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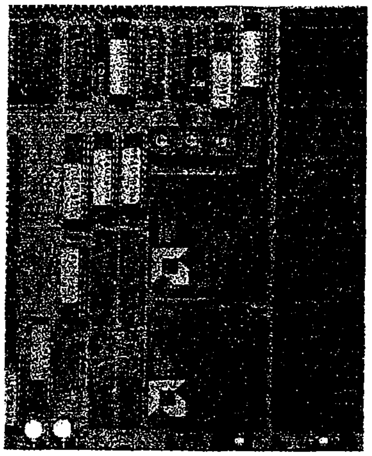

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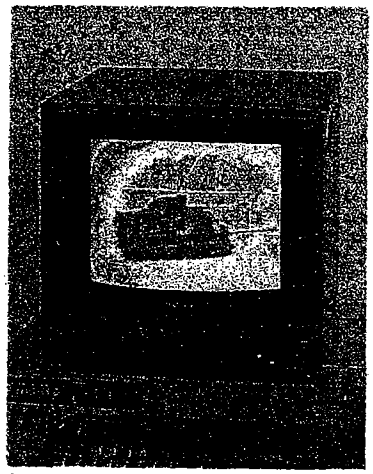

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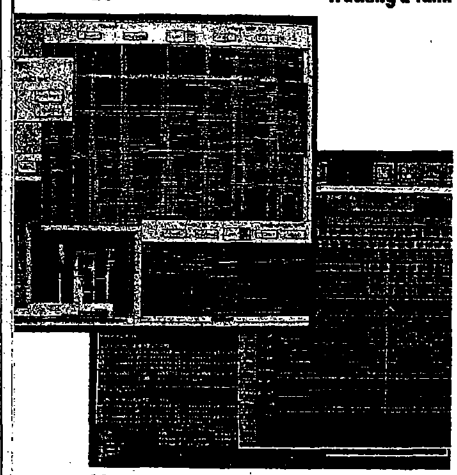

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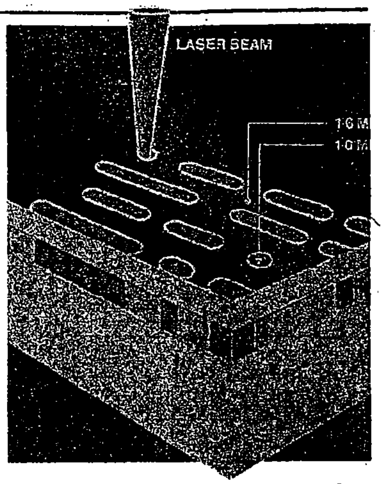

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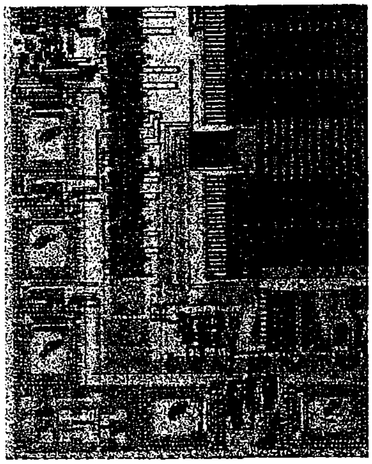
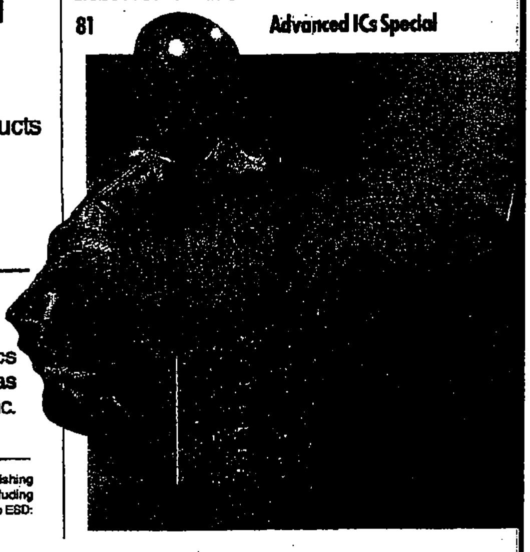


81 Advanced ICs Special



ON THE COVER

An ASIC chip from VLSI Technology becomes the Pharaoh filter integral to a 3D graphics imaging subsystem from Evans and Sutherland. Made up of about 75,000 gates, the chip was designed in just 10 weeks using silicon compiler tools. Cover courtesy of VLSI Technology, Inc. Cover concept by the Hall Kelley Organization, with photography by R.J. Muna.

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Peripheral Storage: Who's Got What

by Carl Warren, Contributing Editor

System platforms, regardless of architecture, have become powerful data processing engines. Like a racing car that gulps gallons of fuel by the second, these new systems gobble up and spit out data streams at unprecedented rates. To match the performance of these "data engines," storage devices such as Winchester disk drives, flexible disk drives, tape subsystems, semiconductors, and emerging optical storage units are offering equally impressive performance and capacity. Moreover, manufacturers of these storage devices can offer this capability at a fraction of the cost of devices available just five years ago.

