hp's new high performance ultrium tape drives

hp surestore
ultrium 230e

hp surestore
ultrium 215i

white paper

HP Ultrium Technology

This white paper explains the features and benefits of the technology incorporated in HP's new high performance HP Ultrium 230 tape drive.

Introduction

Ultrium is an open standard tape format, endorsed by over 30 manufacturers and licensees.

HP, IBM and Seagate jointly conceived and developed Linear Tape Open (LTO) technology. It is expected to become the *de facto* standard for mid-range tape products.

The Ultrium format, built on LTO technology, is designed for ultra-reliable high performance data protection. It was developed using best-of-breed features from existing tape and other storage technologies.

Ultrium is a ½" (12.6 mm), linear, bi-directional format that uses a single reel cartridge. In generation 1, there are 8 read-write channels. This gives a native cartridge capacity of up to 100 GB and a native transfer rate of up to 20 MB/sec.

Ultrium is an open format, endorsed by multiple vendors and licensees and is backed by an independent compliance verification program. Compliance with the Ultrium format ensures media interchange between different vendors' Ultrium products.

The Ultrium format specification does not specify how different Ultrium vendors will implement the Ultrium format in their tape devices. For users this means a range of compatible Ultrium tape drives is available. HP has developed a range of Ultrium products that incorporate technology to deliver unique benefits and differentiate them from other vendors' Ultrium tape devices.

Why tape?

For data protection, tape wins on cost, performance and reliability.

As HP and other vendors develop data protection technologies based on optical, magnetic, magneto-optical and solid state technology the range of data protection alternatives is increasing. The decision by HP and the other LTO technology partners to develop a new tape technology is based on an analysis of current and future data protection options that shows tape remains unrivaled in terms of cost and capacity. No other technology available today, or coming to market in the next few years, combines the low cost, storage density, fast transfer rate, ease of offsite storage and reliability of tape.

Why develop another tape technology?

Ultrium is a no-compromises format with technology from HP, IBM and Seagate.

At the time Ultrium was conceived different vendors were selling more than ten computer tape formats. A primary objective was to develop a multi-vendor, open-standard format to remove the confusion from this array of incompatible formats. An existing format, such as Digital Linear Tape (DLT), could have been developed. However, it was found that starting with an existing format would have required too many compromises. HP, IBM and Seagate took the decision to develop a new format that would be technically superior to existing formats and also remove the disadvantages of the proprietary nature of the existing formats.

Ultrium is future proof

As a new format, a key design objective of the technology partners was to make Ultrium future proof with a defined and deliverable roadmap. Four generations are defined that will take the Ultrium format to a native performance of 800 GB and 160 MB/sec. Unlike many computer products' roadmaps, the technology to achieve the Ultrium roadmap is defined and much of it already proven. This means that Ultrium users can be confident that the future, higher performance, generations of Ultrium will be delivered and delivered on schedule.

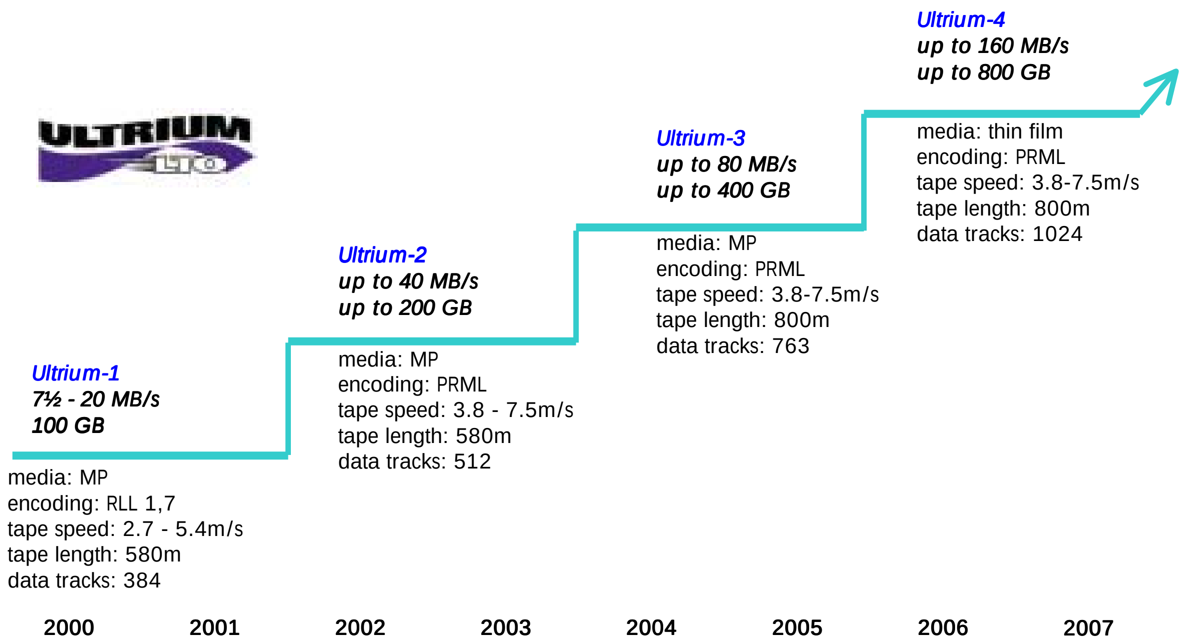


Figure 1: Ultrium format roadmap

Design choices

Ultrium Generation 1 is the foundation for a defined and deliverable product road map.

To meet the program objectives of ultra-high reliability, high performance and a future-proof open format, Ultrium was designed using a "clean sheet of paper". No constraints were imposed upon the designers by requiring backward compatibility with any existing products.

Since the first computer tape product, many leading technology companies have invested thousands of man-years of development in tape technology. The result is many attractive features across more than 10 non-compatible tape formats.

The Ultrium format specification has been chosen to incorporate the best-of-breed strengths of existing tape formats, to leverage developments in other storage technologies such as magnetic disks and develop new technology where required. Figure 2 shows some of the best-of-breed features in current tape formats that have been developed for Ultrium.

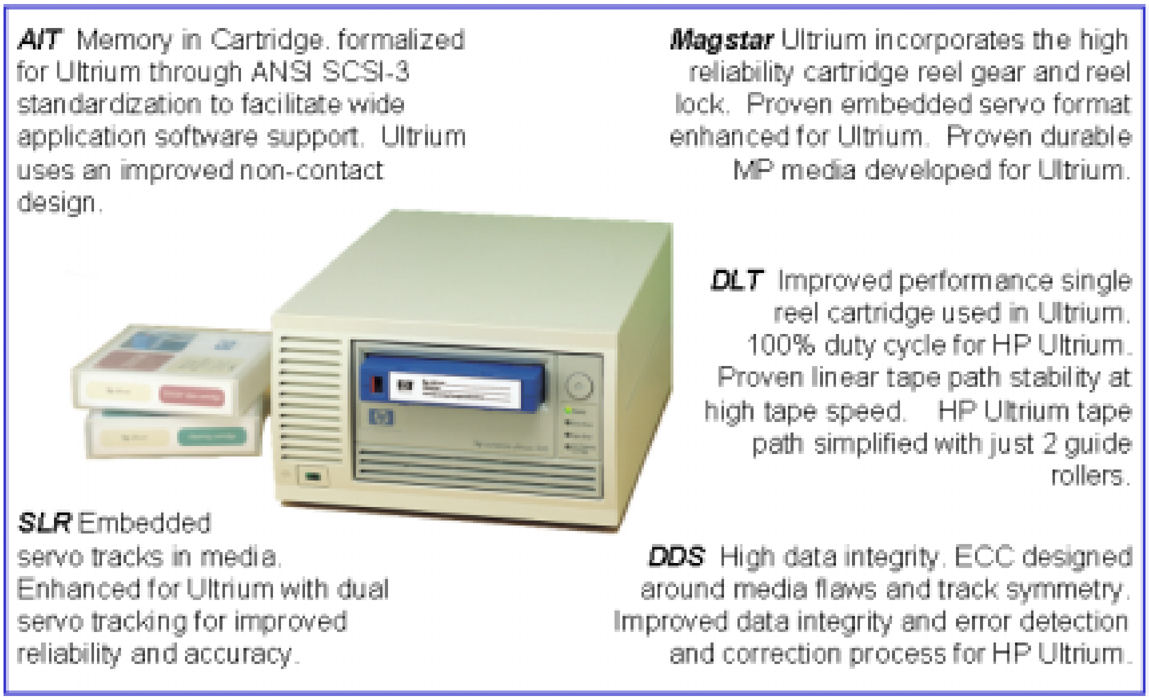


Figure 2: best-of-breed technologies leveraged for HP Ultrium

Fundamental design choices were made early in the program. It was decided to use a linear tape format rather than helical scan because it is easier to develop a multi-channel architecture and has a simpler, more robust tape path for high performance products.

