Mushrooming SCSI Interface Provides Variety Of Implementations

SCSI in the Digital environment offers excellent compatibility with MSCP, support for optical storage, and a cost-effective method of increasing peripheral storage without adding additional controllers

by Brad Harrison

The small computer systems interface (SCSI) is developing continuously greater support in the Digital Equipment Corp. environment. Though Digital itself has not yet made any move toward implementation of it, SCSI is an important standard that should be considered when planning for storage peripheral acquisition.

SCSI evolved from the Shugart Associates Systems Interface (SASI), which was developed in the late '70s as a generic bus for Winchester controller boards. SCSI is defined by ANSI specification X3T9.2, but the myriad products that implement it conform to the standard to varying degrees. SCSI is still evolving, and it remains to be seen just how universal the standard will become.

SCSI is implemented in the Digital environment via host adapters available from a variety of vendors (Table 1). The host adapters plug into the Q-bus and Unibus and support multiple SCSI controllers. A controller is either embedded in the peripheral itself (integrated SCSI peripherals) or separately interfaced to one or more drives via standards such as ESDI and ST506 (separate controller/drive SCSI subsystems). The former provides a less expensive peripheral, while the latter allows for greater system integration flexibility. Figure 1 shows several possible configurations.

Trends

According to the market research firm Peripheral Concepts (Garden Grove, Calif.), host adapters presently account for just 2% of all Q-bus compatible storage controller revenues, but the majority of those revenues are from the sale of SCSI adapters. Peripheral Concepts also believes, however, that SCSI could become more popular in the Digital world with the proliferation of high capacity SCSI-based disk drives and the widespread availability of optical disk drives.

SCSI is extremely popular in the microcomputer world. Apple Computer (Cupertino, Calif.) equipped its Macintosh Plus with a built-in SCSI inter-

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Dual, quad, and hex SCSI boards— (clockwise from left) *Emulex Corp.'s UC14, U.S. Design Corp.'s 1158, Emulex Corp.'s UC04, and U.S. Design Corp.'s 1108.*

face, and a wide variety of SCSI host adapters are available for IBM PC users. It is too soon to know which of the host adapters are compatible with the recently announced VAXmate, but there will no doubt be SCSI support available for the new micro.

Probably the strongest reason why SCSI might have a dramatic impact on the Digital world is that it's extremely compatible with Mass Storage Control Protocol (MSCP). Many host adapter manufacturers provide support of MSCP.

MSCP allows the host operating software to view the connected drives as a class of devices rather than as separate units. It offloads the host of the overhead of having to deal with specific drive geometries. MSCP views all data storage in logical terms: Each logical unit is made up of a certain number of 512-byte logical blocks grouped into files. Logical unit characteristics are passed to the host at system start-up time, then MSCP simply requests logical blocks and receives them without having to deal with any specifics of the storage devices—or, in SCSI systems, any SCSI commands. All communications are accomplished through standard MSCP message packets, though some host adapters implement a special SCSI pass-through command that allows the host access to SCSI-level operations.