The storage device has become the system core, and the latest crop of new storage announcements is stepping ahead in technology capability. For example, system designers can purchase Winchester disk technology in the 765-Mbyte-plus range with under 20-msec average access times, tape drives that match virtually any capacity demand, and even erasable optical storage drives. Further, interfacing technology, due to the increased popularity of the Small Computer Systems Interface (SCSI), is rapidly becoming a commodity business (see *Embedded SCSI Brings High Performance, Smarts to Smaller Drives*, p. 62).

System manufacturers, however, demand more than capacity and performance. Indeed, the real impetus behind the burgeoning storage market is cost/performance per cubic inch. The goal: to inexpensively pack more storage solution into the smallest amount of space. Even full-sized 5¼" Winchester disk drives are staying true to this axiom.

The major performance providers—Control Data Corp. (Minneapolis, MN), Maxtor Corp. (San Jose, CA), and Micropolis Corp. (Chatsworth, CA)—offer fast 380-Mbyte and 765-Mbyte drives with average access times below 20 msec. Workstation vendors and host CPU makers are snatching up these drives.

Demand for the drives is helping to push the price per megabyte into the $2 range; but so are innovative storage subsystem designs. One OEM array solution from Micropolis is the

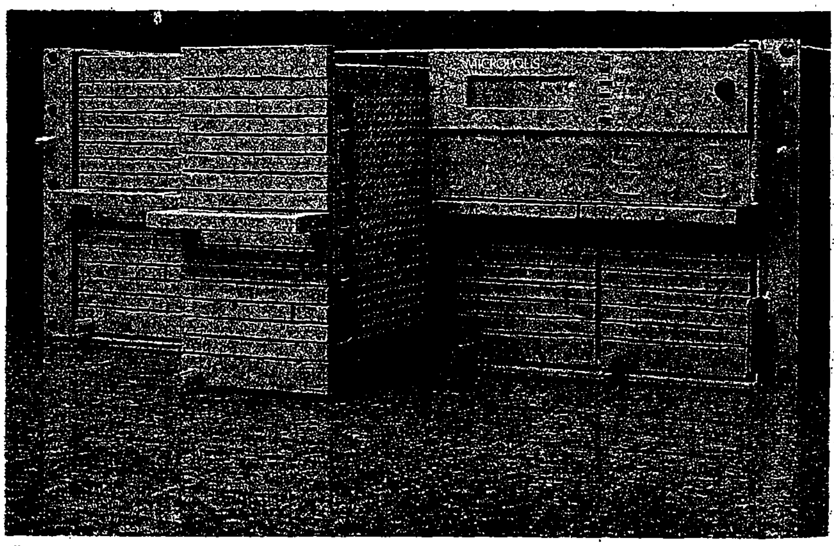

Figure 1: Though this 3-Gbyte data storage array from Micropolis did not prove an apt fit for the company's disk line, such arrays will be pursued by other vendors, especially those who find promise in SCSI-II.

1804 (**Figure 1**). This storage array used a combination of four data drives and a parity drive (4 + 1 array). In addition to enhancing channel performance and increasing overall capacity, this combo also improves the transfer rate. For example, an array using disk drives with 10-MHz transfer rates produces an aggregate bandwidth of 40 MHz (3 Mbytes/sec).

Besides the benefit of a higher bandwidth, arrays fit more storage into smaller footprints. Thus, the overall cost/megabyte/cubic inch is lessened. For example, a 3-Gbyte array built using the Micropolis 1580 series of 15-MHz ESDI drives would fit into less than half the space required for a 1.2-Gbyte IBM 3380 subsystem, and consume one-third the power.

Although arrays offer certain benefits, there is a price to pay. For example, the subsystem demands synchronized controllers, timing controls, and buffers to properly match the transfer rate to the host I/O controller.

Interestingly, designers have been using ESDI drives to achieve high bandwidths. For the best system match, the drives are coupled to SCSI controllers, which increases the overall cost. The trend, however, is to move away from ESDI and instead go straight to SCSI. This is permissible since the emerging SCSI-II more than meets bandwidth requirements for high-performance systems. In addition, command overhead, once the bane of SCSI developers, has dropped from a 1-msec average to the nanosecond range.

Packing more storage solution into a smaller space, at a lower cost, is the goal.

Another company making use of the array concept, but as a fault-tolerant storage system, is Pacstor Inc. (Los Gatos, CA). The company's Integra series of subsystems uses Conner Peripherals' (San Jose, CA) 3½" 100-Mbyte Winchesters to create arrays up to 1.2 Gbytes.

Besides using 3½" Winchesters, the fault-tolerant aspects of the overall system make the Pacstor approach unique. The Integra system is an intelligent standalone unit that uses an Intel 80386 to control file access and data management. Pacstor uses SCSI to its fullest extent as a peripheral bus. Thus, drives can be easily removed or added without disturbing subsystem operation—a function of the disconnect/reconnect feature of SCSI.

Pacstor has also developed proprietary file and error correction management that makes it possible to fully reconstruct a file should a disk drive malfunction. Pacstor pricing is between $4000 and $9000, depending on the configuration.

