The following material is excerpted from:

Parallel Port Complete

Programming, Interfacing, & Using the PC's Parallel Printer Port

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Essentials

A first step in exploring the parallel port is learning how to get the most from a port with your everyday applications and peripherals. Things to know include how to find, configure, and install a port, how and when to use the new bidirectional, EPP, and ECP modes, and how to handle a system with multiple parallel-port peripherals. This chapter presents essential information and tips relating to these topics.

Defining the Port

What is the "parallel port"? In the computer world, a *port* is a set of signal lines that the microprocessor, or CPU, uses to exchange data with other components. Typical uses for ports are communicating with printers, modems, keyboards, and displays, or just about any component or device except system memory. Most computer ports are digital, where each signal, or bit, is 0 or 1. A parallel port transfers multiple bits at once, while a serial port transfers a bit at a time (though it may transfer in both directions at once).

This book is about a specific type of parallel port: the one found on just about every PC, or IBM-compatible personal computer. Along with the RS-232 serial port, the parallel port is a workhorse of PC communications. On newer PCs, you

may find other ports such as SCSI, USB, and IrDA, but the parallel port remains popular because it's capable, flexible, and every PC has one.

The term *PC-compatible,* or *PC* for short, refers to the IBM PC and any of the many, many personal computers derived from it. From another angle, a PC is any computer that can run Microsoft's MS-DOS operating system and whose expansion bus is compatible with the ISA bus in the original IBM PC. The category includes the PC, XT, AT, PS/2, and most computers with 80x86, Pentium, and compatible CPUs. It does not include the Macintosh, Amiga, or IBM mainframes, though these and other computer types may have ports that are similar to the parallel port on the PC.

The original PC's parallel port had eight outputs, five inputs, and four bidirectional lines. These are enough for communicating with many types of peripherals. On many newer PCs, the eight outputs can also serve as inputs, for faster communications with scanners, drives, and other devices that send data to the PC.

The parallel port was designed as a printer port, and many of the original names for the port's signals (*PaperEnd, AutoLineFeed*) reflect that use. But these days, you can find all kinds of things besides printers connected to the port. The term *peripheral*, or *peripheral device* is a catch-all category that includes printers, scanners, modems, and other devices that connect to a PC.

Port Types

As the design of the PC evolved, several manufacturers introduced improved versions of the parallel port. The new port types are compatible with the original design, but add new abilities, mainly for increased speed.

Speed is important because as computers and peripherals have gotten faster, the jobs they do have become more complicated, and the amount of information they need to exchange has increased. The original parallel port was plenty fast enough for sending bytes representing ASCII text characters to a dot-matrix or daisy-wheel printer. But modern printers need to receive much more information to print a page with multiple fonts and detailed graphics, often in color. The faster the computer can transmit the information, the faster the printer can begin processing and printing the result.

A fast interface also makes it feasible to use portable, external versions of peripherals that you would otherwise have to install inside the computer. A parallel-port tape or disk drive is easy to move from system to system, and for occasional use, such as making back-ups, you can use one unit for several systems. Because a backup may involve copying hundreds of Megabytes, the interface has to be fast to be worthwhile.

This book covers the new port types in detail, but for now, here is a summary of the available types:

Original (SPP)

The parallel port in the original IBM PC, and any port that emulates the original port's design, is sometimes called the *SPP*, for standard parallel port, even though the original port had no written standard beyond the schematic diagrams and documentation for the IBM PC. Other names used are *AT-type* or *ISA-compatible*.

The port in the original PC was based on an existing Centronics printer interface. However, the PC introduced a few differences, which other systems have continued.

SPPs can transfer eight bits at once to a peripheral, using a protocol similar to that used by the original Centronics interface. The SPP doesn't have a byte-wide input port, but for PC-to-peripheral transfers, SPPs can use a Nibble mode that transfers each byte 4 bits at a time. Nibble mode is slow, but has become popular as a way to use the parallel port for input.