To achieve high capacity a single reel cartridge was specified because it can house more tape than a dual reel cassette. To speed up file access and cartridge load times an auxiliary cartridge memory is specified in the Ultrium format. For maximum reliability and application flexibility Ultrium specifies a non-contact auxiliary cartridge memory.

HP Ultrium combines new technology with best-of-breed data storage technology.

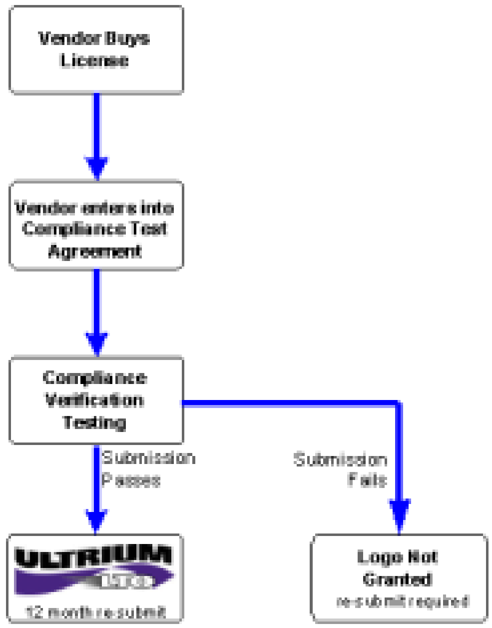
The Ultrium cartridge specification leverages the highly reliable reel gear and reel lock mechanism used in Magstar cartridges. Experience with DLT media has been used to specify a highly rugged cartridge that has 20% lower profile than DLTtape IV tapes. MP media was chosen rather than AME. It is a proven technology and less susceptible to error loss through physical surface damage and oxidation than AME media. The Ultrium cartridge uses a media leader pin for reliable tape threading.

A closed-loop servo control of the tape position as used in Magstar and SLR drives is specified in the Ultrium format. The Ultrium servo system and read-write head assembly draw heavily on technology developed for hard disk drives.

The Ultrium format specification and verification

Independent Ultrium format compliance verification ensures media interchangeability.

The Ultrium format principally defines the parameters needed for media interchange between different vendors' Ultrium products. An independently administered and executed format verification program backs up the format. This tests that the technical parameters of an Ultrium product critical to media interchangeability are within specification. There is a test program for cartridge format verification, shown below, and a test program for drive format verification.



If a drive or media manufacturer passes the compliance verification program their products can use the Ultrium logo. This process means that any media with the Ultrium Logo can be read in or written to using any Ultrium drive with the Ultrium logo.

The law offices of Ladas and Parry, located in Los Angeles, California handle all administration of the format verification process. All technical testing and analysis is executed at an independent laboratory.

Figure 3 Ultium data cartridge compliance verification process

The Ultrium format does not specify reliability, drive form factor, power consumption or absolute performance. It also does not specify any designs, materials or components. It is up to drive and media manufacturers to determine how to meet the Ultrium format specifications and also up to the manufacturers to determine all parameters not defined in the Ultrium format specification. The figure below shows the product attributes specified in the Ultrium format and the attributes defined by the Ultrium vendors such as HP.

HP's Ultrium devices have unique benefits.

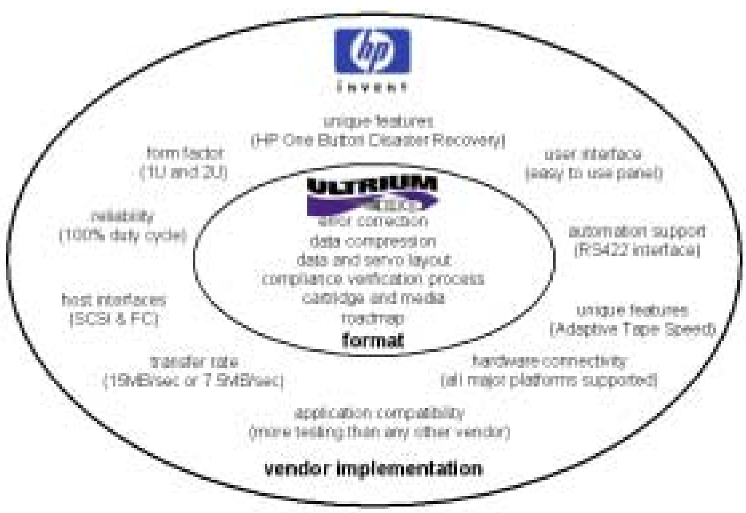


Figure 4: format and vendor-defined product attributes

HP's implementation of the Ultrium format has resulted in two first generation drives and a range of automation solutions that significantly improve the reliability, performance and features of mid-range tape backup devices. The technology incorporated in the HP Ultrium 230 and HP Ultrium 215 devices not only makes these a superior proposition to competing formats such as SuperDLT and Exabyte Mammoth but also makes the HP products the most compelling Ultrium format tape devices. The designed-in reliability, performance and unique features of the HP Ultrium products are described in the following sections.

HP Ultrium logical format

The processes in the transformation from user records to a multi-channel bit stream to be recorded onto tape includes adding error detection and correction code and data compression. A schematic representation of the process is shown in Figure 5.

CRC is added to records before compression for extra protection.

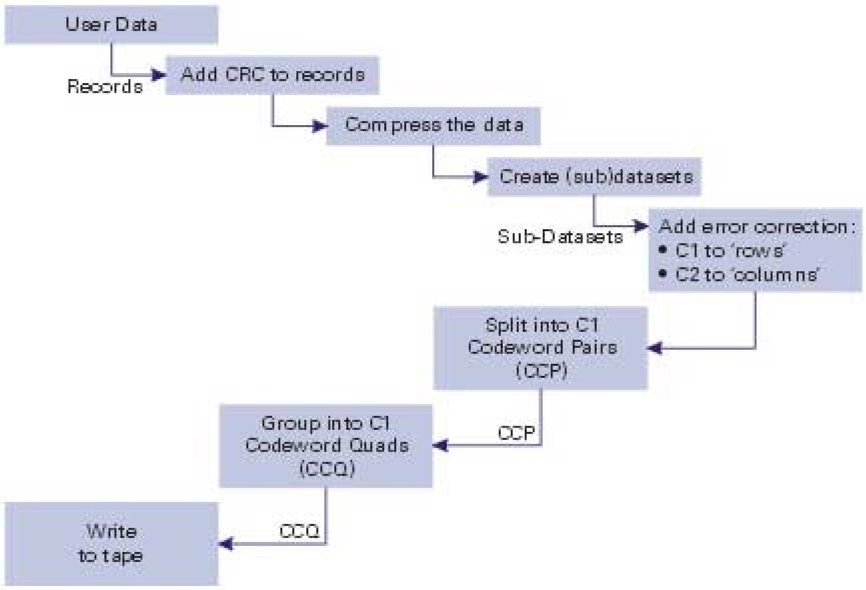


Figure 5: Ultrium logical format

Several new ASICs (application specific integrated circuits) have been developed to implement the HP Ultrium logical format. These draw on HP's extensive experience of developing tape drive data channel architecture. As a first generation product, the HP Ultrium generation 1 logical format has also been developed as a platform for the next three generations of Ultrium.

User data enters the host interface (SCSI or Fibre Channel) ASIC which generates and adds CRC to the transformed user data. The CRC protected records are then compressed.

Smart data compression

The Ultrium format uses highly efficient data compression based on the ALDC algorithm. This has been enhanced to reduce expansion of incompressible data with a pass thru mode and also has embedded control symbols to speed up data throughput.

Without the pass thru mode, incompressible data, typically already compressed files, would expand as it passes through the data compression engine. This can add 10% to the volume of data written to tape with a proportional reduction in transfer rate and storage capacity on the media.

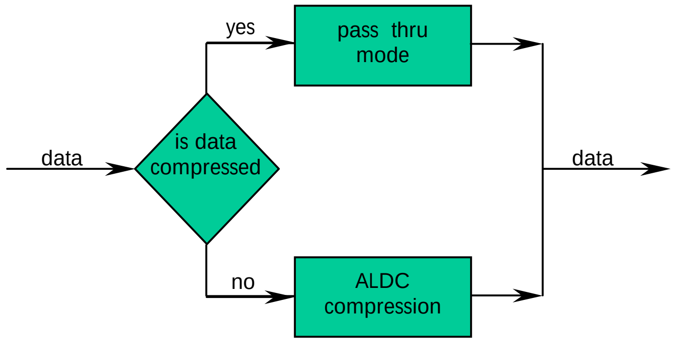


Figure 6: smart data compression

Smart data compression maximizes throughput and cartridge capacity.

The compression engine can switch automatically between these two modes. As soon as incompressible data is detected it operates in pass thru mode. If compressible data is detected, ALDC compression is used. This ability to automatically switch between the two modes almost eliminates data expansion due to attempting to compress incompressible data.