WORMing Its Way In

Write Once Read Many (WORM) optical technology, although not an overwhelming market giant, is proving useful in some niche segments. Ian Turner, vice-president of engineering at Laserdrive Ltd. (Santa Clara, CA), sees the technology as well suited to the imaging business. "Images take up lots of space and usually need to be considered permanent," says Turner. To this

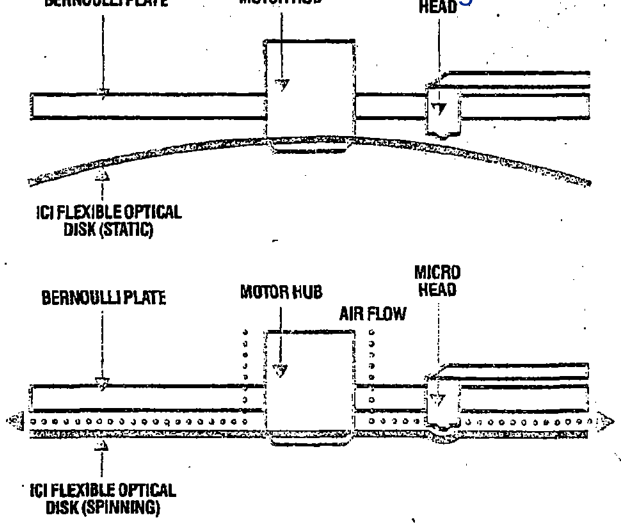

Figure 2: The Bernoulli Optical drive uses the ICI Digital Paper, mounted on a hub under a plate that guides the air flow, creating a lift effect. Thus, the media flies rather than the head. The head/media interface as shown creates a dimpling much like the prow of a boat plowing through water.

end, Laserdrive packages (in a 5¼" form factor) 405 Mbytes per side of storage; a three-interleave Reed-Solomon error correction code (ECC) is implemented with the Neal Glover chip set from Scientific Microsystems Inc. (Mountain View, CA).

Since the Laserdrive 810 series of optical drives are write once, the company has implemented the management of write once protocol in the drive firmware. The upshot is that the host operating system doesn't require any specialized software.

Although WORMs are early to market, 5¼" drives haven't really caught on. Moreover, they may be ignored in favor of emerging erasable optical.

Verbatim first introduced a magneto optical erasable drive over four years ago, but Maxtor stands as today's market leader, with drives developed both in-house and with Seiko/Epson. And by this month, Maxtor should have made early shipments of its Fiji and Tahiti optical drives.

The Fiji I is a 3½" drive with 160 Mbytes of removable storage and a 100-msec average access time. The Tahiti, on the other hand, is a 5¼" optical drive that stores 600 Mbytes to 1 Gbyte of data, depending on the format. Maxtor adheres to the ANSI standard that specs 600 Mbytes, and offers an extended format for higher capacity. OEM pricing for the Tahiti is $2500; $1000 for Fiji. Erasable media will add about $200 to the cost.

The technology used by Maxtor is called thermo magneto optical (TMO). This uses a medium, in this case built by Philips Dupont, that combines optical sensitivity with magnetic read/write characteristics. Here, a laser is used to heat a spot on the media until a bias field of about 250 Oe is achieved, causing a reorientation of the magnetic domain. The result is a written bit that can be sensed by the read/write head.

Although bits can be reoriented, there is no overwrite capability. Consequently, an erase pass must take place before a new bit is written. This might seem to slow operation. However, with careful integration, such as using buffers in combination with a fast Winchester, the system impact should be negligible.

An interesting write once optical technology is being pursued by Iomega Corp. (Roy, UT) in concert with the British firm ICI Electronics. ICI has developed an optical Digital Paper. The drive being developed by a subsidiary of Iomega, Bernoulli Optical Systems Corp. (BOSCO) (Boulder, CO), is based on Bernoulli

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principles whereby the media floats in relationship to the read/write head (**Figure 2**). The company claims the ability to store 1 Gbyte of data, with a 40-msec access time and a SCSI transfer rate of 1.5 Mbytes/sec.

The ICI Digital Paper (**Figure 3**) is a dye polymer infrared sensitive coating on a polyester-based substrate. The media has the look and feel of a wrapping paper, and since it is flexible, it can be used in rotating media, or tape drives. Developed by Creo Products, Inc. (Vancouver, Canada), the Creo drive stores up to 1 Tbyte of data on a 12″ reel.

Half-Inch Upgrades

The half-inch tape is the only standard for interchange. IBM's ½″ cartridge tape drive, the 3480, has been carried over to an easily handled cartridge. But third-party versions are few, and only one firm has emerged with a viable alternative to the high-end 3480.

Working in a very open joint development effort with IBM, Cipher Data Products, Inc. (San Diego, CA) has fabricated the 3000i series of ½″ drives. Designed for 8″ and 5¼″ form factors, the 3000i series drives store 320 Mbytes on a single ½″ cartridge with 600′ of tape.

This significant storage boost over IBM's 200-Mbyte capacity is achieved via the Multitrack Serpentine Recording (MSR) format. A variation of the proposed Half Inch Tape Cartridge (Hi/TC) standard, this format permits serpentine (continuous loop) recording on either two or four tracks on the 24 specified in MSR. This, too, denotes a significant step over IBM's 18-track format. However, IBM writes all 18 in a parallel fashion. The Cipher drive relies on a stepping mechanism to index over the track real estate.