PS/2-type (Simple Bidirectional)

An early improvement to the parallel port was the bidirectional data port introduced on IBM's model PS/2. The bidirectional port enables a peripheral to transfer eight bits at once to a PC. The term *PS/2-type* has come to refer to any parallel port that has a bidirectional data port but doesn't support the EPP or ECP modes described below. Byte mode is an 8-bit data-transfer protocol that PS/2-type ports can use to transfer data from the peripheral to the PC.

EPP

The EPP (enhanced parallel port) was originally developed by chip maker Intel, PC manufacturer Zenith, and Xircom, a maker of parallel-port networking products. As on the PS/2-type port, the data lines are bidirectional. An EPP can read or write a byte of data in one cycle of the ISA expansion bus, or about 1 microsecond, including handshaking, compared to four cycles for an SPP or PS/2-type port. An EPP can switch directions quickly, so it's very efficient when used with disk and tape drives and other devices that transfer data in both directions. An EPP can also emulate an SPP, and some EPPs can emulate a PS/2-type port.

ECP

The ECP (extended capabilities port) was first proposed by Hewlett Packard and Microsoft. Like the EPP, the ECP is bidirectional and can transfer data at ISA-bus speeds. ECPs have buffers and support for DMA (direct memory access) transfers

and data compression. ECP transfers are useful for printers, scanners, and other peripherals that transfer large blocks of data. An ECP can also emulate an SPP or PS/2-type port, and many ECPs can emulate an EPP as well.

Multi-mode Ports

Many newer ports are multi-mode ports that can emulate some or all of the above types. They often include configuration options that can make all of the port types available, or allow certain modes while locking out the others.

System Resources

The parallel port uses a variety of the computer's resources. Every port uses a range of addresses, though the number and location of addresses varies. Many ports have an assigned IRQ (interrupt request) level, and ECPs may have an assigned DMA channel. The resources assigned to a port can't conflict with those used by other system components, including other parallel ports

Addressing

The standard parallel port uses three contiguous addresses, usually in one of these ranges:

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3BCh, 3BDh, 3BEh
378h, 379h, 37Ah
278h, 279h, 27Ah
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The first address in the range is the port's base address, also called the Data register or just the port address. The second address is the port's Status register, and the third is the Control register. (See Appendix C for a review of hexadecimal numbers.)

EPPs and ECPs reserve additional addresses for each port. An EPP adds five registers at *base address + 3* through *base address + 7*, and an ECP adds three registers at *base address + 400h* through *base address + 402h*. For a base address of 378h, the EPP registers are at 37Bh through 37Fh, and the ECP registers are at 778h through 77Fh.

On early PCs, the parallel port had a base address of 3BCh. On newer systems, the parallel port is most often at 378h. But all three addresses are reserved for parallel ports, and if the port's hardware allows it, you can configure a port at any of the addresses. However, you normally can't have an EPP at base address 3BCh, because the added EPP registers at this address may be used by the video display.

IBM's Type 3 PS/2 port also had three additional registers, at *base address +3* through *base address + 5*, and allowed a base address of 1278h or 1378h.

Most often, DOS and Windows refer to the first port in numerical order as *LPT1*, the second, *LPT2*, and the third, *LPT3*. So on bootup, LPT1 is most often at 378h, but it may be at any of the three addresses. LPT2, if it exists, may be at 378h or 278h, and LPT3 can only be at 278h. Various configuration techniques can change these assignments, however, so not all systems will follow this convention. LPT stands for line printer, reflecting the port's original intended use.

If your port's hardware allows it, you can add a port at any unused port address in the system. Not all software will recognize these non-standard ports as LPT ports, but you can access them with software that writes directly to the port registers.

Interrupts

Most parallel ports are capable of detecting interrupt signals from a peripheral. The peripheral may use an interrupt to announce that it's ready to receive a byte, or that it has a byte to send. To use interrupts, a parallel port must have an assigned interrupt-request level (IRQ).

