Chapter 8

USB and IEEE-1394 Ports and Devices

Universal Serial Bus

The *Universal Serial Bus (USB)* port is a dual-speed connection running at 1.5Mbps or 12Mbps, which enables up to 127 devices of many different types to be connected to a single port. The USB port is well on its way to replacing the traditional serial, parallel, and PS/2 ports on new and forthcoming systems, and it is already being used for a wide variety of devices. Use this section to help you detect and configure USB ports effectively.

USB Port Identification

Figures 8.1 and 8.2 help you identify USB devices and ports.

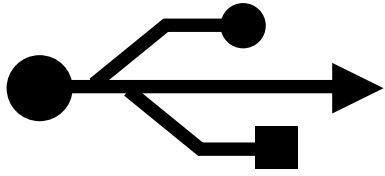


Figure 8.1 This icon is used to identify USB cables, connectors, and peripherals.

Pinout for the USB Connector

Table 8.1 shows the pinout for the USB connector.

Table 8.1 USB Connector Pinout

Pin	Signal Name	Color	Comment
1	VCC	Red	Cable power
2	– Data	White	
3	+ Data	Green	
4	Ground	Black	Cable ground

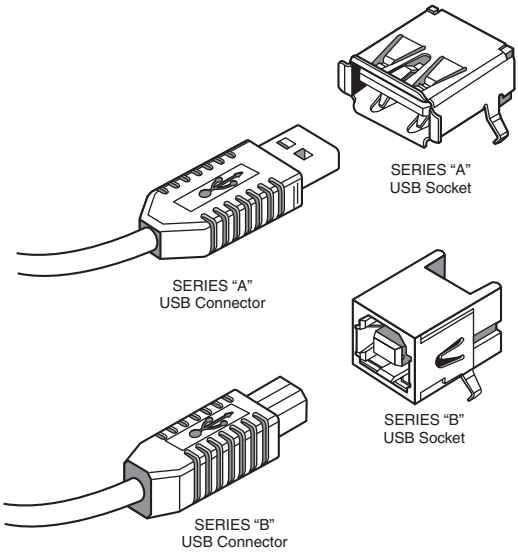


Figure 8.2 USB Series A and Series B plugs and receptacles.

Typical USB Port Locations

The location of USB ports varies with the system. On late-model desktop and tower computers using baby-AT motherboards, you might find one or two USB ports on a card bracket in the rear of the computer. The ports might be mounted on an add-on card or cabled out from motherboard ports.

Most systems using ATX, NTX, or similar motherboards—as well as late-model LPX-based systems—will have one or two USB ports on the rear of the case next to other ports.

Some consumer-oriented, late-model systems have one USB port on the front, sometimes located next to a 9-pin serial port. These ports are located in the front of the computer for easier connection of digital cameras and card readers for digital image downloading.

Adding USB Ports to Your Computer

If your computer doesn't have USB ports onboard, use one of the following options to add them:

- Purchase USB header cables to extend motherboard USB cable connectors to the outside of the case.
- Purchase and install a USB host adapter card.

Even if your baby-AT system has connectors for USB header cables, changes in the USB spec make installing an up-to-date USB host adapter card a better idea for many users.

Prerequisites for Using USB Ports and Peripherals

Before you buy or try to install a USB peripheral, make sure your system meets the requirements shown in Table 8.2. Some adjustments or updates to the system configuration might be necessary.

Table 8.2 Prerequisites for Use of USB Ports/Peripherals

Requirement	Reason	Notes
Windows 98 Windows 2000 Windows Millennium Edition	Built-in support for USB peripherals	Windows 95B OSR 2.1 and above have USB support, but many peripherals require Win98 or above.
Working USB ports	Many systems shipped with disabled USB ports	Check BIOS and enable there if necessary; some systems might require header cables to bring the USB connector to the rear of the system.

You can download the free USB Ready utility program at `www.usb.org/data/usbready.exe` to check your system's USB readiness at both hardware and software levels.

Verify that the peripheral you are installing is designed for your operating system. Although USB ports themselves are found on both PC and Macintosh systems, some USB devices are for use only on PCs or Macintoshes, not both types of systems.

Troubleshooting USB Ports

USB ports built into the computer (also called *root hubs*) are becoming the primary external device connection for an increasing number of PCs. While USB devices are plug and play, requiring (and allowing!) no configuration, persistent problems with USB devices are common for many users. Use the following tips to help you achieve reliable USB operation:

- Check Prerequisites from Table 8.2.
- If devices don't work when plugged into an external hub, plug them into the root hub (USB connector on the system); if they work when attached to the root hub, upgrade the external hub's firmware, attach a power supply to it, or replace it.
- If a new device isn't detected, remove other USB devices, plug in the new device first, and then reattach the other USB devices.

- Check the power usage for the USB bus in the Power dialog box of the operating system.
- Verify that the USB device is drawing no less than 50mA and no more than 500mA.
- Use the Windows Device Manager to verify proper operation of the USB port; adjust IRQ settings if necessary to avoid conflicts with other devices.
- Install the latest USB device drivers for the device and the operating system; USB devices that work in Windows 98 might not be supported by other versions of Windows.
- If a printer doesn't work properly with the "correct" USB driver, try using a compatible driver for an older model as a workaround.
- Install the latest firmware for the USB device; bad firmware creates "ghost" versions of devices in the Device Manager when the device is unplugged and reattached.
- Verify that the USB root hub (port) is assigned an IRQ; normally IRQ 9 is used if available. Make sure IRQ steering is working if all available IRQs are already assigned to other ports.
- Use high-speed (heavily shielded) cabling for high-speed devices, such as printers, scanners, and network connections.
- Separate low-speed from high-speed devices by attaching them to separate USB ports.
- Assign USB controllers to Controller ID 1 if not detected by the game.
- Use the smallest number of hubs possible; some versions of Windows can't use over 5 USB hubs (some devices double as hubs).
- Before you purchase a USB device, verify device driver support for your operating system; Windows 2000 supports USB devices, but many vendors are slow about supplying USB drivers for Windows 2000.
- When possible, buy devices that can be connected by either a USB port or a so-called "legacy" port (PS/2 keyboard/mouse port, serial port, parallel port, or SCSI port) to enable you to use the device even if you have problems with your USB ports or peripherals.

Using USB Hubs with Legacy (Serial, Parallel, and PS/2) Ports

A number of products on the market enable you to connect various legacy products to USB ports. The most economical way to connect serial, parallel, or PS/2-port products is through the use of a multi-purpose hub that also features multiple USB ports.

You can also purchase serial-to-USB or parallel-to-USB converter cables, but these are less flexible and more expensive if you need to connect multiple legacy devices to a system.

Check the list of supported legacy devices before you buy a converter cable or multi-purpose port. USB hubs with PS/2 and serial ports normally support legacy devices such as modems, keyboards, and mice; USB hubs with parallel ports normally support printers. If you use other types of parallel devices, such as drives or scanners, you will need an actual parallel port to connect them. However, because daisy-chaining multiple parallel devices can be difficult, moving the printer to a multi-purpose USB hub can free up the LPT port for use by these other devices.

Online Sources for Additional USB Support

- Linux USB Device Support and Status

  `http://www.qbik.ch/usb/devices/`

- USB News and Troubleshooting Sites

  `http://www.usbman.com/`

  `http://www.usbworkshop.com/`

  `http://www.usb.org`

USB 2.0

USB 2.0 is a backward-compatible extension of the USB 1.1 specification that uses the same cables, connectors, and software interfaces, but which runs 40 times faster than the original 1.0 and 1.1 versions.

All existing USB 1.1 devices will work in a USB 2.0 bus because USB 2.0 supports all the slower-speed connections. USB data rates are shown in Table 8.3.

Table 8.3 USB Data Rates

Interface	Megabits per Second	Megabytes per Second
USB 1.1 low-speed	1.5Mbit/sec	0.1875MByte/sec
USB 1.1 high-speed	12Mbit/sec	1.5MByte/sec
USB 2.0	480Mbit/sec	60MByte/sec

The support of higher-speed USB 2.0 peripherals requires using a USB 2.0 hub. You can still use older USB 1.1 hubs on a 2.0 bus, but any peripherals or additional hubs connected downstream from a 1.1 hub will operate at the slower 1.5MByte/sec USB 1.1 maximum speed. Devices connected to USB 2.0 hubs operate at the maximum speed of the device, up to the full USB 2.0 speed of 60MBytes/sec.

When communicating with an attached USB 2.0 peripheral, the 2.0 hub simply repeats the high-speed signals; however, when communicating with USB 1.1 peripherals, a USB 2.0 hub buffers and manages the transition from the high speed of the USB 2.0 host controller (in the PC) to the lower speed of a USB 1.1 device. This feature of USB 2.0 hubs means that USB 1.1 devices can operate along with USB 2.0 devices and not consume any additional bandwidth.

IEEE-1394

The so-called *FireWire* or *iLINK* interface pioneered by Apple is also available for Windows/Intel–type computers. Despite the fact that IEEE-1394 ports are seldom standard equipment at present, the performance features they offer suggest that they will become a part of the "twenty-first century PC" for many users.

Figure 8.3 shows you how to recognize an IEEE-1394 connector plug, cable, and socket.

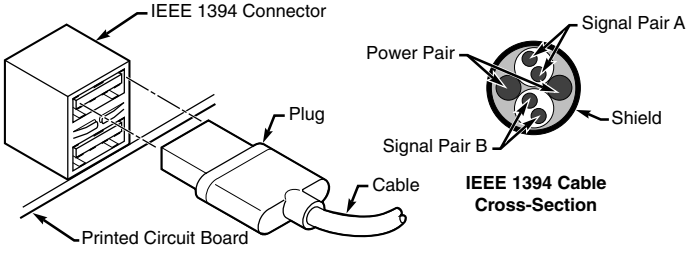


Figure 8.3 IEEE-1394 cable, socket, and connector plug.

Adding IEEE-1394 Ports to Your Computer

While most recent systems have USB ports onboard, IEEE-1394 ports are rare among PCs, but are more common on Macintosh systems.

A wide variety of IEEE-1394 host adapters are available for purchase. Most host adapters provide one or more 6-pin IEEE-1394 ports, provide an adapter for 4-pin IEEE-1394 devices, and use a single 32-bit PCI slot. Adaptec's AHA-8945 and HotConnect Ultra 8945 products combine Ultra SCSI and IEEE-1394 on a single 32-bit PCI slot.

IEEE-1394, like USB, also supports hubs for sharing a single port among multiple devices, although the hubs are different.

Resource Requirements for IEEE-1394 Host Adapters

Regardless of the number of IEEE-1394 ports, an IEEE-1394 host adapter card uses only one IRQ and one I/O port address. The IRQ used by the host adapter should not be shared with other devices. If necessary, take advantage of IRQ steering for PCI cards with Windows 98, 2000, and ME to have other PCI cards share an IRQ to free up an IRQ for the IEEE-1394 host adapter. If your host adapter also has a SCSI port onboard, the SCSI port will also require an IRQ and I/O port address.

The PCI slot you choose for the IEEE-1394 host adapter must support bus-mastering if the host adapter uses this feature. Consult your system or motherboard documentation and your host adapter documentation to see whether this is a requirement for you. You might need to move existing PCI cards around to satisfy this requirement.

Comparing USB and IEEE-1394

Because of the similarity in both the form and function of USB and 1394, some confusion has existed about the two. Table 8.3 summarizes the differences between the two technologies.

Table 8.3 Comparing IEEE-1394 and USB Technologies

	IEEE-1394 (i.LINK) (FireWire)	USB 1.1
PC-Host Required	No	Yes
Maximum Number of Devices	63	127
Hot-Swappable	Yes	Yes
Maximum Cable Length Between Devices	4.5 meters	5 meters
Current Transfer Rate	200Mbps (25MB/sec)	12Mbps (1.5MB/sec) or 1.5Mbps
Future Transfer Rates	400Mbps (50MB/sec) 800Mbps (100MB/sec) 1Gbps+ (125MB/sec+)	480Mbps (USB 2.0)
Typical Devices	DV Camcorders High-Res. Digital Cameras HDTV Set-Top Boxes High-Speed Drives High-Res. Scanners Printers	Keyboards Mice Joysticks Low-Resolution Digital Cameras Low-Speed Drives Modems Printers Low-Res. Scanners

The main difference is speed. Currently, IEEE-1394 offers a data transfer rate that is more than 16 times faster than that of USB 1.1, but which is less than half as fast as USB 2.0. This speed differential might change in the future as higher speed versions of IEEE-1394 debut and faster versions of USB are introduced. In the future, PCs might frequently include both USB and IEEE-1394 interfaces. Together, these two buses can replace most of the standard connections found on the back of a typical PC.

USB 1.1 is clearly designed for low-speed peripherals, such as keyboards, mice, modems, and printers, whereas USB 2.0 can be used to connect most high-speed external devices. 1394 will be used to connect mostly high-performance digital video electronics products.

Another important benefit of 1394 is that a PC host connection is not required. Thus, 1394 can be used to directly connect a Digital Video (DV) camcorder and a DV-VCR for dubbing tapes or editing.

USB ports are standard on all recent desktop and notebook computers because Intel has added USB support to all its motherboard chipsets since 1996. However, IEEE-1394 ports must be added by means of an adapter card because the motherboard chipsets for PCs don't support this interface.

Troubleshooting IEEE-1394 Host Adapters and Devices

- **Host adapter is installed but doesn't work**—Make sure that your system has loaded the correct IEEE-1394 driver for the host adapter. Some host adapters don't use the Windows-provided TI chipset driver.
- **Wrong driver is installed for host adapter**—If you have installed the wrong driver, remove the IEEE-1394 host adapter listing from the Windows Device Manager, have the driver CD or disk supplied with the host adapter handy, restart the system, and have the computer search for the best driver. It will find the driver on the disk or CD-ROM and install it.
- **Choppy video during digital editing**—Use UDMA Bus-mastering drivers with ATA/IDE hard disks to provide smooth flow of digital video; install and enable as necessary (see Chapter 4, "SCSI and IDE Hard Drives and Optical Drives," for details).
- **4-wire devices aren't recognized**—Whereas 6-wire devices get power from the IEEE-1394 bus, 4-wire devices require their own power supply; ensure that it's connected and turned on.

- **Device "disappears" from Windows Device Manager after being connected**—The connected device is probably using power management; after the device's power management is enabled, this is normal. Use the device's power management controls to disable power management while the device is connected to the computer.
- **Device displays a yellow ! in Device Manager or isn't displayed**—Windows 2000 provides support for only host adapters that support OpenHCI (OHCI). Adaptec and other brands that use non-OHCI drivers must install their own drivers to work. Update the drivers or remove the device and reinstall it, providing the correct drivers to correct the problem.

IEEE-1394 and Linux

Linux kernel versions 2.2 and 2.3 support IEEE-1394. To download the support files or for more information about supporting IEEE-1394 devices under Linux, go to the following address:

```
linux1394.sourceforge.net/index.html
```

Online Sources for Additional IEEE-1394 Support

- IEEE-1394 Products

  ```
  www.firewire-1394.com/
  ```

  ```
  www.askfor1394.com
  ```

- IEEE-1394 Trade Association

  ```
  www.1394ta.org
  ```

Chapter 9

Keyboards, Mice, and Input Devices

Keyboard Designs

The primary keyboard types are as follows:

- 101-key Enhanced keyboard
- 104-key Windows keyboard
- 83-key PC and XT keyboard (obsolete)
- 84-key AT keyboard (obsolete)

Note

If you need information about the 83-key PC and XT keyboard or 84-key AT keyboard, see Chapter 7 of *Upgrading and Repairing PCs, 10th Anniversary Edition*—included in PDF format on the 12th Edition CD-ROM.

The 101-Key Enhanced Keyboard

This keyboard design serves as the basis for virtually all current-model keyboards.

101-Key Versus 102-Key Keyboards

Foreign language versions of the Enhanced keyboard include 102 keys and a slightly different layout from the 101-key U.S. versions.

The 104-Key Windows Keyboard

The Microsoft Windows keyboard specification outlines a set of new keys and key combinations. The familiar 101-key layout has now grown to 104 keys, with the addition of left and right Windows keys and an Application key. These keys are used for operating-system and application-level keyboard combinations, similar to today's Ctrl and Alt combinations. (Figure 9.2 shows the standard Windows keyboard layout, including the three new keys.)

Using Windows Keys

Table 9.1 shows a list of all the Windows 9x, Windows NT 4, and Windows 2000 key combinations that can be performed with the

104-key Windows keyboard. These keyboard shortcuts can be useful, especially if your mouse stops working or you want to work more quickly with the Windows desktop.

