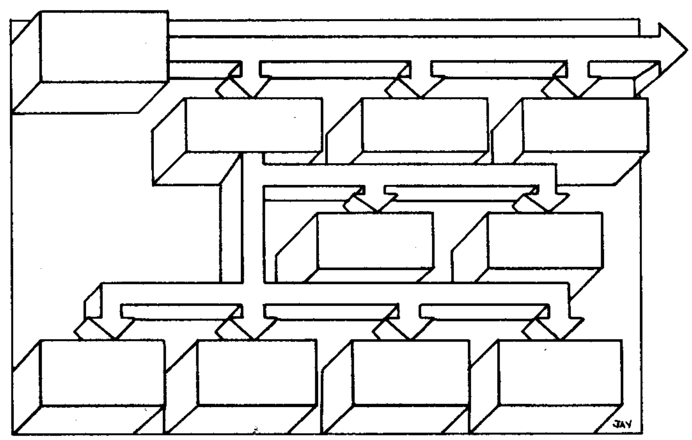
SCSI OPTIMIZES PERIPHERALS INTEGRATION FOR SMALL SYSTEMS

Small systems integrators have traditionally had no choice but to wrestle with a tangle of frequently conflicting specifications. SCSI offers a link for dissimilar devices and defines a complete bus system.

by Ron Thomas and Neal Foxworthy



Systems integrators today face a wide variety of configuration options that defy simple interfacing solutions. The advantages of rapid technological innovation seem to have been offset by the problems associated with a bewildering array of standards, protocols and other proprietary operating parameters for peripherals and systems.

As might be expected, large systems with sophisticated CPU architectures, high-performance peripherals and complex software pose serious integration difficulties. But even low- and mid-range systems now pose the same kind of challenge: how to integrate multiple and dissimilar components in a way that optimizes the system's efficiency, enables the mixing of different types of peripherals, enhances the system's expansion capabilities and minimizes integration time and cost.

Until recently, the small systems integrator had no choice but to wrestle with a tangle of diverse and frequently conflicting specifications. But with the advent of the Small Computer Systems Interface (SCSI), integrators can now link dissimilar devices so that signals from one can be translated and used by another.

Beyond merely acting as an electronic translator, SCSI also defines a complete bus system in which definite electrical paths and communications protocols are clearly determined. This means that devices, like any bus or backplane, can easily be plugged in or unplugged. And because SCSI is a full-fledged bus, many industry observers consider it a major advance in small system architectures, with the potential to simplify small systems integration significantly.

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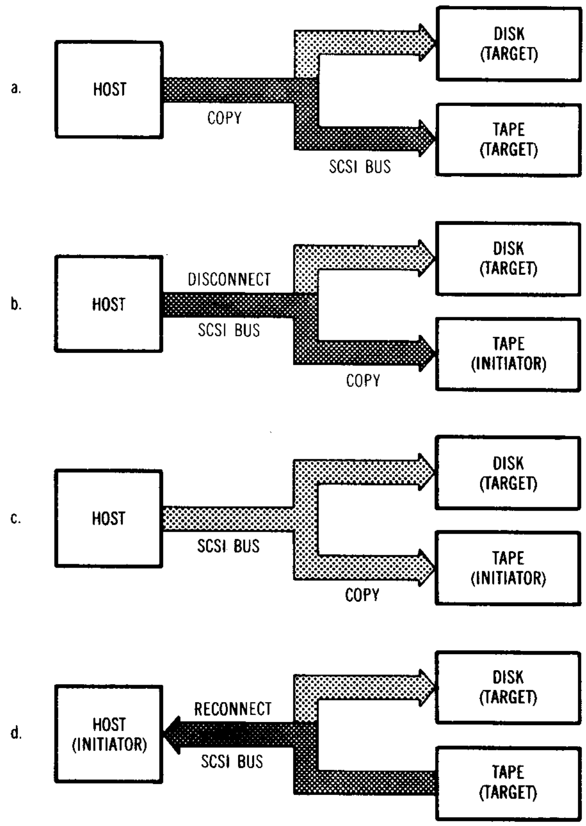
From SASI to SCSI