Conventionally, LPT1 uses IRQ7 and LPT2 uses IRQ5. But IRQ5 is used by many sound cards, and because free IRQ levels can be scarce on a system, even IRQ7 may be reserved by another device. Some ports allow choosing other IRQ levels besides these two.

Many printer drivers and many other applications and drivers that access the parallel port don't require parallel-port interrupts. If you select no IRQ level for a port, the port will still work in most cases, though sometimes not as efficiently, and you can use the IRQ level for something else.

DMA Channels

ECPs can use direct memory access (DMA) for data transfers at the parallel port. During the DMA transfers, the CPU is free to do other things, so DMA transfers can result in faster performance overall. In order to use DMA, the port must have an assigned DMA channel, in the range 0 to 3.

Finding Existing Ports

DOS and Windows include utilities for finding existing ports and examining other system resources. In Windows 95, click on *Control Panel, System, Devices, Ports*, and click on a port to see its assigned address and (optional) IRQ level and DMA

channel. In Windows 3.1 or DOS, you can use Microsoft's Diagnostic (*msd.exe*) to view ports, assigned IRQ levels, and other system details.

Configuring

The parallel port that comes with a PC will have an assigned address and possibly an IRQ level and DMA channel. Multi-mode ports may also be configured with specific modes enabled. You can change some or all of these assignments to match your needs. If you're adding a new port, you need to configure it, making sure that it doesn't conflict with existing ports and other resources.

Port Options

There is no standard method for configuring a port. Some ports, especially older ones, use jumper blocks or switches to select different options. Others allow configuring in software, using a utility provided on disk. A port on a system motherboard may have configuration options in the system setup screens (the CMOS setup) that you can access on bootup. On ports that meet Microsoft's Plug and Play standard, Windows 95 can automatically assign an available port address and IRQ level to a port.

Check your system or port's documentation for specifics on how to configure a port. Some ports allow a choice of just one or two of the three conventional base addresses. A few allow you to choose any uncommitted address, including non-standard ones. On some boards, the jumpers or switches are labeled, which is extremely handy when you don't have other documentation (or can't find it).

If your port supports ECP transfers, assign it an IRQ level and DMA channel if possible. Most ECP drivers do use these, and if they're not available, the driver will revert to a slower mode.

Multi-mode Ports

Configuring a multi-mode port needs special consideration. A multi-mode port's controller chip supports a variety of modes that emulate different port types. In addition to the configuration options described above, on most multi-mode ports, you also have to select a port type to emulate.

The problem is that there is no single standard for the basic setup on the controller chips, and there are many different chips! Usually the setup involves writing to configuration registers in the chip, but the location and means of accessing the registers varies.

For this reason, every port *should* come with a simple way to configure the port. If the port is on the motherboard, look in the CMOS setup screens that you can access on bootup. Other ports may use jumpers to enable the modes, or have configuration software on disk.

The provided setup routines don't always offer all of the available options or explain the meaning of each option clearly. For example, one CMOS setup I've seen allows only the choice of *AT* or *PS/2-type* port. The PS/2 option actually configures the port as an ECP, with the ECP's PS/2 mode selected, but there is no documentation explaining this. The only way to find out what mode is actually selected is to read the chip's configuration registers. And although the port also supports EPP, the CMOS setup includes no way to enable it, so again, accessing the configuration registers is the only option.

If your port is EPP- or ECP-capable but the setup utility doesn't offer these as choices, a last resort is to identify the controller chip, obtain and study its data sheet, and write your own program to configure the port.

The exact terminology and the number of available options can vary, but these are typical configuration options for a multi-mode port:

SPP. Emulates the original port. Also called *AT-type* or *ISA-compatible*.

PS/2, or simple bidirectional. Like an SPP, except that the data port is bidirectional.

EPP. Can do EPP transfers. Also emulates an SPP. Some EPPs can emulate a PS/2-type port.