The 3000i drives employ the standard ½″ tape cartridge used in the IBM drive, which is a chromium dioxide tape that is priced in the $5 range in OEM quantities. Cipher reports 27,000 flux reversals/inch and ensures a 1 × 10-byte to 12-byte error rate.

The Many Lives of Magnetic Tape Technology

by Joe Phillips, 3M Data Storage Products Div., St. Paul, MN

Magnetic tape technology refuses to die, despite periodic predictions of its demise at the hands of competitive products—first from magnetic disk drives as a primary storage medium, and, more recently, from technologies such as optical disk in removable storage applications. Half-inch reel-to-reel tape has survived and flourished by its adaptability to a variety of applications where cost per megabyte and data interchange are the primary concerns.

The earliest data recording tape recorded information at 100 bits/inch. The technology has evolved to a 500-fold increase: The current generation of data storage tape products has boosted density beyond 50,000 bits/inch.

Today's mainstream magnetic tape technologies break down into four general categories: ½″ reel-to-reel; ¼″ data cartridge, both in standard-sized DC600 and the micro-sized DC2000 mini cartridges; ½″ single-reel cartridges (e.g., IBM 3480 and DEC CompacTape media); and various helical scan formats, including 8-mm and Digital Audio Tape (DAT). A possible fifth category having minor applications has developed for digital data cassette systems using a Philips-type cassette and various nonstandard ½″ cartridge designs.

Higher densities now being demonstrated with a helical scan format are the result of advanced tape formulations with greatly increased coercivities—up to 1450 oersted using metal particle tape on DAT cartridges. In comparison, ½″ reel-to-reel tape has held the line at around 290 oersteds. A planned move to higher coercivity pigments for future ¼″ data cartridge media will also offer higher areal recording densities; plans for a next-generation ¼″ data cartridge product specify 40 tracks of data at a linear recording density of 40,000 bits/inch to achieve 1 Gbyte on a standard-size cartridge by 1990. These newer ¼″ data cartridges have moved coercivities to 900 oersteds.

With both product segments (helical and linear recording), as track and bit densities increase, vendors are becoming more concerned with accurate head positioning on these ever-smaller data tracks. Various types of servo positioning systems will be incorporated into these products to ensure the required level of data integrity; sophisticated ECC will be included as well.

Although the venerable 9-track real-to-real systems have served as the dominant means of data interchange in mainframe and minicomputer applications for 25 years, most observers predict that within the next few years drives based on the IBM 3480 ½″ cartridge will become the most popular in the ½″ tape arena. Storage Tek, Hitachi, Fujitsu, NEC, Cipher, and Aspen have all announced 3480 drives, ensuring this technology's use in the major data centers of the world.

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Data Cartridge	16,000	26	Ferric oxide	¼″	320 Mbytes	240 Kbits/sec	120
Reel-to-Reel	6250	9	Ferric oxide	½″	165 Mbytes	1.25 Mbits/sec	200
IBM 3480	38,000	18	Chromium dioxide	½″ cartridge	200 Mbytes	3 Mbits/sec	120
Data DAT	61,000	1869 stripes/inch	Metal particle	3.81 mm	1.3 Gbytes	183 Kbits/sec	122 (effective)

Currently, 3480 cartridges are rated at 200 Mbytes/transport using 18 parallel tracks having a linear recording density of 24,689 flux changes/inch for a bit density of 38,000 bits/inch. The media uses chromium dioxide-based magnetic tape and thin-film read-write heads. Chrome tape has the potential to support much higher densities—over eight times the current level—and it is expected that IBM will soon upgrade the 3480 drive modules, at least doubling current capacity. In some proprietary drives based on the 3480 cartridge, storage capacities of up to 320 Mbytes are now being demonstrated.

The future of tape technology looks promising. Much of the research into magnetic tape coating and resulting developments can be shared both in commercial audio and video applications as well as data recording. The metal particle media used for DAT drives is the same as that used for consumer audio recording. Moreover, research into advanced videotape formulations may possibly provide the answer for the next generation of high-coercivity tape used in data cartridge applications. With this synergistic research, it's a safe bet that continued technical improvements will make magnetic tape products strong competitors in the data storage market well into the next decade.

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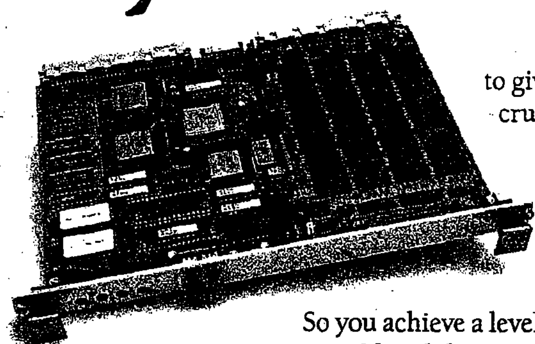

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This low error rate is achieved by using a powerful Reed-Solomon error correction code for each track and by providing a resync burst every 66 bytes versus the 1300 bytes used by GCR (group coded recording) tape drives.

To ease integration pains, Cipher is providing the drives with either the SCSI, the Intelligent Peripheral Interface 3 (IPI-3), or the standard Cipher interface to match existing applications. The 8″ models support all three interfaces; OEM cost is $3710 for the 3832 and $4400 for the 3834. The 5¼″ 3532, priced at $1380, is a SCSI device only. All the drives are available with either ac or dc power capability.