Table 9.1 Windows Key Combinations

Key Combination	Resulting Action
WIN+R	Opens Run dialog box
WIN+M	Minimize All
Shift+WIN+M	Undo Minimize All
WIN+F1	Opens Help
WIN+E	Opens Windows Explorer
WIN+F	Find Files or Folders
Ctrl+WIN+F	Find Computer
WIN+Tab	Cycles through taskbar buttons
WIN+Break	Opens System Properties dialog box
Application key	Displays a context menu for the selected item

When a 104-key Windows keyboard is used with Microsoft IntelliType Software installed, the additional key combinations shown in Table 9.2 can be used.

Table 9.2 Additional Key Combinations

Key Combination	Resulting Action
WIN+L	Logs off Windows
WIN+P	Opens Print Manager
WIN+C	Opens the Control Panel
WIN+V	Opens Clipboard
WIN+K	Opens Keyboard Properties dialog box
WIN+I	Opens Mouse Properties dialog box
WIN+A	Opens Accessibility Options (if installed)
WIN+spacebar	Displays the list of IntelliType hotkeys
WIN+S	Toggles the Caps Lock key on and off

Keyboard-Only Commands for Windows 9x/NT4/2000/Me with Any Keyboard

If your mouse stops working, or if you want to work more quickly, use the keys shown in Table 9.3 to perform common Windows actions.

Table 9.3 Keyboard Commands for Windows 9x/NT4/2000/Me

Key Combination	Resulting Action
F1	Starts Windows Help.
F10	Activates menu bar options.
Shift+F10	Opens a context menu (shortcut menu) for the selected item.
Ctrl+Esc	Opens the Start menu. Use the arrow keys to select an item.
Ctrl+Esc, Esc	Selects the Start button. Press Tab to select the taskbar, or press Shift+F10 for a context menu.
Alt+Tab	Switches to another running application. Hold down the Alt key and then press the Tab key to view the task-switching window.
Shift	Press down and hold the Shift key while you insert a CD-ROM to bypass the AutoPlay feature.
Alt+spacebar	Displays the main window's System menu. From the System menu, you can restore, move, resize, minimize, maximize, or close the window.
Alt+- (Alt+hyphen)	Displays the Multiple Document Interface (MDI) child window's System menu. From the MDI child window's System menu, you can restore, move, resize, minimize, maximize, or close the child window.
Ctrl+Tab	Switches to the next child window of an MDI application.
Alt+<underlined letter in menu>	Opens the corresponding menu.
Alt+F4	Closes the current window.
Ctrl+F4	Closes the current MDI window.
Alt+F6	Switches between multiple windows in the same program. For example, when Notepad's Find dialog box is displayed, Alt+F6 switches between the Find dialog box and the main Notepad window.

Here are the Windows dialog box keyboard commands:

Key Combination	Resulting Action
Tab	Moves to the next control in the dialog box.
Shift+Tab	Moves to the previous control in the dialog box.
Spacebar	If the current control is a button, this keyboard command clicks the button. If the current control is a check box, it toggles the check box. If the current control is an option button, it selects the option button.
Enter	Equivalent to clicking the selected button (the button with the outline).
Esc	Equivalent to clicking the Cancel button.

Key Combination	Resulting Action
Alt+<underlined letter in dialog box item>	Moves to the corresponding item.
Ctrl+Tab/ Ctrl+Shift+Tab	Moves through the property tabs.

These are the keyboard combinations for Windows Explorer tree controls:

Key Combination	Resulting Action
Numeric Keypad *	Expands everything under the current selection.
Numeric Keypad +	Expands the current selection.
Numeric Keypad -	Collapses the current selection.
Right arrow	Expands the current selection if it is not expanded; otherwise, goes to the first child.
Left arrow	Collapses the current selection if it is expanded; otherwise, goes to the parent.

Here are the general Windows folder/shortcut controls:

Key Combination	Resulting Action
F4	Selects the Go To a Different Folder box and moves down the entries in the box (if the toolbar is active in Windows Explorer).
F5	Refreshes the current window.
F6	Moves among panes in Windows Explorer.
Ctrl+G	Opens the Go To Folder tool (in Windows 95 Windows Explorer only).
Ctrl+Z	Undoes the last command.
Ctrl+A	Selects all the items in the current window.
Backspace	Switches to the parent folder.
Shift+click	Selects the Close button. (For folders, closes the current folder plus all parent folders.)

These are general folder and Windows Explorer shortcuts for a selected object:

Key Combination	Resulting Action
F2	Renames object.
F3	Finds all files.
Ctrl+X	Cuts.
Ctrl+C	Copies.

Key Combination	Resulting Action
Ctrl+V	Pastes.
Shift+Del	Deletes selection immediately, without moving the item to the Recycle Bin.
Alt+Enter	Opens the property sheet for the selected object.
To copy a file	Press down and hold the Ctrl key while you drag the file to another folder.
To create a shortcut	Press down and hold Ctrl+Shift while you drag a file to the desktop or a folder.

Standard Versus Portable Keyboards

Table 9.4 lists the differences in configuration and system setup for standard versus portable keyboards.

Table 9.4 Standard and Portable Keyboards Compared

Feature	Standard	Portable
Key size	Full-sized keys on entire keyboard	Full-sized keys on typing keys only; directional and function keys usually smaller
Cursor keys	Inverted-T layout standard	Inverted-T layout seldom used; makes "blind" cursor movements difficult
Numeric keypad	Separate keys at right of directional keys	Embedded into right-hand alphanumerics; should disable numlock in BIOS to avoid keying errors; might require use of F*n* key to use
Add-on keypad	Not needed	Popular option for number-intensive uses; must plug into external port

Keyswitch Types

The most common type of keyswitch is the mechanical type, available in the following variations:

- Pure mechanical
- Foam element
- Rubber dome
- Membrane

Table 9.5 compares user feel, repair, and servicing issues for these keyswitch types.

Table 9.5 Mechanical Keyswitch Types Compared

	Keyswitch Type			
Feature	**Pure Mechanical**	**Foam**	**Rubber-Dome**	**Membrane**
Tactile feedback	Usually a click	Minimal feedback	Soft click	No click
Durability and serviceability	High: 20-million keystroke rating	Variable: Contacts can corrode; easy to clean	High: Rubber dome protects contacts from corrosion	Extreme: No moving parts, sealed unit for harsh industrial environments

The pure mechanical type of keyboard, often using Alps keyswitches, is second only to the keyboards using capacitive switches in terms of tactile feedback and durability. Capacitive keyswitches are rated for up to 25 million keystrokes. Traditionally, the only vendors of capacitive keyswitch keyboards have been IBM and the inheritors of its keyboard technology, Lexmark and Unicomp.

Cleaning a Foam-Element Keyswitch

Figure 9.1 shows a foam-element keyswitch, often found in keyboards sold by Compaq and keyboards manufactured by Keytronics.

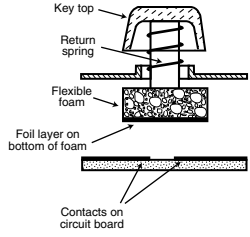


Figure 9.1 A typical foam-element mechanical keyswitch.

The foil contacts at the bottom of the key and the contacts on the circuit board often become dirty or corroded, causing erratic key operation. Disassemble the keyboard to gain access to the foil pads, clean them, and treat them with Stabilant 22a from DW Electrochemicals to improve the switch-contact quality.

If you need to clean or repair a keyboard, you'll find much more information in Chapter 17 of *Upgrading and Repairing PCs, 12th Edition*, from Que.

Adjusting Keyboard Parameters in Windows

To modify the default values for the typematic repeat rate and delay parameters in any version of Windows, open the Keyboard icon in the Control Panel. In Windows 9x/Me/NT/2000, the controls are located on the Speed tab. The Repeat Delay slider controls the amount of times a key must be pressed before the character begins to repeat, and the Repeat Rate slider controls how fast the character repeats after the delay has elapsed. Use the test box to see the effect of the changes you make before you apply them.

Note

The increments on the Repeat Delay and Repeat Rate sliders in the Keyboard Control Panel correspond to the timings given for the MODE command's RATE and DELAY values. Each mark in the Repeat Delay slider adds about 0.25 seconds to the delay, and the marks in the Repeat Rate slider are worth about one character per second each.

Keyboard Layouts and Scan Codes

Figure 9.2 showsthe keyboard numbering and character locations for the 101-key Enhanced keyboard. Table 9.6 shows each of the three scan code sets for each key in relation to the key number and character. Scan Code Set 1 is the default; the other two are rarely used. Figure 9.3 shows the layout of a typical foreign language 102-key version of the Enhanced keyboard—in this case, a U.K. version.

Knowing these key number figures and scan codes is useful when you are troubleshooting stuck or failed keys on a keyboard. Diagnostics can report the defective keyswitch by the scan code, which varies from keyboard to keyboard on the character it represents and its location.

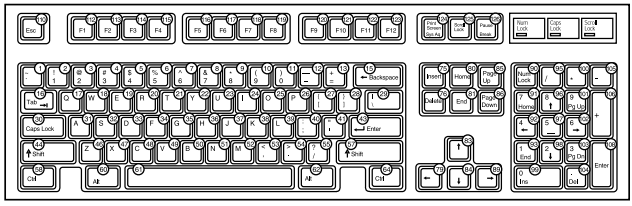


Figure 9.2 101-key Enhanced keyboard key number and character locations (U.S. version).

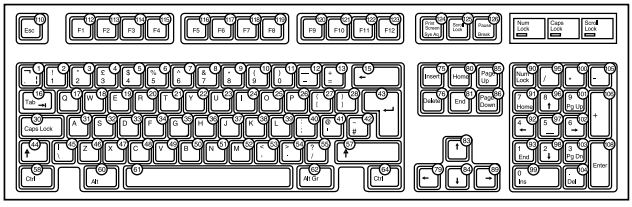


Figure 9.3 102-key Enhanced keyboard key number and character locations (U.K. English version).

Table 9.6 101-/102-Key (Enhanced) Keyboard Key Numbers and Scan Codes

Key Number	Key/Character	Scan Code Set 1	Scan Code Set 2	Scan Code Set 3
1	`	29	0E	0E
2	1	2	16	16
3	2	3	1E	1E
4	3	4	26	26
5	4	5	25	25
6	5	6	2E	2E
7	6	7	36	36
8	7	8	3D	3D
9	8	9	3E	3E
10	9	0A	46	46
11	0	0B	45	45
12	-	0C	4E	4E
13	=	0D	55	55
15	Backspace	0E	66	66
16	Tab	0F	0D	0D
17	Q	10	15	15
18	W	11	1D	1D

Table 9.6 101-/102-Key (Enhanced) Keyboard Key Numbers and Scan Codes Continued

Key Number	Key/Character	Scan Code Set 1	Scan Code Set 2	Scan Code Set 3
19	E	12	24	24
20	R	13	2D	2D
21	T	14	2C	2C
22	Y	15	35	35
23	U	16	3C	3C
24	I	17	43	43
25	O	18	44	44
26	P	19	4D	4D
27	[	1A	54	54
28	]	1B	5B	5B
29	\ (101-key only)	2B	5D	5C
30	Caps Lock	3A	58	14
31	A	1E	1C	1C
32	S	1F	1B	1B
33	D	20	23	23
34	F	21	2B	2B
35	G	22	34	34
36	H	23	33	33
37	J	24	3B	3B
38	K	25	42	42
39	L	26	4B	4B
40	;	27	4C	4C
41	`	28	52	52
42	# (102-key only)	2B	5D	53
43	Enter	1C	5A	5A
44	Left Shift	2A	12	12
45	\ (102-key only)	56	61	13
46	Z	2C	1A	1A
47	X	2D	22	22
48	C	2E	21	21
49	V	2F	2A	2A
50	B	30	32	32
51	N	31	31	31
52	M	32	3A	3A
53	,	33	41	41
54	.	34	49	49

Table 9.6 101-/102-Key (Enhanced) Keyboard Key Numbers and Scan Codes Continued

Key Number	Key/Character	Scan Code Set 1	Scan Code Set 2	Scan Code Set 3
55	/	35	4A	4A
57	Right Shift	36	59	59
58	Left Ctrl	1D	14	11
60	Left Alt	38	11	19
61	Spacebar	39	29	29
62	Right Alt	E0, 38	E0, 11	39
64	Right Ctrl	E0, 1D	E0, 14	58
75	Insert	E0, 52	E0, 70	67
76	Delete	E0, 53	E0, 71	64
79	Left arrow	E0, 4B	E0, 6B	61
80	Home	E0, 47	E0, 6C	6E
81	End	E0, 4F	E0, 69	65
83	Up arrow	E0, 48	E0, 75	63
84	Down arrow	E0, 50	E0, 72	60
85	Page Up	E0, 49	E0, 7D	6F
86	Page Down	E0, 51	E0, 7A	6D
89	Right arrow	E0, 4D	E0, 74	6A
90	Num Lock	45	77	76
91	Keypad 7 (Home)	47	6C	6C
92	Keypad 4 (Left arrow)	4B	6B	6B
93	Keypad 1 (End)	4F	69	69
95	Keypad /	E0, 35	E0, 4A	77
96	Keypad 8 (Up arrow)	48	75	75
97	Keypad 5	4C	73	73
98	Keypad 2 (Down arrow)	50	72	72
99	Keypad 0 (Ins)	52	70	70
100	Keypad *	37	7C	7E
101	Keypad 9 (PgUp)	49	7D	7D
102	Keypad 6 (Left arrow)	4D	74	74
103	Keypad 3 (PgDn)	51	7A	7A
104	Keypad . (Del)	53	71	71
105	Keypad -	4A	7B	84
106	Keypad +	4E	E0, 5A	7C

Table 9.6 101-/102-Key (Enhanced) Keyboard Key Numbers and Scan Codes Continued

Key Number	Key/Character	Scan Code Set 1	Scan Code Set 2	Scan Code Set 3
108	Keypad Enter	E0, 1C	E0, 5A	79
110	Escape	1	76	8
112	F1	3B	5	7
113	F2	3C	6	0F
114	F3	3D	4	17
115	F4	3E	0C	1F
116	F5	3F	3	27
117	F6	40	0B	2F
118	F7	41	83	37
119	F8	42	0A	3F
120	F9	43	1	47
121	F10	44	9	4F
122	F11	57	78	56
123	F12	58	7	5E
124	Print Screen	E0, 2A, E0, 37	E0, 12, E0, 7C	57
125	Scroll Lock	46	7E	5F
126	Pause	E1, 1D, 45, E1, 9D, C5	E1, 14, 77, E1, F0, 14, F0, 77	62

The additional keys on a 104-key Windows keyboard have their own unique scan codes. Table 9.7 shows the scan codes for the new keys.

Table 9.7 104-Key Windows Keyboard New Key Scan Codes

New Key	Scan Code Set 1	Scan Code Set 2	Scan Code Set 3
Left Windows	E0,5B	E0, 1F	8B
Right Windows	E0,5C	E0, 27	8C
Application	E0,5D	E0, 2F	8D

Keyboard Connectors

While some of the newest systems offer color-coded keyboard connectors and cables, the best way to recognize the keyboard connector is still to know what it looks like. Two common standards exist, and low-cost adapters are available to switch a device using one

standard to a connector using the other standard. The keyboard connector standards are as follows:

- **5-pin DIN connector**—Used on most PC systems with Baby-AT form factor motherboards.
- **6-pin mini-DIN connector**—Used on PS/2 systems and most PCs with LPX, ATX, and NLX motherboards.
- **USB connector**—Used on "legacy-free" systems that lack PS/2, serial, or parallel ports.

Figure 9.4 and Table 9.8 show the physical layout and pinouts of the respective keyboard connector plugs and sockets for the DIN and mini-DIN connector. Refer to Chapter 8, "USB and IEEE-1394 Ports and Devices," for USB connectors.

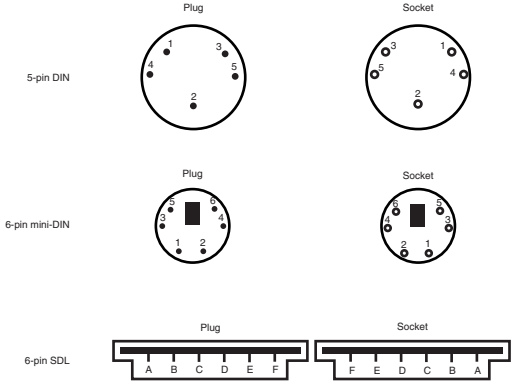


Figure 9.4 Keyboard and mouse connectors.

Keyboard Connector Signals

Table 9.8 lists the keyboard connector signals for three common keyboard connectors.