The second enhancement to the ALDC algorithm adds embedded control symbols to the data stream to mark record boundaries and file marks. This speeds up throughput because the firmware does not have to build headers or trailers for individual records. The only tables created are for large blocks of compressed data.

Error detection and correction code

Downstream of the compression engine, the compressed data is encoded using a new, specially written RLL (1,7) code and has error correction code (ECC) added to it. Before adding ECC, the records are split into data sets of 404,352 bytes. Each data set is split into 16 two-dimensional sub-data sets of 25,272 bytes. C1 (240, 234, 7) ECC is added to each row and C2 (64, 54, 11) ECC code is added to each column.

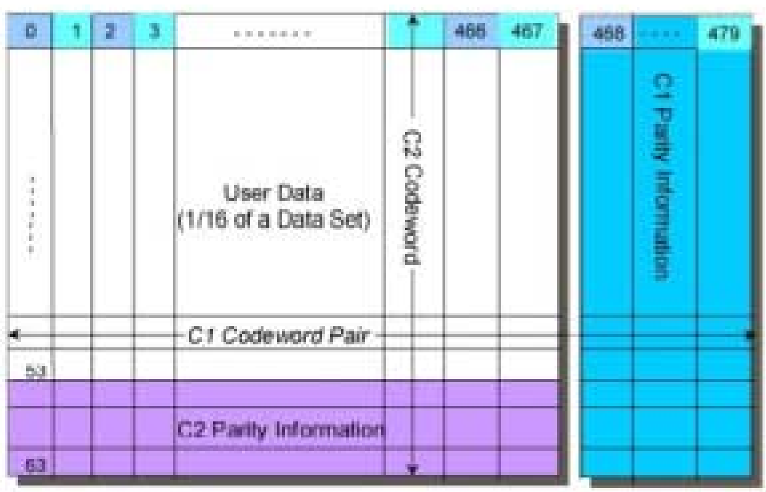


Figure 7: sub-data sets with interleaved C1 codeword pairs

Two levels of ECC are used for improved data integrity.

For added reliability, the data is then split into C1 codeword pairs. Each C1 codeword pair has two 240 byte codewords. The first C1 codeword takes each even-numbered byte in the row, and the second C1 codeword takes each odd-numbered byte in the row. There are 6 bytes of parity in each C1 codeword. The arrangement of the codeword pairs is shown in Figure 7.

In Ultrium generation 1, the data is split into eight channels to be written to tape.

Two C1 codeword pairs from two consecutive sub-data sets are placed end-to-end to form a C1 codeword quad (CCQ). Eight CCQs are written simultaneously to tape. A CCQ set (eight CCQs) is the smallest unit of data that can be written or rewritten to tape. The timings of the eight channels do not have to be exactly synchronized because each channel has a different and complete CCQ set.

One channel in each CCQ set writes a CCQ with the C2 codeword. For each subsequent CCQ set, the CCQ with the C2 codeword is written through a different channel. The effect is to distribute diagonally the C2 codewords across the tape as shown in Figure 8.

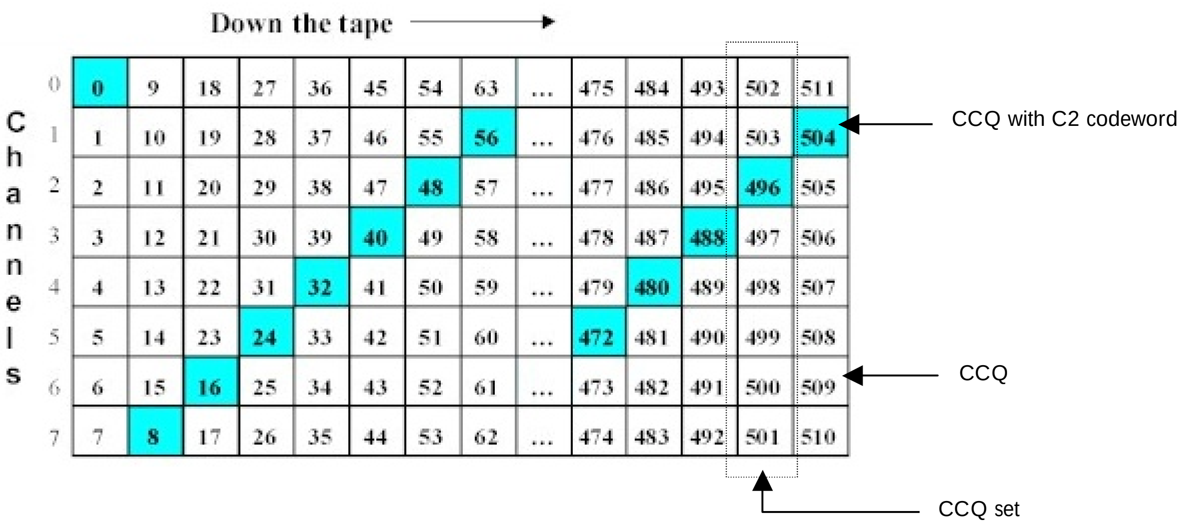


Figure 8: diagonal distribution of C2 codewords in a data set

On tape, 512 CCQs are organized as a data set. To ensure that the data has been correctly written to tape there is a read head directly after each write head. This reads back written data and checks the C1 ECC code to verify that the CCQ is correctly written. In the event of an error the complete CCQ set is rewritten further down the tape with the erroneous CCQ recorded on a different track. Again this CCQ set is read to verify a correct write.

This data distribution makes the format highly resistant to data loss through media damage. For example, up to 32 mm of tape can be totally destroyed or one of the eight data channels can be disabled without any user data being lost.

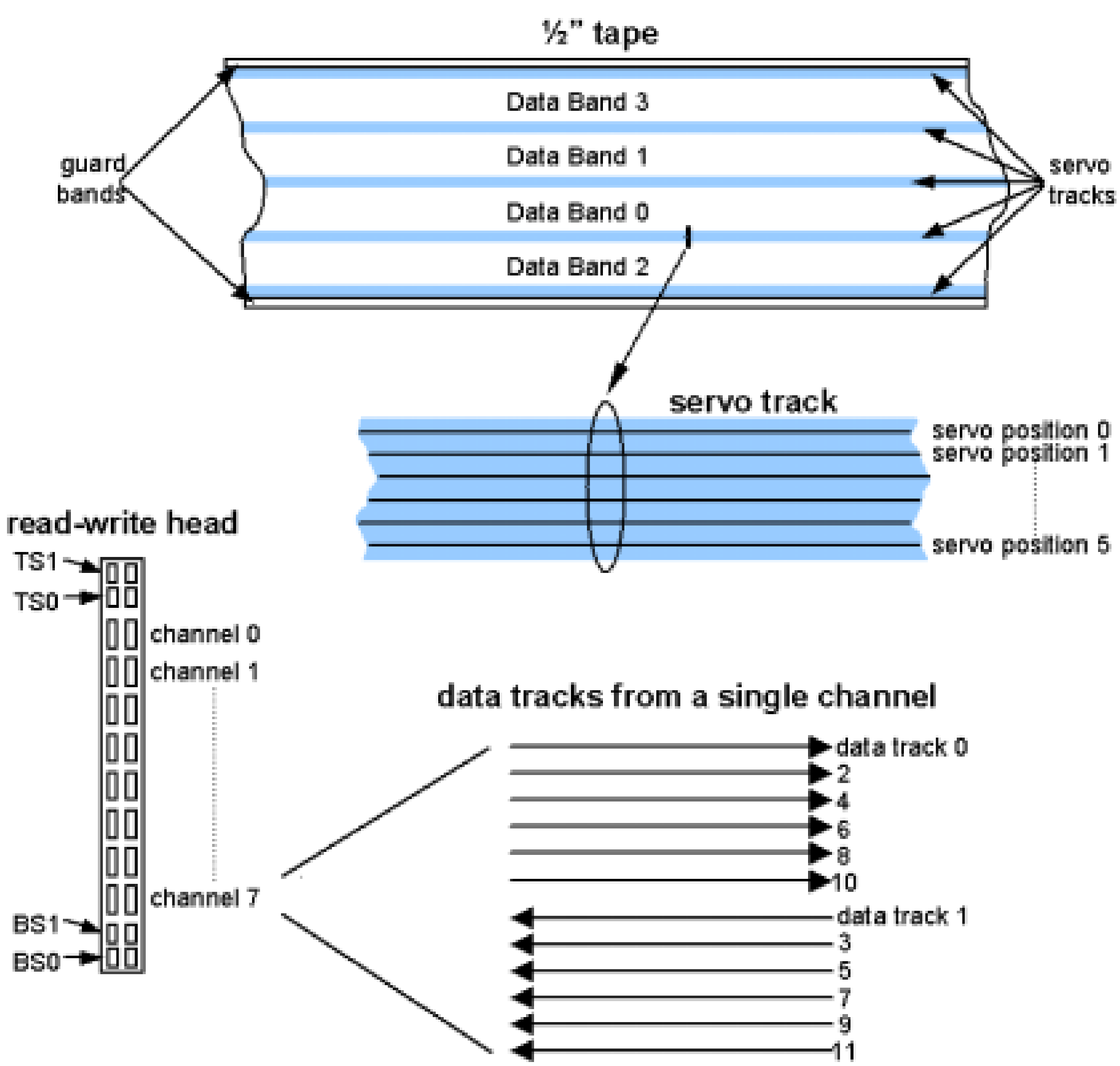
Data layout on tape

Data layout on tape is designed for highest reliability.

