TECHNICAL BRIEF
April 2005

T9840C FICON tape drive performance

1 Executive summary

With the T9840C FICON tape drive, StorageTek® provides its customers with high-performance and high-capacity tape storage while helping customers protect their media investments. The drive's unique characteristics work together with the FICON channel architecture to increase the performance, capacity and effectiveness of data storage.

This paper describes the general characteristics of the T9840C FICON drive in brief and explores its performance characteristics in detail.

2 The challenge

In today's transaction-intensive IT environments, fast data access and high throughput are essential. An organization's competitiveness can depend on its ability to improve response times, shrink batch and backup windows, cut recovery times and gain more value from system resources.

All of this must be accomplished within a framework of broader business goals, such as maximizing the utilization of resources, using the most cost-effective technologies, simplifying management and increasing productivity.

StorageTek's T9840C FICON tape drives respond to these needs. These new-generation drives deliver the performance and reliability needed to meet aggressive IT and business goals.

3 T9840C tape drive overview

The T9840C tape drive is the third-generation tape drive in the highly successful T-Series™ tape drive family, providing industry-leading performance and capacity.

Figure 1: The T9840C drive

While using existing 9840 media, the T9840C doubles the native cartridge capacity to 40 gigabytes using an increased recording density. In practice, the net capacity is further increased through LZ1 data compression so that effective capacities exceeding 160 gigabytes are typical. This increased capacity saves library slots and improves throughput by reducing mount/dismount cycles.

By using an increased recording density rather than longer tape, more than twice as much data can be stored on existing 9840 cartridges without slowing access times. The access-centric design of the T9840C tape path utilizes the same dual-hub cartridge and media introduced with the T9840A tape drive. The dual-hub or cassette design of the cartridge allows for midpoint loading and unloading, greatly improving access times and reducing rewind time. The T9840C continues to use a linear, serpentine recording format reducing search and access times to specific data sets on the cartridge.

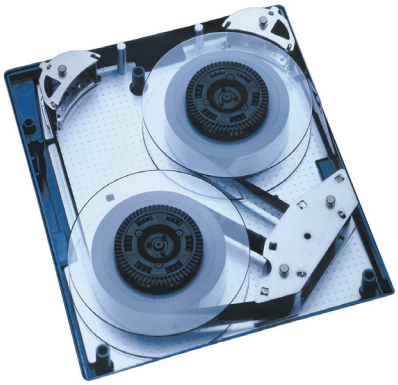


Figure 2: 9840 cartridge (internal view)

The T9840C provides backwards-read compatibility in that it can read cartridges written on T9840A and T9840B tape drives to facilitate migration to the T9840C recording format. Cartridges rewritten on the T9840C are automatically written at the higher recording density.

The native head-to-tape data transfer rate of the T9840C is 30 megabytes per second, almost double the earlier T9840B transport. Combined with the FICON interface, the T9840C is capable of read/write speeds in excess of 60 megabytes per second. The faster throughput significantly reduces backup times and improves the performance of other applications. When used in disaster recovery situations, the T9840C FICON drive helps to quickly restore critical information to DASD, thus minimizing recovery time.

4 FICON architecture implementation

StorageTek's T9x40 FICON tape drives implement native FICON direct-attach interfaces, often referred to as a "1x1" architecture. This means each drive, such as the T9840C FICON, can be connected directly to a FICON channel or FICON director/switch without intervening equipment (Figure 3).