Table 9.8 Keyboard Connector Signals

Signal Name	5-Pin DIN[1]	6-Pin Mini-DIN	6-Pin SDL[2]
Keyboard Data	2	1	B
Ground	4	3	C
+5v	5	4	E
Keyboard Clock	1	5	D
Not Connected	—	2	A

Table 9.8 Keyboard Connector Signals Continued

Signal Name	5-Pin DIN[1]	6-Pin Mini-DIN	6-Pin SDL[2]
Not Connected	—	6	F
Not Connected	3	—	—

1. *DIN = German Industrial Norm (Deutsche Industrie Norm), a committee that sets German dimensional standards.*

2. *SDL = Shielded Data Link, a type of shielded connector created by AMP and used by IBM and others for keyboard cables. It is used inside the keyboard housing to attach the cable to the keyboard's electronics, and the other end of the cable will have the DIN or mini-DIN connector to attach to the computer.*

USB Keyboard Requirements

USB (Universal Serial Bus) devices have become increasingly popular, and over the next few years are expected to replace serial, parallel, keyboard, and mouse port connectors with this single, versatile, sharable port (refer to Chapter 8 for more information about USB).

To use a keyboard connected via the USB port, you must meet three requirements:

- Have a USB port in the system
- Run Microsoft Windows 98, Windows Me, or Windows 2000 (all of which include USB keyboard drivers)
- Have USB Legacy support present and enabled in your system BIOS

USB Legacy support means your motherboard ROM BIOS includes drivers to recognize a USB keyboard. Without USB Legacy support in the BIOS, you can't use a USB keyboard when in MS-DOS or when installing Windows on the system for the first time. Also, if the Windows installation fails and requires manipulation outside Windows, the USB keyboard will not function unless it is supported in the BIOS. Virtually all 1998 and newer systems with USB ports include a BIOS with USB Legacy (meaning USB Keyboard) support.

Keyboard Troubleshooting and Repair

Keyboard errors are usually caused by two simple problems. Other more difficult, intermittent problems can arise, but they are much less common. The most frequent problems are as follows:

- Defective cables
- Stuck keys

Use Table 9.9 to help you troubleshoot a defective keyboard.

Table 9.9 Keyboard Troubleshooting

Problem	Symptoms	Solution
Defective cable	No keyboard operation; all keys produce errors or wrong characters.	Swap keyboard with known, working spare. If problem isn't repeated, original keyboard is the problem. Replace cable with spare (if available, check "scrap" keyboards or vendor spare parts lists) or replace keyboard. Test cable with Digital Multimeter (DMM) with continuity tester; each wire (see pinouts previously) should make a connection, even when you wiggle the cable. Replace failed cable.
Stuck key	"Stuck key error" or 3xx error onscreen during POST.	Look up scancode from table in this chapter to determine which key is stuck. Clean keyswitch.
Damaged motherboard keyboard connector	Known-working keyboards don't work when plugged in.	For a simple test of the motherboard keyboard connector, you can check voltages on some of the pins. Measure the voltages on various pins of the keyboard connector. To prevent possible damage to the system or keyboard, turn off the power before disconnecting the keyboard. Then, unplug the keyboard and turn the power back on. Make measurements between the ground pin and the other pins according to Table 9.10. Repair or replace motherboard if voltage fails specifications.
USB Keyboard works in Windows 98, 2000, or Me, but not in MS-DOS or at startup	USB Legacy mode not enabled in BIOS/CMOS configuration.	Connect standard keyboard, start computer, start BIOS/CMOS configuration, enable USB Legacy mode, save changes, and shut down computer. Reconnect USB keyboard and retry; keyboard should now function at all times.

Keyboard Connector Voltage and Signal Specifications

Use Table 9.10 along with a digital multimeter (DMM) to determine whether your keyboard connector is working correctly.

Table 9.10 Keyboard Connector Specifications

DIN Connector Pin	Mini-DIN Connector Pin	Signal	Voltage
1	5	Keyboard Clock	+2.0v to +5.5v
2	1	Keyboard Data	+4.8v to +5.5v
3	—	Reserved	—
4	3	Ground	—
5	4	+5v Power	+2.0v to +5.5v

If your measurements do not match these voltages, the motherboard might be defective. Otherwise, the keyboard cable or keyboard might be defective. If you suspect that the cable is the problem, the easiest thing to do is replace the keyboard cable with a known good one. If the system still does not work normally, you might have to replace the entire keyboard or the motherboard.

Keyboard Error Codes

Some BIOSs use the following 3*xx*-series numbers to report keyboard errors. These error codes will be displayed onscreen during the startup process. Look up the error code and fix the problem.

Table 9.11 lists some standard POST and diagnostics keyboard error codes.

Table 9.11 Keyboard POST Codes

Error Code	Description
3*xx*	Keyboard errors.
301	Keyboard reset or stuck-key failure (XX 301; XX = scan code in hex).
302	System unit keylock switch is locked.
302	User-indicated keyboard test error.
303	Keyboard or system-board error; keyboard controller failure.
304	Keyboard or system-board error; keyboard clock high.
305	Keyboard +5v error; PS/2 keyboard fuse (on motherboard) blown.
341	Keyboard error.

Table 9.11 Keyboard POST Codes Continued

Error Code	Description
342	Keyboard cable error.
343	Keyboard LED card or cable failure.
365	Keyboard LED card or cable failure.
366	Keyboard interface cable failure.
367	Keyboard LED card or cable failure.

Mice and Pointing Devices

Mouse Motion Detection Methods

The most common type of mouse mechanism is the opto-mechanical, used by Logitech and many other vendors. Dirt on the mouse ball or rollers, or fuzz in the light paths will cause skipping and erratic mouse cursor operation.

Microsoft sells mice based on both mechanical (roller-type) technology and a new optical technology called IntelliEye. The IntelliMouse Optical and IntelliMouse with IntelliEye detect the mouse's motion with a high-speed purely CMOS-based optical sensor that, unlike the old optical mouse designs from Mouse Systems, doesn't require a special pad or special mousing surface. For those who prefer a different color to Microsoft's IntelliEye Red, Logitech's new MouseMan Wheel and Wheel Mouse feature a translucent blue bottom and similar optical detection features.

Although some stores display these mice on a mirrored surface, don't use a mirror or glass as a mousing surface. Your pants leg, airline tray table, or old school tie will work well, though.

Pointing Device Interface Types

The connector used to attach your mouse to the system depends on the type of interface you are using. Mice are most commonly connected to your computer through the following three interfaces:

- Serial port
- Dedicated motherboard mouse port (PS/2 port)
- USB port

Most mice that attach to the USB port can also be adapted to the PS/2 mouse port. Many serial mice are shipped with a PS/2 adapter, too.

The serial port can be seen in Chapter 6, "Serial Ports and Modems." The PS/2 mouse port is the same mechanical connector as the keyboard 6-pin mini-DIN shown earlier in this chapter, but you cannot interchange the mouse and keyboard.

A fourth connector type, the 9-pin mini-DIN bus-mouse connector, is found on the back of a dedicated bus-mouse interface card or on some old ATI video cards. Bus mice are now considered obsolete, and most cannot be adapted to other types of ports.

Note

Microsoft sometimes calls a bus mouse an *Inport mouse*, which is its proprietary name for a bus mouse connection.

Wireless Mouse Types

The following are the two methods for interfacing wireless mice:

- Radio Control
- Infra-Red(IR)

Radio-controlled mice are sold by Logitech, Microsoft, and other companies. The radio receiver plugs in to the standard mouse interface(s) listed previously, and the mouse is cordless, using a small battery to power its radio transmitter. Older versions of these mice were very bulky when compared to corded mice, but new wireless mice are about the same size as their corded cousins.

IR mice are rare, and are most often combined with IR keyboards. The IR receiver plugs in to the standard mouse (and keyboard) connector, and requires a clear line-of-site between the mouse and the receiver.

Software Drivers for the Mouse

Depending on the operating system you're using or the operating mode, you might need to manually load a driver, or it might be loaded automatically for you. Use Table 9.12 to determine what's needed for your mouse.

Table 9.12 Mouse Drive Type and Location by Operating System

Operating System	Driver Type	Loading Method	Notes
Windows 9x, NT, 2000, Me	32-bit .DRV and .VXD	Automatically detected and installed	Most mice with PS/2 ports can use standard Microsoft driver, although third-party drivers provide support for scroll wheels, third buttons, and so on.
MS-DOS mode under Windows 9x/Me	Uses Windows 32-bit driver	Automatically supported in windowed and full-screen modes	In window, can use mouse to mark text for the Windows Clipboard.
MS-DOS, including Windows 9x command prompt (not MS-DOS mode)	Mouse.com or Device= mouse.sys	Run MOUSE from command line or Autoexec.bat *or* Add device= mouse.sys to Config.sys	New versions of Mouse.com from Microsoft and Logitech can load into UMB RAM above 640KB with little conventional memory used.

Mice under Linux are configured through the kernel (for use with standard text-based displays). Xfree86-based graphical user interfaces (*window managers*) require that you specify the device name and mouse protocol used by your mouse or other pointing device. See the manual for your Linux distribution and window manager for details.

Alternative Pointing Devices

Table 9.13 provides an overview of pointing devices used as alternatives to normal mice, including those used with notebook computers.

Table 9.13 Alternative Pointing Devices

Device	Where Located	How Operated	Tips and Notes
Glidepoint Developed by Alps Electric (also called touchpad)	Flat surface below spacebar on notebook PCs; might be separate device or on right side of keyboard on desktop PCs	Move finger across surface; use left and right buttons beneath spacebar, or tap/double-tap with finger in place of click/double-click.	Most commonly used built-in mouse alternative; also available for desktop PCs. Requires you to move hand from keyboard; depends on skin moisture and resistance. Accuracy can be a problem.

Table 9.13 Alternative Pointing Devices Continued

Device	Where Located	How Operated	Tips and Notes
			If you prefer to use a "real" mouse, disable the touchpad in the BIOS, because it can still be active on some machines, even when a mouse is installed.
Trackpoint Developed by IBM	Small "eraserhead" pointing stick located in middle of keyboard	Gently press surface of "eraser" in the direction you want to go.	Very fast operation because it's on the keyboard. Licensed by Toshiba as "Accupoint" and also found on some IBM/Lexmark/Unicomp keyboards and on some other notebook computer brands.
Trackball	Rollerball placed below spacebar on notebook computer; also available integrated into desktop keyboards or as separate devices	Roll ball with fingers or thumb to move mouse pointer in desired direction.	Popular for some users who have comfort or ergonomic issues with mice; are available in ergonomic shapes as separate devices.

Keep in mind that many notebook computer users use "real" mice or trackballs when they have room.

Mouse Troubleshooting

If you are experiencing problems with your mouse, you must look in only two general places—hardware or software. Because mice are basically simple devices, looking at the hardware takes very little time. Detecting and correcting software problems can take a bit longer, however.

Use Table 9.14 to keep your mouse or pointing device in top condition.

Table 9.14 Troubleshooting Mouse and Pointing Device Problems

Symptom	Problem	Solution
Jerky mouse pointer.	Dirt and dust on rollers and ball or sensor.	Remove retainer plate on bottom of mouse, remove ball, and clean ball and rollers with non-abrasive solvents such as contact lens cleaner. Blow dust away from wheels and sensor. Reassemble and test.

Table 9.14 Troubleshooting Mouse and Pointing Device Problems Continued

Symptom	Problem	Solution
		Remove trackball ball from sensor and clean as above.
		Replace TrackPoint eraserhead with a new cap.
Mouse pointer freezes when another device (modem, and so on) is used.	IRQ conflict.	If mouse is PS/2, be sure no other device is using IRQ 12. If mouse is serial, check for modem on same IRQ as mouse. COM 1/3 share IRQ 4; COM 2/4 share IRQ 3 by default. See Chapter 6 for information on avoiding mouse/modem conflicts.
		If mouse is bus, check its IRQ usage and try to find an unused IRQ for bus card.
		Use Windows Device Manager if available to find IRQ information.
Mouse won't work at all.	Defective mouse.	Replace the original mouse with a known-working similar spare. If it works, replace the original mouse for good.
	Defective port.	Any mouse plugged in to the port won't work. First, check to see whether port is disabled. If the port is not disabled, use add-on port card or replace motherboard.
	Disabled COM, USB, or PS/2 port.	Check BIOS or motherboard jumpers and enable if IRQ used by port isn't already in use.
	Radio-controlled mouse has a dead battery.	Check battery in mouse; replace if dead or weak.
	Wrong channel set on mouse or receiver.	Mouse and receiver must be set to same channel; adjust channels on both devices to solve interference problems.
	Infra-red mouse can't "see" IR receiver.	Check line-of-site issues for IR mouse and receiver.
Mouse works as PS/2, but not as serial.	Mouse designed for PS/2 port only.	Most "bundled" mice are designed for the PS/2 port only. Retail mice are designed to be used with adapters. Get a mouse built for the serial port.

Table 9.14 Troubleshooting Mouse and Pointing Device Problems Continued

Symptom	Problem	Solution
Mouse locks up when accessed by Microsoft MSD or other diagnostic.	Bad mouse.	To verify mouse is the problem, run MSD/I to bypass initial detection. Detect computer and other information; then detect mouse. If the mouse is at fault, you'll lock up your system. Turn off system, replace with known-working mouse, and repeat. If replacement mouse works okay, you've solved the problem.
Standard left and right mouse buttons work, but middle or scroll buttons don't work.	Incorrect mouse configuration.	A dual-emulation mouse with a PC/MS slider on the bottom must be set to PC (Mouse Systems) mode to activate the middle button. Most Logitech mice can use the Microsoft driver, but Microsoft mice don't support three buttons. Use the correct driver for the mouse.
	Button not programmed.	Use mouse setup program to verify that the middle button is set to work, and check its function.
	Mouse drivers out of date.	Original scrolling mouse drivers would work only in Web browsers and a few other applications. Download and install new drivers.

Chapter 10

Video and Audio

Selecting a Monitor Size

Table 10.1 shows the monitor's advertised diagonal screen size, along with the approximate diagonal measure of the actual active viewing area for the most common display sizes.

Table 10.1 Advertised Screen Size Versus Actual Viewing Area

Monitor CRT Size (in Inches)	Actual Viewing Area (in Inches)
12	10 1/2
14	12 1/2
15	13 1/2
16	14 1/2
17	15 1/2
18	16 1/2
19	17 1/2
20	18 1/2
21	19 1/2

The size of the actual viewable area varies from manufacturer to manufacturer but tends to be approximately 1 1/2 inches less than the actual screen size. However, you can adjust some monitors—such as some models made by NEC, for example—to display a high-quality image that completely fills the tube from edge to edge. Other makes can fill the screen also, but some of them do so only by pushing the monitor beyond its comfortable limits. The result is a distorted image that is worse than the monitor's smaller, properly adjusted picture.

This phenomenon is a well-known monitor-purchasing issue, and as a result, most manufacturers and vendors have begun advertising the size of the active viewing area of their monitors along with the screen size. This makes it easier for consumers to compare what they are paying for.

Monitor Resolution

Resolution is the amount of detail a monitor can render. This quantity is expressed in the number of horizontal and vertical picture elements, or *pixels*, contained in the screen. The greater the number of pixels, the more detailed the images. Pixels also are referred to as *pels*, which is short for picture elements. The resolution required depends on the application. Character-based applications (such as DOS command-line programs) require little resolution, whereas graphics-intensive applications (such as desktop publishing and Windows software) require a great deal.

CRTs Versus LCDs

CRTs can handle a wide range of resolutions, but LCD panels of any type must use scaling to change to resolutions other than their native setting.

Common Monitor Resolutions

Table 10.2 shows standard resolutions used in PC video adapters and the terms commonly used to describe them.

Table 10.2 Monitor Resolutions

Resolution	Acronym	Standard Designation
640×480	VGA	Video graphics array
800×600	SVGA	Super VGA
1,024×768	XGA	Extended graphics array
1,280×1,024	UVGA	Ultra VGA

However, the terms SVGA, XGA, and UVGA have fallen into disuse. The industry now describes screen resolutions by citing the number of pixels. Nearly all the video adapters sold today support the 640×480, 800×600, and 1,024×768 pixel resolutions at several color depths, and most now support 1,280×1,024 and higher as well.

Note

To understand this issue, you might want to try different resolutions on your system. As you change from 640×480 to 800×600 and 1024×768, you'll notice several changes to the appearance of your screen.

At 640×480, text and onscreen icons are very large. Because the screen elements used for the Windows desktop and software menus are at a fixed pixel width and height, you'll notice that they shrink in size onscreen as you change to the higher resolutions. Some

recent versions of Windows, starting with Windows 98, let you select a large icons option in the Display properties sheet. This enables you to use high-resolution selections (which help you see more of your document) and still have large, legible icons.

Table 10.3 shows the minimum-size monitors I recommend to properly display the resolutions that users typically select.