MSCP supports virtually any storage capacity. With MSCP and SCSI, a

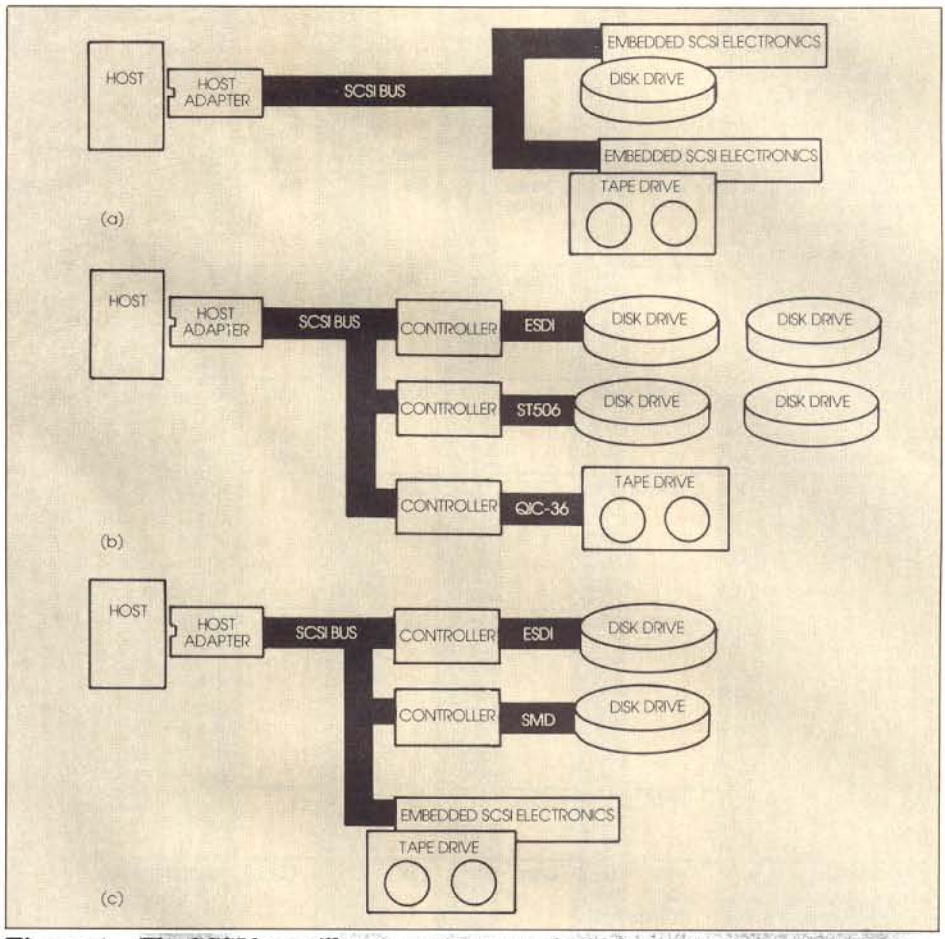

Figure 1—*The SCSI bus will support integrated SCSI peripherals, which have the controller electronics embedded in them* (a), *or SCSI subsystems, which use separate controllers and drives* (b). *A mixture of the two can also be used* (c).

Dual and quad SCSI boards—(clockwise from left) *TD Systems Inc.'s TDL-12 and Viking, Sigma Information Systems' SDC-HA11, and TD Systems Inc.'s UHA-11.*