Format Insurance

Cipher's establishment of a new physical format with MSR leads to some concerns regarding compatibility with existing controllers and software. The 3000i series of drives, however, are logical, as well as file-format-compatible to existing controllers and software. Not all the ½″ cartridge drive solutions offer the compatibility needed, however.

More or less competing for market acceptance is the Hi/TC proposed standard, although committee interest has dwindled to just the California peripheral companies—Caliper and Pertec. Marketing the Laser Magnetic Storage International Co. (Colorado Spring, CO) drive, Pertec claims there is a demand for Hi/TC drives. Like the Cipher entry, Hi/TC drives represent a low-cost alternative to the IBM 3480 standard. The LMS/Pertec drive, dubbed the Patriot, stores 240 Mbytes of data on 24 parallel tracks. The tracks are written two at a time, in a serpentine fashion, at a density of 18,000 bits/inch. This is done with a double-density NRZI (nonreturn to zero inverted) format. The overhead for ECC and block framing takes up about 5300 bits/inch. The drive, which sells for $1250, has a 250-Kbyte/sec transfer rate and embedded SCSI.

Similarly, Caliper claims to match the capabilities of the LMS drive and adhere to the Hi/TC-1 format that demands SCSI-I and 240 Mbytes of capacity. The Hi/TC specification calls for eventual migration to 480 Mbytes and a 500-Kbyte/sec transfer rate and use of the Enhanced Small Device Interface (ESDI) in Hi/TC-5.

No Interchange

Although Cipher's MSR and the Hi/TC version drives do promise low price, they don't provide interchange to each other or to the IBM 3480. The IBM drive stores only 200 Mbytes on 18 parallel tracks written with a flying head. The Cipher and Hi/TC drives use contact recording at a different frequency and have different track spacing. Cipher and Hi/TC adherents argue that their drives fit a different market segment that doesn't need IBM interchange compliance. Moreover, Cipher is betting that since the 3000i series was created in concert with IBM, their approach will win out as the dominant standard. To date, IBM hasn't announced any plans to use the drive. Speculation is that the Cipher drive will be offered as an add-on to IBM's midrange system by early next year.

Facing a similar dilemma are the emerging Digital Audio Tape (DAT) drives, from such sources as Exabyte (Boulder, CO), and GigaTrend (San Diego, CA). GigaTrend's Model Giga-1200 sports 1.2 Gbytes of storage capacity on a 4-mm DAT; transfer rate is 180 Kbytes/sec. The $6700 drive can be connected with SCSI, QIC-02, or the Pertec 9-track interface. But the subsystem is large. This month, the company plans to begin shipping the Giga 1230, a 5¼″ model with 1.2 Gbytes of storage and SCSI-I.

Bucking the trend seems to be fairly common. GigaTrend is eschewing the DATA/DAT physical format devised by Hewlett-Packard and Sony for DAT-class products. The HP/Sony format is endorsed by Archive, Exabyte, LMS, WangDAT, and Wangtek. GigaTrend, however, believes it to be inflexible and doesn't like the idea of paying licenses for what should be an industry-accepted format. To this end, GigaTrend has opted for the format developed by an industry ad-hoc committee based on a Hitachi proposal.

GigaTrend's DATA/DAT physical format has a C-3 error correction scheme that corrects up to 16 tracks at a time. Moreover, GigaTrend's approach embeds ECC within the data and performs repositions and reads to ensure the data integrity. None of these features appear in the HP/Sony format.

One concern of OEMs and system integrators is the inability to do block overwrites. GigaTrend's approach is to do continual repositions and rereading of file marks. Consequently, they claim, a block can be accurately repositioned and rewritten.

Vying for Number Three

Despite the interest in tape storage solutions, flexible disk drive manufacturers are still seeking higher capacities in smaller form factors. Clearly, the demand is for low-cost, high-capacity drives that use inexpensive media.

Three companies are vying for a piece of this market: Brier Technology (San Jose, CA), Insite Peripherals (Santa Clara, CA), and Toshiba America (Irvine, CA).

Toshiba may have a clear path to success if it can introduce the product. The company had planned a major introduction of its 3½″ drive (4 Mbytes unformatted, 2.8 Mbyte formatted) this past August, but decided to hold back for undisclosed business

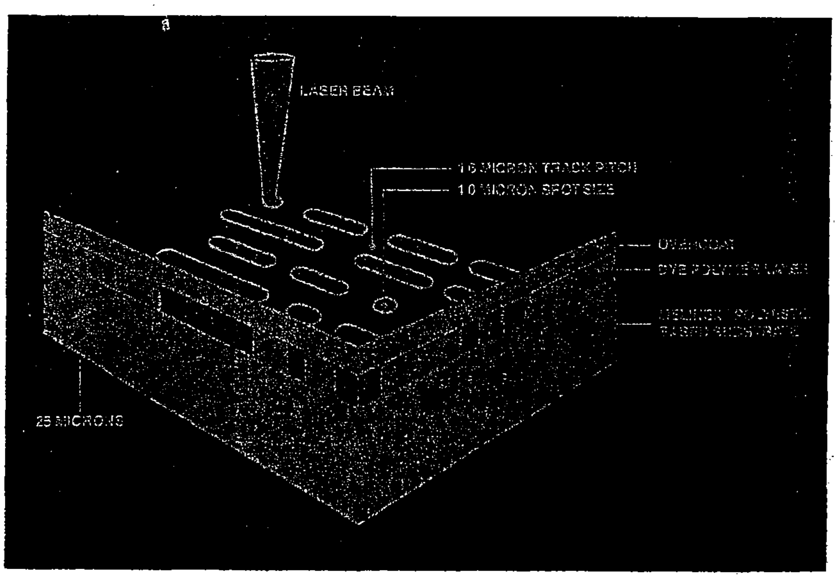

Figure 3: The ICI Digital Paper provides a flexible, paper-like base to embed a dye polymer optical sensitive layer. It can be used in rotating media or tape drives.