A full HP Ultrium tape has 384 data tracks. These are organized into 4 data bands each with a capacity of 96 data tracks. Above and below each data band is a servo track. At each long edge of the tape is a guard band where no data will be written. The read-write heads span a data band and the adjacent servo tracks. This data and servo layout on tape was defined to accommodate and optimize the performance of the thin-film inductive write / MR read head design. It is shown in Figure 9.

Using two servo tracks, rather than a single servo track, increases positional accuracy and provides redundancy. A Direction Buffer is left between the data tracks to minimize cross-track magnetic interference. Dividing the tape into data bands reduces the effects of any tape shrinkage or stretching over time. The guard band reduces the chance of data loss through edge damage. In operation, the four data bands are filled sequentially, inner data bands first (0-1-2-3). Eight data tracks are written to the tape each pass, or wrap, with an 8-channel read-write head. Twelve wraps, six in each direction, fill a data band. In each data band, each read-write channel writes six forward and six reverse data tracks. This means that the data channel pitch is greater than twelve track widths, which reduces the chances of interference between data tracks.

Figure 9: data and servo layout on tape



Within each servo band, six servo positions are defined that allow six forward and six reverse head positions to write the twelve wraps per data band. The distance between two adjacent servo positions corresponds to the distance apart that the data tracks are written. Four servo tracking heads are incorporated in the head stack: Top Servo 1 (TS0) and Top Servo 2 (TS1) at the top of the head stack and Bottom Servo 1 (BS0) and Bottom Servo 2 (BS1) at the bottom of the head stack.

The first track is written with TS1 at servo position 0. The eight data tracks are written until the End of Tape (EoT) marker passes under the head. The tape is then stopped, the head moved down so that TS0 is at servo position 5, the tape direction reversed and the next eight data tracks written in the other direction. When the BoT marker passes under the head the reverse process takes place. This continues until the data band is full. TS1 and BS1 are used for forward wraps and TS0 and BS0 for reverse wraps.

Dual servo controlled tracking

A dual track-following, closed loop, timing-based servo system is used to accurately control the vertical location of the read-write head assembly. In conjunction with the advanced head design used in HP Ultrium, this is a key component that allows the high data capacities and fast data transfer rates.

The closed loop timing-based servo controls the head location with high precision, even under shock and vibration.

In operation, servo heads are positioned over the servo tracks either side of the data band. The servo band is wider than the servo head. Only one servo head is required to provide location data. Using multiple servo heads provides redundancy.

Each servo band contains six servo tracks that define six vertical positions. The timing of the pulse the servo head reads identifies each of the six servo tracks. Two servo heads (TS0, TS1 or BS0, BS1) use these six servo tracks to control the head assembly position to read or write twelve data tracks in each data band.

The servo tracks also provide longitudinal position (LPOS) information. Servo tracks are made up of servo frames, each servo frame is 200 microns wide. One LPOS word is 36 frames (7.2 mm). Each LPOS word includes an incrementing counter as well as an extra character. LPOS is determined by reading the incremental counter. This speeds up file access through efficient access to absolute locations along the length of the tape.

The servo tracks also identify which data band the head assembly is located over and provide manufacturing information about the media.

The servo tracks are factory written. They take up just 8% of the tape width. The servo format used in this first generation Ultrium is expected to remain consistent throughout the life of the Ultrium format. This enables manufacturers to make significant product investments knowing that this can be recouped over many product generations.

HP Ultrium read-write head assembly

The HP Ultrium drives use a head assembly design that leverages technology developed for the hard disk drive industry. The merged thin-film inductive write / MR read modules contain both read-write and servo reading elements. The thin film substrate material is the Al_2O_3/TiC composite.

The head assembly has two physically separated modules to reduce interference.

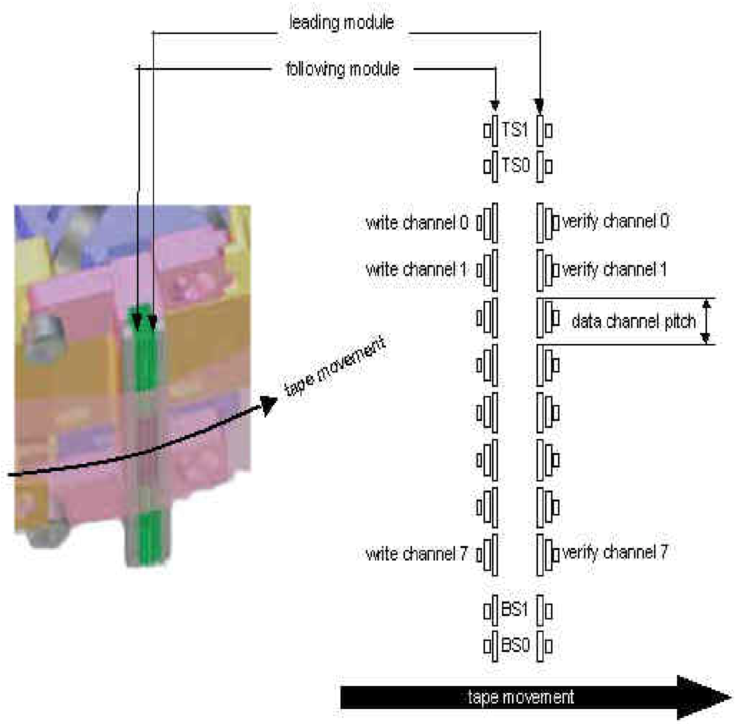


Figure 10: HP Ultrium head assembly

The head assembly has two modules, as Figure 10 shows, to allow reading and writing in both tape pulling directions. Each module has eight read-write head elements and four servo reading elements. During a backup, data is written by the leading module and read immediately afterwards, to verify that it has been recorded correctly, by the following module. The two head modules are contained in the center of the head assembly. These are accurately aligned during manufacturing for accurate read-after-write operation. The bit stream to each module is fed through two separate flexible circuits. Having two flexible circuits and physically separating the two read-write modules reduces cross talk. This translates into very high data integrity.

Head cleaning

HP Ultrium firmware has a preventative maintenance cleaning strategy for high reliability.

The Ultrium media and drive is designed to keep the read-write head assembly free from dust and debris. During operation, the error rate is monitored to determine if a head clean is required. The head is also cleaned periodically as part of a preventative maintenance strategy. This reduces the need for users to clean the drive with a cleaning cartridge.

The head is cleaned when the media is at the beginning of tape (BoT) so the tape can be quickly unthreaded. This strategy minimizes the effect on data throughput. An HP patented active head cleaner, made from specially designed material, is then used to clean the head assembly. The HP active head cleaner is much more effective than a cleaning tape in removing any debris from the grooves in the head assembly.

Should a more thorough clean be required of the tape-bearing surface of the head, the “Use Cleaning Tape” light on the HP Ultrium 230 front panel will flash to prompt cleaning with an Ultrium cleaning cartridge. The Ultrium cleaning cartridge works in conjunction with the active head cleaner. The Ultrium cleaning cartridge is dimensionally the same as the data cartridges. The Cartridge Memory (see next section) identifies it as a cleaning cartridge.

Ultra reliable cartridge loading and tape threading

A mechanical interlock and optical sensors ensure reliable tape threading.

The HP Ultrium tape drive mechanisms have been designed for completely reliable cartridge loading and tape threading. The application of FMEA (failure mode effects and analysis) techniques was used to identify potential failure modes early in the design process. The result of identifying and designing out potential failure modes is a mechanism designed for 100,000 load-unload cycles. A rigid tape leader pin, precision capture mechanism, interlocks and sensors ensure that the tape is threaded reliably every time.

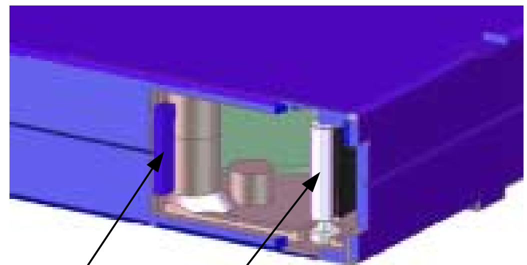
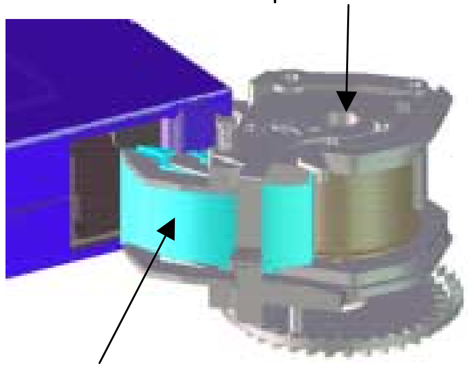


Figure 11: during storage and transportation, the leader pin is securely



The end of the Ultrium tape is securely connected to a leader pin – it resists a separation force of up to 35N. During cartridge storage the leader pin is positively held against two stops inside the cartridge.

