* GA32-0476
- *IBM Ultrium Device Driver Installation and User's Guide,* GA32-0430

8

IBM System Storage TS3400 Tape Library

The IBM System Storage TS3400 Tape Library (Machine type 3577, Model 5LU) is designed to offer high performance drive technology and automation for the Open Systems environment. The IBM System Storage TS3400 Tape Library is a five unit (5U) external desktop or rack-mountable tape library that incorporates up to two IBM System Storage TS1120 Tape Drives.

The IBM System Storage TS1120 Tape Drive has a native capacity of 700 GB when using the IBM Extended Data Cartridge (JB), or 500 GB when using the IBM Data Cartridge (JA). The IBM System Storage TS1120 Tape Drive has a native rate of up to 100 MB/s. The IBM System Storage TS1120 Tape Drive has a dual-ported switched fabric 4 Gbps Fibre Channel attachment. The tape drives must be ordered separately with the final order.

The IBM System Storage TS3400 Tape Library supports the IBM System Storage TS1120 Tape Drive built-in encryption capabilities. The encryption methods are Application-Managed Encryption (AME), System-Managed Encryption (SME), and Library-Managed Encryption (LME).

The IBM System Storage TS1120 J1A Tape Drive is not supported in the IBM System Storage TS3400 Tape Library.

8.1 IBM System Storage TS3400 Tape Library description

Designed for tape automation, the IBM System Storage TS3400 Tape Library can be attached to IBM System i or i5, IBM iSeries, AS/400, IBM System p or p5, IBM pSeries, RS/6000, IBM z or z9, IBM xSeries, Hewlett-Packard (HP), Sun, UNIX, and PC servers.

For the remainder of this chapter, we will use the term TS3400 as a abbreviation for IBM System Storage TS3400 Tape Library and the term TS1120 as a abbreviation for IBM System Storage TS1120 Tape Drive.

To determine the currently supported servers, visit the Web at:

http://www-03.ibm.com/systems/storage/tape/library.html#interoperability

The TS1120 Tape Drive supports a data transfer rate of up to 100 MB/s. The IBM Tape Cartridge 392 Extended Data (JB) and Write Once Read Many (WORM) (JX) cartridges are designed to provide a native physical capacity of up to 700 GB (2.1 TB with 3:1 compression).

The IBM System Storage TS3400 Tape Library has two removable cartridge magazines providing 18 data cartridge slots, including a three slot I/O station. The total native storage capacity is 12.6 TB when using the 700 GB data cartridges.

The IBM System Storage TS3400 Tape Library incorporates IBM Multi-Path Architecture with one or two logical libraries when two IBM System Storage TS1120 Tape drives are installed. The only attachment to the host is a 4 GB/s switch fabric Fibre Channel connection. The TS1120 has two Fibre Channel (FC) dual-ported ports to make a connection to the host. The TS1120 provides a sustained native data transfer rate of 100 MB/s.

Standard features for the IBM System StorageTS3400 Tape Library are Control path and data path failover, a barcode reader, dual power supplies, remote management, and the capability to use the IBM System Storage TS3400 Tape Library in sequential or random access mode.

The TS3400 will be installed by an IBM Service Support Representative (SSR) and in case the TS3400 has a defect, an IBM SSR comes on-site to replace the defective parts. However, it is the client’s responsibility to update the drive and library firmware.

Figure 8-1 shows the front view of the TS3400.

Figure 8-1 IBM System Storage TS3400 Tape Library

Two removable magazines are located on the left side. The Operator Panel, which has a monochrome LCD graphic display, is in the middle. Library operations and service functions are performed from this display. For your convenience, there is a transparent plastic window so you can observe the internal robotics of the TS3400. The I/O slot is accessible from the lower left.

The TS3400 has three status LEDs and four push buttons to configure the library.

Figure 8-2 shows the interior view of the TS3400. The front is on the left side of Figure 8-2 and the back of the TS3400 is on the right side.

8.2 Components

The TS3400 is made for automated backups. The movement is done using a robust accessor, which moves the tapes between the drive, the storage slots, and the I/O station. The Barcode Reader is an integral part of the library accessor.

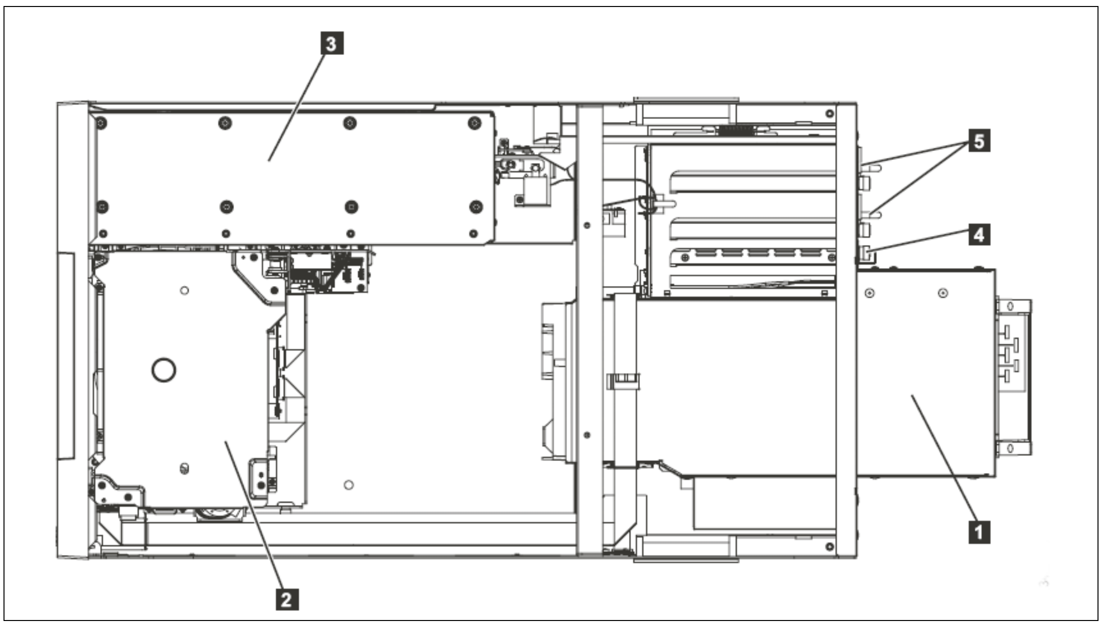


Figure 8-2 Interior components of the IBM System Storage TS3400 Tape Library

The numbers in Figure 8-2 represent the following components:

1. The TS1120 Tape Drive. The second TS1120 is installed above the first TS1120.
2. Library Accessor with the integral Barcode Reader.
3. Cartridge magazines. The three slot I/O station is located in the bottom magazine.
4. Library Control Blade (LCB). This component is a customer replaceable unit (CRU) and stores the user configuration information and vital product data (VPD). The Remote Management Unit (RMU) is embedded on this card.
5. Two redundant power supplies.
6. Robotics.

The TS3400 has an accessor assembly that contains the library robotics system, the picker, and the barcode reader. The accessor moves the cartridges between the:

- I/O station
- Storage slots
- Tape drives

Figure 8-3 shows the accessor assembly.

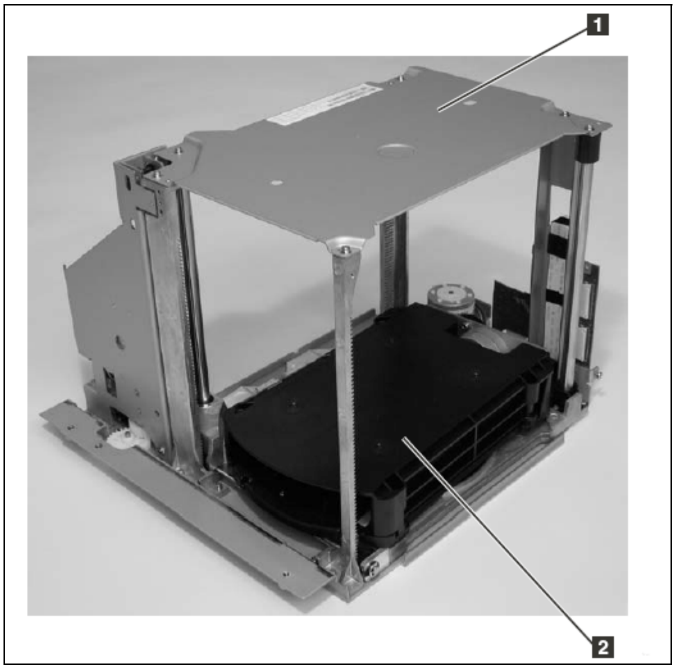


Figure 8-3 TS3400 Accessor Assembly with the picker

The numbers points to the following components:

1. Accessor assembly
2. Picker

The complete accessor assembly moves backward and forward in the TS3400 on an X-axis rail using a rack and pinion gear driven by the X-axis motor. The X-axis is located on the left lower side and the picker is moved up and down along a Y-axis using a belt driven by the Y-axis motor located on the lower right side.

The picker rotates on a swivel plate assembly using a combination of swivel motor and gears. The picker has a finger that enables it to grab tape cartridges and move them to and from the I/O station, storage slots, and drives.

8.2.1 Barcode reader

The barcode reader is an integral part of the library accessor, and it does not affect the slot capacity. The barcode reader provides inventory feedback to the host application, Operator Control Panel display, and Web User Interface by reading cartridge barcode labels. The library stores the customized inventory data in memory. When an application, for example, Tivoli Storage Manager, executes an audit command, the inventory on the inserted data cartridges is transferred to the application so that the application knows which data cartridges are inserted in the TS3400. Figure 8-4 on page 203 shows the barcode reader of the TS3400.

The photo is taken in front of the picker assembly and you can see that the barcode reader is an integral part of the picker assembly.

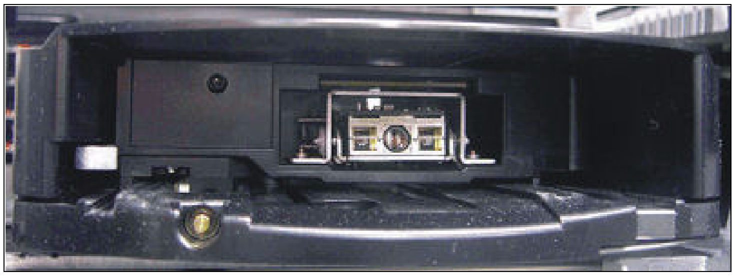


Figure 8-4 Barcode reader of the TS3400

8.2.2 Library Control Blade (LCB)

The LCB manages the entire library, including the Operator Panel and the accessor. It is responsible for monitoring the TS3400 to ensure that the library is functioning properly. The LCB stores the vital product data (VPD), including the library settings, serial number, library logs, and accessor calibration backup data.

Figure 8-5 shows you the LCB.

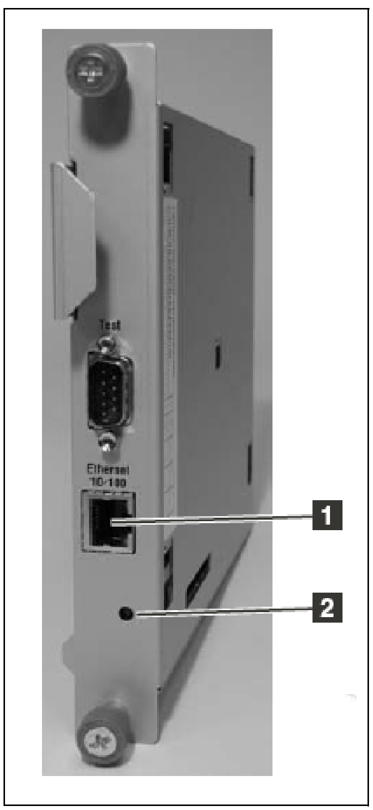


Figure 8-5 Library Control Blade

The numbers represent the following components:

1. Ethernet port for network connection
2. Ethernet activity LED

The RS-232 serial port above the Ethernet port is for use for IBM engineering purposes only. The Ethernet port is used for remote management to the library over a network. This function is imbedded in the Library Control Card. The library can be attached to the network using the 10/100 MB Ethernet port. When the IP address is set on the library using the Operator Control Panel, the library can be monitored and controlled remotely. By entering the IP address in a browser, a graphical representation of the library will be opened. Service actions, such as upgrading the library and drive firmware, can be done by using the remote management facility. Figure 8-6 shows the Welcome page of the Web User Interface of the TS3400.

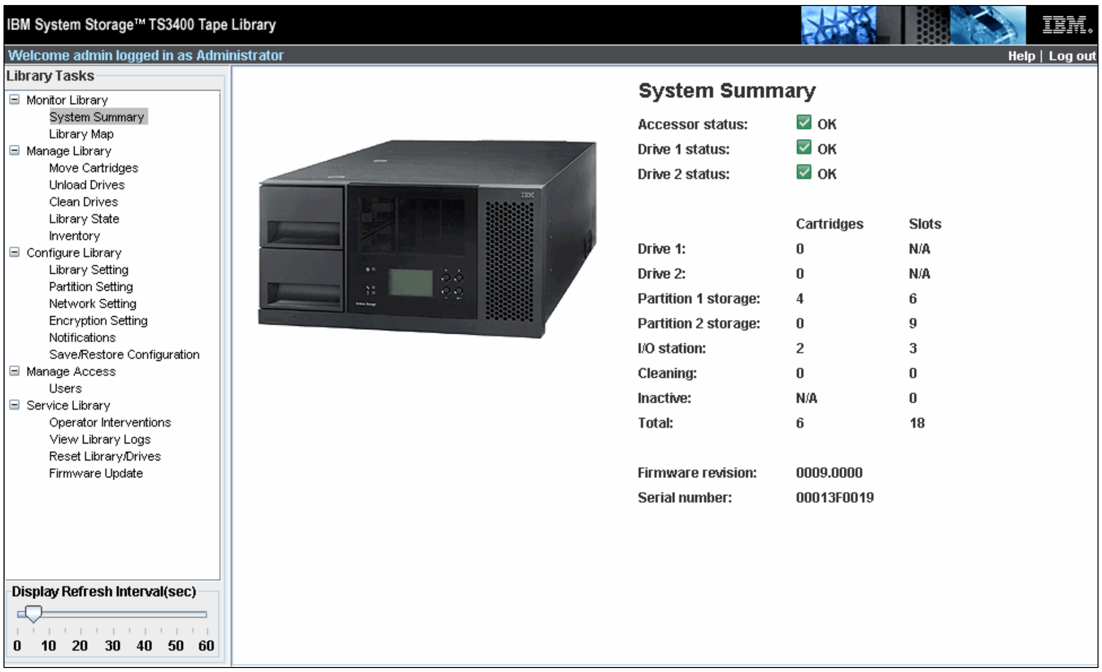


Figure 8-6 Welcome page of the IBM System Storage TS3400 Tape Library

The Welcome page shows the summary of the TS3400, the library, and the drive firmware. We were impressed by the option to manually adjust the refresh rate of the display. We strongly recommend that you configure and use the Web User Interface for monitoring, maintaining, and configuring the TS3400. In older IBM automation products, the Web User Interface was a billable feature, but with the TS3400, it comes as a standard option and we encourage you to use it.

8.2.3 Cartridge magazines

The TS3400 has two removable and identical cartridge magazines. Each storage magazine can hold up to nine data cartridges. The first three slots of the lower left cartridge magazine can be configured as an I/O station and the last two slots in the upper magazine can be configured as cleaning slots.

Figure 8-7 on page 205 shows one cartridge magazine of the TS3400 with five cartridges inserted.

Figure 8-7 Cartridge magazine of the TS3400

The TS3400 is a highly flexible tape library. One of its advantages is that the first three storage slots of the lower cartridge magazine can be configured as an I/O station. You can use the Web User Interface or the Operator Panel to configure the I/O station.

In Figure 8-8, you can see the TS3400 and the three storage slots, which can be configured as an I/O station.

Figure 8-8 I/O station of the TS3400

In Figure 8-8, the number 1 points to the I/O station.

For your convenience, in Figure 8-9 on page 206, we also show you the location coordinates of the two cartridge magazines and various configuration possibilities.

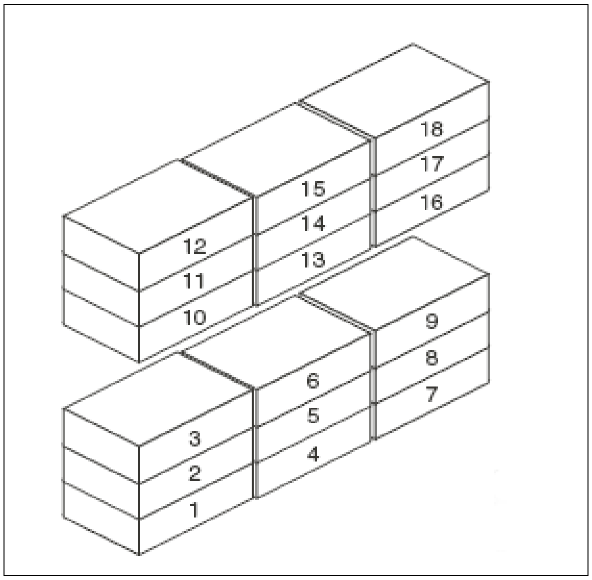


Figure 8-9 Location coordinates of the TS3400

Many applications use storage element addressing to move data cartridges between the I/O station, tape drives, and storage slots. Figure 8-10 and Figure 8-11 on page 207 show the storage element addressing with and without the I/O station configured.

Figure 8-10 shows the storage element addressing as storage.

0x100B (4107)	0x100E (4110)	0x1011 (4113)
0x100A (4106)	0x100D (4109)	0x1010 (4112)
0x1009 (4105)	0X100C (4108)	0x100F (4111)

0x1002 (4098)	0x1005 (4101)	0x1008 (4104)
0x1001 (4097)	0x1004 (4100)	0x1007 (4103)
0x1000 (4096)	0X1003 (4099)	0x1006 (4102)

DRIVE 2 0x101 (257)
DRIVE 1 0x100 (256)

Figure 8-10 Storage element addressing of the TS3400 as storage

Figure 8-11 on page 207 shows the storage element addressing of the TS3400 with the I/O station configured.

0x100B (4107)	0x100E (4110)	0x1011 (4113)
0x100A (4106)	0x100D (4109)	0x1010 (4112)
0x1009 (4105)	0X100C (4108)	0x100F (4111)

0x12 (18)	0x1005 (4101)	0x1008 (4104)
0x11 (17)	0x1004 (4100)	0x1007 (4103)
0x10 (16)	0X1003 (4099)	0x1006 (4102)

DRIVE 2 0x101 (257)
DRIVE 1 0x100 (256)

Figure 8-11 Storage element addressing of the TS3400 with the I/O station configured

Slots are numbered from the bottom to the top and from the front to the back within each magazine cartridge. Slot locations 1 to 9 are in the lower cartridge, and slot locations 10 to 18 are in the upper cartridge. Slot locations 1 to 3 can be configured as I/O station slots to import and export tape cartridges. When the I/O station is configured, the number of data cartridge slots is reduced to 15.

The library beeps a warning when a host computer accesses the library while the I/O station is open. When this occurs, the accessor stops traversing the library and the library queues SCSI commands for five minutes.

Slot locations 17 and 18 can be configured as cleaning cartridge slots for both automatic cleaning and manual cleaning. If only one slot is allocated for cleaning cartridges, slot location 18 is selected. The cleaning slots are used for all drives in the physical library. When the library has two cleaning cartridges, the cartridge with the higher cleaning count usage is selected for the automatic cleaning function.

The Web User Interface can be used for a quick overview of the inserted cartridges. Figure 8-12 on page 208 shows the inventory of the TS3400.

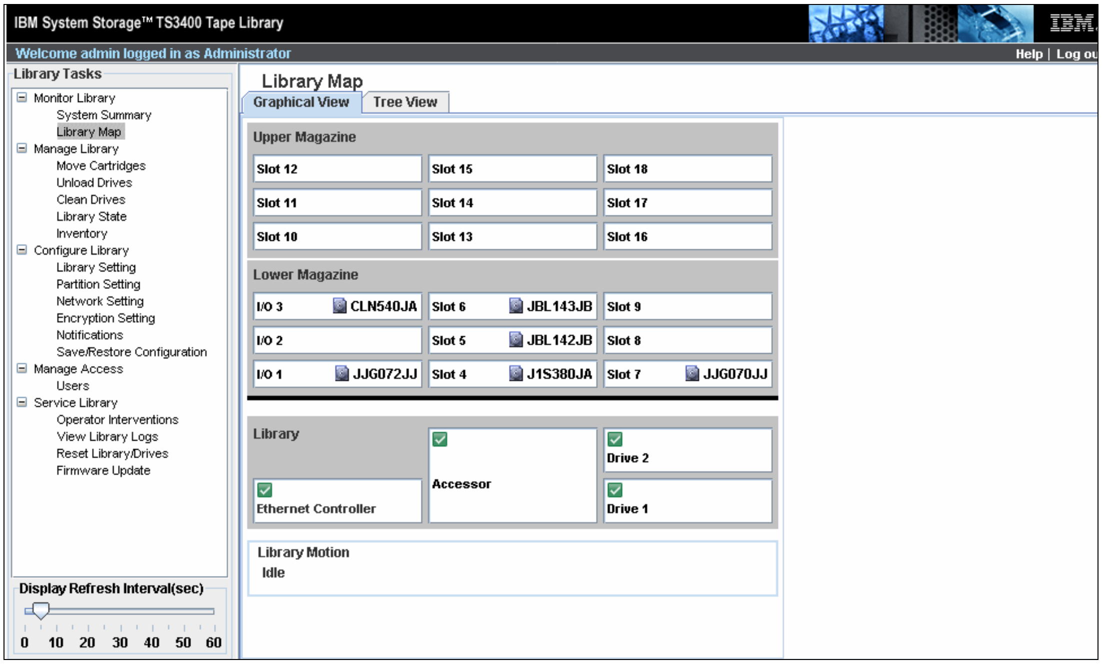


Figure 8-12 Inventory of the TS3400 using the Web User Interface

8.2.4 TS1120 Tape drive

In the TS3400, two TS1120s (3592-E05) can be installed. In a single TS1120 configuration, the tape drive must be installed in the lower tape drive position. When two TS1120s are installed in the TS3400, the physical library can be partitioned into two logical libraries. Each logical library has one drive and one magazine for storage slots. The I/O station storage slots, however, are shared by the two logical libraries.

Each TS1120 is packaged in a container called a *drive canister*. The drive is a field-replaceable unit (FRU) and can be hot-swapped, which means that it is not necessary to power off the TS3400 to replace a single TS1120.

We summarize the highlights of the TS1120 for you in the next sections.

Data encryption

The TS1120 includes data encryption capabilities within the drive itself. This capability is intended to provide clients with a greater ability to protect information if tape cartridges are lost or stolen by supporting the storage of the data in an encrypted form. The IBM Encryption Key Manager component for the Java platform can help generate and manage encryption keys for TS1120 tape drives. This feature uses standard key repositories on supported platforms and supports three encryption management methods: Application-Managed Encryption, System-Managed Encryption, or Library-Managed Encryption.

Dynamic speed matching

To improve system performance, the TS1120 uses a technique called *dynamic speed matching* to adjust its native (uncompressed) data rate to the slower data rate of the attached server.

Channel calibration

The channel calibration feature of the TS1120 customizes each Read/Write data channel for optimum performance. The customization enables compensation for variations in the recording channel transfer function, media characteristics, and Read/Write head characteristics.

Control path failover

A *control path* is a logical path into the library through which a server sends standard Medium Changer commands to control the logical library. Additional control paths reduce the possibility that failure in one control path will cause the entire library to be unavailable. Use of the control path failover feature further reduces that possibility.

Data path failover

Data path failover is designed to provide a failover mechanism in the IBM device driver, which enables you to configure multiple redundant paths in a SAN environment. In the event of a path or component failure, the failover mechanism is designed to automatically provide error recovery to retry the current operation using an alternate, pre-configured path without aborting the current job in progress. This allows you flexibility in SAN configuration, availability, and management.

Figure 8-13 show the TS1120 Tape Drive.

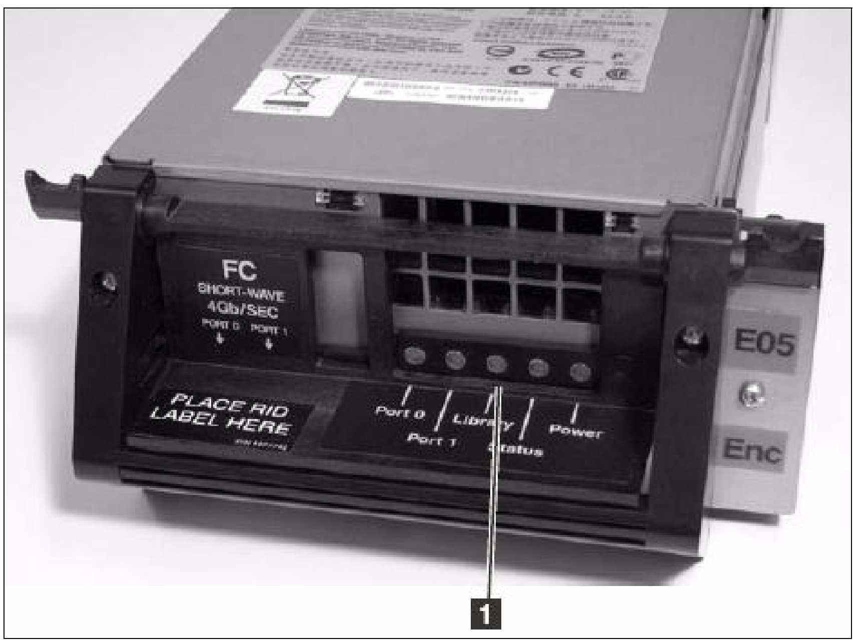


Figure 8-13 IBM System Storage TS1120 Tape Drive

In Figure 8-13, the number 1 points to the TS1120 activity LEDs.

8.2.5 IBM System Storage TS1120 Tape Drive Attachment

The TS1120 Tape Drive has a dual-ported 4 Gbps native switched fabric Fibre Channel interface. This offers attachment flexibility in an Open Systems environment. The TS1120 Tape Drive has two independent Fibre Channel interfaces, or ports. Both ports run the SCSI protocol with Fibre Channel tape support. Two ports allow concurrent attachment of two independent Fibre Channel configurations to each drive. One or both ports can be attached to a variety of Open Systems servers, switches, hubs, and directors.

The TS1120 supports industry standard shortwave LC-Duplex fiber optic cables. This allows cable lengths of up to 500 m (1640 ft.) with 50 micron core fiber.

8.2.6 Data cartridges

The IBM TotalStorage Enterprise Tape Cartridge 3592 is an advanced metal particle tape specifically optimized for the enterprise tape environment. It is available in three sizes. The Data Cartridge 3592 has a standard capacity of 500 GB in E2 format and 300 GB in E1 format (JA media). The Extended Capacity Cartridge 3592 has a capacity of 700 GB in E2 format only (JB media). The Economy Tape Cartridge 3592 has a standard capacity of 100 GB in E2 format and 60 GB in E1 format (JJ media).

All cartridges can be encrypted. Capacities of data cartridges can be increased through data compression, with the actual compression and capacity depending upon the specific data. WORM cartridges are also available in all sizes (JW, JX, and JR media, respectively).

For all available capacities of the Data Cartridge and ordering features, see Appendix A, “IBM LTO Ultrium and 3592 media” on page 393.

8.3 IBM System Storage TS3400 Tape Library setup

The following section provides a global overview of the steps to implement, manage, and operate the TS3400. We provide hints and tips to make it easier for you to set up the TS3400. For a detailed description, follow the *IBM System Storage TS3400 Planning and Operator Guide,* GC27-2107.

The TS3400 will be installed and tested by an IBM Service Support Representative (SSR). After the installation and the testing phase, the SSR turns the TS3400 over to the client. We will describe the following setup steps for the TS3400:

- Setting up the Web User Interface
- Configuring the TS1120 Tape Drive
- Partitioning the TS3400
- Setting up Encryption
- Setting up e-mail and Single Network Management Protocol (SNMP)
- Updating the drive and library firm ware
- Register My Support

8.3.1 User Interfaces

There are two ways to configure the TS3400: using the Operator Panel and the Web User Interface. We strongly recommend that you configure, manage, and control the TS3400 by using the Web User Interface. In order to use the Web User Interface, you can use the default Internet Protocol (IP) address of the TS3400: 192.168.1. Or, you can change the IP address using the Operator Panel. We explain which steps must be followed to change the IP address using the Operator Panel. To configure the TS3400:

1. First, power on the TS3400 and wait until the hardware and software are initialized and the inventory is finished. This process takes several minutes. The login window is displayed when the inventory is complete. Figure 8-14 on page 211 shows the login window of the Operator Panel.

Figure 8-14 TS3400 login window using the Operator Panel

2. To log in, press Enter to display the User Login password window. Figure 8-15 shows the login password window.

Figure 8-15 Login password window of the TS3400

3. Enter the 4-character password for the TS3400. The factory password is `0000`**.** The password can be changed in the configuration menu. When the password is entered successfully, the Operator Panel top menu window is displayed.

   Note: The term Top Menu is the first menu that is displayed when you are logged in the TS3400.

   Figure 8-16 shows the top menu window.

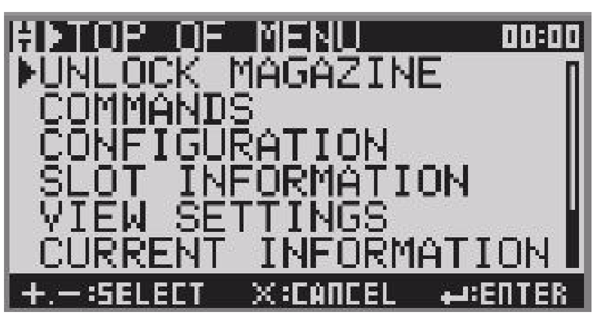


Figure 8-16 Top Menu window of the TS3400

4. You are now logged in the TS3400 and can start to configure the TS3400 IP address.

   In order to configure the IP address, from the top menu, select **Configuration** → **Network Settings** → **IP address**. Here, you can configure the IP address for the TS3400 or one of the following settings:

   – Link Speed

– Dynamic Host Configuration Protocol (DHCP)
– Subnet Mask Address
– Simple Network Time Protocol (SNTP)
– Media Access Control (MAC) address

5. The TS3400 can now be remotely controlled from any server in the network. However, there are prerequisites from a server point of view. The Web User Interface Java Applet, which is running on the TS3400, requires Java 1.5.0 or higher for full functionality and is best viewed using Internet Explorer 6.0 or higher. If your server does not have Java installed or you need to upgrade your installation, download the latest version of the Java Runtime Environment (JRE™) for your platform from:

   http://www.java.com

   Follow the instructions provided to enable and configure the Java Runtime Environment for your browser.

6. When the JRE on your server is installed or upgraded, open your browser and enter the IP address of the TS3400.

   A warning message pops up the first time that you connect to the TS3400. This is message is normal and does not indicate an error. Figure 8-17 shows the Java security warning message.

Figure 8-17 Java security warning message

7. Click **Always trust content from this publisher** to avoid this message in subsequent browser sessions. After launching the Web User Interface, the login window is displayed. See Figure 8-18 on page 213.

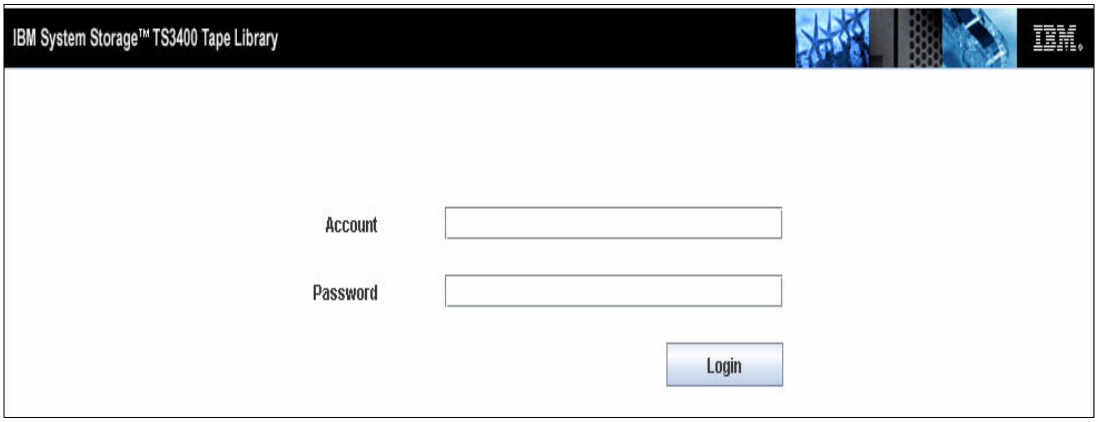


Figure 8-18 IBM System Storage TS3400 Tape Library log in window

The default available user accounts and passwords are:

– Administrator account: `admin`, password: `secure`
– User account: `user`, password: `user`

After logging in, the Welcome page is displayed. Figure 8-19 shows an example of using the Administrator account.

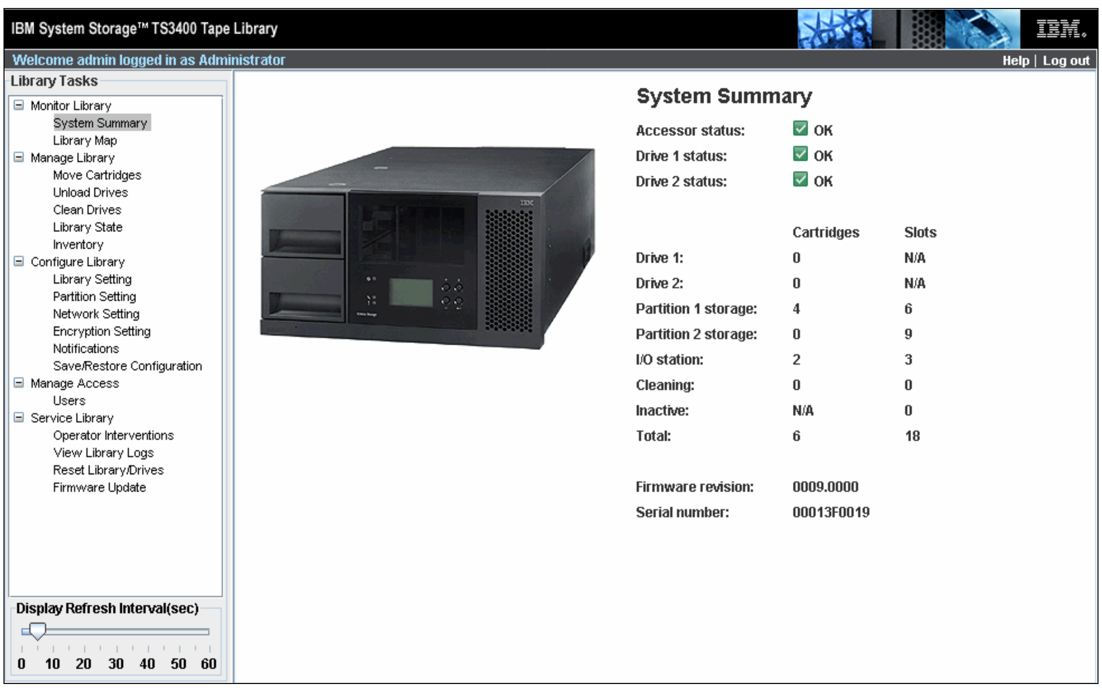


Figure 8-19 Administrator Welcome page of the TS3400

We will now continue configuring the TS3400; however, we will not cover all configuration options. We discuss partitioning the TS3400 into two logical libraries, and we describe data encryption. For a complete overview of all the configuration settings, see the *IBM System Storage TS3400 Tape Library Planning and Operator Guide,* GC27-2107.

8.3.2 Configuring the TS1120 Tape Drive

The installed TS1120s can be configured separately and the following options are available: Topology, Loop ID, and Fibre Channel Link Speed. For a detailed description of every option, see the *IBM System Storage TS3400 Tape Library Planning and Operator Guide* GC27-2107.

The TS1120 can be configured using the Web User Interface. See Figure 8-20.

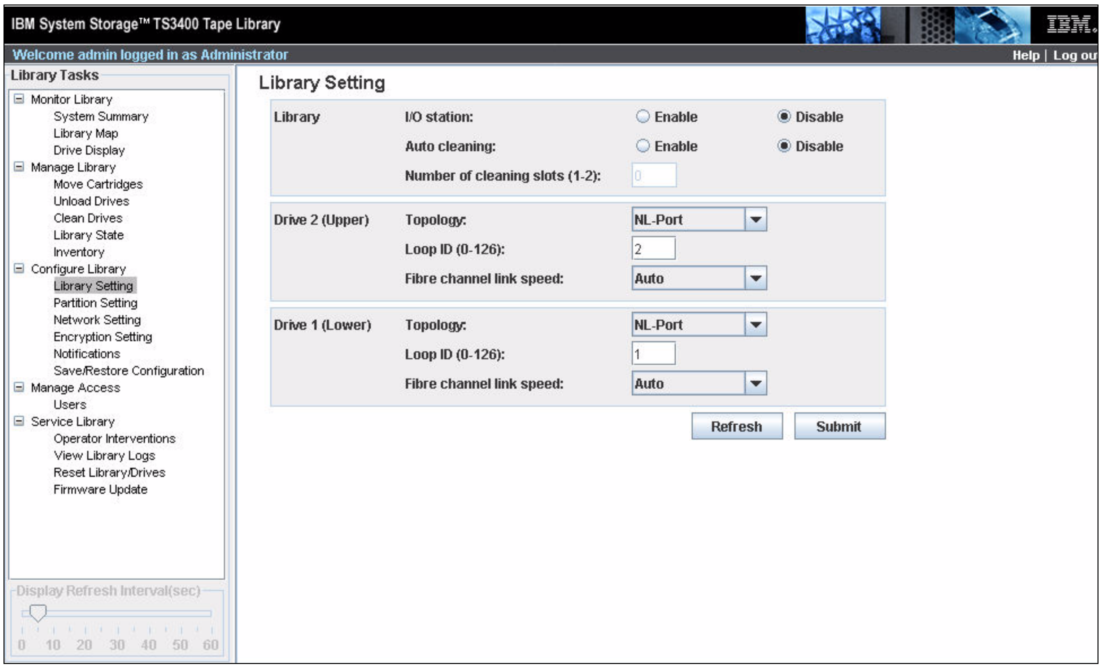


Figure 8-20 TS1120 settings

Each Fibre Channel tape drive in the TS3400 must have a unique Loop ID and corresponding Arbitrated Loop Physical Address (AL_PA) to communicate in a Fibre Channel Topology. Table 8-1 shows the default Loop IDs.

Table 8-1 Default loop IDs and their associated AL_PAs

Drive position	Default Loop ID	Default AP_PA
1	1	X’E8’
2	2	X’E4’

You can change a Loop ID by using the TS3400 Operator Panel or Web User Interface. Using a method called *hard addressing*, the TS1120 then automatically selects the corresponding AL_PA, which is the identifier that devices use to communicate. Valid Loop ID values range between 0 and 126. The higher the number of the Loop ID (and AL_PA), the lower the priority of the devices in the loop.

You can also specify Loop IDs that allow the drive to dynamically arbitrate the AL_PA with other Fibre Channel devices on the loop. This method avoids conflicts over the address and is called *soft addressing*. To dynamically arbitrate the AL_PA, specify a Loop ID of 126 or 127.

Logical unit number (LUN) assignments

All SCSI command communications between the host and the library always access LUN 1 (all other LUNs are invalid addresses). The first drive in each logical library is mandatory and is enabled automatically by library firmware. These devices are compatible with the SCSI-3 standard. The Medium Changer SCSI ID is the same as the SCSI ID for the control path drive. You can enable additional drives to optionally provide Medium Changer (LUN 1) addressing by configuring more than one logical library or by enabling additional control paths.

Persistent binding

When a server is booted, devices are discovered and assigned SCSI target and LUN IDs. It is possible for these SCSI assignments to change between boots. Certain operating systems do not guarantee that devices will always be allocated the same SCSI target ID after rebooting. Also, some software depends on this association, so you do not want it to change. The issue of SCSI ID assignment is addressed by persistent binding.

Persistent binding is a host bus adapter (HBA) function that allows a subset of discovered targets to be bound between a server and a device. Implemented by a worldwide node name (WWNN) or worldwide port name (WWPN), persistent binding causes a tape drive's worldwide name (WWN) to be bound to a specific SCSI target ID. After a configuration has been set, it survives reboots and any hardware configuration changes, because the information is preserved. If a drive needs to be replaced, the new drive assumes the WWNN of the old drive, because the WWNN for the drive is location-dependent within the library. Because the WWNN does not change, persistent binding does not need to be changed, which causes an outage.

8.3.3 Partitioning

When two TS1120s are installed in the TS3400, the library can be partitioned in two logical libraries. When the TS3400 is partitioned, two hosts can be connected to the library. However, when a I/O station is configured, it must be shared between the two logical libraries. Be aware of the following situation. When the TS3400 is partitioned and the I/O is configured, opening the I/O station can post a message to one of the attached hosts while running a backup. To make this clearer, we will explain it with an example.

The TS3400 is partitioned, and two hosts are connected. One host is an AIX server with Tivoli Storage Manager and the other host is a System i partition running Media Recovery and Media Services (BRMS). It is possible to run a backup simultaneously on both hosts. Now, the AIX host is finished, but the System i backup is still running with the backup, and the operator wants to export the cartridges from the AIX host. When the operator opens the I/O station, i5/OS posts a message that the I/O station is open. The operator has to wait until the System i backup job is finished, then the operator can open the I/O station. The TS3400 is working on a first come-first served basis. The application with the first move request for a data cartridge will be served first.

When configuring logical partitioning, different library modes are available for each logical library. Each logical library can be set up differently. It is important to set the control path for the second logical partition. The control path for Drive 1 is always enabled. We will use an example to explain how to set up two logical libraries. We use the Web User Interface for setting up the logical libraries. Logical libraries can also be configured using the Operator Panel, but we prefer and recommend using the Web User Interface. First, we explain the different modes.

Random mode

In Random mode, the library allows the server's (host's) application software to select any data cartridge in any order. It is the server's responsibility to move the cartridges between the I/O station, storage slots, and tape drives. The application must execute an **audit** Tivoli

Storage Manager command to get the inventory from the TS3400 so that the application is aware of the location of the data cartridges.

Sequential mode

In Sequential mode, the library firmware predefines the selection of the data cartridges. After initialization, the firmware causes the library to select the first available data cartridges found (counting from the I/O station through to the last slot in the library) for loading into the drive. The following options are available when using Sequential mode:

- Autoload: Sequential mode with autoload ON loads the first available cartridge (slot with the lowest numerical value that contains a cartridge) automatically if the library powers ON with an empty drive.
- Loop: Sequential mode with loop ON loads the cartridge in the lowest numerical slot after the cartridge in the highest numerical slot has been filled and sent back to its home slot. This allows endless backup operations without user interaction.

The way in which Sequential Mode works depends on the Autoload and Loop settings:

- If the Autoload option is set to ON, the accessor loads the first cartridge (cartridge located in the slot with the lowest numeric value) found in the storage inventory area into the drive when the library powers ON. If the library powers ON with a cartridge already in the drive, sequential mode starts with that cartridge unless the host issues a rewind and unload command to the drive. In that case, the next cartridge in sequence will be loaded into the drive.
- If the Autoload option is set to OFF, sequential mode is started by selecting the `Move Cartridge` command to load the first cartridge into the drive. The sequence then starts with the cartridge loaded into the drive. For example, if a cartridge from the fifth lowest numeric storage slot containing a cartridge is loaded using the `Move Cartridge` command, after the host issues a rewind/unload command, the next cartridge loaded is the cartridge from the next higher numeric slot. Cartridges do not need to be in contiguous slots.
- If the Loop option is set to ON, the accessor will immediately start loading the first cartridge into the drive when the last cartridge (cartridge in the highest numeric slot) is unloaded and placed back into storage.

Sequential mode is stopped when a cartridge is removed from the drive using the `Move Cartridge` command. The next sequential cartridge is not loaded. To restart sequential mode, use the `Move Cartridge` command to load a cartridge. The loading sequence will resume from that numeric slot in the cartridge inventory. The number of active slots in the library determines the number of slots that the library will access before repeating each loop and the number of reserved cartridge slots.

Note: When the TS3400 is connected to a System i host, you must IPL the input/output adapter (IOA); otherwise, the System i host will not recognize the new mode. First, investigate if there are more IOAs under the IOP. When for example, a disk adapter is under the same IOP, this IOA will also be IPLed.

We will now partition the TS3400 into two logical libraries, and we will configure one logical library in Sequential mode and one in Random mode. The first step is configure the TS3400 with Partition 1 in Sequential Mode with loop and auto loop. In Step two, we configure the TS3400 with Partition 2 in Random Mode. The steps are:

1. From the Welcome page, choose **Partition Setting** as shown in Figure 8-21. We changed the settings for Partition 1 and Partition 2. Notice that Partition 1 has the control path disabled. When Sequential mode is enabled, the control path is automatically disabled.

This make sense, because it is the library that takes care of loading and unloading the cartridges in the drive.

Figure 8-21 shows the first step of configuring the TS3400.

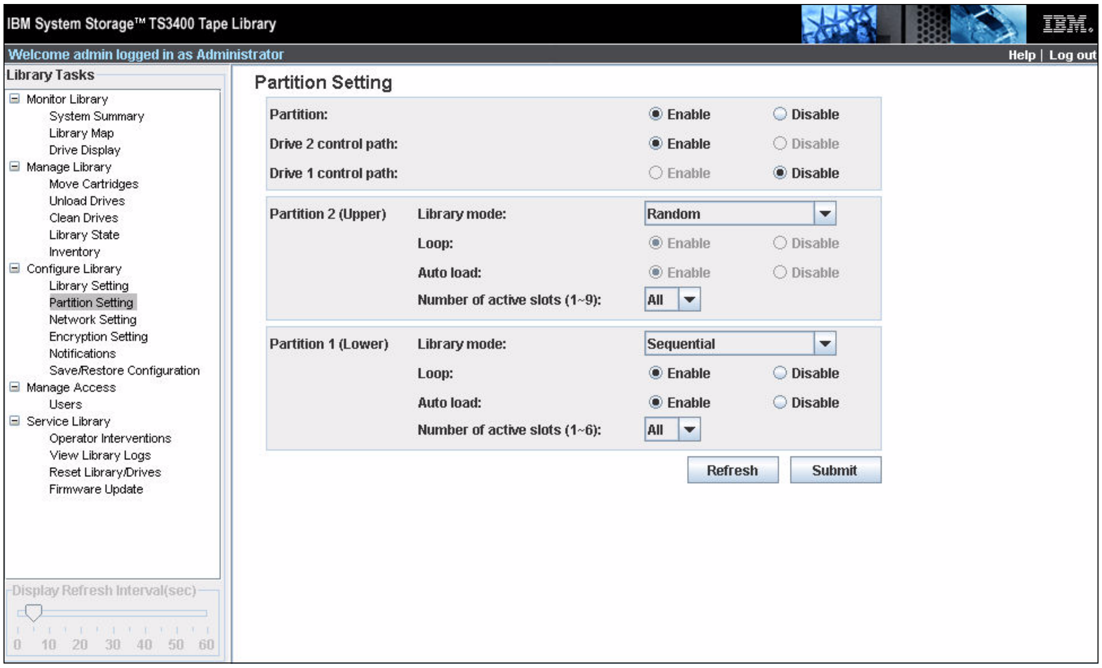


Figure 8-21 Partitioning the TS3400

No reboot of the TS3400 is required for changing the Library mode of the logical libraries.

2. After setting up the logical library, you now have to decide if you want to use the I/O station. Keep in mind that when you enable the I/O station, Partition 1 will lose three storage slots. When you want to enable the I/O station, choose Library Setting on the Welcome page; see Figure 8-22 on page 218. The I/O station is shared between the logical libraries.

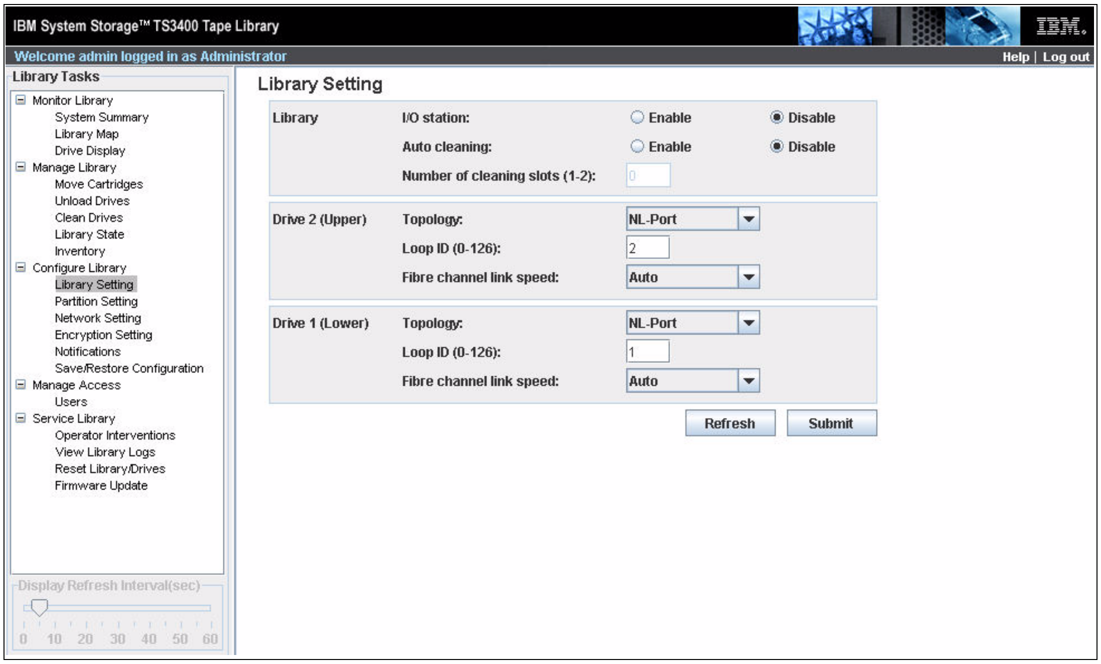


Figure 8-22 Configuring the TS3400 I/O station

3. Click **Submit** to enable the I/O station. The TS3400 responds as shown in Figure 8-23.

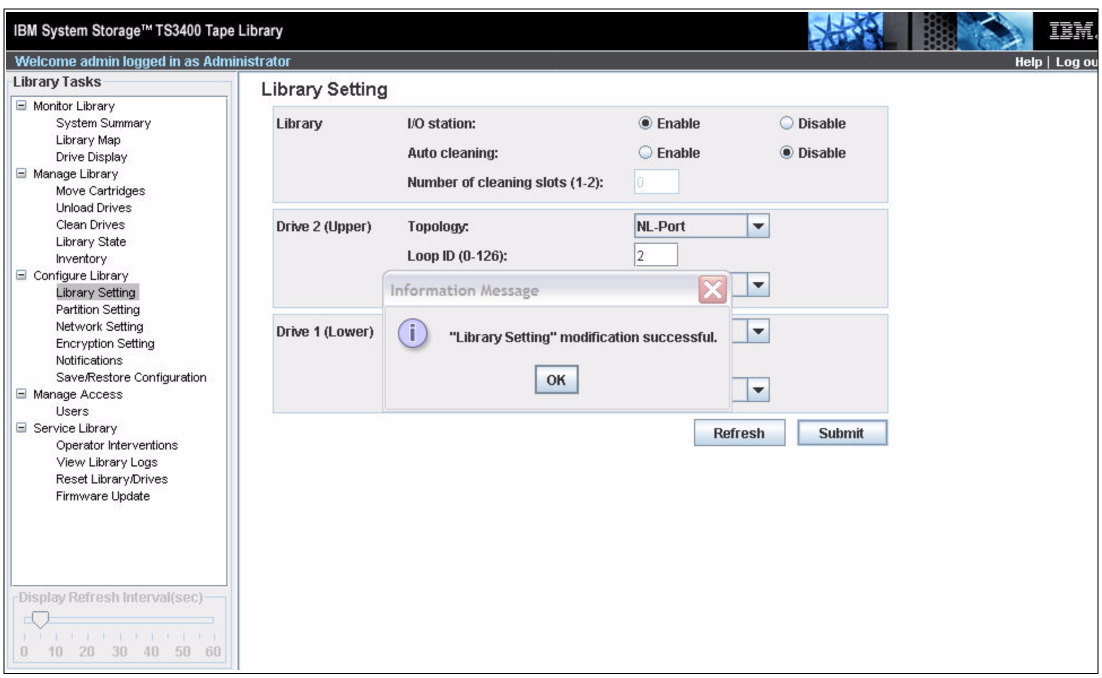


Figure 8-23 After enabling the I/O station

The Web User Interface is a user-friendly way to monitor and configure the TS3400.

In the Library setting menu, you can also configure how many cleaning slots you want to use. When two cleaning slots are configured, those slots are not usable as storage slots. Storage slot numbers 18 and 17 (in that order) can be configured as cleaning slots. Cleaning cartridges are shared between the two logical libraries. It can be confusing to determine how many storage slots you can actually use. Table 8-2 makes it clearer for you.

Table 8-2 The number of available storage slots

Partition	I/O station	Auto Cleaning	Active data cartridge slots[a]
OFF	OFF	OFF	Slots 1 to 18 are available in a single logical library.
		ON	Slots 1 to 17 (1 to 16) are available in a single logical library.
	ON	OFF	Slots 4 to 18 are available in a single logical library.
		ON	Slots 4 to 17 (4 to 16) are available in a single library.
ON	OFF	OFF	Slots 1 to 9 are available in drive 1 logical library.
			Slots 10 to 18 are available in drive 2 logical library.
		ON	Slots 1 to 9 are available in drive 1 logical library.
			Slots 10 to 17 (10 to 16) available in drive 2 logical library.
	ON	OFF	Slots 4 to 9 are available in drive 1 logical library.
			Slots 10 to 18 are available in drive 2 logical library.
		ON	Slots 4 to 9 are available in drive 1 logical library.
			Slots 10 to 17 (10 to 16) are available in drive 2 logical library.

a. The numbers in parentheses indicate the data cartridge slots available when the number of auto cleaning cartridges is set to 2.

Let us summarize what we did so far. We are able to access the TS3400 using the Web User Interface. And, the TS3400 is partitioned in two logical libraries:

- Partition one is in Sequential mode.
- Partition two is in Random mode.

The next step can be to configure one or both logical libraries with encryption. These optional setup steps to enable Encryption are described in 8.3.4, “Tape Encryption” on page 220.

8.3.4 Tape Encryption

The TS1120s installed in the TS3400 support data encryption on any size of IBM TotalStorage Enterprise Tape Cartridge 3592, including WORM cartridges. That means that they are capable of performing hardware encryption. The TS1120 is encryption-capable but must be configured first using the Web User Interface.

Encryption is performed at full line speed in the tape drive after compression (encryption is more efficiently done after compression). The data cartridge is encrypted as a whole; it is never partly encrypted.

Encryption involves the use of several kinds of encryption keys. How those encryption keys are generated, maintained, controlled, and transmitted depends on the operating environments where the TS3400 is installed. Certain applications are capable of performing key management, for example, Tivoli Storage Manager. For environments without this type of application, IBM provides the IBM Encryption Key Manager (EKM) component for the Java platform to perform all necessary key management tasks, such as generating, protecting, storing, and maintaining the encryption keys that are used to encrypt information being written to and decrypt information being read from the data cartridge.

The TS1120 communicates through the TS3400, which uses TCIP/IP to communicate with the server where the EKM is installed. The TS3400 supports up to two key manager addresses, where each key manager is specified using the IP address and port number of a server that has the EKM installed. The EKM is supported on z/OS, i5/OS, AIX, Linux, HP-UX, Sun Solaris, and Windows. The IBM EKM can be downloaded from this Web site:

http://www-1.ibm.com/support/docview.wss?&uid=ssg1S4000504

There are three Tape Encryption methods: Application-Managed Encryption (AME) , System-Managed Encryption (SME), and Library-Managed Encryption (LME). During write operations, the TS1120 uses an encryption key to encrypt the data and, during read operations, a decryption key to decrypt the data. The SME and LME methods use an Encryption Key Manager and a keystore to manage and store the keys. With AME, the application is responsible for managing keys and communicating the keys to the tape drive.

When a scratch cartridge is loaded, for SME and LME, the drive communicates with the key manager, which provides the keys to encrypt the data. When data is appended, it must be encrypted with the same key as the existing data on the cartridge. The data encryption and decryption keys must stay with the data and cannot be stored unencrypted. They are stored in the Cartridge Memory of the cartridge and at the beginning of tape in an encrypted format. The data encryption and decryption keys are encrypted with another set of keys, known as key encryption keys (KEK). The KEKs are also provided by the key manager and are referenced by key labels that you define. These labels can be shared with authorized external users of the data cartridge.

Encryption policy is used for TS3400 to set up encryption for the partition that is configured with encryption. *Encryption policy* is a set of rules, or policies, that specify which data cartridges are to be encrypted. How and where these rules are set up depends on the operating environment.

Note: TS1120s produced before September 8, 2006 do not have the capability to encrypt data on the Data Cartridge. However, there is a chargeable upgrade available (FC5592) to upgrade the TS1120. This encryption capability includes drive hardware, as well as microcode additions and changes.

To set up encryption on your TS3400:

1. Go to the Welcome page of the TS3400 using the Web User Interface and select **Encryption Setting**, and the window shown in Figure 8-24 will be displayed.

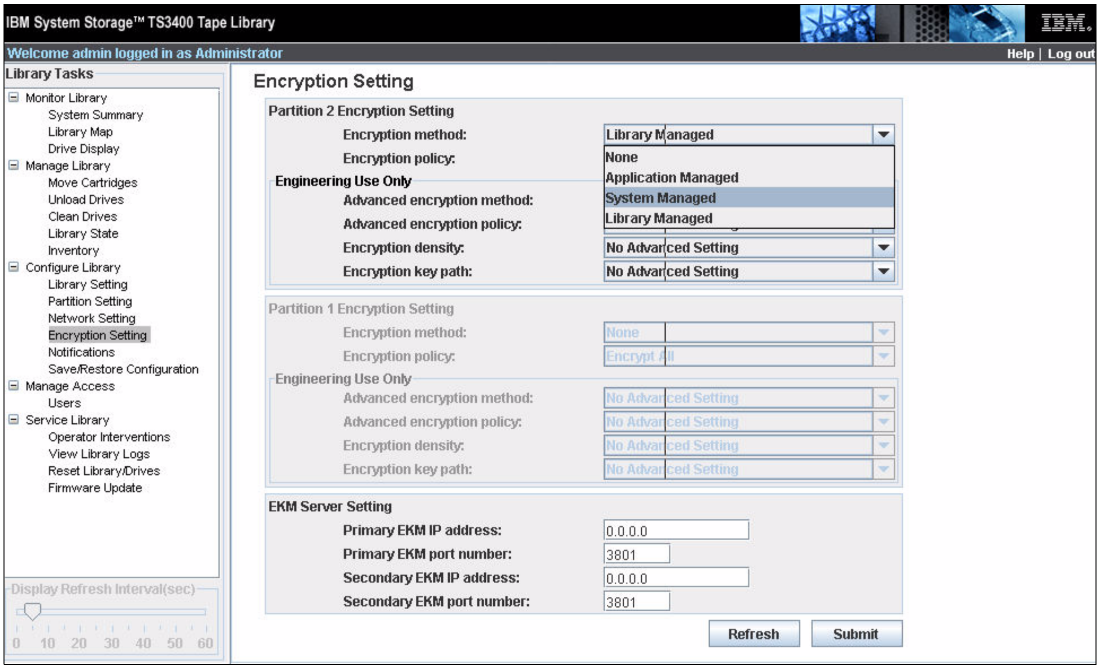


Figure 8-24 Encryption setting menu for the TS3400

On partition two, you are now able to set the methods of encryption that you want to use. There are four possible options:

None No encryption is used on partition two.