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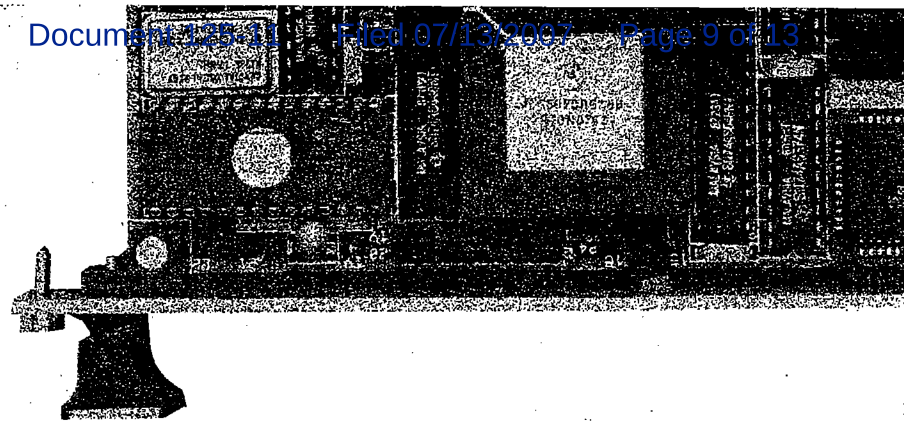

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Circle 25

A Look at the DDS Recording Format

by Celia Watts, Hewlett-Packard Co., Bristol, England

Developed by Hewlett-Packard Co. and Sony Corp., the Digital Data Storage (DDS) recording format supports the use of Digital Audio Tape (DAT) for computer applications and is based on the DAT Conference Standard (developed by 87 companies worldwide). Existing ICs designed for the audio market can be utilized. Extra error correction code, functionality, and flexibility have been designed into the DAT standard to produce DDS. Six tape drive manufacturers—Aiwa, Archive, Exabyte, Wangtek, Wangdat, and Philips/LMSI—have announced their commitment to DDS.

The primary data storage goal of a DAT system is for all recorded data to be readable over the media's lifetime. Other requirements include data interchange, data integrity, performance, and flexibility. Desire for the rapid introduction of a DAT-based data storage product dictated that there be maximum leverage from the audio DAT format. Much of the recording and error correction technology for DAT could also be used for data storage, so the DDS format is structured to overlay the basic audio format. However, in place of the continuous stream of digitized sound used in the audio format, the DDS format consists of a sequence of data groups on the tape.

The overall layout divides the tape into three areas: lead-in-area, data area, and end-of-data area (**Figure 1**). The lead-in-area allows the drive to pull sufficient tape out of the cartridge to wrap around the head drum. It also provides a test area for read and write tests which check the electronics and the servo system. At the end of the lead-in area is the systems section, which is used to log tape usage and performance parameters.

Data area represents the main area of the tape. Data is written in groups of fixed capacity that store the information written by the host computer. Collections of records of stored data are separated by file marks and save-set marks so that the host can identify where logical collections of data begin and end. The end-of-data area is used to mark the location on the tape where the host has stopped writing data. The host does not write this area; it is written by the tape drive when it detects that the host has finished writing data. The EOD area limits the fast-search capability only to the area of recorded data and shows which data is valid.

The data group is used to organize and store data efficiently on the tape (i.e., host-written data, save-set marks, and file marks). Each group consists of a number of frames and has a fixed capacity. This makes ECC generation easier and buffering requirements simpler. Each group does not necessarily have the same number of physical frames. The group's logical capacity remains fixed. If a host record is larger than the space left in the group, that space is filled and any remaining bytes are put into the next group. A complete group is always read or written to tape. No partial groups are written.

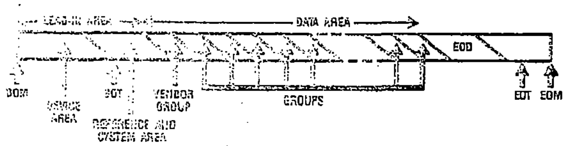


Figure 1: Tape layout divides into lead-in, data, and end-of-data areas. In the data area, the main part of the tape, data is written in groups of fixed capacity that store information.

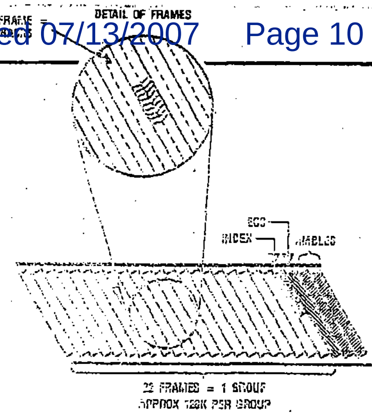


Figure 2: In a typical group layout, an index in each group describes the group's contents. Index size grows as needed.