Table 10.3 Resolution and Monitor Size Recommendations

Resolution	Minimum Recommended Monitor
640×480	13-inch
800×600	15-inch
1,024×768	17-inch
1,280×1,024	21-inch

LCD Versus CRT Display Size

LCD panels, especially all-digital units, provide high-quality displays that are always crisp and perfectly focused. Plus, their dimensions are fully usable and can comfortably display higher resolutions than comparably sized CRTs. Table 10.4 provides common CRT screen sizes and the comparable LCD display panel sizes.

Table 10.4 CRT Versus LCD Usable Screen Size Comparison

CRT Monitor Size Display (in Inches)	CRT Viewing Area (in Inches)	Comparable LCD (Also Viewing Area in Inches)
14	12.5	12.1
15	13.5	13.3, 13.7
16	14.5	14.1, 14.5
17	15.5	15, 15.1
19	17.5	17, 17.1
20	18.5	18.1

As you can see, a 15-inch LCD actually provides a usable viewing area similar to a 17-inch CRT.

Monitor Power Management Modes

One of the first energy-saving standards for monitors was VESA's Display Power Management Signaling (DPMS) spec, which defines the signals a computer sends to a monitor to indicate idle times. The computer or video card decides when to send these signals.

In Windows 9x and 2000, you need to enable this feature if you want to use it because it's turned off by default. To enable it, open the Display properties in the Control Panel, switch to the Screen Saver tab and make sure the Energy Star low-power setting and Monitor shutdown setting are checked. You can adjust how long the system remains idle before either the monitor picture is blanked or the monitor shuts down completely. Windows Me defaults to suspend after 10 minutes, but timings can be adjusted with any of these versions of Windows.

Table 10.5 summarizes the DPMS modes.

Table 10.5 Display Power Management Signaling

State	Horizontal	Vertical	Video	Power Savings	Recovery Time
On	Pulses	Pulses	Active	None	Not applicable
Standby	No pulses	Pulses	Blanked	Minimal	Short
Suspend	Pulses	No pulses	Blanked	Substantial	Longer
Off	No pulses	No pulses	Blanked	Maximum	System dependent

Microsoft and Intel developed a more broadly based power management specification called APM (advanced power management), and Microsoft developed an even more advanced power management specification called ACPI (advanced configuration and power interface) for use with Windows 98 and beyond. Table 10.6 summarizes the differences between DPMS, APM, and ACPI.

Table 10.6 Power Management Standards Compared

Standard	Devices Controlled	How Implemented	Notes
DPMS	Monitor and video card	Drivers for display and video card; must be enabled by operating system, such as Windows 9x/2000/Me via Control Panel	DPMS will work along-side APM or ACPI; user defines timer intervals for various modes listed.
APM	Monitor, hard disks, other peripherals	Implemented in BIOS; enabled in BIOS and in operating system (Windows 9x/2000/Me via Control Panel)	User defines timer intervals for various devices in BIOS or operating system.

Table 10.6 Power Management Standards Compared Continued			
Standard	**Devices Controlled**	**How Implemented**	**Notes**
ACPI	All APM peripherals plus other PC and consumer devices	Implemented in BIOS; support must be present in BIOS and devices; supports automatic power-up and power-off for PC and consumer devices including printers, stereos, CDs, and others	If ACPI support is present in the BIOS when Windows 98/Me/2000 is first installed, Windows ACPI drivers are installed; update BIOS before installing Windows if ACPI support is not present in BIOS.

VGA Video Connector Pinouts

Illustrations of all the following connectors can be seen in Chapter 14, "Connector Quick Reference."

VGA DB-15 Analog Connector Pinout

Virtually all displays in use today are descended from the 1987-vintage IBM VGA display introduced with the IBM PS/2s. The connector pinout is shown in Table 10.7.

Table 10.7 Standard 15-Pin VGA Connector Pinout		
Pin	**Function**	**Direction**
1	Red Video	Out
2	Green Video	Out
3	Blue Video	Out
4	Monitor ID 2	In
5	TTL Ground	—-_ (monitor self-test)
6	Red Analog Ground	-_
7	Green Analog Ground	-_
8	Blue Analog Ground	-_
9	Key (Plugged Hole)	-_
10	Sync Ground	-_
11	Monitor ID 0	In
12	Monitor ID 1	In
13	Horizontal Sync	Out
14	Vertical Sync	Out
15	Monitor ID 3	In

On the VGA cable connector that plugs into your video adapter, pin 9 is often pinless. Pin 5 is used only for testing purposes, and pin 15 is rarely used (these are often pinless as well). To identify the type of monitor connected to the system, some manufacturers use the presence or absence of the monitor ID pins in various combinations.

Digital Flat Panel Pinouts

The Digital Flat Panel (DFP) is a Video Electronic Standards Association specification for digital video displays, especially LCD panels. It was adopted in February 1999, but it already has been superseded for most uses by the DVI standard, discussed in the next section. The DFP supports a maximum resolution of 1280×1024 and transmits only digital signals. The DFP connector has two rows of edge connectors.

Table 10.8 provides the pinouts for DFP. DFP panels can be adapted to the newer DVI by the use of an adapter cable because both standards use the same TDMS PanelLink digital transfer protocol.

Table 10.8 DFP Pinouts

Pin #	Signal	Description
1	TX1+	TDMS Positive Differential output, channel 1
2	TX1-	TDMS Negative Differential output, channel 1
3	SHLD1	Shield for TDMS channel 1
4	SHLDC	Shield for TDMS clock
5	TXC+	TDMS Positive Differential output, reference clock
6	TXC-	TDMS Negative Differential output, reference clock
7	GND	Logic ground
8	+5V	Logic +5V power supply from host
9	No Connect 9	No connection
10	No Connect 10	No connection
11	TX2+	TDMS Positive Differential output, channel 2
12	TX2-	TDMS Negative Differential output, channel 2
13	SHLD2	Shield for TDMS channel 1
14	SHLD0	Shield for TDMS channel 0
15	TX0+	TDMS Positive Differential output, channel 0
16	TX0-	TDMS Negative Differential output, channel 0
17	No Connect 17	No connection
18	HPD	Host Plug Detection (+5v DC to host)

Table 10.8 DFP Pinouts Continued

Pin #	Signal	Description
19	DDC_DAT	DDC2B Data
20	DDC_CLK	DDC2B Clock

Digital Visual Interface Pinouts

The Digital Visual Interface (DVI) connector is used on an increasing number of LCD display panels as well as some CRT monitors. Many of the newest high-performance video cards feature either the DVI-D (digital only) or DVI-I (digital and analog) version of this connector. DVI can support either high-resolution (dual-link, which is above 1280×1024 resolution) or low-resolution (single-link, which has a maximum of 1280×1024 resolution) displays. DVI connectors use three rows of square pins, with pin 14 (power) recessed.

Dual-link displays use all the connectors shown in Table 10.9, whereas single-link displays omit some connectors.

Video cards that have only a DVI-I connector usually come with a special video cable that can connect to either analog VGA or DVI digital display types.

Table 10.9 lists the pin assignments used by both DVI-D and DVI-I connectors.

Table 10.9 DVI-I and DVI-D Pinouts

Row #	Pin #	How It Is Used
1	1	TMDS Data 2-
	2	TMDS Data 2+
	3	TMDS Data 2/4 Shield
	4	TMDS Data 4-
	5	TMDS Data 4+
	6	DDC Clock
	7	DDC Data
	8	Analog Vertical Sync
2	9	TMDS Data 1-
	10	TMDS Data 1+
	11	TMDS Data 1/3 Shield
	12	TMDS Data 3-
	13	TMDS Data 3+
	14	+5V Power
	15	Ground (+5, Analog H/V Sync)
	16	Hot Plug Detect

Table 10.9 DVI-I and DVI-D Pinouts Continued

Row #	Pin #	How It Is Used
	17	TMDS Data 0-
	18	TMDS Data 0+
3	19	TMDS Data 0/5 Shield
	20	TMDS Data 5-
	21	TMDS Data 5+
	22	TMDS Clock Shield
	23	TMDS Clock+
	24	TMDS Clock-

DVI-I also has the following MicroCross/high-speed pins, which are shown in Table 10.10.

Table 10.10 DVI-I Additional Connectors

C1	Analog Red Video Out
C2	Analog Green Video Out
C3	Analog Blue Video Out
C4	Analog Horizontal Sync
C5	Analog Common Ground Return (Red, Green, Blue Video Out)

VGA Video Display Modes

Depending on the application, you might need to identify a desired mode by the BIOS mode numbers listed in this section.

Table 10.11 lists the video modes of the chips and technologies 65554 SVGA graphics accelerator, a typical chipset used today.

Table 10.11 Chips and Technologies 65554 Graphics Accelerator Chipset Video Modes

BIOS Mode	Mode Type	Resolution	Character	Colors (Displayed from Palette)	Scan Freq. (Hor./Vert.)
0, 1	VGA Text	40×25 char	9×16	16KB/256KB	31.5KHz/70Hz
2, 3	VGA Text	80×25 char	9×16	16KB/256KB	31.5KHz/70Hz
4, 5	VGA Graph	320×200 pels	8×8	4KB/256KB	31.5KHz/70Hz
6	VGA Graph	640×200 pels	8×8	2KB/256KB	31.5KHz/70Hz
7	VGA Text	80×25 char	9×16	Mono	31.5KHz/70Hz
D	VGA Graph	320×200 pels	8×8	16KB/256KB	31.5KHz/70Hz
E	VGA Graph	640×200 pels	8×8	16KB/256KB	31.5KHz/70Hz
F	VGA Graph	640×350 pels	8×14	Mono	31.5KHz/70Hz

Table 10.11 Chips and Technologies 65554 Graphics Accelerator Chipset Video Modes Continued

BIOS Mode	Mode Type	Resolution	Character	Colors (Displayed from Palette)	Scan Freq. (Hor./Vert.)
10	VGA Graph	640×350 pels	8×14	16KB/256KB	31.5KHz/70Hz
11	VGA Graph	640×480 pels	8×16	2KB/256KB	31.5KHz/60Hz
12	VGA Graph	640×480 pels	8×16	16KB/256KB	31.5KHz/60Hz
13	VGA Graph	320×200 pels	8×8	256KB/256KB	31.5KHz/70Hz
20	SVGA Graph	640×480 pels	8×16	16KB/256KB	31.5KHz/60Hz 37.6KHz/75Hz 43.2KHz/85Hz
22	SVGA Graph	800×600 pels	8×8	16KB/256KB	37.9KHz/60Hz 46.9KHz/75Hz 53.7KHz/85Hz
24	SVGA Graph	1024×768 pels	8×16	16KB/256KB	35.5KHz/87Hz* 48.5KHz/60Hz 60.0KHz/75Hz 68.8KHz/85Hz
28	SVGA Graph	1280×1024 pels	8×16	16KB/256KB	35.5KHz/87Hz* 35.5KHz/60Hz
30	SVGA Graph	640×480 pels	8×16	256KB/256KB	31.5KHz/60Hz 37.6KHz/75Hz 43.2KHz/85Hz
32	SVGA Graph	800×600 pels	8×16	256KB/256KB	37.9KHz/60Hz 46.9KHz/75Hz 53.7KHz/85Hz
34	SVGA Graph	1024×768 pels	8×16	256KB/256KB	35.5KHz/87Hz* 48.5KHz/60Hz 60.0KHz/75Hz 68.8KHz/85Hz
38	SVGA Graph	1280×1024 pels	8×16	256KB/256KB	35.5KHz/87Hz* 35.5KHz/60Hz
40	SVGA Graph	640×480 pels	8×16	32KB/32KB	31.5KHz/60Hz 37.6KHz/75Hz 43.2KHz/85Hz
41	SVGA Graph	640×480 pels	8×16	64KB/64KB	31.5KHz/60Hz 37.6KHz/75Hz 43.2KHz/85Hz
42	SVGA Graph	800×600 pels	8×16	32KB/32KB	37.9KHz/60Hz 46.9KHz/75Hz 53.7KHz/85Hz

Table 10.11 Chips and Technologies 65554 Graphics Accelerator Chipset Video Modes Continued

BIOS Mode	Mode Type	Resolution	Character	Colors (Displayed from Palette)	Scan Freq. (Hor./Vert.)
43	SVGA Graph	800×600 pels	8×16	64KB/64KB	37.9KHz/60Hz 46.9KHz/75Hz 53.7KHz/85Hz
44	SVGA Graph	1024×768 pels	8×16	32KB/32KB	48.5KHz/60Hz
45	SVGA Graph	1024×768 pels	8×16	64KB/64KB	48.5KHz/60Hz
50	SVGA Graph	640×480 pels	8×16	16MB/16MB	31.5KHz/60Hz
52	SVGA Graph	800×600 pels	8×16	16MB/16MB	37.9KHz/60Hz

**Interlaced displays draw half the screen lines in a single pass. Lines 1, 3, 5, 7, and so forth are drawn in one pass of the electron gun. The second pass draws lines 2, 4, 6, 8, and so on. Interlacing was once common, but is now rare because of improvements in monitor design. Any interlaced display will be prone to eye-straining flicker. Flicker can be minimized by using a dark-glass glare screen.*

From the standpoint of user comfort, you should use this type of information, supplied with both graphics cards and monitors, to select the most comfortable viewing settings. Comfortable viewing comes from the optimal combination of resolution, color depth, and vertical refresh rates.

In deciding whether a video card is suitable for a particular task, or whether it's obsolete and should be replaced, the amount of video RAM on the card is a critical factor.

Video RAM

Video adapters rely on their own onboard memory that they use to store video images while processing them. The amount of memory on the adapter determines the maximum screen resolution and color depth that the device can support.

Most cards today come with at least 4MB, and many have 8MB or more. Although adding more memory is not guaranteed to speed up your video adapter, it can increase the speed if it enables a wider bus (from 64 bits wide to 128 bits wide) or provides non-display memory as a cache for commonly displayed objects. It also enables the card to generate more colors and higher resolutions.

Many different types of memory are used on video adapters today. These memory types are summarized in Table 10.12.

Table 10.12 Memory Types Used in Video Display Adapters

Memory Type	Definition	Relative Speed	Use
FPM DRAM	Fast Page-Mode RAM	Slow	Low-end ISA cards; obsolete
VRAM[1]	Video RAM	Very fast	Expensive; rare today
WRAM[1]	Window RAM	Very fast	Expensive; rare today
EDO DRAM	Extended Data Out DRAM	Moderate	Low-end PCI-bus
SDRAM	Synchronous DRAM	Fast	Midrange PCI/AGP
MDRAM	Multibank DRAM	Fast	Infrequently used; rare
SGRAM	Synchronous Graphics DRAM	Very fast	High-end PCI/AGP
DDR SDRAM[2]	Double Data-Rate Synchronous DRAM	Very Fast	High-end AGP

1. VRAM and WRAM are dual-ported memory types that can read from one port and write data through the other port. This improves performance by reducing wait times for accessing the video RAM.

2. DDR SDRAM can send and receive signals on both the rising and falling parts of a cycle, effectively doubling its speed over normal SDRAM. Because it is otherwise similar to conventional SDRAM, several vendors have introduced faster DDR SDRAM versions of existing video cards.

Memory, Resolution, and Color Depth

For maximum realism in such tasks as full-motion video playback, videoconferencing, and photo-editing, a color depth of 24 bits (over 16 million colors) is desirable at the highest comfortable display resolution possible with your monitor.

Use Tables 10.13 and 10.14 to determine whether your video card has the required memory to display some of the most commonly used screen resolutions and color depths.

Table 10.13 Video Display Adapter Minimum Memory Requirements—2-D Operation

Resolution	Color Depth	Number of Colors	RAM on Video Card	Memory Required
640×480	4-bit	16	256KB	153,600 bytes
640×480	8-bit	256	512KB	307,200 bytes
640×480	16-bit	65,536	1MB	614,400 bytes
640×480	24-bit	16,777,216	1MB	921,600 bytes
800×600	4-bit	16	256KB	240,000 bytes
800×600	8-bit	256	512KB	480,000 bytes
800×600	16-bit	65,536	1MB	960,000 bytes
800×600	24-bit	16,777,216	2MB	1,440,000 bytes

Table 10.13 Video Display Adapter Minimum Memory Requirements—2-D Operation Continued

Resolution	Color Depth	Number of Colors	RAM on Video Card	Memory Required
1,024×768	4-bit	16	512KB	393,216 bytes
1,024×768	8-bit	256	1MB	786,432 bytes
1,024×768	16-bit	65,536	2MB	1,572,864 bytes
1,024×768	24-bit	16,777,216	4MB	2,359,296 bytes
1,280×1,024	4-bit	16	1MB	655,360 bytes
1,280×1,024	8-bit	256	2MB	1,310,720 bytes
1,280×1,024	16-bit	65,536	4MB	2,621,440 bytes
1,280×1,024	24-bit	16,777,216	4MB	3,932,160 bytes

From this table, you can see that a video adapter with 2MB can display 65,536 colors in 1,024×768 resolution mode, but for a true color (16.8M colors) display, you would need to upgrade to 4MB or reduce resolution to 800×600.