Application Managed Encryption
For encryption in operating environments that run an application capable of generating and managing encryption policies and keys. If you select Application-Managed Encryption, no further configuration steps are necessary. At the time of writing this publication, the only Application-Managed Encryption capable application was Tivoli Storage Manager.

System Managed Encryption
For encryption in operating environments where no application is capable of key management runs. Encryption is set up implicitly through each instance of the IBM device driver.

Library Managed Encryption
For transparent encryption by the TS3400 Tape Library tape drive.

Note: SME and LME are transparent. A data cartridge using SME can be decrypted using LME, and the reverse, provided both have access to the same EKM keystore.

2. The next step is to configure the Encryption Policy. From the Welcome Page, select **Encryption Setting** and then **Encryption Policy**. See Figure 8-25.

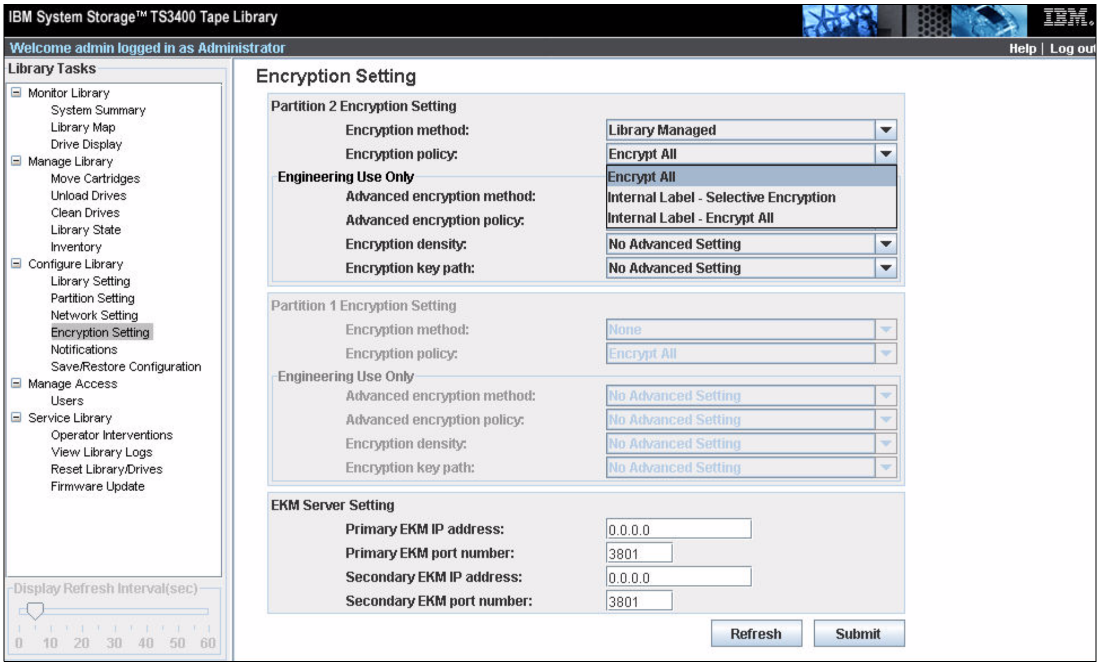


Figure 8-25 Encryption policy setting or the TS3400

The following three encryption policy methods are available for partition 2:

Encrypt All Encrypt All is the default setting. All data cartridges within the logical partition loaded into the tape drive are encrypted.

Internal Label - Selective Encryption
This option is used only for Symantec Veritas NetBackup.

Internal Label - Encrypt All
This option is used only for Symantec Veritas NetBackup.

There is also an Engineering Use Only option available. As the name implies, this option is only for IBM Support personnel (under the direction of the drive development team) to provide a solution to an unforeseen problem or to support a unique configuration. These options are not intended for use by the client without the guidance of IBM Support.

As you can see in Figure 8-24 on page 221 and Figure 8-25, partition 1 is grayed out. The reason for that is that older TS1120s can be installed in the TS3400, but those tape drives do not support encryption because of an older internal chip set. However, all TS1120s ordered with the TS3400 are encryption capable.

Select **Encrypt All** and click **Submit**.

3. The next step is to configure the EKM Server Setting. From the Welcome Page of the TS3400, select **Encryption Settings**. See Figure 8-26 on page 223.

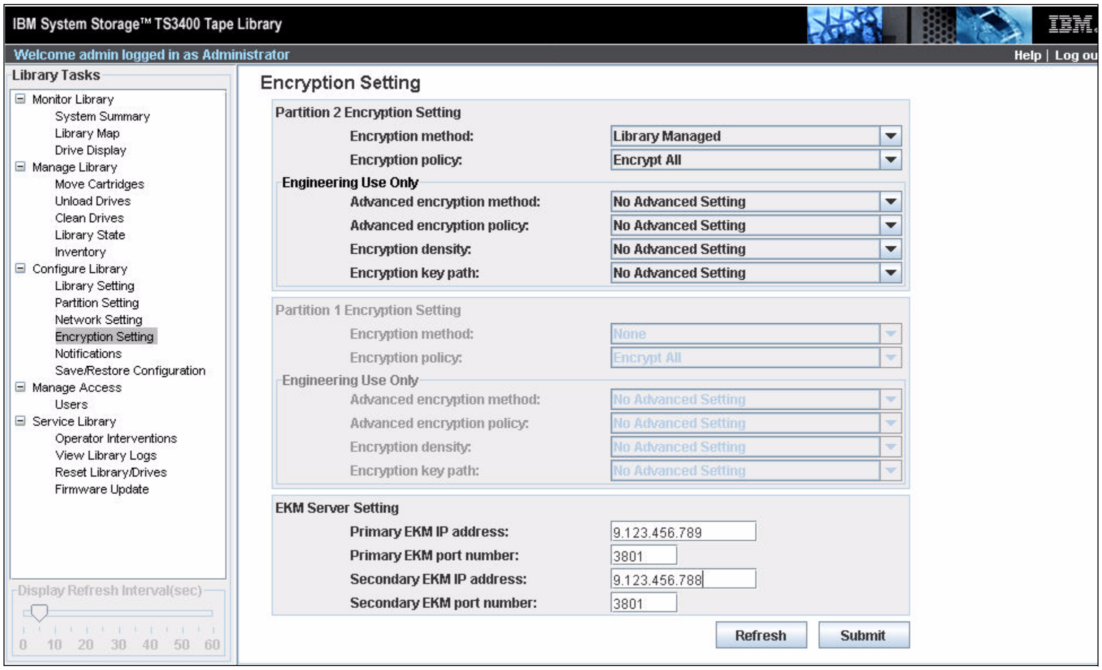


Figure 8-26 EKM settings for the TS3400

In our example, we used for the primary EKM IP address: **9.123.456.789** and the second EKM IP address: **9.123.456.788.**

4. To see if a data cartridge is encrypted, use the option **Library Map** from the Welcome page and click on the cartridge that is inserted in the partition that has encryption enabled. In our example, the cartridge in slot 14 is not encrypted. See Figure 8-27.

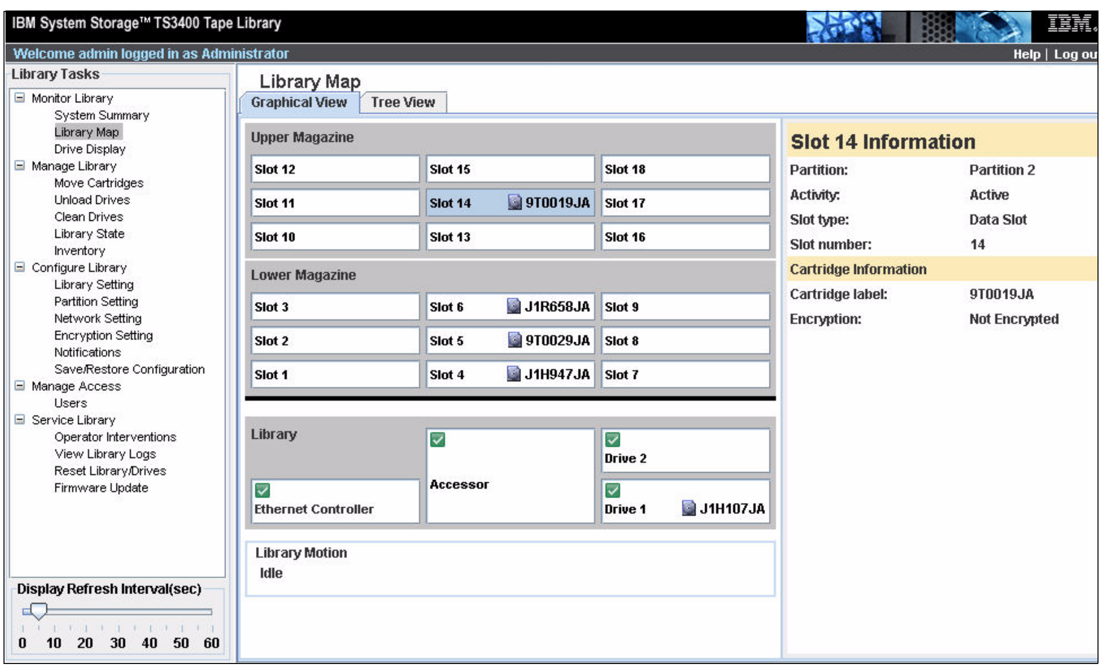


Figure 8-27 Library map graphical view TS3400

5. There are still two settings to configure before connecting the TS3400 to the host. You can change the settings using the Operator Panel or using the Web User Interface. From the

Welcome page for the TS3400, select **Notifications**. Two options are available for sending notifications sending to the host:

– E-mail notification. This feature automatically sends an e-mail containing event information to the e-mail addresses specified whenever an event of a certain level occurs. The contents of the e-mail message are similar to the information that can be obtained by Single Network Management Protocol (SNMP) traps without using SNMP management software. See Figure 8-28.

– SNMP Notification. This is a set of protocols for managing complex networks. SNMP works by sending messages, called *protocol data units (PDUs)*, to different parts of a network. Agents, which are SNMP-compliant devices, store data about themselves in Management Information Bases (MIBs) and return this data to the SNMP requesters, such as the host's monitoring application.

SNMP traps are alerts or status messages that can be collected, monitored, and used to proactively manage attached libraries using the SNMP protocol with the host servers. The tape library supports transmission of SNMP traps and collection of MIB information as an SNMP agent. SNMP traps can be received using an SNMP manager and MIB information can be collected using an MIB browser. See Figure 8-29 on page 225.

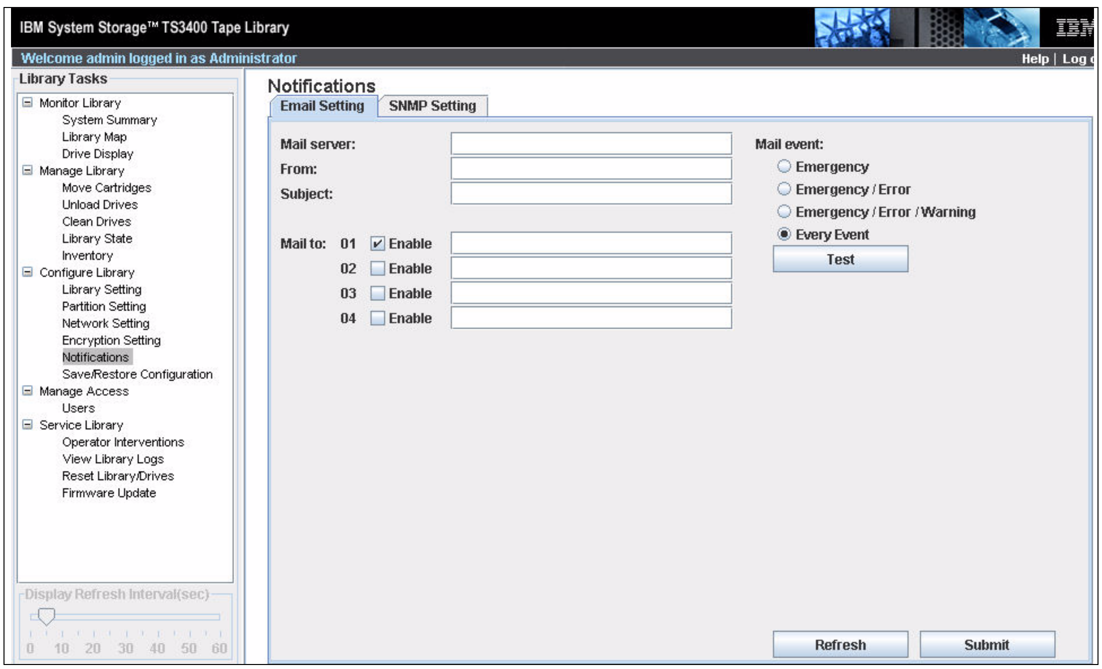


Figure 8-28 E-mail settings notification for the TS3400

Figure 8-29 on page 225 shows the SNMP notification setting window.

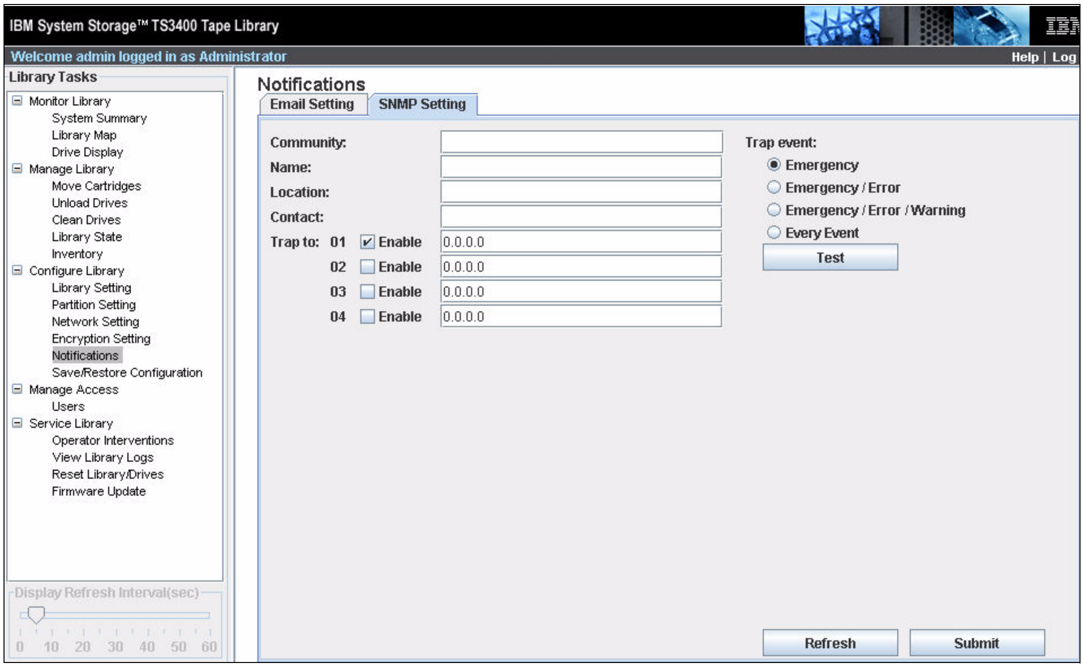


Figure 8-29 SNMP notification setting window

8.3.5 Firmware upgrade

After setting up and configuring the TS3400, we recommend that you verify that the latest firmware is installed for both the library and the tape drive. At installation time, the IBM Support Service Representative (SSR) verifies both firmware levels but it is your responsibility to maintain the firmware. Determine the current level of firmware available from the IBM Technical Support Web sites:

`http://www.storage.ibm.com/`
`ftp://index.storsys.ibm.com`

If the installed firmware of your library or tape drive is down-level, download the firmware from the IBM Web site to your local server.

There are several options to update the firmware of the library or the tape drive. You can use the driver's application interface, for example, NTUTIL, the Web User Interface of the TS3400, or an IBM tool called IBM TotalStorage Tape Diagnostic Tool (ITDT). We recommend that you use the Web User Interface for updating the library or drive firmware.

ITDT can also be used for updating the firmware of the tape drive. This tool is driver independent and can also be used for testing the tape drives and taking drive dumps.

> **Note:** Updating the library firmware is not supported.

ITDT can be downloaded from the following Web site:

`http://www-03.ibm.com/systems/storage/tape`

After updating the TS3400's firmware, it is now time to populated your TS3400 with data cartridges and to connect your TS3400 to the your host. The TS3400 that we used was already populated with data cartridges in order to give you the examples.

For ordering data cartridges and the features, see Appendix A, “IBM LTO Ultrium and 3592 media” on page 393.

8.3.6 Host bus adapter (HBA) support

In order to connect your TS3400 to the host, you have to ensure that the installed Fibre Channel HBA in your server is supported.

On the technical Support Web site from IBM, you can find the System Storage Interoperation Center (SSIC). This Web site is a starting point to find out if your HBA supports the TS1120 Tape Drive. Remember that for each Fibre Channel HBA there is a required minimum level of the Basic Input Output System (BIOS). Unpredictable problems can occur when the BIOS is not at the required level. Always install the latest available BIOS level for your HBA, as well as the latest device driver for your operating system. The Web site for the System Storage Interoperation Center is:

http://www-01.ibm.com/systems/support/storage/config/ssic/index.jsp

We provide an example with a System p server with AIX 5.3 and a 6228 HBA. The System Storage Interoperation Center will take you step-by-step through all the choices. See Figure 8-30.

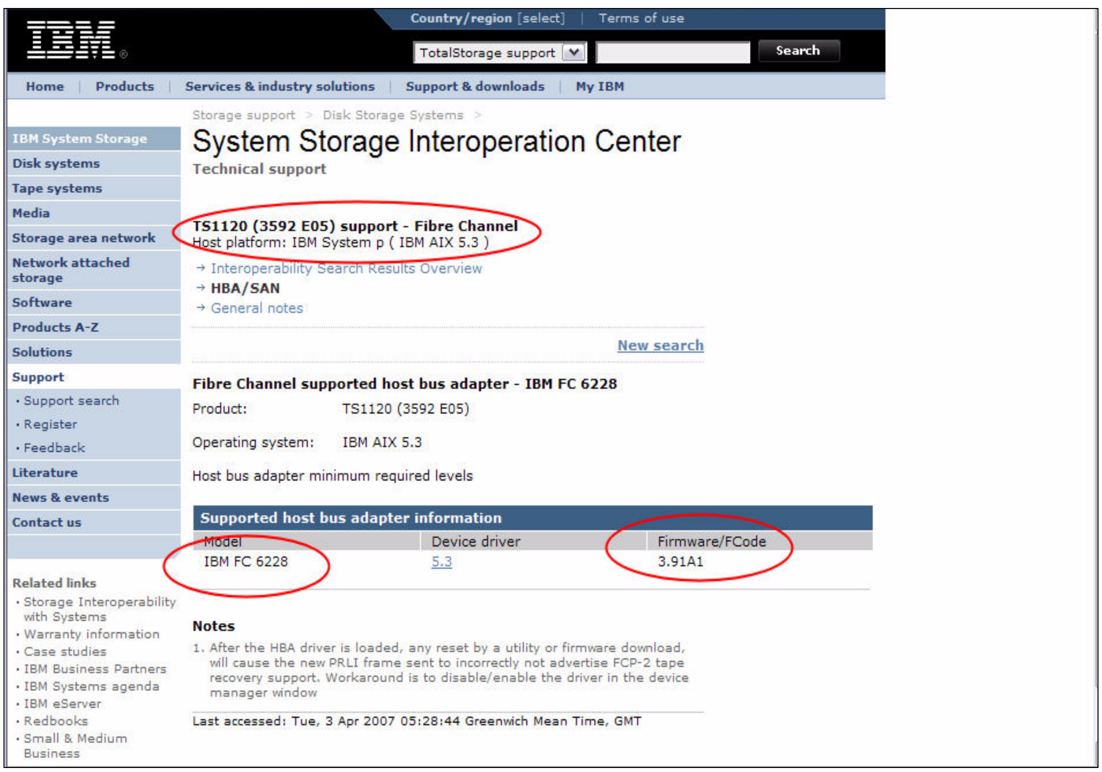


Figure 8-30 System Storage Interoperation Center

The ellipses point to the TS1120 Tape Drive, the Host Platform (AIX 5.3), the supported HBA (6228), and the Firmware level 3.91A1.

Note: The HBA 6228 is one of many supported HBAs. See the SSIC Web site for all supported FC HBAs.

8.3.7 Installing device drivers

To communicate with the TS3400, the appropriate device driver must be installed on your server. Depending on your host operating system, the latest device driver must be installed on your server. Visit the Web site:

http://www-03.ibm.com/servers/storage/tape/

Select **Support & Download** and in the next window, you can type `TS3400` in the search technical support box. Here, you can download the latest device driver for your operating system.

Another way to get the latest device driver is to visit this Web site:

ftp://index.storsys.ibm.com/devdrvr

Choose your operating system and download the device driver.

We do not discuss installing the device driver in this publication. Information about how to install the device driver are described step-by-step in *Implementing IBM TAPE in Unix Systems,* SG24-6502, *Implementing IBM Tape in Linux and Windows,* SG24-6268, and the *IBM Ultrium Device Drivers Installation and User's Guide, GA32-0430.*

All publications are available and can be downloaded from the Web.

You have now completed setting up your TS3400, installing your FC HBA, checking that your HBA is supported, and installing the right device driver.

Congratulations. We recommend that you register yourself for My Support at the IBM Technical Support Web site. When you register at My Support, you will automatically receive an e-mail when there is new firmware available for the TS3400 or other news concerning the TS3400. To register at My Support, go this Web site:

https://www-304.ibm.com/usrsrvc/account/userservices/jsp/login.jsp?persistPage=true

8.4 Technical specifications

In the next section, we summarize all of the technical specifications of the TS3400.

Physical specifications

The TS3400 is a mid-range sized IBM Automation Tape Library with the following physical specifications:

- Width: 44.5 cm (17.5 in.)
- Depth: 89.5 cm (32.2 in.)
- Height: 22.15 cm (8.7 in.)
- Weight (library only) 31 kg (68.3 lbs.)

Electrical specifications

The following values are for a TS3400 with two installed TS1120 Tape Drives:

- Voltage: 100 to 240 Vac.
- Frequency: 50 to 60 Hz.
- Power consumption: 117.85 W

Performance specifications for the TS3400

The TS3400 has the following performance specifications:

- Inventory:
  - Full cartridges with barcode labels: 40 sec.
  - Full cartridges without barcode labels: 100 sec.
  - No cartridges: 100 sec.
- Average access time (maximum):
  - X direction (one way): 3 sec.
  - Y direction (one way): 4.5 sec.
  - Picker direction (one way): 3 sec.

8.5 Feature codes

Table 8-3 shows the available feature codes for the TS3400.

Table 8-3 Feature codes

Description	Feature code
Library and Drive Code Update (one time visit)	0500
Tape Drive Removal	1663
Tape Drive (3592-E05)	4685
LC-SC Fibre Cable Interposer	5096
LC-SC Fibre Channel Cable (5 m)	6005
LC-SC Fibre Channel Cable (13 m)	6013
LC-SC Fibre Channel Cable (25 m)	6025
Rack Mount Kit with 2 RML cords	7004
Additional Cartridge Magazine	8109
3592 Cleaning Cartridge	8802
Encryption Configuration (Documentation)	9900

9

IBM System Storage TS3500 Tape Library

The IBM System Storage TS3500 Tape Library leverages the LTO and Enterprise 3592 drive technologies within the same library. The TS3500 was previously known as the IBM TotalStorage 3584 Tape Library and still has the machine type 3584.

The TS3500 Tape Library provides tape storage solutions for the large, unattended storage requirements from today's mid-range up to enterprise (z/OS and Open Systems) environment. This chapter only covers information relating to the TS3500 Tape Library attachment in an Open Systems environment. For information about TS3500 Tape Library attachment to a System z environment, refer to *IBM System Storage TS3500 Tape Library with System z Attachment: A Practical Guide to TS1120 Tape Drives and TS3500 Tape Automation*, SG24-6789.

Combining reliable, automated tape handling and storage with reliable, high-performance IBM LTO Ultrium tape and 3592 drives, the TS3500 Tape Library offers outstanding retrieval performance with typical cartridge move times of less than three seconds.

The TS3500 Tape Library can be partitioned into multiple logical libraries. This makes it an excellent choice for consolidating tape workloads from multiple heterogeneous Open Systems servers and enables the support for System z attachment in the same library.

In addition, the TS3500 Tape Library provides outstanding reliability and redundancy, through the provision of redundant power supplies in each frame, an optional second cartridge accessor, control and data path failover, and dual grippers within each cartridge accessor. Both library and drive firmware can now be upgraded non-disruptively, that is, without interrupting the normal operations of the library.

The TS3500 supports Tape Encryption on the following tape drives: IBM System Storage TS1040 Tape Drive and the IBM System Storage TS1120 Tape Drive. All three Encryption methods are supported: Application-Managed Encryption (AME), System-Managed Encryption (SME), and Library-Managed Encryption (LME).

9.1 Model description

The IBM TS3500 Tape Library (machine type 3584) is a modular tape library consisting of frames that house tape drives and cartridge storage slots. You can install a single-frame base library (Figure 9-1 on page 231) and grow it to 16 frames, tailoring the library to match your system capacity.

The following maximums can be possible:

- IBM Ultrium 3 Data Cartridges: 26 TB to 2.75 PB (52 TB to 5.51 PB with 2:1 compression)
- IBM Ultrium 4 Data Cartridges: 52 TB to 5.5 PB (104 TB to 11 PB with 2:1 compression)
- 3592 Data Cartridges: 29 TB to 3.13 PB (87 TB to 9.39 PB with 3:1 compression)
- 3592 Extended Data Cartridges: 40.6 TB to 4.38 PB (121.8 TB to 13.14 PB with 3:1 compression)

The high granularity of the IBM TS3500 Tape Library configurations, its features, and its capacities are designed to match a wide variety of client requirements.

The IBM TS3500 Tape Library is an excellent choice if you:

- Are experiencing rapid growth in online storage requirements
- Are considering tape libraries with software for automatic backup, archive, or fast-access tape operation to accommodate growth and reduce manual operations
- Have standardized on IBM LTO Ultrium format tape or are needing to use Enterprise Tape Drives
- Are looking for an IBM tape solution requiring large cartridge capacity and fast data streaming transfer capability
- Have high availability and reliability requirements

In the top right corner of Figure 9-1 on page 231, you can see the minimum configuration of a TS3500 Tape Library, as well as the maximum configuration with 16 frames below.

Figure 9-1 Maximum and minimum TS3500 Tape Library configurations

Five different frames are currently available to build a TS3500 Tape Library. Each frame is identified by a three character model number (L23, L53, D23, D53, or HA1), which describes the nature of the frame. Libraries are built of modules as follows:

- Every library requires a base frame (model L*xx*) to which optional expansion frames (model D*xx*) can be added. Only one base frame is permitted in each library configuration.
- Base and Expansion frames support either:
  - LTO2, 3, and 4 Tape Drives (model *x*53)
  - TS1120 Tape Drives and 3592 drives (model *x*23)
- An optional second accessor is made available through the addition of the model HA1 frames.

All currently available frame models can be intermixed with each other and installed frame models with the provision that there is only one base frame in each library. Installed frame models include the L22, L32, L52, D22, D32, and D52. L22 and D23 frames can be upgraded to the respective *x*23 frames, and *x*52 frames can be upgraded to the respective *x*53 frames. This provides investment protection and considerable flexibility in configuration and expansion.

The following list introduces the currently available frame models:

- *TS3500 Tape Library Model L53*, a base frame that can be installed on its own or in combination with expansion frames. It can host up to 12 Ultrium Tape Drives and up to 287 IBM Ultrium Tape Cartridges.

- *TS3500 Tape Library Model D53*, an expansion frame that can be used to provide an additional 12 Ultrium Tape Drives, and a maximum of up to 440 storage slots (this depends on the number of tape drives installed). Up to 15 expansion frames can be installed with a base frame.
- *TS3500 Tape Library Model L23*, a base frame that can be installed on its own or in combination with expansion frames. It can host up to 12 TS1120 Tape Drives and a maximum of up to 260 storage slots (this depends on the features installed).
- *TS3500 Tape Library Model D23*, an expansion frame that can be used to provide an additional 12 TS1120 Tape Drives and a maximum of up to 400 storage slots (this depends on the number of tape drives installed). Up to 15 expansion frames can be installed with a base frame.
- *IBM 3584 Tape Library Model HA1*, in conjunction with service bay features on the TS3500 Tape Library models D23 and D53, provides for the installation of a second library accessor that is designed to operate simultaneously with the first accessor and service mount requests in the IBM TS3500 Tape Library at the same time.

In addition to the D-Frames, there is also a 4 I/O station door available for either LTO or TS1120/3952 tape drives. One I/O station door has 4 I/O stations with a total of 64 storage slots.

A maximum of three 4 I/O station doors are allowed per TS3500. This maximum configuration then results in a total number of 14 I/O stations. All 4 I/O station doors must be the same type: either LTO or TS1120/3952. No intermix is allowed. Feature Code 1451 must be ordered as a prerequisite when ordering a 4 I/O station door. Two Feature Codes are available:

- FC1685: 4 LTO I/O Station D-Frame
- FC1656: 4 3592 I/O Station D-frame

Note. All 4 I/O station doors must be the same type. There is no mixed media support.

9.1.1 TS3500 frames for IBM LTO Ultrium Fibre Channel drives

The TS3500 Tape Library Models L53 and D53 integrate the TS1030 and TS1040 LTO Ultrium 4 Gbps Fibre Channel Tape Drive. The Model L53 frame includes an enhanced Frame Controller Assembly (FCA) with two power supplies (for redundancy), an optimized dual-gripper cartridge accessor, on demand storage slot capacity, and 16-slot I/O stations. The Model D23 frame can be attached to current or installed frame models.

TS3500 Tape Library Model L53

The L53 can be installed on its own as a complete library enclosure, shown in Figure 9-2 on page 233, or it can have up to 15 expansion frames attached to it. This frame provides the major library components for the whole library, whether it has single or multiple frames. It also provides cartridge storage capacity for LTO media and it can be equipped with IBM Ultrium 1, 2, 3, and 4 tape drives. The expansion frames must be added to the right of the L53 frame.

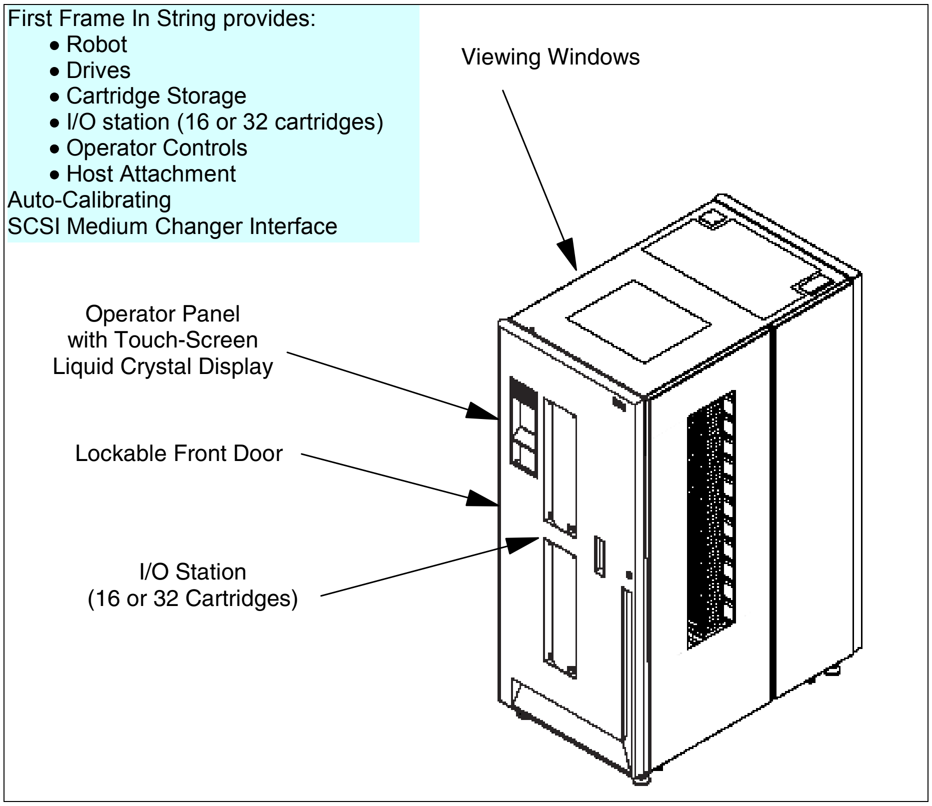


Figure 9-2 IBM TS3500 Tape Library L53 base frame view from front left

The number of LTO cartridge storage slots ranges from 64 to 287. With the minimum configuration, there are just 64 slots available for use, but the maximum of 287 slots are already physically installed. Additional slots can be added for use by simply enabling them through a license key.

The Intermediate Capacity feature (FC1643) gives a total amount of usable cartridge slots of 129. This feature is required to add a Full Capacity feature (FC1644), which gives the capacity of 287 cartridge slots. The full capacity feature is in turn required to add an Additional I/O Slots feature (FC1658 for LTO or FC1659 for 3592) or to attach an optional expansion frame.

This gives a maximum data capacity for the L53 of 229 TB native (up to 458 TB with 2:1 data compression).

Up to 12 IBM Ultrium drives can be installed. All generations of IBM Ultrium LTO tape drives can be installed in the same frame. As you add more than four drives or install the additional I/O station, there is an incremental reduction in storage slots (Table 9-1 on page 234). It is also possible to install the LTO FC Drive Mounting Kit (FC1514) in advance in order to simplify future tape drive installation, but it will also reduce the number of available slots.

Table 9-1 L53 frame capacity

Type of Capacity On Demand expansion feature	Quantity of tape drives + drive mounting kits	Quantity of I/O slots	Quantity of storage slots
Entry	0 to 12	16	64
Intermediate	0 to 12	16	129
Full	0 to 4	16	287
Full	5 to 8	16	273
Full	9 to 12	16	261
Full	0 to 4	32	245
Full	5 to 8	32	231
Full	9 to 12	32	219

Each TS3500 Model L53 has a standard 16-slot LTO cartridge input/output station for importing or exporting cartridges from the library without requiring re-inventory or interruption of library operations. Optional features can provide 16 additional input/output slots for LTO (FC1658) or 3592 media (FC1659). The lockable library door can be opened for bulk-loading IBM LTO Ultrium tape cartridges. Re-inventory of the cartridges is done in fewer than 60 seconds per frame each time the library door is closed. A barcode reader mounted on the autochanger scans the cartridge labels at less than one minute per frame. A door lock is included to restrict physical access to cartridges in the library.

TS3500 Tape Library Model D53

The D53 frame, shown in Figure 9-3, has the same footprint as the model L53.

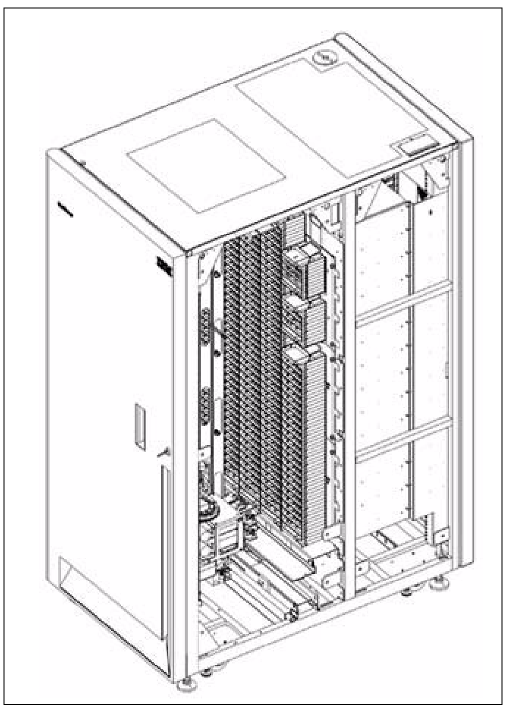


Figure 9-3 IBM TS3500 Tape Library Model D53 viewed from the right

The D53 cannot be installed on its own. It must be connected to a library with a base frame and optionally multiple expansion frames. Up to 16 frames can be connected as shown in Figure 9-1 on page 231.

If one or more tape drives are installed in the D53, the Enhanced Frame Control Assembly Feature (FC1451) is required along with the LTO Fibre Drive Mounting Kit (FC1514). This feature provides the hardware and firmware required to support IBM LTO Ultrium drives within the D53 and also provides a redundant AC line feed for the L frame accessor. The Frame Control Assembly Feature is also required if the LTO Fibre Drive Mounting Kit (FC1504) is installed.

You can easily configure D53 frames according to future requirements. By installing the Enhanced Frame Control Assembly (FC1451), the D53 frame is ready to host LTO drives. The LTO Fibre Drive Mounting Kit (FC1514) prepares the drive slots for hosting an LTO drive. This enables you to install or move LTO drives without any additional hardware changes.

With the installation of drives and Drive Mounting Kits, the storage slot capacity is reduced as shown in Table 9-2.

Table 9-2 D53 frame capacity

Quantity of tape drives + drive mounting kit	Quantity of slots in frame
0	440
1 - 4	422
5 - 8	408
9 -12	396

A fully configured IBM TS3500 Tape Library with one L53 frame and 15 D53 frames supports up to 192 drives. An L53 base frame and 15 D53 expansion frames with a minimal drive configuration provides a maximum capacity of 6887 storage slots with a total capacity of 5.5 PB without compression.

The base L23 or L53 is always on the left and as many as 15 additional D53 and D23 expansion frames can be added to the right side. During the installation of additional D53 frames, the x-rail of the L frame where the accessor resides will be extended, so that the accessor can move through the newly installed frame.

If a D53 is being added to an installed L32 or D32 frame, FC1610 is required, because the D53 is a shorter frame. This feature includes a short rear side cover for the Model D32/L32 frame and the Model D23/D53 front and rear side covers.

An additional 16-slot input/output station for LTO media must be ordered via FC1658 if attaching a D53 expansion frame to an L23 base frame.

Up to four additional 4 I/O station doors can be installed in the TS3500, and FC1451 is a prerequisite when installing a 4 I/O station door. Figure 9-4 on page 236 shows the 4 I/O Station D-Frame. An LED status panel is located on the right upper corner. The LEDs represent the amount of cartridges per I/O station and if the I/O station is locked. The I/O door has a total number of 64 slots, 16 slots per I/O station.

The 4 I/O station door reduces the frame storage slot capacity by 160 for a model D23 and by 176 for a model D53. The I/O stations increase the maximum library I/O station slots from 32 to 224 due to a maximum of three D23 or D53 I/O frames in the sixteen frame library. The D23 and D53 models are compatible with existing models L22, L32, L52, D22, D32, and D52.

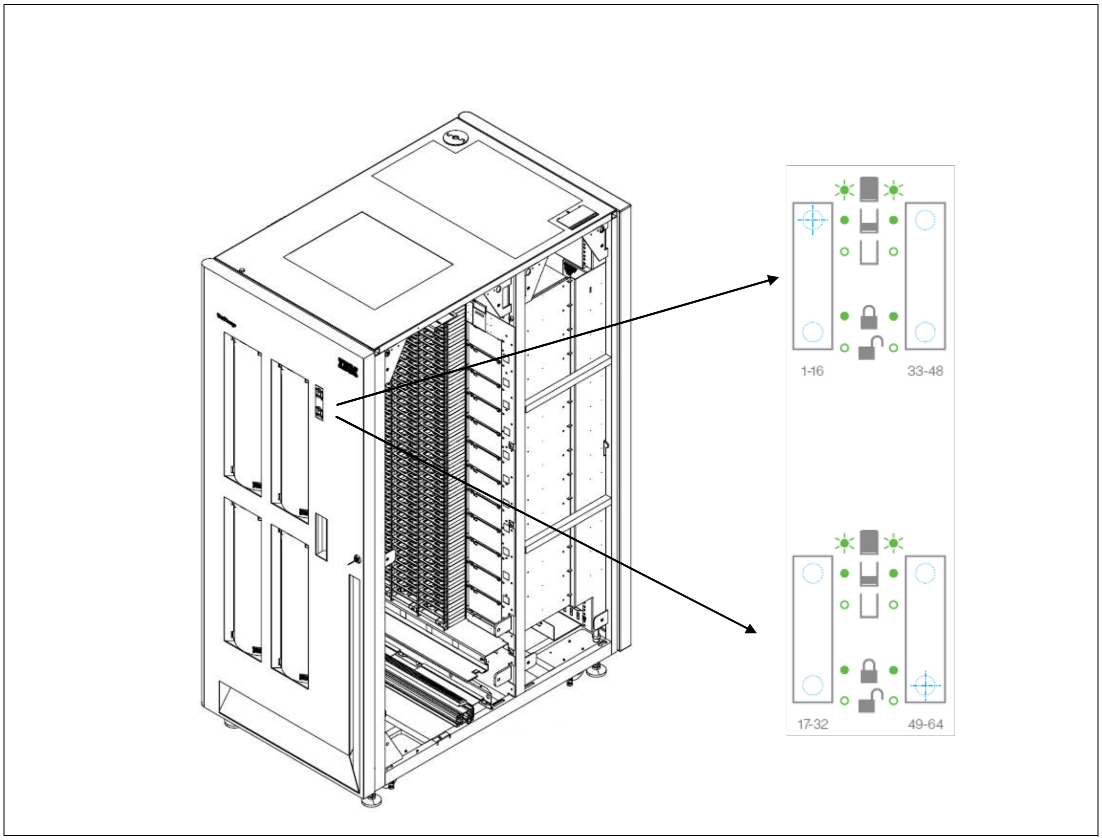


Figure 9-4 4 LTO I/O Station D-Frame

Figure 9-5 on page 237 shows a graphical overview of the 4 I/O station door using the Web User Interface. In our example, there are five cartridges imported in the upper right I/O station and when you put your cursor on the data cartridge, it will show you the volume label.

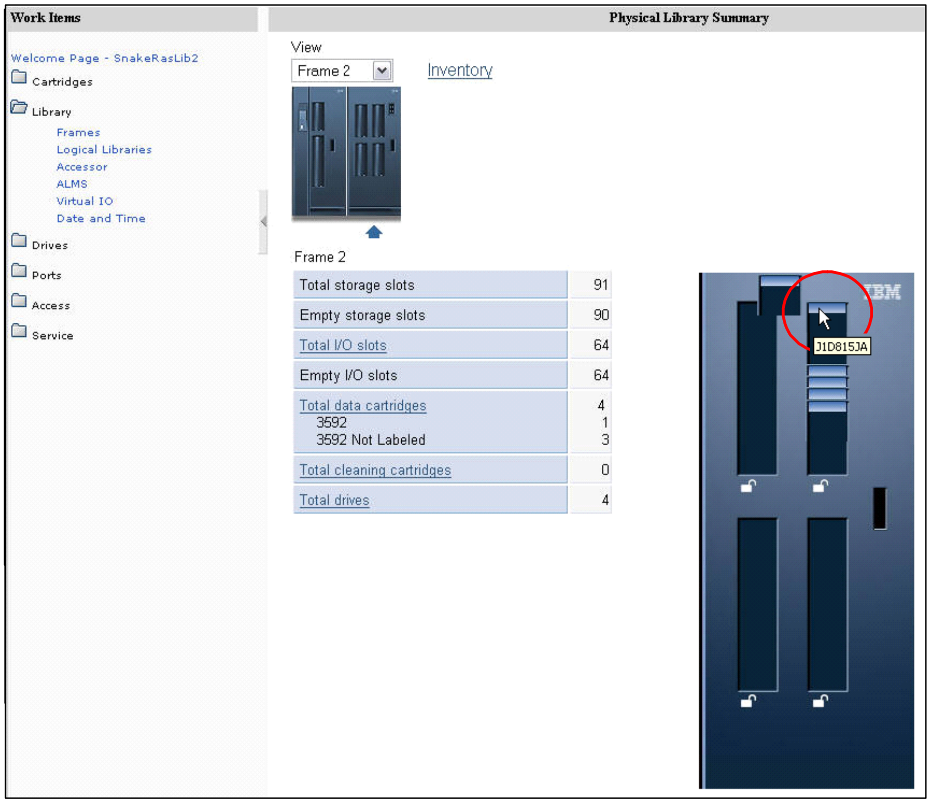


Figure 9-5 A graphical overview of the 4 I/0 station door using the Web User Interface

9.1.2 IBM TS3500 Tape Library frames L23 and D23

The Model L23 and D23 frames integrate the TS1120 Tape Drive with a 4 Gbps dual-ported switched fabric Fibre Channel attachment. The TS3500 Tape Library Model L23 and D23 frames can be attached to LTO Frames (L23 and D53), and, therefore, TS1120 and LTO tape drives can be intermixed within the same TS3500 Tape Library.

The TS1120 Tape Drive used in the IBM TS3500 Tape Library Models L23 and D23 is designed for automation and uses a tape cartridge with a form factor similar to the IBM 3590 tape cartridges. The TS1120 Tape Drive has a dual-ported 4 Gbps Fibre Channel interface and has a native data rate of up to 100 MB/s. The TS1120 Tape Drives are designed to provide high levels of performance, functionality, and cartridge capacity supporting the 3592 tape format, including Write Once Read Many (WORM) media support.

IBM System Storage TS3500 Model L23 Frame

The TS3500 Model L23 frame provides cartridge slots for 3592 media and support for up to twelve TS1120s with an incremental reduction of storage slots beyond four drives or with additional I/O slots. This model has the same footprint as the model L53. Data capacity for the model L23 using 3592 data cartridges is 17 to 78 TB native. The L23 can be installed on its own as a complete library enclosure, or up to 15 Model D23 or D53 can be attached to it. The library capacity and number of drives can be expanded to meet changing needs.

The L23 frame provides the major library components for the whole library, whether it has single or multiple frames. The expansion frames must be added to the right of the L53 frame.

The number of 3592 cartridge storage slots ranges from 58 to 260. The minimum configuration provides 58 slots that are available for actual use, although all 260 slots are already physically installed. To enable the additional slots for use (up to the total of 260), obtain an additional license key by ordering one of the following Capacity On Demand features. The Intermediate Capacity feature (FC1643) gives a total number of 117 usable cartridge slots. This feature is required to add a Full Capacity feature (FC1644), which gives you the capacity of 260 cartridge slots. The Full Capacity feature is required to add an additional I/O Slots feature (FC1658 or FC1659) or to attach the optional expansion frame models D23 or D53.

Up to 12 IBM TS1120 Tape Drives can be installed. Adding more than four drives or drive mounting kits, or installing the additional I/O station, will reduce the number of storage slots available for use (see Table 9-3). You can also install the 3592 Fibre Channel (FC) Drive Mounting Kit (FC1513) in advance, which will simplify future tape drive installation. This kit reduces the storage slots to the appropriate number and provides the power supply and necessary cables for installing a TS1120 drive.

Table 9-3 L23 frame capacity

Type of Capacity On Demand expansion feature	Quantity of tape drives + drive mounting kits	Quantity of I/O slots	Quantity of storage slots
Entry	0 to 12	16	58
Intermediate	0 to 12	16	117
Full	0 to 4	16	260
Full	5 to 8	16	248
Full	9 to 12	16	237
Full	0 to 4	32	222
Full	5 to 8	32	210
Full	9 to 12	32	199

Each L23 has a standard 16-slot 3592 cartridge input/output station for importing or exporting cartridges from the library without requiring re-inventory or interruption of library operations. Optional features can provide 16 additional input/output slots for LTO media. The lockable library door can be opened for bulk-loading cartridges. Re-inventory of the cartridges is done in fewer than 60 seconds per frame each time the library door is closed. A barcode reader mounted on the autochanger scans the cartridge labels at less than one minute per frame. A door lock is included to restrict physical access to cartridges in the library.

IBM System Storage TS3500 Model D23 frame

The D23 frame has the same footprint as the Model L23. The D23 cannot be installed on its own. It must be connected to a base frame and optionally other expansion frames. Up to 16 frames can be connected.

If one or more tape drives are installed in the D23, the Enhanced Frame Control Assembly Feature is also required (FC1451). This feature provides the hardware and firmware required to support IBM 3592 drives within the D23 and provides a redundant line feed for the L23 or L53 accessor.

You can easily configure D23 frames according to future requirements. By installing the Enhanced Frame Control Assembly (FC1451), the D23 frame is ready to host TS1120 Tape

Drives. The 3592 Fibre Channel Drive Mounting Kit (FC1513) prepares the drive slots for hosting a TS1120 Tape Drive. This enables you to install or move 3592 drives without any additional hardware changes.

With the installation of drives or Drive Mounting Kits, the storage slot capacity is reduced as shown in Table 9-4.

Table 9-4 D23 frame capacity

Quantity of tape drives + drive mounting kit	Quantity of slots in frame
0	400
1 - 4	383
5 - 8	371
9 -12	360

A fully configured IBM TS3500 Tape Library with one L23 frame and 15 D23 frames supports up to 192 drives. An L23 base frame and 15 D23 expansion frames with a minimal drive configuration provide a maximum capacity of 6260 storage slots with a total capacity of 1878 TB without compression using the TS1120 Tape Drive.

The base frame (model L*xx*) is always on the left and as many as 15 additional expansion frames (model D*xx*) can be added to the right side. During the installation of additional D23 frames, the x-rail of the L frame where the accessor resides is extended, so that the accessor can move through the newly installed frame.

If a D23 is added to an installed L32 or D32 frame, feature FC1610 is required, because the D23 is a shorter frame. This feature includes a short rear side cover for the Model D32/L32 frame and the Model D23/D53 front and rear side covers.

If attaching a D23 frame to an L53 frame, the First Expansion Frame Attachment Feature (FC9002) for the L53 must be specified. Subsequent expansion requires the Additional Expansion Frame Attachment feature (FC9003).

Additional 16-slot I/O stations for 3592 media must be ordered via FC1659 if attaching a D23 frame to a L53.

9.1.3 IBM 3584 High Availability Unit HA1

The IBM 3584 High Availability Frame Model HA1 can be added to the IBM TS3500 Tape Library Base Frame Models. In conjunction with a service bay feature on the TS3500 Tape Library Model D23 or L23, the Model HA1 provides for the installation and operation of a second library accessor that is designed to operate simultaneously with the first accessor and service mount requests in the IBM TS3500 Tape Library. It is designed to non-disruptively fail over to a redundant accessor when any component of either accessor fails, which helps maintain availability and reliability. This design also includes the ability to add one or more Model D53 or D23 frames to an IBM TS3500 Tape Library that has an attached Model HA1 with minimal disruption.

Dual active accessor support is provided in a mixed media library. This includes any combination of 3592 and LTO Ultrium media types. For example, a single library can have 3592, Ultrium 1, Ultrium 2, Ultrium 3, and Ultrium 4 media installed and configured. The Advanced Library Management System (ALMS) (see 9.5, “ALMS” on page 262) is required for support of dual accessors and two or more media types.

When dual accessors are installed and an attached host issues a command for cartridge movement, the library automatically determines which accessor can perform the mount in the most timely manner. If the library's primary accessor fails, the second accessor assumes control and eliminates system outage or the need for operator intervention.

A dual accessor library will have two garage areas called *service bays* (see Figure 9-6). Service Bay A (the 3584 High Availability Frame Model HA1) is to the left of and adjacent to the L-frame, when facing the front door. Service Bay B (a modified TS3500 Tape Library Model D23 or D53) is to the right of the last active frame in the library.

The TS3500 Tape Library Model HA1 itself provides only a frame, which serves as Service Bay A for the original accessor for the TS3500 Tape Library Model L*xx*. The second accessor is provided by ordering the Service Bay B Configuration and Dual Accessor feature (FC1440) on a TS3500 Tape Library Expansion Frame Model D23 or D53. When this feature is ordered on a Model D23 or D53, that expansion frame will be reserved and function as a Service Bay B for the second accessor. This feature needs to be initially installed on a new Model D23 or D53 frame that is added to the IBM TS3500 Tape Library when ordering the Model HA1. If your library already contains the service bays and you decide to add one or more D23 or D53 expansion frames, Service Bay B will be converted to an expansion frame, the new frame or frames will be added to the right, and the last frame on the right will be converted to Service Bay B. The downtime for this process is designed to be less than an hour.

The service bays will be regular library frames, but they will not have drives, power supplies, or node cards. Storage slots within the service bays will only be used to test service actions. Figure 9-6 demonstrates how the Service Bays surround the other library frames.

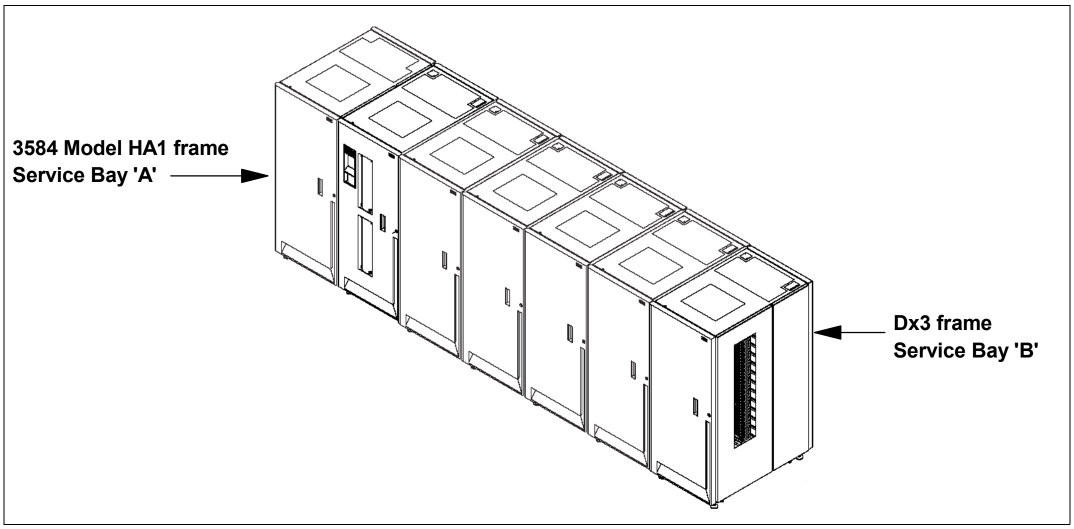


Figure 9-6 Location of service bays in the IBM TS3500 Tape Library

To summarize, implementing non-disruptive accessor failover requires:

- A 3584 Model HA1 frame to act as Service Bay A
- High Availability Library feature (FC9040) for the L*xx* frame
- Advanced Library Management System feature (FC1690)
- A D53 or D23 frame to operate as Service Bay B for the second accessor
- Additional expansion frame attachment (FC9003)
- Service Bay B Configuration with Accessor (FC1440)

9.2 Library components

Figure 9-7 shows the major IBM TS3500 Tape Library components.

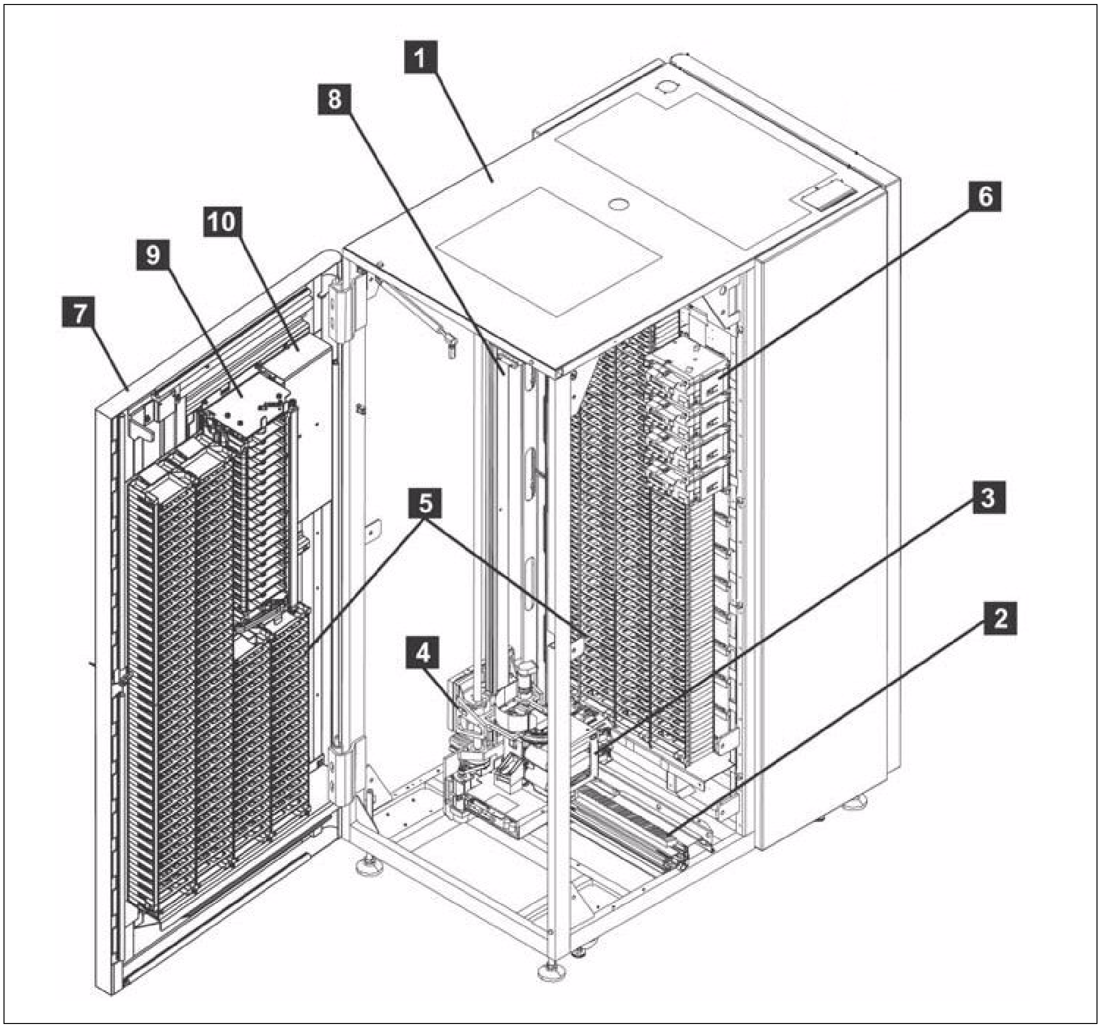


Figure 9-7 IBM TS3500 Tape Library showing major library components

The components shown in Figure 9-7 are:

1. Library frame
2. x-rail system
3. Cartridge accessor with optimized dual-gripper transport mechanism
4. Accessor controller
5. Cartridge storage slots
6. IBM LTO Ultrium Tape Drives or 3592 Tape Drives
7. Front door
8. Door safety switch
9. I/O stations
10. Operator Panel and Operator Panel controller

Other important components, which are not indicated in Figure 9-7, include the frame control assembly (FCA), the enhanced FCA, and the patch panel.

9.2.1 Tape drives supported in the TS3500 Tape Library

This section introduces the types of drives that can be installed in the 3584 Tape Library.

The LTO Ultrium Tape Drives and the 3592 Tape Drives are high-performance, high-capacity data-storage units that can be installed in the TS3500 or 3584 Tape Library. Up to 12 drives can be installed in each frame of the library, but the two types of drives cannot be mixed in the same frame. You can identify a drive by examining the logo at its front or by inspecting the label at the rear of the drive's canister.

You or your IBM Service Support Representative (SSR) can update the firmware of your tape drives, except IBM Ultrium 1 tape drives, without scheduling downtime. This enhancement is called a *non-disruptive drive firmware update*. It is available through the Web User Interface and for the IBM SSR through the CETool, but it is not supported by the SCSI interface. It is not available if you use ITDT or tapeutil.

Note: The non-disruptive drive firmware update takes 30-40 minutes per drive, as compared to less than one minute per drive when using ITDT or tapeutil.

LTO Ultrium Tape Drives

The TS1030 and TS1040 are Linear Tape-Open (LTO) tape drives that facilitate 4 Gbps Fibre Channel connectivity. You can identify the type of model LTO tape drives by the logo at the front of the drive or by the label at the rear of the drive's canister.