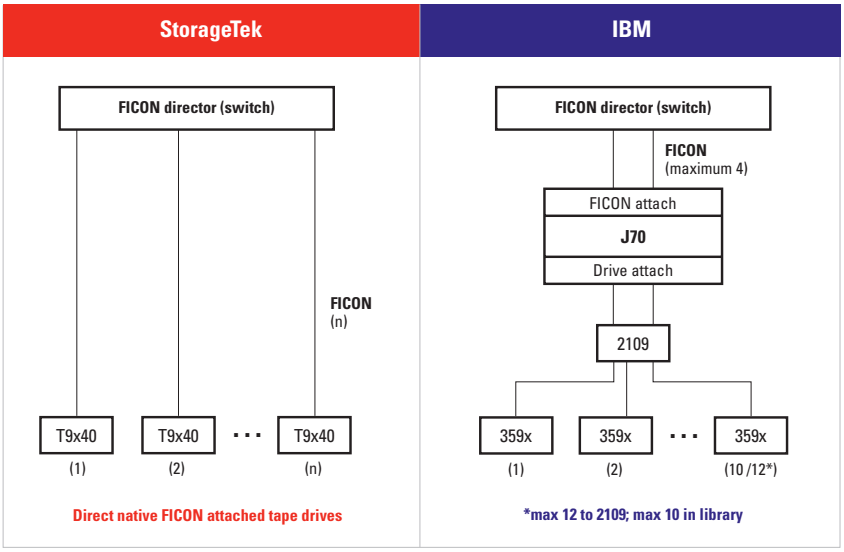
StorageTek allows any number of drives to be attached to the FICON channel, within the architectural limits of FICON. This flexibility helps to give StorageTek customers the greatest performance and availability, while minimizing costs.

Compare this with a shared control-unit-based architecture that contains multiple protocol converters that introduce configuration limitations. The IBM solution allows only four FICON channels into a solitary controller, with only two internal Fibre Channel paths and a limited number of 3590 and 3592 drives. All this added hardware significantly increases the total cost of ownership and

introduces potential failure points. If a failure occurred, the failure points would make all the drives in the subsystem unavailable.The StorageTek 1x1 architecture has been the architecture preferred by customers, since it was introduced with ESCON several years ago. With FICON the 1x1 architecture continues to be the best choice for numerous reasons, for example:

- Greatest flexibility in channel and subsystem configurations
- Greatest performance which reduces backup and recovery times
- Highest reliability, since there is less equipment and no single point of failure to multiple drives
- Lower cost of ownership for the same throughput

Figure 3: StorageTek vs. IBM FICON implementation



5 Measurement environment

To obtain accurate performance data, all performance measurements were conducted on a stand-alone zSeries 800 model 0A1 processor running z/OS.e version 1.4. For purposes of these measurements, all data was transferred through a single FICON express channel. For the multiple drive tests, a McDATA ED6064 FICON switch was used to attach all the T9840C drives to a single FICON CHPID. Due to variations in environments, applications and microcode levels, customers may observe slightly different results in their own data centers.

6 Blocksize

Figure 4 compares the read/write data transfer rates of the T9840C with those of a T9840B FICON drive at various blocksizes using 4:1 data compression. As shown, performance benefits of the T9840C increase with blocksize, up to 38 percent on writes and up to 36 percent on reads using 256 KiB* blocks over the T9840B.

** We use the IEC standard1, in which an "i" is inserted between the SI prefix and base unit to indicate that the prefix is a power of two, rather than the "default" power of ten.*