ECP. Can do ECP transfers. The ECP's internal modes enable the port to emulate an SPP or PS/2-type port. An additional internal mode, *Fast Centronics*, or *Parallel-Port FIFO,* uses the ECP's buffer for faster data transfers with many old-style (SPP) peripherals.

ECP + EPP. An ECP that supports the ECP's internal mode 100, which emulates an EPP. The most flexible port type, because it can emulate all of the others.

Drivers

After setting up the port's hardware, you may need to configure your operating system and applications to use the new port.

For DOS and Windows 3.1 systems, on bootup the operating system looks for ports at the three conventional addresses and assigns each an LPT number.

In Windows 3.1, to assign a printer to an LPT port, click on *Control Panel*, then *Printers*. If the printer model isn't displayed, click *Add* and follow the prompts.
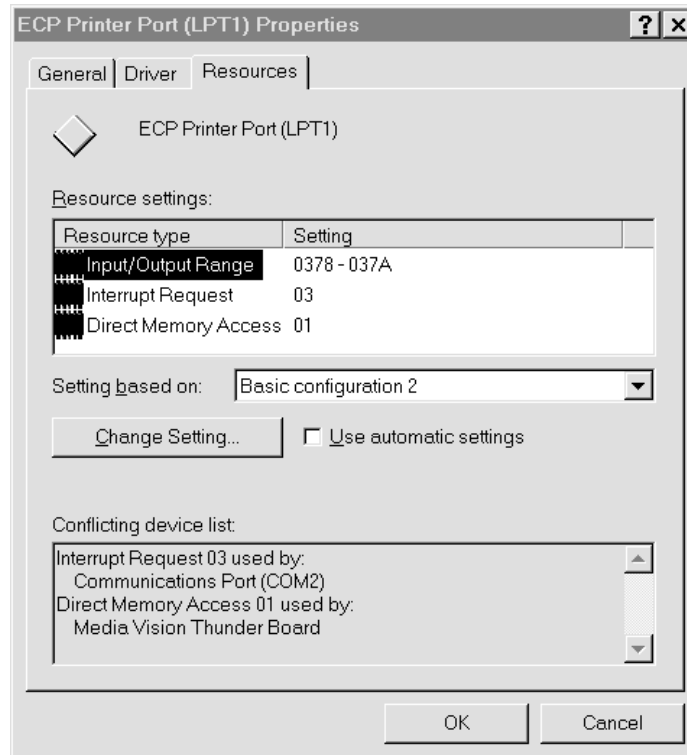
Figure 1-1: In Windows 95, you can select a port configuration in the Device Manager's Resources Window. A message warns if Windows detects any system conflicts with the selected configuration.

Select the desired printer model, then click *Connect* to view the available ports. Select a port and click *OK*, or *Cancel* to make no changes.

In Windows 95, the Control Panel lists available ports under *System Properties, Device Manager, Ports*. There's also a brief description of the port. *Printer Port* means that Windows treats the port as an ordinary SPP, while *ECP Printer Port* means that Windows will use the abilities of an ECP if possible. To change the driver, select the port, then *Properties, Driver*, and *Show All Drivers*. Select the driver and click *OK*. If an ECP doesn't have an IRQ and DMA channel, the Windows 95 printer driver will use the ECP's Fast Centronics mode, which transfers data faster than an SPP, but not as fast as ECP.

The Device Manager also shows the port's configuration. Select the port, then click *Resources*. Figure 1-1 shows an example. Windows attempts to detect these settings automatically. If the configuration shown doesn't match your hardware setup, de-select the *Use Automatic Settings* check box and select a different configuration. If none matches, you can change a setting by double-clicking on the

resource type and entering a new value. Windows displays a message if it detects any conflicts with the selected settings. To assign a printer to a port, click on *Control Panel, Printers,* and select the printer to assign.

Parallel-port devices that don't use the Windows printer drivers should come with their own configuration utilities. DOS programs generally have their own printer drivers and methods for selecting a port as well.