When a cartridge is labeled according to proper IBM barcode label specifications, the last character of its volume serial (VOLSER) number indicates the generation of the media. For example, a cartridge with a VOLSER of `000764L3` is an Ultrium 3 cartridge; a cartridge with a VOLSER of `003995L2` is an Ultrium 2 cartridge. To enhance library performance, Ultrium 3 and Ultrium 2 Tape Drives include speed matching, channel calibration, and power management. *Speed matching* dynamically adjusts the drive's native (uncompressed) data rate to the slower data rate of a server. *Channel calibration* customizes each read/write data channel for optimum performance. The customization enables compensation for variations in the recording channel transfer function, media characteristics, and read/write head characteristics. *Power management* reduces the drive's power consumption during idle power periods.

For further information regarding this tape drive, refer to 2.3, "IBM System Storage TS1030 Tape Drive" on page 66 and 2.4, "IBM System Storage TS1040 Tape Drive" on page 67.

3592 Tape Drives

Introduced in October 2005, the IBM System Storage TS1120 Tape Drive is the second generation of a new family of tape products that are designed to meet the growing needs of both new and existing IBM tape clients across a wide range of environments. The TS1120 Tape Drive is the follow-on to the IBM 3592 Tape Drive Model J1A and the highly successful 3590 Enterprise Tape Drive. It has 500 GB of native capacity in a half-inch format tape cartridge and has a native data rate of up to 100 MB/s. By its design, it is also a foundation of future generations and it helps to protect the client investment of tape cartridges.

IBM System Storage TS1120 Tape Drive

With its higher performance, greater capacity, and smaller size, as compared to a 3590 Tape Drive, the use of the TS1120 Tape Drive can help save costs as you reduce your number of tape drives and cartridges, and the associated floor space.

Highlights of the TS1120 Tape Drive are:

- Up to 100 MB/s native data rate, over 2.5 times the 40 MB/s of the 3592 Model J1A, and over seven times the 14 MB/s of the 3590 E or H Models
- Up to 700 GB native cartridge capacity
- A larger, 512 MB internal buffer
- Dual-ported switched fabric 4 Gbps Fibre Channel attachments
- Small form factor that allows double the drives in a single 3494 frame, as compared to the 3590 Tape Drive
- High reliability and availability design
- Additional performance and access improvements over the 3592-J1A

TS1120 data cartridges are available as machine type 3599. The 3599 media models include:

- R/W 700 GB Data Cartridge
- R/W 500 GB Data Cartridge
- R/W 100 GB Data Cartridge
- WORM 700 GB
- WORM 500 GB
- WORM Economy 100 GB

For further information regarding this tape drive, refer to 2.6, “IBM System Storage TS1120 Tape Drive” on page 90.

9.2.2 Library control systems: Enhanced frame control assembly

The *Enhanced Frame Control Assembly* is a 2N redundant power design, but with fewer components than the original frame control assembly found in earlier frame models. The Enhanced Frame Control Assembly has two redundant power supplies, which are fed directly by independent dual AC line cords. The assembly is constructed with hot-swappable, redundant parts, which (along with the dual AC line cords) remove the possibility of a single part causing failure. If one power supply fails, the remaining power supply provides all of the power to all of the library’s elements.

The Enhanced Frame Control Assembly comes standard with Models L23 and L53 and can be ordered as a feature code for Models D23 and D53. The dual AC line cords are standard on Models L23, D23, L53, and D53 and do not have to be ordered separately.

Medium Changer Assembly in the 3584 Tape Library

Integral to the enhanced frame control assembly power structure is the *Medium Changer assembly (MCA) unit*, a device located above the drives and the fixed power trays in Models L23, D23, L53, and D53 frames. The MCA handles communication between host applications and the library, and it houses two Ethernet ports for connection to the IBM System Storage Tape Library Specialist Web interface, a master console, or both.

Refer to Figure 9-8 on page 244 for a view of the Medium Changer Assembly, identifying the locations of the two Ethernet ports. Use the ports as follows:

- Use Port A (identified as 1 in Figure 9-8 on page 244) to connect to the Tape Library Specialist Web interface.
- Use Port B (2) to connect to an optional TS3000 System Console (TSSC).

Figure 9-8 View of Medium Changer Assembly identifying the two Ethernet ports

You can establish up to five Web sessions to the Tape Library Specialist by using one physical Ethernet port. If you have multiple D*xx* frames, you can add an additional five connections per frame.

If Port A is connected to the Web and Port B is not connected to a TSSC, service personnel can use Port B to connect a laptop to the Tape Library Specialist Web interface. A special Ethernet crossover cable is needed to make the connection.

You can also use Port B for the TSSC attachment with the Call Home feature of the TS3500 Tape Library, which is further described in 9.2.12, “Remote support” on page 253.

The *Call Home feature* retrieves library and drive logs (as well as other pertinent information) and saves them to the Remote Technical Assistance Information Network (RETAIN®) where they can be examined for both failure and maintenance analysis. In the past, this was done by using an analog modem attached to a serial port or by using an Ethernet port in a second frame that was connected to the TS3000 System Console (TSSC). The second frame was necessary because the TSSC required a private network that was separate from the client network. The dual Ethernet ports of the MCA makes the Ethernet port in a second frame unnecessary.

Ethernet cables to the MCA can be routed through the top or bottom of the frame.

A library control system is required for a library to operate. Conventional libraries, such as the IBM 3494, use a single library controller that handles all of the different inputs and controller output commands. The IBM TS3500 Tape Library uses a system of distributed embedded controllers, each with its own processor.

Medium Changer Assembly (MCA) This controls power up, handles all communications to the drives via RS/422, and communicates with the rest of the cards via the internal Controller Area Network (CAN) in the library. It has a serial interface for Call Home and two Ethernet interfaces, for the Web UI (port A) and the System Console (port B).

Operator Panel Controller (OPC) This controls all Operator Panel operations and the I/O station lock switch.

Accessor Controller Card (ACC) The master controller of the accessor mechanism. This has high level control of cartridge movement. The ACC issues commands to the MDA when X/Y motion is required. It also controls the grippers and the barcode reader.

Motor Drive Assembly (MDA) This controls fine movement by the accessor as directed by the ACC.

The four controllers are in different locations. The Operator Panel controller is located directly on the Operator Panel. The accessor and MDA are attached to the accessor. The MCA is located above the drives as seen in Figure 9-8 on page 244.

The advantages of a distributed control system are:

- Improved reliability:
  - Reduces single points of failure.
  - Smaller FRU components.
- Simplified library repair:
  - Functionality is isolated to a single area of the library.
- Easier upgrades:
  - Distributed components only require power and communication wires.
  - Modular design for “building block” approach.
- More performance than a single library controller:
  - Each major library component has its own processor.

9.2.3 Operator interface

The operator interface, located on the front of the frame (see Figure 9-2 on page 233), provides a set of indicators and controls that enables an operator to perform operations and determine library status. The panel, as shown in Figure 9-9 on page 246, consists of the library power switch, a power-on indicator, power switch door (L53 and L23 frames only), a touch-screen LCD and controller, and the controller for the I/O station. The Operator Panel controller is located inside the library behind the Operator Panel (number 11 in Figure 9-7 on page 241). It is a logic card that facilitates communication between the Operator Panel and the accessor controller. The Operator Panel controller posts status and information about the sensing and locking of the I/O station to the Operator Panel LCD.

The Operator Panel touch screen LCD consists of the touch keys area and the activity screen as shown in the expanded area of Figure 9-9 on page 246. The activity screen displays `Ready` on the touch screen when the library is ready (that is, when host applications can interact with the library). The first line on the screen shows the current level of library firmware and the panel screen number. The left field on the second line indicates that the library is either ready, not ready (not interacting with host applications), or initializing. The right field indicates the status of one or more I/O stations. The activity screen also shows the current activity in a large font and provides a history of preceding operations in a smaller font. Operations are listed from top to bottom with the most recent at the top. The activity screen automatically displays an error message when an error condition is detected. See 9.10, “Operator displays and buttons” on page 277 for more information.

Security can be enabled on the operator interface. The Operator Panel is then password protected and a time interval can be set. You can also specify a time-out period that, when exceeded, causes the Operator Panel to lock.

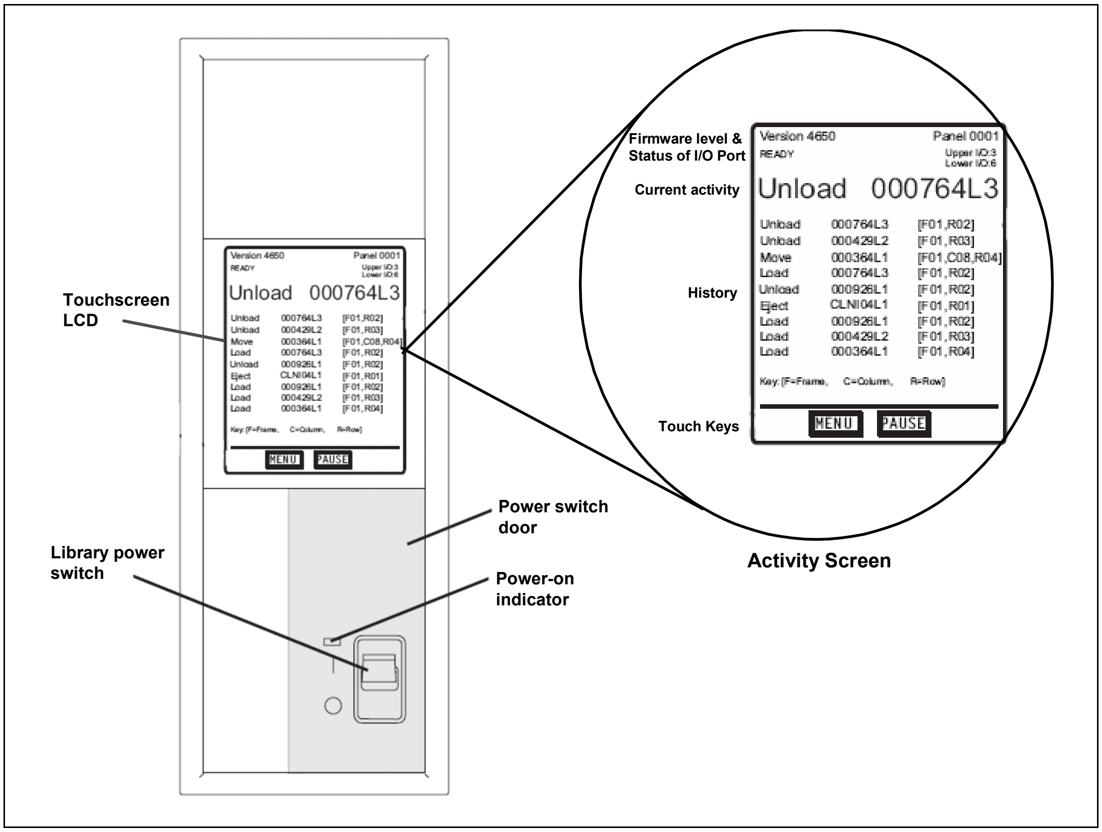


Figure 9-9 Operator Panel

9.2.4 Robotic cartridge accessor

The *cartridge accessor* is the assembly that moves tape cartridges between storage slots, tape drives, and the I/O station (number 3 in Figure 9-7 on page 241). The accessor assembly moves horizontally through the library frames using a rail system (number 2 in Figure 9-7 on page 241); it uses both top and bottom rails.

The accessor assembly consists of an optimized dual gripper (number 4 in Figure 9-7 on page 241 and in more detail in Figure 9-10 on page 247) mounted on a vertical pole. The gripper can move up and down vertically and also rotates to access cartridge slots on both the back walls and front doors of the library frames. In libraries that mix drive types, the optimized dual grippers can house both Ultrium and 3592 tape cartridges. Thus, if one gripper fails, another gripper will act as backup to process a cartridge. A barcode reader is mounted on the accessor and can scan the cartridges in one frame in less than a minute.

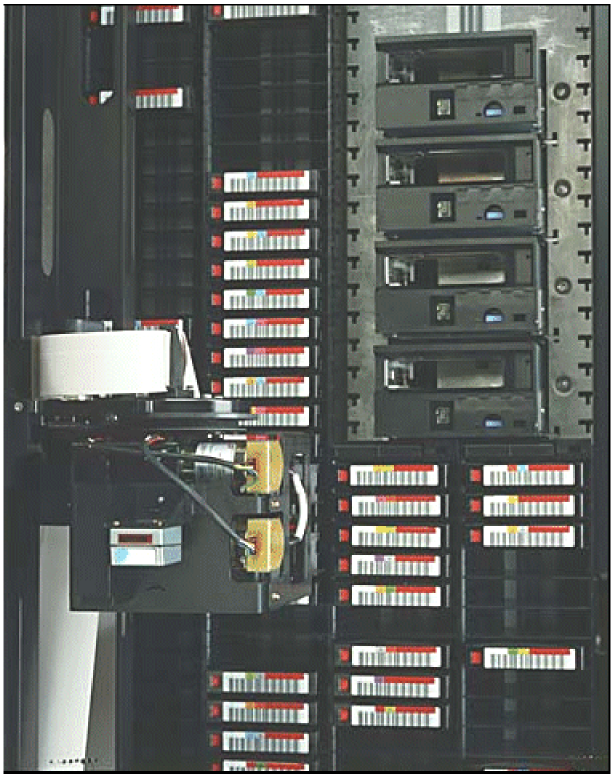


Figure 9-10 IBM TS3500 Tape Library accessor assembly

X- and Y-axis motion assemblies

These assemblies include a controller (circuit board) for the Controller Area Network interface, servo motor, pinion drive gear, and lead screw. These assemblies provide the motive force to move the accessor side to side (on the X-axis) and up and down (on the Y-axis). The controller part of this assembly is referred to as the *MDA*.

Pivot assembly

This group of parts provides a mounting platform for the gripper mechanism and the barcode reader. This assembly is capable of 180-degree rotation around the vertical axis.

Optimized dual gripper

This electromechanical device (mounted on the pivot assembly) gets or puts cartridges from or to a storage slot, tape drive, or I/O station. The gripper is independently controlled and can grip a single cartridge. There are two grippers on the pivot assembly (Gripper 1 and Gripper 2). The gripper installed in L53 or L23 can handle both LTO and 3592 tape cartridges. It can be changed without any tools and has been redesigned to eliminate weak points, therefore improving its lifetime. The cartridge presence sensor was also simplified. The original gripper in L32 must be replaced by ordering feature support (FC1608) in order to handle LTO and 3592 media.

Tip: The gripper installed in L53 or L23 can handle both LTO and 3592 tape cartridges, which provides gripper redundancy in a mixed LTO/3592 library.

Many libraries offer support for different drives and media, such as LTO, DLT, or AIT. Typically, they use a universal gripper for cartridge handling; clam shell grippers are a common design approach. This might decrease performance and reliability, because a “catch-all” gripper cannot be optimized for each media type. The LTO (and also the 3592) cartridge was designed with automation in mind, and IBM was a key player in this effort. The cartridge contains automation handling features, such as the notches seen in Figure 9-11. The IBM TS3500 Tape Library gripper takes advantage of the handling features and uses hooks to handle the cartridge. This approach offers significant performance improvements as described in 9.3, “Performance” on page 259 and is more reliable than a catch-all gripper.

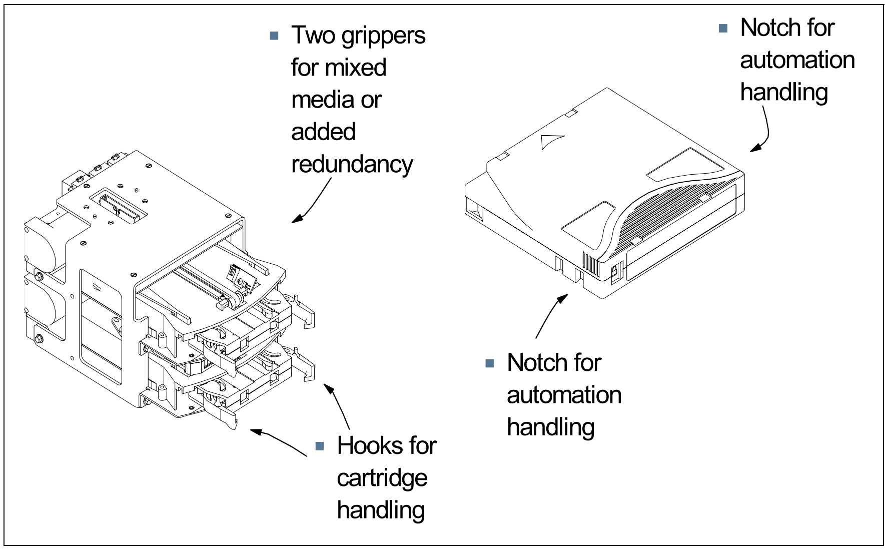


Figure 9-11 IBM TS3500 Tape Library gripper

The use of a dual-gripper accessor reduces the time taken to move cartridges in the library and can improve overall performance on large libraries. It increases redundancy and reliability. Note that library functions are controlled by host application software, and to make use of the dual gripper function, the software itself must be able to use two grippers simultaneously. If it does not, the library will function as though it had only a single gripper. If only one gripper is used at a time, the library periodically switches between both grippers to balance use.

Barcode reader

The barcode reader reads the barcode on a label that is attached to a cartridge or at the rear of every storage slot (which indicates an empty storage slot). The barcode reader is mounted on the pivot assembly and is used during inventories, audits, insertions, and inventory updates. The inventory is updated whenever the door is opened, and it determines whether cartridges have been added to, removed from, or moved within the library.

Because all storage slots have empty storage cell labels, the library can easily and quickly recognize whether there is a labeled cartridge or an empty storage slot in every location. This eliminates the need to reread or manually intervene in storage cells if no label is readable. Without this approach, the library cannot differentiate between a slot that is unlabeled, badly labelled, or empty.

Calibration sensor

This provides a means to locate certain positions within the library very precisely during the calibration operation. The calibration sensor is mounted on the underside of gripper 1. (For the optimized dual gripper, the sensor is mounted on the top of gripper 2.) All positions are calculated from these locating positions.

9.2.5 Rail assembly

The cartridge accessor moves through the library on a rail assembly (number 2 in Figure 9-7 on page 241). The system consists primarily of a main rail assembly and support rail, and a trough for the power and control cable. The main rail assembly includes a main bearing way with a rack gear. Its support rail is an L-shaped rail that runs along the top of the frames and provides smooth transport for the cartridge accessor. The power and control cable is kept clear of the accessor in a covered trough at the bottom rear of the library.

9.2.6 Library-centric WWNN convention

Every device in a Storage Area Network (SAN) environment uses a unique worldwide node name (WWNN) for identification in the SAN. In a conventional library, if the drives are swapped, the WWNN is also changed, and therefore you have to reconfigure both the SAN and the server. If you are using persistent binding on your server, a server reboot is also necessary.

The IBM TS3500 Tape Library assigns the WWNNs to the drives. This technique is referred to as *library-centric worldwide names*. Every potential drive slot is assigned a unique worldwide name (WWN). If a drive is replaced, the new drive gets the same WWN as the old one. This is controlled by the MCA. Because of this library behavior, you can easily identify the position of the drive in the library by the WWNN. The last two digits represent the drive's location in the library. The last digit indicates the drive row, starting from 1, and the second to last indicates the frame, counting from 0. The remaining digits are encoded with the vendor ID and the library-specific data, ensuring that every drive has a unique WWNN. Figure 9-12 shows the drive WWNNs in an IBM TS3500 Tape Library.

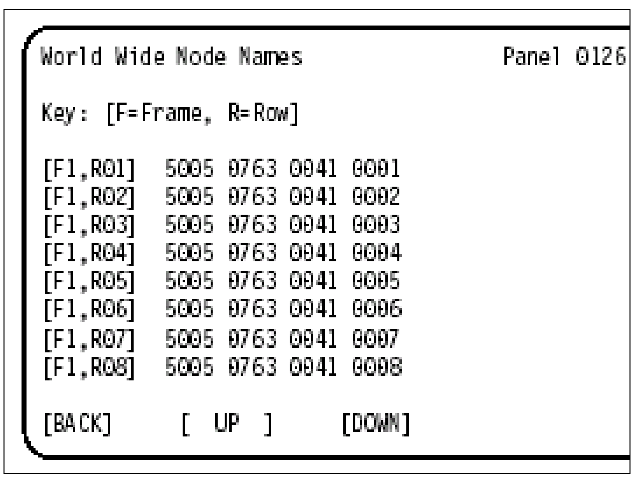


Figure 9-12 Drive WWNNs of an IBM TS3500 Tape Library

9.2.7 Control path failover

Alternate path support, currently available for AIX, Linux, Solaris, HP-UX, and Windows hosts, configures multiple physical control paths to the same logical library within the device driver and provides automatic failover to an alternate control path when a permanent error occurs on one path. This is transparent to the running application.

For example, consider a simple multi-path architecture connection consisting of two HBAs in a host that are connected to a library with two or more drives (Figure 9-13 on page 250). Two drives have the control ports enabled. The two HBAs are connected to the first and second control port drives, respectively. This simple configuration provides two physical control paths to the library for redundancy if one path from an HBA to the library fails. When the server boots, each HBA detects a control port to the library, and two medium changer devices (`smc0` and `smc1`) are configured. Each logical device is a physical path to the same library; however, an application can open and use only one logical device at a time, either `smc0` or `smc1`.

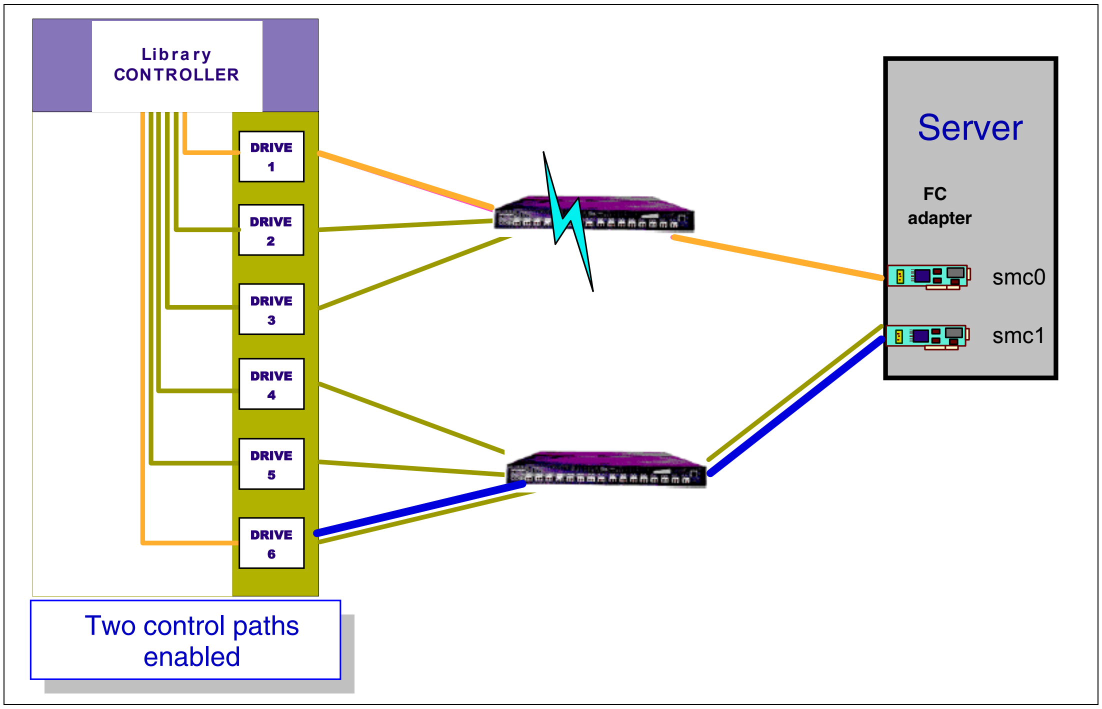


Figure 9-13 Redundant control paths to the library controller

Without the device driver alternate pathing support, if an application opens `smc0` and a permanent path error occurs (because of an HBA, cable, switch, or drive control port failure), the current command to the library fails. It is possible to initiate manual failover by changing the device path to the alternate path (`smc1`), but this is a manual operation and the last failing command has to be resent.

When the alternate pathing support is enabled on both `smc0` and `smc1`, the device driver configures them internally as a single device with multiple paths. The application can still open and use only one logical device at a time (either `smc0` or `smc1`). If an application opens `smc0` and a permanent path error occurs, the current operation continues on the alternate path without interrupting the application.

Activation of control path failover is done by entering a license key at the library Operator Panel. Control path failover is provided by an optional FC1680 for L*x*2 frame models and requires the use of the IBM Atape device driver. For L*x*3 models, control path failover and data path failover are available with the optional Path Failover feature (FC1682).

9.2.8 Data path failover

Data path failover and load balancing exclusively support native Fibre Channel Ultrium and IBM 3592 tape drives in the IBM TS3500 Tape Library using the IBM device driver. Data path failover is now supported for AIX, Linux, HP, Solaris, and Windows hosts. Load balancing is supported for AIX, Linux, and Solaris. Refer to the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430*,* for current support and implementation details. Data path failover provides a failover mechanism in the IBM device driver, so that you can configure multiple redundant paths in a SAN environment. If a path or component fails, the failover mechanism is designed to provide automatic error recovery to retry the current operation using an alternate, preconfigured path without stopping the current job in progress. This improves flexibility in SAN configuration, availability, and management. When accessing a tape drive device that has been configured with alternate pathing across multiple host ports, the IBM device driver automatically selects a path through the HBA that has the fewest open tape devices and assigns that path to the application. This autonomic self-optimizing capability is called *load balancing*. The dynamic load balancing support is designed to optimize resources for devices that have physical connections to multiple HBAs in the same machine. The device driver is designed to dynamically track the usage on each HBA as applications open and close devices and balance the number of applications using each HBA in the machine. This can help optimize HBA resources and improve overall performance. Further, data path failover provides autonomic self-healing capabilities similar to control path failover, with transparent failover to an alternate data path in the event of a failure in the primary host-side path.

Data path failover and load balancing for Linux and Solaris are provided by an optional feature (FC1681) for L*x*2 models. Data path failover is included in the Path Failover feature (FC1682) for L*x*3 models, which also includes control path failover.

Data path failover and load balancing support for AIX or for IBM 3592 tape drives do not require this feature.

9.2.9 Tape Library Specialist

The IBM TS3500 Tape Library's Web User Interface enables operators and administrators to manage storage devices from any location in an enterprise. The IBM TS3500 Tape Library Specialist enables direct communication with an IBM TS3500 Tape Library and provides a full range of user, operator, and administrator tasks, which can be executed remotely.

Firmware for the library and drives can be updated non-disruptively if using the Web User Interface. Note that non-disruptive library firmware updates require that a library control path using an LTO3 tape drive is used. LTO1 and LTO2 drives receive a SCSI Reset command during the firmware installation.

Multiple simultaneous Web clients

Each Ethernet capable Medium Changer Assembly (MCA) on the IBM TS3500 Tape Library allows five simultaneous Tape Library Specialist users.

Individual Web login IDs and passwords

For the IBM TS3500 Tape Library, the Web User Interface supports a list of users who can access various areas of the Web User Interface. An administrator can create up to fifteen additional user IDs. Each user has a 30-character name, a 15-character login ID, a 15-character password, and an access level. The access level defines the level of Web access that the user is allowed. A maximum of five users can be signed on to the Specialist at the same time.

There are four access levels available:

- **Monitor**: Can view all physical and logical library data.
- **Service**: Can perform only service-related functions, such as update firmware, download logs, and view vital product data (VPD).
- **Superuser**: Can perform all tasks of a monitor or service role, plus change library settings and perform library operations. This role cannot change the password of others or enable or disable security.

- **Administrator**: Can perform all user management tasks.

Note that users can change their own password.

Multiple simultaneous Web clients and individual Web ID functions can be made available to existing IBM TS3500 libraries by upgrading to the latest firmware.

Customizable Web access

Customized Web access provides a way for the administrator or superuser to add roles with access to specific libraries and specific pages within the logical libraries for the Tape Library Specialist Web interface.

Like the standard roles that are delivered with the Tape Library Specialist, these custom roles can be assigned to multiple users. Customized Web access pages are not available unless Web security is enabled and password protection is turned on.

9.2.10 Expanded I/O station

L23 and L53 frames can have either a 16-slot 3592 or LTO cartridge input/output (I/O) station. An additional 16-slot I/O station can be ordered via FC1658 (for LTO) or FC1659 (for 3592).

A single frame cannot combine both the 3592 and LTO drives. However, in a library with mixed frame types, you can insert IBM 3592 cartridges into the lower I/O station of a Model L53 or L32 frame for transport (by the cartridge accessor) to a Model D23 (your library must contain an I/O station that will accept 3592 cartridges). Similarly, you can insert LTO Ultrium cartridges into the lower I/O station of a Model L23 for transport (by the cartridge accessor) to a Model D53 or D32 (again, your library must contain an I/O station that can accept Ultrium cartridges).

Support for more than 32 I/O slots can be made available through *Virtual I/O*, a feature available with ALMS, which virtualizes storage slots to be used as I/O slots, also known as *Import/Export Elements (IEEs)*. For more information, see 9.5.2, “Virtual I/O” on page 266.

9.2.11 Reliability

The IBM TS3500 Tape Library is designed for high availability and reliability. Most essential components are redundant. These components have been described previously. Here is a summary of the high-availability features and components of the IBM TS3500 Tape Library:

- Redundant grippers:
  - A failure of one gripper will cause the library to switch to a second gripper.
- Redundant accessors (optional):
  - Second library accessor operates simultaneously with the first accessor to service mount requests.
  - Designed to non-disruptively fail over to a redundant accessor when any component of either accessor fails.
- Redundant library and drive power:
  - A single frame library contains one redundant power supply in the Enhanced Frame Controller. This provides power to the library robotics and the tape drives. The power requirements are distributed evenly over both power supplies under normal operating conditions, failing over to a single power supply if required.

- Redundant control and data paths:
  - Any LTO drive can be used as a library control path.
  - Automatic control path failover currently available for AIX, Solaris, Red Hat and SuSE Linux, Windows, and HP-UX.
  - Data path failover is currently available for AIX, HP-UX, Red Hat and SuSE Linux, Solaris, and Windows.
- Redundant copies of Vital Library Data:
  - Includes configuration data, calibration data, setup data, and so forth.
  - One node card contains the primary copy and another node card contains a backup copy.
  - Backup and restore process is completely automated.
- Redundant copies of library firmware:
  - Each node card contains the firmware for every other processor card.
  - Component replacement is simplified.
  - Each node card contains two copies of operational firmware.
  - Protects the library from potentially harmful firmware update disruptions.
  - Helps reduce the risk of memory failures.
- Closed loop servo systems:
  - This includes horizontal motion, vertical motion, pivot motion, gripper extend, and retract motion.
  - Each servo system uses feedback.
  - Velocity and position are monitored.
  - This allows higher performance (as shown in Table 9-6 on page 260), and knowing velocity and position allows greater control.
  - Closed loop is more reliable.
  - Collisions and gripper damage can be avoided by monitoring position and velocity.

9.2.12 Remote support

This section describes the types of remote support that the TS3500 and its drives use to detect and solve problems.

Optional remote support is available for the TS3500 through its Call Home capability. The Call Home feature uses a modem connection and a master console to report failures that are detected by the library or a tape drive. Whenever a failure is detected, Call Home sends detailed error information to an IBM Support Center. Qualified Support Specialists will analyze the call home data and decide if an action is required as a result of that call home data. The library might also periodically send support information (such as configuration, library and drive code versions, and error logs) to IBM.

The Call Home feature of the TS3500 has two different, but related, capabilities:

Problem Call Home The TS3500 or one of its drives detects a problem and the library performs a Call Home operation to create a Problem Management Record (PMR) in the IBM Remote Technical Assistance Information Network (RETAIN) and information will be transferred to IBM for analysis of the problem.

Heartbeat Call Home On a scheduled basis (once a week or one hour after a code update has been completed), the TS3500 sends home (to IBM) the following files: a Machine Reported Product Data (MRPD) file, a library error log file, and a drive error log file. The MRPD file contains information about the machine (library), including the number of frames and drives, the model and serial number of each frame, the type and serial number of each drive, the code version of the library and each drive, and any machine-detectable features, such as additional I/O stations, capacity expansion, and so forth.

Remote support through a modem

Optional remote support is available for the TS3500 through its Call Home capability through a no charge feature (FC2710). This permits a single Tape Library with Call Home capability the remote support described previously.

Remote support through the TS3000

This section describes remote support to the TS3500 or 3584 Tape Library through a master console. A *master console* is a service tool that is present in most environments where one or more IBM tape storage devices, such as the IBM 3953 Tape System (3953-F05 Tape Frame and 3953-L05 Library Manager), are connected to a System z server (mainframe host). The TS3000 System Console (TSSC) provides the same functionality to attach a TS3500 or 3584 Tape Library that is connected to an Open Systems server.

When the TS3500 or 3584 Tape Library is in an environment that includes a master console, IBM recommends that the library perform the Call Home function through the master console instead of through a direct modem connection. This avoids the need for a dedicated analog phone line for the library's Call Home modem.

To perform a Call Home operation through a master console, the TS3500 or 3584 Tape Library sends Call Home information across a private Ethernet connection to the master console. The master console then performs the Call Home operation and sends the information to IBM RETAIN through the master console's modem connection.

For remote support through a master console, the Tape Library needs a minimum of two Ethernet ports: one attached to your network for use by your administrator and one attached to the private master console network for remote support. The library feature code (FC9217) provides an Ethernet cable for the remote support connection from the TS3500 to a master console.

Figure 9-14 on page 255 shows the flow of data in a configuration in which a single Master Console is supporting three Call Home capable Tape Libraries.

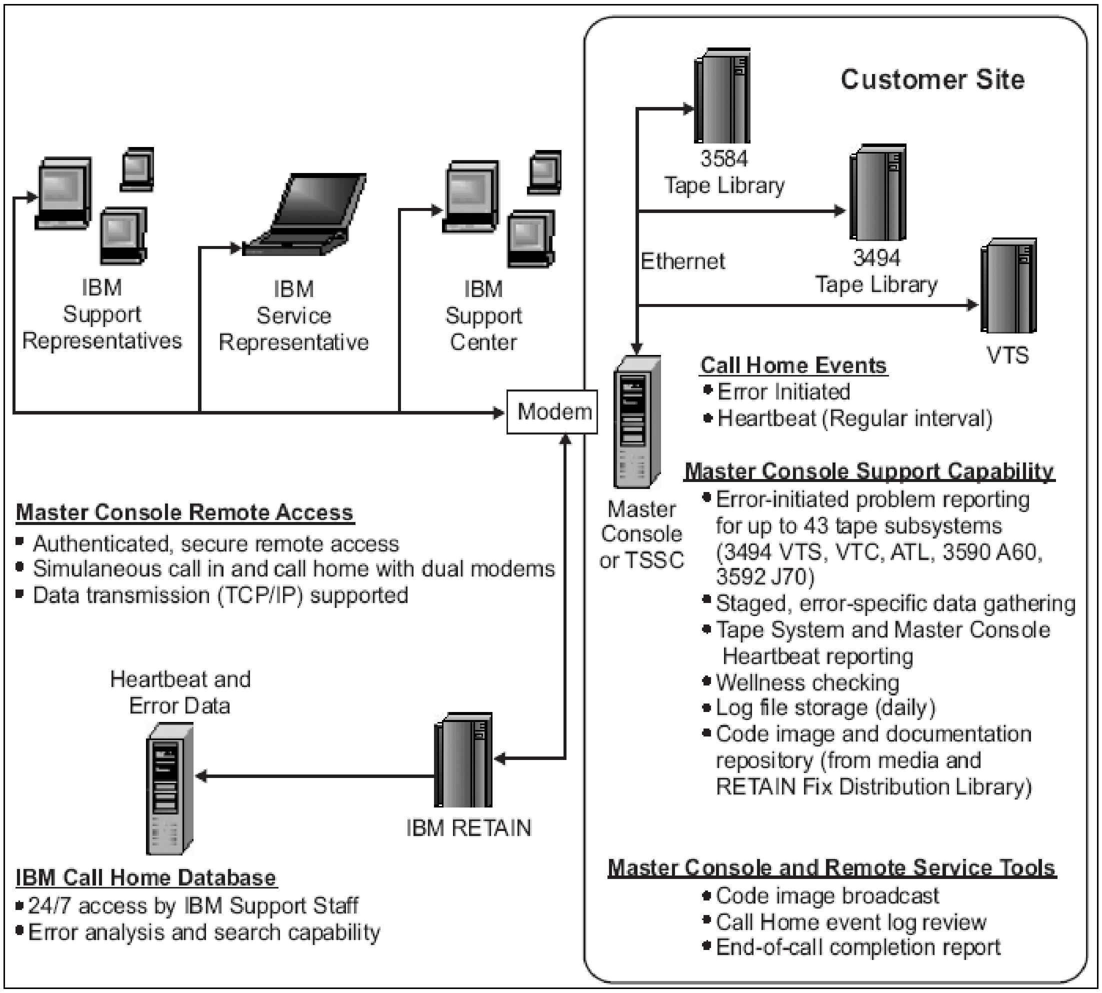


Figure 9-14 Flow of data from a Master Console supporting three Tape Libraries

A new feature code is available for the TS3000 System Console. Feature Code 2730 offers a 1U rack mountable server and comes with a Keyboard, Display, Mouse, and Ethernet Switch.

Figure 9-15 on page 256 shows the rack mountable TS3000 System Console.

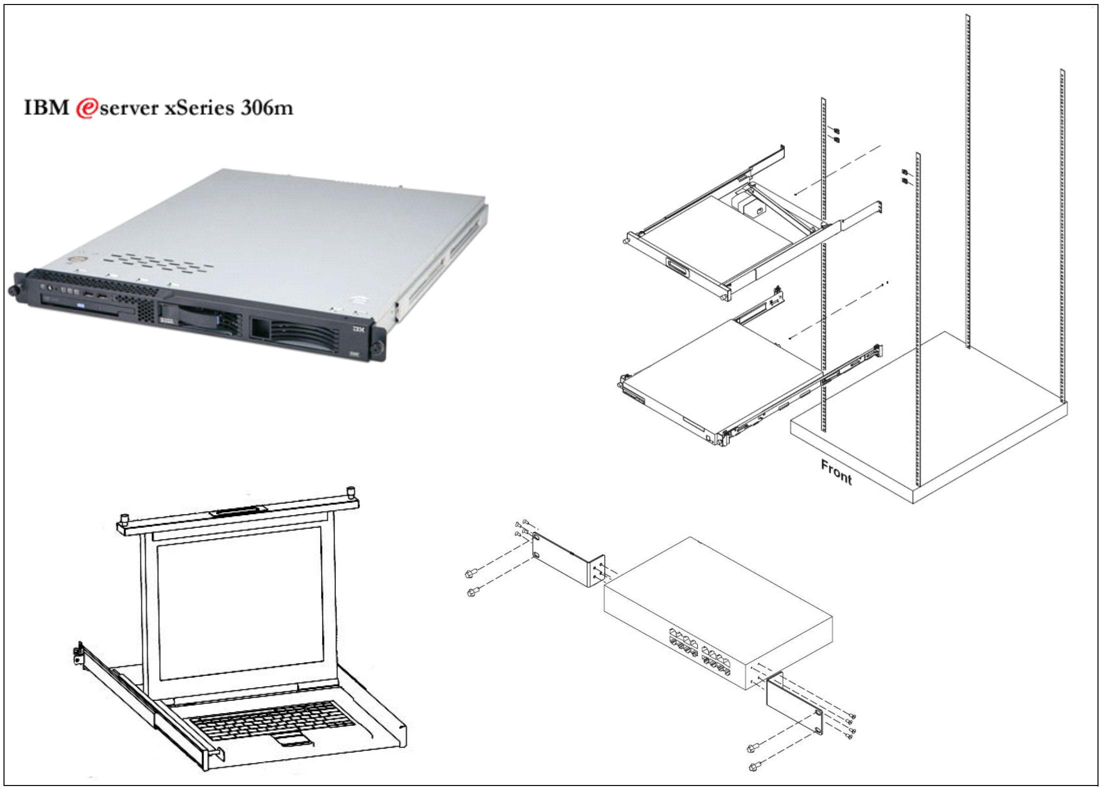


Figure 9-15 Rack mountable TS3000 System Console

SNMP

Occasionally, the IBM TS3500 Tape Library might encounter a situation that needs to be reported, such as an open door that causes the library to stop. Because many servers can attach to the IBM TS3500 Tape Library by different attachment methods, the library provides a standard TCP/IP protocol called *Simple Network Management Protocol (SNMP)* to send alerts about conditions (such as an opened door) over a TCP/IP LAN network to an SNMP monitoring server. These alerts are called *SNMP traps*. Using the information supplied in each SNMP trap, the monitoring server (together with client-supplied software) can alert operations staff of possible problems or operator interventions that occur. Many monitoring servers (such as IBM Tivoli NetView®) can be used to send e-mail or pager notifications when they receive an SNMP alert.

The monitoring server must be loaded with systems management software that can receive and process the trap, or the trap will be discarded. SNMP trap support does not provide a mechanism for the operator to gather more information about a problem or to query the library about its current status.

If your systems management software includes an SNMP compiler, you might not need to manually interpret SNMP traps, but you will need the library's Management Information Base (MIB). The MIB contains units of information that specifically describe an aspect of a system, such as the system name, hardware number, or communications configuration. Obtain the MIB for the IBM TS3500 Tape Library from:

`ftp://ftp.software.ibm.com/storage/358x/3584`

For information about interpreting an SNMP trap or using SNMP MIBs to monitor your library, see the appropriate sections in the *IBM System Storage TS3500 Tape Library Operator Guide*, GA32-0468.

SMI-S support

This section describes how the IBM TS3500 Tape Library uses the Storage Management Initiative Specification (SMI-S) to communicate in a SAN environment.

To communicate with storage devices in a SAN, management software can use other software known as the SMI-S Agent for Tape. The SMI-S Agent for Tape is available for Intel-based SuSE LINUX Enterprise Server 9. The SMI-S Agent for Tape communicates by using the Web-Based Enterprise Management (WBEM) protocol, which allows management software to communicate with the IBM TS3500 Tape Library.

The SMI-S Agent for Tape is designed for compliance with the SMI-S. The SMI-S is a design specification of the Storage Management Initiative (SMI) that was launched by the Storage Networking Industry Association (SNIA). The SMI-S specifies a secure and reliable interface that allows storage management systems to identify, classify, monitor, and control physical and logical resources in a SAN. The interface is intended as a solution that integrates the various devices to be managed in a SAN and the tools used to manage them. The SMI-S was developed to address the problems that many vendors face in managing heterogeneous storage environments. It creates a management interface protocol for multivendor storage networking products. By enabling the integration of diverse multivendor storage networks, the initiative is able to expand the overall market for storage networking technology.

For detailed information about SMI-S, see the *IBM TotalStorage SMI-S Agent for Tape Installation Guide*, GC35-0512.

The SMI-S agent ran normally on a separate LINUX PC but from library firmware level 7050 SMI-S, in a limited form, is running on the MCP. The level of SMI-S is 1.1 and the following functions are supported within the Server Profile:

- Library code level

  Use IBMTSSML3584_SoftwareIdentity VersionString

- Library name

  Use IBMTSSML3584_TapeLibrary ElementName

- Administrator and Contact information

  Use IBMTSSML3584_TapeLibrary PrimaryOwnerName and PrimaryOwnerContact

There is no support for Service Location Protocol (SLP) and Secure Socket Layer (SSL) at the time of writing this publication.

The external LINUX PC supports the following protocols:

- Server Profile SMI-I Version 2
- Storage Media Library Version 2:
  - Limited Access Port 1.1
  - Chassis 1.1
  - FC Port 1.1
  - Software 1.1
  - Physical Package 1.1

In the future, the imbedded SMI-S will have the same functions as the external LINUX PC.

Note: The imbedded SMI-S function requires a LX3 Frame and a library firmware level that supports SMI-S.

The TS3500 also provides detailed information regarding activity during the last 24 hours in four files that you can download by using the Web User Interface. See “Enhanced Data Gathering and Reporting” on page 299 for a detailed explanation.

9.2.13 Adding and removing cartridges

You can insert cartridges in the IBM TS3500 Tape Library in two ways.

The first method is to insert cartridges through the I/O station (see Figure 9-2 on page 233) that is located on the front door of the L*xx* frame of the IBM TS3500 Tape Library. With this method, you can insert and remove cartridges from the library enclosure without interrupting library operation. The I/O station is controlled by the host application software that uses the library or from the Operator Panel. Insertion of cartridges into the I/O station alerts the application software, which registers the additional cartridges and their status in its database and then instructs the accessor to move the new cartridges into library slots. The slot location of each cartridge is held in the host application software database. A detailed description of how to insert cartridges can be found in the *IBM System Storage TS3500 Tape Library Operator Guide*, GA32-0468.

The second method to insert cartridges is to open the front door of a frame and bulk load the cartridges directly into empty storage slots. When the door is closed, the library will perform a cartridge inventory operation, which checks to determine whether each cartridge storage slot in the frame is empty or full and scans the cartridge barcode labels. When the library performs an automatic inventory in this way, the inventory will occur only for those frames whose doors had been opened.

A cartridge inventory operation occurs whenever you:

- Power on the library
- Issue the SCSI command `Initialize Element Status with Range`[1]
- Select Inventory from the Manual Operations menu
- Select the appropriate menus from the Library Specialist Web interface
- Close the front door after manually accessing the library

When the library performs an automatic inventory because the front door was closed, the inventory occurs only for those frames whose doors have been opened. A door lock is provided to restrict physical access to cartridges in the library. This can be used to secure the cartridges and prevent unauthorized library access. Although the time required for the library to inventory cartridges is less than 60 seconds per frame, the door lock reduces the possibility of frames being opened in error and causing unnecessary inventory activity.

There is also a safety switch in the frame door (number 9 in Figure 9-7 on page 241) that shuts down the power to the cartridge accessor whenever the front door is opened.

Removal of data cartridges can be performed not only by using your host application software, but also through the Tape Library Specialist or the Operator Panel. For a detailed description of how to remove cartridges, see the *IBM System Storage TS3500 Tape Library Operator Guide*, GA32-0468.

Cartridge Assignment Policy

The Cartridge Assignment Policy (CAP) of the IBM TS3500 Tape Library enables you to assign ranges of cartridge volume serial (VOLSER) numbers to specific logical libraries through the Tape Library Specialist. When a cartridge is inserted into the I/O station or through bulk loading as described in the previous section, the Cartridge Assignment Policy

[1] The TS3500 Tape Library library tracks the logical location of all elements in the library by performing an automatic inventory as required (therefore, the SCSI Initialize Element Status command is allowed but ignored).

will first be used to attempt to associate the cartridge with a logical library. If the cartridge is not in the CAP and Insert Notification (see “Insert Notification” on page 259) is enabled, you can assign the cartridge to a logical library by using the Insert Notification process on the library’s Operator Panel or keep the cartridge as unassigned and assign it later by using the IBM System Storage Tape Library Specialist Web interface. If the Insert Notification feature is not enabled and the cartridge was not in the CAP, the cartridge will eventually be available to all hosts. Unassigned cartridges can also be assigned to a logical library by creating a new VOLSER range and then performing a manual inventory to assign those cartridges through the Cartridge Assignment Policy.

The Cartridge Assignment Policy is media-type specific. As such, it is based on the six most significant characters of the cartridge label. The ranges of VOLSERs do not include the media-type indicator (L2, L3, JA, and so forth). This means that two identical labels (except for the media-type indicator) can be assigned to two different logical libraries, for example, libraries that contain Ultrium or 3592 drives.

Note: The Cartridge Assignment Policy does not reassign an assigned tape cartridge. To reassign a cartridge, use the procedure for assigning cartridges to a logical library.

Insert Notification

Insert Notification is an option that enables the IBM TS3500 Tape Library to monitor the I/O station for any new media that does not have a logical library assignment. This feature can be enabled through the Operator Panel or through the Tape Library Specialist. With Insert Notification enabled, when new media is detected the Operator Panel displays a message that asks you to select a logical library. Any unassigned cartridges in the I/O station will be assigned to the logical library that you select (and all other logical libraries will not be able to access the cartridges). The library includes an option to defer any assignment and there is a timeout period when the deferral will automatically take effect.

Note: When one or more 4 I/O station doors are installed, the Insert Notification cannot be enabled.

9.3 Performance

The performance capability of a tape library solution depends on both the individual bandwidth capability of the drives and data bus and the speed of the robotic handling. The degree of importance for each of these elements depends on the quantity of data transferred during one operation. For example, when reading or writing large files (larger than 800 MB) to tape, then the data rate of the tape drive will be the overriding contributor to the speed of the operation. However, for reading or writing many small files (25 MB or less) to different tapes, the cartridge move and load times become the overriding contributor.

The following elements contribute to the high-performance capabilities of IBM TS3500 libraries:

- Library bandwidth

  You see the bandwidth of the IBM TS3500 Tape Library in Table 9-5 on page 260 relating to the drive performance given in 2.4.2, “LTO performance” on page 71. Compressed drive performance can be calculated by assuming a compression ratio of 2:1 for LTO.

Table 9-5 IBM TS3500 Tape Library bandwidth

Tape drives	LTO Ultrium 1 native	LTO Ultrium 2 native	LTO Ultrium 3 native	IBM 3592 native	TS1120 native
72	3.9 TB/hr.	9.1 TB/hr.	20.7 TB/hr.	10.4 TB/hr.	29.5 TB/hr.
192	10.4 TB/hr.	24.2 TB/hr.	55.3 TB/hr.	27.6 TB/hr.	69.1 TB/hr.

- Cartridge move time

  Move time is the time required for the cartridge accessor to pick a cartridge from a random slot, move the cartridge to a drive, pivot (if required), and insert the cartridge into the drive. In a single-frame IBM TS3500 Tape Library, the typical time to move a cartridge from a cartridge storage slot to a tape drive, for example, is less than 2.7 seconds; for a six-frame configuration it only increases to 3.8 seconds; for the maximum 16 frames, the average move time is still only 6.2 seconds, as shown in Table 9-6. For maximum performance, as demonstrated in the table, drives must be centrally located and as close together as possible. The table does not apply to libraries that contain dual accessors.

Table 9-6 Library performance without dual accessor

Library configuration	Average move times with all drives in frame 1	Average move times with all drives in central frame
1 Frame	2.7 seconds	N/A
2 Frames	2.6 seconds	N/A
4 Frames	3.3 seconds	2.9 seconds
6 Frames	3.8 seconds	3.3 seconds
8 Frames	4.4 seconds	3.7 seconds
12 Frames	5.3 seconds	4.3 seconds
16 Frames	6.2 seconds	4.7 seconds

- Mount throughput

  Mount throughput is a measure of the overall capability of the cartridge accessor and tape drives. It is defined as the number of cartridges that the tape library can mount in one hour. A *mount*, often called the *mount/demount cycle*, involves removing the cartridge from a drive, returning it to its storage slot, collecting another cartridge from a random storage slot, moving it to the drive, and loading the cartridge into the drive.

  Table 9-7 shows the mount throughput performance for the UltraScalable Tape Library with and without dual accessors. The table demonstrates that to maximize performance with dual accessors, each accessor must have drives centrally located in its preferred zone.

Table 9-7 Library mount throughput

Library configuration	Without dual accessor		With dual accessor	
	Mounts per hour with all drives in frame 1	Mounts per hour with all drives in central frame	Mounts per hour with all drives in frame 1	Mounts per hour with all drives in central frame
1 Frame	550	N/A	N/A	N/A
2 Frames	520	N/A	N/A	N/A

Library configuration	Without dual accessor		With dual accessor	
	Mounts per hour with all drives in frame 1	**Mounts per hour with all drives in central frame**	**Mounts per hour with all drives in frame 1**	**Mounts per hour with all drives in central frame**
4 Frames	410	430	N/A	1000
6 Frames	350	380	N/A	900
8 Frames	310	350	N/A	800
12 Frames	255	300	N/A	700
16 Frames	215	260	N/A	600

Note: The dual accessor mount throughput assumes that the library is partitioned into at least two logical libraries such that each of the cartridges located in the two zones are mounted in drives within each zone with no accessor path overlap.

- EXCHANGE MEDIUM command

  Another method of increasing mount rate performance is using dual active grippers and the EXCHANGE MEDIUM command (as documented in *IBM System Storage TS3500 Tape Library SCSI Reference*, GA32-0454-02) to implement the exchange at cell algorithm. In this algorithm, a mount/demount cycle consists of the following series of operations:

  – Move to drive; unload cartridge into gripper 2.

  – Move to new cartridge; pick up cartridge with gripper 1.

  – Return cartridge in gripper 2 to the storage slot that was just vacated.

  – Move back to drive; load cartridge with gripper 1.

  With the use of the floating home cell algorithm, cartridges are not returned to their original storage slots. Instead, the ejected cartridge is placed in the slot where the next mounted cartridge is located. Check with your backup software application for support.

- Library inventory time

  During normal use of the IBM TS3500 Tape Library for bulk loading of cartridges, the library will perform an inventory operation to check the (possibly new) content of the cartridge storage slots. During this time, the accessor is occupied scanning the barcode labels and empty slots.

  The inventory process for the IBM TS3500 Tape Library is performed very efficiently, usually taking fewer than 60 seconds per frame.

9.4 Upgrades and optional features

The IBM TS3500 Tape Library has a number of optional additional features. These features enhance the library by providing extra functions, additional capacity, higher reliability, and greater serviceability.

For more information about available features, see the sales manual for the IBM TS3500 Tape Library. You can access the sales manual at:

http://www.ibm.com/common/ssi/OIX.wss

9.5 ALMS

The Advanced Library Management System (ALMS), an optional extension to the IBM patented multi-path architecture (FC1690), provides enhanced flexibility and capabilities for partitioning the IBM TS3500 Tape Library. ALMS virtualizes the SCSI element addresses while maintaining the approach of the multi-path architecture and using SCSI3 Medium Changer commands. Without ALMS, everything is based on the SCSI element address (location-centric) and partitioning is based on real cartridge slots and drive slots. With ALMS, there is no affinity between a real slot address and a SCSI element address reported to the server and used by the server. Instead, there is now an affinity with the VOLSER (volume serial numbers on the barcode label of the cartridge).

ALMS allows the following new capabilities on the IBM TS3500 Tape Library:

- Dynamic partitioning:
  - Storage slot pooling
  - Flexible drive assignment
- Add and remove storage capacity transparent to any host application
- Configure drives or L*xx* storage capacity without taking the library offline
- Virtualize I/O slots to automatically manage the movement of cartridges between I/O station slots and storage slots

The IBM TS3500 Tape Library is compliant with the SCSI Medium Changer standard whether ALMS is enabled or not; when enabled, ALMS is completely transparent to the application. The SCSI Medium Changer can be thought of as a “location-centric” interface. The application controlling a SCSI Medium Changer device specifies a source and destination location for each request to move a cartridge. The traditional SCSI library does not have control of the cartridge locations; instead, the SCSI library just acts on behalf of the server.

Restriction: ALMS is available only for the IBM TS3500 Tape Library and requires FC1690 for enablement.

9.5.1 Functional description

In this section, we give a functional description of the ALMS features. The information is based on the *IBM TotalStorage UltraScalable Tape Library TS3500 Tape Library Advanced Library Management System Technology White Paper* by Lee Jesionowski, which can be found at:

http://www.ibm.com/servers/storage/tape/resource-library.html#whitepapers

Storage slot virtualization

The host view of a cartridge location is known as the *SCSI storage element address*. Without ALMS, the storage element address maps directly to a specific storage slot after the library is configured. With ALMS enabled, a given storage element address is no longer associated with a specific storage slot. Instead, storage slots are virtualized by dynamically associating them with element addresses, as required. An element address will be associated with a storage slot, selected by the library, as cartridges are moved and inventoried. In the case of a storage element that is empty due to a move, that source element address will become unassociated. Association of storage element addresses is accomplished in a way that is completely transparent to the application software.

The number of storage element addresses for a logical library (as reported to the host application software) is selectable by changing the Maximum Number of Cartridges setting for that logical library using the Web User Interface (Tape Library Specialist). For each logical library, the default value for Maximum Number of Cartridges is the number of addressable storage slots that are installed in the library for that cartridge type at the time that ALMS is first enabled or, after ALMS is enabled, at the time the logical library is created. The Maximum Number of Cartridges setting can be changed for each logical library, but the value must always be greater than or equal to the number of actual cartridges currently assigned to that logical library. It is possible to set Maximum Number of Cartridges to a value that is higher than the number of addressable storage slots installed at the time in order to allow future library capacity expansion to be transparent to the host application software; however, application performance might degrade slightly due to the greater number of addresses. Care must be taken to not exceed the license limitations of the host application software.

The starting element address for storage slots of each logical library will be x'400' (1024) plus the associated logical library number. For example, logical library 1 starts at x'401' (1025), logical library 2 starts at x'402', and so on (see Figure 9-16 on page 264). The reason they do not all start at x'401' is because some applications have to be able to differentiate between different logical libraries from the same physical library.

Drive assignment

Using the ALMS flexible drive assignment capability, any drive in any position within any frame can be assigned to any logical library without creating any gaps in drive addresses. Drive (data transfer) element addresses will still be mapped to specific drive locations when the drive is assigned, but any drive location can now be assigned to any logical library (intermix supported) using the Tape Library Specialist. Each drive added to a logical library will be assigned to the lowest available element address, regardless of drive location.

When ALMS is first enabled, the Data Transfer Element (DTE) addresses of all installed and assigned drives are not changed from their previous values. However, after ALMS is enabled, the DTE addresses for any newly installed and assigned drives no longer depend on the drive’s position. Instead, the DTE address for any newly installed or assigned drive is determined by the sequence in which the drive is assigned to each logical library. After enabling ALMS, drives are assigned to logical libraries using the Drive Assignment page of the Tape Library Specialist.

Using this interface, the DTE address for the first drive assigned to a new logical library is 257 (x'101'); see Figure 9-16 on page 264. The DTE address for any other drive assigned to a logical library is based on the next available DTE address in that particular logical library. The next available DTE address is the lowest available DTE address after the starting DTE address. (This will fill any gaps that are created when drives are unassigned and removed from a logical library.) When a drive is unassigned from a logical library using the Web interface, only that DTE address is made available for future usage, no other DTE addresses are affected.

The Drive Assignment page also supports the option to share a drive between two or more logical libraries. The drive will be assigned a DTE address in more than one logical library. Note that the DTE addresses that are assigned to a shared drive might differ by logical library.

By using ALMS’ dynamic Drive Assignment capability, any drive in any position in any frame is available to be assigned to any logical library without creating gaps in DTE addresses.