Although many of the newest video cards on the market today have memory sizes of 8MB, 16MB, or even 32MB, this additional memory will not be used for 24-bit color in high resolutions for 2-D graphics unless the display resolution exceeds 1,280×1,024 at 24-bit color. The additional RAM is used for 3-D texture mapping and display caching.

Use Table 10.14 to determine whether you have sufficient display memory for the desired 3-D video operation.

Table 10.14 Video Display Adapter Memory Requirements—3-D Operation

Resolution	Color Depth	On-Board Video RAM	Actual Memory Required
640×480	16-bit	2MB	1.77MB
640×480	32-bit[1]	4MB	2.93MB
800×600	16-bit	4MB	2.76MB
800×600	32-bit[1]	8MB	4.58MB
1,024×768	16-bit	8MB	4.50MB
1,024×768	32-bit[1]	8MB	7.50MB
1,280×1,024	16-bit	8MB	7.50MB

1. Although 3-D adapters typically operate in a 32-bit mode, this does not necessarily mean that they can produce more than the 16,277,216 colors of a 24-bit true color display. Many video processors and video memory buses are optimized to move data in 32-bit words, and they actually display 24-bit color while operating in a 32-bit mode, instead of the 4,294,967,296 colors that you would expect from a true 32-bit color depth.

Determining the Amount of RAM on Your Display Card

Because the size of video memory is increasingly important to most computer users, it's useful to know how much memory your display card has onboard.

Table 10.15 summarizes some methods you can use.

Table 10.15 Methods for Determining the Amount of RAM on a Video Card

Method	Benefits	Cautions
Use memory/resolution table earlier and adjust video settings to options requiring 1MB, 2MB, 4MB, and 8MB.	If the settings work (a reboot is often required), you have at least that much RAM on your video card.	Method assumes that video card is set correctly by system; often can't be used to detect memory above 4MB because of driver limitations.
Use third-party system diagnostics to probe video card.	Universal solution for organizations with mixed display card standards.	Must use up-to-date diagnostics; might be confused by shared memory technologies found on low-cost systems.
Use diagnostics provided by video card or video chipset maker to probe video card.	Best source for technical information.	Must use different programs for different chipsets.

Given the low cost and high performance of today's video cards, you should seriously consider replacing any video card with less than 8MB of display memory onboard because even the least powerful cards in use today far outstrip top-end models of just a couple of years ago.

Local-Bus Video Standards

If you are in the market for a new video card, you need to consider your upgrade options. All video cards worth considering use a so-called local-bus technology, which uses a high-speed connection to the CPU that bypasses the slow ISA standard in use for many years. The major current standards are PCI (Peripheral Component Interconnect) and AGP (Advanced Graphics Port). The original local-bus standard, VL-Bus (the VESA Local-Bus), became outdated when the 486 CPU was replaced by Pentium-class CPUs.

PCI and AGP have some important differences, as Table 10.16 shows.

Table 10.16 Local Bus Specifications

Feature	PCI	AGP
Theoretical maximum	132MB/sec[1]	533MB/sec throughput (2X) 1.06GB/sec throughput (4X)
Slots[2]	4/5 (typical)	1
Plug and Play support	Yes	Yes
Cost	Slightly higher	Slightly higher than PCI
Ideal use	High-end 486, Pentium, P6	Pentium II, III, Celeron, AMD K6, K7

1. At the 66MHz bus speed and 32 bits. Throughput will be higher on the 100MHz system bus.

2. More slots are possible through the use of PCI bridge chips.

Obviously, of the three local-bus standards, AGP is the fastest, but only very recent systems offer AGP video. Use Table 10.17 to determine what your best video upgrade is, depending on your system.

Table 10.17 Best Video Upgrades by CPU and Slot Type

CPU	Slot Type	Best Option	Notes
486	VL-Bus	No current video cards available in VL-Bus; obsolete.	Buy used or surplus; replace motherboard; retire system.
486	PCI	Buy any low-cost PCI card with at least 4MB of RAM.	Verify that card will work with 486; some require Pentium.
Pentium, K6 MII	PCI	Buy PCI card with at least 8MB of RAM; look for DVD playback, TV out as desirable features.	Choose a card with a chipset that can be used as secondary video in case you move to AGP later by upgrading to a new motherboard or by moving the card to a system with AGP.
Pentium II/ III/Celeron K6/Athlon Duron	AGP	Buy AGP card with 16MB or more RAM; should support AGP 2X or faster speed; look for DVD playback, TV out as desirable features; DVI option desirable for display upgrades.	AGP upgrade is available only on systems with AGP slot. Many low-cost systems have AGP video on motherboard only; must use PCI for upgrade (see previous table entry).

Table 10.18 lists motherboard chipsets that support AGP. Note that the use of this chipset doesn't guarantee that every system using this chipset on its motherboard will be capable of accepting an AGP card because integrated AGP video is common on many low-cost systems today.

Table 10.18 AGP Support by Chipset

Manufacturer	Chipset	CPUs Supported
Intel	440LX, 440EX, 440ZX-66	Celeron
	440BX, 440ZX	Pentium II, Pentium III, Celeron
	820[1]	Pentium III, Pentium II
Ali	Aladdin Pro II	Pentium II
	Aladdin V	Socket 7
Via	Apollo VP3	Socket 7
	Apollo MVP3	Socket 7
	Apollo Pro 133A[1]	Pentium II/III/Celeron
	Apollo Pro 133	Pentium II/III/Celeron
	Apollo Pro Plus	Pentium II/III/Celeron
	Apollo KX133[1]	AMD Athlon
SiS	SiS5591/5595	Socket 7
	SiS600/5595	Pentium II
	SiS5600/5595	Pentium II

1. These chipsets support AGP version 2.0, which supports AGP 4x speed. Others listed support AGP version 1.0, which supports AGP 1x and 2x speeds.

RAMDAC

The speed of the RAMDAC (the digital-to-analog converter) is measured in MHz; the faster the conversion process, the higher the adapter's vertical refresh rate. Table 10.19 shows the effect of faster RAMDAC chips on typical video card chipsets. As RAMDAC speed increases, higher resolutions with higher vertical refresh rates are supported.

Table 10.19 Typical Chipset and RAMDAC Speed Pairings and Their Effects on Resolution and Refresh Rates

Chipset	RAMDAC Speed	Maximum Resolution	Refresh Rate
Matrox G200	250MHz	1920×1200 (2-D) 1920×1080 (3-D)	70Hz (2D)
Matrox G400MAX	360MHz	2048×1536 (2-D/3-D)	85Hz (2-D) 75Hz (3-D)

Note

In some cases, the maximum resolutions and refresh rates listed for any video card might require a RAM upgrade or the purchase of a video card with more RAM.

Refresh Rates

The speed of the RAMDAC affects the vertical refresh rate. The refresh rate (also called the *vertical scan frequency*) is the rate at which the screen display is rewritten. This is measured in hertz (Hz). A refresh rate of 72Hz means that the screen is refreshed 72 times per second. A refresh rate that is too low causes the screen to flicker, contributing to eyestrain. A *flicker-free refresh rate* is a refresh rate high enough to prevent you from seeing any flicker; eliminating flicker reduces eyestrain. The flicker-free refresh rate varies with the resolution of your monitor setting (higher resolutions require a higher refresh rate) and must be matched by both your monitor and your display card.

Low-cost monitors often have refresh rates that are too low to achieve flicker-free performance for most users, and thus can lead to eyestrain.

Table 10.20 compares two typical 17-inch CRT monitors and a typical mid-range graphics card.

Although the Matrox Millennium G200 video card supports higher refresh rates than either monitor, rates higher than the monitor can support cannot be used safely because rates in excess of the monitor's maximum refresh rate can damage the monitor.

Table 10.20 Refresh Rates Comparison

Resolution	G200 Video Card Vertical Refresh	LG 760SC (17") Monitor Vertical Refresh (Maximum)	LG 790SC (17") Monitor Vertical Refresh (Maximum)
1024×768	60–140	87Hz[1]	124Hz[1]
1,280×1024	60–100Hz[1]	65Hz	93Hz[1]
1,600×1200	52–85Hz[1]	Not supported	80Hz[1]

1. Rates above 72Hz will be flicker free for many users; the VESA standard for flicker-free refresh is 85Hz or above.

For a user who wants to run at resolutions above 1,024×768, the monitor with the higher refresh rate is preferable.

Adjusting the Refresh Rate of the Video Card

The refresh rate of the video card can be adjusted in several ways:

- With older cards, a command-line program or separate Windows program was often provided.
- With recent and new cards, the standard display properties sheet offers a selection of refresh rates.

In any case, you need to know the allowable refresh rates for the monitor before you can make an appropriate selection. If your

Windows installation uses an unknown, Default Monitor, or Super VGA display type, rather than a particular brand and model of monitor, you will be prevented from selecting the higher, flicker-free refresh rates. Install the correct driver for your monitor model to get the highest refresh rates.

Comparing Video Cards with the Same Chipset

Many manufacturers create a line of video cards with the same chipset to sell at different pricing points. Why not save some dollars and get the cheapest model? Why not say "price is no object" and get the most expensive one? When you're faced with various cards in the chipsetX family, look for differences such as those shown in Table 10.21.

Table 10.21 Comparing Video Cards with the Features You Need

Feature	Effect on You
RAMDAC speed	Less-expensive cards in a family often use a slower RAMDAC. Buy the card with the fastest RAMDAC, especially for use with 17-inch or larger monitors. Faster RAMDACs are often paired with SGRAM or DDR SRAM, which are the fastest types of RAM currently found on video cards.
Amount of RAM	Although AGP video cards can use *AGP memory* (a section of main memory borrowed for texturing), performing as much work as possible on the card's own memory is still faster. PCI cards must perform all functions within their own memory. Less-expensive cards in a chipset family often have lower amounts of memory onboard, and most current model cards aren't expandable. Buy a card with enough memory (8MB–16MB or more) for your games or applications—today and tomorrow.
Memory type	High-end video cards frequently use the new SGRAM (Synchronous Graphics RAM) or DDR SRAM (Double-Data-Rate Synchronous DRAM), with regular SDRAM as a popular choice for mid-range video cards. Choose DDR SRAM, SGRAM, and then SDRAM, in order of preference when possible.
Memory and core	Many suppliers adjust the recommended speed of graphics controllers in an effort to provide users with maximum performance. If you have questions about the rated speed of a controller, check the chip supplier's Web site. Many reputable companies do use overclocked parts, but the best vendors supply large heat sinks or even powered fans to avoid overheating.
TV tuner	You can save some money by having it built in, but it's not as important as the other issues listed earlier.

Setting Up Multiple Monitor Support in Windows 98/Me/2000

Windows 98 was the first version of Windows to include a video display feature that Macintosh systems have had for years: the capability to use multiple monitors on one system. Windows 98

and Windows Me support up to nine monitors (and video adapters), each of which can provide a different view of the desktop. You can display a separate program on each monitor, use different resolutions and color depths, and enjoy other features.

On a multi-monitor Windows 98 or Windows Me system, one display is always considered to be the *primary* display. The primary display can use any PCI or AGP VGA video adapter that uses a Windows 98 mini-driver with a linear frame buffer and a packed (non-planar) format, meaning that most of the brand-name adapters sold today are eligible. Additional monitors are called *secondaries* and are much more limited in their hardware support.

Video cards with the Permedia chipset (not the later Permedia NT and Permedia 2) can't be used in a multiple-monitor configuration.

The following list of video card chipsets with the specified Microsoft Windows 98 or Me drivers can be used in any combination of primary or secondary adapters. Unlisted chipsets also can work as primary adapters. This list is condensed from Microsoft's Knowledge Base article #Q182/7/08 (check it for updates):

- **ATI**—Mach 64 GX and beyond, including 3-D cards, Rage Pro series, Xpert series, and others using the ATIM64.drv or ATIR3.drv
- **S3**—765 (Trio64V+) S3MM.drv

Note

Only certain updates work. These are 40, 42, 43, 44, 52, 53, and 54. Note that if the card is at one of these updates, Windows 98 recognizes the card as a Trio 64V+, provided the Microsoft driver is used. If the card is not at one of these updates, it is recognized as a Trio 32/64. Some OEM drivers don't care which update is present; be sure to note carefully which Microsoft driver Windows 98 selects when you use this card.

Other S3 chipsets include the Trio64V2 and various Diamond, STB, Hercules, Number Nine, and other cards using the Virge or newer chipsets.

- **Cirrus**—5436, Alpine, 5446, and other cards using the CIRRUSMM.drv
- **Tseng**—Cards with the ET6000 chipset
- **Trident**—9685/9680/9682/9385/9382/9385 chipsets

Windows 2000 also provides multiple-monitor support, but with some differences from Windows 98/Me, as seen in Table 10.22.

Table 10.22 Comparing Windows 98/Me and Windows 2000 Multiple-Monitor Support

Windows Version	Number of Adapters/ Monitors Supported	How Compatible Cards Are Listed	Finding Compatible Cards
98/Me	10	By chipset	On Microsoft's Web site
2000	9	Brand and model	HCL listing on CD-ROM

As of the initial release of Windows 2000, some of the major brands with products on the multiple-monitor approved list include:

- 3DFX
- 3Dlabs
- Creative Labs
- Diamond Multimedia
- ELSA
- Matrox
- Number Nine
- nVidia
- SiS 300 compatible
- STB

Windows 2000's Hardware Compatibility List is organized by graphics card brand and model, rather than by chipset (check the Windows 2000 CD-ROM Hardware Compatibility List for details). This list is likely to change as Windows 2000 support becomes more widespread, but unfortunately the online version of the Windows 2000 HCL doesn't provide an updated list of cards that support multiple-monitor configurations. You should check with your video card or chipset manufacturer for the latest information on Windows 2000 and multiple-monitor support issues.

Some video card manufacturers, including Appian and Matrox, make video cards that can support two or more monitors with a single card, avoiding the problems of using multiple cards for multiple-monitor support.

Useful third-party Web sites for multiple-monitor support include the following:

```
www.realtimesoft.com/multimon/

www.digitalroom.net/techpub/multimon.html
```

System Configuration Issues for Multiple-Monitor Support

If the BIOS on your computer does not let you select which device should be the primary VGA display, it decides based on the order of the PCI slots in the machine; AGP slots on most systems have a lower priority than PCI slots. You should, therefore, install the primary adapter in the highest-priority PCI slot. Because many systems do not list the slot priority in their documentation, you might need to experiment by switching the cards around between different PCI expansion slots.

After the hardware is in place, you can configure the display for each monitor from the Display Control Panel's Settings page. The primary display is always fixed in the upper-left corner of the virtual desktop, but you can move the secondary displays to view any area of the desktop you want. You also can set the screen resolution and color depth for each display individually.

Video Card and Chipset Makers Model Reference

3-D Chipsets

As with standard 2-D video adapters, several manufacturers of popular 3-D video chipsets exist and many more manufacturers of video adapters that use them exist.

Note

See Chapter 15 of *Upgrading and Repairing PCs, 12th Edition*, for an exhaustive listing of current 3-D chipsets and the boards on which they are found.

Multimedia Devices

When choosing TV, video-out, or video capture options for your PC, use Table 10.23 to help you decide which solution is best for you.

Table 10.23 Multimedia Device Comparison

Device Type	Pros	Cons
Graphics card w/ built-in TV tuner	Convenience, single-slot solution.	Upgrading requires card replacement.
TV-tuner attachment	Allows upgrade to existing graphics cards; might be movable to newer models.	Can't be used with all graphics cards.

Table 10.23 Multimedia Device Comparison Continued

Device Type	Pros	Cons
Parallel-port attachment	Universal use on desktop or notebook computer; inexpensive.	Frame rate limited by speed of port.
USB-port attachment	Easy installation on late-model, USB-equipped computers with Windows 98/Me/2000.	Might not work on Windows 95B OSR 2.x with USB; requires active USB port.
Dedicated ISA or PCI interface card	Fast frame rate for realistic video; doesn't require disconnecting parallel printer; works with any graphics card.	High resource requirements (IRQ and so on) on some models; ISA nearly obsolete; requires internal installation.
IEEE-1394 (FireWire, iLINK) connection to digital video	No conversion from analog to digital needed; all-digital image is very high quality without compression artifacts (blocky areas) in video; fast throughput.	Requires IEEE-1394 interface card and IEEE-1394 digital video source; new and expensive; card requires internal installation.

Troubleshooting Video Capture Devices

Table 10.24 provides some advice for troubleshooting problems with video capture devices.