Figure 4: R/W rates with EXCP 4:1 data compression, chain=50

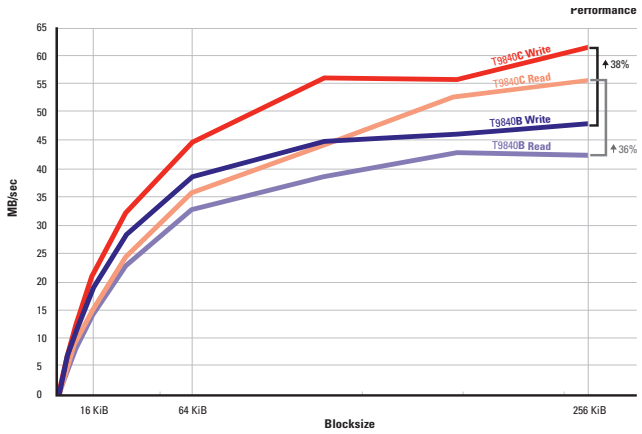


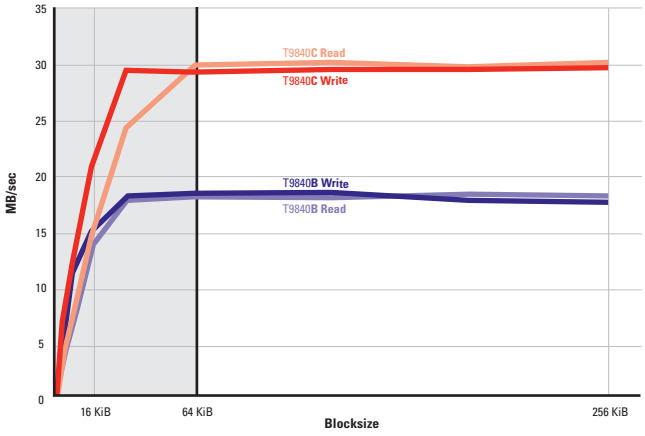
Figure 4 can also be used to estimate the performance of applications based on their blocksizes. Table 1 lists some applications and their respective blocksizes. Note that maximum performance can be achieved using large block applications such as StorageTek's Extended High-Performance Data Mover (ExHPDM) software.

Table 1: Application blocksizes

Application	Blocksize
DFHSM	16 KiB
FDR	64 KiB
ExHPDM	256 KiB

Figure 5 shows information similar to Figure 4, except that uncompressable or 1:1 data compression was used. This graph clearly shows the increased head-tape data transfer rate of the T9840C. For certain applications that read and write uncompressable data, their performance can be estimated from this chart.

Figure 5: R/W rates with EXCP 1:1 data compression, chain=4



7 Chain length

Figure 6 shows the benefits of using longer chain lengths, that is, chaining more read or write commands into a single channel program so that more blocks are transferred per START SUBCHANNEL instruction.

Figure 6: R/W rates versus chain length (EXCP 4:1 262, 140)

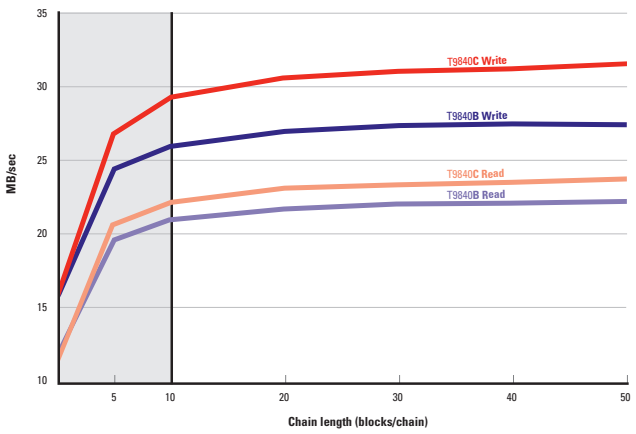
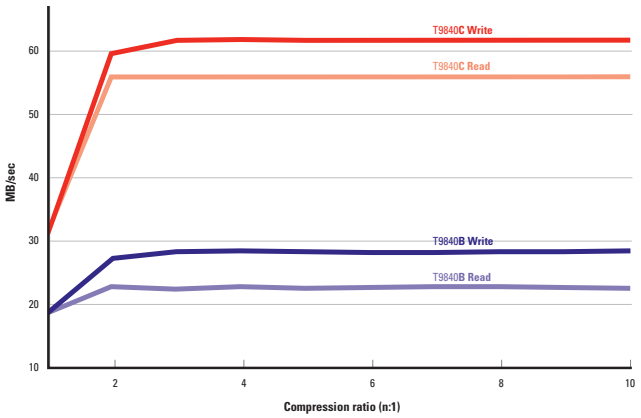


Figure 6 was created using an EXCP application in which the chaining length was explicitly specified. However, coding DCB=BUFNO=nnn in DD statements can be used with several of the other access methods to control the chain length of channel programs. This is accomplished indirectly by specifying the number of buffers used by the access method. For example, QSAM will, on average, transfer BUFNO/2 blocks per I/O operation from the application.