Figure 2 shows a typical group layout on tape. An index in each group describes the group contents. Indexing allows the format to map variable-size computer records onto fixed-size groups. The index indicates the location of each piece of data because the group may contain bytes of data from different records. Rather than being fixed, index size grows as needed to describe the contents of the group.

The audio format's error correction capability is adequate for audio applications, but data storage demands a higher level of data reliability. The DDS format has several error correction and management facilities. There are 10 facilities in the DDS format to assure that data is recovered reliably. The three main facilities are described below.

One facility is third-level error correction. Two levels of error correction are used in the audio DAT format. They are contained within each frame and can only correct data within that frame. The ECC scheme for DDS involves adding an extra frame of error correction information at the end of the 22 frames of data in the group. This third level of ECC can correct any two tracks in a group, enabling data recovery across frames. Each group contains its own ECC, assuring that each group exists independently.

Read-after-write also improves data integrity. To verify that data written to the tape contains no errors, data must be read after it is written. With a DDS drive, two more heads are added to the drum of the audio DAT mechanism, making four in total. Two of the heads only read data and the other two only write. As data is written on tape, the read-heads read it back. If an error is detected, the frame is rewritten further down the tape. Read-after-write is repeated until no errors are detected. The bad frame does not have to be written immediately, allowing bad areas of the tape to be passed over. The drive rewrites the data without help from the host computer.

And finally, DDS supports a multiple group-writing mode of operation for applications requiring an extremely high level of data integrity. Every group of data can be duplicated a fixed number of times as specified by the host computer. If an error is detected on reading the first instance of the group, the second (or third, etc.) repetition of the same data will be used instead. This is independent of the host computer. Although simple to implement, speed and capacity are sacrificed by its implementation, due to the duplication of redundant data on the tape.

In addition to the storage of data into groups, areas of the tape are provided for the tape description. With both the audio DAT format and DDS, 60% of a track is user data. The rest consists of ATF (Automatic Track Finding), used to center the head on the track, and subcode areas. These subcode areas contain information that specifies the location of items on the tape and can be read at up to 200 times the normal read/write speed, providing an average access time of 20 sec to any position on a 1300-Mbyte tape. This fast access capability opens up new applications for tape drives.

reasons. However, speculation is that the decision was influenced by a major customer—possibly IBM. The drive, however, is expected to be introduced with much fanfare before year's end, along with multiple second sources.

The Toshiba drive, which has been debuted as a technology announcement for the past four years at various trade shows, uses a barium ferrous oxide media to support parallel recording—magnetic domains are vertically oriented—to increase the bits per inch, rather than the tracks per inch. This eliminates the need for "servo-ing" systems. Packaged in a Sony-like cartridge, the barium-coated media is expected to sell for about $15 to the end user.

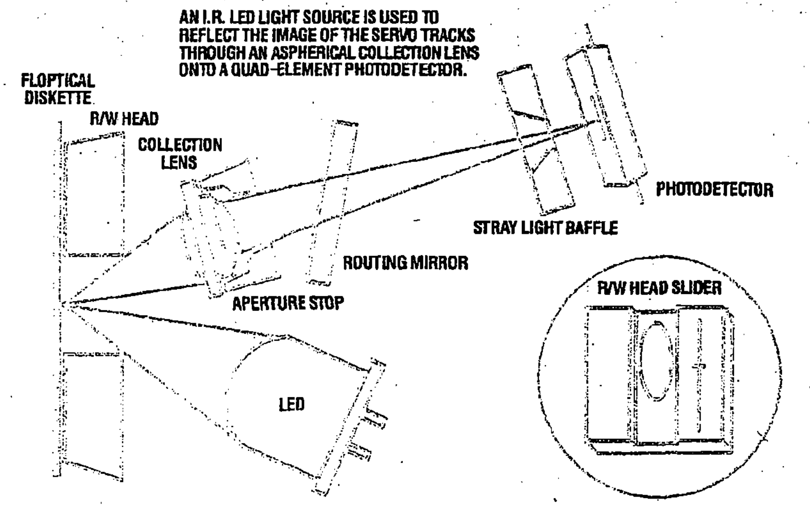


Figure 4: The Insite Floptical disk drive uses an infrared LED as a light source to reflect the optically embedded servo grooves to a four-quadrant detector that positions the centerline of the read/write head to the centerline of the magnetic track.

Toshiba's vice-president of marketing and planning, D. Barry Donahue, says maintaining backward compatibility to 1- and 2-Mbyte drives is important. "Providing full read/write mode compatibility across all versions of the media is important," insists Donahue.

Agreeing with Donahue is James W. Adkisson, president of startup Insite Peripherals. "You really can't claim compatibility until you can read and write across a whole range of media in a particular drive class."

The initial Insite drive, Model 1325 (called the Floptical), packs 25 Mbytes unformatted (20.8 Mbytes formatted) onto a more or less standard Sony 3½" disk cartridge. But investigation indicates that the media is dissimilar to conventional media used in 1- and 2-Mbyte 3½" products.