Figure 12: capture actuator and leader block

When the cartridge is loaded, the loading mechanism opens a door, as shown in Figure 11, to allow access to the leader pin. The leader pin is accurately positioned against its stops in the cartridge and the cartridge is accurately and solidly located in the mechanism. The leader block is transported to engage the leader pin by the capture actuator as show in Figure 12. Once engaged the leader pin is mechanically locked into the leader block to ensure that it remains connected, as shown in Figure 13. A mechanical interlock ensures that if the leader pin is not properly engaged the leader block will not be pulled into the Ultrium drive. To provide additional security two optical sensors determine if the leader pin is properly engaged in the leader block.

Only when the mechanical interlocks are in place and the optical sensors detect proper engagement of the leader pin is the leader block pulled through the tape path. If both these conditions are not met there is a series of recovery algorithms that will manage the leader pin engagement to ensure that the pin is safely engaged and that the tape is reliably threaded.

Threading tracks guide the leader block onto the take-up reel and prevent any contact with the assembly.

The leader block is connected to the take up reel by strong plastic tape. When the mechanical interlock and optical sensors determine that the leader pin is securely engaged, the take-up reel is rotated to thread the tape. An assembly containing upper and lower threading tracks guides the leader block through the drive mechanism, as shown in Figure 14.

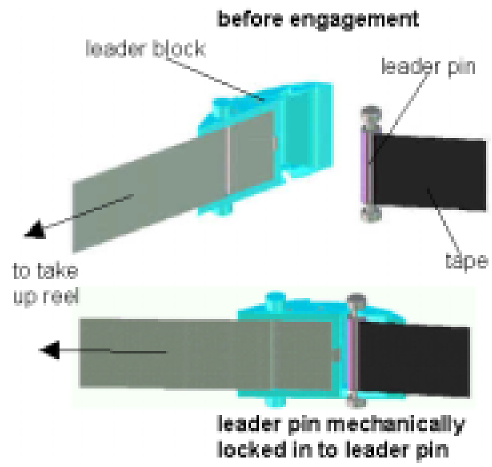
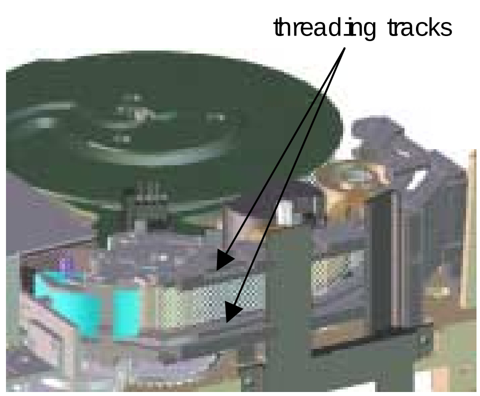


Figure 13: capture and engagement of leader pin into leader block



Threading tracks guide the leader block past the head into the take-up reel. The tracks guide the leader block so it does not contact the head stack as it passes. The tracks also ensure that the tape leader is not tangled in the event of a power failure during threading. The leader block fits precisely into the take-up reel to form a very accurate cylinder for consistent tape packing. The engagement of the leader block into the take up reel is shown in Figure 15.

Figure 14: threading tracks

Prior to an unload, the tape is rewound and the leader pin and leader block are unthreaded in an equally reliable process. All the checks applied during threading are applied during unthreading. In the cartridge, the leader pin is parked against its stops and the reel lock is applied.

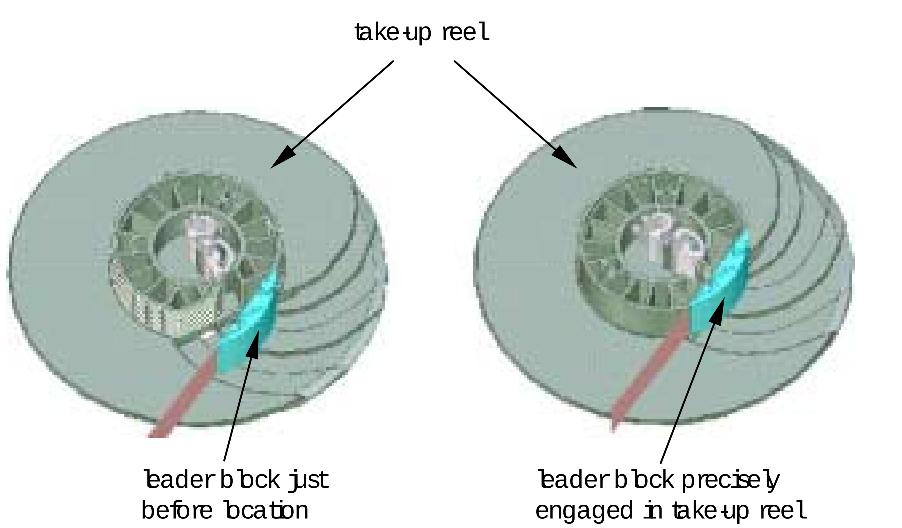


Figure 15: the leader block completes an accurate cylinder on the take-up reel

Simple tape path

For reliability only two guide rollers are in the HP Ultrium tape path.

The tape path between the take-up reel and the cartridge reel has been designed to be extremely simple and exert minimal stress on the tape. For minimum stress on the tape, there are only two guide rollers on the tape path as Figure 16 shows. This compares to six rollers on a DLT tape device.

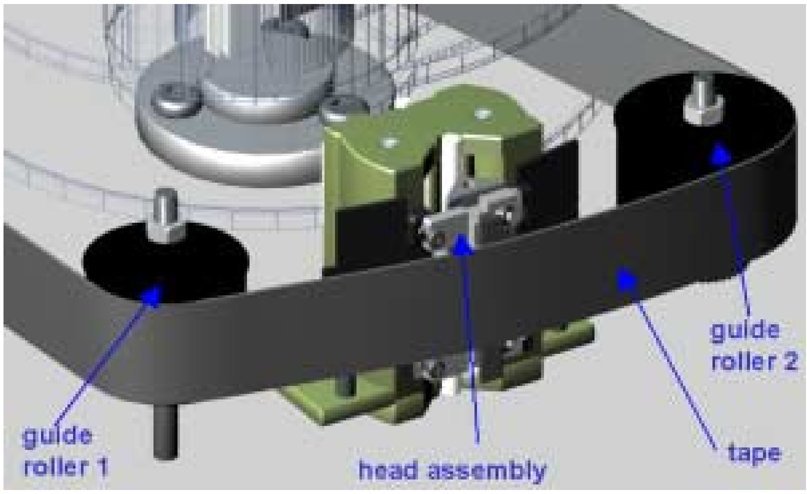


Figure 16: simple tape path with only two guide rollers

HP Ultrium soft tape load

No handles or buttons are needed to load an HP Ultrium cartridge.

An electronically controlled soft load-unload mechanism is standard on all HP Ultrium products. No handles or buttons are needed to load a cartridge. The soft load starts when the back of the cartridge is between 15 mm and 10 mm from the front of the front panel (20 mm and 15 mm from the mechanism). The cartridges are ejected so that the back of the cartridge is 20 mm from the front of the front panel (25 mm from the mechanism).

Load-unload operations can be controlled from the front panel, the backup application software or via the Automation Control Interface (ACI).

The key benefit of the HP Ultrium soft load-unload is the added reliability through consistency. This is especially important in automation applications.

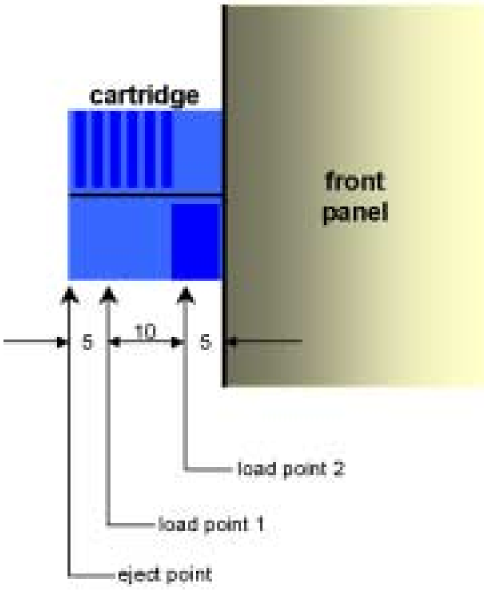


Figure 17: load-unload points

Cartridge Memory (CM)

Cartridge identity, contents and usage data are held in Cartridge Memory.