8 Compression

The T9840C tape drive continues the use of an LZ1 data compression algorithm which is implemented in the hardware. Data compression not only allows for greater effective storage capacities but also improves throughput, as shown in Figure 7.

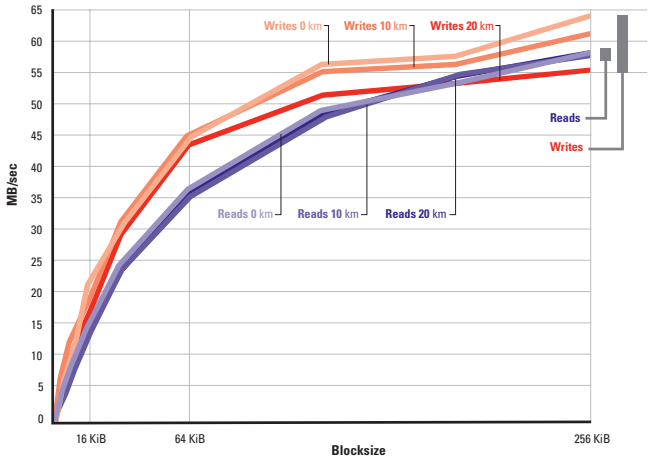
Figure 7: R/W rates versus data compression (EXCP 262, 140 chain=50)



9 Distance

FICON is specified to operate at distances of up to 100 kilometers without severe performance degradation. At this time, optics are available to support distances of up to 35 kilometers before repeaters are required. Measurements of a T9840C at simulated distances of 0 kilometers, 10 kilometers and 20 kilometers using several blocksizes are shown in Figure 8. Blocksize is the critical factor in influencing performance. Distance has minimal effect.

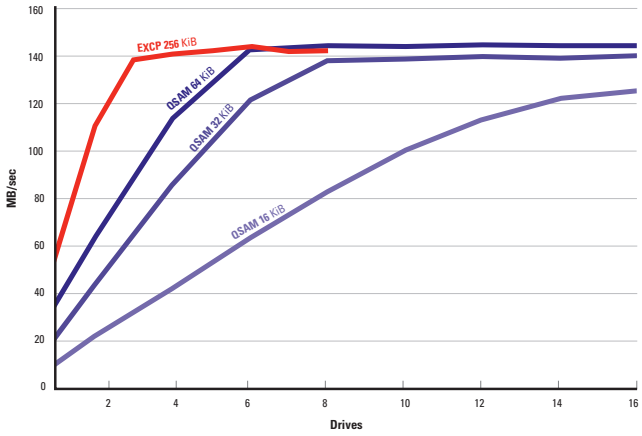
Figure 8: R/W rates versus distance (T9840C F3590 EXCP 4:1 chain=50



10 Channel loading

In typical configurations, several T9840C FICON drives would be attached to a single FICON channel via a FICON switch. In Figure 9, we see results of different blocksizes as drives are added to the channel. A complete description of how the channel loading tests are performed is given in item 6 of the Bibliography.

Figure 9: Channel loading (4:1 writes)



11 Backward-read compatibility

The T9840C has the capability to read cartridges written on the earlier T9840A and T9840B drives. Since the data written on the earlier drives was done at a lower recording density, there are some circumstances where reading it on a T9840C is somewhat slower. The following series of graphs contrast T9840C read performance with the following scenarios:

- Reading a cartridge on a T9840C that was written on a T9840B
- Reading a cartridge written and read on a T9840B
- Reading a cartridge written and read on a T9840C

Figure 10 shows the read data rate at various blocksizes using 4:1 data compression. Here we see that reading a cartridge written in a T9840B is just as fast as reading a cartridge written on the T9840C.