Table 10.24 Troubleshooting Video Capture Devices

Device Type	Problem	Solution
Parallel-port attachment	Can't detect device, but printers work okay.	Check port settings; device might require IEEE-1284 settings (EPP and ECP); change in BIOS; make sure device is connected directly to port; avoid daisy-chaining devices unless device specifically allows it; check Windows 9x Device Manager for IRQ conflicts.
TV tuners (built-in graphics card or add-on)	No picture.	Check cabling; set signal source correctly in software.
All devices	Video capture is jerky.	Frame rate is too low; increasing it might require capturing video in a smaller window; use fastest parallel-port setting you can.
	Video playback has pauses, dropped frames.	Hard disk might be pausing for thermal recalibration; use AV-rated SCSI hard drives or new UDMA EIDE drives; install correct bus-mastering EIDE drivers for motherboard chipset to speed things up.

Table 10.24 Troubleshooting Video Capture Devices Continued

Device Type	Problem	Solution
USB devices	Device can't be detected or doesn't work properly.	Use Windows 98 or above; late versions of Windows 95 have USB drivers, but they often don't work; if you use a USB hub, make sure it's powered.
Interface cards (all types)	Card can't be detected or doesn't work.	Check for IRQ conflicts in Windows Device Manager; consider setting card manually if possible.
All devices	Capture or installation problems.	Use the newest drivers available; check manufacturer's Web site for updates, FAQs, and so on.

Testing a Monitor with Common Applications

Even without dedicated test and diagnostics software, you can use the software accessories (WordPad, Paint, and so on) that come with Microsoft Windows to test a monitor for picture quality.

One good series of tasks is as follows:

- Draw a perfect circle with a graphics program. If the displayed result is an oval, not a circle, this monitor will not serve you well with graphics or design software.
- Using a word processor, type some words in 8- or 10-point type (1 point equals 1/72 inch). If the words are fuzzy or if the black characters are fringed with color, select another monitor.
- Turn the brightness up and down while examining the corner of the screen's image. If the image blooms or swells, it is likely to lose focus at high brightness levels.
- Display a screen with as much white space as possible and look for areas of color variance. This might indicate a problem only with that individual unit or its location, but if you see it on more than one monitor of the same make, it can be indicative of a manufacturing problem; or it could indicate problems with the signal coming from the graphics card. Move the monitor to another system equipped with a different graphics card model and retry this test to see for certain whether it's the monitor or video card.
- Load Microsoft Windows to check for uniform focus. Are the corner icons as sharp as the rest of the screen? Are the lines in the title bar curved or wavy? Monitors usually are sharply focused at the center, but seriously blurred corners indicate a poor design. Bowed lines can be the result of a poor video

adapter, so don't dismiss a monitor that shows those lines without using another adapter to double-check the effect.

- A good monitor will be calibrated so that rays of red, green, and blue light hit their targets (individual phosphor dots) precisely. If they don't, you have bad convergence. This is apparent when edges of lines appear to illuminate with a specific color. If you have good convergence, the colors will be crisp, clear, and true, provided there isn't a predominant tint in the phosphor.
- If the monitor has built-in diagnostics (a recommended feature), try them as well to test the display independent of the graphics card and system to which it's attached.

Use Table 10.25 to troubleshoot specified problems.

Table 10.25 Troubleshooting Display Problems

Symptom	Cause	Solution
No Picture	LED indicates power-saving mode (flashing green or yellow by power switch).	Move the mouse or press Alt+Tab on the keyboard and wait up to one minute to wake up the system if the system is turned on.
	LED indicates normal mode.	Check monitor and video data cables; replace with known, working spare.
		Turn off monitor; reset mode switch to correct setting (analog for VGA).
		Check brightness and contrast control; adjust as necessary.
No picture; no power lights on monitor	No power flowing to monitor.	Cycle monitor off and on in case power management has kicked in; check power cable and replace; check surge protector and replace; replace monitor and retest.
Jittery picture quality	LCD monitors display not adjusted.	Use display-adjustment software to reduce or eliminate pixel jitter and pixel swim.
	Cables loose.	Check cables for tightness at the video card and the monitor (if removable).
	Defective main or extender cable.	Remove the extender cable and retest with the monitor plugged directly into the video card; if the extended cable is bad, replace it; if the main cable is bad, replace it.
	Jitter is intermittent.	Check for interference; microwave ovens near monitors can cause severe picture distortion when turned on.

Table 10.25 Troubleshooting Display Problems Continued

Symptom	Cause	Solution
	CRT monitor—wrong refresh rate.	Check settings; reduce refresh rate until acceptable picture quality is achieved.
		Use onscreen picture adjustments until an acceptable picture quality is achieved.
	Intermittent—not due to external interference.	If the problem can be fixed by waiting or gently tapping the side of the monitor, the monitor power supply is probably bad or has loose connections internally; service or replace the monitor.
Picture in DOS, not Windows	Incorrect or corrupted Windows video driver.	Boot Windows 9x in Safe Mode; boot Windows 2000 in Enable VGA Mode. If these display modes work, delete current video card from Device Manager and restart system to reinstall drivers. If incorrect drivers are selected by Windows, manually choose correct drivers in Device Manager.

Audio I/O Connectors

Sound cards, or built-in audio chips, provide another significant part of modern PCs' multimedia capabilities. Learning the correct uses for the basic input/output connectors will help you as you set up typical sound-equipped computers. See Chapter 14 for examples of these connectors.

- **Stereo line out or audio out connector**—The line out connector is used to send sound signals from the audio adapter to a device outside the computer, such as stereo speakers, a headphone, or a stereo system. Some adapters provide two jacks for line out: one for the left channel and the other for the right channel.
- **Stereo line or audio in connector**—With the line in connector, you can record or mix sound signals from an external source, such as a stereo system or VCR, to the computer's hard disk.
- **Speaker/headphone connector**—The speaker/headphone connector is provided on most audio adapters, but not necessarily all of them. Some systems use line out instead. When the adapter provides both a speaker/headphone and a line out connector, the speaker/headphone

connector provides an amplified signal that can power your headphones or small bookshelf speakers. Most adapters can provide up to four watts of power to drive your speakers. The signals that the adapter sends through the line out connector are not amplified. The line out connector generally provides better sound reproduction because it relies on the external amplifier built in to your stereo system or speakers, which is typically more powerful than the small amplifier on the audio adapter.

- **Microphone or mono in connector**—The mono in connector is used to connect a microphone for recording your voice or other sounds to disk. This microphone jack records in mono, not in stereo, and is therefore not suitable for high-quality music recordings. Many audio adapter cards use Automatic Gain Control (AGC) to improve recordings. This feature adjusts the recording levels on-the-fly. A 600-ohm to 10KB-ohm dynamic or condenser microphone works best with this jack. Some inexpensive audio adapters use the line in connector instead of a separate microphone jack.

- **Joystick connector**—The joystick connector is a 15-pin, D-shaped connector that can connect to any standard joystick or game controller. Sometimes the joystick port can accommodate two joysticks if you purchase an optional Y-adapter.

- **MIDI connector**—Audio adapters typically use the same joystick port as their MIDI connector. Two of the pins in the connector are designed to carry signals to and from a MIDI device, such as an electronic keyboard. In most cases, you must purchase a separate MIDI connector from the audio adapter manufacturer that plugs into the joystick port and contains the two round, 5-pin DIN connectors used by MIDI devices, plus a connector for a joystick. Because their signals use separate pins, you can connect the joystick and a MIDI device at the same time. You need this connector only if you plan to connect your PC to external MIDI devices. You can still play the MIDI files found on many Web sites by using the audio adapter's internal synthesizer.

- **Internal pin-type connector**—Most audio adapters have an internal pin-type connector that you can use to plug an internal CD-ROM drive directly into the adapter, using a small, round cable. This connection enables you to channel audio signals from the CD-ROM directly to the audio adapter, so you can play the sound through the computer's speakers. This connector does not carry data from the CD-ROM to the system bus; it only provides the CD-ROM drive with direct audio access to the speakers. If your adapter lacks

this connector, you can still play CD audio through the computer speakers by connecting the CD-ROM drive's headphone jack to the audio adapter's line in jack with an external cable.

Tip

The line in, line out, and speaker connectors on an audio adapter all use the same 1/8-inch mini-jack socket. The three jacks are usually labeled, but when setting up a computer on or under a desk, these labels on the back of the PC can be difficult to read. One of the most common reasons a PC fails to produce any sound is that the speakers are plugged into the wrong socket.

If your sound card, microphone, and speakers aren't color-coded, do it yourself. See Chapter 1, "General Technical Reference," for the PC99 standards for color-coding for audio and other ports.

Connectors for Advanced Features

Many of the newest sound cards are designed for advanced gaming, DVD audio playback, and sound production uses, and have additional connectors:

- **MIDI In/MIDI Out**—Some advanced sound cards don't require you to convert the game port (joystick port) to MIDI interfacing by offering these ports on a separate external connector. This permits you to use a joystick and have an external MIDI device connected at the same time. Its typical location is in an external device.
- **SPDIF (also called SP/DIF) In and SPDIF Out**—The Sony/Philips Digital Interface Format connector receives digital audio signals directly from compatible devices without converting them to analog format first. Its typical location is in an external device. SPDIF interfaces are also referred to by some vendors as Dolby Digital interfaces.
- **CD SPDIF**—Connects compatible CD-ROM drives with SPDIF interfacing to the digital input of the sound card. Its typical location is on the side of the audio card.
- **TAD In**—Connects modems with Telephone Answering Device support to the sound card for sound processing of voice messages. Its typical location is on the side of the audio card.

- **Digital DIN Out**—This supports multi-speaker digital speaker systems. Its typical location is in an external device.
- **Aux In**—Provides input for other sound sources, such as a TV tuner card. Its typical location is on the side of the audio card.
- **I2S In**—This enables the sound card to accept digital audio input from an external source, such as 2-channel decoded AC-3 from DVD decoders and MPEG-2 Zoom Video. Its typical location is on the side of the audio card.

Sound Quality Standards

Many sound card owners never record anything, but if you like the idea of adding sound to a Web site or presentation, you should know the quality and file size impact that typical sound settings will have. The Windows 9x/2000/Me standard sound quality settings are shown in Table 10.26.

Table 10.26 Windows 9x/2000/Me Sound File Resolutions

Resolution	Frequency	Bandwidth	File Size
Telephone quality	11,025Hz	8-bit mono	11KB/sec
Radio quality	22,050Hz	8-bit mono	22KB/sec
CD quality	44,100Hz	16-bit stereo	172KB/sec

Note that the higher the sound quality, the larger the file size. The file sizes are for .WAV files saved with the Windows Sound Recorder's default settings. If you want to add sound effects or speech to a Web site, you should get a program such as Real Networks's RealProducer, which is capable of compressing sound as much as 100:1 while still maintaining reasonable quality.

Many new sound cards also support a 48KHz standard designed to match the requirements of DVD audio playback and Dolby AC-3 audio compression technologies. This frequency must be set manually in Sound Recorder if you need to record at this high frequency level.

Configuring Sound Cards

Traditionally, sound cards have been one of the toughest single installation tasks because they use three of the four settings possible for an add-on card: IRQ, DMA, and I/O port addressing. The rule of thumb is: "The sound card first!"—no matter what else you need to install.

PCI Versus ISA Sound Cards

PCI cards have become the best choice recently for all types of upgrades, including sound cards. Compared to ISA cards, PCI cards are faster, have a lower CPU utilization rate, and use fewer hardware resources (see Table 10.27). Compare the configuration of the Sound Blaster 16 card with the native configuration for an Ensoniq-chipset PCI sound card.

Table 10.27 Default Resource Assignments for ISA and PCI Sound Card in Native and Emulation Modes

Card Onboard Device	IRQ	I/O	DMA (16 Bit)	DMA (8 Bit)
Sound Blaster 16—ISA Bus				
Audio	5	220h-233h	5	1
MIDI Port	—	330h-331h	—	—
FM Synthesizer	—	388h-38Bh	—	—
Game Port	—	200h-207h	—	—
Ensoniq Audio PCI—PCI Bus Native Mode				
Audio	11	DC80-DCBFh	—	—
Game Port	—	200h-207h	—	—
Ensoniq Audio PCI—PCI Bus Legacy (SB Pro) Mode				
Audio	7*	DC80-DCBFh	—	—
MIDI Port	—	330h-331h	—	—
FM Synthesizer	—	388h-38Bh	—	—
(Ensoniq SoundScape)	—	0530-0537h	—	—
Game Port	—	200h-207h	—	—

**Shared IRQ with printer port; allowed by Ensoniq driver*

While the Ensoniq Audio PCI card uses only one IRQ and one I/O port address in its native mode, if you have software (mostly older Windows and DOS game/educational titles) that requires Sound Blaster Pro compatibility, the Legacy settings must also be used. However, if you are *not* running Sound Blaster–specific software (all your software is native Windows 9x, for example), you might be able to disable the Legacy mode for a PCI-based sound card.

Multifunction (Modem and Sound) Cards

Multifunction cards that use DSP (digital signal processor) technology, such as IBM Mwave-based cards, can be very difficult to install in today's IRQ-starved systems. These cards typically combine a

modem plus a Sound Blaster–compatible sound card. They also typically require an IRQ and one or more I/O port address ranges for the DSP as well as the normal settings seen previously and in Chapter 6, "Serial Ports and Modems," for the sound card and modem functions.

These cards also might require a very complex software installation process for the DSP, sound, modem, and soft wavetable sound samples. Because they are resource hungry, often have limited modem speeds, and are usually ISA based, I recommend replacing these types of multifunction cards with separate PCI-based sound and modem cards if possible.

Troubleshooting Audio Hardware

Hardware (Resource) Conflicts

You might notice that your audio adapter doesn't work (no sound effects or music), repeats the same sounds over and over, or causes your PC to freeze. This situation is called a *device*, or *hardware*, conflict centering around IRQ, DMA, and I/O port address settings in your computer (see Chapter 2, "System Components and Configuration").

Detecting Resource Conflicts

Use Table 10.28 to help you determine resource conflicts caused by your sound card.

Table 10.28 Resolving Sound Card Resource Conflicts

Problem	Symptom	How to Detect	Solution
Sound card using same IRQ as another device.	Skipping, jerky sound, or system lockups.	Use Windows Device Manager. For other systems, use IRQ and DMA card, as described in Chapter 2.	For PnP device: Disable automatic configuration for conflicting device and try to set card manually through direct alteration of settings or by choosing alternative configurations.
Sound card and another device using the same DMA channel.	No sound at all from sound card.		For non-PnP device: Move conflicting device to another setting to allow sound card to use defaults.

Table 10.28 Resolving Sound Card Resource Conflicts Continued

Problem	Symptom	How to Detect	Solution
PCI-slot sound card works okay with Windows, but not MS-DOS apps.	Windows software plays; DOS software doesn't play card; can't detect card.	Check for Legacy or SB settings in the Windows 9x Device Manager.	If no Legacy support is installed, install it. Follow instructions carefully for using the card with older software. You might need to run Setup program or TSR before starting DOS program. You might need software patch from game developer. In extreme cases, you might need to use an actual SB Pro/16 card alongside your PCI sound card and use it instead.
Some DOS and Windows software works, but some can't use card.	Error messages about incorrect card settings.	Check card or Legacy software settings; alternative settings work okay for some programs, but not others.	Software expects SB default settings; use settings in preceding table for Sound Blaster 16 (all but DMA 5 apply to SB Pro).
DSP-equipped card, such as IBM Mwave, not installed properly or out of resources.	Multifunction sound and modem card doesn't work.	Check Windows 9x Device Manager for DSP host configuration.	Mwave and similar cards require basic SB settings as in previous entry, plus serial (COM) port setting resources for the DSP! Reinstall card with all drivers.
PnP card on a non-PnP system was working, but has now stopped in these files.	PnP enumerator program in startup process probably removed or damaged.	Check CONFIG.SYS or AUTOEXEC.BAT for driver; use REM to create labels before and after driver commands.	Reinstall software and test; upgrade BIOS to PnP mode if possible.

Most Common Causes of Hardware Conflicts with Sound Card

The most common causes of system resource conflicts are the following:

- SCSI host adapters
- Network interface cards

- Bus mouse adapter cards
- Serial port adapter cards for COM3 or COM4
- Parallel port adapter cards for LPT2
- Internal modems
- Scanner interface cards

All these cards use IRQ, DMA, and I/O port addresses, which in some cases can overlap with default or alternative sound card settings.

Freeing Up IRQ 5 for Sound Card Use While Still Printing

If you are using an LPT2 port card for a slow-speed device, such as a dot-matrix or low-end inkjet printer, you can often free up its default IRQ 5 by disabling EPP/ECP/IEEE-1284 modes. These modes require use of an IRQ (ECP also uses a DMA channel). Reverting to standard printing will cause most LPT ports to use only I/O port addresses. This will enable you to use the port for printing and its IRQ 5 for a sound card.

Other Sound Card Problems

Like the common cold, audio adapter problems have common symptoms. Table 10.29 will help you diagnose sound card problems.