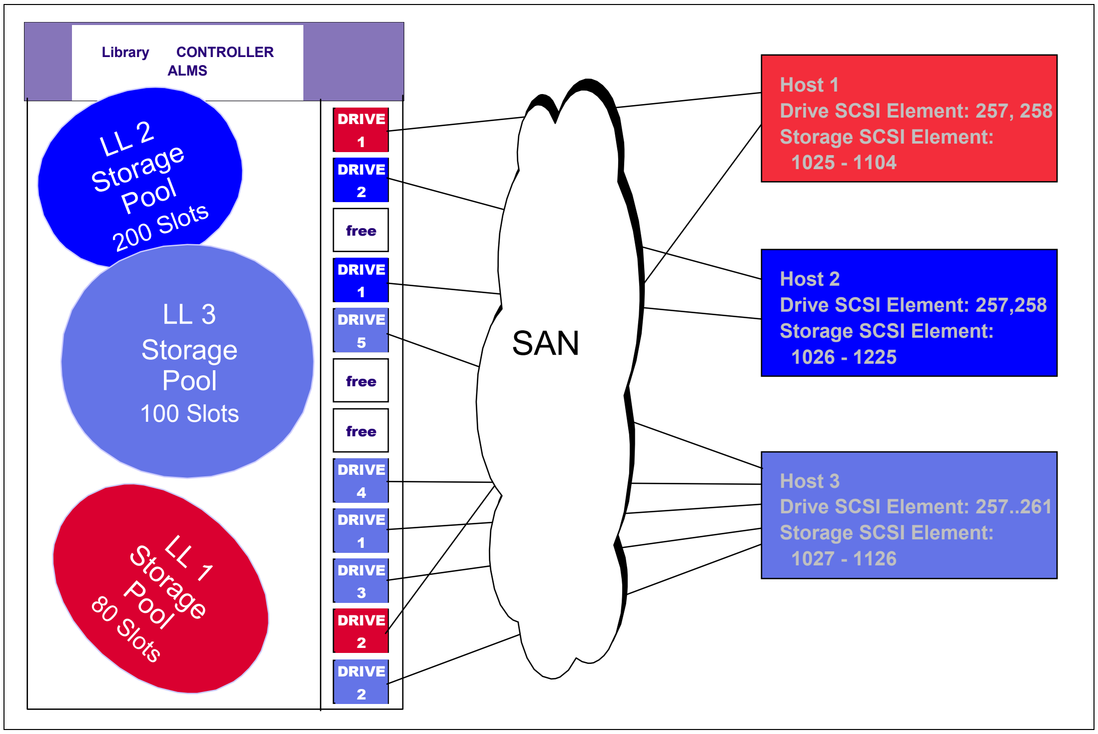


Figure 9-16 IBM TS3500 Tape Library with ALMS

Storage slot pooling

With ALMS, logical libraries can be added or deleted non-disruptively. All storage slots are first-come-first-served to each logical library based on cartridge insert operations. Therefore, storage slots are pooled as a shared resource such that changes to the capacity allocation for each logical library can occur without any downtime or administrator involvement whatsoever. Indications of a full or nearly full physical library will continue to be provided via the Operator Panel, Tape Library Specialist, and SNMP traps.

The minimum logical library simply has a name and can be thought of as a file folder that has no content. Drives can be placed in the file folder using the Drive Assignment screen of the Tape Library Specialist. Cartridges can also be placed in the file folder, based on their volume serial (VOLSER) numbers and by using one of the following methods (in priority order):

- Migration from static partitioning (UI enablement of ALMS)
- Cartridge Assignment Policy (automatic at time of insertion)
- Insert Notification (Operator Panel selection at time of insertion)
- Software application move from I/O station (based on source of command)
- Manual assignment using the Tape Library Specialist

The VOLSER assignment and physical location of cartridges are stored in non-volatile RAM (both primary and backup copies).

Shared drive assignment

Some clients require the ability to easily share a drive on an exception basis; for example, a drive might be required for a once-a-month job or as a temporary replacement for a failed drive. The Tape Library Specialist drive assignment UI supports the ability to assign a drive to multiple logical libraries. Therefore, each logical library will consist of dedicated drives and shared drives. Each logical library will map a drive element address to the location of both dedicated and shared drives.

This option reduces the requirement to configure and unconfigure the tape drive every time it is needed or not.

The Drive Assignment Web window supports the following point-and-click capabilities, which are non-disruptive to other logical libraries:

- Assign the drive
- Remove the drive assignment
- Reassign the drive

When a cartridge is mounted in a shared drive, the library will only accept a demount command requested via the source logical library; any demount command requested via other logical libraries will be rejected.

However, the data path to the tape drive itself is not protected by the library. Therefore, the administrator must ensure that shared drives are not accessed by the wrong application via the data path. One option to ensure this is to use the SCSI reserve and release option on open and close. The device driver together with the application handles this. On a device open, the application initiates a SCSI reserve through the tape device driver. No other server can now access the tape drive (except for commands such as inquiry), ensuring that data is not overwritten by any other host or application. After the device is closed, the application must send a SCSI release to the tape drive. Most applications handle this, but it is best to check with the backup software provider to confirm.

SAN zoning can also be used to prevent access to the same tape drives by different servers.

When a tape drive is shared by applications, any application using the drive has no knowledge of the other applications sharing the tape drive. Therefore, a cartridge might be loaded already and in use by application A, but if application B does not know it and tries to mount a cartridge in the same drive, application B gets a failure and the job that application B was executing fails. Several applications periodically scan all the tape drives and if they recognize that there is a cartridge mounted without initiation from the application itself, the application considers this tape drive offline.

In any case, we recommend not allowing multiple applications to use shared tape drives concurrently. In other words, set tape drives offline (or in service mode) from the application whenever they are not in use by that application.

The sharing option is mainly intended for environments where certain drives are needed only occasionally and must be preconfigured for the application.

Important: An application that occasionally leaves cartridges in drives or periodically scans all configured drives is not a good candidate for sharing drives between logical libraries.

Eliminates downtime for total capacity changes

With ALMS enabled, the total library capacity (number of addressable storage slots) can be changed transparently to each application, because the Maximum Number of Cartridges value is not affected by changes to the number of storage slots. The additional storage slots are simply new candidates for cartridges to be moved to upon insertion.

Furthermore, using the new Intermediate and full Capacity on Demand capabilities of the TS3500 Tape Library Models L23 and L53 requires no downtime at all for the change to total L-frame capacity.

Cartridge Assignment Policy

The Cartridge Assignment Policy (CAP) of the IBM TS3500 allows you to assign ranges of cartridge volume serial (VOLSER) numbers to specific logical libraries through the Tape Library Specialist. When a cartridge is inserted into the I/O station, the Cartridge Assignment Policy will be used to attempt to associate the cartridge with a logical library. If the cartridge is not in the CAP and Insert Notification (discussed in the next section) is enabled, you can assign the cartridge to a logical library by using the Insert Notification process on the library's Operator Panel or keep the cartridge as unassigned and assign it later using the Tape Library Specialist. If the Insert Notification feature is not enabled, and the cartridge was not in the CAP, the cartridge will eventually be available to all hosts. Unassigned cartridges can also be assigned to a logical library by creating a new VOLSER range, then performing a manual inventory to assign those cartridges through the Cartridge Assignment Policy.

The Cartridge Assignment Policy is media-type specific. As such, it is based on the six most significant characters of the cartridge label. The ranges of VOLSERs do not include the media-type indicator (L3, L4, JA, JJ, and so forth). This means that two identical labels (except for the media-type indicator) can be assigned to two different logical libraries, for example, libraries that contain LTO or 3592 drives.

> **Note:** The Cartridge Assignment Policy does not reassign an assigned tape cartridge. To reassign a cartridge, use the procedure for assigning cartridges to a logical library.

Insert Notification

Insert Notification is an option that enables the IBM TS3500 to monitor the I/O station for any new media that does not have a logical library assignment. This feature can be enabled through the Operator Panel or through the Tape Library Specialist. With Insert Notification enabled, when new media is detected, the Operator Panel displays a message that asks to select a logical library. Any unassigned cartridges in the I/O station will be assigned to the logical library that you select (and all other logical libraries will not be able to access the cartridges). The library includes an option to defer any assignment and there is a time-out period when the deferral will automatically take effect.

9.5.2 Virtual I/O

The IBM TS3500 Tape Library has I/O stations and I/O slots that enable you to import and export up to 32 cartridges at any given time. The I/O slots are also known as *import/export elements (IEEs)*. Virtual I/O (VIO) slots increase the quantity of available I/O slots by allowing storage slots to appear to the host as I/O slots. Storage slots that appear to the host as I/O slots are called *virtual import/export elements (VIEEs)*. The goal of virtual I/O slots is to reduce the dependencies between the system administrator and library operator so that each person performs their import and export tasks without needing the other person to perform any actions. With virtual I/O slots, the library automatically moves cartridges from the I/O stations to physical storage slots and from physical storage slots to the I/O stations.

With virtual I/O slots, you can configure up to 255 VIEEs per logical library. Each logical library will have a unique VIEE address space that is not accessible by other logical libraries. New logical libraries will by default be assigned the maximum number of virtual I/O slots, while logical libraries that were defined before ALMS is enabled initially have the number of physical I/O slots in the library.

Prior to virtual I/O slots, the IEE space was comprised of physical I/O station slots (10, 30, 16, or 32 depending on the frame model type) that were shared by all logical libraries. If the application or system administrator did not explicitly import the cartridges from the I/O station into library storage, the cartridges remain in the I/O station. This reduced the number of IEEs available to process imports and exports.

With virtual I/O slots, when cartridges are inserted into the I/O station, the library will work with the Cartridge Assignment Policy or Insert Notification to assign a cartridge to the correct logical library VIEE space and cartridges will automatically be moved into library storage slots. If there is no Cartridge Assignment Policy assigned and Insert Notification is disabled for a particular cartridge, that cartridge will be inserted into the VIEE space of all logical libraries and automatically get moved into a library storage slot. The VIEE temporarily takes on the attributes of an IEE until a host moves the cartridge into a *storage element (StE)*. When the host move occurs, if the cartridge is in a storage slot, no physical move is needed and the element transitions from a VIEE to an StE. Similarly, when a host exports a cartridge from an StE, the physical storage slot will be reported as a VIEE without moving the cartridge to the I/O station. The library will monitor when free space is available in the I/O station and move exported cartridges at the library's convenience.

If a cartridge cannot be assigned, this will be reported as *Assignment Pending*. This can occur if the assigned logical library does not have any available VIEE slots, or if all of the logical libraries do not have a common VIEE to share. To resolve this, either free up VIEE addresses so this is available in all libraries, or make a specific assignment of this cartridge to a logical library.

With VIO, there is a option to *Hide/Show Exports*. Show Exports, the default, shows a VIEE inventory of cartridges exported from the logical library. These cartridges then fill one of the VIEE slots for that logical library. `Export Complete` is shown when the exported cartridge is physically in an I/O station slot.

Selecting Hide Exports moves the exported cartridges to a library-maintained export queue, the VIEE is free immediately for other imports or exports, and the exported cartridge disappears from the host application's inventory data. Exporting a cartridge will be reported as `Export in Progress` if there is no available VIEE and will not complete until one is available. With Hide Exports, this situation will not occur.

Support for Virtual I/O slots is provided at library microcode level 5360 and higher and is enabled by default when ALMS is enabled. Existing clients who have already enabled ALMS on their IBM TS3500 Tape Library will have to install a newer level of library microcode that supports virtual I/O and then manually enable the virtual I/O slots.

9.5.3 Using ALMS in practice

So how will working with ALMS be different from working without ALMS? Let us imagine an environment in which there are two people who work with the Tape Library each day:

- The Media Operator who physically loads and unloads cartridges into the I/O station
- The Storage Application Administrator who configures the library and uses the application to move tapes in and out of the library

We now consider the steps necessary to move 30 cartridges in and out of a TS3500 Tape Library with a 16 port I/O station, both with and without ALMS.

Loading 30 cartridges into a library without ALMS

The Media Operator:

- Manually sorts the cartridges into groups for different logical libraries
- Loads 16 cartridges from one of the groups into the I/O station

- Responds to a prompt on the Operator Panel regarding assigning the cartridges to one of the logical libraries
- Contacts the Storage Application Administrator to request that the cartridges are moved into the library to create room for the remaining cartridges
- Waits until the I/O station is empty and then inserts the next group of cartridges
- And so on

In the scenario above, the Storage Application Administrator must run the application commands to move cartridges into storage slots each time the I/O station is filled.

Loading 30 cartridges into a library with ALMS

The Media Operator:

- Loads any 16 cartridges
- Watches the library move the cartridges into the body of the library as soon as the I/O station door is closed
- Loads the remaining cartridges
- Contacts the Storage Application Administrator to inform the Storage Application Administrator that the cartridges have been put in the library

In this scenario, the Storage Application Administrator must still run the application commands to move cartridges into storage slots. As far as the application is concerned, the cartridges are in I/O slots, not storage slots. You and I know that the cartridges are actually located in a slot in the body of the library that is masquerading as an I/O slot, or in ALMS terms, a *virtual* I/O slot. The application is blissfully unaware of this. When it executes the command to move the cartridge from the I/O slot into a storage slot, there is no cartridge movement. Instead, ALMS changes the status of the slot from a virtual I/O slot to a storage slot. And this happens in an instant.

Unloading 30 cartridges from a library without ALMS

The Storage Application Administrator:

- Determines how many I/O station slots are currently empty.
- Uses the application to move the same number of cartridges into the I/O station
- Contacts the Media Operator and asks the Media Operator to remove the cartridges now to create empty slots
- Waits for confirmation from the Media Operator that the Media Operator has emptied the I/O station
- Uses the application to move the remaining cartridges into the I/O station
- Informs the Media Operator that there are additional cartridges to be unloaded and the Media Operator then removes the remaining cartridges

Unloading 30 cartridges from a library with ALMS

The Storage Application Administrator:

- Uses the application to move all the cartridges into the I/O station.
- Informs the Media Operator that there are 30 cartridges to be unloaded and the Media Operator then removes cartridges present in the I/O station, closes the I/O station door, and watches the remaining cartridges get immediately ejected. The last cartridges can then be removed.

In this scenario, the Storage Application Administrator does not need to be concerned when the I/O station fills. When it does fill, ALMS will change the status of the storage slots that contain the outstanding cartridges still in the body of the library to virtual I/O slots. From the viewpoint of the application, it has completed its job successfully. Actually, ALMS will move the remaining cartridges into the I/O station when the Media Operator has removed the cartridges currently present.

9.6 Environmental specifications

The IBM TS3500 Tape Library is a stand-alone tape subsystem consisting of one or more frames and capable of modular expansion to provide large capacities. The frames join end-to-end with the base frame on the left (viewed from the front) and the expansion frames extending to the right.

9.6.1 Physical dimensions

Table 9-8 indicates the physical dimensions of the IBM TS3500 Tape Library frames, and Table 9-9 gives their weights according to the number of installed drives, robotics, and tape cartridges.

Table 9-8 Physical dimensions

	Width	Depth	Height
L32, D32	72.5 cm (28.5 in.)	152 cm (59.8 in.)	180 cm (70.9 in.)
L23, D23, L53, D53, and HA1	72.5 cm (28.5 in.)	121.2 cm (47.72 in.)	180 cm (70.9 in.)

Table 9-9 IBM TS3500 Tape Library weight

	Weight of base frame with 1 drive and 0 cartridges	Weight of base frame with 12 drives and maximum cartridges
L32	425 kg (937 lb.)	570 kg (1256 lb.)
D32	355 kg (784 lb.)	558 kg (1229 lb.)
L53	366 kg (806 lb.)	526 kg (1160 lb.)
D53	274 kg (604 lb.)	483 kg (1065 lb.)
L23	364 kg (802 lb.)	534 kg (1178 lb.)
D23	270 kg (596 lb.)	494 kg (1089 lb.)
HA1	261 kg (575 lb.)	N/A

Each frame has a set of casters and four leveling jackscrews. The nominal height from the bottom of the jackscrews to the top of the frame is 1840 mm (72.4 in.) and can be varied by ±40 mm (±1.6 in.). The shipping height of the IBM TS3500 Tape Library (on its casters and with jackscrews raised) is 1800 mm (70.9 in.).

When planning for the installation, consider the space implications in your computer room for the possibility of adding more frames in the future.

9.6.2 Floor requirements

Install the library on a raised or solid floor. The floor must have a smooth surface and, if raised, must not have ventilation panels beneath the leveling jackscrews. If carpeted, ensure that the carpet is approved for computer-room applications. To accommodate unevenness in the floor, you can raise or lower the leveling jackscrews to the following specifications:

- Maximum allowable variance must not exceed 7 mm (0.27 in.) per 76 mm (3 in.).
- Maximum out-of-level condition must not exceed 40 mm (1.6 in.) over the entire length and width of the library.

The floor on which the library is installed must be able to support:

- Up to 4.8 kilograms per square cm (68.6 lbs. per square inch) of point loads exerted by the leveling jackscrews
- Up to 211 kilograms per square meter (43.4 lbs. per square foot) of overall floor loading

The number of point loads exerted depends on the number of frames that make up the library. There are four point loads per frame (located at the corners of each frame).

9.6.3 Operating environment

The IBM TS3500 Tape Library is designed to operate in the following environment:

- Temperature: 16 - 32 C (61 - 89 F)
- Relative Humidity: 20% - 80%
- Wet Bulb: 23 C (73.4 F) maximum

9.6.4 Power and cooling specifications

Power and cooling for the IBM TS3500 Tape Library components are provided by the housing frame. Each base and expansion frame that contains drives has its own *frame control assembly (FCA)*, which receives power from a client-supplied outlet and, in turn, provides AC power to all tape drives within the frame. The FCA for the L32, L53, and L23 contains two DC power supplies; actually, only one DC power supply is needed to operate the entire library. Before support was provided for 16 frames, all additional FCAs in D frame included one additional DC power supply for redundancy. With support for 16 frames, the additional FCAs in the D32 no longer have a default-installed DC power supply.

Additional DC power supplies can nevertheless be ordered or made available for extra frames, as explained in 9.2.2, “Library control systems: Enhanced frame control assembly” on page 243.

The FCA is not required in expansion frames that contain no tape drives.

Each frame receives single-phase (200-240 V AC) power on its own power cord from a client-supplied outlet. Certain countries or regions require two-phase power to achieve the 200-240 V AC required by the frame.

A Dual AC Power feature (FC1901), supporting either 110 V AC or 220 V AC, is available for the IBM TS3500 Tape Library, providing two independent line cords that can be connected to two independent client branch circuits. A power switch connects to one of two client power feeds and passes all AC power to the frame from that feed. The switch monitors the AC line voltage from the feed that it is using and automatically switches to the alternate AC power feed if the incoming voltage drops below a preset level.

Table 9-10 on page 271 lists the power requirements for the L53 and D53 frames.

Table 9-10 Power requirements for the IBM TS3500 Tape Library

Power requirements	**Types of line cord**	
	220 V AC line cord	**110 V AC line cord**
AC line voltage	200 to 240 V AC (nominal)	100 to 127 V AC (nominal)
AC line frequency	50 to 60 Hz	50 to 60 Hz
Nominal power	1.4 kW	1.2 kW
Line current	8.0 A	12.0 A
kVA	1.6 kVA	1.2 kVA
Heat output	4.8 kBTU/hr.	4.1 kBTU/hr.
Inrush current	200 A (peak for 1/2 cycle)	100 A (peak for 1/2 cycle)

Note: Values shown are for frames with 12 tape drives installed.

9.7 Host platforms and device drivers

The IBM TS3500 Tape Library is supported on many operating systems. For a current list of host software versions and release levels that support the TS3500 Tape Library, refer to:

http://www-03.ibm.com/systems/storage/tape/

9.7.1 Feature codes

The following no-charge specify feature codes indicate the server platform to which the IBM TS3500 Tape Library is attached. These features are used by IBM for device driver distribution:

- FC9210: Attached to HP-UX
- FC9211: Attached to Sun system
- FC9212: Attached to Windows system
- FC9213: Attached to other non-IBM system
- FC9215: Attached to Linux system
- FC9216: Attached to System z Linux system
- FC9400: Attached to System i
- FC9600: Attached to System p

You are not limited to one platform-attach feature, because the library can be attached to more than one of these platforms. You cannot add more than one of each feature; in other words, if you have two or more Windows servers, only one FC9212 is required. The device driver is delivered on a CD that contains all available device drivers for each operating system and the documentation.

Tip: Always check this FTP site for the latest device drivers:

ftp://ftp.software.ibm.com/storage/devdrvr/

9.7.2 Device driver installation

Install the IBM device drivers for the IBM TS3500 Tape Library as follows:

- If you intend to use the IBM TS3500 Tape Library with a commercial software application (such as VERITAS Backup Exec or EMC Legato NetWorker), refer to that application's installation instructions to install the device driver and configure the IBM TS3500 Tape Library.
- If you do not intend to use the IBM TS3500 Tape Library with a commercial software application, install the latest tape and medium device driver from the following Web site:

  `ftp://ftp.software.ibm.com/storage/devdrvr/`

Refer to the installation instructions in the *IBM SCSI Tape Drive, Medium Changer, and Library Device Drivers Installation and User's Guide*, GC35-0154.

> **Note:** If you use the IBM TS3500 Tape Library with a commercial software application, IBM recommends that you install any IBM-supplied device driver only if instructed to do so in the installation instructions supplied by the vendor of the application. Otherwise, if the application supplies its own driver code, conflicts can occur over which driver controls the drive. Many examples are given in the *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

9.8 Storage applications

Software to exploit the IBM TS3500 Tape Library is not provided with the library. Additional software support is available through products that you must obtain separately from IBM, IBM Business Partners, or independent software vendors. A list of compatible software is available at:

`http://www-03.ibm.com/systems/storage/tape/pdf/compatibility/lto_isv_matrix.pdf`

You will find details for each application that supports Ultrium and 3592 Tape Drives and attachment methods. You must also contact your storage application vendor for more information about specific versions and supported platforms. Several examples of third-party software applications with IBM LTO drives and libraries are given in *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

9.9 IBM TS3500 Tape Library initial setup

The following sections cover several of the major items required to implement, manage, and operate the IBM Ultrium tapes and libraries. We do not cover all tasks, and we do not intend to cover all of the specific commands. For more details, refer to the *IBM System Storage TS3500 Tape Library Installation and Planning Guide*, GA32-0469, and for a practical installation with examples, *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

9.9.1 Tape Encryption overview

The TS1120 and the TS1040 Tape Drives both support Tape Encryption with all three encryption methods. You can encrypt all 3592 data cartridges including the WORM and the extended data cartridges when you are using the TS1120 Tape Drive. For encryption on the TS1040 tape drive, you must use Ultrium 4 data cartridges or WORM 4 cartridges.

The TS3500 supports the following three encryption methods:

- Application-Managed Encryption
  The application controls the encryption process and generates and provides the encryption keys to the tape drives, for example, Tivoli Storage Manager.
- Library-Managed Encryption
  The tape library controls the encryption process through the library interface. An external Encryption Key Manager (EKM) is needed for this method of encryption and is available for AIX, i5/OS, Linux, HP-UX, Sun Solaris, and Windows. The tape drive is communicating with the EKM through the library interface using TCP/IP.
- System-Managed Encryption
  The encryption process is set up implicitly through each instance of the IBM device driver.

Encryption is available at no charge for the TS1120 for all encryption methods. The TS1040 supports Application-Managed Encryption (AME) at no charge. However, we recommend that you order FC9900 for AME as well.

Feature Code 1604 and FC9900 must be ordered when you are planning to implement Library-Managed Encryption (LME) or System-Managed Encryption (SME) with the TS3500.

Configuring and managing encryption is a client responsibility and not the responsibility of the IBM SSR. In certain instances, SSRs will be required to enable encryption at a hardware level when service access or service password-controlled access is required.

You can set up to four key manager TCP/IP addresses when LME is used as an encryption method.

Setting up encryption

Setting up or changing the encryption can only be done using the Web User Interface and not using the Operator Panel. Before you start configuring your encryption on the TS3500, the EKM must already be installed. The IBM EKM is the component that assists the TS1120 and the TS1040 in generating, protecting, storing, and maintaining encryption keys. EKM R2 must be used when TS1040s are installed in a tape library.

Basic setup steps

To set up or change the encryption method for each TS1120 or TS1040, perform the following steps:

1. Type the Ethernet IP address on the URL line of the browser and press Enter. The Welcome Page displays.
2. Select **Library** → **Logical Libraries**. The Manage Logical Libraries window displays. For each logical library, the Encryption Method column indicates whether encryption is **Library-Managed**, **System-Managed**, **Application-Managed**, is assigned no method (**None**), or is unable to be set (**N/A**).
3. To set or change a drive's method of encryption, select the check box of the logical library to which the drive belongs. If you select multiple logical libraries with dissimilar encryption methods, the Encryption Method field displays Mixed and no changes can be made.
4. If ALMS is not enabled, all logical libraries for a given media type must be selected in order for the Modify Encryption Method to be invoked.
5. From the Select Action drop-down box, select **Modify Encryption Method** and select **Go**. The Modify Encryption Method pop-up window displays.
6. In the Encryption Method field, select the type that you want.

If you select the System-Managed Encryption method when using TS1120 Tape Drives, the window displays the installed TS1120 Tape Drives and indicates whether they are encryption-capable. Select the encryption-capable drives that you want to become encryption-enabled, then select **Apply**.

7. If the encryption method is Library-Managed Encryption, the Encryption Policy selections are:
   – Barcode (default)
   – Internal Label-Selective Encryption
   – Internal Label-Encrypt All. This selection is only used for Symantec Veritas NetBackup.

   Note: The default setting of the Library-Managed Encryption method is to encrypt all cartridges in a logical partition.

Advanced Encryption Settings

The purpose of Advanced Encryption Settings is to allow only IBM Support personnel (under the direction of the drive development team) to provide a solution to an unforeseen problem or to support a unique configuration. This option is not intended for the client to use without the guidance of IBM Support.

Setting up EKM addresses

The next step is to set one or more EKM addresses. You can create, modify, or delete a key manager address by using the Tape Library Specialist Web interface but not by using the Operator Panel. You can test a key manager address by using both the Web and the Operator Panel.

1. Type the Ethernet IP address on the URL line of the browser and press Enter. The Welcome Page displays.
2. Select **Access** → **Key Manager Addresses.** The Key Manager Addresses window is displayed.
3. Perform one of these actions:
   – To create a key manager address: From the Select Action drop-down box, select **Create**, then select **Go**. The Key Manager Create window displays. Enter the IP address and port of the key manager. Select **Apply**.
   – To change a key manager address: Select the key manager address that you want to change. From the Select Action drop-down box, select **Modify**, then select **Go**. The Key Manager Modify window displays. Enter any necessary changes in the IP Address or Port fields. Select **Apply**.
   – To delete a key manager address: Select the key manager address that you want to delete. From the Select Action drop-down box, select **Delete**, then select **Go**. The window displays the message, “`Are you sure you want to delete this key manager entry?`” Select **OK**. A pop-up window confirms the deletion. Select **Close**.

Operational topics

In the next steps, we explain how to determine which encryption method is used for a tape drive and to determine whether a data cartridge is encrypted or not. We start first with the tape drive.

Determine encryption method

You can view a drive’s method of encryption by using the Tape Library Specialist Web interface, but not by using the Operator Panel:

1. Type the Ethernet IP address on the URL line of the browser and press Enter. The Welcome Page displays.

2. Select **Library** → **Logical Libraries**. The Manage Logical Libraries window displays. For each logical library, the Encryption Method column indicates whether encryption is **Library-Managed**, **Application-Managed**, **System-Managed**, is assigned no method (**None**), or is unable to be set to encryption (**N/A**).
3. To view a drive's method of encryption, select the check box of the logical library to which the drive belongs.
4. From the Select Action drop-down box, select **View Encryption Method**, and select **Go**. The View Encryption Method pop-up window displays.
5. Locate the entry in the Encryption Method field. To return to the previous window, select **Cancel**.
6. If the encryption method is Library-Managed Encryption, the Encryption policy selections are:
   - Barcode (default)
   - Internal Label-Selective Encryption. This selection is only used for Symantec Veritas NetBackup.
   - Internal Label-Encrypt All. This selection is only used for Symantec Veritas NetBackup.

Cartridge status

If you want to determine whether a data cartridge is encrypted:

1. Type the Ethernet IP address on the URL line of the browser and press Enter. The Welcome Page displays.
2. Select **Cartridges** → **Data Cartridges**. The Cartridges window displays.
3. Select whether the cartridges are in a frame or logical library, select how you want the cartridges to be sorted, then select **Search**. The page refreshes and displays a list of VOLSER ranges as links in the upper right. It also displays information about each cartridge in the library. If the library is installed with an encryption-enabled TS1120 Tape Drive or TS1040 Tape Drive, the window includes an Encryption column that indicates whether the cartridge is **Encrypted**, **Not Encrypted**, or **Unknown**. An Unknown cartridge is one that has not been previously mounted in a 3592 Tape Drive or TS1040 Tape Drive.

There are more options available for Tape Encryption. To find out all options for Tape Encryption, see *IBM System Storage TS3500 Tape Library Operator Guide,* GA32-0560.

The methods of encryption for the TS1120 and the TS1040 Tape Drives are different. If you want to learn more about the difference between the two encryption methods, go to 2.2, "Tape Encryption overview" on page 56.

> **Note:** TS1120 Tape Drives manufactured before September 8, 2006, do not have the capability to encrypt data on the data cartridge. However, there is a chargeable upgrade available (FC5592) to upgrade the TS1120. This encryption capability includes drive hardware, as well as microcode additions and changes.

9.9.2 SCSI ID

The IBM TS3500 Tape Library uses multi-path architecture, so it has no direct SCSI connection to a host system. When the host communicates with the library, it must send the communication via a control path to a drive designated as logical unit number 1 (LUN 1). A *control path* is the drive SCSI port through which a host system sends its commands to a logical library within the IBM TS3500 Tape Library. Refer to 2.4.7, "Multi-path architecture" on page 79 for an explanation of the concept of logical libraries. When you add multiple control paths to the IBM TS3500 Tape Library, any single, configured logical library can be accessed by multiple host systems.

Additional control paths also reduce the possibility that failure in one control path will cause unavailability of the entire library.

Note: The setup and SCSI configuration of the IBM TS3500 Tape Library are usually performed by an IBM SSR.

9.9.3 Element number

Element numbers identify the physical location within the library. This information is required mostly for storage applications, such as IBM Tivoli Storage Manager, which translate the device to a name that the robotic system understands.

In the IBM TS3500 Tape Library, each SCSI storage element is assigned a SCSI element address. A SCSI storage element is a physical location capable of holding a tape cartridge (such as an I/O slot, drive, or storage slot). The element numbering is grouped in:

- Tape drive sequence
- I/O station sequence
- Cartridge slot sequence

Note: The numbering is contiguous for the cartridge slot sequence. However, the addition, removal, or movement of one or more tape drives affects the element numbering of the cartridge slots.

Table 9-11 shows the element numbers for tape drives in each IBM TS3500 Tape Library frame up to six frames. For element numbers up to the maximum 16 frames, see the *IBM System Storage TS3500 Tape Library Operator Guide,* GA32-0560.

Table 9-11 IBM TS3500 Tape Library tape drive element numbers

Drive number	Frame 1 (L*x*3)	Frame 2 (D*x*3)	Frame 3 (D*x*3)	Frame 4 (D*x*3)	Frame 5 (D*x*3)	Frame 6 (D*x*3)
1	257	269	281	293	305	317
2	258	270	282	294	306	318
3	259	271	283	295	307	319
4	260	272	284	296	308	320
5	261	273	285	297	309	321
6	262	274	286	298	310	322
7	263	275	287	299	311	323
8	264	276	288	300	312	324
9	265	277	289	301	313	325
10	266	278	290	302	314	326
11	267	279	291	303	315	327
12	268	280	292	304	316	328

Each element in the IBM TS3500 Tape Library (the cartridge storage slots, I/O storage slots, and tape drives) has two addresses:

- Physical address
- SCSI element address

When initiating an operation, such as moving a tape cartridge or performing manual cleaning, you can use the physical or logical address to specify a location in the library.

The physical address consists of frame, column, and row identifiers that define a unique physical location in the library. The address is represented as:

- *Fx,Cyy,Rzz* for a storage slot (where *F* equals the frame and *x* equals its number, *C* equals the column and *yy* equals its number, and *R* equals the row and *zz* equals its number)
- *Fx,Rzz* for a tape drive and I/O storage slot (where *F* equals the frame and *x* equals its number, and *R* equals the row and *zz* equals its number)

The SCSI element address consists of a bit and hex value that defines to the SCSI interface a logical location in the library. This logical address is represented as *xxxx (X'yyy')*, where *xxxx* is a bit value and *yyy* is a hex value. It is assigned and used by the host when the host processes SCSI commands. The SCSI element address is not unique to a storage slot, drive, or I/O slot; it varies, depending on the quantity of drives in the library.

For example, the storage slot address `F2,C03,R22` means:

- `F2`: Frame 2 (first expansion frame)
- `C03`: Column 3 (second column from left on drive side)
- `R22`: Row 22 (22nd position down from the top of the column)

Each drive has a unique address to indicate its physical location. The drive address consists of two values: a frame number and a row number:

- Frame number: Represented as *Fx*, where *F* equals the frame and *x* equals its number. Regardless of whether any drives are installed, the frame number for the base frame is 1 and increments by one for each adjacent expansion frame.
- Row number: Represented as *Rzz*, where *R* equals the row and *zz* equals its number. The row number is 1 for the top drive position in the frame and increments by one for each row beneath the top drive. Regardless of whether drives are installed, the row numbering is the same for every frame.

A drive address of `F2,R10` means frame 2 (that is, the first expansion frame), row 10 (tenth drive position from the top of the column).

Note: ALMS will virtualize a SCSI element address. Therefore, there is no relationship between physical location and SCSI element address if you use ALMS.

9.10 Operator displays and buttons

The IBM TS3500 Tape Library-L*x*3 operator display is a touch screen with integrated touch buttons. The display default setting returns to the basic main menu after five minutes of inactivity. The window has three sections (Figure 9-17 on page 278):

- Menu title and panel number
- Informational section
- Selectable buttons

Navigate through the Operator Panels by pressing the touch screen buttons:

- BACK: Will take you back to the previous window. You might need to press the BACK button several times to return to the main status window.
- UP and DOWN: If you are on a menu panel, these keys will navigate up and down in the current panel, scrolling one line when pressed once. If you keep the UP or DOWN keys pressed, scrolling will speed up. The longer you hold the keys, the faster the scrolling.

  If you are selecting a value, the keys will increment or decrement the value.
- ENTER: The selected item is shown using reverse video. No action is processed until you press ENTER.

The default display is the Activity Status Display. The information in the Activity window is replaced automatically by an error message whenever the Ultrium tape library detects that:

- A permanent error has occurred.
- A drive requires cleaning, and automatic cleaning has been enabled.
- A drive requires cleaning, and no cleaning cartridge is present in the library.

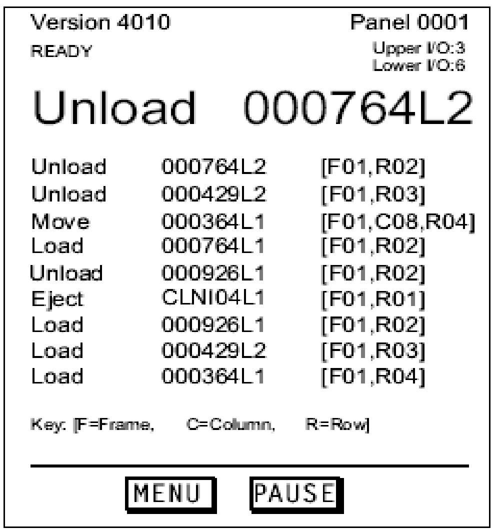


Figure 9-17 IBM TS3500 Tape Library-L32 operator display

Other commands or options will appear on various windows. From the main activity window, you can access the Library Main Menu by pressing MENU, or pause the library for a maintenance operation with the PAUSE key.

The PAUSE key causes the library to park the cartridge accessor in an area that gives clear access to the library's interior (if you need to open the front door). If you accidentally press the PAUSE key, wait for the 30-second time-out. The library will automatically resume operation.

Important: If you press the PAUSE key and open the front door, the library rejects requests for new operations.

When selecting a critical command, such as pressing PAUSE, a confirmation window displays with a text message with two keys, CONTINUE and CANCEL. The CONTINUE key proceeds and executes your command, and the CANCEL key returns to your previous window.

The windows on the Operator Panel fall into six categories:

Library status Provides data about the accessor, cartridge locations, drives, and slots.

Manual operations Enables manual intervention, such as cartridge movements, cleaning, and inventory.

Settings Displays and changes configuration setup variables, such as cleaning mode, date, enabling and disabling drives, and virtual library configuration.

Statistics Reports usage data about the accessor, drives, and cleaning cartridges.

Vital Product Data (VPD) Describes the library, drives, and accessor. This includes such information as the machine types, model numbers, serial numbers, and the level of firmware.

Service Places the library into service mode to carry out repairs or upgrades.

10

Library management

In this chapter, we discuss the tools and technologies that you can use to perform initial and ongoing library configuration and maintenance and to monitor the technical health of the library. We provide an introduction to the Storage Management Initiative Specification (SMI-S), an emerging standard that you can exploit to significantly reduce the effort associated with the management of storage devices, such as disk arrays, SAN fabric devices, and more recently, tape libraries.

In addition, we discuss management features unique to specific tape library models.

10.1 Library Management overview

For the purposes of this chapter, we define *library management* to embrace the tasks associated with initially configuring a tape library and then performing the ongoing tasks necessary to maintain technical health. We are not discussing operational tasks, such as loading and unloading cartridges. This chapter therefore describes the tools available (rather than describing each of the management tasks in detail) to assist you in performing the following tasks. These tasks are general and do not necessarily apply to all libraries:

- **Configuration customization**, which includes the following tasks:
  - Defining logical libraries
  - Defining a network address for the library Ethernet interface
  - Bringing drives and logical libraries online and offline
  - Defining how many characters to use in the VOLSER
  - Defining user IDs to use to access the Web interface or Operator Panel
  - Enabling automatic tape drive cleaning
- **Configuration viewing,** which includes displaying the following information regarding the library configuration:
  - Drive information, such as serial numbers, worldwide names (WWNs), and which cartridges are loaded
  - Cartridge inventory
  - I/O slot occupancy
  - Logical library configuration
- **Displaying error messages.** Seeing which error messages have been recorded by library components and tape drives
- **Alerting error messages**. Sending error messages to another location for attention, which can occur by e-mail or Simple Network Management Protocol (SNMP)
- **Updating firmware.** Keeping library and drive firmware up to date.

10.2 Management tools and technologies

In this section, we introduce the tools and technologies that you can use to assist with Library management:

- Operator Panel
- Web User Interface
- TapeAlert
- SNMP
- SMI-S
- IBM TotalStorage Tape Diagnostic Tool (ITDT)
- IBM Ultrium Device Driver

10.2.1 Operator Panel

The Operator Panel is the Liquid Crystal Display (LCD) on the front of each library. You control it by pressing buttons or it can be touch-sensitive. You perform the majority of tape management tasks directly via the Operator Panel. Note that the menu items available are different on different models of tape libraries. To confirm exactly which menu options a particular library displays, refer to the relevant Setup and Operator Guide.

Typical features available through the Operator Panel on most IBM tape libraries include:

- Library configuration:
  - Setting the network address
  - Bringing drives online and offline
  - Changing the mode of the library from random to sequential (TS3100, TS3200, and TS3400)
  - Configuring logical libraries (TS3100, TS3200, TS3400, TS3310, and TS3500)
  - Configuring the library to e-mail error conditions (TS3100, TS3200, TS3400, and TS3310)
  - Configuring the library to send error conditions as SNMP traps (TS3100, TS3200, TS3400, TS3310, and TS3500)
- Viewing configuration details. Displaying information regarding:
  - Firmware levels for the library and the drives
  - Library inventory
  - Drive serial numbers
  - The number of empty slots and occupied slots
  - Cartridges in the I/O slots
- Diagnostics:
  - Displaying error logs
  - Running diagnostic routines to test the library and tape drives
- Control:
  - Unlocking the I/O station
  - Moving cartridges
  - Performing an inventory

Table 10-1 summarizes the management tasks that are available through the Operator Panel.

Table 10-1 Summary of management capabilities available with the Operator Panel

Set configuration	**Display configuration**	**View errors**	**Send error alerts**	**Update firmware**
Yes	Yes	Yes	No, although the Operator Panel does not perform alerting, configuration to e-mail or send SNMP traps is performed here.	No. Strictly speaking this functionality is available to some degree on certain libraries, but it is not the recommended approach.

Most management tasks can be performed through the Operator Panel. However, the inherent drawback is that someone must be physically present to activate the panel and view the output (directing a colleague over the phone to operate the panel and read back what that person sees generally yields unsatisfactory results). With tape libraries often located remotely from those people who manage them, the Operator Panel is often inadequate in meeting the needs of Library Managers. It is, however, the main interface used by IBM Support Service Representatives (SSRs).

The remainder of the tools and technologies introduced in this chapter provide remote management capability.

10.2.2 Web User Interface

Remote management of tape libraries through a Web User Interface (Web UI) is a standard feature of all currently marketed IBM Tape Libraries. Note that the menu options and even the style of the Web UI differs between different library models. However, they offer broadly similar functionality. Use of the Web UI is implemented by configuring an IP address through the Operator Panel. In addition, user IDs and passwords can be defined with different access levels.

> **Note:** Each tape library ships with a default administrative user ID and password (`admin/secure`) for accessing the Web UI. Change this immediately after defining the network address.
>
> Also, be aware that restricting access to the Web UI is optional on earlier tape libraries. We strongly recommend that restricting access is always enabled.

Display the Web UI sign-on in a window by entering the Web address into your browser, as shown in Figure 10-1.

Figure 10-1 The Web User Interface log in window for the TS3310

After logging in, a menu appears that offers broadly the same functionality as that provided by the Operator Panel. The window in Figure 10-2 on page 285 shows summary information and the fully expanded menu available on the TS3310 Tape Library.

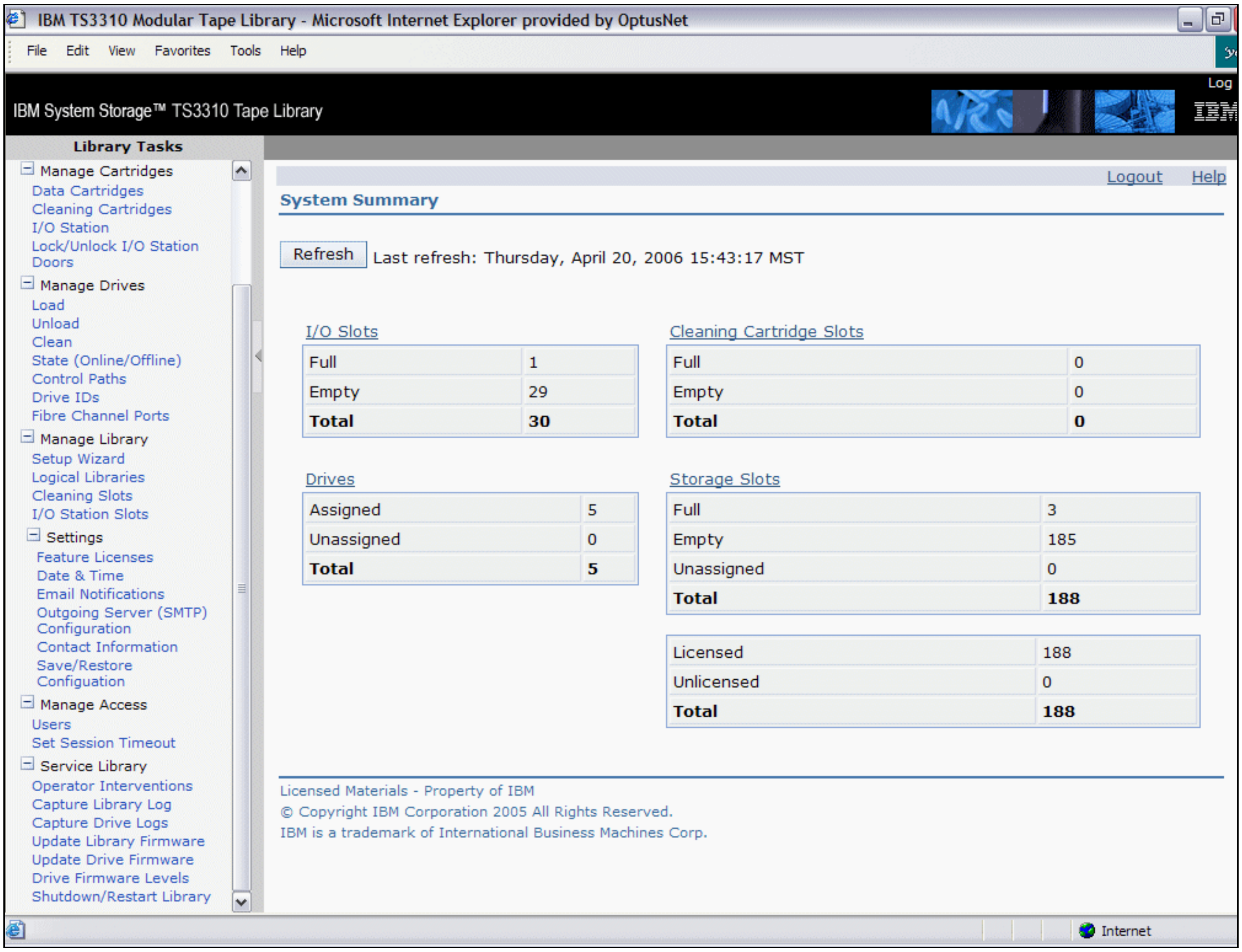


Figure 10-2   Web User Interface menu and System Summary display

Although the Web UI and Operator Panel functionality are similar, certain library models can have specific functionality that is only available through the Web UI. For example:

- The TS3100 and TS3200 Tape Libraries:
  - Event notification configuration
  - Error log configuration
  - Library restart
  - Encryption
  - Library firmware upgrade (only possible via the Web UI)
- The TS3310 Tape Library

  Library firmware upgrade (only possible via the Web UI)
- The TS3400:
  - Encryption
  - Event notification configuration
  - Error log configuration
- The TS3500 Tape Library:
  - Advanced Library Management System (ALMS) configuration

– Detailed logs regarding the mount history, drive statistics, Fibre Channel port statistics (available with library firmware 5500), and library statistics (available with library firmware 6*xxx*) can be downloaded.

This list is not meant to be comprehensive. Check the documentation shipped with each library to confirm the functionality available through the Web UI for specific library models.

To summarize the management functionality that is available through the Web UI, see Table 10-2.

Table 10-2 Summary of management capabilities available with the Web User Interface

Set configuration	Display configuration	View errors	Send error alerts	Update firmware
Yes	Yes	Yes	No. Although the Operator Panel does not perform alerting, configuration to e-mail or send SNMP traps is performed here.	Yes

The Web UI is clearly a comprehensive tool. We recommend that every library is network-connected to take advantage of the facilities available. Indeed, certain functionality outlined above is *only* available via the Web UI, making this tool indispensable.

10.2.3 TapeAlert

All IBM Ultrium Tape Libraries are compatible with TapeAlert technology, which provides error and diagnostic information about the drives and the library to the server to which the drives are connected. *TapeAlert* is an industry standard that defines status conditions and problems experienced by devices, such as tape drives, autoloaders, and libraries. The standard enables a TapeAlert-aware application, such as Tivoli Storage Manager, to read TapeAlert messages (called *flags*) from a tape drive via the SCSI bus. The server reads the flags from Log Sense Page 0x2E.

For a full list of the possible flags, refer to the appendix of the relevant Setup and Operator Guide.

TapeAlert Messages and Tivoli Storage Manager

In Tivoli Storage Manager, you can set tape alert messages to be on or off by using the Tivoli Storage Manager Administration command **`set tapealertmsg on`** or **`set tapealertmsg off`**. You can query tape alert messages by using the **`query tapealertmsg`** command.

TapeAlert has only three severity levels:

- Critical
- Warning
- Informational

Some critical messages result in ANR*xxxx*S, while others use ANR*xxxx*E, depending on the text. Examples of each warning type are:

- **ANR*xxxx*S** Device /dev/rmt1, volume VOL123 has issued the following Critical TapeAlert: Your Data is at risk. 1. Copy any data you require from this tape. 2. Do not use the tape again. 3. Restart the operation with a different tape.
- **ANR*xxxx*E** Device /dec/lb0, volume NONE has issued the following Critical TapeAlert: The library has a problem with the host interface. 1. Check the cables and cable connections. 2. Restart the operation.
- **ANR*xxxx*W** Device /dev/lb0, volume NONE has issued the following Warning TapeAlert. A hardware failure of the library is predicted. Call the library supplier helpline.
- **ANR*xxxx*I** Device /dev/mto, volume MYVOL1 has issued the following Informational TapeAlert. You have tried to load a cartridge of a type which is not supported by this drive.

If you monitor Tivoli Storage Manager events using the Tivoli Enterprise™ Console or SNMP, you can also monitor IBM Ultrium tape libraries indirectly by enabling tape alert messaging as just described within Tivoli Storage Manager.

Table 10-3 Summary of management capabilities available with TapeAlert

Set configuration	Display configuration	View errors	Send error alerts	Update firmware
No	No	No	Yes	No

TapeAlert is a technology inherent to IBM Ultrium tape drives to permit sending of tape and library alerts to servers connected to the tape library. It is especially useful if you are already monitoring your servers and applications, such as Tivoli Storage Manager, because this effectively means that the tape libraries and drives are also monitored by default.

10.2.4 SNMP

Simple Network Management Protocol (SNMP) forms part of the Internet protocol suite as defined by the Internet Engineering Task Force. Originally developed in 1988, the protocol can support monitoring of network-attached devices for any conditions that warrant administrative attention. The protocol has been developed from its original inception as Version 1 to Version 2 and Version 3.

Managed devices (*agents*) can send SNMP "*traps*" or "*notifications*" (essentially alerts concerning a change in state) to an SNMP Manager, such as IBM Tivoli NetView, from which multiple network devices can be monitored and managed.

The details of exactly what conditions can cause alerts are described in a *Management Information Base (MIB)*. A MIB is a formal description of a set of network objects that can be managed using SNMP. This file must be loaded into the SNMP Manager so that the notifications received can be correctly interpreted.

Library configuration information can be requested with an SNMP Manager. This is achieved using a MIB Browser, which runs an SNMP WALK command to retrieve all managed object values.

The TS3100, TS3200, TS3310, TS3400, and TS3500 Tape Libraries support SNMP. For the TS3500 library, you can find the MIB file at:

`ftp://ftp.software.ibm.com/storage/358x/3584/`

For the other tape libraries, go to:

http://www-01.ibm.com/systems/support/storage/

Table 10-4 is a summary of the management capabilities that are available with SNMP.

Table 10-4 Summary of management capabilities available with SNMP

Set configuration	Display configuration	View errors	Send error alerts	Update firmware
No	Yes	No. Errors are always alerted to be viewed remotely.	Yes	No

10.2.5 SMI-S

As Storage technologies become increasingly affordable, the demand for storage hardware has also increased. As a consequence, the workload associated with managing this expanding infrastructure is also increasing. The task of staying in control of tape libraries, SAN switches, and disk arrays from a variety of vendors, each with their own unique management tools, naturally becomes a greater challenge.

It is against this background that the Storage Networking Industry Association (SNIA), a vendor neutral organization, defines standards-based management for storage devices. The goal of using a single tool to permit management of storage devices from a wide variety of vendors is only possible if those storage devices conform to an agreed to management interface. The SNIA has defined an interface for just this purpose, the Storage Management Interface Specification (SMI-S). If a device conforms to SMI-S, then Resource Management Applications, which use the SMI-S, such as the IBM TotalStorage Productivity Center, are able to manage aspects of those storage devices that are defined in that version of the SMI-S.

SMI-S 1.1 has been defined for Library Management, and Storage Working Groups in SNIA are now working on SMI-S 1.2 to broaden the scope of the interface. This will permit a greater range of common functionality to be managed centrally from a common interface. SMI-S is therefore an evolving standard.

Products that conform to SMI-S can be submitted to the SNIA to demonstrate that they pass conformance tests that are defined by the Storage Working Groups in the SNIA. You can view a list of providers of products that can demonstrate conformance at the following Web site:

http://www.snia.org/ctp/conformingproviders

IBM tape libraries and SMI-S

IBM has achieved official conformance for the management of the TS3500 Tape Library, which is achieved by implementing “SMI-S Agent for Tape” on a Linux system. The Agent acts as an interface between the Resource Management Application and one or multiple TS3500 Tape Libraries.

In addition, the TS3310 Tape Library natively supports SMI-S 1.1. The SMI-S support is embedded within the library. The tape library has not yet been submitted to the SNIA for conformance testing. After conformance is achieved, this product will be listed on the Web site.

The 3494 has very limited support for SMI-S. However, certain library details can be seen in the IBM Resource Management Application, the IBM TotalStorage Productivity Center (TPC). In addition, you can start the Web User Interface from within TPC.

Although no other IBM Tape Libraries support SMI-S, it is still possible to list unsupported libraries in a Storage Resource Manager and then initiate the Web User Interface.

IBM TotalStorage Productivity Center (TPC)

TPC is a suite of storage infrastructure management software that can centralize, automate, and simplify the management of complex and heterogeneous storage environments. It can improve storage capacity utilization and improve administration efficiency. TPC brings together in a single interface the management of storage devices, fabric, data, and now, with the release of TPC V3.1, tape libraries.

TPC provides the following capabilities:

Device discovery Tape libraries, disk, and fabric devices can be automatically discovered to facilitate TPC configuration.

A topology viewer This displays how storage elements are connected, for example, which tape drives are connected to which ports on a SAN switch.

Configuration display The current configuration and utilization of storage devices can be viewed.

Monitoring Thresholds can be set which will trigger actions; for example, if a file system utilization expands beyond 90%, a script can be run to increase the size.

Alerting Conditions, such as SNMP traps issued from managed devices, can be logged and can optionally cause another action to be initiated, for example, sending the event to a Tivoli Enterprise Console®.

Management Devices can be manually configured from within the TPC, such as the SAN Volume Controller.

For further information regarding TPC, refer to *IBM TotalStorage Productivity Center V3.1: The Next Generation*, SG24-7194.

Tape library management through TPC

TPC can display all information that is currently defined in SMI-S 1.1. The next few pages show windows available within TPC to demonstrate the configuration and status information that is currently viewable. Note that SMI-S 1.1 does not include the concept of logical libraries or virtual I/O slots so this information cannot be displayed. Note also that SMI-S 1.1 is limited to *displaying* configuration information, not *changing* configuration information. This is achieved by starting the Web User Interface from within TPC. Alerts from SNMP traps are logged and displayed in TPC, but it is not yet possible to initiate actions as a result of those traps, for example, to forward the error condition to a Tivoli Enterprise Console.

To provide a better appreciation of tape library management within TPC, we display some of the windows you view when working with the Tape Manager. TPC provides a menu on the left of the window which provides the capability to work with different classes of storage devices. As you can see in Figure 10-3 on page 290, this includes:

- Data Manager
- Data Manager for Databases
- Data Manager for Chargeback
- Disk Manager

- Fabric Manager
- Tape Manager

Tape Manager is used to drill down to view all the tape libraries and work with them. Our demonstration begins with selecting the Tape Manager menu (Figure 10-3).

Selecting Tape Libraries

This first window is viewed by selecting Tape Libraries under the Tape Manager. In this demonstration environment, only one library is being managed and this is identified on the right along with its current status, number of tape drives, and cartridges. The Element Manager refers to the Web User Interface.

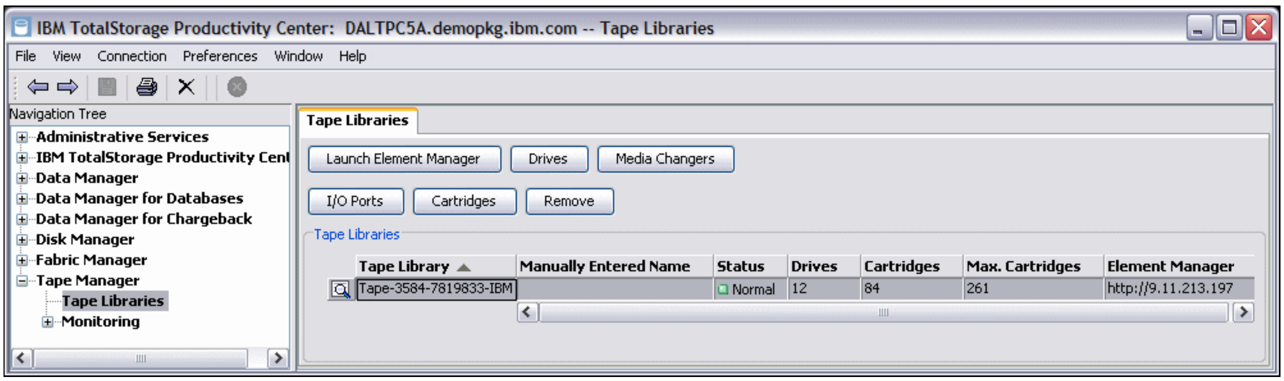


Figure 10-3   TPC window showing a list of Tape Libraries managed

The following pages show the windows displayed when selecting:

- The magnifying glass to the left of the Tape Libraries in the list (a short list of one in this example)
- The Drives button
- The Media Changers button
- The I/O Ports button
- The Cartridges button

Selecting the magnifying glass

Figure 10-4 on page 291 provides further details concerning this library including the option to update fields, for example, to include contact details for on-site staff.

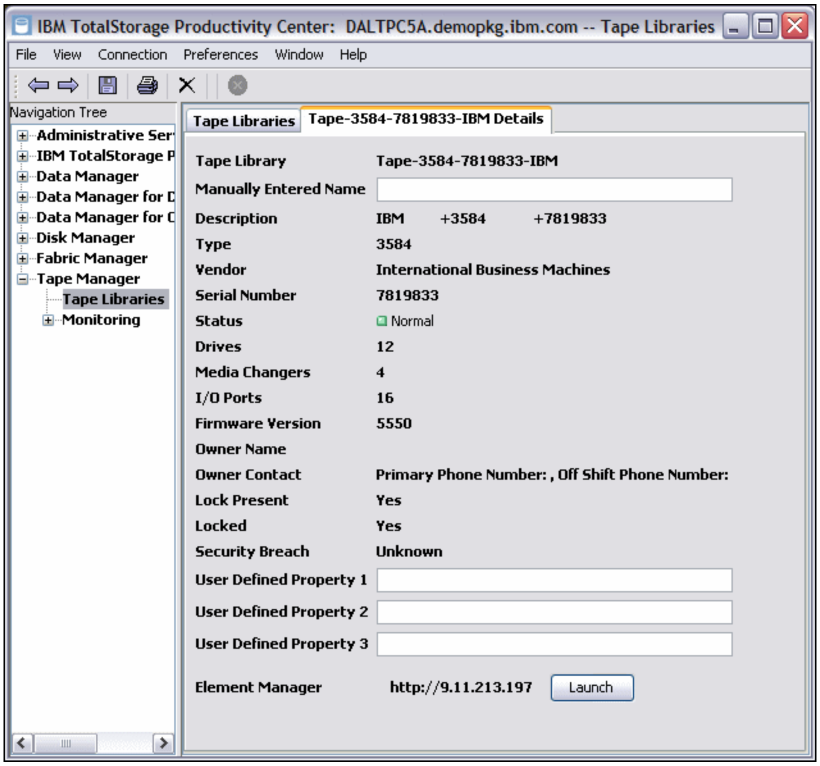


Figure 10-4 TPC window showing tape library details

Selecting drives

Figure 10-5 shows information, such as the status for each drive, the number of mounts performed by the drive, and firmware levels.

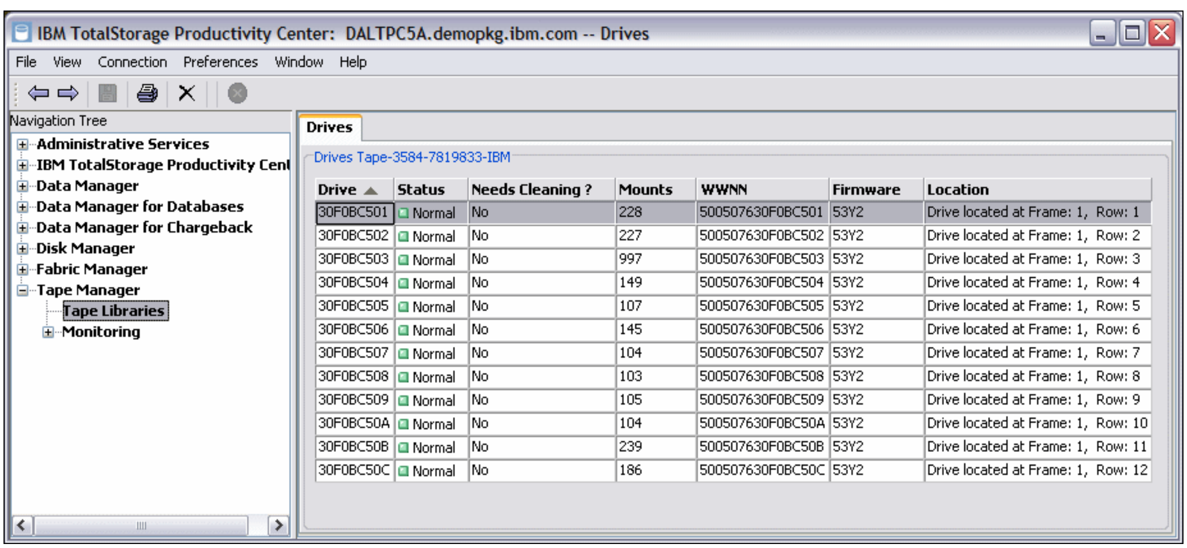


Figure 10-5 TPC window shown when selecting drives

Selecting media changers

Figure 10-6 on page 292 lists all the media changers available for a library. Each of these provide an independent path that you can use to control the library. Define redundant paths, per logical library, in order to allow control of the library in the event of a path failure.