Storing information about a tape's contents, usage and identity in on-board memory located in the cartridge rather than in a tape header increases performance and usability as well as improving media and drive reliability. For these reasons, Cartridge Memory (CM) is an integral part of the Ultrium format. The Ultrium CM also has many management benefits that software applications can deliver. Both data and cleaning cartridges have a CM.

In parallel with the Ultrium CM development, additional SCSI Medium Auxiliary Memory (MAM) commands have been agreed. These are defined in ANSI document T10/99-148r7. SCSI MAM consists of two new commands to read from (READ ATTRIBUTE) and write to (WRITE ATTRIBUTE) any on-board, non-volatile media memory. Information in the media's memory is stored as a series of attributes. These commands will be incorporated into the next draft of the SCSI-3 Primary Commands (SPC-3).

The HP Ultrium specification defines the implementation of SCSI MAM commands for accessing the Ultrium CM. This standards-based approach facilitates development by backup software vendors to use the Ultrium CM to deliver value added features in their backup applications.

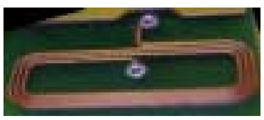


Figure 18: inductive coil in drive to communicate with CM

The Ultrium CM is a non-contact design for improved reliability and flexibility compared to a contact design. Data is transferred to and from the cartridge using proximity inductive coupling. The passive RF interface gives a range of up to 20 mm. The power comes from the inductive coil in the drive (shown in Figure 18), library reader or a hand-held CM reader. The operational principles are similar to a smart card. High data integrity is assured with parity and CRC added to the CM data.

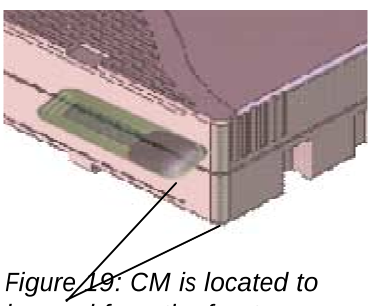


Figure 19: CM is located to be read from the front or bottom of the cartridge

As Figure 19 shows, the CM is contained within the cartridge shell for mechanical protection. It is located at the rear of the Ultrium cartridge at an angle of 45° to the cartridge base. This orientation allows a tape drive, a tape library or a hand-held CM reader to access the CM contents from the back or the bottom of the cartridge.

In the CM, data is stored in a 32 kilobit (4kB) flash EEPROM memory chip organized as 128 x 32-Byte blocks. Data is transferred to and from the CM in 32 Byte blocks.

Approximately 3kB of the CM is allocated during the production of the cartridge. The remaining 1kB is unallocated.

The 3kB of allocated CM contains three classes of attributes as explained in figure 20. The unallocated area of CM is available to writers of backup software to use for application specific purposes.

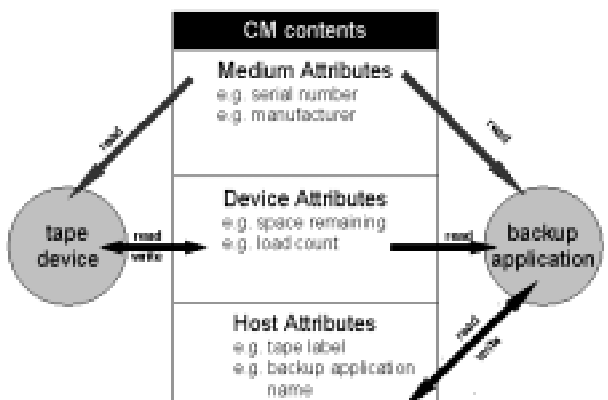


Figure 20: CM attribute classes

The CM is designed to be highly reliable, with an operational life of more than 500,000 write cycles and a 20-year data retention life. If the CM does fail, the HP Ultrium drive will recognize the failure and treat the Ultrium cartridge as read-only and allow all data on the tape to be recovered.

Application software support for Ultrium CM is facilitated by using standard SCSI commands.

HP's ultra reliable Ultrium media and cartridge

Ultrium cartridges use highly reliable MP media.

Ultrium Generation 1 cartridges use proven Metal Particle (MP) media. The Ultrium format defines a media thickness of 8.9± 0.3µm for Ultrium generation 1. The 100 GB (native) cartridges contain 609 m of ½" (12.6 mm) tape of which 580 m is available to write data. The cartridge is designed to withstand 20,000 load and unloads to meet the requirements for automation devices.

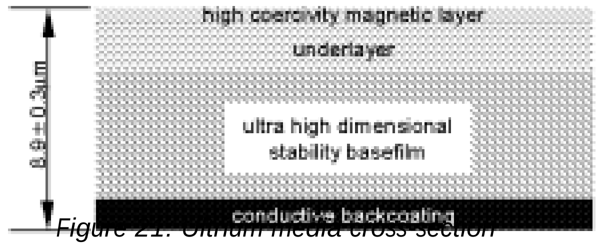


Figure 21: Ultrium media cross-section

Figure 21 shows the layers of the media. The magnetic layer is made from metal particles held in a durable binder material to provide extremely high storage density with low error rates. The underlayer, between the magnetic layer and basefilm, provides reinforcement and a lubrication reservoir and helps promote a smooth magnetic layer. The basefilm is manufactured from PEN (Polyethylene Naphthalate) for improved performance compared to the PET (Polyethylene Terephthalate) used in current MP media such as DLTtapeIV. The PEN basefilm has excellent dimensional stability to ensure accurate head-tape alignment across all operating conditions. A conductive, carbon-filled backcoating prevents the build up of any electrical charge on the tape.

Ultrium uses a robust low profile cartridge – 21.5 mm compared to 25.0 mm for a DLTtape IV. It is designed to be highly reliable in use, transport and storage.

The compact, efficient, IBM 3590-style, reel lock prevents tape movement and maintains tape pack tension when the cartridge is not in a drive. When the cartridge is loaded the reel lock is released to allow the tape to be threaded.

The media is housed in a robust low profile cartridge.

The dimensions of the Ultrium cartridge prevent incorrect loading. The drive also prevents any other type of media being loaded, if it is inserted into the drive in error. The cartridge has a write-protect switch. The position (write-enabled or write-protected) can be seen when the cartridge is loaded in a drive but this should only be changed when the cartridge is outside the drive.

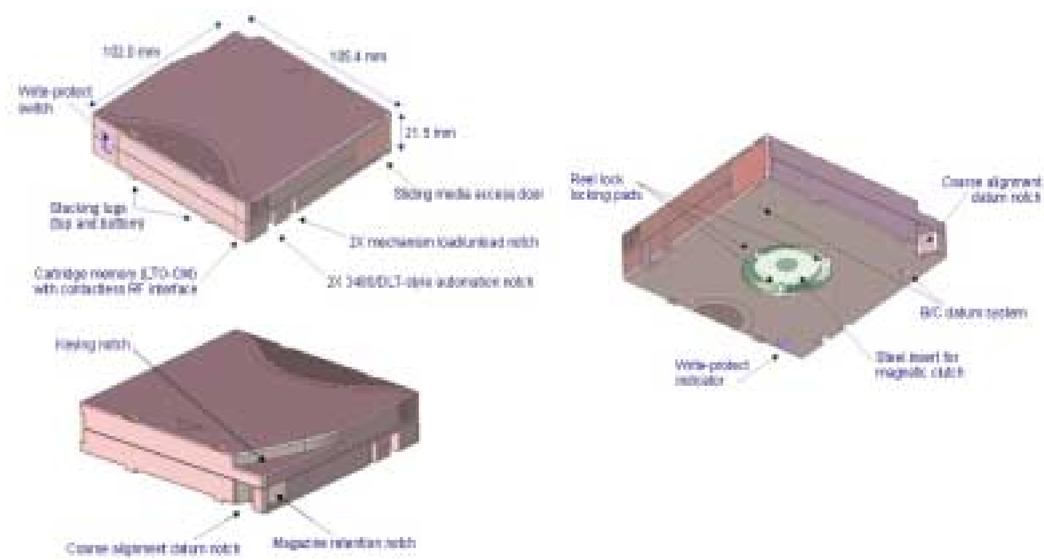


Figure 22: Ultrium cartridge external features

The cartridge contains location notches for drives and automation robotics. The leader pin is accessed via a door that is sprung loaded for protection. Stacking lugs and recesses mean reliable stacking of media. These and other features of the cartridge are shown in Figure 22.

All HP's Ultrium media will comply with the Ultrium U-18 specification for media to guarantee interchange between any Ultrium drive. Additionally, all HP Ultrium media has to pass what HP believes is the industry's most extensive test program. The testing is described in more detail in the HP whitepaper "Media Qualification and Testing – HP Does More". In summary, all HP Ultrium media must pass severe environmental testing, drop testing and simulated customer usage such as load-unload cycling and repeated repositioning. This test program is developed to simulate the conditions cartridges will be subject to in the harshest production environments.