Adding a Port

Most PCs come with one parallel port. If there's a spare expansion slot, it's easy to add one or two more. Expansion cards with parallel ports are widely available.

Cards with support for bidirectional, EPP, and ECP modes are the best choice unless you're sure that you won't need the new modes, or you want to spend as little as possible. Cards with just an SPP are available for as little as $15. A card salvaged from an old computer may cost you nothing at all.

You can get more use from a slot by buying a card with more than a parallel port. Because the port circuits are quite simple, many multi-function cards include a parallel port. Some have serial and game ports, while others combine a disk controller or other circuits with the parallel port. On older systems, the parallel port is on an expansion card with the video adapter. These should include a way to disable the video adapter, so you can use the parallel port in any system.

When buying a multi-mode port, it's especially important to be sure the port comes with utilities or documentation that shows you how to configure the port in all of its modes. Some multi-mode ports default to an SPP configuration, where all of the advanced modes are locked out. Before you can use the advanced modes, you have to enable them. Because the configuration methods vary from port to port, you need documentation.

Also, because the configuration procedures and other port details vary from chip to chip, manufacturers of ECP and EPP devices may guarantee compatibility with specific chips, computers, or expansion cards. If you're in the market for a new parallel port or peripheral, it's worth trying to find out if the peripheral supports using EPP or ECP mode with your port.

Port Hardware

The parallel port's hardware includes the back-panel connector and the circuits and cabling between the connector and the system's expansion bus. The PC's microprocessor uses the expansion bus's data, address, and control lines to trans-

Figure 1-2: The photo on the left shows the back panel of an expansion card, with a parallel port's 25-pin female D-sub connector on the left side of the panel. (The other connector is for a video monitor.) The photo on the right shows the 36-pin female Centronics connector used on most printers.

fer information between the parallel port and the CPU, memory, and other system components.

Connectors

The PC's back panel has the connector for plugging in a cable to a printer or other device with a parallel-port interface. Most parallel ports use the 25-contact D-sub connector shown in Figure 1-2. The shell (the enclosure that surrounds the contacts) is roughly in the shape of an upper-case D. Other names for this connector are the subminiature D, DB25, D-shell, or just D connector. The IEEE 1284 standard for the parallel port calls it the IEEE 1284-A connector.

Newer parallel ports may use the new, compact, 36-contact IEEE 1284-C connector described in Chapter 6.

The connector on the computer is female, where the individual contacts are sockets, or receptacles. The cable has a mating male connector, whose contacts are pins, or plugs.

The parallel-port connector is usually the only female 25-pin D-sub on the back panel, so there should be little confusion with other connectors. Some serial ports use a 25-contact D-sub, but with few exceptions, a 25-pin serial D-sub on a PC is male, with the female connector on the cable—the reverse of the parallel-port convention. (Other serial ports use 9-pin D-subs instead.)

SCSI is another interface whose connector might occasionally be confused with the parallel port's. The SCSI interface used by disk drives, scanners, and other devices usually has a 50-contact connector, but some SCSI devices use a 25-contact D-sub that is identical to the parallel-port's connector.

If you're unsure about which is the parallel-port connector, check your system documentation. When all else fails, opening up the enclosure and tracing the cable from the connector to an expansion board may offer clues.

The Circuits Inside

Inside the computer, the parallel-port circuits may be on the motherboard or on a card that plugs into the expansion bus.

The motherboard is the main circuit board that holds the computer's microprocessor chip as well as other circuits and slots for expansion cards. Because just about all computers have a parallel port, the port circuits are often right on the motherboard, freeing the expansion slot for other uses. Notebook and laptop computers don't have expansion slots, so the port circuits in these computers must reside on the system's main circuit board.

The port circuits connect to address, data, and control lines on the expansion bus, and these in turn interface to the microprocessor and other system components.