Table 1—SCSI Host Adapters

Company	Product	Price*	Host Bus	DEC Compatibility	Width	SCSI Transfer Rate	Interrupt Priority Level	SCSI Configurations	Disconnect/Reconnect	Seek Optimization	Block Mode DMA	Board Test Capability	Other Features
Computer Extension Systems Inc. 16850 Titan Dr. Houston, TX 77058 713-488-8830 **Enter No. 700**	MDC8	$1,250	Omnibus (PDP-8)	Custom driver from supplier	Hex	.6 Mbytes/sec.	N/A	Up to 8 controllers; maximum 4 devices per controller			•		Includes second port (40 pin parallel) that supports 3M 75-Mbyte block-oriented tape drive with random access capability
Data Technology Corp. (DTC) 2775 Northwestern Parkway Santa Clara, CA 95051 408-496-0434 **Enter No. 701**	11QS	$798	Q-bus	RLV, custom driver from supplier	Dual	2.2 Mbytes/sec.	Software selectable	Supports up to 8 peripheral devices, including controllers, 5¼-in.-14-in. Winchesters, and 5¼-in.-8-in. floppy drives; controller interfaces can be DTC-ESDI, ST506/412, or SMD	•	•	•		Price includes software driver, standalone format program, and all documentation required for installation
Distributed Logic Corp. (DILOG) 1555 S. Sinclair St. Anaheim, CA 92806 714-937-5700 **Enter No. 702**	SQ706	POR*	Q-bus	MSCP	Dual	1.5 Mbytes/sec.	4,5,6,7 selectable	Up to 7 controllers; up to 4 logical units/node; maximum total SCSI devices is 8	•	•	•	•	Common Command Set implementation; on-board formatter and diagnostics; SCSI pass-through mode; product availability – January 1987
Emulex Corp. 3545 Habor Blvd. Costa Mesa, CA 92626 714-662-5600 **Enter No. 703**	UC01/LX	$1,500	Q-bus	RLV11 (18-bit address), RLV12 (22-bit address)	Quad	INP*	5	INP*	•			•	BDV11 compatible clock simulator plus bootstrap programmable ROMs and Q-bus termination resistors; compatible with all DEC OS used on LSI-11 CPUs that support DEC RL01 or RL02 disk subsystems
	UC04	$1,800	Q-bus	MSCP	Dual	INP*	4,5	Disk: Medalist MD01-8-in. removable cartridge and 5¼-in. disk drive; champion MD21-1 or 2 5¼-in. disk drives Tape: Titleist MT01-¼-in. streaming cartridge; MT02-QIC-36 tape; MT03-5¼-in. tape drive, ¼-in. streaming tape drive	•	•	•	•	Optical support, large data buffers (20 Kbyte), 22-bit addressing, NOVRAM, SCSI protocol controller
	UC14	$2,200	Unibus	MSCP	Quad	INP*	5	Disk: MD01, MD21, MD23 Tape: MT01, MT02	•	•		•	Adaptive DMA, optical support, large data buffer (20 Kbyte), 18-bit addressing, NOVRAM, SCSI protocol controller
Sigma Information Systems 3401 E. La Palma Ave. Anaheim, CA 92806 714-630-6553 **Enter No. 704**	SDC-HA11: SCSI bus to Q-bus host adapter	$417	Q-bus	INP*	Dual	INP*	4,5,6,7	Maximum 8 controllers					Operates in slave, DMA, or interrupt mode; provides jumper selectable address and vector interrupt, includes jumper selectable interrupt level and jumper selectable SCSI bus parity enable; includes program-controlled SCSI device 0-7 selection
TD Systems Inc. 24 Payton St. Lowell, MA 01853 617-937-9465 **Enter No. 705**	Viking/QDA	$1,195	Q-bus (22 bit)	MSCP	Dual	1.5 Mbytes/sec.	4	Single initiator-single target, or single initiator-multiple target (7 maximum), or multiple initiator-multiple target (8 total); supports up to 8 fixed and/or removable disks	•	•	•	•	Available from stock; on-board serial diagnostic/utility port; optional front panel
	Viking/QSC	$1,195	Q-bus (22 bit)	Nonemulating – direct SCSI	Dual	1.5 Mbytes/sec.	4	Single initiator-single target, or single initiator-multiple target (7 maximum), or multiple initiator-multiple target (8 total)	•		•	•	Available from stock; custom software drivers are available through TD Systems
	Viking/UDA	$1,495	Unibus	MSCP	Quad	1.5 Mbytes/sec.	Selectable 4-7	Single initiator-single target, or single initiator-multiple target (7 maximum), or multiple initiator-multiple target (8 total); supports up to 8 fixed and/or removable disks	•	•		•	Product availability – April 1987; on-board serial diagnostic/utility port; optional front panel
	Viking/USC	$1,495	Unibus	Nonemulating – direct SCSI	Quad	1.5 Mbytes/sec.	Selectable 4-7	Single initiator-single target, or single initiator-multiple target (7 maximum), or multiple initiator-multiple target (8 total)	•			•	Product availability – April 1987; custom software drivers are available through TD Systems
	TD11-12	$695	Q-bus	RLV-12	Dual	.8 Mbytes/sec.	4	Single initiator-single or multiple target; in emulating mode up to 4 fixed and/or removable disks; in direct SCSI mode, up to 7 targets				•	Available from stock; direct SCSI mode included in standard product
	UHA-11	$895	Unibus	RL-11	Quad	.6 Mbytes/sec.	Selectable 4-7	Single initiator-single or multiple target; in emulating mode, up to 4 fixed and/or removable disks; in direct SCSI mode, up to 7 targets				•	Available from stock; direct SCSI mode included in standard product
U.S. Design Corp. 5100 Philadelphia Way Lanham, MD 20706 301-577-2880 **Enter No. 706**	1108-01	$1,500	Q-bus	MSCP (disk), TS-11 (tape)	Quad	1 Mbyte/sec. burst, 650 Kbyte/sec. typical	4	MSCP support for up to 7 targets and 32 logical units; TS-11 emulation for start/stop units		•		•	Command queing and seek optimization for up to 24 commands; 1108-01 married with Maxtor 280 Mbyte drive is the 280-Q add-in expansion kit for MicroVAX II BA-123; SCSI pass-through mode supported for both MSCP and non-MSCP programming suitable for all operating systems; dual port capability with other U.S. Design adapters