The foundation of a small system integration solution became clear when the Shugart Associates System Interface (SASI) was introduced in 1979. SASI had the revolutionary ability to accept host adapters,



To begin the copy command sequence (a), the host reserves the disk for the tape drive, reserves the tape drive for its own use, and sends the Copy command to the tape drive. The tape drive then acknowledges the Copy command (b) by disconnecting from the host as a target, and reconnecting to the bus as an initiator, freeing the host for other tasks. The tape drive maintains initiator status until the copy operation is complete (c) and the disk signals its status. If there are no error conditions, the tape drive disconnects from the bus as an initiator and reconnects to the bus as a target. The tape drive then selects the host and presents ending status information (d). The host reestablishes initiator status and releases the tape and disk drives, completing the copy command sequence.

providing an elegant solution to the problem of integrating Shugart's SA-1000 and other 8-in Winchester drives into different types of microcomputers, regardless of the system bus structure. Together with Data Technology (Santa Clara, CA), Shugart Associates developed SASI as a general-purpose interface based on IBM's I/O channel architecture.

After Shugart subcontracted the development of SASI and made the specifications freely available, it became the preferred interface for OEMs to integrate SA-1000 and ST506 disks more easily. A large SASI aftermarket soon developed when independent controller houses started providing it as a vehicle for attaching floppy disks, Winchesters, and ¼-in. tape cartridge drives. As more manufacturers adopted it, SASI quickly became a de facto standard.

In 1981, at the urging of NCR (Dayton, OH), Shugart brought SASI to ANSI to be reviewed. Prompted by the large number of installed Shugart disk drives, the ANSI Committee X3T9.2 was assigned to develop a refined document for the X3T9 parent committee. Since a company name like Shugart was inappropriate for an industry-wide specification standard, the name "Small Computer Systems Interface" was chosen.

More importantly, the X3T9.2 committee decided to broaden the definition of the SASI standard so that SCSI could be implemented in multiuser systems as a general-purpose bus for a wide range of peripherals: magnetic disks, tape drives, optical storage devices, printers and data communications peripherals. Today, although the term SASI is often confused with SCSI, there are important differences between the two interface standards.

The SCSI advantage

Perhaps the single biggest advance that SCSI makes over the de facto SASI standard is its provision for multiple-host architectures. Moreover, SCSI is a peer-to-peer interface, rather than a master/slave interface such as SASI, so that data transfer can be initiated by any device (or "initiator" device) on the SCSI bus to any other device (or "target" device). With its bus arbitration capabilities, an SCSI-based system can perform concurrent I/O operations among different devices by prioritizing bus usage.

SCSI-based peripherals offer the OEM and other systems integrators convenient building blocks for assembling, updating, mixing and interchanging different types of I/O devices in computer system configurations. Additionally, an SCSI bus fits with any popular host adapter: the IBM PC, XT and AT, Q-bus, Unibus, Multibus and others. Through the use of a common I/O bus and standard peripheral interface, SCSI provides the capability to build systems easily and with maximum flexibility.

Although the SCSI interface can serve as an I/O bus, it should not be mistaken for a local area network. In its present implementation (a 50-wire, daisy-chained ribbon cable), distances are limited to 25 meters. But SCSI can function as a link between a LAN and devices that are clustered around the SCSI bus.

Another important advantage of SCSI is that since it is designed for higher performance than that provided by available peripherals, system performance is improved. Also, the SCSI bus is controlled by powerful commands for:

- •Formatting storage devices
- •Reading and writing data to and from peripherals
- •Directing output to various hard copy or storage devices
- •Copying data from one device to another, or sending it from one host to another.