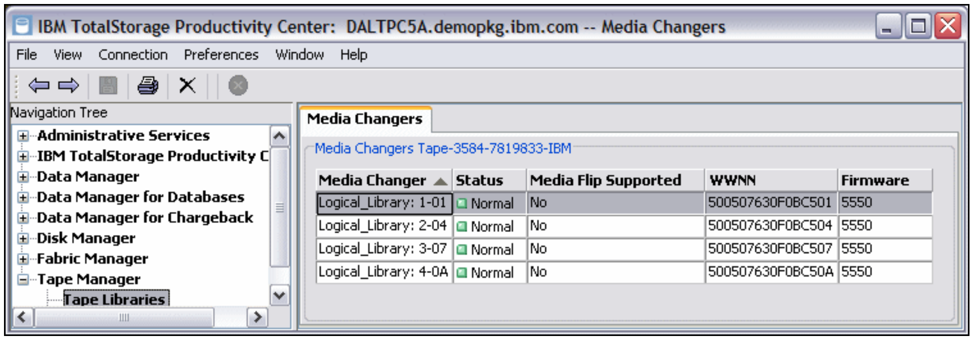


Figure 10-6   TPC window shown when selecting Media Changers

Selecting I/O ports

Figure 10-7 shows each I/O port in the library and its location.

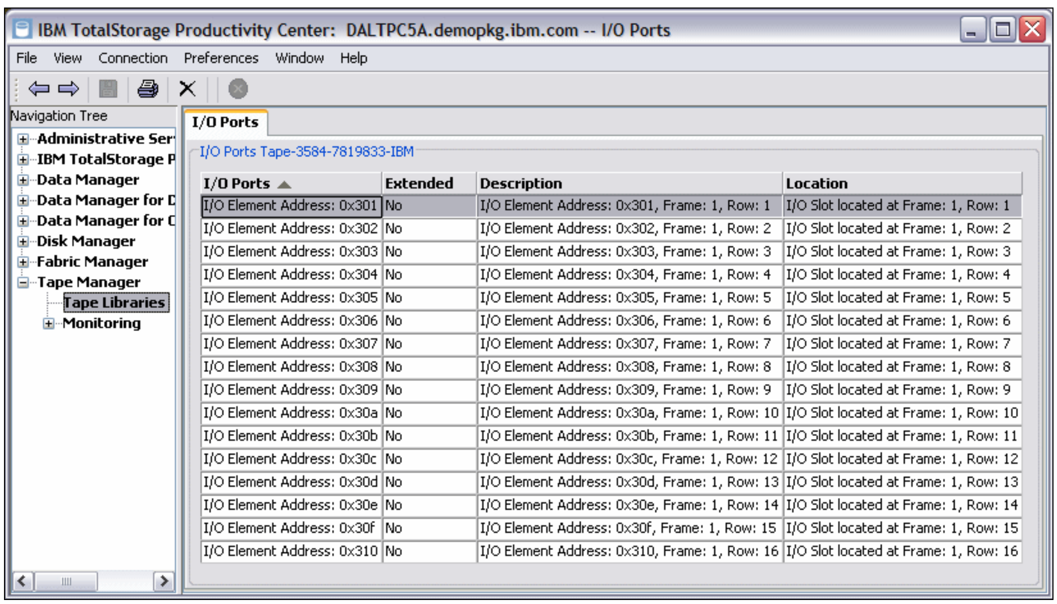


Figure 10-7   TPC window shown when selecting I/O ports

Selecting cartridges

To conclude this demonstration, we can see the inventory of the library and the location of each cartridge in that inventory in Figure 10-8 on page 293.

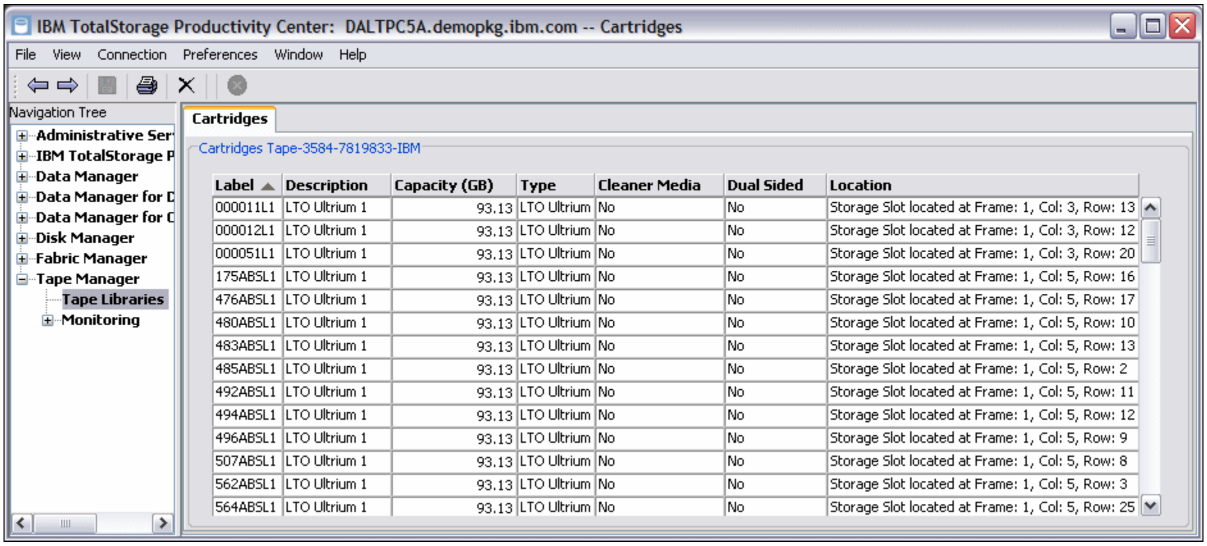


Figure 10-8 TPC Windows shown when selecting Cartridges

Table 10-5 is a summary of the management capabilities.

Table 10-5 Summary of management capabilities available using SMI-S and TPC

Set configuration	Display configuration	View errors	Send error alerts	Update firmware
No	Yes	Yes, we can view SNMP traps issued by the library, but not read the detailed drive and library logs on the library itself, although you can access these via the Web UI which you can start from within TPC.	Yes, that is, we can view SNMP traps sent to TPC.	No

10.2.6 IBM TotalStorage Tape Diagnostic Tool (ITDT)

A newly designed command line tool, ITDT, provides a quick and simple means to:

- Update drive and library firmware
- Run diagnostic tests on tape drives
- Create tape drive dumps
- Perform a full write test

Using ITDT on the server connected to your tape library is the recommended way to upgrade drive firmware on all IBM LTO tape libraries due to its speed and ease of use. The tool does not require any special device drivers and is supported on Windows, AIX, Linux, and Solaris platforms.

ITDT supports the IBM Ultrium Tape Drive and the 3592 models J1A and E05.

Using ITDT

After you enter **itdt** at the command line, the information shown in Figure 10-9 displays.

```
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
    IBM TotalStorage Tape Diagnostic Tool V1.0

     Entry Menu

     [S] Scan for tape drives

     [H] Help
     [Q] Quit program



     Notes:
     - During a test, user data on the cartridge will be erased!
     - Make sure no other program is accessing the devices used by ITDT!
     - A device scan may take several minutes in some cases!

     - Q + Enter will always close this program.
     - H + Enter will display a Help page.




 <[H] Help | [Q] Quit | Command > s
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
```

Figure 10-9 Initial window displayed after starting ITDT

When you enter S, a scan starts that finds and displays for selection all IBM LTO devices. Non-IBM devices are not displayed. After the scan is complete, a window similar to the one shown in Figure 10-10 displays.

```
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

     IBM TotalStorage Tape Diagnostic Tool   -   Device List

       Host Bus  ID   LUN  Model          Serial       Ucode  Changer     [#]
 +----+----+----+----+----+--------------+------------+------+------------+-+
 | 0  | 1  | 0  | 4  | 0  | ULT3580-TD1  | 6811003728 | 36UG | IBM7801127 | |
 | 1  | 1  | 0  | 5  | 0  | ULT3580-TD1  | 6811003629 | 36UG | IBM7801127 | |
 | 2  | 1  | 0  | 6  | 0  | ULT3583-TL   | IBM7801127 | 2.86 |            | |
 | 3  |    |    |    |    |              |            |      |            | |
 | 4  |    |    |    |    |              |            |      |            | |
 | 5  |    |    |    |    |              |            |      |            | |
 | 6  |    |    |    |    |              |            |      |            | |
 | 7  |    |    |    |    |              |            |      |            | |
 | 8  |    |    |    |    |              |            |      |            | |
 | 9  |    |    |    |    |              |            |      |            | |
 | 10 |    |    |    |    |              |            |      |            | |
 | 11 |    |    |    |    |              |            |      |            | |
 +----+----+----+----+----+--------------+------------+------+------------+-+


 [S] Scan            [T] Test Device
 [D] Firmware Dump   [M] Microcode DL    [I] Manual Inspect

 <[H] Help | [Q] Quit | Line # | Command >

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
```

Figure 10-10 ITDT window listing devices discovered during the scan

As you can see, you can select five possible actions:

[S] Scan This initiates another SCSI bus scan to seek further devices.

[D] Firmware Dump This dumps the memory into two files. The dumps require special tools for analysis so this option is only of value if an IBM Support Service Representative (SSR) asks you to provide dumps.

[T] Test Device This exercises and tests a tape drive.

[**M] Microcode DL** This option performs a firmware upgrade.

[I] Manual Inspect Use this if directed by an SSR. It provides a general interface for reporting problems for devices not automatically detected.

Downloading ITDT

To download ITDT and instructions for using the tool, visit the following Web site and search for `ITDT`:

`http://www-03.ibm.com/servers/storage/support/`

Table 10-6 shows a summary of ITDT capabilities.

Table 10-6 Summary of management capabilities available using ITDT

Set configuration	Display configuration	View errors	Send error alerts	Update firmware
No	No	No, but you can test tape drives.	No	Yes

As you can see, ITDT is principally valuable as a tool for updating tape drive firmware. Indeed, IBM recommends this tool for drive firmware updates because of its speed and ease of use.

10.2.7 IBM Ultrium Device Driver

The IBM Ultrium tape and medium changer device drivers are designed specifically to take advantage of the features provided by the IBM Ultrium tape drives and medium changer devices. The goal is to give applications access to the functions required for basic tape functions, such as backup and restore, and medium changer operations, such as cartridge mount and demount, as well as to the advanced functions needed by full tape management systems, such as Tivoli Storage Manager. Whenever possible, the driver is designed to take advantage of the device features transparent to the application.

In addition to the functionality outlined above, the IBM Ultrium Device Driver provides the following capabilities that are relevant to tape library management:

- Control path and data path failover configuration
- Tape utility program:
  - Tape drive service aids:
    - Tape dump
    - Firmware load
- Error logging and the automatic dump facility

You can find a full description of all IBM Ultrium Device Driver functionality for AIX, Linux, HP-UX, Solaris, and Windows platforms in the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430.

Control path and data path failover configuration

Prior to enabling alternate pathing support with the device driver, the appropriate path failover feature code must be installed in the tape library.

Systems with multiple paths to a tape or changer device are labelled as primary or alternate. In the case of AIX, you can define up to 16 paths and enable them for path failover. The steps required to enable path failover depend upon the platform. Refer to the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430, for specific instructions.

The IBM tape utility program

Installed with the device driver is a tape utility program, which is called tapeutil in AIX and Solaris, IBMtapeutil in Linux, and ntutil in Windows, that exercises or tests the functions of the tape device and the device driver. It also performs basic tape and medium changer operations. The tape utility program provides two versions: the interactive interface and the command-line interface.

You can use the tape utility program to access tape drive service aids from within the interactive interface. Among other things, this provides facilities to:

- Force a microcode dump
- Load firmware
- Perform error log analysis

Prior to the availability of ITDT, using tapeutil often provided the simplest means of performing these tasks. However, these tasks are performed more elegantly now with ITDT.

> **Note:** Use of tapeutil does *not* require root access, unlike ITDT.

Error logging and the automatic dump facility

The device driver provides error logging on most platforms to the system log. On AIX, each error is logged with an associated error label and error ID, which identify the type of error:

TAPE_ERR1	Tape media error.
TAPE_ERR2	Tape hardware error.
TAPE_ERR4	SCSI adapter detected error.
TAPE_ERR5	Unknown error.
RECOVERED_ERROR	Temporary tape hardware or media error.
TAPE_DRIVE_CLEANING	Tape drive needs cleaning.
DEV_DUMP_RETRIEVED	Device dump retrieved.

The error is then further described with the Detail Data option. An explanation of the numerous fields is in the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430; however, such logs are generally analyzed by technical support staff.

The AIX device driver provides an automatic dump facility for IBM Ultrium tape drives. Whenever a check condition occurs and the sense data indicates a dump is available, the device driver reads the dump from the device and stores it in the /var/adm/ras directory. A maximum of three dumps for each device is stored in this directory as:

Atape.rmt*x*.dump1
Atape.rmt*x*.dump2
Atape.rmt*x*.dump3

In this dump name, *x* is the device number, for example, `rmt0`. When the device is first configured, the dump name is set to dump1. If more than three dumps occur, the driver starts over at dump1; therefore, it always keeps the last three dumps. The device driver also creates an entry in the AIX error log labeled “`DEV_DUMP_RETRIEVED`” when an automatic dump was either attempted and failed or was successful. Technical Support might ask for these dumps.

Trace facility

Technical Support might ask you to use this tool also. You can manually start and stop traces via the command line. The command to use is operating system-dependent and is documented with the **`trace`** and **`trcstop`** commands.

Table 10-7 summarizes the management capabilities available with the IBM Ultrium Device Driver.

Table 10-7 Management capabilities available using the IBM Ultrium Device Driver

Set configuration	Display configuration	View errors	Send error alerts	Update firmware
No	No	Yes, you can view tape errors by Error log analysis.	Yes, tape drive errors are sent to the System error log.	Yes

ITDT has largely superseded tapeutil in terms of tape drive management. However, the logging of errors to the System log and the creation of automatic dumps are useful facilities to aid in the detection and resolution of tape drive errors.

10.2.8 Summary of management capabilities

Table 10-8 summarizes the management capabilities available with each tool or technology.

Table 10-8 Management capabilities available with each tool or technology

Tool or technology	Set configuration	Display configuration	View errors	Send error alerts	Update firmware
Operator Panel	Yes	Yes	Yes	No	No
Web UI	Yes	Yes	Yes	No	Yes
TapeAlert	No	No	No	Yes	No
SNMP	No	Yes	No	Yes	No
SMI-S	No	Yes	Yes	Yes	No
IBM Ultrium Device Driver	No	No	Yes	Yes	Yes
ITDT	No	No	No	No	Yes

10.3 Library specific management capabilities

Management of IBM Ultrium Tape Libraries is similar between models; however, certain models have additional features. This section discusses certain differences among the models.

10.3.1 TS3100

Characteristics of the TS3100:

- Error messages can be e-mailed.
- Library firmware can be updated via Web or tapeutil.
- SNMP is supported.

10.3.2 TS3200

Characteristics of the TS3200:

- Error messages can be e-mailed.
- Library firmware can be updated via the Web or tapeutil.
- SNMP is supported.

10.3.3 TS3310

Characteristics of the TS3310:

- Error messages can be e-mailed.
- Library firmware can be updated via the Web or tapeutil.
  This is the only library whose firmware cannot be updated by ITDT.
- SNMP is supported.
- Native SMI-S support is provided.
- It has a color touch-sensitive Operator Panel.
- Errors are grouped as Operator Intervention Messages in the Control Panel and Web UI.

10.3.4 TS3400

Characteristics of the TS3400:

- Error messages can be e-mailed.
- Library firmware can be updated via the Web User Interface.
- It has an LCD Operator Panel controlled by buttons on the right side of the Operator Panel.

10.3.5 TS3500

Characteristics of the TS3500:

- Error messages cannot be e-mailed.
- Library firmware can be updated via ITDT, tapeutil, or Web UI.
- SNMP is supported.
- SMI-S 1.1 conformance with “SMI-S Agent for Tape” is provided.
- Non-disruptive library firmware update is provided, which means that there is no need to bring the library down during the firmware update. This function is available with firmware level 6*xxx*.
- Non-disruptive drive firmware update is available with firmware level 5500, but it is significantly slower than via ITDT.
- Advanced Library Management System can only be configured through the Web UI.

Call Home

The TS3500 Tape Library can call an IBM Support Center when an error occurs. The library reports codes indicating the replacement parts that might be required and the urgency of the problem. The library can also periodically send support information, such as configuration, library and drive code versions, and error logs, to IBM.

The IBM 3584 Call Home feature has two different, but related, capabilities:

- Problem Call Home

  The IBM 3584 or one of its drives detects a problem and the library performs a Call Home operation to create a RETAIN Problem Management Record (PMR). This is a single page of text data that enables the Support Center or the SSR to access an action plan and a list of parts called *field replaceable units* (FRUs).

- Heartbeat Call Home

  On a scheduled basis (once a week or one hour after a code update has been completed or a power cycle), the IBM 3584 sends home (to IBM) the following files: a Machine Reported Product Data (MRPD) file, a library error log file, and a drive error log file. The MRPD file contains information about the machine (library), including the number of frames and drives, the model and serial number of each frame, the type and serial number of each drive, the code version of the library and each drive, and any machine-detectable features, such as additional I/O stations, capacity expansion, and so forth.

A test call home can also be initiated from the Operator Panel.

When a Problem Call Home or a Heartbeat Call Home is initiated, the IBM 3584 also sends data files that might be helpful to Support Center personnel. In the case of a Heartbeat Call Home, the library also sends the library error log and drive error log. In the case of a Problem Call Home, the library sends any trace files that might be related to the problem.

Call home is provided by a no-charge FC2710 (Remote Support Facility), which provides a modem and cable (15.2 m or 50 feet). The client must provide an analog phone line to use the Call Home feature. This phone line needs to be close to the library (within 15.2 m or 50 feet). See 9.2.12, “Remote support” on page 253 for further details regarding Call Home.

Enhanced Data Gathering and Reporting

There are four files that you can download from the TS3500, which provide detailed information regarding activity during the last 24 hours:

Library Statistics.csv Contains information about the maximum cartridge residency, mount and eject times, average cartridge residency, mount and eject times, and total cartridge inserts, mounts, and ejects. The information is provided for each hour of a 24-hour period and for each logical library.
Download via Web UI: **Manage Library** → **By Logical Library** and then select the download link.
or
Directly from the library:
http://*LibraryName*/FS/LIBLG_01_LP.csv
Note that the library statistics are only available with L*x*3 models.

Drive Statistics.csv Contains information about each drive’s last mount; only installed drives are shown in the drive statistics log.
Download via Web UI: **Manage Drives** → **Drive Summary** and then select the download link.
or
Directly from the library:
http://*LibraryName*/FS/LIBLG_01_DS.csv

Port Statistics.csv Contains Fibre Channel port information about the last mount; only installed drives with Fibre Channel ports are shown in the port statistics log.
Download via Web UI: **Manage Ports** → **Fibre Channel Summary** and then select the download link.
or
Directly from the library:
http://*LibraryName*/FS/LIBLG_01_PS.csv

Mount history.csv Includes statistics about the last 100 cartridges that were demounted in the library and information about the TS1120 Tape Drives (at firmware level 16E4 or later) that is derived from the customer-centric Statistical Analysis and Reporting System (ccSARS).
Download via Web UI: **Manage Cartridges** → **Data Cartridges** and then select the download link.
or
Directly from the library:
http://*LibraryName*/FS/LIBLG_01_CS.csv

The Web User Interface provides a detailed help function that explains the details of each file. You can also find a detailed description of each of the files in a white paper accessible from the Tape Systems Resource Library at the following Web site:

`http://www-03.ibm.com/servers/storage/tape/resource-library.html`

10.4 Best practices

This is a list of library management recommendations:

- Connect every library to your network to take advantage of the Remote Management capability and use the Web UI. This is the only way to access certain functionality on each library, and it provides an extremely effective means of monitoring and managing the library.
- Keep the library and drive firmware up to date. Not only do firmware updates correct errors, but they add functionality to both the Operator Panel menus and the Web UI. If you encounter a library or drive error and need to place a call with IBM Support, it is likely they will ask you to upgrade to the last firmware if you have not already done so. Achieving resolution is assisted by already being up-to-date with firmware levels.
- Securing Web access to the TS3500 Web UI must be enabled. It is already enabled on the other library models, which means that you need a login and password to access the Web UI.
- If your library is located in an insecure area, you must secure access to the Operator Panel by requiring that users log in.
- Install ITDT on your server and use this to upgrade the drive firmware. This is the fastest way to update drive firmware on all tape libraries.
- Use the non-disruptive library firmware update available via the Web UI on the TS3500 rather than using ITDT (which requires bringing the library offline).
- Use Call Home if you have an IBM TS3500 Tape Library. The service is free (you only need to provide an analog line) and provides an extremely effective means of monitoring the library.
- Take advantage of data and control path failover and load balancing with the optional features that provide path failover for all operating systems that use the IBM Tape Device Driver.

- Ensure that the operating environment meets the specifications documented in the Setup and Operator Guide. In addition to temperature and humidity tolerances, ensure that the library is located in an area free of airborne particulate matter.

And while we have your attention:

- Only use supported media. IBM Ultrium Tape Drives are very reliable, but the use of uncertified media can damage drives. We, the authors of this book, have first-hand experience of tape drives needing replacement after they were used with unsupported media. Indeed, the use of unsupported media can invalidate your maintenance contract. For a list of certified media, refer to:

  http://www-1.ibm.com/support/docview.wss?uid=psg1MIGR-39931

- Pack cartridges with care prior to transport. Handle cartridges just as you handle hard disk drives. It is important that they are protected from contaminants (any particulate matter whatsoever) and are packed to avoid shaking. The edges of tapes get damaged if the cartridges are dropped or allowed to move in the packing cases during transport. The IBM Ultrium technology implementation is designed to tolerate minor edge damage, but inadequate packing will result in irrecoverable damage. For more information, refer to:

  ftp://ftp.software.ibm.com/common/ssi/rep_sp/n/TSB00180USEN/TSB00180USEN.PDF

Part 3

Previous IBM Tape Libraries

In this part, we describe previous versions of IBM tape libraries and autoloaders for installation of LTO tape drives.

11

IBM TotalStorage 3580 Tape Drive

The IBM TotalStorage 3580 Tape Drive is the smallest in the family of IBM Ultrium tape solutions. It is an external, standalone, SCSI-attached tape drive that attaches to iSeries, pSeries, xSeries, RS/6000 SP, and other UNIX and PC servers supporting OS/400, IBM AIX, Sun Solaris, HP-UX, Microsoft Windows NT®, Microsoft Windows 2000, Microsoft Windows 2003, and Red Hat and SUSE LINUX using a supported SCSI adapter.

The IBM TotalStorage 3580 Tape Drive is a cost-effective solution for save-and-restore and archiving functions, and it provides an excellent migration path from SDLT, 1/4-inch, 4 mm, or 8 mm tape drives.

11.1 Model description

The IBM 3580 (Figure 11-1 and Figure 11-2) is a large-capacity, high-performance Ultrium tape drive available in four model types, depending on the capacity and SCSI[1] interface required.

Figure 11-1 IBM 3580 model L23/H23 tape drive

Figure 11-2 IBM 3580 model L33/L3H

The available IBM 3580 models are:

- IBM 3580-L23 - Ultrium 2 drive with Low-Voltage Differential (LVD) Ultra2 SCSI attachment that connects to LVD fast/wide adapters.
- IBM 3580-H23 - Ultrium 2 drive with High-Voltage Differential (HVD) Ultra SCSI attachment that connects to HVD fast/wide adapters.
- IBM 3580-L33 and IBM 3580-L3H - Ultrium 3 drive with Low-Voltage Differential (LVD) Ultra SCSI attachment that connects to LVD fast/wide adapters.

The IBM 3580-L33 and IBM 3580-L3H are functionally identical; the only difference is the IBM 3580-L3H is an Express Model, which is part of the Express Portfolio™.

[1] Refer to “Interfaces” on page 51 for an explanation of HVD and LVD.

Note: The IBM Express Portfolio is a set of IBM offerings for Business Partners in Small and Medium Business. For details, see the Web site:

http://www.ibm.com/partnerworld/pwhome.nsf/weblook/pub_strategies_smb_express.html

The IBM 3580-L23 and H23 use the Ultrium 2 LTO cartridge, which has a capacity of 200 GB (400 GB with 2:1 compression), and are capable of sustaining a data rate of up to 35 MB/s (uncompressed).

The IBM 3580-L33 and L3H use the Ultrium 3 LTO cartridge, which has a capacity of 400 GB (800 GB with 2:1 compression), and are capable of sustaining a data rate of up to 80 MB/s (uncompressed).

Note: Although the IBM 3580 provides the capability for high tape performance, other components of the system may limit the actual performance achieved. Also, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

11.2 Feature codes

The IBM 3580 can be ordered with the following feature codes (Table 11-1). We have not included the various cabling options; refer to the product publications for detailed information about configuring and ordering cables.

Table 11-1 IBM 3580 feature codes

Feature code	Description	Comments
7003	19-inch Rack Mount Kit	
8001	One 100 GB data cartridge	Plant only; see 11.9, “Media” on page 311 for details.
8101	One 200 GB data cartridge	Plant only; see 11.9, “Media” on page 311 for details.
8301	One 400 GB data cartridge	Plant only; see 11.9, “Media” on page 311 for details.
8002	One cleaning cartridge	Plant only; see 11.9, “Media” on page 311 for details.
8723	Rack mount kit	

11.3 SCSI attachment

The Ultrium 3 IBM 3580-L33/L3H is an LVD drive.

For Ultrium 2, the SCSI interface (HVD or LVD) on each IBM 3580 is chosen by selecting the appropriate model number.

The IBM 3580 can be attached to pSeries, IBM RS/6000, xSeries, iSeries, AS/400, other Intel, HP-UX, and Sun systems that support Ultra/Wide SCSI HVD and Ultra2/Wide SCSI LVD interface specifications. The interface you choose will depend on the available adapter in the host, which must be of the same type as the drive interface.

The IBM 3580 also may be compatible with other servers, operating systems, and SCSI adapters. Contact your local IBM representative for a current list of supported open system configuration and software vendors, or go to:

http://www.ibm.com/servers/storage/tape/3580/interop.html

11.4 SCSI cabling

A SCSI cable is required for each IBM 3580 connection to a SCSI bus. For Ultrium 2 IBM 3580 drives, a single 2.5 m SCSI cable is available as a no-charge feature; if an alternate length is required, it must be included in the initial order. A SCSI terminator is included with each drive.

An *interposer* (a connector that matches the pin pattern of the host adapter to the pin pattern of the cable) also may be required for attachment to particular server adapters.

11.4.1 Cables (Ultrium 1 and Ultrium 2)

A single SCSI cable is available as a no-charge feature (either FC9702 or FC9703) specified only with the initial IBM 3580 order. It is not orderable as a miscellaneous equipment specification (MES) for installation later. Feature FC9702 supplies a 2.5 m universal SCSI cable with HD68 connectors at each end; feature FC9703 supplies a VHDCI connector at one end and HD68 at the other.

Additional SCSI cables are available as optional features on the IBM 3580 for LVD and HVD attachment to host adapters.

The following cables have an HD68 connector at each end:

- Feature FC5301: 0.4 m (1.3 feet) SCSI cable
- Feature FC5302: 2.5 m (8.2 feet) SCSI cable
- Feature FC5305: 5 m (16.4 feet) SCSI cable
- Feature FC5310: 10 m (32.8 feet) SCSI cable
- Feature FC5318: 18 m (59.1 feet) SCSI cable
- Feature FC5325: 25 m (82.0 feet) SCSI cable

These cables have a VHDCI connector at one end and an HD68 connector at the other end:

- Feature FC5602: 2.5 m (8.2 feet) SCSI cable
- Feature FC5604: 4.5 m (14.8 feet) SCSI cable
- Feature FC5610: 10 m (32.8 feet) SCSI cable
- Feature FC5620: 20 m (65.6 feet) SCSI cable
- Feature FC5625: 25 m (82.0 feet) SCSI cable

11.4.2 Cables (Ultrium 3)

The following Ultra2 SCSI cables are available as optional features for attaching the IBM 3580 to servers and other adapters. A SCSI differential terminator is included with each tape drive.

These cables are available with a VHDCI connector on one end and an HD68 connector on the other end:

- Feature FC5602: 2.5 m (8.2 feet) VHDCI/HD68 SCSI Cable
- Feature FC5604: 4.5 m (14.8 feet) VHDCI/HD68 SCSI Cable
- Feature FC5610: 10 m (32.8 feet) VHDCI/HD68 SCSI Cable

11.4.3 Interposers (Ultrium 1 and Ultrium 2 only)

An interposer might be required to connect host adapters that do not have HD68 connectors to the SCSI cables. The following chargeable interposers are available:

- Ultrium 1 only, FC2895 interposer to connect System i adapter FC6501.
- Ultrium 1 and Ultrium 2, FC5099 interposer to connect a mini-68-pin VHDCI connector to the 68-pin HD68 connector on the SCSI cable. The interposer (a 0.3 m cable) has a male mini-68-pin VHDCI connector on one end and a female 68-pin HD68 connector on the other.
- Ultrium 1 and Ultrium 2, FC5098, Inline HVD SCSI Terminator, is required when attaching to Hewlett-Packard V-Class systems with adapter A4800A.

11.4.4 SCSI length limitations

The overall LVD SCSI cable length is limited to 25 m (82 feet) using point-to-point interconnection. If using multi-drop interconnection, then the overall LVD SCSI cable length is limited to 12 m (39.4 feet). The stub length at each device must not exceed 0.1 m (0.33 feet).

The overall HVD SCSI cable lengths are limited to 25 m (82 feet) using point-to-point or multi-drop interconnection. The stub length at each device must not exceed 0.2 m (0.66 feet).

11.5 Environmental specifications

The IBM 3580 is designed to be placed on or beside the attached host server or installed in a standard 19-inch rack.

11.5.1 Physical dimensions

The IBM 3580 is a relatively small single tape drive enclosure:

- Width: 17.1 cm (6.73 in.)
- Depth: 33.3 cm (13.1 in.)
- Height: 14.6 cm (5.75 in.)
- Maximum weight: 6.6 kg (14.6 lbs.)

11.5.2 Operating environment

The IBM 3580 can be installed in a normal office environment and does not need to be in a specialized machine room. Refer to the product publications for specific information.

11.6 Host platforms and device drivers

The following no-charge specify feature codes indicate the server platform to which the IBM 3580 is attached:

- FC9210: attached to HP-UX
- FC9211: attached to Sun system
- FC9212: attached to Windows NT or Windows 200x system
- FC9213: attached to other non-IBM system
- FC9215: attached to Linux system
- FC9400: attached to AS/400 system
- FC9600: attached to RS/6000

A device driver is additional code on the host server platform that enables it to recognize and talk to a peripheral device (in this case, the IBM 3580). Sometimes the driver code is supplied as part of the operating system code (for example, in OS/400), sometimes a software patch is required, and sometimes the driver is installed separately from a CD or diskette (either an operating system CD or provided with a vendor application).

The IBM 3580 is shipped with device drivers to support Ultrium 1, Ultrium 2, and Ultrium 3 drives in the following operating environments at the minimal levels shown:

- AIX 5L Versions 5.1, 5.2, 5.3, and higher
- Sun Solaris 7, 8, and 9
- Windows NT 4.0 with Service Pack 6 or later
- Windows 2000 build 2195 or later
- Windows Server 2003 build 3790 or later
- HP-UX 11.0, 11.i, or 11.i v2
- OS/400 V5R1, V5R2, or V5R3
- Red Hat Advanced Server 3, SUSE LINUX Enterprise Server 8 or 9

For the current list of supported operating systems and host adapters, refer to:

http://www.ibm.com/servers/storage/tape/3580/interop.html

> **Tip:** The device driver CD or diskette that is shipped with the IBM 3580 might not contain the device drivers with the most recent level or the device drivers for all supported systems. Always check the following FTP site for the latest device drivers:
>
> ftp://ftp.software.ibm.com/storage/devdrvr/

11.6.1 Device driver installation

Install the IBM device drivers for the IBM 3580 as follows:

- If you intend to use the IBM 3580 with a commercial software application (such as IBM Tivoli Storage Manager, VERITAS Backup Exec, or EMC Legato NetWorker), refer to that application's installation instructions to install the device driver and configure the IBM 3580.
- If you do not intend to use the IBM 3580 with a commercial software application, install the tape and medium device driver from the CD that is shipped with the drive. Refer to the installation instructions in the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430, which is supplied on the CD with the driver code.

> **Note:** If you use the IBM 3580 with a commercial software application, IBM recommends that you install any IBM-supplied device driver only if instructed to do so in the installation instructions from the application's vendor. Otherwise, if the application supplies its own driver code, conflicts could occur over which driver controls the drive. Redbooks *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502, give examples of using the Ultrium drives.

11.7 Storage applications

The software to manage the IBM 3580 is not provided with the libraries. Additional software support is available through library management software products that must be obtained separately from IBM, Business Partners, or independent software providers. A list of compatible software is available at the Web site:

http://www.ibm.com/servers/storage/tape/lto/lto_isv.html

You will find details for each application, including Ultrium support and specific Ultrium models and attachment methods. You should also contact your storage application vendor for more detailed information about supported versions and platforms.

11.8 Performance considerations

For best performance, IBM recommends that you attach only one tape drive per SCSI bus. This may not be a realistic objective, but minimizing the number of devices per bus will improve performance. Attaching other SCSI devices on the same SCSI bus as the IBM 3580 may affect performance of those devices.

iSeries configurators allow only one drive per input/output port for maximum performance. Installing more than one Ultrium tape drive on an I/O port may affect system performance.

Although the compression technology can increase the amount of data stored on the media, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

11.9 Media

One Ultrium cleaning cartridge and one Ultrium data cartridge are included with each IBM 3580 drive order[2]. With the initial order, you may order additional data and cleaning cartridges as chargeable features for the IBM 3580:

- FC8101 provides a single 200 MB Ultrium 2 Data Cartridge.
  It is a chargeable feature, and you can order a maximum of five.
- Feature FC8301 provides a single 400 MB Ultrium 3 Data Cartridge.
  It is a chargeable feature, and you can order a maximum of five.
- Feature FC8002 provides a single Ultrium Cleaning Cartridge.
  It is a chargeable feature, and you can order a maximum of five.
- Feature FC8001 provides a single 100 MB Ultrium 1 Data Cartridge.
  It is a chargeable feature, and you can order a maximum of five.
  Note: This feature has been withdrawn from marketing.

Subsequent to the initial order, you can order additional supplies from the IBM media business or a third-party media vendor. Refer to Appendix A, “IBM LTO Ultrium and 3592 media” on page 393 for details about ordering supplies and cartridges, with or without labels.

11.10 IBM 3580 Ultrium Tape Drive initial setup

This section covers some of the major items required to implement, manage, and operate the IBM 3580 Tape Drives. It does not cover all of the tasks, nor do we intend to cover all of the specific commands. For more details, refer to *IBM 3580 Ultrium Tape Drive Setup, Operator and Service Guide*, GA32-0415; *IBM TotalStorage Ultrium Tape Drive 3580 Models L23 and H23 Setup and Operator Guide*, GA32-0460; *IBM TotalStorage 3580 Tape Drive Setup,*

[2] All media and cleaning cartridges are warranted separately from the IBM 3580.

Operator, and Service Guide, GC26-7708; and the Redbooks *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

11.10.1 SCSI ID

If you attach multiple IBM 3580 SCSI devices in the same chain, they should each use different SCSI IDs starting with the lowest number on the first device as depicted in Figure 11-3. The last device of that SCSI chain must have a valid terminator. The SCSI ID setup button is located at the rear of the IBM 3580.

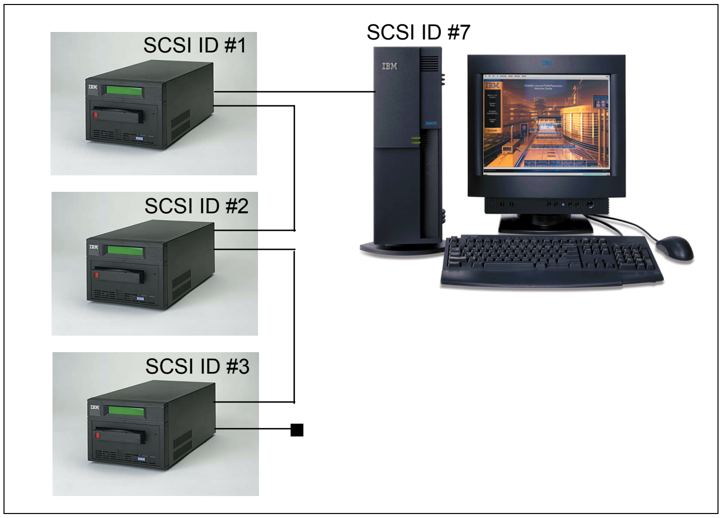


Figure 11-3 SCSI ID setup example

11.11 Operator displays and buttons

The IBM 3580-L23 and IBM 3580-H23 have a simple operating interface consisting of:

- A status light
- A message display
- A single character display
- An unload push button

The IBM 3580-L33 and IBM 3580-L3H have a simple operating interface consisting of:

- A status light
- A single character display
- An unload push button
- A power on/off push button

11.11.1 Status light

The status light (labeled 2 in Figure 11-4 on page 314 and Figure 11-5 on page 314) provides information about the state of the IBM 3580. The light can be either green or amber (yellow), and, when lit, either solid or flashing. These are the possible conditions of the status light and an explanation of what each condition means:

- Off: The IBM 3580 Tape Drive has no power or is powered off.
- Green/solid: The IBM 3580 Tape Drive is idle, or if C displays simultaneously in the single-character display (see label 3 in Figure 11-4 on page 314 or Figure 11-5 on page 314), it needs cleaning.
- Green/flashing: The IBM 3580 is reading or writing data, rewinding the tape, locating data on the tape, or unloading the tape.
- Amber (Yellow)/solid: The IBM 3580 is in maintenance mode or is running power-on self-test diagnostic routines.
- Amber/flashing: The IBM 3580 requires service or is updating firmware. Note the code on the single-character display. Refer to the Setup and Operator Guides (GA32-0415 for Ultrium1, GA32-0460 for Ultrium 2, or GC26-7708 for Ultrium 3).

11.11.2 Message display (Ultrium 1 and Ultrium 2 only)

The message display (labeled 4 in Figure 11-4 on page 314 and Figure 11-5 on page 314) is a liquid crystal display (LCD) that provides information about the status of the tape drive and error conditions.

The message display consists of two rows, with 20 characters available in each row. During operation, the IBM 3580 tape drive continuously queries the drive and updates the display with status messages. When in an idle (non-operating) state, the tape drive displays the following messages:

```
Ultrium Tape Drive
Drive Empty
```

11.11.3 The single-character display

The IBM 3580 features a light-emitting diode (LED) display (labeled 3 in Figure 11-4 on page 314 and Figure 11-5 on page 314). The LED presents a single-character code for:

- Error conditions and informational messages
- Diagnostic or maintenance functions (while in maintenance mode only)

For the list of messages, refer to the Setup and Operator Guides (GA32-0415 for Ultrium 1, GA32-0460 for Ultrium 2, or GC26-7708 for Ultrium 3).

If multiple errors occur, the code with the highest priority (represented by the lowest number) displays first. When the error is corrected, the code with the next highest priority displays, and so on, until no errors remain.

The single-character display is blank during normal operation of the IBM 3580 tape drive.

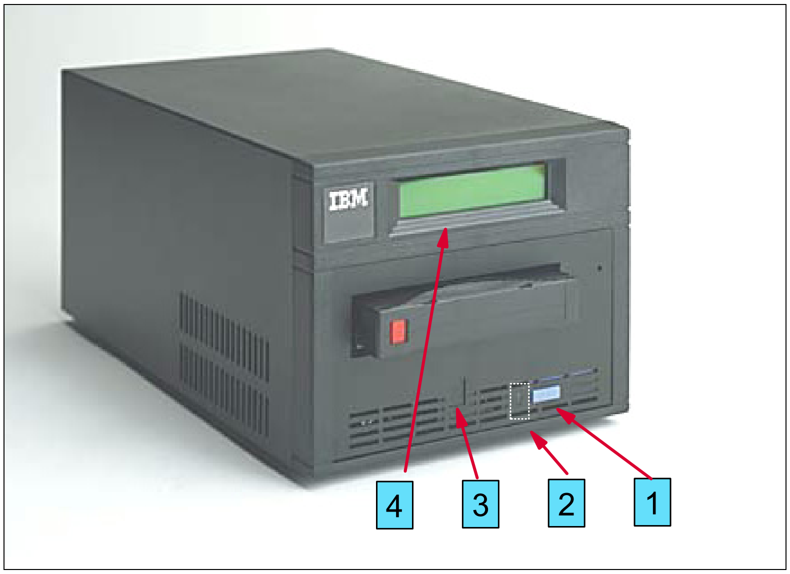


Figure 11-4 Front view of the IBM 3580 model L11/L13/L23 or H11/H13/H23 Tape Drive

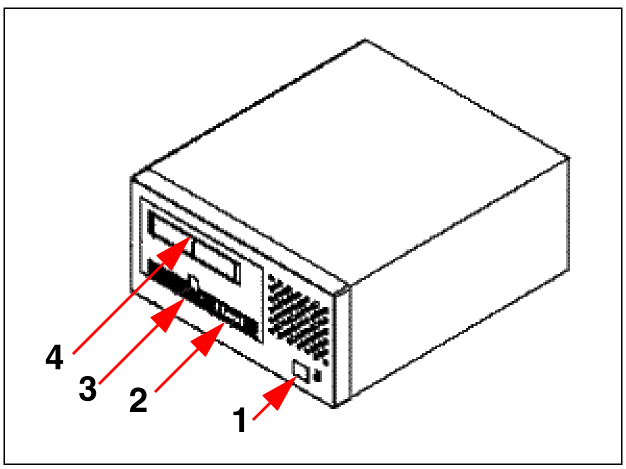


Figure 11-5 Front view of the IBM 3580-L33/L3H Tape Drive

11.11.4 Unload push button

The unload push button enables you to perform several functions. You can:

- Rewind the tape in the cartridge and eject the cartridge from the tape drive.
- Enter or exit maintenance mode or perform diagnostic or maintenance functions.
- Scroll through the maintenance menus.
- Execute a panic reset.

Important: If you press the Unload button during operation, the IBM 3580 ends the current job, and the IBM 3580 unloads and ejects the tape cartridge.

11.11.5 Power push button (Ultrium 3)

The Power push button (labeled 1 in Figure 11-5) turns the tape drive on or off. The button is located on the front panel. When the Power Button is in the off position, the primary electrical power within the enclosure is still active. To remove all electrical power to the enclosure, unplug the power cord at the rear of the drive from the receptacle.

11.12 Drive cleaning

All IBM Ultrium tape drives have an integrated cleaning mechanism that brushes the head at cartridge load time and again when unloading a cartridge. Along with this, the drives have a cleaning procedure that uses a special cleaning cartridge.

> **Important:** When cleaning the drive head, use only the IBM LTO Ultrium Cleaning Cartridge or an IBM-approved cleaning cartridge.

Clean the drive head in the IBM 3580 whenever `C` displays on the single-character display and the status light is solid green. IBM does not recommend that you clean the drive head on a periodic basis; only when `C` displays.

To clean the head, insert the cleaning cartridge into the tape load compartment. The tape drive performs the cleaning automatically. The cleaning cycle takes less than two minutes. When the cleaning is finished, the drive ejects the cartridge.

> **Important:** If you insert a cleaning cartridge when the drive does not need cleaning or if you insert a cleaning cartridge that has expired, the drive automatically ejects the cartridge.

11.13 Firmware upgrade

Drive firmware is best updated using the driver's application interface, SCSI or Fibre Channel.

There are tools readily available to facilitate this process. The recommended tool, the IBM Totalstorage Tape Diagnostic Tool (ITDT), is available on the IBM Web site and requires no special device drivers. To download ITDT and instructions for using the tool, visit:

http://www-03.ibm.com/servers/storage/support/

ITDT is available for multiple platforms. You can use other tools, such as ntutil and TapeUTIL, for drive firmware updates. The library also supports drive firmware update by creating and using an Field Microcode Replacement (FMR) cartridge.

The recommended method to update drive firmware is:

1. Download the latest drive firmware to your host computer by visiting:

   http://www-1.ibm.com/servers/storage/tape/lto/.

> **Note:** Carefully select the correct firmware, because there is different firmware for Fibre Channel drives, SCSI drives, and also LTO1, LTO2, and LTO3 drives.

2. Update all SCSI and Fibre Channel drives in the library by using ITDT.

Using ITDT to update drive firmware

A newly designed tool, ITDT, has multiple functional capabilities and is a very quick, convenient, and efficient method for performing drive firmware updates. As a note, ITDT performs drive dump retrievals as well. Below are some of the capabilities of this tool:

- Firmware update capability via SCSI to all IBM LTO Tape Drive products.
- The tool does not require any special device drivers.
- The tool is available for most major platforms (Windows, AIX, SUN, Linux, and NetWare).
- The tool is capable of uploading drive dump files.
- The tool's primary function is thoroughly testing a drive. However, if the library is online to the server/host where the tool resides, ITDT communicates with the drive through the library to load and unload a test cartridge, therefore exercising several library functions.
- The tool scans the SCSI bus, finds all IBM LTO devices, and displays them for selection. The tool does not display or allow for selection any non-IBM device.
- Each function has a Help selection which explains the required syntax as well as a brief description of the particular function.
- A Readme text file is posted with the .exe for a thorough explanation of initial tool download information from the Web as well as an explanation of tool capabilities.
- The tool is currently a command line tool you start by simply typing the executable name, itdt, from the directory where the tool exists.

Other methods for updating drive firmware

When updating drive firmware by using SCSI or Fibre Channel the procedure varies, depending on whether you use an IBM tape device driver or a non-IBM tape device driver (such as a driver from Sun, Hewlett-Packard, or Microsoft).

If you use an IBM tape device driver, you can update drive firmware by using the tapeutil or ntutil tools. The *IBM Ultrium Device Drivers Installation and User's Guide,* GA32-0430, explains these tools.

If you use a non-IBM tape device driver, refer to the relevant documentation.

12

IBM TotalStorage 3581 Tape Autoloader

Note: All models of the IBM TotalStorage 3581 Tape Autoloader: IBM 3581-L17/H17, IBM 3581-L13/H13, and IBM 3581-L23/H23 were withdrawn from marketing in October 2004. A newer IBM 3581 with a 2U form factor offers a single Ultrium 2 tape drive and storage for up to eight tape cartridges. We describe it in Chapter 13, “IBM TotalStorage 3581 2U Tape Autoloader” on page 335.

The IBM TotalStorage 3581 Tape Autoloader is an external, single-drive, SCSI-attached, standalone or rack-mounted autoloader that attaches to iSeries, AS/400, pSeries, RS/6000, xSeries, Microsoft Windows NT, Microsoft Windows 2000, Windows 2003, Sun Solaris, HP-UX, and Linux systems using a SCSI adapter.

The IBM TotalStorage 3581 Tape Autoloader uses a single IBM LTO Ultrium tape drive. The autoloader contains seven tape slots[1] providing a media capacity of up to 700 GB (1.4 TB with 2:1 compression) per autoloader, and is capable of sustaining a data rate of up to 15 MB/s (uncompressed).

[1] When the optional barcode reader is installed the cartridge capacity is reduced to six.

12.1 Model description

There are six separate model types of the IBM TotalStorage 3581 Tape Autoloader, depending on the capacity and required SCSI[2] interface.

Figure 12-1 IBM TotalStorage 3581 Tape Autoloader

The six models are:

- *IBM 3581-L17* and *IBM 3581-L13* - seven cartridge slots and a .7 TB native data capacity with a Low-Voltage Differential (LVD) Ultra2 SCSI attachment that connects to LVD fast/wide adapters.
- *IBM 3581-H17* and *IBM 3581-H13* - seven cartridge slots and a .7 TB native data capacity with a High-Voltage Differential (HVD) Ultra SCSI attachment that connects to HVD fast/wide adapters.

  The IBM 3581-L17, -L13, -H17, and -H13 all use the same Ultrium 1 LTO cartridge, which has a capacity of 100 GB (200 GB with 2:1 compression) and are capable of a sustained data rate of up to 15 MB/s (uncompressed).

  The IBM 3581-L17 and IBM 3581-L13 are functionally identical, as are the IBM 3581-H17 and IBM 3581-H13. The only difference is that the IBM 3581-L13 and the IBM 3581-H13 have a three-year Customer Element Exchange warranty.
- *IBM 3581-L23* and *IBM 3581-H23* - seven cartridge slots and a 1.4 TB native data capacity with a Low-Voltage Differential (LVD) Ultra160 SCSI attachment (IBM 3581-L23) or a High-Voltage Differential (HVD) Ultra SCSI attachment (IBM 3581-H23).

  The IBM 3581-L23 and IBM-H23 both use the same Ultrium 2 LTO cartridge, which has a capacity of 200 GB (400 GB with 2:1 compression), and are capable of a sustained data rate of up to 35 MB/s (uncompressed). IBM Ultrium 2 Tape Drives can read and write original LTO Ultrium Data Cartridges at original Ultrium 1 capacities and with an improved performance of up to 20 MB/s native data transfer rate (40 MB/s with 2:1 compression.

> **Note:** Although the IBM TotalStorage 3581 Tape Autoloader provides the capability for high tape performance, other components of the system may limit the actual performance achieved. Also, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

[2] Refer to “Interfaces” on page 51 for an explanation of HVD and LVD.

Feature codes

The IBM 3581 can be upgraded with the following feature codes (Table 12-1). We have not included the various cabling options; refer to the product publications for detailed information about configuring and ordering the IBM TotalStorage 3581 Tape Autoloader.

Table 12-1 IBM 3581 feature codes

Feature code	Description	Comments
7003	5U rack mount option	Plant or field install
7004	Barcode reader	
8001	One 100 GB data cartridge	Plant only; see 12.9, “Media” on page 325 for details.
8101	One 200 GB data cartridge	Plant only; see 12.9, “Media” on page 325 for details.
8002	One cleaning cartridge	Plant only; see 12.9, “Media” on page 325 for details.
9210	Attached to HP-UX	
9211	Attached to Sun Solaris System	
9212	Attached to Windows system	
9213	Attached to other non-IBM system	
9215	Attached to Linux system	
9400	Attached to i5/OS or OS/400 system	
9600	Attached to AIX system	

12.1.1 Access mode

The IBM 3581 can be operated in sequential or random-access mode. In sequential mode, the IBM 3581 loads cartridges one after another, controlled by the hardware when it receives the unload command from the host server. In random-access mode, the IBM 3581 relies on application software for cartridge management.

12.1.2 SCSI devices

Although it has only a single tape drive, the 3581 appears as two SCSI devices on the SCSI bus. In other words, the autoloader and the drive have separate SCSI addresses.

The IBM 3581 only operates on a single path, and control of the autoloader is handled by a single server. Connection to multiple servers can be achieved when using SAN technology and appropriate application software for cartridge management, such as IBM Tivoli Storage Manager.

12.1.3 Adding and removing cartridges

The IBM 3581 does not have a cartridge I/O station. To insert and remove cartridges from the slots you have to open the autoloader door. The IBM TotalStorage 3581 Tape Autoloader can contain up to seven tape cartridges, as labeled in Figure 12-2:

1. Five cartridges in the front, slots 1 through 5 (referred to as front slots)
2. Two cartridges in the rear, slots 6 and 7 (referred to as rear slots)

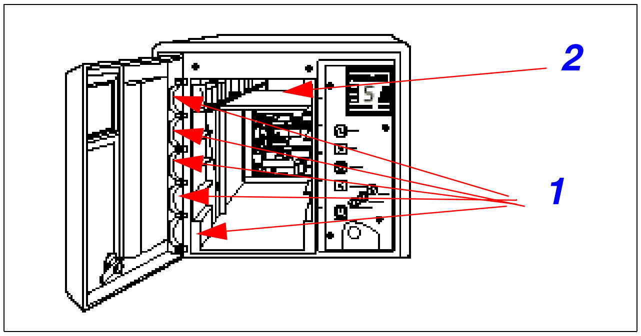


Figure 12-2 IBM 3581 cartridge slots

12.1.4 Operation

The IBM 3581 autoloader is designed for easy, unattended operation. An optional barcode reader makes tape inventory tasks more efficient. Indicators on the operator's panel provide information about:

- Power
- Autoloader and drive activity
- Error status
- Message information

Push buttons provide display, mode, and power controls.

12.2 SCSI attachments

The SCSI interface (HVD or LVD) on each IBM TotalStorage 3581 Tape Autoloader is chosen by selecting the appropriate model number (H17/13/23 or L17/13/23).

The IBM TotalStorage 3581 Tape Autoloader can be attached to pSeries, IBM RS/6000, xSeries, iSeries, AS/400, other Intel, HP-UX, and Sun systems that support Ultra/Wide SCSI HVD and Ultra2/Wide SCSI LVD interface specifications. The interface you choose depends on the available adapter in the host, which must be of the same type as the drive interface.

SCSI cables and appropriate interposers, as required, must be ordered for attachment to a server. A power cord feature code must also be specified.

The IBM TotalStorage 3581 Tape Autoloader may also be compatible with other servers, operating systems, and SCSI adapters. Contact your local IBM representative for a current list of supported open system configuration and software vendors.

12.3 SCSI cabling

A SCSI cable is required for each IBM 3581 connection to a SCSI bus. A single 2.5 m SCSI cable is available as a no-charge feature; if an alternate length is required it must be included in the initial order. A SCSI terminator is included with each autoloader. An interposer (a connector that matches the pin pattern of the host adapter to the pin pattern of the cable) may also be required for attachment to particular server adapters.

12.3.1 Cables

A single SCSI cable is available as a no-charge feature (FC9702 or FC9703) only with the initial IBM 3581 order. These no-charge features cannot be ordered later as a miscellaneous equipment specification (MES); however, the same cables can be ordered later as chargeable MES upgrades using FC5302 and FC5602. FC9702 supplies a 2.5 m SCSI cable with HD68 connectors at each end; FC9703 differs in that one end has a VHDCI connector.

Additional SCSI cables are available as optional features on the IBM 3581 for LVD and HVD attachment to host adapters:

- FC5301: 0.4 m (1.3 feet) SCSI cable
- FC5302: 2.5 m (8.2 feet) SCSI cable
- FC5305: 5 m (16.4 feet) SCSI cable
- FC5310: 10 m (32.8 feet) SCSI cable
- FC5318: 18 m (59.1 feet) SCSI cable
- FC5325: 25 m (82.0 feet) SCSI cable

The cables can be used with an HVD Ultra SCSI bus or LVD Ultra2 SCSI bus and have an HD68 connector on each end. A SCSI terminator is included with each IBM 3581.

The following cables differ in that they have a VHDCI connector at one end:

- FC5602: 2.5 m (8.2 feet) SCSI cable
- FC5604: 4.5 m (14.8 feet) SCSI cable
- FC5610: 10 m (32.8 feet) SCSI cable
- FC5620: 20 m (65.6 feet) SCSI cable
- FC5625: 2 5m (82.0 feet) SCSI cable

12.3.2 Interposers

An interposer is required to connect host adapters that do not have HD68 connectors to the SCSI cables. The following chargeable interposers are available:

- FC2895 interposer to connect iSeries adapter FC6501.
- FC5099 interposer to connect a mini-68-pin VHDCI connector to the 68-pin HD68 connector on the SCSI cable.

  This interposer (a 0.3 m cable) has a male mini-68-pin VHDCI connector on one end and a female 68-pin HD68 connector on the other.

12.3.3 SCSI length limitations

The IBM 3581 has one SCSI ID for the drive and one for the loader, so the SCSI interconnection is multi-drop. This means that the overall LVD SCSI cable length is limited to 12 m (39.4 feet). The stub length at each device must not exceed 0.1 m (0.33 feet).

The overall HVD SCSI cable lengths are limited to 25 m (82 feet) using multi-drop interconnection. The stub length at each device must not exceed 0.2 m (0.66 feet).

12.4 Upgrades and optional features

The IBM 3581 H17/13/23 and L17/13/23 are single tape drive autoloaders and cannot be upgraded to any other models.

Two additional optional features are available:

- FC7003: 5U Rack Mount Option

  The IBM 3581 can be installed as a standalone single unit, or two units can be mounted side-by-side in a standard 19-inch rack, requiring 5 EIA units of rack space. This chargeable feature provides the necessary hardware to mount the autoloader in the rack.

- FC7004: Barcode Reader

  This optional chargeable feature enables the IBM 3581 autoloader to read cartridge information contained in a barcode label on the IBM Ultrium cartridges. User-installed application software provides the inventory management functions enabled by the barcode reader feature.

  Note: Installing FC7004 reduces the autoloader capacity to six data cartridges. The barcode reader connects to the interface connector on the inside top panel of the IBM 3581. This location prevents you from using cartridge storage slot 1 (see Figure 12-2 on page 320). When you install the barcode reader, you reduce the capacity of the autoloader to six cartridge storage slots. The front storage slots are still numbered 1 through 5, but the autoloader's menu functions and the server's application software cannot select or use slot 1.

  This is illustrated when, with the barcode reader installed, the operator LOAD SLOT function uses storage slots 2 and 3 as the cartridge source locations to load slots 6 and 7; without the barcode reader installed, the LOAD SLOT function uses storage slots 1 and 2 as the source locations. See Figure 12-2 on page 320 for slot locations.

12.5 Environmental specifications

The IBM 3581 is a medium-sized desktop or standalone unit that optionally can be integrated into a standard 19" rack for space optimization. Two IBM 3581s can be installed side-by-side in a rack using 5 EIA space units.

12.5.1 Physical dimensions

The IBM 3581 models H17/13 and L17/13 are medium-sized single tape drive autoloaders:

- Width: 21.9 cm (8.62 in.)
- Depth: 58.1 cm (22.87 in.)
- Height: 19.0 cm (7.48 in.)
- Maximum weight: 13.0 kg (28.7 lbs.)

12.5.2 Operating environment

The IBM 3581 can be installed in a normal office environment and does not need to be in a specialized machine room.

12.6 Host platforms and device drivers

These no-charge specify feature codes indicate the server platform to which the IBM 3581 is attached:

- FC9210: attached to HP-UX
- FC9211: attached to Sun system
- FC9212: attached to Windows NT system
- FC9213: attached to other non-IBM system
- FC9215: attached to Linux system
- FC9400: attached to i5/OS or OS400 system
- FC9600: attached to AIX system

A device driver is additional code on the host server platform that enables it to recognize and talk to a peripheral device (in this case, the IBM 3581). Sometimes the driver code is supplied as part of the operating system code (such as, in OS/400), sometimes a software patch is required, and sometimes the driver is installed separately from a CD or diskette (either an operating system CD or provided with a vendor application).