Low power consumption and cool running

Much effort went into reducing the power requirement for HP's Ultrium devices. Reducing the power requirement improves reliability of the drive (and host computer) and allows installation into a wider range of computers. The main components consuming power are the electric motors and the ASICs.

State-of-the-art ASIC design techniques resulted in reduced power consumption and heat generation.

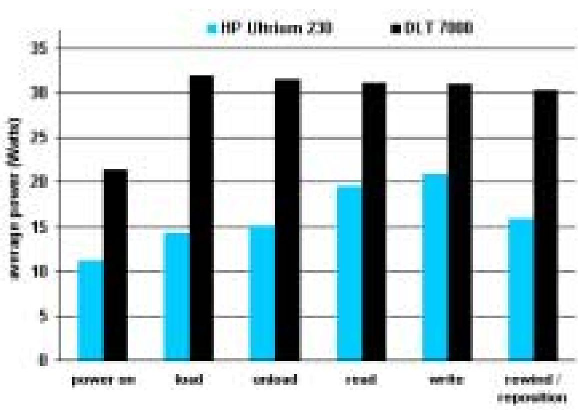
The formatter ASIC is the highest power-consuming ASIC. To reduce power consumption this operates at 3.3V, reduced from 5V in previous HP tape drives. Frequency directly impacts throughput so was not reduced - the formatter runs at 66 MHz. A significant power saving was achieved by "micro clock gating". Using a newly developed tool, the formatter ASIC has been designed so that small groups of elements can have their clock turned off when they are not operational. By gating elements and removing their clock when they are not operational the power requirement is reduced by 50%.

A SIMULINK® model was built of the mechanism control system. Using this, the motor sizes to achieve a given level of performance were evaluated. Particular attention went into the repositioning and end-of-wrap power requirements. As well as optimizing the motors for the performance required, the drive and load-unload mechanism was designed to require as little power as possible. When the tape is being pulled the drive comes from the leading motor and the trailing reel motor acts as generator. This regeneration supplies electricity back to the overall system and reduces power consumption.

As well as minimizing heat generated, the HP Ultrium drives have been designed so that the cooling air flow is under mechanism and across PCA to remove heat from the drive as efficiently as possible. Cooling air flow is also managed so that the media is kept cool, which increases its life.

HP Ultrium 230 requires 30% to 50% less power than DLT 7000.

Comparing the HP Ultrium drive to the much lower performance DLT 7000 drive can see the result of this focus on minimizing the power requirement. The Ultrium 230 requires 30% to 50% less power, depending on the operation, than the DLT 7000.



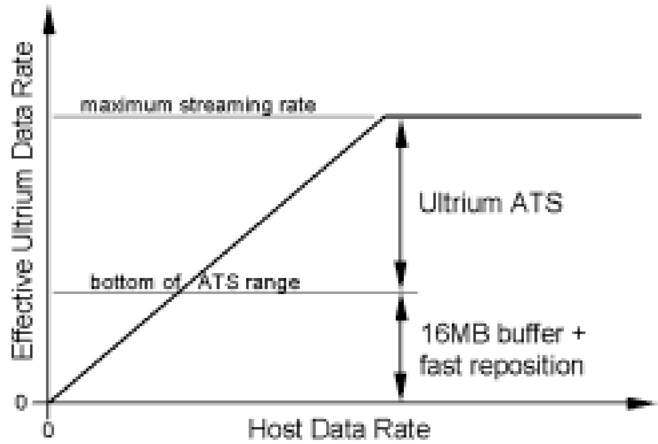


Figure 23: HP Ultrium 230 (15 MB/sec) requires significantly less power than DLT 7000 (5 MB/sec)

The low power requirement combined with the efficient cooling translates into improved reliability and the unique capability to deliver a half-height product, the HP Ultrium 215.

HP Ultrium's adaptive tape speed (ATS)

A feature unique to HP's implementation of the Ultrium format is the continuous monitoring and adaptation of the tape pulling speed so that the Ultrium device operates at the most appropriate data rate for the host. The Adaptive Tape Speed (ATS) works for both backup and restore operations.

Figure 24: ATS controls effective data rate to match the host data rate

ATS sets the HP Ultrium data rate to match the host computer or network rate.

ATS improves drive and media reliability and also improves data throughput to and from slow hosts. It is much more effective than increasing buffer size. HP Ultrium ATS operates from 6.0 MB/sec up to the device's native data rate. The ATS operation is shown in Figure 25.

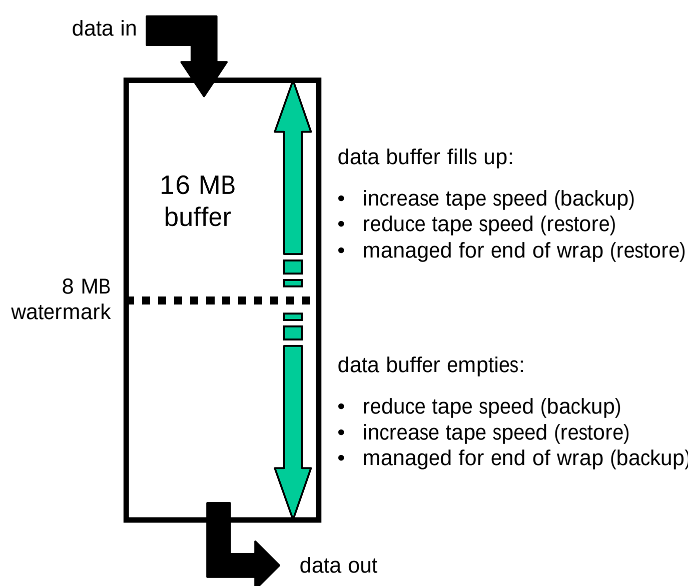


Figure 25: ATS operation

ATS increases reliability and improves data transfer rate.

From 6.0 MB/sec (bottom of Ultrium ATS range) to the drive's streaming rate the ATS algorithm contiguously adapts the effective data rate to match the host data rate. This removes the need for repositioning with the effect of improving reliability and improving throughput.

Below the ATS range the data buffer is used to store data while the Ultrium drive repositions. At 6.0 MB/sec host data rate, the HP Ultrium drive's buffer will store approximately 2 seconds of backup data. The HP Ultrium drives have fast repositioning so that the host does not have to wait to transfer data resulting in maximum throughput.

As Figure 25 illustrates, ATS works by monitoring the level of data in the buffer. In steady state operation this is maintained at half full (8 MB). During a backup, as the buffer starts to fill, the tape speed is increased. When the buffer starts to empty the tape speed is reduced. To maintain maximum data transfer from the host at the end of a wrap the data buffer is emptied as the tape approaches end of wrap. While the tape reverses and the head assembly repositions, the buffer fills up. The buffer is emptied to the watermark level at the start of the next wrap. For data restore the operation is reversed at the end of a wrap.

HP Ultrium is designed for automation

Precision soft load, the ACI and cartridge memory all facilitate integration into automation products.

All the reliability and performance benefits of the stand-alone drives are carried into automation applications. The media includes standard notches for automation pickers. The precision soft load-unload can be customized to suit the application. The HP Ultrium 230 has an Automation Control Interface to facilitate better integration in to automation products.

The Automation Control Interface (ACI) is mounted next to the SCSI interface at the rear of the drive. The ACI is a serial bus with additional control lines to connect the Ultrium drive to an automation controller. As shown in Figure 26, the physical interface is based on a 9-pin RS-422 serial connector (9,600 -115,200 baud rates).

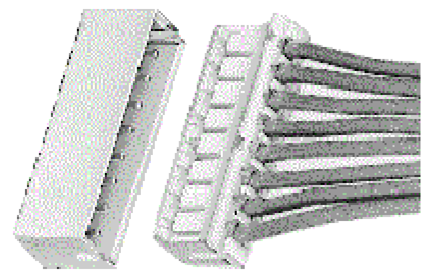


Figure 26: automation control interface

HP Ultrium interfaces - SCSI and Fibre Channel

At launch, the HP Ultrium drives will use a 68-pin SCSI Ultra 2 LVD interface. In wide mode this will operate at a sustained 80 MB/sec. In narrow mode this will operate at a sustained 40 MB/sec. In single-ended mode this will operate at a sustained 10 MB/sec (narrow) and 20 MB/sec (wide). There will be no native HVD SCSI implementation.

There will be a Fibre Channel interface to follow the SCSI interface. This will be a class 3 Tape Profile capable of 100 MB/sec public and private operation. It will use an 80 pin SCA-2 connector.