In addition, SCSI's well-defined bus structure eliminates many costly and lengthy interfacing tasks—particularly in the integration of multiuser and multitasking systems. In fact, since the SCSI bus design is hierarchical, it provides almost automatic system integration. The bus specification clearly reflects how system architectures go together and are extended. System integrators can attach one or several host computers to the SCSI bus via the host adapters, which tailor the host bus to the electrical and software characteristics of SCSI.

Also, in an SCSI-based system, each device provides the host with its unique profile, making it independent of the host. This ability becomes especially important as the number of devices grows. Most SCSI systems can support as many as eight SCSI-addressed devices, with each device supporting as many as eight logical units, for a total of 64 devices. Moreover, SCSI simplifies system hardware integration by requiring only one bus connection for an entire system, rather than requiring a unique hardware interface for each peripheral device.

At the software level, SCSI cuts through the conventional tangle of diverse device technologies. Because it is device-generic, isolating software from device-specific technology, it lowers the cost of software development and maintenance, a major boon for OEMs. Already, the availability of SCSI in silicon is beginning to have a significant impact on device interfaces. When it is possible to integrate SCSI within a peripheral at the same cost as a device interface, the market will probably swing away from "device" interfaces on low- to medium-performance peripherals.

SCSI versus IPI

As a superset of SASI, SCSI significantly extends SASI's capabilities, offering greater capability and isolation from changes for peripheral device technologies in low- and medium-range systems. SCSI has such broad capability that it is already being utilized in high-performance minicomputer-based systems that were originally intended to be served by the Intelligent Peripheral Interface (IPI). Another standard under development by ANSI, IPI is designed to address high-end applications. So far, though, a lack of products that can use the IPI specification has caused some OEMs to implement SCSI instead.

In fact, many companies which were planning on developing IPI Level 2 and Level 3 products are now implementing SCSI for short-term development projects to achieve the device commonality necessary for current systems. Some have already proposed enhancements to the current SCSI standards to stretch its usefulness until disk and system developers can progress further with their IPI programs. For example, the proposed SCSI enhancement would increase the number of possible addressed devices from eight to 64. Because each SCSI controller on the bus can handle as many as eight peripherals, up to 512 peripheral devices could be accommodated.

The proposed SCSI enhancement would also give a target device the ability to request an interrupt of an initiator in systems where an arbitration scheme has not been implemented, priority of devices on the bus is not fixed, and access to the bus can be decided by software running on the I/O processor.

Benefits for today

To summarize, SCSI offers the OEM or systems integrator virtually automatic system configuration, simplified hardware and software integration, and simplified system support. Systems integrators can attach one or several host computers to the SCSI bus via the host adapters. For the end user, SCSI means true plug-and-run operation of peripherals and increased system performance at reduced cost. It is also significant that SCSI is a true interface standard recognized by ANSI. This makes a level of system planning possible that not even the SASI standard can match. And, unlike IPI, which appears to be two years away from major OEM product shipments, SCSI is a reality today.

Recognizing the important impact of intelligent interfaces for peripherals, especially in the disk and tape drive areas, Cipher Data Products (San Diego, CA) was an early SCSI supporter. After years of working with ANSI's X3T9.2 committee, Cipher Data now offers the SCSI interface as an optional embedded feature on its Model 540 ¼-in. tape cartridge drive and as a controller bridging SCSI to the Cipher interface for its line of ½-in. reel-to-reel tape drives.

Cipher also will offer SCSI as an embedded feature of its coming family of ½-in. tape cartridge drives. This will enable the smooth migration to future higher performance products that go beyond standard-height ¼-in. tape cartridge drives.

Cipher employs a fully enclosed SCSI unit that includes the printed circuit board, an integrated 5-V power supply and cabling (ANSI Standard X3T9.2, Rev 14B) for connecting the bridge controller and tape drive. The bridge controller draws power from its own internal power supply, rather than from the bus or the host. This simplifies the system's power and packaging requirements.