Figure 10: Compatibility mode read with EXCP 4:1 data compression (reads)

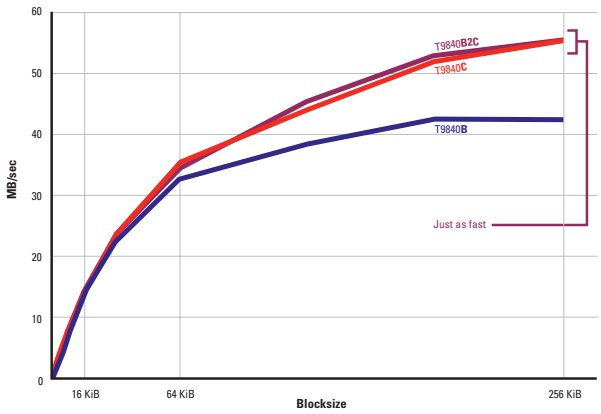


Figure 11 shows the same scenarios using uncompressable or 1:1 data compression. Here we see that the T9840C reads the T9840B cartridge at about one half of normal speed. This fits with expectations, because the data on the T9840B is written at about one half the recording density as a native T9840C.

Figure 11: Compatibility mode read with EXCP 1:1 data compression

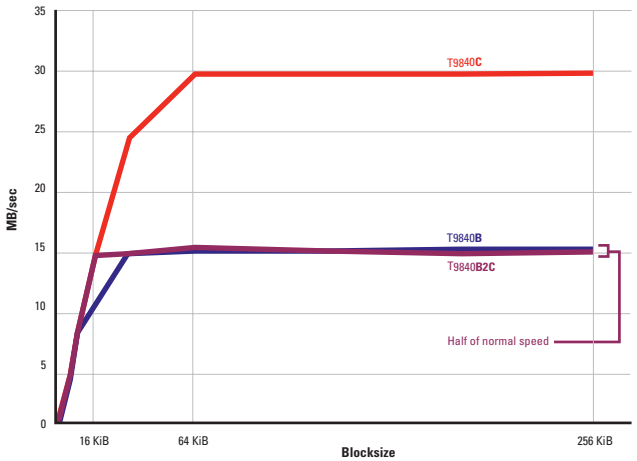
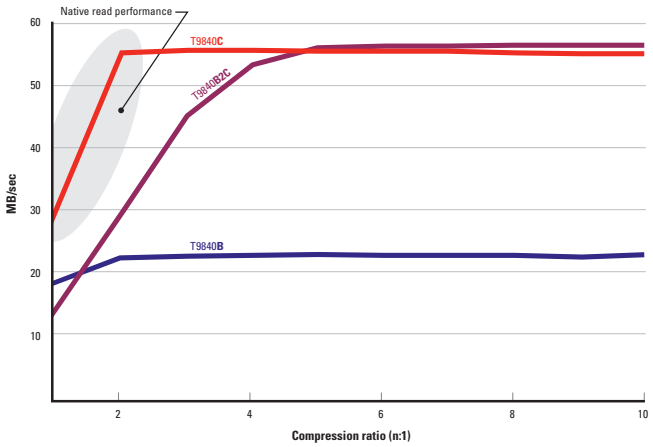


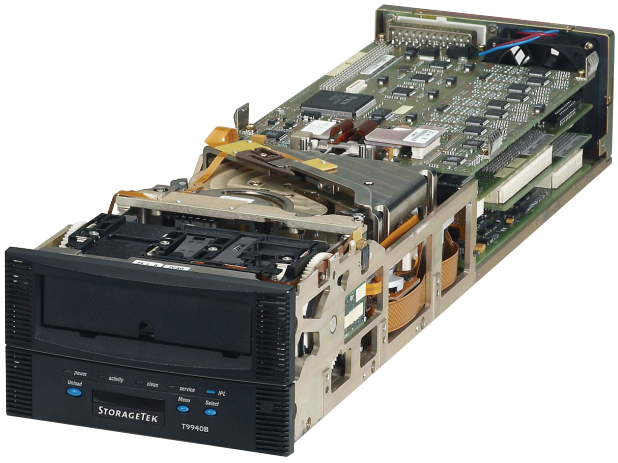
Figure 12 shows the same combination of scenarios at various levels of data compression. It can be seen that with 4:1 compression or better, the T9840C is able to achieve native read performance while reading in compatibility mode at the lower density.