Ultrium 1

The IBM TotalStorage 3581 Tape Autoloader ships with device drivers to support Ultrium 1 drives in the following operating environments at the minimal levels shown:

- AIX Versions 4.3.2 or later
- Sun Solaris 2.6, 7, and 8
- Windows NT 4.0 with Service Pack 6
- Windows 2000 (build 2195 or greater)
- Windows 2003
- HP-UX 11.0
- OS/400 V4R4

Ultrium 2

The IBM TotalStorage 3581 Tape Autoloader ships with device drivers to support Ultrium 2 drives in the following operating environments at the minimal levels shown:

- OS/400 V5R1, or later
- AIX V5.1, or later
- Sun Solaris 7, 8, or 9
- Microsoft Windows 2000 (build 2195 or greater)
- Microsoft Windows 2003 (build 3790 or greater)
- HP-UX 11.0, HP-UX 11i (64-bit), and HP-UX 11i v2
- Linux distributions: Red Hat Advanced Server 3, SuSE LINUX Enterprise Server 8, 9

Tip: The device driver CD or diskette that ships with the IBM 3581 might not contain the device drivers with the most recent level or the device drivers for all supported systems. Therefore, you should always check the following FTP site for the latest device drivers:

`ftp://ftp.software.ibm.com/storage/devdrvr/`

12.6.1 Device driver installation

Install the IBM device drivers for the IBM 3581 as follows:

- If you intend to use the IBM 3581 with a storage management application (such as Tivoli Storage Manager, VERITAS Backup Exec, or EMC Legato NetWorker), refer to that application's installation instructions to install the device driver and configure the IBM 3581.
- If you do not intend to use the IBM 3581 with a commercial software application, install the tape and medium device driver from the CD that ships with the autoloader. Refer to the installation instructions in the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430, which is supplied on the CD with the driver code.

Note: If you use the IBM 3581 with a commercial software application, IBM recommends that you install an IBM-supplied device driver *only* if instructed to do so in the application vendor's installation instructions. Otherwise, if the application supplies its own driver code, conflicts could occur over which driver controls the tape subsystem. Many examples of using the LTO drives are given in the Redbooks *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

12.7 Storage applications

The software to manage the IBM 3581 is not provided with the libraries. Additional software support is available through library management software products that must be obtained separately from IBM, IBM Business Partners, or independent software vendors. A list of compatible software is available at:

http://www.ibm.com/servers/storage/tape/lto/lto_isv.html

You will find details for each application including Ultrium 1 and Ultrium 2 support and specific Ultrium models and attachment methods. You should also contact your storage application vendor for more-detailed information about specific versions and supported platforms.

12.8 Performance considerations

For best performance, we recommend that you attach only one tape drive per SCSI bus. This may not be a realistic objective, but minimizing the number of devices per bus will improve performance. Attaching other SCSI devices on the same SCSI bus as the IBM 3581 drive may affect performance of those devices.

iSeries configurators allow only one drive per input/output port for maximum performance. Installing more than one LTO tape drive on an I/O port may affect system performance.

Although the compression technology can increase the amount of data stored on the media, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

12.9 Media

One Ultrium cleaning cartridge and one Ultrium data cartridge are included with each autoloader order[3]. With the initial order, additional data and cleaning cartridges were available as chargeable features for the IBM 3581:

- FC8001 provides a single 100 MB Ultrium Data Cartridge.
  It is a chargeable feature, and a maximum of seven can be ordered.
- FC8101 provides a single 200 MB Ultrium Data Cartridge.
  It is a chargeable feature, and a maximum of 20 can be ordered.
- FC8002, provides a single Ultrium Cleaning Cartridge.
  It is a chargeable feature, and a maximum of three can be ordered.

Subsequent to the initial order, additional supplies can be ordered from the IBM media business or a third-party media vendor. Refer to Appendix A, "IBM LTO Ultrium and 3592 media" on page 393 for details about ordering supplies and cartridges, with or without labels.

12.10 IBM 3581 initial setup

The following section covers some of the major items required to implement, manage, and operate the IBM 3581. It does not cover all tasks and we do not intend to list all of the specific commands. For more details, refer to the *IBM TotalStorage 3581 Tape Autoloader Setup, Operator and Service Guide*, GA32-0461, and to the Redbooks *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

12.10.1 SCSI ID

The IBM 3581 consists of two SCSI devices: the autoloader and the drive. The default settings for the SCSI IDs as displayed on the message display panel are `LdR Id 1`[4] (for the autoloader) and `dRV Id 3` (for the drive). Depending on your requirements, you may need to change the SCSI ID default settings for your installation. When setting a SCSI ID:

- Do not select an ID that is already in use.
- Do not select the SCSI ID of the server SCSI adapter card. The SCSI ID of the server SCSI adapter card is usually higher than any device on the SCSI bus. Generally, the SCSI ID for the server adapter is set to 7.
- Do not use F, as it is reserved for internal use by the SCSI library.
- Unless you choose another operation, the IBM 3581 times out 30 seconds after each operation and `LdR REAdY` appears in the message display (label 1 in Figure 12-3 on page 327).
- Functions and messages in the message display can only be scrolled forward. To select a previously viewed function, continue to scroll through the choices until the function that you want appears on the message display.
- As with the IBM 3580, the IBM 3581 can be part of a SCSI chain. The same rules apply for SCSI addresses as for the IBM 3580.

Refer to the Setup and Operator Guide for details about determining and changing SCSI IDs.

[3] All media and cleaning cartridges are warranted separately from the IBM TotalStorage 3581 Tape Autoloader.
[4] The message display panel displays a D as a lower case letter so we have shown the message as it would appear.

12.10.2 Element numbers

Element numbers (also called element addresses) identify the physical location within the autoloader. This information is required by storage management applications such as IBM Tivoli Storage Manager.

Table 12-2 shows the three types of elements in the IBM 3581.

Table 12-2 IBM 3581 element numbers

Element	Element number
Picker (media transport element)	57 hexadecimal
Tape drive (data transfer element)	52 hexadecimal
Storage element	01 - 07 hexadecimal

The IBM 3581 has one storage element for each of the cartridge storage slots.

A host application controls movement within the autoloader by issuing one of these SCSI commands:

- MOVE MEDIUM: This SCSI command tells the autoloader to move a cartridge from the source element to the destination element. The elements are identified using the element numbers shown in Table 12-2. So, for example, a MOVE MEDIUM command could be issued to tell the library to move a cartridge from the picker to the drive.
- POSITION TO ELEMENT: This positions the picker to a specified element number.

12.10.3 Operator displays and buttons

Management of the IBM 3581 is performed by using the status lights, message display panel, and push buttons on the control panel behind the front door.

Status lights

The IBM 3581 has three status lights on the Operator Panel (label 2 in Figure 12-3 on page 327):

- POWER™: The green POWER light comes on whenever you turn on the power.
- ACTIVITY: The amber ACTIVITY light indicates robotic or drive activity. A slowly blinking light indicates robotic activity; a rapidly blinking light indicates drive activity.
- ALARM: The red ALARM light comes on whenever an error occurs. To resolve the error, refer to the Setup and Operator Guide.

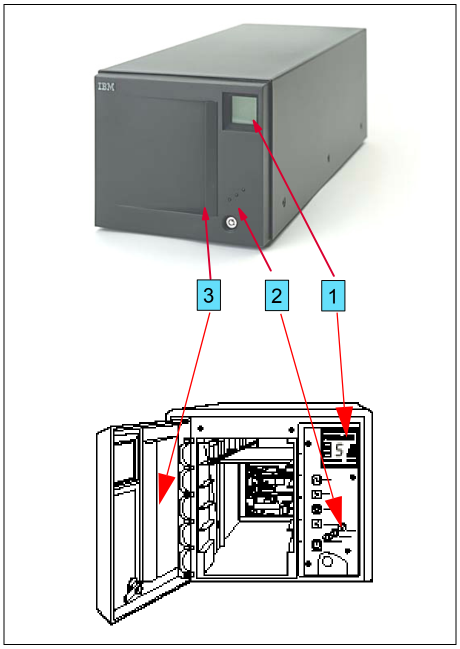


Figure 12-3 IBM 3581 front view

12.10.4 Message display

The IBM 3581 has a one-line, 10-character front panel with a liquid crystal display (LCD) that provides operational information as well as diagnostics and messages.

The LCD message display (label 1 in Figure 12-3) provides information about the status of the IBM 3581 and any error conditions. When in an idle (non-operating) state, the autoloader message panel displays `LdR REAdY`. In addition, the following characters (shown in Figure 12-4 on page 328) may appear on the left side of the display:

DC Indicates that data compression is selected on the drive.
WP Indicates that a write-protected data cartridge is loaded in the drive.
CT Indicates that the drive head needs to be cleaned.

The large field in the center of the display indicates the number of the storage slot from which the picker removed a cartridge for loading into the drive. Whenever an error occurs, `E` displays in this field and the error message is displayed on line 1.

The activity bars on the right (in conjunction with the activity light) indicate robotic and drive activity:

- The bottom bar blinks when no activity is taking place.
- A slow interval between the bars appearing and disappearing indicates robotic activity.
- A fast interval between the bars appearing and disappearing indicates drive activity.

The seven numeric fields at the bottom of the display indicate the current cartridge inventory. Each will appear only if a cartridge is present in that storage slot, as shown in Figure 12-4 on page 328.

Figure 12-4 IBM 3581 message display

12.10.5 Drive status messages

During operation, the IBM 3581 places messages about the drive's status in the message display. These messages can appear:

CLEANING The drive is cleaning the head with the cleaning cartridge.
EJECTING The drive is unloading the tape.
ERASING The drive is erasing the tape.
LOADING The drive is loading the tape.
LOCATING The drive is locating the position on the tape.
READING The drive is reading from the tape.
REWINDING The drive is rewinding the tape.
WRITING The drive is writing to the tape.

If an error occurs during operation, the IBM 3581 halts the current operation and displays an error code in the message display. The following list provides the most common errors codes and gives a description of each:

CT FAILED Cleaning tape failed to clean drive.
DEST FULL The destination location was full.
DRIVE BUSY The drive is busy and cannot unload the tape.
DRIVE FULL The drive was full.
DRIVE PGRM: The attempt to set drive parameters failed.
DRIVE POST The drive failed its Power-On Self Test (POST).
FRONT SLOT A front slot sensor was not tripped.
FRONT TAPE A front tape sensor was not tripped.
LDR INIT The autoloader could not complete its initialization.
PCKR EMPTY The picker was empty.
PCKR FULL The picker was full.
REAR SLOT A rear slot sensor was not tripped.
REAR TAPE A rear tape sensor was not tripped.
ROBOT POST The robotics failed its Power-On Self Test (POST).
SRC EMPTY The source location was empty.
SLOT EMPTY No slot beam was detected.
PWR SWITCH The front power switch was pressed.
SLOT FULL A cartridge was already in the slot.

This list is not complete. See the Setup and Operator Guide for the full error list.

12.10.6 Control buttons

The control buttons are push buttons on the Operator Panel that let you interact with the menus on the message display (Figure 12-5 on page 330):

MODE Scrolls through the commands that you can use to operate the IBM 3581 (label 1 in Figure 12-5 on page 330).

NEXT Highlights the next item or value in the currently displayed menu (label 2 in Figure 12-5 on page 330)

SELECT Selects the currently displayed operation (label 3 in Figure 12-5 on page 330).

PREVIOUS Highlights the previous item or value in the currently displayed menu (label 4 in Figure 12-5 on page 330).

To operate a button, press and release it. You can use the control buttons to:

- Load a tape cartridge into a drive (LOAd dRV)
- Eject a tape cartridge from the drive and put it into the storage slot that it was loaded from (EJECT dRV)
- Load slot 6 from slot 1, or load slot 7 from slot 2 (LOAD SLOT)
- Move a cartridge from slot 6 to slot 1 or from slot 7 to slot 2 (EJECT SLOT)
- Eject a tape cartridge that was left in the media picker into an empty destination slot (EJECT PCKR)
- Set the SCSI ID of the autoloader or the drive (SET SCSI)

Note: The procedure for loading slots 1 through 5 differs from loading slots 6 and 7. If you are loading seven cartridges, load slots 6 and 7 first. See “Inserting a Cartridge into Slots 6 and 7” of the chapter “Operating the IBM 3581 Tape Autoloader” in *IBM TotalStorage 3581 Tape Autoloader Setup, Operator and Service Guide*, GA32-0461, which also contains a complete list of commands.

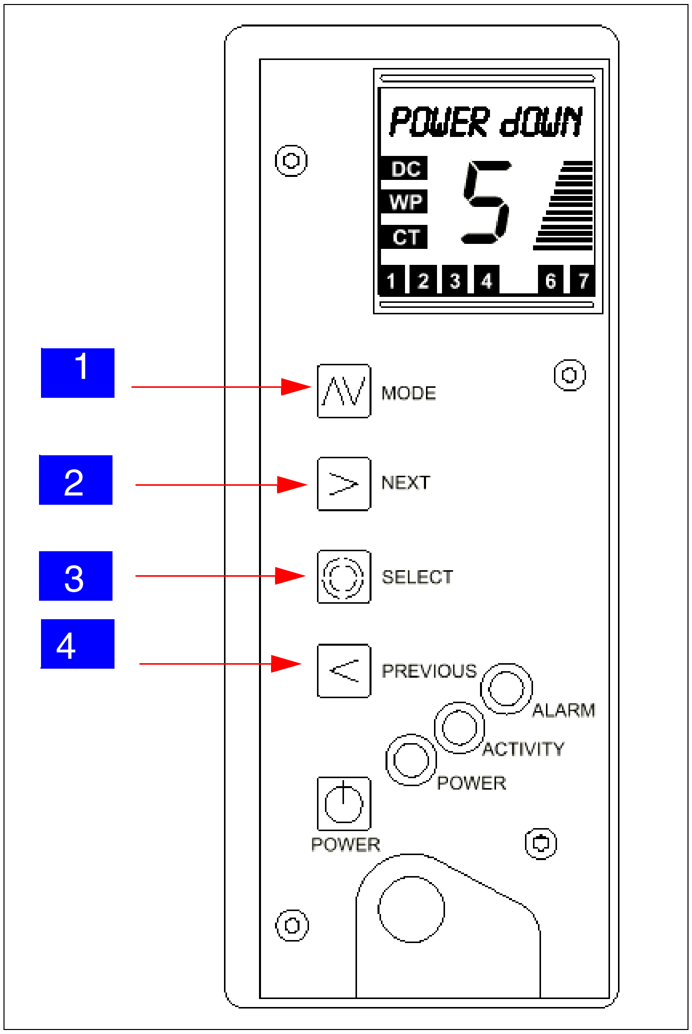


Figure 12-5 IBM 3581 Operator Panel

12.10.7 Operating modes

The IBM 3581 operates in both random access mode (in which the server's application software manages the cartridges) and sequential access mode (in which the autoloader's firmware manages the cartridges).

Change between random and sequential mode through the Diagnostic Menus.

Select CHG MODE to toggle between the random access and sequential access modes. The IBM 3581 can operate in either mode:

- In random access mode, the autoloader allows the server's application software to select any data cartridge in any order. You can logically divide cartridge usage to satisfy particular data storage needs. For example, you can assign one or more cartridges to specific data functions (such as certain directories or network servers), or you can assign specific cartridges to individual users or groups (such as Sales or Engineering).
- In sequential access mode, all cartridges present are considered to be a single volume. The autoloader's firmware predefines the selection of the cartridges. After initialization, the firmware causes the autoloader to always load the first cartridge found (counting from 1 through 7) into the drive. After the server's application software has filled this cartridge and

unloaded the drive, the autoloader automatically returns the cartridge to its storage slot and loads the next cartridge in order. Empty storage slots are ignored. The autoloader continues this process until the volume is full.

Note: While in sequential access mode, the autoloader's robotics are not logically connected to the SCSI bus and do not respond to SCSI commands.

To change the mode of operation:

1. Ensure that `LdR REAdY` appears on the message display.
2. Press and hold the **NEXT** button and then the MODE button until `dIAG MENU` displays (approximately 5 seconds).
3. Press and hold **MODE** until `CH MOdE` appears on the message display.
4. Press **SELECT** to display the current mode of operation.
5. Press **NEXT** or **PREVIOUS** to toggle the mode between `SEQUENTIAL` and `RANdOM`.
6. Choose the mode that you want and press **SELECT**. `CYCLE PWR` blinks on the message display. If you changed to random mode, `LdR REAdY` then displays; if you changed to sequential mode, `SEQ REAdY` then displays.
7. To activate the new mode of operation, cycle power (turn off, then on) to the IBM 3581.

The complete list of mode set-up commands is in the Operator and Setup Guide.

12.11 Drive cleaning

All IBM Ultrium tape drives have an integrated cleaning mechanism that brushes the head at load time and again when unloading a cartridge. There is also a cleaning procedure using a special cleaning cartridge.

Important: When cleaning the drive head, use only the IBM LTO Ultrium Cleaning Cartridge or an IBM-approved cleaning cartridge.

The IBM 3581 internal tape drive determines when the head needs to be cleaned and alerts you by displaying `CT` on the message display (label 1 in Figure 12-3 on page 327). This is the *only* occasion when a cleaning cartridge should be used. The IBM 3581 supports three methods of cleaning the drive:

- Host cleaning: Host cleaning enables the server software to detect the need to clean an Ultrium Tape Drive and to control the cleaning process. The cleaning cartridge must be stored in one of the available storage slots within the 3581.
- Automatic cleaning (AUTOCLEAN): Automatic cleaning enables the 3581 to automatically respond to any tape drive's request for cleaning and to begin the cleaning process. Automatic cleaning makes the cleaning process transparent to any host application using the autoloader. If the server application does not support the host cleaning function, use the autoclean function.
- Manual cleaning: Manual cleaning requires you to select a menu option from the autoloader's display. Manual cleaning is always supported, regardless of whether host cleaning or automatic cleaning is enabled or disabled.

In all methods, the autoloader performs the cleaning after you unload the data cartridge from the drive and before the next load.

Note: Whenever you enable host application cleaning or the autoloader's autoclean function, the tape capacity of the autoloader is reduced to six tapes without the barcode reader and to five cartridges with the barcode reader feature installed. The extra slot is used for storing the cleaning cartridge within the IBM 3581.

You can find proper instructions for cleaning the IBM 3581 in "Performing Diagnostic and Maintenance Functions" in the *IBM TotalStorage 3581 Tape Autoloader Setup, Operator, and Service Guide*, GA32-0470.

12.12 Firmware upgrade

There are tools readily available to facilitate this process. The recommended tool, the IBM TotalStorage Tape Diagnostic Tool (ITDT), is available on the IBM Web site and requires no special device drivers. To download ITDT and instructions for using the tool, visit:

http://www-03.ibm.com/servers/storage/support/

ITDT is available for multiple platforms. Other tools, such as ntutil and tapeutil, can also be used for drive firmware updates. The library also supports drive firmware update by creating and using a Field Microcode Replacement (FMR) cartridge.

The recommended method to update drive firmware:

1. Download the latest drive firmware to your host computer by visiting:

   http://www-1.ibm.com/servers/storage/tape/lto/

Important: Be careful to select the correct firmware. There is different firmware for Fibre Channel drives and SCSI drives, in addition to different firmware for LTO1, LTO2, and LTO3 drives.

2. Update all SCSI and Fibre Channel drives in the library by using ITDT.

Using ITDT to Update Drive Firmware

A newly designed tool, ITDT, is a tool with multiple functional capability and is a very quick, convenient, and efficient method for drive firmware updates. As a note, drive dump retrievals can be performed by the tool as well. Below are some of the capabilities of this tool:

- Firmware update capability via SCSI to all IBM LTO Tape Drive products.
- The tool does not require any special device drivers.
- The tool is available for most major platforms (Windows, AIXR, SUN, Linux, and NetWare).
- The tool is capable of uploading drive dump files.
- The tool's primary function is thoroughly testing a drive. However, if the library is online to the server or host where the tool resides, ITDT will communicate with the drive through the library to load and unload a test cartridge thereby exercising some library functions.
- The tool scans the SCSI bus to find and display for selection all IBM LTO devices. The tool does not display or allow for selection any non-IBM device.
- Each function has a Help selection which explains the required syntax as well as a brief explanation of the particular function.
- A Readme text file is posted with the .exe file for a thorough explanation of initial tool download information from the Web, as well as an explanation of tool capabilities.

- The tool is currently a command line tool you start by simply typing the executable name, itdt, from the directory where the tool is located.

Other methods for Updating Drive Firmware

When updating drive firmware by using the SCSI or Fibre Channel the procedure varies, depending on whether you use an IBM tape device driver or a non-IBM tape device driver (such as a driver from Sun, Hewlett-Packard or Microsoft).

If using an IBM tape device driver, drive firmware may be updated using the tapeutil or ntutil tools. These are explained in the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430.

If using a non-IBM tape device driver, refer to the relevant documentation.

13

IBM TotalStorage 3581 2U Tape Autoloader

The IBM TotalStorage 3581 2U Tape Autoloader (IBM 3581 2U) is a desktop or rack-mountable unit (requiring two rack units, therefore “2U”) that operates in automatic, sequential, or random mode and comes equipped with a robotic interface that moves tape cartridges to and from the drive and a cartridge carousel.

The IBM TotalStorage 3581 2U Tape Autoloader offers high capacity, performance, and technology designed for the midrange Open Systems environment. It also constitutes an excellent tape storage solution for clients with existing digital linear tape experience or requiring high-performance automated tape backup.

Optional features include a Remote Management Unit (RMU) and a barcode reader (BCR).

13.1 Description

The IBM TotalStorage 3581 2U Tape Autoloader (Figure 13-1 on page 337) uses the IBM Ultrium 2 and Ultrium 3 drives for fast data transfer and reliability in automated library services. The Ultrium 2 cartridge has a native capacity of 200 GB. The Ultrium 3 cartridge has a native capacity of 400 GB.

The IBM TotalStorage 3581 2U Tape Autoloader has an eight-cartridge capacity. With an IBM Ultrium 2 drive, the native media capacity is 1.6 TB (3.2 TB with 2:1 compression) with a sustained data rate up to 35 MB/s (uncompressed). With an IBM Ultrium 3 drive, the native media capacity is 3.2 TB (6.4 TB with 2:1 compression) with a sustained data rate up to 80 MB/s (uncompressed) with Ultrium 3 media.

The IBM TotalStorage 3581 2U Tape Autoloader attaches to a variety of server and operating system platforms. (See 13.6, “Host platform and device drivers” on page 346.)

The four models of the IBM TotalStorage 3581 2U Tape Autoloader are:

- The IBM TotalStorage 3581 2U Tape Autoloader Model L28
  - The IBM 3581-L28 has an Ultrium 2 drive and a Low-Voltage Differential (LVD) Ultra 160 SCSI attachment that connects to LVD fast/wide adapters.
  - Using the optional High-Voltage Differential (HVD) converter (FC3104), a SCSI LVD to HVD converter/expander converts the autoloader’s low voltage differential (LVD) to wide high voltage differential (HVD).
- The IBM TotalStorage 3581 2U Tape Autoloader Model F28

  The IBM 3581-F28 has an Ultrium 2 drive and a 2 Gbps native switched fabric Fibre Channel attachment.
- The IBM TotalStorage 3581 2U Tape Autoloader Model L38/L3H

  The IBM 3581-L38 has an Ultrium 3 drive and a Low-Voltage Differential (LVD) Ultra 160 SCSI attachment that connects to LVD fast/wide adapters.
- The IBM TotalStorage 3581 2U Tape Autoloader Model F38/F3H

  The IBM 3581-F38 has an Ultrium 3 drive and a 2 or 4 Gbps Native Switched Fabric Fibre Channel attachment.

The IBM 3581-L38 and IBM 3581-L3H are functionally identical. The IBM 3581-F38 and IBM 3581-F3H are functionally identical. The only difference is that the IBM 3580-L3H and IBM 3581-F3H are Express Models and are part of the IBM Express Portfolio.

Note: The IBM Express Portfolio is a set of IBM offerings for Business Partners in Small and Medium Business. For details, see the Web site:

http://www.ibm.com/partnerworld/pwhome.nsf/weblook/pub_strategies_smb_express.html

Figure 13-1 IBM TotalStorage 3581 2U Tape Autoloader

The autoloader's robotic system includes an I/O door, a cartridge carousel with eight cartridge slots, and a cartridge loader. The I/O door allows the importing or exporting of a single cartridge to or from the autoloader. The cartridge carousel encircles the Ultrium 2 or 3 drive and positions the specified cartridge slot in front of the tape drive. A robotic cartridge loader moves the cartridges between the cartridge slots and the tape drive. (See Figure 13-2.)

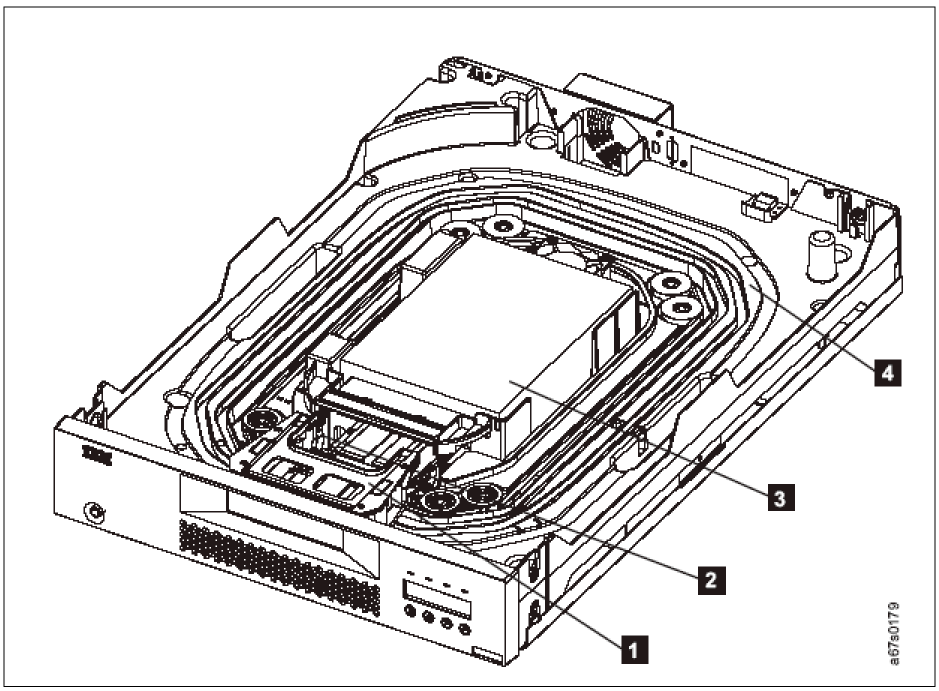


Figure 13-2 Interior components with one cartridge slot

1. Cartridge slot

   Each cartridge is installed in a cartridge slot to ensure that the cartridge is properly aligned for insertion into the tape drive.

2. Cartridge loader

   The cartridge loader moves cartridges between the cartridge slots and the tape drive. When a cartridge slot is positioned in front of the drive, the loader grips the sides of the cartridge and slides it forward or backward between the slot and drive. The loader then releases the cartridge and pushes it firmly into the drive or slot.

3. Ultrium 2 or Ultrium 3 Tape Drive (LVD or Fibre Channel)

   The autoloader contains one LVD (IBM 3581 L28/L38/L3H) or Fibre Channel (IBM 3581 F28/F38/F3H) Ultrium tape drive. The Ultrium 2 IBM 3581 L28/F28 provides a sustained data transfer rate of 35 MB/s (compressed) and can store up to 200 GB of uncompressed information on a single data cartridge. (400 GB assuming an average compression ratio of 2:1.) The Ultrium 3 IBM 3581 L38/F38/L3H/F3H provides a sustained native data transfer rate of 80 MB/s and can store up to 400 GB of uncompressed information on a single data cartridge. (800 GB assuming an average compression ratio of 2:1.)

4. Carousel

   The carousel stores up to eight Ultrium 3, Ultrium 2, or Ultrium 1 data cartridges. The carousel consists of a drive chain, guides, and gears that move the cartridges into position in front of the drive.

13.1.1 IBM 3581-L28/F28 (Ultrium 2) characteristics

Digital speed matching

The IBM 3581 performs dynamic to adjust the drive’s native data rate as closely as possible to the net host data rate (after data compressibility has been factored out). This offers the dual benefit of reducing the number of backhitch repositions and improving throughput performance.

Power management

The power management function controls the drive’s electronics to be either completely turned off or to be in a low-power mode. These power modes occur only when the circuit functions are not needed for drive operation.

Channel calibration

The IBM 3581-L28/F28 channel calibration feature allows for customization of each read/write data channel for optimum performance. The customization enables compensation for variations in the recording channel transfer function, media characteristics, and read/write head characteristics.

The autoloader also presents the following characteristics:

- Separate writing of multiple filemarks

  Separate writing of multiple filemarks causes any write command of two or more filemarks to cause a separate data set to be written containing all filemarks after the first. This feature has two advantages:

  – First, it can improve performance if a subsequent append overwrites somewhere after the first filemark.

  – Second, a write of multiple filemarks typically indicates a point where an append operation might occur after the first of these filemarks.This change prevents having to rewrite datasets containing client data and the first filemark in cases if such an append occurs.

- Large internal buffer

  The Ultrium 2 tape drive has a 64 MB internal data buffer.

- Fast cartridge fill times

Table 13-1 Data cartridge fill times

Tape drive	Cartridge fill time (sustained data rate)	
	Ultrium 2 cartridge (200 GB)	Ultrium 1 cartridge (100 GB)
Ultrium 2	1 hr. 44 min.	1 hr. 29 min.
	(122.8 GB/hr.)	(71.0 GB/hr.)

- Fast data access, rewind, and load times

Table 13-2 Data access, rewind, and load times

Action	Ultrium 2 tape drive
Cartridge load time	15 seconds
Maximum rewind time	80 seconds
Average file access time	49 seconds

13.1.2 IBM 3581-L38/L3H/F38/F3H (Ultrium 3) characteristics

The Ultrium 3 Tape Drive offers the following significant improvements over the Ultrium 2.

Increased performance

Maximum tape drive throughput data rate performance is more than doubled, up to 80 MB/s native data transfer rate. Data tracks are now written 16 at a time. IBM Ultrium 3 Tape Drives can read and write, at 8 data tracks at a time, LTO Ultrium 2 Data Cartridges at Ultrium 2 capacities and rates. IBM Ultrium 3 Tape Drives can read LTO Ultrium 1 Data Cartridges at Ultrium 1 capacities with improved rates.

Note: Although the IBM 3581 2U provides the capability for excellent tape performance, other components of the system may limit the actual performance achieved. Also, whereas the compression technology used in the tape drive can typically double the amount of data that can be stored on the media, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

Larger capacity

The tape cartridge capacity is doubled over the Ultrium 2 Data Cartridge up to 400 GB native physical capacity (800 GB with 2:1 compression), with the use of the IBM TotalStorage LTO Ultrium 400 GB Data Cartridge. This is achieved by increasing the linear density, the number of tape tracks, and the media length. The tape itself is an advanced metal particle tape developed to help provide durability and capacity.

Ultrium 2 cartridge compatibility

The Ultrium 3 Tape Drive can read and write on Ultrium 2 cartridges.

SCSI Ultra160 LVD attachment

The Model L38 comes with a SCSI Ultra160 LVD attachment, for connection to a wide spectrum of open system servers. It is supported on AIX, OS/400, i5/OS, Sun Solaris, HP-UX, Microsoft Windows 2000, Windows 2003, Linux, and other Open Systems.

Fibre Channel attachment

The Model F38 comes with a native switched fabric 2 Gbps Fibre Channel attachment. It is supported on AIX, OS/400, Sun Solaris, HP-UX, Microsoft Windows 2000, Windows 2003, Linux, and other Open Systems.

Larger internal data buffer

There is a 128 MB internal data buffer in the Ultrium 3 Tape Drive as compared to a 64 MB internal data buffer in the Ultrium 2 Tape Drive.

Graceful dynamic braking

In the event of power failure, reel motors are designed to maintain tension and gradually decelerate instead of stopping abruptly, which helps reduce tape breakage, stretching, and loose tape wraps during a sudden power-down.

Other IBM LTO Ultrium features enhanced in Ultrium 3

- Servo and track layout technology

  There are 704 data tracks in Ultrium 3 versus 512 data tracks in Ultrium 2. The high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

- Magneto Resistive (MR) head design

  Use of flat lap head technology in MR heads for Ultrium 3 helps minimize contact, debris accumulation, and wear on the tape as it moves over the read/write heads.

- Digital speed matching

  The Ultrium 3 Tape Drive is designed to perform dynamic (at one of five speeds: 40, 50, 60, 70, or 80 MB/s) to adjust the drive’s native data rate as closely as possible to the net host data rate (after data compressibility has been factored out). This helps reduce the number of backhitch repositions and improve throughput performance. on Ultrium 3 ranges from 40 to 80 MB/s versus 17.5 to 35 MB/s on Ultrium 2.

- Robust drive components optimized for automation environments

  To help enhance reliability and prolong the life of the drive, it was designed using some of the most robust components available, such as: 1) all metal clutch, 2) steel ball bearings in loader, 3) robust leader block design, 4) single circuit card.

- Power management

  The Ultrium 3 Tape Drive power management function is designed to control the drive electronics to be either completely turned off or to be in a low-power mode when the circuit functions are not needed for drive operation.

- Adaptive read equalization

  The drive is designed to automatically compensate for dynamic changes in readback signal response.

- Dynamic amplitude asymmetry compensation

  Readback signals are designed to dynamically optimize for linear readback response from magneto resistive read head transducers.

- Separate writing of multiple filemarks

  Separate writing of multiple filemarks is designed to cause any write command of two or more filemarks to cause a separate data set to be written containing all filemarks after the first. This feature has two advantages: it helps improve performance if a subsequent append overwrites somewhere after the first filemark, and write of multiple filemarks typically indicates a point where an append operation might occur after the first of these filemarks. This change helps prevent having to rewrite datasets containing client data and the first filemark if such an append occurs.

- LTO Data Compression (LTO-DC)

  The Ultrium 3 uses LTO-DC, which is an implementation of a Lempel-Ziv class 1 (LZ-1) data compression algorithm. LTO-DC is an extension of Adaptive Lossless Data Compression (ALDC) and an improvement over previous IBM lossless compression algorithms. The IBM-patented “Scheme-Swapping” compression is designed to look ahead at incoming data and determine the most efficient storage method (either ALDC or pass-through mode) to help provide optimal data compression and increased data throughput.

- LTO Cartridge Memory (LTO-CM)

  Contained within the LTO Ultrium data cartridge is the LTO-CM, which is a passive, contactless silicon storage device that is physically a part of the cartridge. The LTO-CM is used to hold information about that specific cartridge, the media in the cartridge, and the data on the media. The storage capacity of the LTO-CM is 4,096 bytes. Communication between the drive and the LTO-CM is via a low-level RF field transmitted by the drive to the cartridge.

- Statistical Analysis and Reporting System (SARS)

  The Ultrium 3 Tape Drive uses SARS to help isolate failures between media and hardware. The SARS uses the cartridge performance history saved in the CM module and the drive performance history kept in the drive flash Electronically Erasable Programmable Read-Only Memory (EEPROM) to help determine the more likely cause of failure. SARS can cause the drive to request a cleaner tape, to mark the media as degraded, and to indicate that the hardware has degraded.

With support for LTO Ultrium-format tape data cartridges, the IBM 3581 provides an excellent migration path from digital linear tape (DLT or SDLT), 1/4-inch, 4 mm, or 8 mm tape drives.

13.2 Feature codes

You can order the IBM TotalStorage 3581 2U Tape Autoloader and upgrade it with the following features.

Table 13-3 Feature codes for the IBM 3581 2U

Feature code	Description	Comments
1660	RMU	
3104	HVD Converter Kit	3581-L28 only
5096	SC-LC Fibre Cable Interposer	
5099	VHCDCI/HD68 Cable Interposer	
7003	Rack Mount Option	
7004	Barcode Reader	
8002	Cleaning Cartridge	Plant only
8101	1 200 GB Ultrium 2 Data Cart	Plant only
8301	1 400 GB Ultrium 3 Data Cart	Plant only

Barcode reader (BCR)

The BCR reads barcode labels and sends the label IDs to the server (host) and to the Remote Management Unit (RMU), if installed. The barcode reader is installed at the back of the unit so it does not affect the slot capacity of the unit.

Remote Management Unit (RMU)

The Remote Management Unit (RMU) provides remote access to the autoloader over a network. The autoloader can be attached to the network through a 10/100 Ethernet port located on the RMU. Any server (host) can access the autoloader if it has a Web browser installed and the IP address of the autoloader is known.

HVD converter

The HVD converter is a SCSI LVD to HVD converter/expander. It converts the autoloader's low voltage differential (LVD) to wide high voltage differential (HVD). This enables LVD peripherals to be used on an HVD bus. The converter can also be used to reshape poor quality LVD signals, and allow additional cable length.

Rack Mount Kit

The Rack Mount Kit supplies the necessary mounting hardware to install the autoloader in a 19-inch rack.

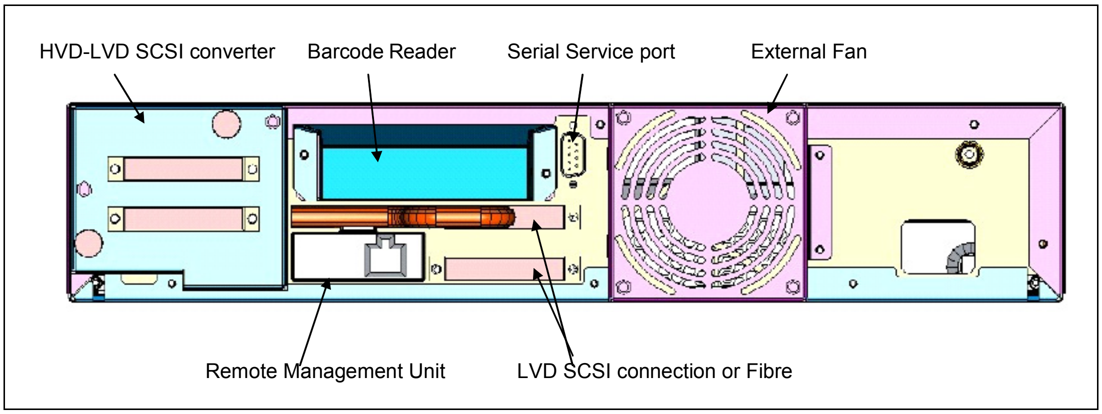


Figure 13-3 Back view of the IBM 3581 2U

13.3 Access modes

The IBM TotalStorage 3581 2U Tape Autoloader can operate in two different modes, automatic or sequential:

- Automatic mode

  Automatic mode is the default setting. It enables the autoloader to switch between sequential and random modes depending on the SCSI command received. In automatic mode, sequential mode is activated when the autoloader is powered on. When the autoloader receives a MOVE MEDIUM, READ ELEMENT STATUS, or an INITIALIZE ELEMENT STATUS command, sequential mode is disabled and random mode becomes active. The autoloader will switch back to sequential mode with every OCP-initiated LOAD or UNLOAD command.

- Sequential mode

  In sequential mode, the autoloader's firmware predefines the selection of the cartridges. After initialization, the firmware causes the autoloader to select the first available cartridge found (counting from 1 through 8) for loading into the drive. If AUTOLOAD MODE is set to ON, the first cartridge will load automatically. Otherwise, the OCP's LOAD CARTRIDGE command must be executed. After the server's (host's) application software fills this cartridge with data and issues an UNLOAD command, the autoloader returns the cartridge to its storage slot and loads the next cartridge in order. Empty storage slots are ignored. The autoloader continues this process until all cartridges have been filled with data.

  > **Note:** While in sequential mode, the autoloader's robotics are not logically connected to the SCSI bus and do not respond to SCSI commands.

Associated with sequential mode are LOOP MODE and AUTOLOAD MODE:

- **Loop mode**

  LOOP MODE can be used with sequential mode. Sequential mode with LOOP MODE turned ON loads the cartridge in slot 1 after the cartridge in slot 8 has been filled and sent back to its home slot. This allows endless backup operations without user interaction.

- **Random mode**

  In random mode, the autoloader allows the server's (host's) application software to select any data cartridge in any order.

13.4 Physical attachments

The IBM 3581 2U features LVD Ultra160 SCSI and 2 Gb Fibre Channel interfaces, attaching to pSeries, iSeries, xSeries, zSeries (Fibre Channel only), RS/6000, AS/400, Sun, and HP-UX systems. Native device driver support is available for AIX, OS/400, Windows NT, Windows 2000, Windows Server 2003, Sun Solaris, HP-UX, and Linux. Refer to 13.6, "Host platform and device drivers" on page 346 for more details.

SCSI cables and appropriate interposers, as required, must be ordered for attachment to a server. A power cord feature code also must be specified.

The IBM 3581 2U may be compatible with other servers, operating systems, and SCSI adapters. Contact your local IBM representative for a current list of supported open system configuration and software vendors, or go to:

http://www.ibm.com/servers/storage/tape/3581/interop.html

13.4.1 SCSI cabling

A SCSI or Fibre cable is required to attach the IBM 3581 2U to the server host bus adapter. At least one Fibre cable must be specified on the initial plant order. A SCSI cable and terminator is supplied with IBM 3581-L38. An interposer or interposers may be required for attachment to various server adapters. Additional SCSI cables are available as optional features on the IBM 3581-L28 for LVD and HVD attachment to host adapters.

Clients are responsible for selecting and ordering the correct cables and interposers to match the IBM LTO Ultrium SCSI interface and the server SCSI interface.

SCSI cables

The following cables are available for SCSI LVD attachment of the IBM 3581 2U.

These cables comes with HD68 connectors on both ends (Ultrium 2 only):

- FC5302: 2.5 m (8.2 feet) SCSI cable
- FC5305: 5 m (16.4 feet) SCSI cable
- FC5310: 10 m (32.8 feet) SCSI cable
- FC5325: 25 m (82 feet) SCSI cable
- FC9702: 2.5 m (8.2 feet) SCSI cable (plant only)

These cables have a VHDCI connector on one end and an HD68 connector on the other end:

- FC5602: 2.5 m (8.2 feet) SCSI cable
- FC5604: 4.5 m (14.8 feet) SCSI cable
- FC5610: 10 m (32.8 feet) SCSI cable
- FC5625: 25 m (82 feet) SCSI cable (Ultrium 2 only)
- FC9703: 2.5 m (8.2 feet) SCSI cable (Ultrium 2 and plant only)

Interposers

An interposer is required to connect a SCSI cable with HD68 connectors to a VHDCI connector. The following interposer is available:

- FC5099: VHDCI/HD68 interposer to connect a mini-68-pin VHDCI connector on one end and a female 68-pin HD68 connector on the other.

SCSI length limitations

SCSI length limitations apply, depending on the connection type.

- HVD connections

  Total HVD SCSI cable lengths are limited to 25 m (82 feet) using point-to-point (that is, one host connected to only one tape drive), or multi-drop interconnection (that is, one host connected to more than one tape drive on the same SCSI bus). Stub length at each device must not exceed 0.2 m (0.66 feet).

- LVD connections

  Total LVD SCSI cable length is 12 m (39.4 feet) due to an internal multi-drop interconnection. Stub length at each device must not exceed 0.1 m (0.33 feet).

13.4.2 FC cabling

A Fibre Channel cable is required to attach an IBM 3581 2U to host Fibre Channel adapters, Fibre Channel switches, or other Fibre Channel components. The IBM LTO Ultrium 2 and Ultrium 3 Fibre Tape Drive come with an LC Duplex connector.

FC cables

Features available for Fibre Channel cables and their respective lengths are:

- FC5907: 7 m (23.0 feet) SC-LC Fibre Channel Cable - Ultrium 2 only
- FC5922: 22 m (72.0 feet) SC-LC Fibre Channel Cable - Ultrium 2 only
- FC5961: 61 m (200.1 feet) SC-LC Fibre Channel Cable - Ultrium 2 only
- FC6005: 5 m (16.4 feet) LC-LC Fibre Channel Cable
- FC6013: 13 m (42.7 feet) LC/LC Fibre Channel Cable - Ultrium 3 only
- FC6025: 25 m (82.0 feet) LC-LC Fibre Channel Cable
- FC6061: 61 m (200.1 feet) LC-LC Fibre Channel Cable - Ultrium 2 only

Interposer

A interposer may be required to connect a fibre cable with LC Duplex connectors to another SC Duplex connector. The following interposer is available:

- FC5096: Interposer SC-LC Fibre

13.5 Specifications

The IBM TotalStorage 3581 2U Tape Autoloader is a standalone, medium-sized library unit that can be placed on a desk or in a rack. It requires 2 EIAs of rack space.

Table 13-4 Physical specifications for the IBM 3581 2U

Physical specifications		
	Desktop version	**Rack mount version**
Width	321 mm/16.6 in.	483 mm/19 in.
Depth	665 mm/26.2 in.	864 mm/34 in.
Height	86 mm/3.4 in.	89 mm/3.5 in.
Weight	Approximately 12.5 kg/27.56 lbs.(max) without Rack Mount Kit	

Table 13-5 Power specifications for the IBM 3581 2U

Power specifications	
AC line voltage	100 to 240 Vac
Line frequency	50 to 60 Hz auto-ranging
Line current at 100 Vac	1.3 A
Line current at 240 Vac	0.7 A
Maximum heat output	100 watts (86 KCAL/hr.)

Table 13-6 Acoustic specifications for the IBM 3581 2U

Acoustic Specifications		
Maximum noise level	**Idling**	**Operating**
	60 db (6.3 bels)	62 db (6.5 bels)

Table 13-7 Environmental specifications for the IBM 3581 2U

Environmental specifications				
Environmental factor	**Power on**	**Power off**[a]	**Storage**[b]	**Shipment**
Temperature	+10°C to +35°C	+10°C to +43°c	1°C to 60°C	-40°C to +60°C
Temperature Variation	10°C/Hr. max	10°C/Hr. max	10°C/Hr. max	10°C/Hr. max
Relative humidity (non-condensing)	15% to 85%	10% to 90%	10% to 90%	10% to 90%

Environmental specifications				
Wet Bulb (max)	26°C	27°C	29°C	29°C
Altitude	0 to 3048 m	0 to 2500 m	0 to 2500	0 to 12192

a. Indicated values are valid for the unpacked unit with no data cartridge. If there is a cartridge with the unit either inside or out, then the "Power On" specification must apply to the "Power Off" situation.
b. Indicated values are valid for the packaged unit. The storage period should not exceed three years. The limits are for the ambient temperature within 1 meter from the packaged unit.

Note: The operating environment of the autoloader must not conflict with the media storage requirements. While the autoloader may be capable of operating at elevated temperatures for an extended period of time, the temperature could shorten the useful life of media that is stored in the autoloader. If media is stored in the autoloader for more than 10 hours, the storage temperature requirements for media should be met. It should be assumed that media stored in the autoloader will be 2 degrees above ambient room temperature when the autoloader is powered on.

13.6 Host platform and device drivers

The following no-charge codes indicate the server platform to which the IBM TotalStorage 3581 2U Tape Autoloader is attached:

- FC9210 attached to HP-UX system
- FC9211 attached to Sun systems
- FC9212 attached to Windows systems
- FC9213 attached to Non-IBM systems
- FC9215 attached to Linux systems
- FC9216 attached to zSeries Linux (F38 model only)
- FC9400 attached to i5/OS or OS/400 system
- FC9600 attached to AIX system

A device driver is additional code on the host server platform that enables it to recognize and talk to a peripheral device (in this case, the IBM 3581 2U). Sometimes the driver code is supplied as part of the operating system code (such as in OS/400), sometimes a software patch is required, and sometimes the driver is installed separately from a CD or diskette (either an operating system CD or provided with a vendor application).

The library is shipped with the device drivers to support the following operating environments at the minimal levels shown:

- OS/400 V5R1 or later
- AIX V5.1, 5.2 or later
- Sun Solaris 7, 8, or 9
- Microsoft Windows NT Server 4 SP6 or later
- Microsoft Windows 2000 (build 2195 or greater)
- Microsoft Windows 2003 (build 3790 or greater)
- HP-UX 11.0, HP-UX 11i (64 bit) and 11i V2
- Linux distributions:
  - Red Hat Enterprise Linux 3
  - SuSE LINUX Enterprise Server 8, 9

Host software versions and release levels that support the IBM 3581 2U are listed at:

http://www.ibm.com/servers/storage/tape/3581/interop.html

13.6.1 Device driver installation

Install the IBM device drivers for the IBM 3581 2U as follows:

- If you intend to use the IBM 3581 2U with a commercial software application (such as VERITAS Backup Exec or EMC Legato NetWorker), refer to that application's installation instructions to install the device driver and configure the IBM 3581 2U.
- If you do not intend to use the IBM 3581 2U with a commercial software application, install the tape and medium device driver from the CD that ships with the drive. Refer to the installation instructions in the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430, which ships on the CD with the driver code.

> **Tip:** The device driver CD that ships with the IBM 3581 2U may not contain the device drivers with the most recent level or the device drivers for all supported systems.

13.7 Media

One Ultrium Cleaning Cartridge and one Ultrium 200 GB Data Cartridge are included with each order. Additional data and cleaner cartridges are optional and have to be ordered, as needed, using the appropriate feature codes:

- FC8002 provides a single Ultrium Cleaning Cartridge - maximum of 5.
- FC8101 provides a single 200 GB Ultrium 2 Data Cartridges - maximum of 20.
- FC8301 provides a single 400 GB Ultrium 3 Data Cartridges - maximum of 5.

Subsequent to the initial order, additional supplies can be ordered from the IBM media business or a third-party media vendor. Refer to Appendix A, "IBM LTO Ultrium and 3592 media" on page 393 for details about ordering supplies and cartridges, with or without labels.

13.7.1 Media compatibility

Ultrium 2

The Ultrium 2 Tape Drive is compatible with the cartridges of its predecessor, the Ultrium 1 Tape Drive. Cartridge compatibility for the Ultrium 2 Tape Drive is as follows:

- Reads and writes Ultrium 2 format on Ultrium 2 cartridges
- Reads and writes Ultrium 1 format on Ultrium 1 cartridges
- Does not write Ultrium 2 format on Ultrium 1 cartridges
- Does not write Ultrium 1 format on Ultrium 2 cartridges

Ultrium 3

The Ultrium 3 Tape Drive is compatible with the cartridges of its predecessors, the Ultrium 2 and Ultrium 1 Tape Drive. Cartridge compatibility for the Ultrium 3 Tape Drive is as follows:

- Reads and writes Ultrium 3 format on Ultrium 3 cartridges
- Reads and writes Ultrium 2 format on Ultrium 2 cartridges
- Reads Ultrium 1 format on Ultrium 1 cartridges
- Does not write Ultrium 3 format on Ultrium 2 cartridges
- Does not write Ultrium 2 format on Ultrium 3 cartridges

13.8 IBM 3581 2U initial setup

The following section covers some of the major items required to implement, manage, and operate the IBM 3581 2U. It does not cover all tasks and we do not intend to cover all of the specific commands. For more details, refer to the *IBM TotalStorage 3581 Tape Autoloader Setup, Operator, and Service Guide*, GA32-0470.

13.8.1 SCSI ID

The IBM 3581 2U´s drive must be assigned a unique ID to be recognized by and to be able to communicate with the server (host). The IBM 3581 2U comes with a default SCSI ID 2 for the drive. The SCSI ID can be changed by using the OCP. When the IBM 3581 2U is the last device on the SCSI string, be sure that the proper SCSI terminator is installed; for example, when the optional HVD converter is installed the HVD terminator should be installed.

13.8.2 Storage element addressing

Storage element addresses (also called *element numbers*) identify the physical location within the IBM 3581 2U. This information is needed, for example, when testing the IBM 3581 2U with ntutil. Table 13-8 shows the storage element addresses and indexes.

Table 13-8 IBM 3581 2U element numbers and element indexes

Element	Element number (hex)	Element indexes
Cartridge Slot 1	1 (1h)	1
Cartridge Slot 2	2 (2h)	2
Cartridge Slot 3	3 (3h)	3
Cartridge Slot 4	4 (4h)	4
Cartridge Slot 5	5 (5h)	5
Cartridge Slot 6	6 (6h)	6
Cartridge Slot 7	7 (7h)	7
Cartridge Slot 8	8 (8h)	8
Cartridge Loader and carousel	82 (52h)	
Tape Drive	86 (56h)	

13.8.3 Operator Control Panel

The Operator Control Panel (OCP) is an interface between the operator and the IBM 3581 2U. See Figure 13-4 on page 349. All changes can be performed using the OCP. The OCP can be password-protected. The default setting of the IBM 3581 2U is Off.

The OCP contains four LEDs (light-emitting diodes), a display, and four push buttons.

The four LEDs contains status information about:

READY/ACTIVITY (green) Turns on any time the autoloader is powered on and able to function. This LED should blink whenever there is autoloader or tape drive activity.

CLEAN DRIVE (amber) Turns on when the tape drive needs to be cleaned. This LED will turn off after the drive is cleaned.

MEDIA Important	(amber) Turns on when there has been a failure that indicates that there is a piece of media that is bad, marginal or invalid. This LED will turn off when all marginal and invalid cartridges have been exported from the autoloader.
ERROR	(red) Turns on when there is an unrecoverable tape drive or autoloader failure. This LED should turn on at the same time the error message is displayed on the window and will remain on until the error state is resolved.

Figure 13-4 IBM 3581 2U Operator Control Panel

Two menus are available when using the Operator Control Panel: the Online menu and the Offline menu.

Online menu

After powering on the autoloader, the Online Menu is available (see Figure 13-5). The Online Menu contains the Information Menu and Go Offline.

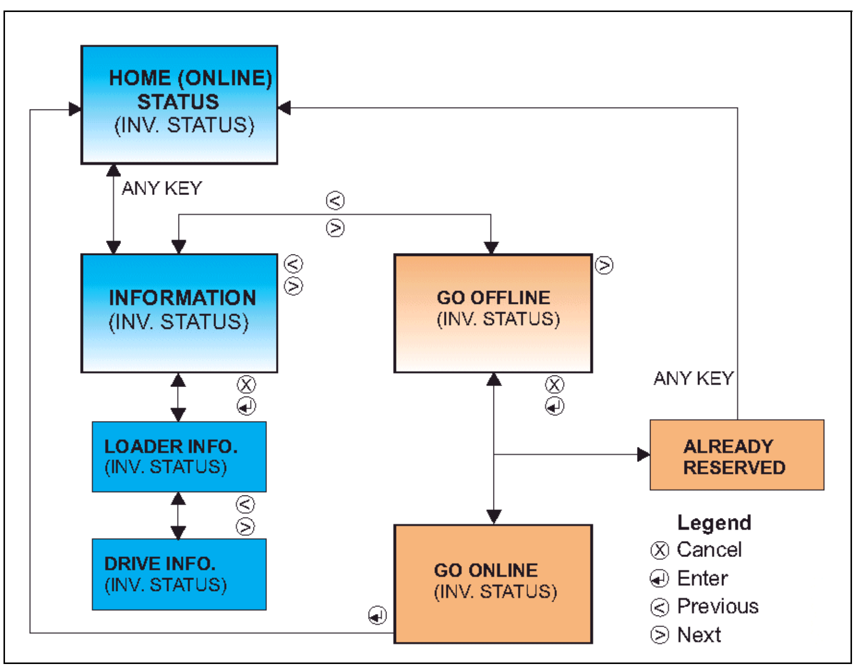


Figure 13-5 3581 2U Online Menu

Offline menu

After logging on from an RMU or going offline from the OCP, the user has access to the Offline Menu. The contents of the Online Menu depend on whether you are logging on with a SCSI (IBM 3581-L28/L38/L3H) or a native Fibre Channel (IBM 3581-F28/F38/F3H) drive. See Figure 13-6 and Figure 13-7 on page 351, respectively.

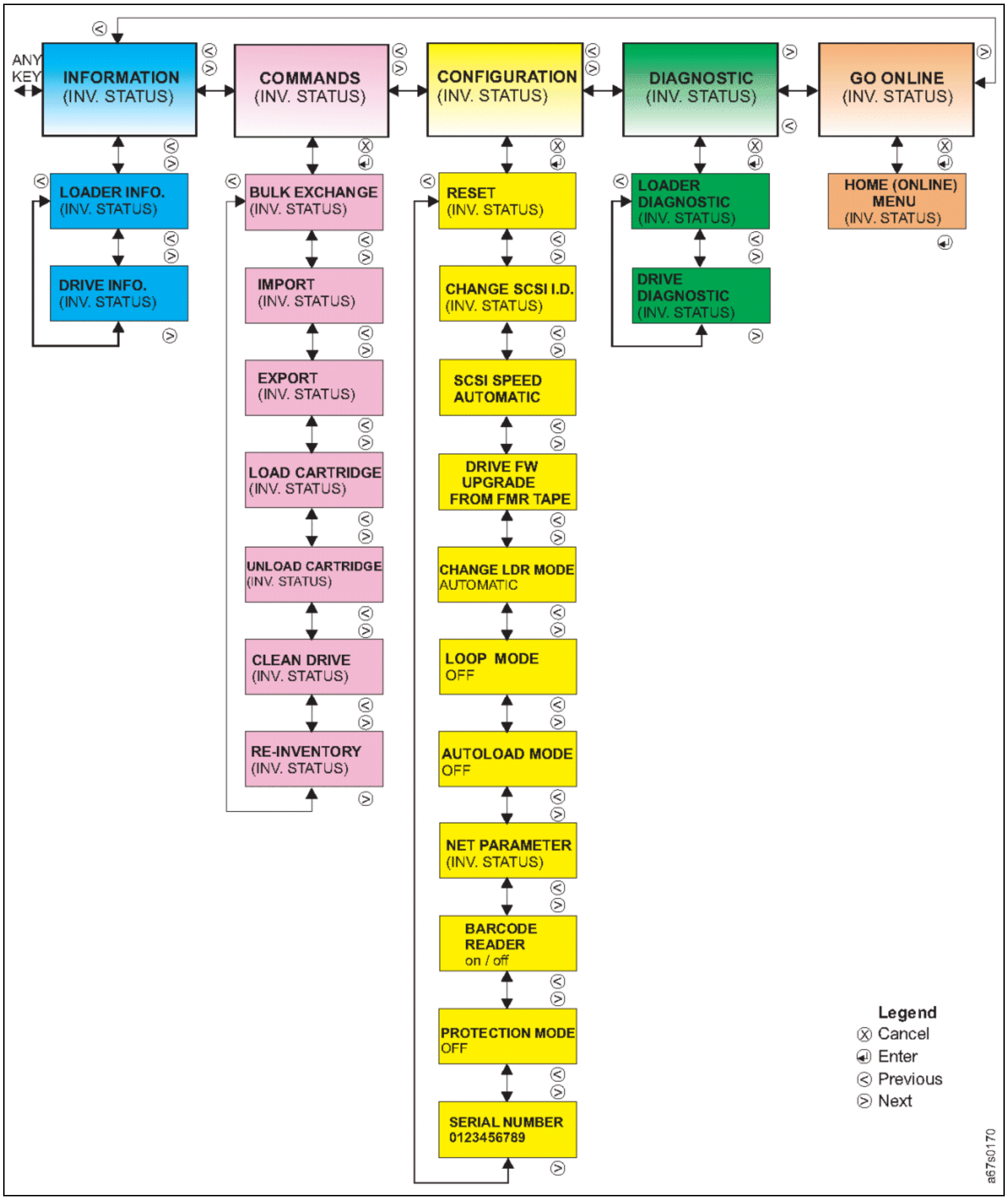


Figure 13-6 3581 2U Online Menu: SCSI drive

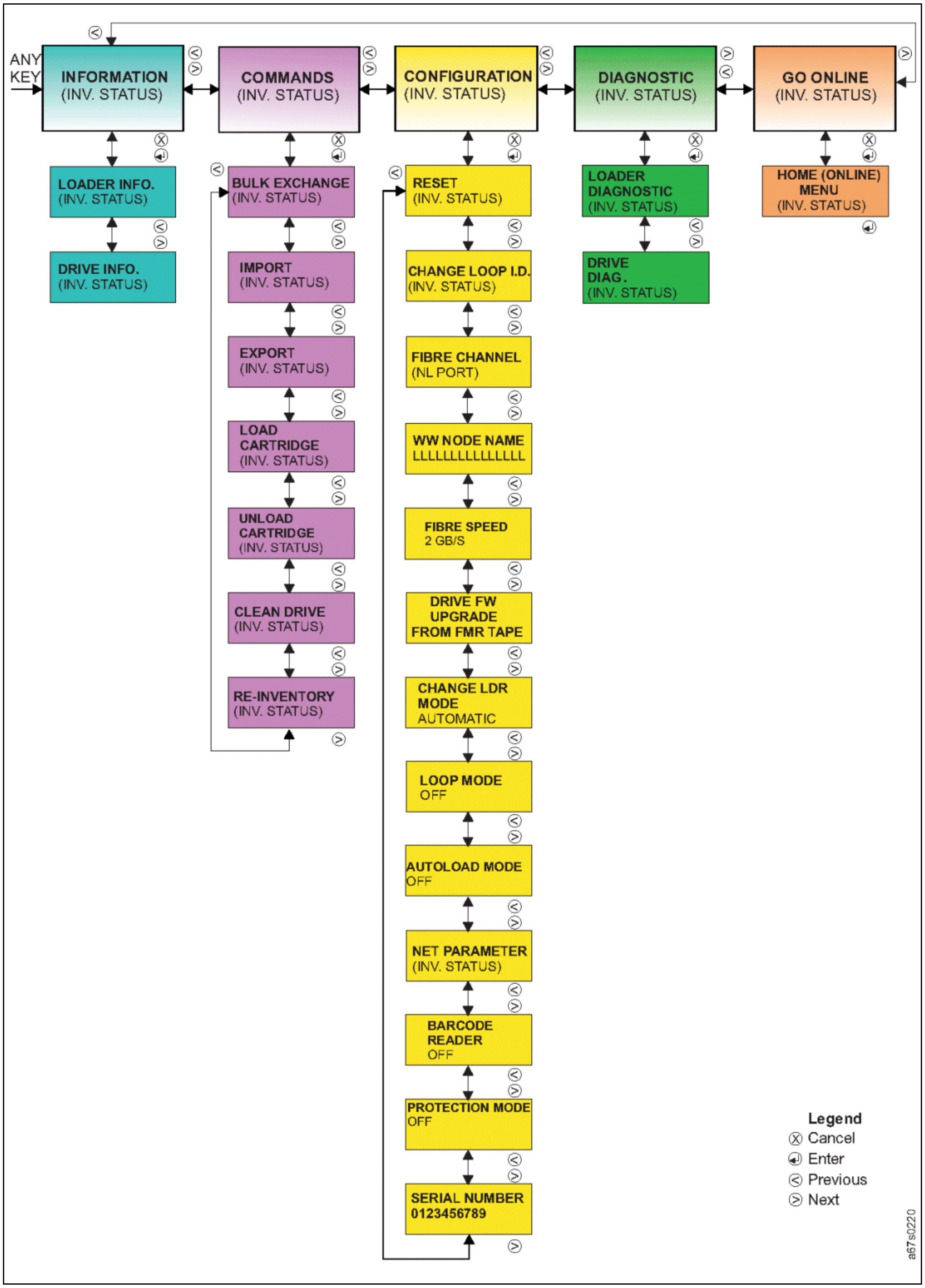


Figure 13-7 3581 2U Offline Menu - Fibre Channel drive

Each menu is accessible through the Operator Control Panel push buttons. Refer to the *IBM TotalStorage 3581 Tape Autoloader Setup, Operator, and Service Guide*, GA32-0470, for all menu items.