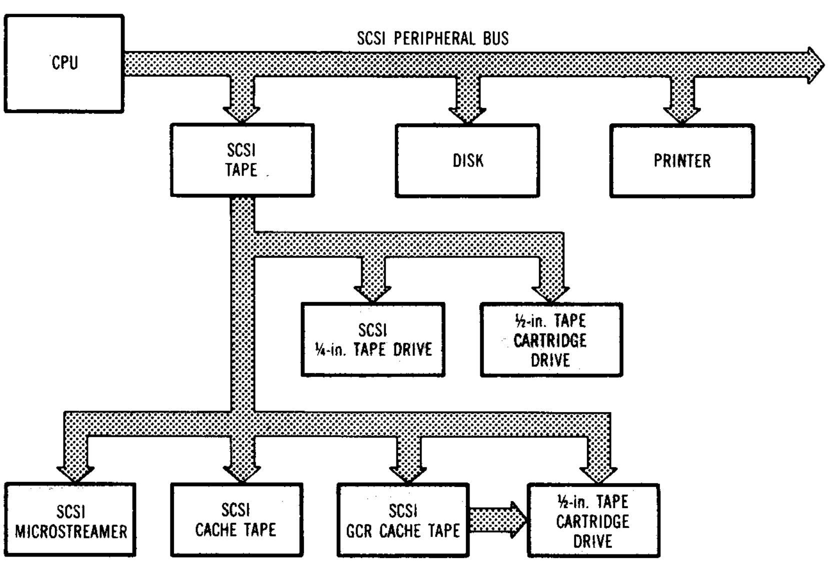
The SCSI interface supports data transfer rates up to 1.5 Mbytes, as well as interperipheral data transfers that are host independent. The adapter also provides bus parity and recovery procedures for bus protocol errors during all phases of operation. Also, several diagnostic commands are included to initiate peripheral diagnostics and receive test results.

Because the size of the data blocks is the basis of media efficiency, Cipher designed its SCSI buffer to be large enough to accommodate block sizes of up to 64 kbytes (64 kbytes × 9 bits in buffered mode), even though the most common range of reel-to-reel block sizes is from 16 to 32 kbytes. Cipher's implementation of SCSI also enables data transfer rates of up to 1.5 Mbytes/s—the maximum possible rate for SCSI in asynchronous mode. Cipher's decision to support this rate means that an initiator tape drive can get on and off the bus as quickly as possible, and that a continuous stream of data can be provided for streaming the tape drives.

Unlike some interpretations of SCSI that fail to extend the capabilities of SASI, Cipher's implementation of SCSI provides for all standard sequential access device commands, plus optional commands required to optimize the performance of specific tape drives. For example, Cipher's implementation of the SCSI Copy command uses the Disconnect/Reconnect message, the Reserve/Release and Third-Party Reservation commands and bus arbitration. System implementations that do not have all of these capabilities typically cannot use the SCSI Copy command.

The function of the Copy command is to allow the tape drive to control the disk without host intervention. With this command, the disk can dump data to tape, or vice versa, while the host is processing or performing other chores. In the Cipher standard configuration, the host is the initiator and the tape and disk drives are targets. The process begins when the host uses the Third-Party Reservation command to reserve the disk drive for the tape drive. The host then reserves the tape drive for its own use and sends the Copy command to the tape drive. Once the tape drive receives and recognizes the Copy command, it sends the Disconnect message to the host, removes itself as a host target, then reconnects to the bus as an initiator.

At this point, the host is free to go on to other tasks, while the tape drive becomes the initiator, starting the copy sequence to read from or write to the disk drive. The tape drive maintains initiator status, and the disk drive maintains target status, until the copy operation is completed. The disk drive then sends status information to the tape drive. Once the tape drive receives a valid status message and there are no error conditions, it disconnects from the bus as an initiator and reconnects to the bus as a target. The tape drive then selects the host and presents the ending status information, and the host reestablishes its initiator status and releases both the tape and disk drives. This completes the Copy command sequence.