Figure 12: Compatibility reads versus compression ratio (EXCP 262, 140)



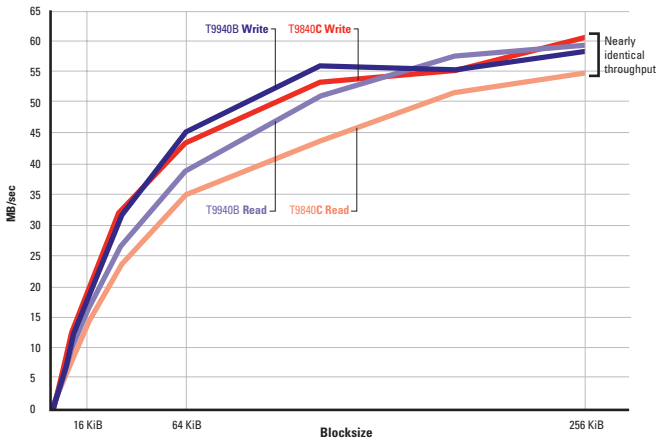
12 The T9940B FICON

Figure 13: T9940B FICON



Like the T9840C tape drive, the T9940B has a similar 30 megabyte-per-second native head-to-tape speed and similar FICON interface. As a result, the T9940B FICON drive throughput is nearly identical to the T9840C FICON drive (Figure 14).

Figure 14: T9840C FICON versus T9940B FICON (F3590 EXCP 4:1 chain=50)



Unlike the dual-hub, access-centric design of the T9840 series drives, the T9940 series utilizes a single-hub, storage-centric design. This allows the T9940B to store up to 200 gigabytes of uncompressed data, five times that of the T9840C! Yet, with its data compression feature, the T9940B can typically store approximately 800 gigabytes of data on a single cartridge.

While the single-hub cartridge of the 9940 media allows more tape to be stored and greater capacity, it is not midpoint load/unload capable like the 9840 media. Therefore, the access and rewind times on the T9940B are longer than the T9840C. A comparison of access times is shown in Table 2.

Table 2: Access times

Metric	T9840C	T9940B
Average load and thread to ready	4 sec	18 sec
Average search time	8 sec	41 sec
Average rewind time	8 sec	45 sec
Unload time	4 sec	18 sec

13 The opportunity

T9840C FICON tape drives deliver unique advantages for organizations that are looking to improve the performance and cost-effectiveness of their storage environments.

These drives help organizations meet important business goals, which include:

- Reduce costs — Faster data access enables businesses to meet more of their data storage needs with affordable tape, minimizing the need for higher-cost disk.
- Reduce batch and backup windows — With read/write speeds that can exceed 60 megabytes per second, T9840C FICON tape drives store more data in less time to help meet shrinking batch and backup windows.
- Increase productivity — Higher data transfer rates enable IT staff to reduce batch and backup windows, decrease recovery times and improve access to information.

- Improve resource utilization — With the ability to store up to 40 gigabytes of uncompressed data on a single cartridge, T9840C tape drives allow an organization to store more information in the same footprint.
- Simplify storage management — Easy-to-use software lets storage administrators manage data on multiple platforms and operating systems from a central location, saving time and IT resources.

14 Appendix A — Bibliography

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WORLD HEADQUARTERS

Storage Technology Corporation
One StorageTek Drive
Louisville, Colorado 80028 USA
1.800.877.9220 or 01.303.673.5151

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