13.9 Firmware upgrades

At installation time, you should make sure the current firmware is installed on your IBM LTO tape drives and library. As the IBM 3581 2U is designated as a Customer Setup Machine, it is the customer's responsibility to have the current firmware installed. Determine the latest level of firmware available from the IBM Technical Support Web sites:

http://www.ibm.com/servers/storage/support/lto/3581-2u/
ftp://index.storsys.ibm.com/358x/

The following methods can be used for upgrading the firmware:

- Using the serial interface and a communication program such as HyperTerminal (Windows).

  This method must be used when the optional RMU is not installed.

- Using the optional RMU interface.

  The RMU uses the Ethernet interface for upgrading the firmware.

- Using ntutil, tapeutil, or both.

  Ntutil and tapeutil use the SCSI interface or Fibre Channel interface for upgrading the firmware. ntutil and tapeutil are both part of the IBM driver.

- Using LTO-TDX.

  This tool, LTO-TDX, is an alternative method for downloading LTO drive firmware across the SCSI bus or Fibre Channel. In addition, this tool can be used to upload LTO drive error dumps. The tool supports all IBM LTO Generation 1 and Generation 2 SCSI and Fibre Channel drives. The tool *will not* support any other manufacturer's LTO drive.

- Follow the instructions for updating your firmware in the *IBM TotalStorage 3581 Tape Autoloader Setup, Operator, and Service Guide*, GA32-0470.

Note: AS/400, iSeries and System i clients can update the autoloader and drive firmware using the serial interface. The Field Microcode Replacement (FMR) upgrade function is not supported on the IBM 3581 2U.

Only the *drive* firmware can be updated with the LTO-TDX tool.

The LTO-TDX is supported on Windows, Linux, and NetWare operating systems. The LTO-TDX tool can be downloaded from:

ftp://ftp.software.ibm.com/storage/358x/tools/

14

IBM TotalStorage 3582 Tape Library

The IBM TotalStorage 3582 Tape Library (IBM 3582) is an entry-level tape library that can accommodate one or two Ultrium 2 or Ultrium 3 drives, shown in Figure 14-1 on page 354. It is a high-performance, reliable, scalable tape subsystem. Designed for tape automation, you can attach the IBM TotalStorage 3582 Tape Library to iSeries, pSeries, zSeries Linux, xSeries, Intel (running Windows or Linux), Sun SPARC, Hewlett-Packard, and other Open Systems using SCSI or Fibre Channel attachment. It uses the IBM Ultrium tape drives for fast data transfer and reliability in automated library service. Each aspect of the library subsystem has been optimized for repeated, reliable unattended tape handling.

14.1 Model description

The IBM 3582 can have one or two IBM Ultrium 2 or Ultrium 3 tape drives. Ultrium 2 has a native data transfer rate of 35 MB/s and a cartridge capacity of 200 GB, while Ultrium 3 supports 80 MB/s and 400 GB native. The drives feature data compression hardware using an adaptation of the IBM LZ1 compression algorithm that provides an effective 2:1 compression rate.

The IBM 3582 has one I/O slot plus additional cartridge capacity of 23 slots (24 slots in all), allowing a native capacity of 4.8 TB/9.6 TB of uncompressed data (with Ultrium 2/3 drives respectively). With compression (assuming 2:1), the IBM 3582 can store 9.6 TB/19.2 TB of data (with Ultrium 2/3 drives). These capacities assume that the I/O slot has been configured as an additional storage slot, increasing the overall library capacity.

The IBM 3582 is an excellent high-performance, entry-level choice for entry-level and midrange systems.

Figure 14-1 IBM TotalStorage 3582 Tape Library

The IBM TotalStorage 3582 Tape Library supports all three Ultrium 2 drive types: Ultrium 2 Low-Voltage Differential (LVD), Ultrium 2 High-Voltage Differential (HVD), and Ultrium 2 FC, as well as the two Ultrium 3 types: Ultra 160 LVD and FC. The drives can be intermixed. The IBM 3582 comes standard with multi-path architecture and the ability to partition the library into two logical libraries. The library can be configured as a standalone unit or mounted in an industry-standard 19-inch rack. Additional optional features include control path failover in AIX, Windows, HP-UX, Solaris, and Linux environments, and a Remote Management Unit/Specialist (RMU) for remote library management.

LTO1 tape cartridges are also supported for read-only access.

Table 14-1 IBM 3582 model summary

Model	Cartridge slots	Data capacity (native)	Data capacity (compressed)	IBM Ultrium tape drives
3582-L23	23[a]	4.6 TB LTO2 9.2 TB LTO3	9.2 TB LTO2 18.4 TB LTO3	1-2

a. The one I/O station slot can be assigned as an additional storage slot. If this is done, the library native capacity is 4.8 TB/9.6 TB and compressed capacity is 9.6 TB/19.2 TB.

14.1.1 Tape drives

The IBM 3582 can use the Ultrium 2 and Ultrium 3 drives.

It is mandatory to have at least one IBM Ultrium drive installed in the IBM 3582. An additional Ultrium drive may be added at the initial order or as a field upgrade performed by the client.

The drives may be any mixture of LVD, HVD, or Fibre Channel. The drives are ordered for plant or field installation using chargeable feature codes. Plant installation will be one or two drives of the same type; however, field installation allows any mixture of available drives.

For an Ultrium 3 initial order:

- FC8033 provides one IBM Ultrium 3 tape drive with a Low Voltage Differential (LVD) Ultra160 SCSI Connection.
- FC8035 provides one IBM Ultrium 3 tape drive with a native 2 Gb Fibre Channel Connection.

Table 14-2 on page 357 shows other feature codes, including those used to order Ultrium 2 drives.

Each IBM Ultrium tape drive contains the electronics and logic for reading and writing data, control of the tape drive, management of the data buffer, and error-recovery procedures. All tape drives are packaged as a common assembly that is a Field Replaceable Unit (FRU), designed for quick removal and replacement.

14.1.2 Cartridge storage

As well as the installed tape drives, the library enclosure contains cartridge storage slots, arranged in two rows. The row toward the front of the library is made of two removable magazines of seven slots each. The row toward the rear of the library contains nine slots (Figure 14-3 on page 356). The magazines are designed so that tape cartridges can only be inserted in the proper orientation. Once inserted, the tape cartridges will be retained in the magazine so that they remain in place even when the magazine is inverted and shaken lightly. The magazines can only be inserted one way into the mounting columns in the library.

In Figure 14-2, one magazine is loaded and the other is removed.

Figure 14-2 IBM 3582 seven-slot magazines

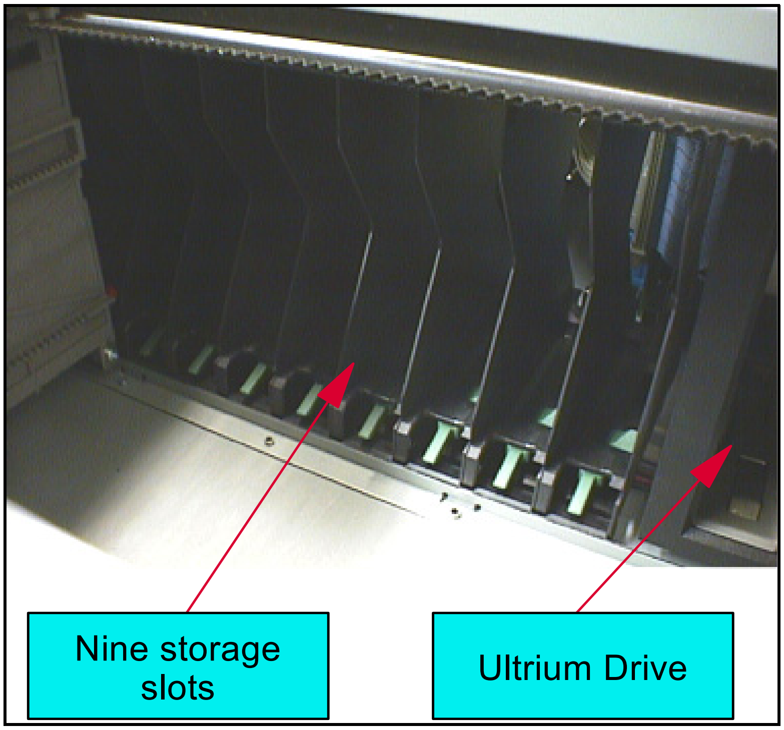


Figure 14-3 IBM 3582 rear-mounted storage slots

14.1.3 Barcode scanner

A barcode scanner is provided as standard with the IBM 3582, and it does not affect the slot capacity. The barcode scanner is used during the inventory process to locate all cartridges inserted into the library. This action is repeated every time the front door is opened to ensure that the inventory is updated if a cartridge has been manually added, moved, or removed while the door was open.

14.1.4 I/O station

This facility enables the insertion and ejection of cartridges without interrupting the normal operation of the library. There is a single-slot I/O station where a cartridge can be inserted or ejected by opening the I/O station door.

14.1.5 Robotic system

In conjunction with the library control microcode, the robotic system identifies and moves cartridges between the storage slots, tape drives, and the I/O station. It has a number of components:

- A cartridge picker for placing cartridges in storage slots, tape drives, or the I/O station
- A barcode scanner used to set up the library initially when it identifies the types of storage arrays and tape drives installed in the library, and in normal operation for reading the external labels on the cartridges, when it locates and categorizes all cartridges installed in the library
- X-axis and Z-axis drive motors for moving the picker assembly inside the library enclosure

14.1.6 Library control and operation

The library control unit contains the electronics and logic for autochanger operations. It controls all operations in the IBM 3582, including the interaction between the library and operators. The control unit Licensed Internal Code creates and maintains the library configuration, the physical location of the robotic system, and the inventory of cartridges. The database is kept in the flash memory of the library control hardware.

Requests issued from the server result in cartridge movement in the library. The primary requests issued are for mounting and dismounting cartridges to and from the tape drives and for inserting and ejecting cartridges. The host has records of the physical location of a cartridge in the library, and the physical location is also managed by the library.

In addition to requesting movement of cartridges in the library, the host can obtain status, performance, configuration information, and information about the cartridges stored in the IBM 3582.

Each cartridge must have a machine- and operator-readable external barcode label to identify a media cartridge in the library during initial inventory and any time a cartridge is added to the library. The library stores the physical location of the cartridge in an inventory database based on the cartridge label. All host application requests for operations involving movement or use of a cartridge need only reference the physical location of the cartridge (using an element number as described in 14.10.3, “Identifying library location element numbers” on page 364) for the library to perform the request.

14.1.7 Operator Panel

An LCD operator control panel on the front of the machine provides status information and menu options. From this panel the operator can initiate actions such as moving and loading tape cartridges or invoking diagnostics.

14.1.8 Maintenance

The cartridge storage slots, cartridge picker, and tape drives are accessed for maintenance purposes by opening the front door of the library. The tape drives, power supplies, and host interface board are reached from the back of the library.

14.2 Feature codes

The IBM 3582 can be ordered and upgraded with the feature codes shown in Table 14-2. We have not included the various cabling options, or some options referring to LTO2; refer to the product publications for detailed information about configuring and ordering.

Table 14-2 IBM 3582 feature codes

Feature	Description	Comment
1660	RMU/Specialist	Required for FC
1680	Control Path Failover	
1681	Data Path Failover	Ultrium 3 FC only
2200	standalone Kit	
7003	Rack Mount Kit	

Feature	Description	Comment
8002	1 cleaning cartridge	Plant only; see 14.8, “Media” on page 362 for details.
8033	Ultrium 3 LVD drive	
8035	Ultrium 3 Native FC drive	
8034	Ultrium 3 LVD drive	Client setup
8036	Ultrium 3 Native FC drive	Client setup
8103	Ultrium 2 LVD drive	
8104	Ultrium 2 HVD drive	
8105	Ultrium 2 Native FC drive	
8203	CSU Ultrium 2 LVD drive	Client setup
8204	CSU Ultrium 2 HVD drive	Client setup
8205	CSU Ultrium 2 Native FC drive	Client setup
8305	5 Ultrium 3 data cartridges	
8320	20 Ultrium 3 data cartr.	
9210	Attached to HP-UX	
9211	Attached to Sun	
9212	Attached to Windows	
9213	Attached to other non-IBM	
9215	Attached to Linux	
9216	Attached to zSeries Linux	
9400	Attached to iSeries, AS/400	
9600	Attached to pSeries AIX	

14.3 Physical attachments

The IBM 3582 can be attached to iSeries, pSeries, IBM RS/6000, xSeries, zSeries Linux, Intel, Sun, and HP systems, that support the Ultra/Wide SCSI HVD, Ultra2/Wide SCSI LVD, and Fibre Channel interface.

SCSI or Fibre Channel cables and appropriate interposers, as required, should be ordered for attachment to a server. A power cord feature code also should be specified.

The IBM 3582 may be compatible with other servers, operating systems, SCSI adapters, and HBAs. Contact your local IBM representative for a current list of supported open system configuration and software vendors, or go to:

http://www.ibm.com/servers/storage/tape/3582/interop.html

14.4 Cabling

Cables are required to attach tape drives in the IBM 3582 to each server connection (up to the number of tape drives installed). An interposer also may be required for attachment to various server adapters. One or more of the following Fibre Channel or SCSI cables should be specified on the IBM 3582.

The following specifications are primarily for the Ultrium 3 devices. There may be some other options available for the Ultrium 2. Refer to the product publications for detailed information about configuring and ordering.

14.4.1 Fibre Channel cables

A Fibre Channel cable is required to attach an IBM 3582 with the Fibre Drive feature (FC8035 or FC8036) to host Fibre Channel adapters, Fibre Channel switches, or other Fibre Channel components. The IBM LTO Ultrium 3 Fibre Tape Drive (FC8035 or FC8036) comes with an LC Duplex connector.

Features available for Fibre Channel cables, and their respective lengths, are:

- FC5907: 7 m SC-LC Fibre Channel Cable
- FC5913: 13 m SC-LC Fibre Channel Cable (LTO2 only)
- FC5922: 22 m SC-LC Fibre Channel Cable
- FC5961: 61 m SC-LC Fibre Channel Cable
- FC6005: 5 m LC-LC Fibre Channel Cable
- FC6013: 13 m LC-LC Fibre Channel Cable (LTO2 only)
- FC6025: 25 m LC-LC Fibre Channel Cable
- FC6061: 61 m LC-LC Fibre Channel Cable

14.4.2 SCSI cables

A SCSI cable is required to attach an IBM 3582 with an IBM LTO Ultrium 3 LVD Tape Drive feature (FC8033 or FC8034) to each server connection (up to the number of tape drives installed). At least one SCSI cable should be specified on the initial plant order. A SCSI terminator is included with each IBM Ultrium Tape Drive. An interposer or interposers may be required for attachment to various server adapters. Clients are responsible for selecting and ordering the correct cables and interposers to match the IBM LTO Ultrium SCSI interface and the server SCSI interface. An interposer may also be required for attachment to various server adapters.

The IBM LTO Ultrium 3 Tape Drives come with an HD68 connector for SCSI attachment. Features for specifying SCSI cables available for LVD Ultra160 SCSI attachment, and their respective lengths, are as follows for LTO3 attachments.

Cables with HD68 connector on both ends:

- FC5302: 2.5 m (8.2 feet) SCSI cable
- FC5305: 5 m (16.5 feet) SCSI cable (LTO2 only)
- FC5310: 10 m (33 feet) SCSI cable

The following cables differ in that they have a VHDCI connector at one end.

Cables with a VHDCI connector on one end and an HD68 connector on the other end:

- FC5602: 2.5 m (8.2 feet) SCSI cable
- FC5604: 4.5 m (14.5 feet) SCSI cable
- FC5610: 10 m (33 feet) SCSI cable

14.4.3 Interposers

An interposer may be required to connect a Fibre cable with LC Duplex connectors to another SC Duplex connector. The following interposer is available:

- FC5096: Interposer SC-LC Fibre

An interposer may be required to connect a SCSI cable with HD68 connectors to another connector. The following interposer is available

- FC5099: VHDCI/HD68 cable/interposer

  This interposer (a 0.3 m cable) has a male mini-68-pin VHDCI connector on one end and a female 68-pin HD68 connector on the other.

14.4.4 SCSI length limitations

The overall LVD SCSI cable length is limited to 25 m (81 feet) using point-to-point interconnection. If using multi-drop interconnection, then the overall LVD SCSI cable length is limited to 12 m (39 feet). The stub length at each device must not exceed 0.1 m (0.33 feet).

14.5 Environmental specifications

The IBM TotalStorage 3582 Tape Library is a standalone, medium-sized library unit that can be placed on a desk or in a rack.

The IBM 3582 has one or two drives and 23 cartridge slots, plus a single-slot I/O station. The physical dimensions are:

- Width: 45.5 cm (17.9 in.)
- Depth: 66.0 cm (26.0 in.)
- Height: 19.4 cm (7.7 in.) for a standalone library on casters
- Maximum weight: 30.3 kg (66.7 lb.) with two drives
- 4 EIA units high (if rack-mounted)

14.6 Host platforms and device drivers

The following no-charge codes indicate the server platform to which the IBM 3582 is attached:

- FC9210: attached to HP-UX
- FC9211: attached to Sun system
- FC9212: attached to Windows 2000 or Windows 2003 system
- FC9213: attached to other non-IBM system
- FC9215: attached to Linux system
- FC9216: attached to zSeries Linux system
- FC9400: attached to iSeries, AS/400 system
- FC9600: attached to pSeries, RS/6000 system

A device driver is additional code on the host server platform that enables it to recognize and talk to a peripheral device (in this case, the IBM 3582). Sometimes the driver code is supplied as part of the operating system code (such as in OS/400), sometimes a software patch is required, and sometimes the driver is installed separately from a CD or diskette (either an operating system CD or provided with a vendor application).

The library is shipped with the device drivers to support the following operating environments at the minimal levels shown:

- AIX 5L, V5.1
- Solaris 8, or 9
- Windows 2000 (build 2195)
- Windows 2003 (build 3790)
- HP-UX 11.0, 11.i (64 bit)
- OS/400 V5R1 or later
- Linux distributions: Red Hat Enterprise Linux version 3, SUSE LINUX Enterprise Server 8

For a detailed list of currently supported operating systems and host adapters, refer to:

http://www.ibm.com/servers/storage/tape/3582/interop.html

> **Tip:** The device driver CD or diskette that is shipped with the IBM 3582 may not contain the device drivers with the most recent level or the device drivers for all supported systems. Always check the following FTP site for the latest device drivers:
>
> ftp://ftp.software.ibm.com/storage/devdrvr/

14.6.1 Device driver installation

Install the IBM device drivers for the IBM 3582 as follows:

- If you intend to use the IBM 3582 with a commercial software application (such as IBM Tivoli Storage Manager, VERITAS Backup Exec, or EMC Legato NetWorker), refer to that application's installation instructions to install the device driver and configure the IBM 3582.
- If you do not intend to use the IBM 3582 with a commercial software application, install the tape and medium device driver from the CD that is shipped with the drive. Refer to the installation instructions in *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430, which is supplied on the CD with the driver code.

> **Note:** If you use the IBM 3582 with a commercial software application, IBM recommends that you install any IBM-supplied device driver only if instructed to do so in the installation instructions supplied by the vendor of the application. Otherwise, if the application supplies its own driver code, then conflicts could occur over which driver controls the drive. Many examples using Ultrium drives are given in the Redbooks *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

14.7 Storage applications

The software for managing the IBM 3582 is not provided with the library. It is not really feasible to use the IBM 3582 without some additional application software to manage the slots and cartridge inventory. Additional software support is available through library management software products, which can be obtained separately from IBM, IBM Business Partners, or independent software providers. A list of compatible software is available at this Web site (look for product details and interoperability):

http://www.ibm.com/servers/storage/tape/lto/lto_isv.html

You will find details for each application including Ultrium 2 and Ultrium 3 support and specific Ultrium models and attachment methods. Contact your storage application vendor for more detailed information about specific versions and supported platforms.

14.8 Media

An Ultrium cleaning cartridge and a pack of 5 or 20 Ultrium 3 data cartridges can be included with the 3582 order[1]. Additional Ultrium 3 or Ultrium 2 data and cleaning cartridges may be ordered as chargeable features for the IBM 3582. Refer to the product publications for further information about ordering.

- FC8305 provides a five-pack 400 GB Ultrium 3 Data Cartridge.
  Up to five features can be ordered. The cartridges come with a barcode label, but it is not affixed.
- FC8002 provides a single Ultrium Cleaning Cartridge.
  It is a chargeable feature, and a maximum of five can be ordered.
- FC8320 provides a pack of twenty 400 GB Ultrium 3 Data Cartridges
  Up to four features can be ordered. The cartridges come with a barcode label, but it is not affixed.

Subsequent to the initial order, additional supplies may be ordered from the IBM media business or a third-party media vendor. Refer to Appendix A, "IBM LTO Ultrium and 3592 media" on page 393 for details about ordering supplies and cartridges, with or without labels.

14.8.1 Ultrium 2 media

These feature codes are required to order Ultrium 2 media (plant install) with your IBM 3582:

- FC8101 provides a five-pack 200 GB Ultrium 2 Data Cartridge.
  Up to four FC8101 features can be ordered. The cartridges come with a barcode label but it is not affixed.
- FC8002 provides a single Ultrium Cleaning Cartridge.
  It is a chargeable feature, and a maximum of five can be ordered.
- FC8110 provides a pack of twenty 200 GB Ultrium Data Cartridges with unattached barcode labels. A maximum of four can be ordered.

14.9 Installation and performance considerations

When attaching to an iSeries, only one drive per input/output port is allowed for maximum performance. Installing more than one Ultrium tape library on an I/O port may affect drive performance.

Installing more than one Ultrium drive on a SCSI bus may affect tape drive performance. For optimal performance, we recommend that no more than one IBM Ultrium drive be attached to an individual SCSI bus.

Intermixing of other SCSI devices on the same SCSI bus as the IBM 3582 can affect performance of those devices.

While IBM Ultrium tape drives provide the capability for high tape performance, other components of the system can limit the actual performance achieved. The compression technology used in the tape drive can typically double the amount of data that can be stored on the media; however, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

[1] All media and cleaning cartridges are warranted separately from the IBM 3582.

The IBM 3582 has multi-path architecture; see 2.4.7, “Multi-path architecture” on page 79 for more information. This means the library can be logically divided into two separate physical libraries with one drive each, a seven-slot magazine each, and a pre-determined number of slots in the rear storage area of the IBM 3582. If the I/O slot is defined it can be shared.

14.10 IBM 3582 initial setup

The following section covers some of the major items required to implement, manage, and operate the IBM 3582 Tape Library. It does not cover all tasks and we do not intend to cover all of the specific commands. For more details, refer to the *IBM TotalStorage 3582 Tape Library Setup, Operator, and Service Guide*, GA32-0458.

14.10.1 Fibre Channel

Ultrium Fibre Channel drives offer a 2 Gbps interface with 200 MB/s, serial-communications technology capable of interconnecting when separated by as much as 10 km (7 miles). You can establish Fibre Channel connections between Fibre Channel ports that reside in the library, one or more servers, and the network interconnecting them. The network can consist of such elements as switches, hubs, bridges, and repeaters used in the interconnection.

Each library Fibre Channel tape drive must have a Fibre Channel Loop ID and corresponding Arbitrated Loop Physical Address (AL_PA) to communicate in a Fibre Channel topology. Table 14-3 lists the default Fibre Channel Loop IDs and AL_PAs for each drive in the library. The Fibre Channel Loop IDs are given in decimal format and the AL_PA values are given in the hexadecimal format.

Table 14-3 Fibre Channel IDs

Drive	Fibre Channel Loop ID	AL_PA
1	17	X’CC’
2	18	X’CB’

You can change a Fibre Channel Loop ID by using the library’s Operator Panel or RMU. Using a method called hard addressing, the drive then automatically selects the corresponding AL_PA, which is the identifier that devices use to communicate. Valid Fibre Channel Loop ID values range between 0 and 125. The higher the number of the Fibre Channel Loop ID (and AL_PA), the lower the priority of the device in the loop.

You can also specify Fibre Channel Loop IDs that allow the drive to dynamically arbitrate the AL_PA with other Fibre Channel devices on the loop. This method avoids conflicts over the address and is called soft addressing. To dynamically arbitrate the AL_PA, specify a Fibre Channel Loop ID of 126 or 127.

14.10.2 SCSI ID

The IBM 3582 has one or two SCSI devices/addresses: the two drives. The default settings for the SCSI IDs are 0 and 1. Depending on your requirements, you may have to change the SCSI ID default settings for your installation.

The IBM 3582 uses a path through one or more of the tape devices to access the tape library robot. The tape device is LUN 0, and the library robot will be LUN 1. A SCSI ID does not have to be set for the library robot.

The IBM 3582 is a SCSI target device and it can be connected to a single-ended, Low Voltage Differential or High Voltage (Ultrium 2 only) Differential SCSI bus. The SCSI bus must be terminated, and a terminator is shipped with each drive.

14.10.3 Identifying library location element numbers

To manipulate the media within the library, the host must reference each movement with source and target designations. This is done via element addressing, which specifies precisely which slots within the library are to be used. Table 14-4 shows the element addressing scheme used for the unpartitioned IBM 3582.

Table 14-4 IBM 3582 element numbering

Column	Element numbers
Picker	1
I/O station	16
Drives	256 - 257
Storage	4096 - 4116

Drives are addressed left to right.

The I/O station is a single slot. Storage slots are addressed from left to right, front first and then back.

14.11 Operator displays and buttons

Normally, the host issues commands to the IBM 3582 Tape Library. Operator control is provided via the Operator Panel. The operator is responsible for:

- Starting the IBM 3582 Tape Library
- Shutting down the IBM 3582 Tape Library
- Handling media

Refer to the *IBM TotalStorage 3582 Tape Library Setup, Operator, and Service Guide*, GA32-0458, for general procedures.

14.11.1 Operator Panel

The Operator Panel provides communication between the operator and the IBM 3582. Visual indications and push buttons enable the operator to control the IBM 3582.

As shown in Figure 14-4 on page 365, the IBM 3582 Operator Panel has two areas:

1. Operator Panel Keyboard

   The Operator Panel Keyboard is a five-button keypad that lets you control the library operations interactively. Using the Operator Panel, you can set library options, check library status, and diagnose errors.

2. Operator Panel Display

   The Operator Panel Display is an LCD on the library front panel that is used to display icons and text.

Figure 14-4 IBM 3582 Operator Panel

Menu options

Figure 14-5 shows the layout of the menu options on the Operator Panel.

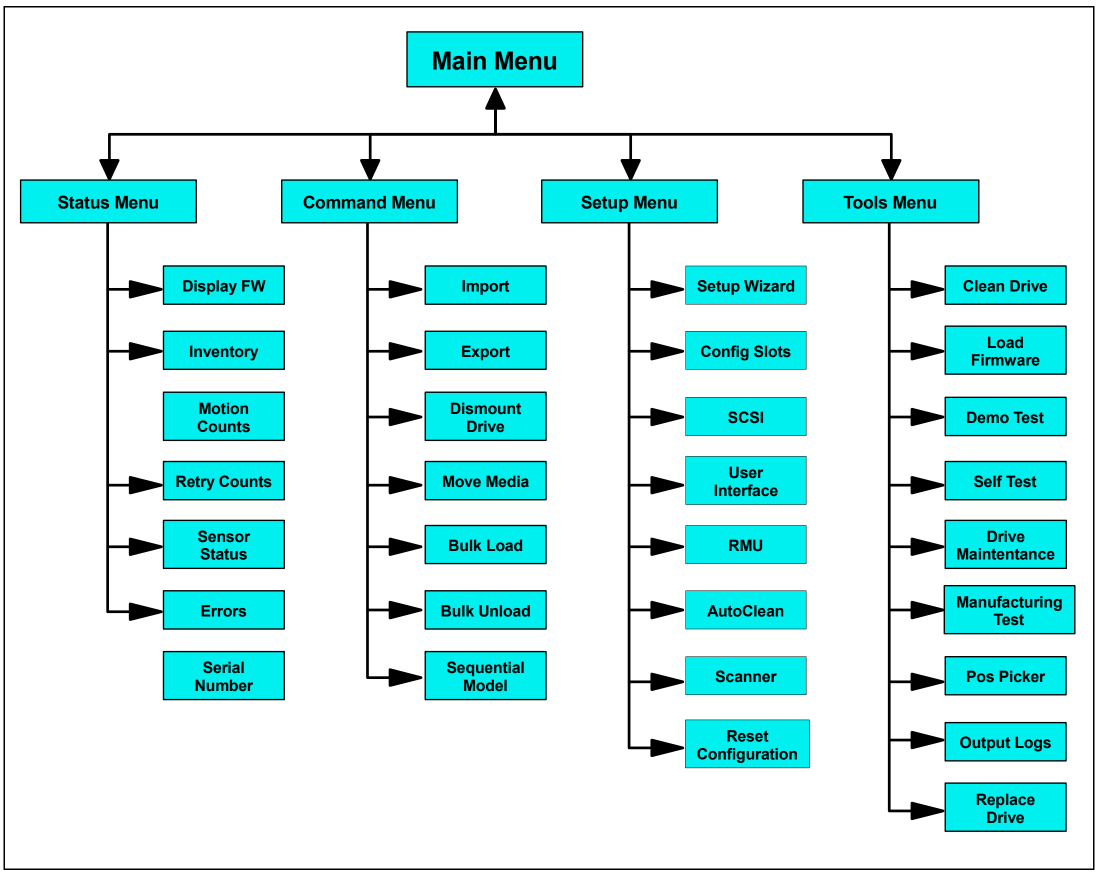


Figure 14-5 IBM 3582 top-level menu options

Each menu is accessible through the Operator Panel push buttons. The complete layout may change with the installed firmware. See the Operator section of the *IBM TotalStorage 3582 Tape Library Setup, Operator, and Service Guide*, GA32-0458, for details for all menu items.

Using commands that require an offline state

Some commands require that the library be in an offline state. If any such commands are attempted while the library is in an online state, the operator will be requested to take the library offline.

Operator intervention message

If a problem causes an operator intervention message to appear, refer to the Troubleshooting and Diagnostics section in the *IBM Total Storage 3582 Tape Library Setup, Operator, and Service Guide*, GA32-0458.

14.12 Library mode

The library operates in one of two modes: random mode or sequential mode.

Sequential mode is used with applications that recognize the tape drives, but not the medium changer. Tape cartridge locations and loading are managed by the library, and data is written to tapes in the order in which they are stored in the library.

Random mode is used with applications that recognize the medium changer and drives. The application manages the tape loading, slot positioning, and the order in which cartridges are used.

Libraries usually are set up using random mode.

14.13 Drive cleaning

All of the IBM Ultrium Tape Drives have an integrated cleaning mechanism that brushes the head at load time and again when unloading a cartridge. Drives also have a cleaning procedure that uses a special cleaning cartridge, should this become necessary.

Important: When cleaning the drive head, use only the IBM LTO Ultrium Cleaning Cartridge or an IBM-approved cleaning cartridge.

A specially labeled IBM LTO Ultrium Cleaning Cartridge should be ordered with each IBM 3582 Tape Library. The drive determines when the drive head needs to be cleaned, and alerts you by displaying `CT` on the message display. Additional preventive cleaning is discouraged.

14.14 Firmware upgrades

Each IBM Ultrium tape drive and tape library contains IBM Licensed Internal Code, often referred to as firmware. At installation time, you should make sure the current firmware is installed on your IBM LTO tape drives and library. As the IBM 3582 is designated as a Customer Setup Machine, it is the customer's responsibility to have the current firmware installed. Determine the latest level of firmware available from the IBM Technical Support Web site:

http://www.ibm.com/servers/storage/support/lto/3582/index.html

Click the **Download** tab, and click **Firmware**. Follow the instructions for updating your firmware in the *IBM TotalStorage 3582 Tape Library Setup, Operator, and Service Guide*, GA32-0458.

15

IBM TotalStorage 3583 Tape Library

The IBM TotalStorage 3583 Tape Library is a high-performance, reliable, scalable tape subsystem. Designed for tape automation, the IBM TotalStorage 3583 Tape Library (IBM 3583) can be attached to iSeries, pSeries, xSeries, zSeries, AS/400, RS/6000, Intel, HP, and Sun systems that support SCSI High-Voltage Differential (HVD), SCSI Low-Voltage Differential (LVD), and Fibre Channel interfaces.

It uses IBM Ultrium tape drives for fast data transfer and reliability in automated library service. Each aspect of the library subsystem has been optimized for repeated, reliable unattended tape handling. Multiple-drive models provide additional enhanced functions such as fast transfer of data, simultaneous backup, concurrent read-write operations, control path failover, and fault tolerance. The multi-path architecture enables a single library to be shared by multiple homogeneous or heterogeneous applications.

15.1 Model description

The IBM 3583 houses from one to six IBM Ultrium tape drives, which can have a native data transfer rate of up to 80 MB/s and a cartridge capacity of up to 400 GB, depending on whether it is an Ultrium 1, Ultrium 2, or Ultrium 3 drive. Any combination of the different Ultrium drives may be installed. (Note that the Ultrium 1 tape drive was withdrawn from marketing on October 1, 2004.)

Figure 15-1 IBM TotalStorage 3583 Tape Library

The drives feature data compression hardware using an adaptation of the IBM LZ1 compression algorithm, which provides an effective data rate of up to 160 MB/s and a cartridge capacity of up to 800 GB (with 2:1 compression) on IBM Ultrium 3 400 GB media.

The IBM 3583 models feature cartridge capacities of 18, 36, and 72 cartridges; that is, capacities of 7.2 TB, 14.4 TB, and 28.8 TB of uncompressed Ultrium 3 data. With compression (assuming 2:1), the largest model of the IBM 3583, the Model L72, can store 57.6 TB of Ultrium 3 data.

The IBM 3583 comes standard with remote library management, multi-path architecture, and the ability to partition the library into three logical libraries. The library can be configured as a standalone unit or can be mounted in an industry-standard 19-inch rack. Additional optional features include control path failover for AIX, HP-UX, Solaris, Windows, and Linux when using the IBM tape device driver. The IBM 3583 comes in three different models. The major difference between the models is the number of storage cells shipped with the initial order:

- *IBM 3583 Model L18* is supplied with space for 18 cartridges.
- *IBM 3583 Model L36* is supplied with space for 36 cartridges.
- *IBM 3583 Model L72* is supplied with space for 72 cartridges.

The models are summarized in Table 15-1 on page 369.

Table 15-1 IBM 3583 model summary

Model	Cartridge slots	Native data capacity with Ultrium 2	Native data capacity with Ultrium 3	IBM Ultrium Tape Drives
L18	18[a]	3.6 TB	7.2 TB	1-6
L36	36[b]	7.2 TB	14.4 TB	1-6
L72	72[c]	14.4 TB	28.8 TB	1-6

a. Plus one I/O station slot
b. Plus one I/O station slot
c. Including 12 I/O station slots

The model numbering is an indication of how many cartridge slots the model was originally shipped with. However, all of the IBM 3583 models are the same physical size, and the two smaller models, L18 and L36, can be field-upgraded to hold up to 72 cartridges by the addition of upgrade features. The effect of these upgrades is shown in Table 15-3 on page 377.

15.1.1 Tape drives

The IBM 3583 libraries support the IBM LTO Ultrium 3 tape drives as well as the Ultrium 2 and Ultrium 1 tape drives. All types of tape drives and cartridges can be resident in the same IBM 3583 frame. It is mandatory to have at least one IBM Ultrium drive installed in any of the libraries. Up to five more drives may be added either on the initial order or as field upgrades.

The installed drives may be any mixture of LVD, HVD (Ultrium 1 and 2 only), or 2 Gbps switched fabric Fibre Channel attached up to a total of six. LVD and HVD interfaced drives cannot be connected on the same SCSI bus. The drives are ordered for plant or field installation using chargeable feature codes:

- FC8033 provides one IBM Ultrium 3 tape drive with a Low Voltage Differential (LVD) Ultra160 SCSI interface.
- FC8035 provides one IBM Ultrium 3 tape drive with a Fibre Channel Interface.
- FC8103 provides one IBM Ultrium 2 tape drive with a Low Voltage Differential (LVD) Ultra160 SCSI interface.
- FC8104 provides one IBM Ultrium 2 tape drive with a High Voltage Differential (HVD) Ultra/Wide SCSI interface.

Note: Ultrium 1 tape drive features FC8003 and FC8004 (together with the FC8005 SAN Data Gateway Module) may be used with the IBM 3583, but these features were withdrawn from marketing as of October 1, 2004.

Each IBM Ultrium tape drive contains the electronics and logic for reading and writing of data, control of the tape drive, management of the data buffer, and error recovery procedures. All tape drives are packaged as a common assembly that is a Field Replaceable Unit (FRU), designed for quick removal and replacement. The cartridge capacities are unaffected by the number of drives installed.

15.1.2 Cartridge storage

As well as the installed tape drives, the library enclosure contains cartridge storage slots that are arranged in columns (from one to four including the I/O column, depending on the library model). Each of the storage columns has provision for an additional fixed slot located at the top of each column. This slot is reserved for future use.

The tape cartridges are stored in removable magazines, which are installed into the columns in the library (three magazines to each column). The magazines are designed so that tape cartridges can only be inserted in the proper orientation. After they are inserted, the tape cartridges will be retained in the magazine so that they remain in place even when the magazine is inverted and shaken lightly. The magazines can only be inserted one way into the mounting columns in the library.

15.1.3 Barcode reader

A barcode reader is provided as standard with all IBM 3583 models, and it does not affect the slot capacity of the libraries. The barcode reader is used during the inventory process to locate all cartridges inserted in the library. This action is repeated every time the front door is opened to ensure that the inventory is updated, should a cartridge have been manually added, moved, or removed while the door was open.

15.1.4 I/O station

This facility allows the insertion and ejection of cartridges without interrupting the normal operation of the library. There are two types of I/O station:

- The single-cartridge station, where one cartridge can be inserted or ejected by opening the I/O station door.
- The 12-cartridge station, where 12 cartridges are contained in two removable magazines. The cartridges can be inserted or ejected by opening the I/O station door.

Models L18 and L36 have the single-cartridge I/O station for tape cartridges and can be upgraded to a 12-cartridge station by the FC8012. This feature also adds 6 data cartridge slots below the I/O station. The 12-element I/O station may be configured as data storage. (See Table 15-3 on page 377.) The model L72 has the 12-cartridge station installed as standard equipment.

15.1.5 Robotic system

In conjunction with the library control microcode, the robotic system identifies and moves cartridges between the storage slots, tape drives, and the I/O station. It has a number of components:

- A cartridge picker for placing cartridges in storage slots, tape drives, or the I/O station
- A barcode reader used to set up the library initially when it identifies the types of storage arrays and tape drives installed in the library; and in normal operation for reading the external labels on the cartridges, when it locates and categorizes all cartridges installed in the library
- A picker assembly for mounting the cartridge picker and the barcode scanner
- Y-axis and Z-axis drive motors for rotating the picker assembly, and moving it vertically, inside the library enclosure

15.1.6 Library control and operation

The library control unit contains the electronics and logic for autochanger operations. It controls all operations in the IBM 3583 libraries, including the interaction between the library and operators. The control unit Licensed Internal Code creates and maintains the library configuration, the physical location of the robotic system, and the inventory of cartridges. The database is kept in the flash memory of the library control hardware.

Requests issued from the server result in cartridge movement in the library. The primary requests issued are for mounting and dismounting cartridges to and from the tape drives and for inserting and ejecting cartridges. The host has records of the physical location of a cartridge in the library, and the physical location is also managed by the library.

In addition to requesting movement of cartridges in the library, the host can obtain status, performance, configuration information, and information about the cartridges stored in the IBM 3583.

Each cartridge must have a machine- and operator-readable external barcode label to identify a media cartridge in the library during initial inventory and any time a cartridge is added to the library. The library stores the physical location of the cartridge in an inventory database based on the cartridge label. All host application requests for operations involving movement or use of a cartridge need only reference the physical location of the cartridge (using an element number as described in 15.11.4, “Element numbers” on page 384) for the library to perform the request.

15.1.7 Operator Panel

An LCD operator control panel on the front of the machine provides status information and menu options. From this panel the operator can initiate actions such as moving and loading tape cartridges or invoking diagnostics.

15.1.8 Remote Management Unit

A *Remote Management Unit* (RMU) comes standard in every IBM 3583. The RMU provides an Ethernet 10/100 port so that the library can be configured as a TCP/IP device on the network. Library status can be sent to the network as Simple Network Management Protocol (SNMP) traps. The IBM Tape Library Specialist. enables network access (via Web browser) to the library for more detailed status and control. All library Operator Panel functions can be accessed using this Web interface.

15.1.9 Library partitioning

The IBM 3583 multi-path architecture (see 2.4.7, “Multi-path architecture” on page 79 for more information) enables homogeneous or heterogeneous Open Systems hosts to share the library’s robotics without storage management middleware or a dedicated server acting as a library manager.

The library can be partitioned into as many as three logical libraries in order to share the library between different software platforms and applications (such as Windows 2003 and UNIX). Partitioning in this way means that they can share the library robotics independent of each other. Each logical library has its own distinct drives, cartridge storage slots, and control paths. If the application supports it, both Ultrium 2 and 3 drives and media are allowed in the same logical library. Cartridges under library control are not shared between logical libraries, nor allowed to be moved between logical libraries. Input/output (I/O) slots are shared on a first-come-first-served basis.

For more information about the multi-path and partitioning capabilities of the IBM 3583, refer to the library partitioning sections in these IBM Redbooks:

- *Implementing IBM Tape in Linux and Windows*, SG24-6268
- *Implementing IBM Tape in UNIX Systems*, SG24-6502

15.1.10 Control path failover

For enhanced availability, you can use control path failover. This optional feature provides automatic control path failover to a pre-configured redundant control path in the event of a loss of a host adapter or control path drive, without stopping the current job in progress. With control path failover installed, the alternate control path can include another HBA, SAN, or library control path drive. Support is provided under AIX, Linux, HP-UX, Windows, and Solaris for both SCSI and Fibre Channel attachments when the IBM tape device driver is used.

15.1.11 Data path failover and load balancing

Data path failover exclusively supports native Fibre Channel Ultrium 3 or Ultrium 2 drives in the IBM 3583 using the IBM tape device driver for AIX, Linux, and Solaris. Load balancing exclusively supports native Fibre Channel Ultrium 3 or Ultrium 2 drives in the IBM 3583 using the IBM tape device driver for AIX and Linux. It is not supported for Solaris.

Data path failover is designed to provide a failover mechanism in the IBM device driver, which enables you to configure multiple redundant paths in a SAN environment. In the event of a path or component failure, the failover mechanism is designed to automatically provide error recovery to retry the current operation using an alternate, pre-configured path without stopping the current job in progress. This allows you flexibility in SAN configuration, availability, and management.

15.1.12 SAN Data Gateway Module

The SAN Data Gateway Module (FC8005) functions as an interface between LVD SCSI Ultrium 1 tape drives (FC8003) in the library and Fibre Channel devices on the SAN. It provides attachment support for Fibre Channel interfaces using a Shortwave Gigabit Interface Convertor (GBIC) with SC connectors. The SAN Data Gateway Module is managed over the IP network. It has an Ethernet 10/100 interface with an RJ-45 connector.

Note: Ultrium 1 tape drive features FC8003 and FC8004 together with the FC8005 SAN Data Gateway Module will still work with the IBM 3583, but were withdrawn from marketing as of October 1, 2004.

15.1.13 Maintenance

The cartridge storage slots, cartridge picker, and tape drives are accessed for maintenance purposes by opening the front door of the library. The tape drives, power supplies, and host interface board are accessed from the back of the library for maintenance.

15.2 Feature codes

The IBM 3583 can be ordered and upgraded with the feature codes in Table 15-2. We have not included the various cabling options (see 15.4, “Cabling” on page 374), or all LTO2 options; refer to the product publications for detailed information about configuring and ordering.

Table 15-2 IBM 3583 feature codes

Feature	Description	Comment
1450	Multi-path - Field Specify	Field only

Feature	Description	Comment
1660	RMU/StorWatch Specialist	Included as standard
1680	Control Path Failover	Automatic control path failover to a pre-configured redundant control path in the event of the loss of a host adapter or control path drive, without stopping the current job in progress
1681	Data Path Failover	Ultrium 3 FC only
8002	IBM Ultrium Cleaning Cartridge	
8033	LTO Ultrium 3 LVD Drive	
8035	LTO Ultrium 3 Native FC Drive	
8006	Rack mount option	
8007	18-slot Tape Storage Column	Adds 18 slots Maximum: - Model L18: two - Model L36: one
8008	Redundant power module	Redundant dc power module
8305	5-pack IBM Ultrium 3, 400 GB Data Cartridges	Plant only. See 15.9, “Media” on page 379 for details
8320	20-pack IBM Ultrium 3, 400 GB Data Cartridges	Plant only. See 15.9, “Media” on page 379 for details
8012	12-cartridge I/O station	Adds 18 slots in the door (12 of them can be used for non-disruptive exchange of cartridges) Maximum: - for L18 and L32: one - standard on L72
8013	6-cartridge magazine	Plant only
8103	LTO Ultrium 2 LVD Drive	
8104	LTO Ultrium 2 HVD Drive	
8105	LTO Ultrium 2 Fibre Drive	
8110	20-pack of IBM Ultrium 200 GB Data Cartridges	Plant only. See 15.9, “Media” on page 379 for details.
9210	Attached to HP-UX	
9211	Attached to Sun	
9212	Attached to Windows	
9213	Attached to other non-IBM	
9215	Attached to Linux system	
9216	Attached to zSeries Linux systems	
9400	Attached to AS/400	
9450	Multi-path - Plant Specify	Plant only

Feature	Description	Comment
9600	Attached to AIX	

15.3 Physical attachments

In each of the different IBM 3583 models, the interface (LVD, HVD, or Fibre Channel) on each of the drives is chosen by selecting the appropriate drive type indicated by feature code numbers (Table 15-2 on page 372).

The IBM 3583 can be attached to the iSeries, pSeries, xSeries, zSeries, AS/400, RS/6000, RS/6000 SP systems, Netfinity® and non-IBM servers, workstations, and personal computers that support the Ultra/Wide SCSI HVD, Ultra 160 SCSI LVD, and Fibre Channel (FC) interface.

SCSI or FC cables and appropriate interposers, as required, should be ordered for attachment to a server. A power cord feature code should also be specified.

The IBM 3583 might be compatible with other servers, operating systems, and adapters. Contact your local IBM representative for a current list of supported configurations. You can also refer to the Interoperability Matrix (List of Supported Servers) on this Web site:

http://www.ibm.com/servers/storage/tape/3583/interop.html

Another resource is the IBM TotalStorage Fibre Channel HBA Search Tool site:

http://knowledge.storage.ibm.com/servers/storage/support/hbasearch/interop/hbaSearch.do

15.4 Cabling

Cables are required to attach tape drives in the IBM 3583 to each server connection (up to the number of tape drives installed).

An interposer might also be required for attachment to various server adapters. One or more of the following Fibre Channel or SCSI cables should be specified on the IBM 3583.

The following specifications are primarily for the LTO3 drives. There might be some other options available for the LTO2 drives. Refer to the product publications for detailed information about configuring and ordering.

15.4.1 Fibre Channel cables

Additional FC cables are available as optional features on the IBM 3583 for Fibre Channel attachment to host Fibre Channel adapters, Fibre Channel switches, or other Fibre Channel components.

A Fibre Channel cable is required to attach an IBM 3583 with the Fibre Drive feature to host Fibre Channel adapters, Fibre Channel Switches, or other Fibre Channel components. The IBM LTO Ultrium 3 Fibre Tape Drive (FC8035) comes with an LC Duplex connector. The IBM LTO Ultrium 2 Fibre Tape Drive (FC8105) also comes with an LC Duplex connector.

Features available for Fibre Channel cables, and their respective lengths, are as follows:

- FC5907: 7 m SC-LC Fibre Channel Cable
- FC5913: 13 m SC-LC Fibre Channel Cable
- FC5922: 22 m SC-LC Fibre Channel Cable
- FC6005: 5 m LC-LC Fibre Channel Cable
- FC6013: 13 m LC-LC Fibre Channel Cable
- FC6025: 25 m LC-LC Fibre Channel Cable

15.4.2 SCSI cables

A SCSI cable is required to attach an IBM 3583 with an IBM LTO Ultrium 3 LVD Tape Drive feature (FC8033) to each server connection (up to the number of tape drives installed). At least one SCSI cable should be specified on the initial plant order. A SCSI terminator is included with each IBM Ultrium Tape Drive. An interposer or interposers might be required for attachment to various server adapters. Clients are responsible for selecting and ordering the correct cables and interposers to match the IBM LTO Ultrium SCSI interface and the server SCSI interface.

The IBM LTO Ultrium 3 drives come with an HD68 connector for SCSI attachment. Features for specifying SCSI cables available for LVD Ultra160 SCSI attachment, and their respective lengths, are as follows:

Cables with HD68 connector on both ends:

- FC5302: 2.5 m (8.2 feet) SCSI cable
- FC5305: 5 m (16.5 feet) SCSI cable
- FC5310: 10 m (33 feet) SCSI cable

Cables with a VHDCI connector on one end and an HD68 connector on the other end:

- FC5602: 2.5 m (8.2 feet) SCSI cable
- FC5604: 4.5 m (14.5 feet) SCSI cable
- FC5610: 10 m (33 feet) SCSI cable

15.4.3 Interposers

An interposer might be required to connect a Fibre cable with LC Duplex connectors to another SC Duplex connector. The Interposer SC-LC Fibre interposer (FC5096) is available.

An interposer might be required to connect a SCSI cable with HD68 connectors to another connector. The following interposer is available: FC5099 - VHDCI/HD68 cable/interposer. This interposer (a 0.3 m cable) has a male mini-68-pin VHDCI connector on one end and a female 68-pin HD68 connector on the other.

15.4.4 Terminator

An inline terminator is required when attaching the IBM 3583 to Hewlett-Packard V-Class systems with adapter A4800A. The following inline terminator is available: FC5098, Inline HVD SCSI Terminator.

15.4.5 Cable length limitations

The native Fibre Channel drive and the SAN Data Gateway Module are capable of 2 Gbps speed. They automatically switch to a 1 Gbps speed if they are attached to a 1 Gbps HBA, switch, or other Fibre Channel components. At 2 Gbps, the maximum cable length is limited to 300 m (984 feet), and at 1 Gbps to 500 m (1640 feet).

The overall LVD SCSI cable length is limited to 25 m (81 feet) using point-to-point interconnection (for example, one host connected to only one tape drive). If using multi-drop interconnection (such as one host connected to more than one tape drive on the same SCSI bus), then the overall LVD SCSI cable length is limited to 12 m (39 feet). The stub length at each device must not exceed 0.1 m (0.33 feet).

The overall HVD SCSI cable lengths are limited to 25 m (81 feet) using point-to-point or multi-drop interconnection. The stub length at each device must not exceed 0.2 m (0.66 feet).

15.5 Upgrades and optional features

You can add MES features to each model type in the IBM 3583 family in order to add capacity in terms of drives and cartridge cells and to add the 12-cartridge I/O station. This effectively takes the place of model upgrades because no upgrades are available for the IBM 3583 series.

In other words, you cannot “upgrade” an IBM 3583-L18 to an IBM 3583-L36 or L72. Similarly, an IBM 3583-L36 cannot be “upgraded” to an IBM 3583-L72.

15.5.1 Upgrade features

You can expand any IBM 3583 model to the maximum capacity of the largest model (L72) with the addition of MES features.

Adding drives

You can add IBM LTO Ultrium drives to any library model to a maximum of six drives in total. The drives may be LVD, HVD, or Fibre in any combination. To install an LVD drive, add FC8103 (Ultrium 2) or FC8033 (Ultrium 3), to add an HVD drive add FC8104 (Ultrium 2), and to add a Fibre drive, add FC8105 (Ultrium 2) or FC8035 (Ultrium 3).

Adding cartridge capacity

You can add an additional 18 tape cartridge slots to either of the smaller IBM 3583 models using FC8007. You can add one or two of these features to model L18 (for a total of 36 or 54 cartridge slots), and you can add one feature to model L36 (to total 54 cartridge slots).

You can install a 12-cartridge I/O station to models L18 and L36 by adding FC8012. This feature accommodates the 12 cartridges in two six-slot cartridge magazines that are accessed by opening the I/O station door. In addition to the two magazines, this feature supplies six additional fixed slots in the library door for a total of 18 additional slots. This feature in combination with FC8007 provides the maximum slot capacity and function for the two smaller IBM 3583 models.

Table 15-3 on page 377 shows how to upgrade the capacity of 3583-L18 and 3583-L36 libraries by adding extra 18-slot tape storage columns (FC8007) and by adding the 12-cartridge I/O station (FC8012). You may set up the12-cartridge I/O station as storage slots or I/O slots.

Table 15-3 IBM 3583 capacity upgrades

3583 model	Single cartridge I/O station	12 cartridge I/O station FC8012 defined as storage	12 cartridge I/O station FC8012 defined as I/O
L18	18 storage 1 I/O	36 storage 0 I/O	24 storage 12 I/O
L18 with one FC8007 (18 slot option)	36 storage 1 I/O	54 storage 0 I/O	42 storage 12 I/O
L18 with two FC8007 (18 slot option)	54 storage 1 I/O	72 storage 0 I/O	60 storage 12 I/O
L36	36 storage 1 I/O	54 storage 0 I/O	42 storage 12 I/O
L36 with one FC8007 (18 slot option)	54 storage 1 I/O	72 storage 0 I/O	60 storage 12 I/O
L72 (FC8012 is default)	not available	72 storage 0 I/O	60 storage 12 I/O

15.5.2 Optional features

Two optional features are available:

- FC8006, rack mount option: The IBM 3583 libraries can be installed either standalone or in a standard EIA 19-inch rack. They occupy the full width of the rack and require 14 units of rack space (62.2 cm or 24.5 in.). This is the chargeable feature that provides the necessary hardware to mount the library in the rack.
- FC8008, redundant power module: This chargeable feature supplies a redundant DC power module for clients requiring an extra level of backup protection. You can order one of these features per library.

15.6 Environmental specifications

The IBM 3583 is a standalone, medium-sized library unit that can be placed in a rack or on the floor.

IBM 3583 models have from one to six drives and up to 72 cartridge slots. The physical dimensions are:

- Width: 48.1 cm (18.9 in.)
- Depth: 73.5 cm (28.9 in.)
- Height: 68.5 cm (27.0 in.) for a standalone library on casters
- Maximum weight: 116.6 kg (257 lb.) with six drives and 72 cartridges

15.7 Host platforms and device drivers

The following no-charge specify feature codes indicate the server platform to which the IBM 3583 is attached:

- FC9210: attached to HP-UX
- FC9211: attached to Sun system
- FC9212: attached to Windows system

- FC9213: attached to other non-IBM system
- FC9215: attached to Linux system
- FC9216: attached to zSeries Linux system
- FC9400: attached to iSeries system
- FC9600: attached to pSeries, RS/6000 system

A device driver is additional code on the host server platform that enables it to recognize and talk to a peripheral device (in this case, the IBM 3583). Sometimes the driver code is supplied as part of the operating system code (for example, in OS/400), sometimes a software patch is required, and sometimes the driver is installed separately from a CD or diskette (either an operating system CD or provided with a vendor application).

The library ships with the device drivers to support the following operating environments at the minimal levels shown:

- AIX 5L V5.1
- Solaris 8 or 9
- Windows 2000 (build 2195)
- Windows 2003 (build 3790)
- HP-UX 11.0, 11.i (64-bit)
- OS/400 V5R1 or later
- Linux distributions: Red Hat Enterprise Linux Version 3, SuSE LINUX Enterprise Server 8

For a detailed list of currently supported operating systems and host adapters, refer to:

http://www.ibm.com/servers/storage/tape/3583/interop.html

> **Tip:** The device driver CD or diskette that ships with the IBM 3583 might not contain the device drivers at the most recent level or the device drivers for all supported systems. Always check the following FTP site for the latest device drivers:
>
> ftp://ftp.software.ibm.com/storage/devdrvr/

15.7.1 Device driver installation

Install the IBM device drivers for the IBM 3583 as follows:

- If you intend to use the IBM 3583 with a commercial software application (such as IBM Tivoli Storage Manager, VERITAS Backup Exec, or EMC Legato NetWorker), refer to that application’s installation instructions to install the recommended device driver and configure the IBM 3583.
- If you do not intend to use the IBM 3583 with a commercial software application, install the tape and medium device driver from the CD that ships with the drive. Refer to the installation instructions in the *IBM Ultrium Device Drivers Installation and User’s Guide*, GA32-0430, which is supplied on the CD with the driver code.