Intelligent interface strategies enable the smooth migration from existing, standard-height, ¼-in. cartridge tape drives to the coming generation of higher performance ½-in. tape cartridge drives.

During this sequence, as when other commands or two hosts vie for the bus at the same time, bus arbitration must occur. As part of the arbitration phase, the device (whether initiator or target) with the highest preassigned priority gains first use of the bus. The initiator keeps its status until the transfer is complete, but does not restrict bus activity. The target, knowing the extent of possible physical bus delays, actually controls the bus activity.

Integrating SCSI-based tape drives

For systems integrators and OEM manufacturers who are planning to offer high-performance SCSI-based systems, secondary data storage units such as SCSI tape drives are mandatory. The primary and secondary storage needs of the system must also be anticipated to reap the full benefits of SCSI.

For example, an SCSI-based system could be configured initially with a ¼-in. cartridge drive that could be replaced by a ½-in. cartridge drive—without any need to change the interface hardware or system software. But this type of "plug-and-play" migration is only possible if the system is designed with enough advance information for the development of a common software driver.

Also, while the physical tape drive performance (speed, density and storage capacity) are not affected by SCSI, the logical tape drive performance (data block size, interface transfer rate and latency) can be optimized through proper use of SCSI.

The data block size, which is the basis for media efficiency, ranges from 512 bytes for standard ¼-in. cartridge (QIC) tape drives, to up to 64 kbytes for user-specified ½-in. reel-to-reel tape drives. Most SCSI designs have been used with QIC-based tape drives where 2-kbyte buffers are sufficient. But these SCSI designs that support buffers of up to only 2 kbytes present problems as SCSI design migrates up to reel-to-reel drives. For these drives, the most common range of data block sizes is from 16 to 32 kbytes, and a 2-kbyte buffer is not large enough to optimize hardware operation.

Similarly, although the interface transfer rate is the basis for bus efficiency, the usefulness of the data rate depends on whether the full SCSI bus bandwidth capability is supported, what types of peripherals are on the system and whether the size of the SCSI buffer is sufficiently large to support the requested data block sizes. Also, the data rate can also determine whether a steady stream of data will be provided. The SCSI maximum data rate of 1.5 Mbytes/s (in asynchronous mode) maximizes streaming-tape drive performance.

Finally, the latency time between the transfer of data blocks has a direct effect on whether the streaming-tape drives will have to reposition and slow down the physical transfer rate. The effects of latency can be minimized by the size of the SCSI buffers, which must be large enough to accommodate the largest data block size expected.

Planning ahead

SCSI offers the systems integrator true migration capability for various system configurations. For data storage, it not only delivers a common interface for both primary and secondary storage, but also enables real migration—from ¼- to ½-in. tape, or from cartridge to reel-to-reel.

But all of this requires foresight and imagination in developing the initial software drivers. These drivers must be designed to simplify long-term peripheral integration and improve peripherals and system performance. If a systems integrator can foresee a need to migrate from ¼-in. to nine-track tape at some point in the future, today's software driver should be written with that probable development in mind.

Systems integrators will also eventually be faced with a choice between SCSI and the higher performance IPI Level 3. When computer manufacturers and disk drive suppliers begin to focus more heavily on IPI, it will probably migrate down into the minicomputer market, which will initially be served by the more readily available SCSI standard. During the period when the two interfaces coexist, IPI will provide the higher performance interface option.

The need to move to SCSI for intelligent peripherals in low-end and medium-performance computer systems is even clearer today than the needs that propelled the SASI interface. When the need for a high-performance implementation of SCSI is considered, it is obvious that there would be a demand for systems that are considerably more sophisticated than those anticipated by SASI.

As a solution for cutting through much of the integration and configuration tangle, SCSI is fast becoming the most intelligent option in integrating small system peripherals. **CD**

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