Table 10.29 Diagnosing Sound Card Problems

Symptom	Cause	Solution
No sound.	Incorrect or missing speaker wires.	Plug speakers into the correct jack (stereo line out/speaker out).
	No power to amplified speakers.	Turn on; attach to AC adapter or use fresh batteries.
	Mono speaker attached to stereo plug.	Use stereo speaker or headset.
	Mixer settings too low.	Adjust master volume setting; turn off mute option.
	Sound card might not be working.	Test with diagnostic software and sounds provided.
	Sound card hardware needs to be reset.	Power down, then on again, or use reset button to restart PC.
	Some games play, but others don't.	Check hardware defaults as above; verify correct version of Windows DirectX or other game API is installed.

Table 10.29 Diagnosing Sound Card Problems Continued

Symptom	Cause	Solution
Mono Sound.	Mono plug in stereo jack.	Use stereo speaker jack.
	Incorrectly wired speakers.	Check color coding.
	Audio card in left-channel mono fail-safe mode because of driver problem.	Reload drivers and test stereo sound.
	Speakers with independent volume controls might be set differently.	Adjust volume to match on both.
Low volume.	Speakers plugged into headphone jack.	Use higher powered speaker jack if separate jacks are provided.
	Mixer settings too low.	Boost volume in mixer.
	Hardware volume control (thumbwheel) on sound card turned too low.	Adjust volume on card.
	Speakers not powered or require more power.	Power speakers, add amplifier, or replace speakers.
Scratchy sound.	Audio card picking up interference from other cards.	Move away from other cards.
	ISA sound card might be dropping signals during hard disk access.	Normal problem due to high CPU utilization of ISA card; use PCI sound card instead.
	Interference from monitor causing interference.	Move speakers farther away. Put subwoofers on the floor to maximize low-frequency transmission and to keep their big magnets away from the monitor.
	Poor quality FM-synthesis music from sound card.	Change to wavetable sound card; check wavetable settings.
Computer won't start after card installation.	Card not seated tightly in expansion slot.	Remove card, reinsert, and restart PC.
IOS Error displayed during Windows 95 startup; system locked up.	Sound card software clashes with Windows Input/Output System (IOS).	Check with sound card vendor for an IOS fix program; might be supplied on install disk; start Windows 9x in Safe mode to locate and install.
Joystick doesn't work.	Duplicate joystick ports on sound card and another card causing I/O port address conflict.	Disable sound card joystick port.
	Computer too fast for inexpensive joystick port.	Buy high-speed joystick port; disable port on sound card; install replacement joystick port card.
		Slow down computer with de-turbo button or BIOS routine.

Table 10.29 Diagnosing Sound Card Problems Continued

Symptom	Cause	Solution
Can't play DVD audio or MP3 files, or use SPDIF connections.	Hardware resource not enabled on sound card.	Enable hardware resource.
	Wrong playback program for media type.	Use correct playback program.
	Volume set too low in sound card mixer program.	Adjust volume for correct playback device in sound mixer program; check volume and power to speakers.
	Cabling incorrect.	Adjust cabling.

Chapter 11

Networking

Client/Server Versus Peer-to-Peer Networking

Table 11.1 compares the features of client/server networking (such as with Novell NetWare, Windows NT Server, and Windows 2000) with peer-to-peer networking (such as with Windows for Workgroups, Windows 9x, Windows Me, and Windows NT Workstation). This table will help you decide which type of network is appropriate for your situation.

Note

Networking is an enormous topic. The following content serves as a reference for field technicians and other professionals. If you need more in-depth information about networking, see Chapter 19 of *Upgrading and Repairing PCs, 12th Edition*, or pick up a copy of *Upgrading and Repairing Networks, Second Edition*.

Table 11.1 Comparing Client/Server and Peer-to-Peer Networking

Item	Client/Server	Peer-to-Peer
Access control	Via user/group lists of permissions; single password provides user access to only the resources on his/her list; users can be given several different levels of access.	Via password lists by resource; each resource requires a separate password; all-or-nothing access; no centralized user list.
Security	High, because access is controlled by user or by group identity.	Low, because knowing the password gives anybody access to a shared resource.
Performance	High, because server doesn't waste time or resources handling workstation tasks.	Low, because servers often act as workstations.
Hardware cost	High, because of specialized design of server, high-performance nature of hardware, redundancy features.	Low, because any workstation can become a server by sharing resources.
Software cost	License fees per workstation user are part of the cost of the Network Operating System server software (Windows NT and Windows 2000 Server, Novell NetWare).	Free; all client software is included with any release of Windows 9x, Windows NT Workstation, Windows 2000 Professional, or Windows Me.

Table 11.1 Comparing Client/Server and Peer-to-Peer Networking Continued

Item	Client/Server	Peer-to-Peer
Backup	Centralized when data is stored on server; allows use of high-speed, high-capacity tape backups with advanced cataloging.	Left to user decision; usually mixture of backup devices and practices at each workstation.
Redundancy	Duplicate power supplies, hot-swappable drive arrays, and even redundant servers are common; network OS normally capable of using redundant devices automatically.	No true redundancy among either peer "servers" or clients; failures require manual intervention to correct with high possibility of data loss.

If you choose any form of Ethernet network hardware for your peer-to-peer network, you can upgrade to a client/server network later by adding a server with the appropriate network operating system. Your existing network cards, cables, and other hardware can still be used with the new server.

Choosing Network Hardware and Software

In this section, you'll receive a detailed checklist of the hardware and software you need to build your network. Although many options are available on the market for network hardware, this discussion assumes that you will be choosing Fast Ethernet hardware that can also work with standard Ethernet networks ("dual-speed" 10/100 cards and hubs). This is the most popular and cost-effective network currently available.

First, start with the number of computers you plan to network together. You need the items discussed in the following section to set up your network.

NIC

One network interface card (NIC) is required for every computer on the network. To simplify technical support, buy the same model of NIC for each computer in a peer-to-peer workgroup network. Today, the best price-performance combination is Fast Ethernet (100BASE-TX) NICs. You should choose dual-speed (10/100) versions of these cards to enable interconnection with standard 10Mbps Ethernet networks.

You should record the brand name and model number of the NIC(s) you are using, as well as the driver version or source. Use Table 11.2 as a guide.

Table 11.2 NIC Location and Information Worksheet

NIC Location and Computer ID	Brand Name	Model #	Cable Type(s)	Speed	Driver Source or Version

UTP Cable

Each NIC must be connected by a cable long enough to reach comfortably between the NIC and the hub, which connects multiple computers. Use Table 11.3 as a guide for recording necessary information regarding your cabling. Your cabling should be Category 5 or better.

Table 11.3 UTP Cable Worksheet

Computer ID	Cable Length	Wiring Standard

You need only one hub for the typical workgroup network.

Hub

Buy a hub of the correct speed with at least enough RJ-45 ports for each computer on the network; for expansion, buy a hub with a couple of empty ports. Use the worksheet shown in Table 11.4 as a guide for recording information about your hub or hubs. Dual-speed 10/100 Ethernet/Fast Ethernet hubs will enable you to connect with existing standard Ethernet networks.

Table 11.4 Hub Worksheet

Hub #	Brand	Model#	# of Ports	Uplink?	Speed(s)

Software

Start by using the built-in networking software supplied with your version of Windows. Any recent version of Windows contains network client and simple peer-server software. Your workgroup network can contain any combination of the following:

- Windows for Workgroups 3.11
- Windows 95
- Windows 98

- Windows 2000 Professional
- Windows NT 4.0 Workstation
- Windows Me

Table 11.5 shows the basic configuration you'll need to complete for any client (accessing services on another PC) and server (sharing services with other PCs) using these versions of Windows.

Table 11.5 Minimum Network Software for Peer-to-Peer Networking

Item	Client	Server
Windows network client	Yes	No
NetBEUI protocol	Yes	Yes
File and print sharing for Microsoft Networks	No	Yes
NIC installed and bound to previous protocols and services	Yes	Yes
Workgroup identification (same for all PCs in workgroup)	Yes	Yes
Computer name (each PC needs a unique name)	Yes	Yes

Any system that will be used as both a client and a server must have the components from *both* columns installed.

Depending on how you plan to use the computer, one or both of the following might also need to be installed:

- If the computer is going to access a Novell NetWare client/server network, the IPX/SPX protocol must also be installed and configured.
- If the computer is going to be used to access the Internet or any other TCP/IP-based network, the TCP/IP protocol must also be installed.

Note that Windows 2000 and Windows Me do *not* install the NetBEUI protocol by default. You must specify it when you set up the network features of either version of Windows if you want to use Direct Cable Connection or create a simple workgroup network. Windows 2000 and Windows Me use TCP/IP as their default network protocol.

Use the Network icon in the Windows Control Panel to choose your network settings. You'll need the following software to set up the network:

- Operating system CDs, disks, or hard-disk image files
- NIC drivers

Network Protocols

The second most important choice you must make when you create your network is which network protocol you will use. The network protocol affects with which types of computers your network can connect.

The three major network protocols are TCP/IP, IPX/SPX, and NetBEUI. Unlike data-link protocols, though, network protocols are not tied to particular hardware (NIC or cable) choices. Network protocols are software and can be installed or removed to any computer on the network at any time as necessary.

Table 11.6 summarizes the differences between these protocols.

Table 11.6 Overview of Network Protocols and Suites

Protocol	Included in Protocol Suite	Best Used for	Notes
IP	TCP/IP	Internet and large networks	Also used for dial-up Internet access; native protocol suite of Windows 2000, Windows Me, and Novell NetWare 5.x
IPX	IPX/SPX	Networks with Novell 4.x and earlier servers	Used by NetWare 5.x for certain special features only
NetBEUI	N/A	Windows 9x, Me, 2000, or Windows for Workgroups peer networks	Can't be routed between networks; simplest network protocol; also used with Direct Cable Connection NIC-less "networking"

All the computers on any given network must use the same network protocol or protocol suite to communicate with each other.

IP and TCP/IP

IP stands for Internet Protocol; it is the network layer of the collection of protocols (or protocol suite) developed for use on the Internet and commonly known as *TCP/IP* (Transmission Control Protocol/Internet Protocol).

Later, the TCP/IP protocols were adopted by the UNIX operating systems, and they have now become the most commonly used protocol suite on PC LANs. Virtually every operating system with networking capabilities supports TCP/IP, and it is well on its way to displacing all the other competing protocols. Novell NetWare 5 and Windows 2000 both use TCP/IP as their native protocol for most services.

Selecting a Network Data-Link Protocol (Specification)

Regardless of the type of network (client/server or peer-to-peer) you select, you can choose from a wide variety of network data-link protocols, also known as *specifications*. The most common ones in use for PCs are listed here. Use Table 11.7 to understand the requirements, limitations, and performance characteristics of the major types of network data-link protocols.

Table 11.7 Network Data-Link Protocols Summary

Network Type	Speed	Max Number of Stations	Cable Types	Notes
ARCnet	2.5Mbps	255 stations	RG-62 coax UTP[1]/Type 1 STP[2]	Obsolete for new installations; was used to replace IBM 3270 terminals (which used the same coax cable).
Home PNA 1.0	1Mbps	N/A	RJ-11 phone cable	Easy home-based networking via parallel-port connections or internal ISA, PCI, or PC Card NICs or USB port; replaced by Home PNA 2.0.
Home PNA 2.0	10Mbps	N/A	RJ-11 phone cable	Easy, faster home-based networking via PCI or PC Card NICs or USB port.
Ethernet	10Mbps	Per segment: 10BASE-T-2 10BASE-2-30 10BASE-5-100 10BASE-FL-2	UTP[1] Cat 3 (10BASE-T), Thicknet (coax; 10BASE-5), Thinnet (RG-58 coax; 10BASE-2), Fiber optic (10BASE-F)	Being replaced by Fast Ethernet; can be interconnected with Fast Ethernet by use of dual-speed hubs and switches; use switches and routers to overcome "5-4-3" rule in building very large networks.
Fast Ethernet	100Mbps	Per segment: 2	Cat 5 UTP[1]	Fast Ethernet can be interconnected with standard Ethernet through use of dual-speed hubs, switches, and routers.

Table 11.7 Network Data-Link Protocols Summary Continued

Network Type	Speed	Max Number of Stations	Cable Types	Notes
Gigabit Ethernet	1000Mbps	Per segment:	2 Cat 5 UTP	Gigabit Ethernet can be interconnected with Fast and/or standard Ethernet through use of dual-speed hubs, switches and routers.
Token Ring	4Mbps or 16Mbps	72 on UTP[1] 250-260 on type 1 STP[2]	UTP[1], Type 1 STP[2], and Fiber optic	High price for NICs[3] and MAUs[4] to interconnect clients; primarily used with IBM mid-size and mainframe systems.

1. UTP = Unshielded Twisted Pair
2. STP = Shielded Twisted Pair
3. NIC = Network Interface Card
4. MAU = Multiple Access Unit

Network Cable Connectors

Several types of network cable connectors are available. Table 11.8 summarizes these and indicates which ones are in current use.

Table 11.8 Network Cable Connectors

Connector Type	Used By	Notes
DB-15	Thick Ethernet	Used a "vampire tap" cable from the connector to attach to the main cable; obsolete.
DB-9	Token Ring	Obsolete.
BNC	RG-62 ARCnet (obsolete), RG-58 Thin Ethernet	Thin Ethernet uses T-connector to enable pass-through to another station or a terminating resistor to indicate end of network segment. Obsolete in most installations; BNC still used in small networks or to connect hubs.
RJ-45	Newer Token-Ring, 10BASE-T Ethernet, Fast Ethernet, Gigabit Ethernet	Twisted-pair cabling overwhelming favorite for most installations.

While virtually all newly installed networks today with conventional cables use twisted-pair cabling, many networks are mixtures of twisted-pair and older cabling types. Token-Ring Network Interface cards and Ethernet cards with all three of the popular

Ethernet connector types remain in wide use. When a network interface card has more than one connector type, you might need to use the card's setup program to select which connector to use.

Wire Pairing for Twisted-Pair Cabling

For large, multi-office installations, network cables are usually built from bulk cable stock and connectors. Because the twisted-pair cabling has eight wires, many pairings are possible. If you are adding cable to an existing installation, you should match the wire pairings already in use. However, the most popular wiring standard is the AT&T 258A standard detailed in Table 11.9. You can buy pre-built cabling that matches this standard or build your own.

Table 11.9 RJ-45 Connector Wire Pairing and Placement AT&T 258A Standard

Wire Pairing	Wire Connected to Pin #	Pair Used For
White/blue and blue	White/blue - #5 Blue - #4	Not used[1]
White/orange and orange	White/orange - #1 Orange - #2	Transmit
White/green and green	White/green - #3 Green - #6	Receive
White/brown - brown	White/brown - #7 Brown - #8	Not used[1]

1. This pair is not used with 10BASE-T or Fast Ethernet 100BASE-TX, but all four pairs are used with Fast Ethernet 100BASE-T4 and with Gigabit Ethernet 1000BASE-TX standards.

Thus, a completed cable that follows the AT&T 268A (also called the EIA/TIA 568B) standard should look similar to the following when viewed from the flat side of the RJ-45 connector (from left to right): orange/white, orange, green/white, blue, blue/white, green, brown/white, brown.

Making Your Own UTP Cables

You will need the following tools and supplies to build your own Ethernet cables:

- UTP cable (Category 5 or better)
- RJ-45 connectors
- Wire stripper
- RJ-45 crimping tool

You can buy all the previous tools for a single price from many different network-products vendors. If you are working with a network with a wiring closet, you will also want to add a punchdown tool to your kit.

Before you create a "real" cable of any length, follow these procedures and practice on a short length of cable. RJ-45 connectors and bulk cable are cheap; network failures are not.

Follow these steps for creating your own twisted-pair cables:

1. Determine how long your UTP cable should be. You'll want to allow adequate slack for moving the computer and for avoiding strong interference sources. Keep the maximum distances for TP cables (listed later in this chapter) in mind.
2. Roll out the appropriate length of cable.
3. Cut the cable cleanly from the box of wire.
4. Use the wire stripper to strip the insulation jacket off the cable to expose the TP wires; you'll need to rotate the wire about 1 1/4 turns to strip away all of the jacket. If you turn it too far, you'll damage the wires inside the cable.

Caution

Don't strip the UTP wires themselves; just the jacket!

5. Check the outer jacket and inner TP wires for nicks; adjust the stripper tool and repeat steps 3 and 4 if you see damage.
6. Arrange the wires according to the AT&T 268B/EIA 568B standard listed previously.
7. Trim the wire edges so the eight wires are even with one another and are slightly less than 1/2" past the end of the jacket. If the wires are too long, crosstalk (wire-to-wire interference) can result; if the wires are too short, they can't make a good connection with the RJ-45 plug.
8. With the clip side of the RJ-45 plug facing away from you, push the cable into place. Verify that the wires are arranged according to the EIA/TIA 568B standard *before* you crimp the plug on to the wires. Adjust the connection as necessary.
9. Use the crimping tool to squeeze the RJ-45 plug on to the cable. The end of the cable should be tight enough to resist being removed by hand.