* Quantity One * POR — price on request * INP — information not provided

(Cont.) U.S. Design Corp. 5100 Philadelphia Way Lanham, MD 20706 301-577-2880 **Enter No. 706**	1108-03	$2,000	**Q-bus**	MSCP (disk), TS-11 (tape)	Quad	1 Mbyte/ sec. burst, 650 Kbyte/ sec. typical	4	Any combination of optical disk and magnetic disk; up to 7 targets; 32 logical disks supported; TS-11 emulation for start/stop units	•	•	**Tailored for support of optical drives; switch selectable options for all major optical manufacturers using one set of firmware; switch selectable to form 2, 500 Mbyte logicals on a 1 Gbyte platter; optical utility software available for optical backup/ restore functions; both MSCP and non-**MSCP SCSI pass-through supported
	1108-10	$3,500	Q-bus	MSCP (disk), TS-11 (tape)	Quad	1 Mbyte/ sec. burst, 650 Kbyte/ sec. typical	4	Any combination of optical disk and magnetic disk; up to 7 targets; 1108-10 includes exclusive physical to logical mapping algorithms used to re-vector logical block requests to multiple physical units; this allows optical and magnetic disks to be virtualized for file structure applications; TS-11 emulation for start/ stop units	•	•	**1108-10 is the heart of the virtual optical storage (VOS) optical system; directory and file structure accesses are re-vectored to companion magnetic disk for full Files-11 compatibility without OS patches; all features of 1108-01 and 1108-03 adapters supported (major optical vendors via switches, 24 command que, etc.); VOS supports VMS and MicroVMS**
	1158-01	$2,000	Unibus	MSCP (disk), TS-11 (tape)	Hex	1 Mbyte/ sec. burst, 650 Kbyte/ sec. typical	4	Any combination of disks or TS-11 emulation for start/stop units; up to 7 targets supported with up to 32 logical units; dual port capability with other U.S. Design adapters	•	•	SCSI pass-through mode supported for both MSCP and non-MSCP programming **suitable for all OS; command queing and seek optimization for up to 24 commands; compatible SCSI devices are being qualified as they become available**
	1158-03	$2,500	Unibus	MSCP (disk), TS-11 (tape)	Hex	1 Mbyte/ sec. burst, 650 Kbyte/ sec. typical	4	Any combination of optical disk and magnetic disk; up to 7 targets; 32 logical disks supported; TS-11 emulation for start/ stop units	•	•	**Tailored for support of optical disks; switch selectable options for all major optical manufacturers using one set of firmware; switch selectable to form 2, 500 Mbyte logicals on a 1 Gbyte platter; optical utility software available for optical backup/ restore functions; both MSCP and non-**MSCP SCSI pass-through supported
	1158-10	$4,000	Unibus	MSCP (disk), TS-11 (tape)	Hex	1 Mbyte/ sec. burst, 650 Kbyte/ sec. typical	4	Any combination of optical disk and magnetic disk; up to 7 targets; 1158-10 includes exclusive physical to logical mapping algorithms used to re-vector logical block requests to multiple physical units; this allows optical and magnetic disks to be virtualized for file structure applications; TS-11 emulation for start/	•	•	**1158-10 is the heart of the virtual optical storage (VOS) optical system; directory and file structure accesses are re-vectored to companion magnetic disk for full Files-11 compatibility without OS patches; all features of 1158-01 and 1158-03 adapters supported (major optical vendors via switches, 24 command que,** etc.); VOS supports VMS and MicroVMS

variety of drives can be mixed without requiring any operating system patches or modifications. Additionally, MSCP-SCSI corrects soft errors, alerting the host only if a hard error occurs. MSCP-SCSI provides a virtually unlimited, error-free storage medium.