HP Ultrium One-Button Disaster Recovery (HP OBDR)

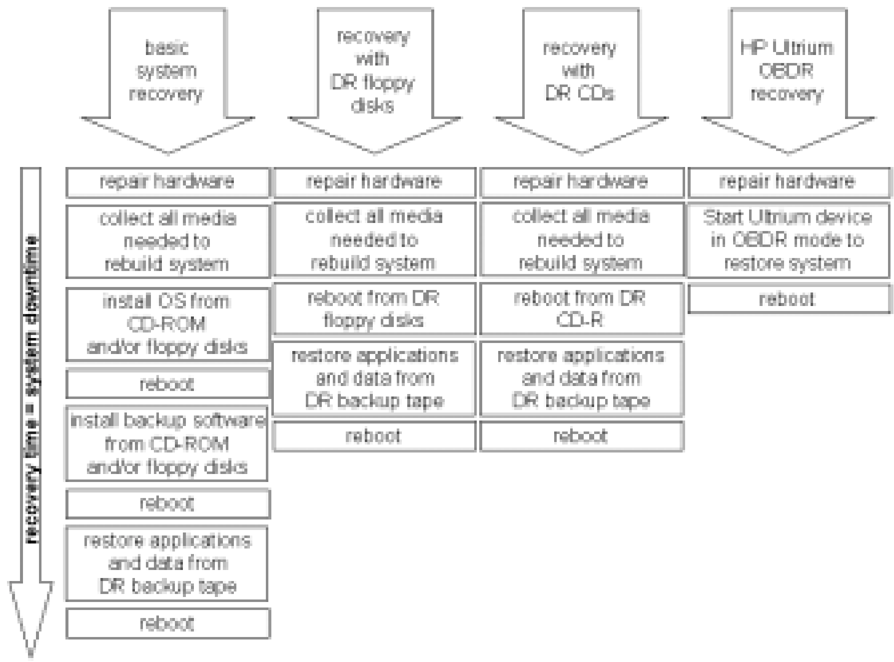
HP OBDR is proven as the fastest method to get a failed system back online.

HP OBDR is a proven feature on many existing HP tape drives. This feature is used to recover after a complete system failure resulting from catastrophic hardware failure, theft or irretrievable software corruption or a terminal virus. As soon as the new or repaired hardware is available or the corrupt hard disks erased then all system files and settings, operating system, applications and data can be restored from an HP OBDR tape. No floppy disks, CD-ROMs or key codes are needed to rebuild the failed computer. Additionally the process is so simple that there is no need to wait for an IT member of staff.

The process of creating an HP OBDR tape is automatic. Every time a full system backup is made, using a backup application that supports HP OBDR, this tape becomes an OBDR tape. A disaster recovery bootable image is written to tape with the backup session. This process is automatic each time a full backup is run, unlike the requirement to remake disaster recovery floppy disks or disaster recovery CDs each time a system setting is changed.

Figure 27: comparison of system recovery options

HP OBDR preparation and system recovery does not require IT skills.



The operation of HP OBDR uses a patented process. This process enables the HP Ultrium tape drive to emulate CD-ROM device if it is started in OBDR mode. In this mode, if the computer supports bootable CD-ROMs, the Ultrium device becomes the boot device.

To start the Ultrium device in OBDR mode it is powered on with the eject button held down. The Ultrium device then emulates a CD-ROM device. Next, the most recent full backup cartridge is inserted into the Ultrium drive. The system now boots as if it was booting from a CD-ROM. When a minimal operating system has been restored a CD-ROM Mode Select command switches the Ultrium drive back to tape drive mode using the CD-emulation mode page. The SCSI bus is reset and the full system; applications and data; are reloaded to the host.

As Figure 27 shows there is no faster way, unless the system is mirrored, to get a system back into production. A second advantage of the HP OBDR feature on HP Ultrium tape devices is that the DR media is automatically part of the backup process and does not require the DR floppy disks or the DR CDs to be changed each time a system change is made.

HP Surestore Ultrium product family

HP has the widest Ultrium tape product range of any vendor. This range is currently based around two HP Ultrium drives. The first is the high performance Ultrium 230 and the entry level Ultrium 215. The Ultrium 215 is the only half-height (1.75” high) Ultrium product available. A range of automation products is built around the HP Ultrium 230.

The table below shows the specification of the branded Ultrium drives, the HP SureStore Ultrium 230 and HP SureStore Ultrium 215. The complete product range is shown on the following page.

Table 1: HP Surestore Ultrium product family

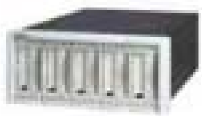
The HP Ultrium 230 can back up over 100 GB in an hour (assuming 2:1 data compression).

The HP Ultrium 215 is the only half-height (U1) Ultrium drive available.

	HP Surestore Ultrium 230	HP Surestore Ultrium 215
performance		
transfer rate (native)	15 MB/sec	7.5 MB/sec
tape capacities (native)	100 GB, 50 GB	
transfer rate (compressed)	30 MB/sec	15 MB/sec
tape capacities (compressed)	200 GB, 100 GB	
data compression		
tape search speed	4.1 m/s	2.05 m/s
reliability		
MTBF	250,000 hours at 100% duty cycle	
uncorrectable error rate	1×10^{-17}	
load-unload	100,000 cycles	
integration		
form factor (internal model)	full height (2U), 5½ x 8”	half height (1U), 5½ x 8”
interface	SCSI Ultra II LVD (80MB/sec) high density 68 pin connection	
standby power (no cartridge)	5W	5W
standby power (with cartridge)	12W	12W
operating power	30W	20W
peak operating power	50W	35W
automation control interface	9-pin RS-422	
part numbers		
desktop drive	Ultrium 230e – C7401A	Ultrium 215e - C7377A
internal drive	Ultrium 230i - C7400A	Ultrium 215i – C7378A
data cartridges	50GB – C7970A 100GB – C7971A	
cleaning cartridge	C7979A	

HP Ultrium 215 Entry level HP Ultrium drive. 100 GB native capacity and 7.5 MB/sec native transfer rate. The only half-height (1U) Ultrium drive available. HP One-Button Disaster Recovery (HP OBDR) and Adaptive Tape Speed (ATS). Internal and external (desktop) versions.

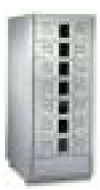
HP Ultrium 230 High performance HP Ultrium drive. 100 GB native capacity and 15 MB/sec native transfer rate. HP One-Button Disaster Recovery (HP OBDR) and Adaptive Tape Speed (ATS). Internal, external (desktop), rackable and automation module versions.



HP Ultrium Tape Array 5500 A rack enclosure to house up to five HP Ultrium 230 drives. Five independent SCSI buses allow back up of five separate servers or can operate as a Tape RAID (RAIT). Highest density tape rack in its class. Designed for installation in 19” racks, only 4U high.

HP Ultrium Autoloader 1 – 9 Single drive mini-library with 9 cartridge slots. Up to 900GB native capacity. Two 1-9 Autoloaders can be rack mounted side by side in a standard 19” rack. Also available as a desktop version.

HP Ultrium Tape Library 2-20, HP Ultrium Tape Library 4-40, HP Ultrium Tape Library 6-60 This HP library family is based on a common architecture and includes three configurable models: a 1- or 2-Ultrium drive 20-slot model; a 2- or 4-Ultrium drive 40-slot model; and a 2-, 4- or 6-Ultrium drive 60-slot model. This family gives a capacity range from 2TB to 6TB (native). Modular design means capacity and speed can be added if storage needs increase.



HP Ultrium Tape Library 6-140 Available with 4 HP Ultrium drives and 100 cartridge slots or 6 HP Ultrium drives and 100, 120 or 140 cartridge slots. Housed in a cabinet that's the same size as an industry-standard rack. Provides up to 14 TB (native) of storage capacity.

HP Ultrium Tape Library 10-180, HP Ultrium Tape Library 20-700 The 10/180 and 20/700 libraries are part of a family of scalable, hi-availability, hi-end libraries for enterprise scale applications. Users can configure a number of HP Ultrium tape drives and cartridges to match application requirements then add cartridge capacity, as application needs increase. Status reports and diagnostics information and library management available via a remote browser. Fast robotics provides up to 450 cartridge exchanges per hour, quiet enough to be placed in an office environment.

Conclusions

HP has developed a range of Ultrium products that deliver the benefits of an open standard. In addition HP has added features and designed in reliability to make its Ultrium products the most attractive tape data protection devices available. Adaptive Tape Speed (ATS) and the low power consumption illustrate the significant development aimed at delivering an ultra reliable product. HP One-Button Disaster Recovery (HP OBDR) and the half-height (1U) Ultrium 215 illustrate benefits unique to HP's range of Ultrium products.

It is expected that the Ultrium format will be the *de facto* mid-range tape data protection format. By delivering a range of products with the technology and benefits described in this white paper HP intends to be the vendor of choice for Ultrium products.

Further information

The latest information about HP tape products is available on the World Wide Web at *http://www.hp.com/go/tape*

For the latest hardware connectivity and software compatibility for HP Surestore products consult *http://www.hp.com/go/connect*