Cables

Most printer cables have a 25-pin male D-sub connector on one end and a male 36-contact connector on the other. Many refer to the 36-contact connector as the Centronics connector, because it's the same type formerly used on Centronics printers. Other names are parallel-interface connector or just printer connector. IEEE 1284 calls it the 1284-B connector.

Peripherals other than printers may use different connectors and require different cables. Some use a 25-pin D-sub like the one on the PC. A device that uses only a few of the port's signals may use a telephone connector, either a 4-wire RJ11 or an 8-wire RJ45. Newer peripherals may have the 36-contact 1284-C connector.

In any case, because the parallel-port's outputs aren't designed for transmitting over long distances, it's best to keep the cable short: 6 to 10 feet, or 33 feet for an IEEE-1284-compliant cable. Chapter 6 has more on cable choices.

Multiple Uses for One Port

If you have more than one parallel-port peripheral, the easiest solution is to add a port for each. But there may be times when multiple ports aren't an option. In this case, the alternatives are to swap cables as needed, use a switch box, or daisy-chain multiple devices to one port.

If you use only one device at a time and switch only occasionally, it's easy enough to move the cable when you want to use a different device.

For frequent swapping, a more convenient solution is a switch box. A typical manual switch box has three female D-sub connectors. A switch enables you route

the contacts of one connector to either of the others. To use the switch box to access two peripherals on one port, you'll need a cable with two male D-subs to connect the PC to the switch box, plus an appropriate cable from the switch box to each peripheral.

You can also use a switch box to enable two PCs to share one printer or other peripheral. This requires two cables with two male D-subs on each, and one peripheral cable. Switch boxes with many other connector types are also available.

Manual switches are inexpensive, though some printer manufacturers warn that using them may damage the devices they connect to. A safer choice is a switch that uses active electronic circuits to route the signals. Some auto-sensing switches enable you to connect multiple computers to one printer, with first-come, first-served access. When a printer is idle, any computer can access it. When the printer is in use, the switch prevents the other computers from accessing it. However, these switches may not work properly if the peripherals use bidirectional communications, or if the peripheral uses the control or status signals in an unconventional way.

The parallel ports on some newer peripherals support a daisy-chain protocol that allows up to eight devices to connect to a single port. The PC assigns a unique address to each peripheral, which then ignores communications intended for the other devices in the chain. The software drivers for these devices must use the protocol when they access the port. The last device in the chain can be daisy-chain-unaware; it doesn't have to support the protocol. Chapter 11 has more on daisy chains.

Security Keys

Security keys, or dongles, are a form of copy protection that often uses the parallel port. Some software—usually expensive, specialized applications—includes a security key that you must plug into the parallel port in order to run the software. If you don't have the key installed, the software won't run.

The key is a small device with a male D-sub connector on one end and a female D-sub on the other. You plug the key into the parallel-port connector, then plug your regular cable into the security key. When the software runs, it attempts to find and communicate with the key, which contains a code that the software recognizes. The key usually doesn't use any conventional handshaking signals, so it should be able to live in harmony with other devices connected to the port.

The keys do require power, however. If you have a key that draws more than a small amount of current, and if your parallel port has weak outputs, you may have problems in using other devices on the same port as the key.

Alternatives to the Parallel Port

The parallel port is just one of many ways to interface inputs and outputs to a computer. In spite of its many virtues, the parallel port isn't the best solution for every project. These are some of the alternatives:

Serial Interfaces

One large group of parallel-port alternatives is serial interfaces, where data bits travel on a single wire or pair of wires (or in the case of wireless links, a single transmission path.) Both ends of the link require hardware or software to translate between serial and parallel data. There are many types of serial interfaces available for PCs, ranging from the ubiquitous RS-232 port to the newer RS-485, USB, IEEE-1394, and IrDA interfaces.

RS-232

Just about every PC has at least one RS-232 serial port. This interface is especially useful when the PC and the circuits that you want to connect are physically far apart.