> **Note:** If you use the IBM 3583 with a commercial software application, IBM recommends that you install any IBM-supplied device driver only if instructed to do so in the installation instructions supplied by the vendor of the application. Otherwise, if the application supplies its own driver code, then conflicts could occur over which driver controls the drive. Many examples of using the Ultrium drives are given in *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

15.8 Storage applications

The software to manage the IBM 3583 is not provided with the libraries. Additional software support is available through library management software products that must be obtained separately from IBM, IBM Business Partners, or independent software vendors. A list of compatible software is available at:

http://www.ibm.com/servers/storage/tape/lto/lto_isv.html

You will find details for each application including Ultrium 1, 2, and 3 support, and specific Ultrium models and attachment methods. You should also contact your storage application vendor for more detailed information of specific versions and platforms supported.

15.9 Media

An Ultrium cleaning cartridge and a pack of 20 Ultrium 3 data cartridges can be included with the 3583 order[1]. Additional Ultrium 3 or Ultrium 2 data and cleaning cartridges may be ordered as chargeable features for the IBM 3583. Refer to the product publications for further information about ordering.

- FC8002 provides a single Ultrium Cleaning Cartridge.
  This is a chargeable feature. A maximum of three can be ordered.
- FC8320 provides a pack of twenty 400 GB Ultrium 3 Data Cartridges.
  The cartridges come with a barcode label, but it is not affixed.

Subsequent to the initial order, additional supplies can be ordered from the IBM media business or a third-party media vendor using the product number IBM 3589. Refer to Appendix A, “IBM LTO Ultrium and 3592 media” on page 393 for details about ordering supplies and cartridges, with or without labels.

15.9.1 Ultrium 2 media

These feature codes are required if you need to order Ultrium 2 media with your IBM 3583:

- FC8101 provides a single 200 GB Ultrium 2 Data Cartridge.
  The cartridges come with a barcode label but it is not affixed.
- FC8110 provides a pack of twenty 200 GB Ultrium Data Cartridges with unattached barcode labels. A maximum of five can be ordered.

Note: All of the media features are available only with the initial order. They cannot be ordered as an MES feature. After the initial order, additional supplies can be ordered from the IBM media business or a third-party media vendor. Refer to Appendix A, “IBM LTO Ultrium and 3592 media” on page 393 for details about ordering supplies and cartridges, with or without labels.

15.10 Installation and performance considerations

When attached to an iSeries, only one drive should be configured per input/output port for maximum performance. Installing more than one Ultrium tape library on an I/O port may affect drive performance.

[1] All media and cleaning cartridges are warranted separately from the IBM 3583.

Installing more than one Ultrium drive on a SCSI bus may affect tape drive performance. For optimal performance, we recommend that no more than one IBM Ultrium drive is attached to an individual SCSI bus.

Intermixing other SCSI devices on the same SCSI bus with the IBM 3583 can affect performance of those devices.

Although the IBM Ultrium tape drives provide the capability for high tape performance, other components of the system might limit the actual performance achieved. The compression technology used in the tape drive can typically double the amount of data that can be stored on the media; however, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

The weight of the IBM 3583, depending on the number of drives and cartridges, may be up to 116.6 kg (257 pounds). Mounting more than one library in a rack can create a tipping hazard. We advise clients to take safety precautions when mounting the libraries in the racks.

15.11 IBM 3583 initial setup

The following section covers some of the major items required to implement, manage, and operate the IBM 3583. It does not cover all tasks and we do not intend to cover all of the specific commands. For more details, refer to the chapter “Determining SCSI and FC IDs” in the *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411.

15.11.1 Fibre Channel

Ultrium Fibre Channel drives have a 2 Gbps interface with 200 MB/s, serial-communications technology capable of interconnecting when separated by as much as 10 kilometers (7 miles). You can establish Fibre Channel connections between Fibre Channel ports that reside in the library, one or more servers, and the network interconnecting them. The network can consist of such elements as switches, hubs, bridges, and repeaters used in the interconnection.

Each library Fibre Channel tape drive must have a Fibre Channel Loop ID and corresponding Arbitrated Loop Physical Address (AL_PA) to communicate in a Fibre Channel topology. Table 15-4 lists the default Fibre Channel Loop IDs and AL_PAs for each drive in the library. The Fibre Channel Loop IDs are given in decimal format and the AL_PA values are given in the hexadecimal format.

Table 15-4 Fibre Channel IDs

Drive	Default FC Loop ID	Default AL_PA
1	0	X’EF’
2	1	X’E8’
3	2	X’E4’
4	3	X’E2’
5	4	X’E1’
6	5	X’E0’

You can change a Fibre Channel Loop ID by using the library's Operator Panel or the RMU. Using a method called *hard addressing*, the drive then automatically selects the corresponding AL_PA, which is the identifier that devices use to communicate. Valid Fibre Channel Loop ID values range between 0 and 125. The higher the number of the Fibre Channel Loop ID (and AL_PA), the lower the priority of the device in the loop.

You can also specify Fibre Channel Loop IDs that allow the drive to dynamically arbitrate the AL_PA with other Fibre Channel devices on the loop. This method avoids conflicts over the address and is called *soft addressing*. To dynamically arbitrate the AL_PA, specify a Fibre Channel Loop ID of 126 or 127.

15.11.2 SCSI ID and LUN assignment

The SCSI ID and LUN assignment in the IBM 3583 depends on whether the multi-path feature is installed. The IBM 3583 consists of up to seven SCSI devices: the library and up to six drives.

If the multi-path feature is installed, the Logical Unit Number (LUN) for the tape drive is always LUN 0, and the LUN for the Medium Changer device is always LUN 1. All other LUNs are invalid addresses. The default SCSI IDs for the drives are 1 through 6.

Note: The Medium Changer SCSI ID is the same as the SCSI ID for the first drive. You can enable additional drives to optionally provide Medium Changer (LUN 1) addressing by configuring more than one logical library or by enabling additional control paths.

If the multi-path feature is not installed, the IBM 3583 uses a separate SCSI device address for the robot so you will have to define a SCSI ID for the tape library unit. In this case, the LUNs for both the library and the tapes are always LUN 0. The default settings for the SCSI IDs are 6 for the library and 0 through 5 for the drives. Depending on your requirements, you may need to change the SCSI ID default settings for your installation.

Note: Do not use SCSI ID *F* because it is reserved for internal use by the SCSI library. SCSI ID 7 is also often used by the host SCSI adapter.

The IBM 3583 is a SCSI target device and can be connected to a single-ended LVD or HVD SCSI bus. Both ends of the bus must be terminated and a terminator is shipped with each drive. The design of an IBM 3583 enables the SCSI type (single-ended, LVD, or HVD) to be configured at the client site via a switch located on the SCSI Interface PCBA.

15.11.3 Identifying library locations

The convention in Table 15-5 is used to identify the coordinates of each library element (storage, slots, or drives).

Table 15-5 IBM 3583 storage slot coordinates

First digit	Second digit	Third digit
Column	Magazine	Row

The columns are numbered from 1 to 5 starting from the I/O station column and continuing clockwise (see Figure 15-2 on page 382).

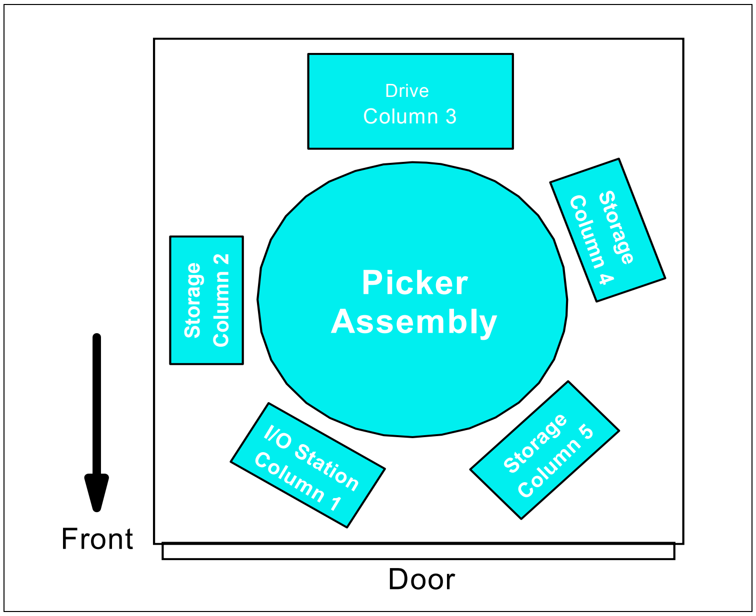


Figure 15-2 IBM 3583 storage columns: Top view

Figure 15-3 on page 383 follows this legend:

- The magazines within each column are designated A to C from top to bottom (label 1).
- The rows within each magazine are numbered from 1 to 6 from top to bottom (label 2).
- The drives within the drive column are designated from A to F from bottom to top (label 3).
- The fixed slots in the storage columns (label 4) are reserved for future functions.

So, to illustrate this convention, consider the coordinates:

```
1-A-6
```

These coordinates would refer to the slot found in column 1, the topmost of the three magazines, and the bottom slot within that magazine.

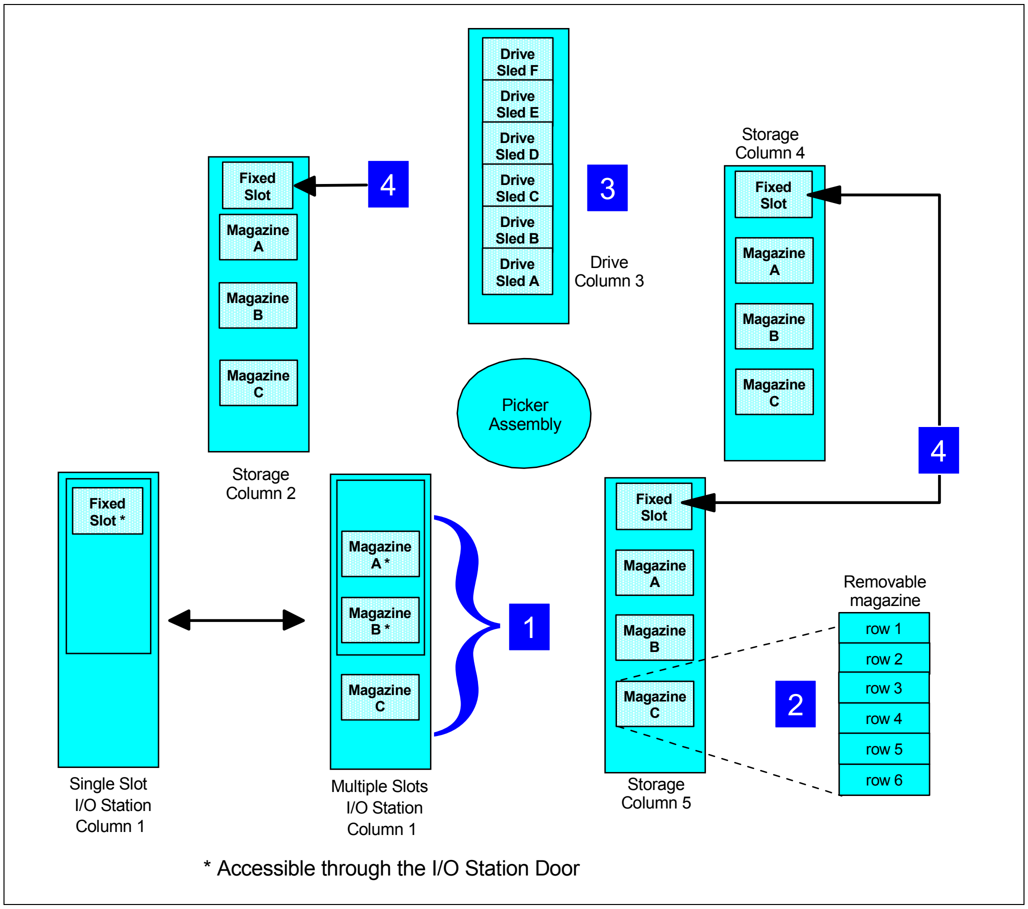


Figure 15-3 IBM 3583-L72 location logical view

Figure 15-4 shows the IBM 3583 with a view of the front door opened showing I/O station column 1. This diagram also shows a good view of the 12-slot I/O station option.

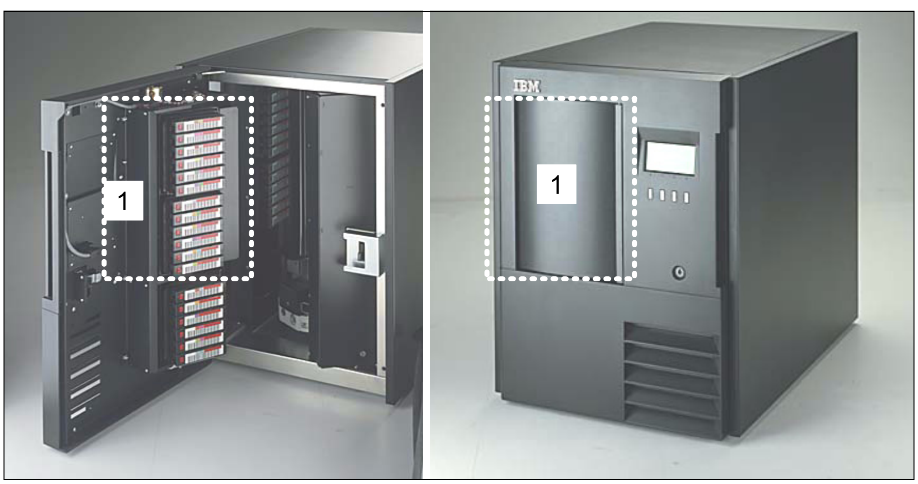


Figure 15-4 IBM 3583 front view, open door

Note: The only components accessible in a non-disruptive mode are the magazines located in the I/O station door (label 1 in Figure 15-4).

15.11.4 Element numbers

To manipulate the media within the library, the host must reference each movement with source and target designations. This is done via element addressing, which specifies precisely which slots within the library to use. Table 15-6 shows the basic element addressing scheme used for the IBM 3583.

Table 15-6 IBM 3583 element numbering

Column	Element numbers (in hexadecimal)
Picker	1h (1)
Single-Slot I/O Station	10h (16)
Multi-Slot I/O Station	10h - 1Bh (16 - 27)
Drives	100h - 105h (256 - 261)
Storage	1000h - 1047h (4096 - 4167)

Drives are addressed from bottom to top.

The I/O station is addressed from top to bottom. Storage slots are addressed from top to bottom, column by column.

For additional details, see the Appendix "Element Addressing" in *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411.

15.12 Operator Panel and RMU

Normally, the host issues commands to the IBM 3583. Operator control is provided via the Operator Panel or via the Tape Library Specialist Web interface on the Remote Management Unit (RMU). The operator is responsible for:

- Starting the IBM 3583
- Shutting down the IBM 3583
- Handling media
- Updating firmware
- Cleaning drives

For more about operator tasks, refer to "Operating Procedures" in the *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411.

15.12.1 Operator Panel

The Operator Panel provides communication between the operator and the IBM 3583. Visual indications and push buttons enable the operator to control the IBM 3583.

As shown in Figure 15-5 on page 385, the IBM 3583 Operator Panel has six discrete areas:

- The I/O station status area provides constant information about the I/O station (label 1 in Figure 15-5 on page 385). The information provided states whether the I/O station is locked. The status of the I/O door and a physical representation of an occupied I/O station slot are indicated by a blacked-out area.
- The library status area displays informational status, such as the library's online or offline status, and the library reports status or messages to solicit operator intervention (label 2 in Figure 15-5 on page 385).

- The message area displays six lines of text, graphic representations, or a combination of both (label 3 in Figure 15-5). Each text line can be up to 20 characters long. The display communicates interactive dialogs, special messages, alerts, and library configurations. More details are in “Using the Operator Panel Menu” in *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411.
- The drive status area (label 4 in Figure 15-5) provides constant information about the drives, such as:
  - Presence of tape drive (illustrated by a black outlined box for each drive)
  - Power to the tape drive
  - Cleaning requirements
  - Compression
  - Write protection
  - Tape activity (read, write, load, unload, and so forth)
  - Error codes
- The soft keys reference the push buttons located beneath them. They are used to perform the commands displayed in the soft keys area and to move through the various displays of the Operator Panel (label 5 in Figure 15-5).
- Push buttons (label 6 in Figure 15-5) are the actual physical buttons that perform the commands referred to by the soft keys located above each one of them.

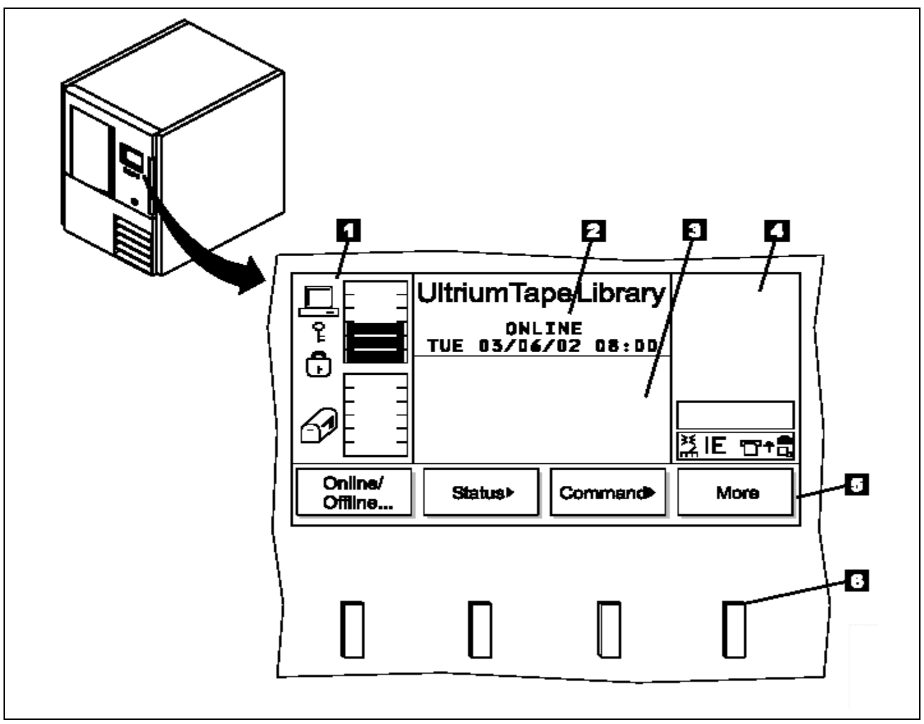


Figure 15-5 IBM 3583 Operator Panel

Menu options

Each menu is accessible through the Operator Panel push buttons. Figure 15-6 on page 386 shows the flow chart of the IBM 3583 library menu options. For more information about these functions, refer to the “Operating Procedures” chapter in *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411.

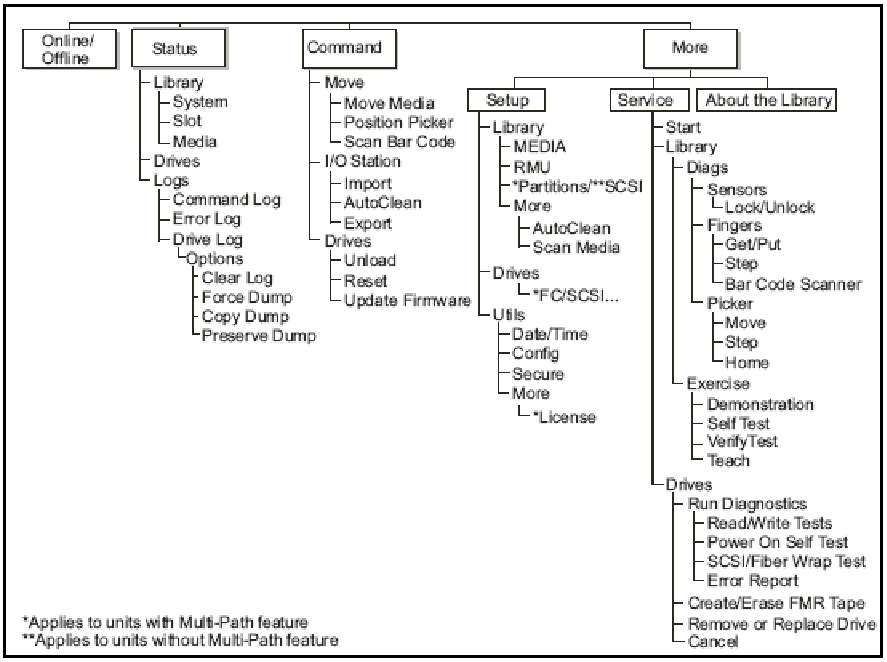


Figure 15-6 IBM 3583 flow chart of library functions

Menu guidelines

All of the menus and their options are grouped according to function. As shown in Figure 15-7, some options are followed by special characters, based on the following system:

- A keyword leading to another menu is suffixed by a small black arrow.
- A keyword leading to a dialog box is suffixed with three closely spaced dots.
- A keyword leading to an immediate action has no suffix.

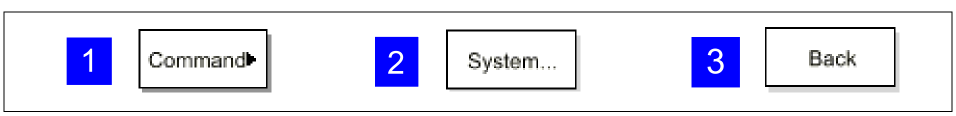


Figure 15-7 IBM 3583 soft key symbols

- Most fields on the menus, submenus, dialogs, and screens are read-only. Fields that are writable are shown in reverse video (Figure 15-8).

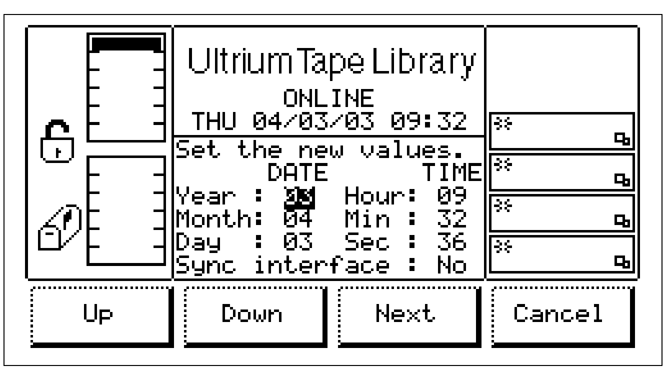


Figure 15-8 IBM 3583 Operator Panel: Input field

Note: The information menus are not updated dynamically. To view changes, reselect the menu that was changed.

Using commands that require an offline state

Some commands require that the library is in an offline state. If any such commands are attempted while the library is in an online state, the operator will be requested to take the library offline.

Operator intervention message

If a problem causes an operator-intervention message to appear, refer to “Operator Intervention Messages” in the Error Messages appendix of the *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411.

15.12.2 RMU with Tape Library Specialist

The Remote Management Unit (RMU) provides remote access to the IBM 3583 over a network. You can attach the library to the network through a 10/100 Ethernet port on the RMU. All available functions are accessible without the need of a dedicated server or separate software. You can access the library through any server on the network by entering the IP address or IP name in a Web browser. The Operator Panel page of the Ultrium Tape Library Specialist Web interface is protected by a password and is a direct interface to the Operator Panel of the attached library.

As shown in Figure 15-9 on page 388, the IBM 3583 Tape Library Specialist Web interface has three discrete frames:

- The left navigation frame (label 1 in Figure 15-9 on page 388) contains hyperlinks where you can log out the current user, display a brief description of the tabs from the center navigation frame, open the library’s online documentation, download the SNMP MIB file, display contact information for technical support, and display the current version of the RMU firmware.
- The center navigation frame (label 2 in Figure 15-9 on page 388) has tab-style hyperlinks for Status information, Configuration, Firmware, Diagnostics file, Operator Panel, and Logs. If you select a tab other than the Status tab, then you have to enter a logon name and password.
- The top information frame (label 3 in Figure 15-9 on page 388) contains information for you to identify the tape library that you are remotely managing. The frame shows the URL identifier and library type. The URL identifier is the host name given to the library during initial configuration. The library type is the ID string of the library and is taken from standard inquiry data.

More details are covered in Operator Panel and RMU section in the *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411.

Initial setup of the RMU is done using the Operator Panel, and you should establish password protection from the first logon.

Figure 15-9 IBM 3583 TotalStorage Specialist Web interface

15.13 Random access

The library operates in random access mode, which means that you can access any cartridge in any sequence. This mode normally requires software that generates commands that are sent to the library. The server's application software manages the cartridges (and therefore the data). See 15.8, "Storage applications" on page 379.

15.14 Drive cleaning

All of the IBM Ultrium Tape Drives have an integrated cleaning mechanism that brushes the head at load time and again when unloading a cartridge. Along with this, drives have a cleaning procedure using a special cleaning cartridge, should this become necessary.

> **Important:** When cleaning the drive head, use only the IBM LTO Ultrium Cleaning Cartridge or an IBM-approved cleaning cartridge.

With each IBM 3583, a specially labeled IBM LTO Ultrium Cleaning Cartridge is supplied to clean the drive head. The drive determines when the head needs to be cleaned, and alerts you by displaying `CT` on the message display. Any additional preventive cleaning is discouraged.

15.15 Firmware upgrades

Each IBM Ultrium tape drive and tape library contains IBM Licensed Internal Code, often referred to as *firmware*. At installation time, you should make sure the current firmware is installed on your IBM LTO tape drives, library, and RMU. As the IBM 3583 is designated as a Customer Setup Machine, it is the customer's responsibility to have the current firmware installed. Determine the latest available level by clicking **Firmware** at:

http://www.ibm.com/servers/storage/support/lto/3583/downloading.html

Follow the instructions for updating your firmware in the "Operating Procedures" chapter in *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411, or from:

http://www.ibm.com/servers/storage/support/lto/ltofaqs_updatefw.html

Part 4

Appendixes

A

IBM LTO Ultrium and 3592 media

When an IBM Tape Library is ordered, it is supplied with one Ultrium data cartridge or one 3592 data cartridge and one cleaning cartridge at no charge. Each member of the IBM 35*xx* and TS3*xxx* Tape Library family has different media features and rules that apply when placing the order. The following information will assist you in ordering additional media.

If you want to order media for your Ultrium or 3592 tape drives, go to this Web site:

`http://www-03.ibm.com/servers/storage/media/distributors/index.html`

Select your geographic location and your country and a list of authorized distributors is presented.

Refer to “Features available with IBM hardware initial order” on page 394 for a list of additional features for IBM LTO Ultrium and 3592 supply data cartridges with barcode labels that are separated delivered to the data cartridges. The actual value of barcode labels cannot be predetermined. For cartridges with predefined barcode labels and predetermined barcode values, order cartridges from a authorized dealer. See Table A-9 on page 404.

The media suppliers can supply tape cartridges from different manufacturers or offer a choice of brands. The tape cartridges you use must be manufactured by a qualified LTO media company to meet the LTO standards.

Features available with IBM hardware initial order

The following media features are available for inclusion with the initial hardware order. Note that all media and cleaning cartridges are warranted separately from the IBM Ultrium hardware.

IBM TotalStorage 3581 2U Tape Autoloader (Models L38 and F38) - Ultrium 3

These chargeable features provide media with the IBM 3581 Ultrium 2 Tape Drive and are available only with the initial order:

- FC8301 provides a single 400 GB Ultrium data cartridge. A maximum of 20 is allowed.
- FC8002 provides a single Ultrium cleaning cartridge. A maximum of five is allowed.

IBM System Storage TS2230 Tape Drive

Because the TS2230 Tape Drive is an Express model, a part number is used instead of a feature code:

- Part number 95P2020 provides a pack of five Ultrium 3 data cartridges.

IBM System Storage TS2340 Tape Drive

Because the TS2340 Tape Drive is an Express model, a part number is used instead of a feature code:

- Part number 95P4278 provides a pack of five Ultrium 4 data cartridges.

IBM System Storage TS3100 Tape Library

The TS3100 Tape Library can be an Express model so a part number can be used or a feature code can be used when ordering data cartridges:

- Part number 95P2020 provides a pack of five Ultrium 3 data cartridges.
- Feature code 8405 provides a pack of five Ultrium 4 data cartridges.

IBM System Storage TS3200 Tape Library

These chargeable features provide media with the TS3200 Tape Library and are available with the initial order:

- Feature code 8305 provides a pack of five 400 GB Ultrium 3 data cartridges.
- Feature code 8405 provides a pack of five Ultrium 4 data cartridges.

IBM System Storage TS3310 Tape Library

See “IBM 3589 LTO Ultrium tape cartridges” on page 395 for more information about ordering tape cartridges.

IBM System Storage TS3400 Tape Library

No feature code is available for ordering data cartridges at the initial order.

IBM System Storage TS3500 Tape Library

For ordering media supplies for the TS3500 Tape Library, go to “IBM 3589 LTO Ultrium tape cartridges” on page 395 and “IBM 3599 tape cartridges” on page 399.

IBM 3589 LTO Ultrium tape cartridges

To ensure that the IBM Ultrium Tape Drive conforms to the IBM specification for reliability, IBM recommends that you use only IBM LTO Ultrium tape cartridges. IBM TotalStorage LTO Ultrium Data Cartridges cannot be interchanged with the media used in other IBM non-LTO Ultrium tape products.

Table A-1 shows the different generations of IBM TotalStorage Ultrium data cartridges identified by color.

Table A-1 LTO Ultrium data cartridges identified by color

Data cartridge	Case color
Ultrium 4 WORM	Green top; platinum (silvery gray bottom)
Ultrium 4	Green
Ultrium 3 WORM	Blue top; platinum (silvery gray bottom)
Ultrium 3	Blue
Ultrium 2	Purple
Ultrium 1	Black

All four generations contain 1/2-inch, dual-coat, metal-particle tape. Table A-2 shows the native capacity of Ultrium data cartridges.

Table A-2 Native capacity of the Ultrium data cartridges

Data cartridge	Native data capacity
Ultrium 4 WORM	800 GB (1600 GB at 2:1 compression)
Ultrium 4	800 GB (1600 GB at 2:1 compression)
Ultrium 3 WORM	400 GB (800 GB at 2:1 compression)
Ultrium 3	400 GB (800 GB at 2:1 compression)
Ultrium 2	200 GB (400 GB at 2:1 compression)
Ultrium 1	100 GB (200 GB at 2:1 compression)

Cartridge compatibility

Table A-3 on page 396 shows the compatibility of all four generation Ultrium cartridges in an Ultrium 4 tape drive.

Table A-3 Ultrium data cartridge compatibility with an Ultrium 4 tape drive

IBM Ultrium Tape Drive	**IBM TotalStorage LTO Ultrium Data Cartridge**			
	800 GB (Ultrium 4)	400 GB (Ultrium 3)	200 GB (Ultrium 2)	100 GB (Ultrium 1)
Ultrium 4	Read/Write	Read/Write	Read only	N/A
Ultrium 3	N/A	Read/Write	Read/Write	Read only
Ultrium 2	N/A	N/A	Read/Write	Read/Write
Ultrium 1	N/A	N/A	N/A	Read/Write

Model description and ordering media supplies

We have put together two tables where you easily find the media description and the several ways to order the media.

Table A-4 lists the twelve models of the IBM TotalStorage Tape Media 3589 for use with IBM Ultrium tape drives.

With the media identifier, the type of cartridge is identified. Media identifier L1 is an Ultrium 1 cartridge. Media identifier L2 is an Ultrium 2 cartridge. Media identifier L3 is an Ultrium 3 cartridge. And, media identifier LT is a WORM cartridge.

Table A-4 3589 media

Model	**Description**	**Media identifier**	**Feature code**
3589-02	IBM Ultrium 1 cartridge (100 GB) with Labels (20-pack)	L1	FC2020
3589-03	IBM Ultrium 1 cartridge (100 GB) without Labels (20-pack)	L1	FC3020
3589-06	IBM Ultrium 2 cartridge (200 GB) with Labels (20-pack)	L2	FC6020
3589-07	IBM Ultrium 2 cartridge (200 GB) without Labels (20-pack)	N/A	FC7020
3589-08	IBM Ultrium 3 cartridge (400 GB) with Labels (20-pack)	L3	FC0820
3589-09	IBM Ultrium 3 cartridge (400 GB) without Labels (20-pack)	N/A	FC0920
3589-10	IBM Ultrium 4 cartridge (800 GB) with Labels (20-pack)	L4	FC1020
3589-11	IBM Ultrium 4 cartridges without Labels (20-pack)	N/A	FC1120
3589-28	IBM Ultrium 3 WORM cartridge (400 GB) with Labels (20-pack)	LT	FC2820
3589-29	IBM Ultrium 3 WORM cartridge (400 GB) without Labels (20-pack)	N/A	FC3920
3589-32	IBM Ultrium 4 WORM cartridge (800 GB) with Labels	LT	FC3220
3589-33	IBM Ultrium 4 WORM cartridge (800 GB) without Labels	N/A	FC3320

Table A-5 on page 397 shows another way of presenting the 3589 media and links to the Internet, as well as telephone numbers for ordering the 3589 media.

Table A-5 Media supplies

Supply item	Methods of ordering
IBM TotalStorage LTO Ultrium 800 GB Data Cartridge Barcode labels are pre-applied to cartridges.	Order the cartridge from your IBM Marketing Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 010. Specify the VOLSER characters that you want. Order as part number 96P1470 (color label) or 96P1471 (black and white label) through an IBM-authorized distributor. Specify the VOLSER characters that you want.
IBM TotalStorage LTO Ultrium 800 GB Data Cartridge Order VOLSERS labels separately.	Order the cartridge from your IBM Marketing Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 011. Specify the VOLSER characters that you want. Order as part number 24R1922 through an IBM-authorized distributor. Specify the VOLSER characters that you want.
5-PACK IBM TotalStorage LTO Ultrium Data Cartridge	Order as part number 95P2020 through an authorized IBM Business Partner. Specify the VOLSERS characters that you want.
IBM TotalStorage LTO Ultrium 400 GB Data Cartridge Barcode labels are pre-applied to cartridges. This media can be used with Ultrium 3 drives (read/write).	Order the cartridge from your IBM Marketing Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 009. Specify the VOLSER characters that you want. Order as part number 96P1470 (color label) or 96P1471 (black and white label) through an IBM-authorized distributor. For the closest distributor, visit the Web at: `http://www.ibm.com/storage/media` Or, call 1-888-IBM-MEDIA. Specify the VOLSER characters that you want.
IBM TotalStorage LTO Ultrium 400 GB Data Cartridge Order VOLSER labels separately. This media can be used with Ultrium 3 drives.	Order the cartridge from your IBM Marketing Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 008. Order as part number 24R1922 through an IBM-authorized distributor. For the closest distributor, visit the Web at: `http://www.ibm.com/storage/media` Or, call 1-888-IBM-MEDIA. Specify the VOLSER characters that you want.

Supply item	Methods of ordering
IBM Ultrium 3 400 GB WORM Tape Cartridge (with attached labels) IBM TotalStorage 3589 Model 028/Feature Code 2820 is a 20-pack of WORM cartridges labeled with starting volume serial information and, optionally, packed in individual jewel cases. Attached labels have been preprinted with a barcode that ends with LT, where L stands for LTO, and T identifies the cartridge as a WORM cartridge. This media can be used with Ultrium 3 drives.	Order by Machine Type/Model and Feature Code through an IBM-authorized distributor. For the closest distributor, visit the Web at: `http://www.ibm.com/storage/media` If you do not have Internet access, order the cartridge from any authorized IBM Business Partner or your IBM Marketing Representative. Call 1-888-IBM-MEDIA.
IBM Ultrium 3 400 GB WORM Tape Cartridge (without attached labels) IBM TotalStorage 3589 Model 029/Feature Code 2920 is a 20-pack of WORM cartridges packed in individual jewel cases with unattached blank labels. This media can be used with Ultrium 3 drives (read/write).	Order by Machine Type/Model and Feature Code through an IBM-authorized distributor. For the closest distributor, visit the Web at: `http://www.ibm.com/storage/media` If you do not have Internet access, order the cartridge from any authorized IBM Business Partner or your IBM Marketing Representative. Call 1-888-IBM-MEDIA.
IBM TotalStorage LTO Ultrium 200 GB Data Cartridge Barcode labels are pre-applied to cartridges. This media can be used with LTO2 drives (read/write) and LTO3 drives (read/write).	Order the cartridge from your IBM Marketing Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 006. Specify VOLSER characters you want. Call 1-888-IBM-MEDIA.
IBM TotalStorage LTO Ultrium 200 GB Data Cartridge Order VOLSER labels separately (see “Ordering barcode labels” on page 404). This media can be used with LTO2 drives (read/write) and LTO3 drives (read/write).	Order the cartridge from your IBM Marketing Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 007. call 1-888-IBM-MEDIA.
IBM LTO Ultrium 100 GB Data Cartridge Order VOLSER labels separately (see “Ordering barcode labels” on page 404). This media can be used with LTO1 drives (read/write), LTO2 drives (read/write), and LTO3 drives (read only).	Order as part number 08L9120 through an IBM-authorized distributor. For the closest distributor, visit the Web at: `http://www.ibm.com/storage/media` if you do not have Internet access, order the cartridge from any authorized IBM Business Partner or your IBM Marketing Representative. Call 1-888-IBM-MEDIA.

Supply item	Methods of ordering
IBM TotalStorage LTO Ultrium Cleaning Cartridge Universal cleaning cartridge for use with Ultrium 1, Ultrium 2, and Ultrium 3 drives. VOLSER labels are included.	Order as part number 08L9120 through an IBM-authorized distributor. For the closest distributor, visit the Web at: `http://www.ibm.com/storage/media` if you do not have Internet access, order the cartridge from any authorized IBM Business Partner or your IBM Marketing Representative. Call 1-888-IBM-MEDIA.

IBM 3599 tape cartridges

This section provides information about ways of ordering media supplies, including feature codes and part numbers for ordering media supplies for 3592 tape drives. Selected media supplies can be ordered using feature codes when purchasing a 3592 drive. This is the pack-in method of ordering, and the media will be shipped with the hardware order. Not all media types are available with this method.

The 3599 Tape Media method is available for ordering all types of data and cleaning cartridges. This method is typically used for ordering larger quantities and for ordering initialized and pre-labeled cartridges. Media supplies can also be ordered using part numbers through IBM-authorized distributors.

Model description

For clients who order media using the 3599 Tape Media method, IBM TotalStorage Enterprise Tape Media 3599 provides the ability to order unlabeled, pre-labeled, initialized, and bulk-packaged tape data cartridges in a wide variety of combinations and cleaning cartridges for the 3592-J1A Tape Drive and the TS1120 Tape Drive.

The TotalStorage Enterprise Tape Cartridge 3592 (DATA) has a native capacity of 500 GB when formatted for EFMT2, and 300 GB when formatted for EFMT1 or 700 GB when the Extended data cartridges is used. The 3592-J1A writes in E1 mode, and the 3592-E05 can write in either E1 or E2 mode.

The actual compression is dependent upon the data. The TotalStorage Enterprise Tape Cartridge 3592 (ECONOMY) has a native capacity of 100 GB in E2 and 60 GB in E1. Capacities of data cartridges can be increased through data compression, with the actual compression and capacity depending upon the specific data. WORM cartridges are also available in both capacities.

Segmentation/capacity scaling options are also available on the 300 GB Data cartridge for a 60 GB fast access capability, and a 260 GB segmented tape with 60 GB of fast access, and 200 GB of additional capacity.

With the 3599 Tape Media method of ordering, model numbers are used to identify the cartridge types, and feature code combinations are used to specify the quantities, labeling, and initialization options. See Table A-6 on page 400.

Table A-6 3599 media feature description

3599 Model	Media ID feature code	Feature code for labelling, initialization, and quantity	Individual cartridge capacity	Description
011	JA/9030	1020	300 GB	20-pack 3592 Data Cartridges, labeled and initialized in E1 format
011	JA/9081	1020	500 GB	20-pack 3592 Data Cartridges, labeled and initialized in E2 format
012	JA/9030	1020	300 GB	20-pack 3592 Data Cartridges, labeled not initialized
013	JA/9030	3020	300 GB	20-pack 3592 Data Cartridges, not labeled or initialized
014	JB	4020	700 GB	20-pack Data Cartridges labeled and initialized
015	JB	5020	700 GB	20-pack Data Cartridges labeled not initialized
016	JB	6020	700 GB	20-pack Data Cartridges not labeled or initialized
E11	JJ/9050	1020	60 GB	20-pack 3592 Economy cartridges, labeled and initialized in E1 format
E11	JJ/9081	1020	100 GB	20-pack 3592 Economy cartridges, labeled and initialized in E2 format

E12	JJ/9050	2020	60 GB	20-pack 3592 Economy cartridges, labeled, not initialized
E13	JJ/9050	3020	60 GB	20-pack 3592 Economy cartridges, not labeled or initialized
021	JW/9040	1020	300 GB	20-pack 3592 WORM cartridges, labeled and initialized in E1 format
021	JW/9081	1020	500 GB	20-pack 3592 WORM cartridges, labeled and initialized in E2 format
022	JW/9040	2020	300 GB	20-pack 3592 WORM cartridges, labeled, not initialized
023	JW/9040	3020	300 GB	20-pack 3592 WORM cartridges, not labeled or initialized
024	JX	2420	700 GB WORM	20-pack 3592 WORM cartridges, labeled and initialized
025	JX	2520	700 GB WORM	20-pack 3592 WORM cartridges, labeled not initialized
026	JX	2620	700 GB WORM	20-pack 3592 WORM cartridges, not labeled or initialized

E21	JR/9042	1020	60 GB	20-pack 3592 Economy WORM cartridges, labeled and initialized in E1 format
E21	JR/9081	1020	100 GB	20-pack 3592 Economy WORM cartridges, labeled and initialized in E2 format
E21	JR/9042	2020	60 GB	20-pack 3592 Economy WORM cartridges, labeled, not initialized
E21	JR/9042	3020	60 GB	20-pack 3592 Economy WORM cartridges, not labeled or initialized
017	JA	7005	Cleaning, 50 uses	5-pack 3592 Cleaning Cartridges, labeled and initialized
017	JA	7006	Cleaning, 50 uses	5-pack 3592 Cleaning Cartridges without media identification labels

Table A-7 lists the data cartridges and media supplies that you can order for the 3592 tape drives. You can use one of the followings methods to order the cartridges:

- Order by part number through an IBM-Authorized distributor. For the closest distributor, visit the Web at:

  http://www.ibm.com/storage/media

- If you do not have Internet access, order the cartridges from any authorized IBM Business Partner or your IBM Marketing Representative.
- Call 1-888-IBM-MEDIA.

Table A-7 Media supplies for the 3592 drive

Supply item	Capacity	Part number
IBM TotalStorage Enterprise Data Cartridge	700 GB	25R9830
IBM TotalStorage Enterprise Data Cartridge	500 GB	18P7534

Supply item	Capacity	Part number
IBM TotalStorage Enterprise Data Cartridge	300 GB	18P7534
IBM TotalStorage Enterprise Data Cartridge 3592 Economy	60 GB	24R0316
IBM TotalStorage Enterprise Data Cartridge 3592 WORM	700 GB	23R9831
IBM TotalStorage Enterprise Data Cartridge 3592 WORM	300/500 GB	18P7538
IBM TotalStorage Enterprise Data Cartridge 3592 Economy WORM	60 GB	24R0317
IBM TotalStorage Enterprise Data Cartridge 3592 cleaning	Cleaning, 50 uses	18P7535

Labeling service

This service applies to IBM 3589 and IBM 3599 media types that have labels as described in the previous two sections.

There are six characters in the VOLSER, and IBM provides specific codes to allow you the flexibility to choose where to begin the volume range that you require. The sixth character is always a zero character (0), because your volume serial range must always begin at a 0 boundary for labeling, and the labels supplied are sequential. So, for example, if you order 20 cartridges, the first cartridge will be labeled with a sixth digit of 0, and the twentieth cartridge will be labelled with a sixth digit of 9.

The character identifier features are four-digit feature numbers of the form 9*nnn*, composed as:

- The first digit 9 means the feature carries no charge.
- A second digit of 1, 2, 3, 4, or 5 indicates which character in the VOLSER this feature is specifying (1st, 2nd, 3rd, 4th, or 5th).
- The third and fourth digits range from 00 through 35, where 00 through 09 represent the characters 1 through 9, and 10 through 35 represent the characters A through Z.

Choose the first 1, 2, 3, 4, or 5 digits by using the feature numbers as follows:

- First alphanumeric digit (0 to 9 or A to Z): use FC9100 (0) to FC9135 (Z).
- Second alphanumeric digit (0 to 9 or A to Z): use FC9200 (0) to FC9235 (Z).
- Third alphanumeric digit (0 to 9 or A to Z): use FC9300 (0) to FC9335 (Z).
- Fourth numeric digit (0 to 9): use FC9400 (0) to FC9409 (9).
- Fifth numeric digit (0 to 9): use FC9500 (0) to FC9509 (9).
- Sixth numeric digit is set to 0 as standard.
- Seventh and eighth characters of the VOLSER are set based on media type. See the Media Identifier column in Table A-4 on page 396 and “Labeling service” on page 403.

If you do not specify a feature code, the supplied starting character will be a zero. Therefore, if you specify features for the first thee characters as `ABC` but no more, the sequence of labels will begin `ABC000`.

Two specific features indicate requirements for colored labels:

- FC9077 specifies a white background.
- FC9022 specifies a colored background for the alpha characters.

If you specify FC9022, you can choose from 10 available colors as shown in Table A-8.

Table A-8 Color specify feature codes for the IBM 3599

Alpha prefix background	Feature code	Alpha prefix background	Feature code
Red	9003	Orange	9008
Yellow	9004	Pink	9009
Light green	9005	Dark green	9010
Light blue	9006	Light orange	9011
Gray	9007	Purple	9012

Ordering barcode labels

You can order barcode labels from one of the following authorized suppliers. See Table A-9.

Table A-9 Authorized suppliers of custom barcode labels

In the Americas	In Europe and Asia
EDP/Colorflex 2550 West Midway Boulevard Broomfield, CO 80020-1633 U. S. A. Telephone: 800-432-1337 or 303–666-2160 http://www.colorflex.com/Ai/Home.asp	EDP Europe, Ltd. 43 Redhills Road South Woodham Ferrers Chelmsford, Essex CM3 5UL U. K. Telephone: 44 (0) 1245-322380 http://www.edpeurope.com/media_labelling.htm
Dataware 7570 Renwick Houston TX 77081 U. S. A. Telephone: 800-426-4844 http://www.datawarelabels.com/	Dataware Labels Europe Heubergstrasse 9 D-83052 Bruckmuhl-Gotting Germany Telephone: 49 806-29455 http://www.datawarelabels.com/
NetC P. O. Box 320784 Fairfield, CT 06432 U. S. A. Telephone: 203-372-6382 http://www.netcllc.com/	NetC Europe Ltd Town Farm Bungalow North Curry Taunton Somerset U. K. TA3 6LX Telephone: 44 (0) 1823 491439 http://www.netclabels.co.uk
	NetC Asia Pacific Pty Ltd Locked Bag 14 Kenthurst NSW Australia 2156 Telephone: 61 (0) 2 9654 8272 http://www.netclabels.com.au

B

Renaming IBM Tape products

On October 11, 2005, IBM started an initiative to rename its new announcement products. All product names are preceded by the *IBM* brand and either *TotalStorage* (for current products) or *System Storage* for new products.

Introducing the new TS*xxxx* “series family names”:

- The 1000 series is reserved for tape drives:
  - For example, the 3592 becomes the TS1120 Tape Drive.
- The 3000 series is reserved for automation:
  - For example, the 3576 becomes the TS3300 Tape Library.
  - The 3584 becomes the TS3500 Tape Library.

In the following tables, you can find IBM tape products with the new naming and a model description.

TS1000 Tape Drives (LTO)

Table B-1 TS1000 Tape Drive naming

M/T	Model	Existing name	New name
3580/3588			
3580	L33	3580 Tape Drive Model L33	
	L3H	3580 Tape Drive Model L3H	
	L3H	3580 Tape Drive Express Model L3H	
3588	F3B		IBM System Storage TS1030 Tape Drive
3588	F4A		IBM System Storage TS1040 Tape Drive

TS1100 Tape Drive (Enterprise)

Table B-2 TS1100 Tape Drive naming

M/T	Model	Existing name	New name
3592			
3592	J1A	3592 Tape Drive Model J1A	
3592	E05	IBM System Storage TS1120 Tape Drive	
3592	C06		IBM System Storage TS1120 Tape Controller
3592	C20	3592 Tape Library Frame Model C20	IBM 3592 Tape Frame Model C20

TS3100 Tape Library

Table B-3 TS3100 Tape Library naming

M/T	Model	Existing name	New name
3573			IBM System Storage TS3100 Express Tape Library
3573	L4S		IBM System Storage TS3100 Express Tape Library Model L4S
3573	S4S		IBM System Storage TS3100 Express Tape Library Model S4S
3573	F4S		IBM System Storage TS3100 Express Tape Library Model F4S
3573	L32		IBM System Storage TS3100 Express Tape Library Model L32

M/T	Model	Existing name	New name
3573	S32		IBM System Storage TS3100 Express Tape Library Model S32

TS3200 Tape Library

Table B-4 TS3200 Tape Library naming

M/T	Model	Existing name	New name
3573			IBM System Storage TS3200 Express Tape Library
3573	F4S		IBM System Storage TS3200 Express Tape Library Model F4S
3573	L4S		IBM System Storage TS3200 Express Tape Library Model L4S
3573	S4S		IBM System Storage TS3200 Express Tape Library Model L4S
3573	S32		IBM System Storage TS3200 Express Tape Library Model S32
3573	L32		IBM System Storage TS3200 Express Tape Library Model L32

TS3310 Tape Library

Table B-5 TS3310 Tape Library naming

M/T	Model	Existing name	New name
3576		IBM System Storage TS3310 Tape Library	
3576	L5*x*		IBM System Storage TS3310 Model L5B
3576	E9*x*		IBM System Storage TS3310 Model E9U

TS3500 Tape Library

Table B-6 TS3500 Tape Library naming

M/T	Model	Existing name	New name
3584		3584 Tape Library	IBM System Storage TS3500 Tape Library
	L23		IBM System Storage TS3500 Model L23
	L53		IBM System Storage TS3500 Model L53

M/T	Model	Existing name	New name
	D23		IBM System Storage TS3500 Model D23
	D53		IBM System Storage TS3500 Model D53
	HA1	3584 High Availability Frame Model HA1	IBM System Storage TS3500 Model HA1

IBM Express Portfolio is a set of IBM offerings for IBM Business Partners in Small and Medium Business. For details, see the following Web site:

http://www-1.ibm.com/partnerworld/pwhome.nsf/weblook/pub_strategies_smb_express.html

Abbreviations and acronyms

AC	Alternating Current
AIM	Automatic Identification Manufacturers
AIT	Advanced Intelligent Tape
AIX	Advanced Interactive Executive
ALDC	Adaptive Lossless Data Compression
ALMS	Advanced Library Management System
AME	Advanced Metal Evaporative
AMP	Advanced Metal Powder
ANSI	American National Standards Institute
API	Application Programming Interface
ATF	Auto Tracking Following
BRMS	Business Recovery and Management Services
CM	Cartridge Memory
CRC	Cyclic Redundancy Check
CVE	Compliance Verification Entity
DAT	Digital Audio Tape
DC	Direct Current
DDS	Digital Data Standard
DLT	Digital Linear Tape
DTE	Data Transfer Element
ECC	Error checking and correction
ECMA	European Computer Manufacturer's Association
EEPROM	Electrically Erasable Programmable Read-Only Memory
EOT	End of tape
EOV	End of volume
ESCON	Enterprise Systems Connection
FC	Fibre Channel/feature code
FC-AL	Fibre Channel arbitrated loop
FCP	Fibre Channel protocol
FICON	Fiber Connectivity
FRU	Field replaceable unit
GBph	Gigabytes per hour
HBA	Host bus adapter
HSM	Hierarchical storage management
HVD	High voltage differential
IBM	International Business Machines
IDRC	Improved Data Recording Capability
IEEE	Import/Export element
IOP	Input/output processor
ISV	Industry solution provider
ITSO	International Technical Support Organization
LAN	Local area network
LGMR	Laser Guided Magnetic Recording
LIP	Loop initialization protocol
LPAR	Logical partition
LPOS	Longitudinal Positioning
LTO	Linear Tape-Open
LTO-CM	Linear Tape-Open-Cartridge Memory
LTO-DC	Linear Tape-Open Data Cartridge
LUN	Logical unit number
LVD	Low voltage differential
MCC	Medium changer controller
MES	Machine equipment specification
MFM	Modified Frequency Modulation
MIB	Management information block
MRC	Magneto-Resistive Cluster
MTBF	Mean time between failures
OEM	Original equipment manufacture
P/N	Part number
PCBA	Printed circuit board assembly
PCI	PC Connect interface
POS	Pivoting Optical Servo
PRML	Partial Response Maximum Likelihood
PTF	Program temporary fix
QIC	Quarter-inch cartridge
RF	Radio frequency
RLL	Run Length Limited
RMU	Remote Management Unit
/s	per second
SAN	Storage Area Network
SARS	Statistical Analysis and Reporting System

SCSI	Small computer systems interface
SDG	SAN Data Gateway
SDLT	SuperDLT
SLDC	Streaming lossless data compression
SMI-S	Storage Management Initiative Specification
SMIT	Systems Management Interface Tool
SNIA	Storage Networking Industry Association
SNMP	Simple Network Management Protocol
STE	Storage element
TCP/IP	Transmission Control Protocol/Internet Protocol
VHDCI	Very High Density Cable Interconnect
VIEE	Virtual Import/Export element
VPD	Vital Product Data
WORM	Write Once Read Many
WWN	Worldwide Name

Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this IBM Redbooks publication.

IBM Redbooks publications

For information about ordering these publications, see “How to get IBM Redbooks publications” on page 413. Note that some of the documents referenced here might be available in softcopy only:

- *Designing an IBM Storage Area Network,* SG24-5758
- *iSeries in Storage Area Networks: A Guide to Implementing FC Disk and Tape with iSeries*, SG24-6220
- *IBM Tape Solutions for Storage Area Networks and FICON*, SG24-5474
- *IBM System Storage TS3500 Tape Library with System z Attachment: A Practical Guide to TS1120 Tape Drives and TS3500 Tape Automation*, SG24-6789
- *Tivoli Storage Manager Version 5.1 Technical Guide*, SG24-6554
- *IBM TotalStorage Enterprise Tape 3592: Presentation Guide*, REDP-3749
- *Implementing IBM Tape in UNIX Systems*, SG24-6502
- *Implementing IBM Tape in Linux and Windows*, SG24-6268
- *Implementing IBM Tape in i5/OS,* SG24-7440
- *The LTO Ultrium Primer for IBM eServer iSeries Customers*, REDP-3580

Other publications

These publications are also relevant as further information sources:

- *IBM Tape Device Drivers Installation and User’s Guide,* GC27-2130
- *IBM System Storage TS2230 Tape Drive Setup, Operator and Service Guide,* GC27-2099
- *IBM System Storage TS2340 Tape Drive Setup, Operator and Service Guide,* GC27-2103
- *IBM System Storage TS3400 Planning and Operator Guide,* GC27-2107
- *IBM TotalStorage Tape Device Drivers Programming Reference,* GC35-0346
- *IBM Ultrium Device Drivers Installation and User’s Guide*, GA32-0430
- *IBM SCSI Tape Drive, Medium Changer, and Library Device Drivers Installation and User’s Guide*, GC35-0154
- *IBM System Storage TS3500 Tape Library Operator Guide,* GA32-0560
- *IBM TotalStorage SMI-S Agent for Tape Installation Guide*, GC35-0512
- *IBM TotalStorage 3580 Tape Drive Setup, Operator, and Service Guide*, GC26-7708
- *IBM TotalStorage 3581 Tape Autoloader Setup, Operator, and Service Guide*, GA32-0470
- *IBM TotalStorage 3581 Tape Autoloader Setup, Operator and Service Guide*, GA32-0461
- *IBM TotalStorage 3582 Tape Library Setup, Operator, and Service Guide*, GA32-0458

- *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411
- *IBM TotalStorage 3584 Tape Library Installation and Planning Guide*, GA32-0469
- *IBM TotalStorage 3584 Tape Library Operator Guide*, GA32-0468
- *IBM TotalStorage Enterprise Tape System 3592 Introduction and Planning Guide*, GA32-0464
- *IBM TotalStorage UltraScalable Tape Library 3584 Advanced Library Management System Technology White Paper*, by Lee Jesionowski, which can be found at:

  http://www.storage.ibm.com/tape/lto/white_papers/pdf/advanced_library_management_system.pdf

Online resources

These Web sites and URLs are also relevant as further information sources:

- This is the main Web site for information about IBM LTO products:

  http://www.ibm.com/storage/lto
- The Linear Tape-Open Technology Organization Web site provides information about the technology, formats, and licensing:

  http://www.lto-technology.com/
  http://www.ultrium.com
- The SCSI Trade Association Web site provides information about SCSI standards and terms:

  http://www.scsita.org
- This Web site describes the media available from IBM:

  http://www.ibm.com/storage/media
- This Web site describes IBM Microelectronics products including compression devices:

  http://www.chips.ibm.com
- This Web site describes the Streaming Lossless Compression Algorithm:

  http://www.ecma-international.org/publications/standards/ECMA-321.HTM
- IBM Tivoli Storage Manager SAN device support:

  http://www.ibm.com/software/tivoli/products/storage-mgr-san/platforms.html
- Ultrium device driver downloads:

  ftp://ftp.software.ibm.com/storage/devdrvr
- ISV Support Matrix for LTO:

  http://www.storage.ibm.com/hardsoft/tape/conntrix/pdf/lto_isv_matrix.pdf
- Ultrium 3580 Drive firmware information:

  http://www.ibm.com/support/docview.wss?rs=543&org=ssg&doc=S4000055&loc=en-us
- IBM 3582 Interoperability Matrix:

  http://www.storage.ibm.com/tape/lto/3582/3582opn.pdf
- IBM 3583 Interoperability Matrix:

  http://www.storage.ibm.com/tape/lto/3583/3583opn.pdf

- IBM 3584 Interoperability Matrix:

  http://www.storage.ibm.com/tape/lto/3584/3584opn.pdf
- IBM 3584 drive and library firmware:

  ftp://ftp.software.ibm.com/storage/358x/3584
- IBM Sales Manual:

  http://usmweb.boulder.ibm.com
- IBM ServerProven compatibility for hardware, applications, and middleware:

  http://www.pc.ibm.com/us/compat
- System x tape storage:

  http://www.pc.ibm.com/ww/eserver/xseries/tape.html
- System i technical support:

  https://techsupport.services.ibm.com/server/support?view=iSeries

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IBM System Storage Tape Library Guide for Open Systems

(0.5” spine)
0.475”<->0.873”
250 <-> 459 pages

IBM System Storage Tape Library Guide for Open Systems

Learn about Tape Encryption for the TS1120 ad TS1040 Tape Drives

Read about the new TS2230, TS2340, and TS3400

Discover the new functions for existing Tape Libraries

This IBM Redbooks publication presents a general introduction to Linear Tape-Open (LTO) technology and the implementation of corresponding IBM products. It describes both general LTO technology specifications and specific details of the unique design of IBM Ultrium tape drives and libraries.

This sixth edition of the book includes information about the third-generation Ultrium drive and about the recently announced IBM System Storage TS3100, TS3200, and TS3310 Tape Libraries. You will find technical information about each of the IBM tape products for Open Systems, including generalized sections about SCSI and Fibre Channel connections, multi-path architecture configurations, and new IBM System Storage TS3500 features, such as the Advanced Library Management System (ALMS) and virtual I/O. The book now also includes a detailed discussion of tools and techniques for Library Management.

This book is intended for anyone who wants to understand more about the general LTO technology specification and how it came about, as well as the IBM implementation of that specification. It is suitable for IBM clients, IBM Business Partners, IBM specialist sales representatives, and technical specialists. If you do not have a background in computer tape storage products, you might need to reference other sources of information. In the interest of being concise, topics that are generally understood are not covered in detail.

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