But not all manufacturers are betting on SCSI's success. The inherent limitation on maximum throughput, using a single channel to the host bus for support of several storage devices, is a strong reason to avoid SCSI. A combination host adapter/controller allows for fine-tuning that cannot be achieved with SCSI. SCSI goes a long way toward remedying its inherent single-channel throughput problem via DMA capabilities and disconnect/reconnect (by which multiple seeks can be simultaneously initiated on separate drives), and manufacturers are claiming that much higher transfer rates will soon be available. Currently 1.5 Mbytes/sec. is typical, but with perfection of the SCSI implementation, rates in the 4–5 Mbyte/sec. range and higher are expected. With these higher rates, the overall host bus bandwidth will be used, making SCSI a serious contender in the peripheral storage marketplace.

In the near-term, however, SCSI will probably be used mostly for archival storage and applications where cost and standardization are more important than performance. Archival storage access is basically read-only, so the small degree of I/O activity can be handled easily even if large amounts of storage are supported by only a single channel. And for microcomputer users, decreasing prices resulting from high volume sales of embedded SCSI drives provide them with maximum storage for their dollar.

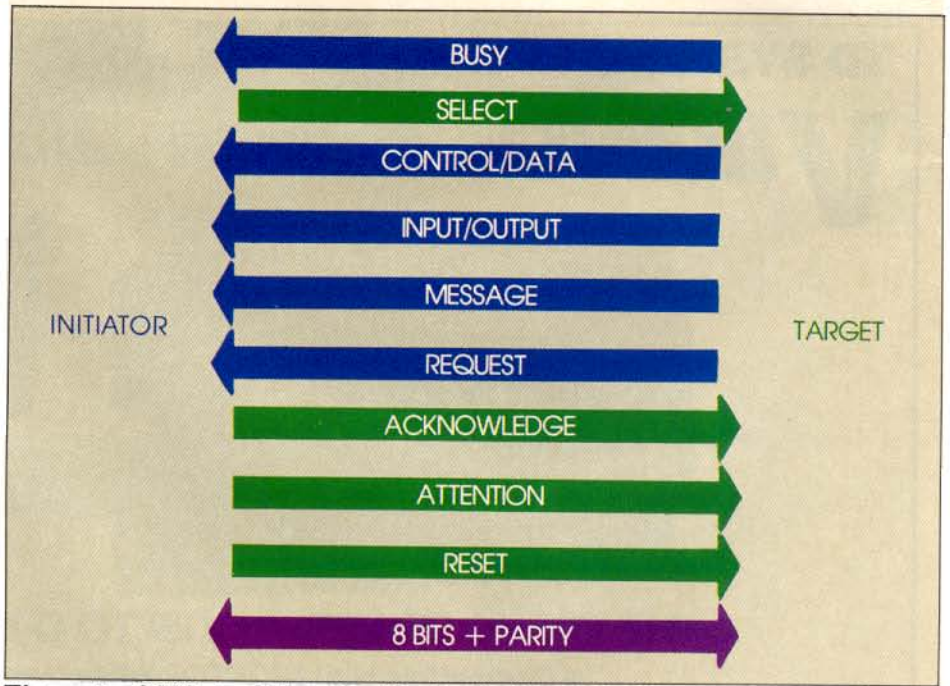

Figure 2—*SCSI signal lines consist of 9 for data and 9 for control. In distributed systems, the host adapter and controllers can act as either initiator or target.*

How SCSI Works

SCSI bus devices are daisy-chained together using a common cable. Each controller on the bus is assigned an address, and all signals are common between all devices. There's a total of 18 signals on the SCSI bus (Figure 2). Nine

are used for control and nine are used for data. Data transfer occurs in 8-bit bytes and the 9th line is used for parity. The SCSI bus is terminated at both ends.

When the host adapter is to connect with a controller, as directed by an I/O request from the host, it puts that controller's address out onto the bus. It is acting as initiator on the SCSI bus. The controller then establishes itself as a target when it responds to the request for service.

If the host adapter supports SCSI distributed arbitration, it has the highest SCSI address. Distributed arbitration awards control of the bus to the device with the highest address that is contending for use of the bus. Under distributed arbitration, both the host adapter and the controllers compete for bus control.