Manufactured by Kodak and Xidex, the media used by Insite has optically inscribed concentric rings on the recording surface, spaced at 20-μm intervals corresponding to a track density of 1250 tracks/inch. These encoded tracks enable the drive's read/write heads, through a closed-loop servo, to follow the magnetic tracks recorded.

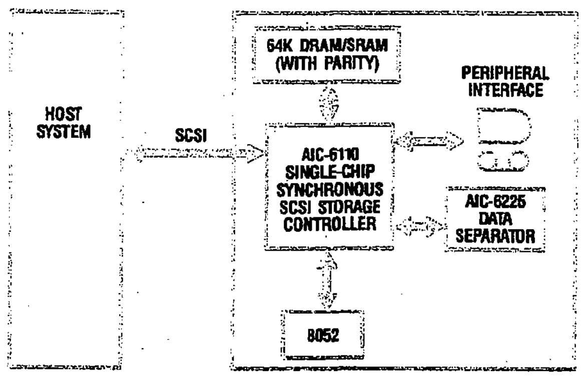
The Insite track-following mechanism uses components

Embedded SCSI Brings High Performance, Smarts to Smaller Drives

by Deb Lovig, Adaptec, Inc., Milpitas, CA

Hard disk drive manufacturers continue to pack more information on smaller and smaller drives. Currently, 3½" and 5¼" drives make up about 90% of drives shipped. At the same time, disk drive technology is becoming more of a commodity. Drive manufacturers must be able to differentiate and add value to their products to fend off competition.

Using the Small Computer Systems Interface (SCSI) has become a popular approach to enhancing hard drives. In addition to flexibility and compatibility, SCSI improves overall system performance by offloading intelligence from the CPU. Every major drive manufacturer currently offers, or is developing, SCSI products.



Data can be transferred across the SCSI bus at 5 Mbytes/sec synchronously, which is much faster than on other standard buses. With SCSI, up to eight devices can be connected. Each device can operate as an initiator or target, allowing the devices to interact without CPU intervention. For example, a tape drive can act as an initiator and request data from a hard disk drive for periodic backups without disturbing the CPU, which remains free to perform other tasks.

SCSI can be embedded directly on a hard disk drive, providing a fast, intelligent interface. Embedded SCSI solutions improve drive-level performance with higher data rates and higher capacities, and boost interface-level capabilities. The drive can do on-board data correction, automatic retry, sector buffering, defect management, and a host of other functions previously performed by the CPU.

Adaptec was a forerunner in implementing a flexible chip set for embedded SCSI drives, and has recently introduced a single-chip solution. The Adaptec AIC-6110 incorporates the functions of a programmable controller, buffer manager, 2,7 RLL encoder/decoder, and synchronous SCSI protocol. It enables controller designs of less than four square inches.

APBU-00000724

developed for compact disks. The drive (**Figure 4**) employs an infrared light-emitting diode and a four-quadrant sensor. The LED generates light that is reflected off the embedded grooves, which are detected by the diode array. The comparison denotes the location of the center line of the read/write head, which should be on the center of a write track land of the media.

With this scheme, Insite offers a drive with 20.8 Mbytes of formatted data, arranged in 1250 tracks/inch, a recording density of 24,145 bits/inch using run-length limited (RLL) encoding, and a spindle speed of 720 rpm yielding a transfer rate of 1.6 Mbits/sec from the diskette and 2.0 Mbytes/sec from the SCSI buffer. Even though there may be some disparities in compatibility and early second sourcing, the price tag may make the difference. The company is asking $250 in OEM quantities.

Brier Technology's approach is similar to Insite in that they also offer 25 Mbytes of storage, operate at 720 rpm and similar data rates, and are built around the standard Sony 3½″ media. The difference, however is important. The Brier Model BR 3020 uses zone bit recording (ZBR), a technique that increases the number of sectors in given recording zones as the head moves out from the center. The idea is to increase capacity by taking advantage of the extra surface, and keeping the bit density the same—in Brier's case 26,000 bits/inch.

Brier's track-following method is similar to Insite's in that it is a continuous servo. But rather than use optical methods, Brier's writes a magnetic servo strip on each track at a very low frequency, which isn't interfered with by read/write frequencies used during recording. The company claims the price will be under $300 in OEM quantities.

Small, Fast, and Cheap

Winchester technology remains the storage mainstay, and 3½″ technology is clearly leading the pack, especially for desktop workstations and portable applications. Currently, Conner Peripherals and Seagate enjoy the lion's share of the 100-Mbyte and above market. Meanwhile, Maxtor has launched a 200-Mbyte model, and Micropolis is expected to offer a 200-Mbyte model with a 14-MHz transfer rate, 17-msec average access time, and either a SCSI or AT interface.

In the meantime, startup Areal Technology, Inc. (Santa Clara, CA) is in the description stage of a 100-Mbyte low-power Winchester for the laptop market. The drive features a head disk assembly of 0.7″, which will fit well into a 1″ high frame. But being small is only part of the solution, says company president Jack Swartz. Areal's goal is to reduce the power and weight. Thus, the drive is planned to weigh only 8.5 oz. and consume 1W of power—making battery operation acceptable. **ESD:**

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