As a rule, parallel-port cables should be no longer than 10 to 15 feet, though the IEEE-1284 standard describes an improved interface and cable that can be 10 meters (33 feet). In contrast, RS-232 links can be 80 feet or more, with the exact limit depending on the cable specifications and the speed of data transfers.

RS-232 links are slow, however. Along with each byte, the transmitting device normally adds a start and stop bit. Even at 115,200 bits per second, which is a typical maximum rate for a serial port, the data-transfer rate with one start and stop bit per byte is just 11,520 bytes per second.

RS-485

Another useful serial interface is RS-485, which can use cables as long as 4000 feet and allows up to 32 devices to connect to a single pair of wires. You can add an expansion card that contains an RS-485 port, or add external circuits that convert an existing RS-232 interface to RS-485. Other interfaces similar to RS-232 and RS-485 are RS-422 and RS-423.

Universal Serial Bus

A new option for I/O interfacing is the Universal Serial Bus (USB), a project of a group that includes Intel and Microsoft. A single USB port can have up to 127 devices communicating at either 1.5 Megabits/second or 12 Megabits/second over a 4-wire cable. The USB standard also describes both the hardware interface and software protocols. Newer PCs may have a USB port built-in, but because it's so new, most existing computers can't use it without added hardware and software drivers.

IEEE 1394

The IEEE-1394 high-performance serial bus, also known as Firewire, is another new interface. It allows up to 63 devices to connect to a PC, with transmission rates of up to 400 Megabits per second. The 6-wire cables can be as long as 15 feet, with daisy chains extending to over 200 feet. The interface is especially popular for connecting digital audio and video devices. IEEE-1394 expansion cards are available for PCs.

IrDA

The IrDA (Infrared Data Association) interface allows wireless serial communications over distances of 3 to 6 feet. The link transmits infrared energy at up to 115,200 bits/second. It's intended for convenient (no cables or connectors) transmitting of files between a desktop and laptop computer, or any short-range communications where a cabled interface is inconvenient. Some computers and peripherals now have IrDA interfaces built-in.

Other Parallel Interfaces

SCSI and IEEE-488 are two other parallel interfaces used by some PCs.

SCSI

SCSI (small computer system interface) is a parallel interface that allows up to seven devices to connect to a PC along a single cable, with each device having a unique address. Many computers use SCSI for interfacing to internal or external hard drives, tape back-ups, and CD-ROMs. SCSI interfaces are fast, and the cable can be as long as 19 feet (6 meters). But the parallel-port interface is simpler, cheaper, and much more common.

IEEE 488

The IEEE-488 interface began as Hewlett Packard's GPIB (general-purpose interface bus). It's a parallel interface that enables up to 15 devices to communicate at

speeds of up to 1 Megabit per second. This interface has long been popular for interfacing to lab instruments. Expansion cards with IEEE-488 interfaces are available.

Custom I/O Cards

Many other types of input and output circuits are available on custom expansion cards. An advantage of these is that you're not limited by an existing interface design. The card may contain just about any combination of analog and digital inputs and outputs. In addition, the card may hold timing or clock circuits, function generators, relay drivers, filters, or just about any type of component related to the external circuits. With the standard parallel port, you can add these components externally, but a custom I/O card allows you to place them inside the computer.

To use an expansion card, you of course need an empty expansion slot, which isn't available in portable computers and some desktop systems. And the custom hardware requires custom software.

PC Cards

Finally, instead of using the expansion bus, some I/O cards plug into a PC Card slot, which accepts slim circuit cards about the size of a playing card. An earlier name for these was PCMCIA cards, which stands for *Personal Computer Memory Card International Association,* whose members developed the standard. Many portable computers and some desktop models have PC-Card slots. Popular uses include modems and data acquisition circuits. There are even PC Cards that function as parallel ports. You don't need an internal expansion slot, and you don't have to open up the computer to plug the card in. But again, the standard parallel-port interface is cheaper and more widely available.