Distributed arbitration radically speeds up the SCSI bus. It allows for disconnect/reconnect operation by which a controller disconnects from the host adapter after receiving a SCSI command and reconnects (by arbitrating for the bus) after it is finished. In this way, overlapped seeks are performed on many drives, and the controllers have the capability of connecting with other controllers for operations such as backup (copy).

Table 2—SCSI Bus Phases

Phase	Description
Bus Free	Indicates that no SCSI device is actively using the SCSI bus
Arbitration	Allows one SCSI device to gain control of the SCSI bus
Selection	Allows an initiator to select a target
Reselection	Allows a target to reconnect to an initiator
Command	Commands are transferred from initiator to target
Data	Data transferred between initiator and target
Status	Status after a command is returned from target to initiator
Message	Messages are transferred between initiator and target

SCSI bus operation consists of several phases (Table 2). If distributed arbitration is not implemented by the host adapter, the SCSI system functions in single-initiator mode, and the arbitration bus phase is not used (Figure 3).

ANSI standard SCSI, in addition to

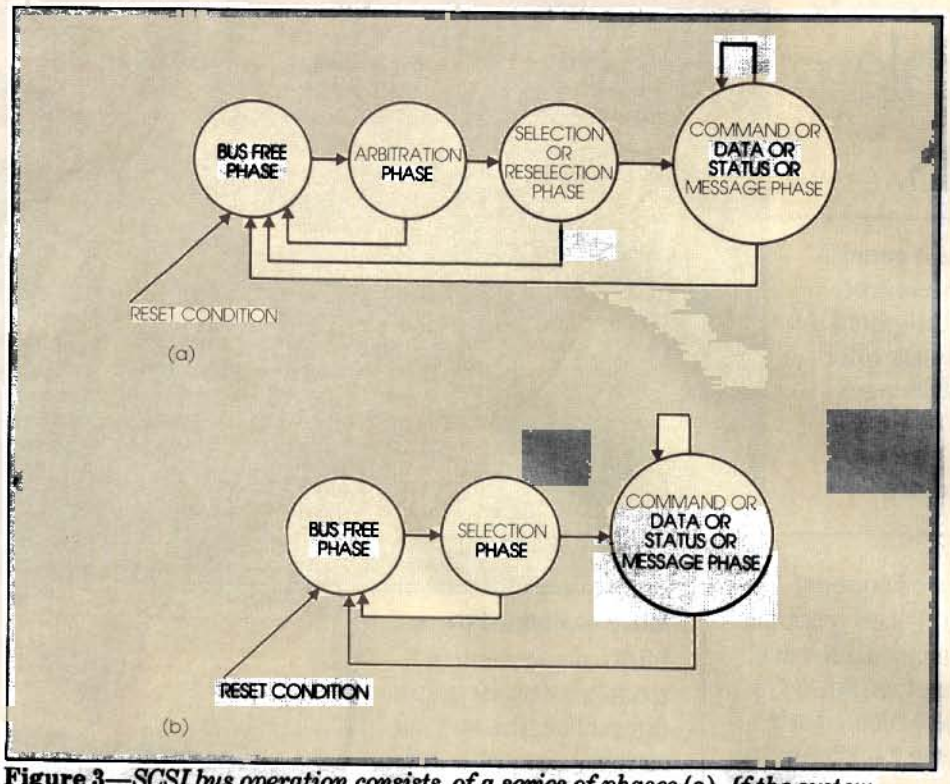

Figure 3—*SCSI bus operation consists of a series of phases* (a). *If the system functions in single initiator mode, the phase sequences occur without arbitration* (b).

defining signal lines and protocol, specifies several options such as synchronous or asynchronous transfer and hard vs. soft reset. Manufacturers of SCSI devices are confronted with an exhaustive standard and many commands. There is currently a movement in the industry toward specification of a SCSI Common Command Set so that all manufacturers are implementing SCSI in the same way. Scientific Micro Systems (Mountain View, Calif.) has been coordinating this effort. To date, ANSI has already developed an internal working document reflecting the work that has been done. The document defines the Common Command set and is available to developers.

A block diagram of a typical SCSI host adapter is shown in Figure 4. The host adapter passes the host computer's requests to store and receive data to the controllers it supports. Some host adapters implement a command buffer and have the capability of scanning the various seeks that need to be performed and determining the most efficient order in which to do them.

The host adapter is organized around a microprocessor that controls operations. It implements commands from the host and sets up the host and SCSI interfaces for control and data transmission. If the host adapter supports a command buffer, it optimizes the order in which operations occur. If DMA is supported, it controls those operations as well.

The firmware contains the host adapter control program executed by the microprocessor, and the RAM is used for data buffering and working storage. Some host adapters implement custom chips for interface control and DMA addressing and control.

State-of-the-art SCSI host adapters are advanced enough that an investment in one will provide many years of efficient, relatively high speed, extensive data storage. The SCSI standard will surely mature quickly, but what's currently available for Digital users seems sufficient to provide excellent performance for many applications. ■

Brad Harrison is Hardcopy *technical editor.*

How would you rate the technical information in this article?

Too complex	Enter No. 410
Just right	Enter No. 414
Too simplistic	Enter No. 416

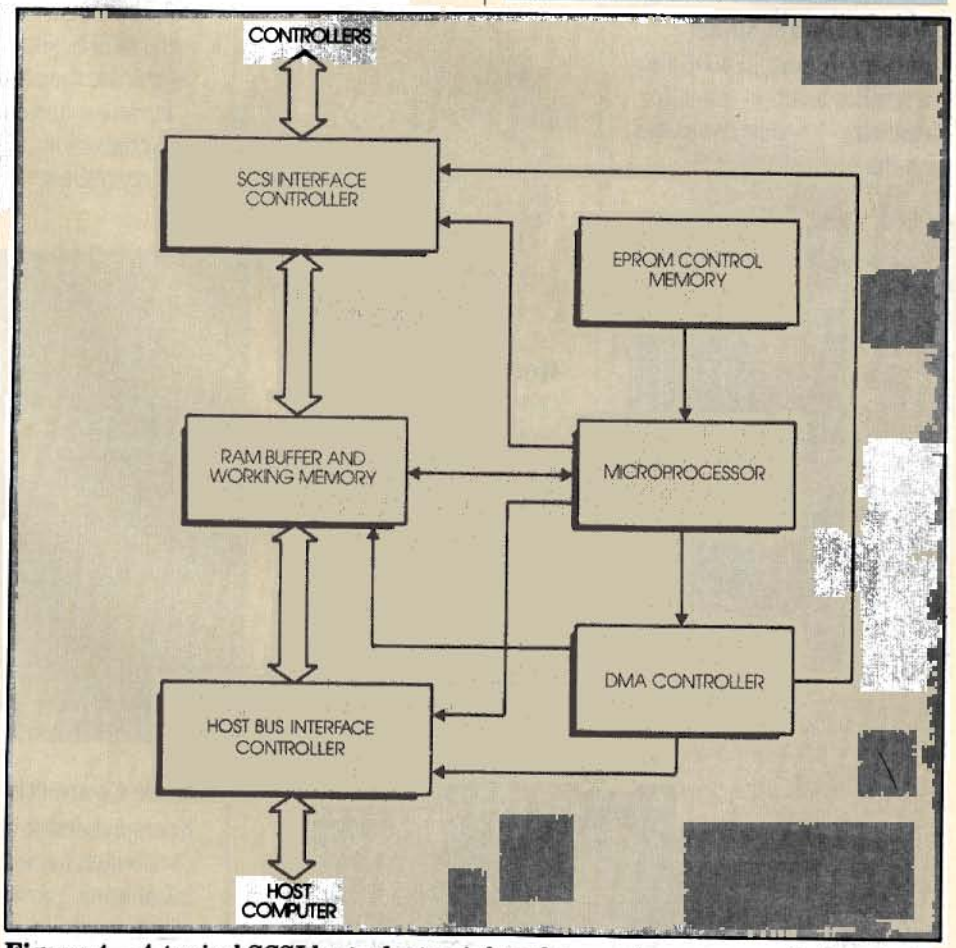

Figure 4—*A typical SCSI host adapter is based on a microprocessor that controls the bus interfaces and transfer of data between them.*