10. Repeat steps 4—9 for the other end of the cable. Recut the end of the cable if necessary before stripping it.
11. Label each cable with the following information:
    - Wiring standard
    - Length
    - End with crossover (if any)
    - _____ (blank) for computer ID

Note

The cables should be labeled at both ends to make matching the cable with the correct computer easy and to facilitate troubleshooting at the hub. Check with your cable supplier for suitable labeling stock or tags you can attach to each cable.

An excellent online source for this process, complete with illustrations, is `http://www.duxcw.com/digest/Howto/network/cable/`.

Network Cabling Distance Limitations

Network distance limitations must be kept in mind when creating a network. If you find that some users will be "out of bounds" because of these limitations, you can use repeaters, routers, or switches to reach distant users.

Table 11.10 lists the distance limitations of various kinds of LAN cable.

In addition to the limitations shown in the table, keep in mind that you cannot connect more than 30 computers on a single Thinnet Ethernet segment, more than 100 computers on a Thicknet Ethernet segment, more than 72 computers on a UTP Token-Ring cable, and more than 260 computers on an STP Token-Ring cable.

Table 11.10 Network Distance Limitations

Network Adapter	Cable Type	Maximum	Minimum
Ethernet	Thin[1]	607 ft.	20 in.
	Thick (drop cable)[1]	164 ft.	8 ft.
	Thick (backbone)[1]	1,640 ft.	8 ft.
	UTP	328 ft.	8 ft.

Table 11.10 Network Distance Limitations Continued

Network Adapter	Cable Type	Maximum	Minimum
Token Ring	STP	328 ft.	8 ft.
	UTP	148 ft.	8 ft.
ARCnet[1] (passive hub)		393 ft.	Depends on cable
ARCnet[1] (active hub)		1,988 ft.	Depends on cable

1. Indicates obsolete for new installations; may be found in existing installations.

Cabling Standards for Fast Ethernet

Thanks to low costs for cabling, network interface cards, and now hubs, Fast Ethernet networks can be built today at a cost comparable to conventional Ethernet networks. Note that the distance limitations given for 100BASE-TX (the most common type) are the same as for 10BASE-T. Consider using 100BASE-FX fiber-optic cable with media converters for longer runs.

Table 11.11 lists the cabling standards for Fast Ethernet.

Table 11.11 100BASE-T Cabling Standards

Standard	Cable Type	Segment Length
100BASE-TX	Category 5 (2 pairs)	100 meters
100BASE-T4	Category 3, 4, or 5 (4 pairs)	100 meters
100BASE-FX	62.5/125[1] multimode 400 meters (2 strands)	

1. First figure is core diameter; second figure is cladding diameter; both in micrometers

Properly constructed Fast Ethernet 100BASE-TX Category 5 cable can be certified for Gigabit Ethernet operation. Gigabit Ethernet uses all four wire pairs.

Specialized Network Options

The following sections cover specialized networks you might encounter, including the Home PNA networking and wireless networking standards.

What About Home Networking?

So-called *SOHO (small-office/home-office)* users want networks for Internet connection sharing, printer sharing, and file transfer. To avoid the cabling problems and protocol configuration and setup issues of traditional Ethernet networks, the Home Phoneline Network Association (HomePNA) established the HomePNA 1.0 and faster 2.0 standards for using existing phone wiring for networking.

The advantages include

- Easy setup for technical novices because of the integrated nature of the hardware and software
- Choice of internal (card-based) or external (parallel port or USB-based) solutions
- No rewiring needed; uses the phone lines in the home or home office

The disadvantages include

- Difficult to have a portable computer set up to use both HomePNA and standard Ethernet-based networking; special dual-purpose devices are required
- Low speed: HomePNA 2.0 is still just 10Mbps
- Can't turn HomePNA-based network into a client/server network later

Wireless Networking Standards

Wireless networking, once considered a narrow "niche" technology hampered by a lack of standards, is now becoming a major network type.

Star-Topology Wireless Networks

The following networks use a star topology: Wireless NICs send signals to an access point, which relays the signal to the receiving computer. By using multiple access points in a building or campus environment, users can stay connected as they move from room to room or building to building. The NICs automatically switch to the strongest signal from an access point; thus, this type of wireless network is similar in concept to cellular phone networks. The networks are as follows:

- **IEEE 802.11b**—The leading industry standard is IEEE 802.11b, a wireless Ethernet standard designed to interconnect easily with standard Ethernet 10BASE-T networks. It runs at 11Mbps and uses the same 2.4GHz wavelength used by cellular phones and other communications devices. IEEE 802.11b is supported by a number of leading network hardware vendors, and products from different vendors can be mixed and matched just as conventional "wired" Ethernet products can be.
- **RadioLAN Wireless MobilLINK**—The proprietary RadioLAN Wireless MobilLINK runs at 5.8GHz for faster performance. It can't connect directly to IEEE 802.11b devices, but can be connected to standard 10BASE-T Ethernet networks.

Point-to-Point Wireless Networks

Each wireless client sends its signal directly to the receiving client. This is much slower, but also much simpler and less expensive than star-topology wireless LANs. The following standards use a point-to-point topology:

- **HomeRF**—HomeRF is a home-oriented network standard that runs at just 1.6Mbps currently, but future versions will run at 10Mbps. It also can be connected to standard Ethernet networks by means of a wireless bridge. HomeRF products running at 1.6Mbps are available now.
- **Bluetooth**—Bluetooth is a very short-range, slow-speed (400Kbps) standard primarily designed for data interchange between appliance devices, such as pagers, PDAs, and wireless phones, as well as notebook computers. Bluetooth-enabled devices should become available in late 2000.

Both HomeRF and Bluetooth use the same 2.4GHz frequency as IEEE 802.11b, so interference between these types of networks is possible.

Table 11.12 provides an overview of the various wireless network standards currently in use.

Table 11.12 Comparison of Current Wireless Networks

Network	Rated Speed	Logical Topology	Connects with 10BASE-T Ethernet via	Maximum Number of PCs per Access Point	Average Cost per User[5]
IEEE 802.11b	11Mbps	Logical Star (requires access point)	Access point	Varies by brand and model; up to 2048	$525[1,2]
RadioLAN	10Mbps[3]	Logical Star (requires access point)	Wireless BackboneLINK (access point)	128	$600[2]
HomeRF[4]	1.6Mbps	Point-to-Point	Symphony Cordless Ethernet Bridge	10	$139

1. Average price of products from Cisco, Lucent, and 3Com as of 2000.

2. Price includes access point (required).

3. Actual throughput of RadioLAN compared to average of IEEE 802.11b products is about 25% faster due to higher radio frequency used.

4. Figures for Proxim Symphony, first HomeRF product available.

5. Average cost per user based on a four-station network with two PCI desktop and two notebook PCs and one access point (if needed).

Wireless Network Configuration and Selection Issues

Wireless NICs require an IRQ and I/O port address range, just as conventional NICs do. Other configuration and product selection issues include the following:

- **NIC Card Type**—With most wireless networks, you can choose PCI-based NICs for desktop computers and PC Card—based NICs for notebook computers. Although the speed of current wireless networks also permits the use of ISA cards, you should avoid these because this 16-bit card design is obsolete.
- **Network Security and Encryption**—For maximum security, select wireless network products that support either of these features:
    - A seven-digit security code called an ESSID; wireless devices without this code can't access the network
    - A list of authorized MAC numbers (each NIC has a unique MAC); a wireless device not on the MAC list can't access the network

These features must be enabled to be effective. Also, use the strongest data encryption your network supports. Many of the early versions of IEEE 802.11b network devices supported only the "weak" 40-bit encryption when introduced, but installable updates to "strong" 128-bit encryption should be available later. You should switch to strong encryption as soon as possible to provide another layer of network security.

TCP/IP Network Protocol Settings

TCP/IP is taking over the computing world, replacing the hodgepodge of competing protocols used earlier in networking (NetBIOS, NetBEUI, and IPX/SPX). TCP/IP is the standard protocol of the World Wide Web, as well as of the latest network operating systems from Novell (NetWare 5) and Microsoft (Windows 2000). Even though it's used by both dial-up (modem) users and LAN workstations, the typical configurations in these situations have virtually nothing in common. Use Table 11.13 as a guide to what must be set, and remember to record the settings your TCP/IP connections use.

Table 11.13 TCP/IP Properties by Connection Type—Overview

TCP/IP Property Tab	Setting	Modem Access ("Dial-Up Adapter")	LAN Access ("XYZ Network Card")
IP Address	IP Address	Automatically assigned by ISP	Specified (get value from network administrator)
WINS[1] Configuration	Enable/Disable WINS Resolution	Disabled	Indicate server or enable DHCP[2] to allow NetBIOS over TCP/IP
Gateway	Add Gateway/ List of Gateways	None (PPP is used to connect modem to Internet)	IP address of to Gateway used connect LAN to Internet
DNS[3] Configuration	Enable/Disable Host Domain	Usually disabled, unless proxy server used by ISP	Enabled, with host and domain specified (get value from network administrator)

1. *WINS = Windows Internet Naming Service; used on NT servers to automatically manage the association of workstation names and locations to IP addresses; used with DHCP (see note 2)*
2. *DHCP = Domain Host Configuration Protocol; sets up IP addresses for PCs connected to an NT network*
3. *DNS = Domain Name System; matches IP addresses to Web site names through the use of name servers*

TCP/IP Protocol Worksheet

Use the worksheet shown in Table 11.14 to track TCP/IP settings for either network card or dial-up connections. The settings are based on the Networks icon in Windows 9x. The first worksheet is blank; the second worksheet lists typical (fictitious) settings for a workstation on a LAN.

Table 11.14 TCP/IP Protocol Settings Worksheet

IP Address					
Address	Subnet	Automatically assigned			
WINS Configuration					
Enable/ Disable	Primary WINS Server	Secondary WINS Server	Scope ID	Use DHCP for WINS Resolution	
Gateway (list in order; top = first)					
First	Second	Third	Fourth	Fifth	Sixth
Bindings That Will Use This Protocol (list)					
Advanced (list)					
Use TCP/IP as Default					

Table 11.14 TCP/IP Protocol Settings Worksheet Continued

IP Address

DNS Configuration

Disable/ Enable DNS	Host	Domain			
First DNS Server	Second DNS Server	Third DNS Server	Fourth DNS Server	Fifth DNS Server	Sixth DNS Server
First Domain Suffix	Second Domain Suffix	Third Domain Suffix	Fourth Domain Suffix	Fifth Domain Suffix	Sixth Domain Suffix

Table 11.15 shows how TCP/IP protocols could be set up to enable Internet access via a LAN in an office building. If you use TCP/IP for both Internet and LAN access as your only protocol, your settings will vary.

Table 11.15 Completed TCP/IP Protocol Settings Worksheet—LAN Connection

IP Address

Address	Subnet	Automatically assigned	Notes
192.168.0.241	255.255.255.0	No	If automatically assigned = "Yes", no values are used for either address or subnet

WINS Resolution

Enable/ Disable	Primary WINS Server	Secondary WINS Server	Scope ID	Use DHCP for WINS resolution	Notes
Disable	(blank)	(blank)	(blank)	(blank)	If "disable", no values for other fields

Gateway (list in order; top=1st)

First	Second	Third	Fourth	Fifth	Sixth
192.168.0.1	192.168.0.2	(blank)	(blank)	(blank)	(blank)

Bindings That Will Use this Protocol (list)

Client for Microsoft Networks enabled	File and Print Sharing for Microsoft Networks* disabled	Note *This is a very dangerous setting. While this may be listed as an option, do not enable it if you use another protocol for your LAN. Enabling this setting would allow anybody on the Web access to your system!

Advanced (list)

Use TCP/IP as Default	Other value(s)	Note *This network also uses NetBEUI for internal LAN communications; if TCP/IP were the only protocol, it would be enabled as default.
disabled*	(none)	

Table 11.15 Completed TCP/IP Protocol Settings Worksheet—LAN Connection Continued

DNS Configuration					
Disable/ Enable DNS	Host (list)	Domain			
Enabled	smithy	Biz-tech.com			
First DNS Server	Second DNS Server	Third DNS Server	Fourth DNS Server	Fifth DNS Server	Sixth DNS Server
192.168.0.1	(none)	(none)	(none)	(none)	(none)
First Domain Suffix	Second Domain Suffix	Third Domain Suffix	Fourth Domain Suffix	Fifth Domain Suffix	Sixth Domain Suffix
(none)	(none)	(none)	(none)	(none)	(none)

Troubleshooting Networks

Use Tables 11.16 and 11.17 to help you find solutions to common networking problems.

Troubleshooting Network Software Setup

Table 11.16 Troubleshooting Network Software Setup

Problem	Symptoms	Solution
Duplicate computer IDs.	You get a "duplicate computer name" message at startup.	Make sure that every computer on the network has a unique ID (use Control Panel, Network Identification to view this information). Set the ID before connecting to the network.
Workgroup name doesn't match.	You don't see other workstations in Network Neighborhood.	Make sure that every computer that's supposed to be working together has the same workgroup name. Different workgroup names actually create different workgroups, and you'd need to access them by browsing via "Entire Network."
Shared resources not available.	You can't access drives, printers, or other shared items.	Make sure that shared resources have been set for any servers on your network (including "peer servers" on Windows 9x). If you can't share a resource through Windows Explorer on the peer server, make sure that File and Printer Sharing has been installed.
Changes to configuration don't show up.	Network doesn't work after making changes.	Did you reboot? Any change in the Network icon in Windows 9x Control Panel requires a system reboot. Did you log in? Any network resources can't be accessed unless you log in when prompted. You can use Start, Shutdown, Close all Programs, and log in as a new user to recover quickly from a failure to log in.

Troubleshooting Networks in Use

Table 11.17 Troubleshooting Networks On-the-Fly

Problem	Symptoms	Solution
Connection to network not working for one user	Other users can use shared printers, drives, and so on.	First, have the user use Start, Close All Programs and log in as new user. Pressing Cancel or Esc instead of logging in keeps the user off the network. Use Network Neighborhood to browse other computers on network. If browse won't work, make sure correct Network name is listed in properties and that correct protocols and protocol configurations are present. All computers in a workgroup must use same the workgroup name and protocol(s). Next, check cable connections at the server and workstation. Check NIC for proper operation. Use diagnostics software provided with most cards to test NVRAM, interrupt, loopback, and send/receive signal functions. Use the diagnostics on two NICs on the same network to send and receive signals from each other. Use Windows 9x or 2000's Device Manager and check NIC's properties. If any resource conflicts are present, card won't work. Note that IRQ steering on PCI cards with recent chipsets enables multiple devices to share an IRQ without a conflict.
Connection to network not working for multiple users	No one can access network.	Loose terminators or BNC T-connectors will cause trouble for all workstations on Thinnet cable segment. Hub power or equipment failure will cause trouble for all stations using UTP.
Have read-only access instead of full access	Can't save files to shared drive.	If you save your passwords in a password cache, entering the read-only password instead of the full-access password will limit your access with peer servers.

Table 11.17 Troubleshooting Networks On-the-Fly Continued

Problem	Symptoms	Solution
Have read-only access instead of full access	Can't save files to shared drive.	Try un-sharing the resource and try to re-share it, or have the user of that peer server set up new full-access and read-only passwords. Or, don't use password caching by unchecking the Save Password box when you log in to a shared resource. With a client/server network with user lists and rights, check with your network administrator because he or she will need to change the rights for you.

Troubleshooting TCP/IP

Use Table 11.18, in addition to the TCP/IP information presented earlier, to troubleshoot a TCP/IP connection on either a LAN or dial-up connection.

Windows 2000 uses a single networking wizard to configure both types of network connections. With other versions of Windows, TCP/IP configuration for LANs takes place in the Network icon in Control Panel, whereas modems are configured through the Dial-Up Networking properties sheet for a given dial-up connection.

Web browsers that communicate through proxy servers or gateways with the Internet also might require special configuration options. Use the Internet icon in Control Panel to adjust Microsoft Internet Explorer TCP/IP settings. With Netscape Navigator/Communicator, use Edit, Preferences, Advanced, Proxies to adjust proxy server settings.

Table 11.18 Troubleshooting TCP/IP Connections

Problem	Symptoms	Solution
Incorrect settings in network properties.	Can't connect to any TCP/IP resources.	Get correct TCP/IP settings from administrator and enter; restart PC.
Problem with server type or PPP version.	Can't keep connection running in Dial-Up Networking.	Might have wrong version of PPP running (classic CompuServe uses CISPPP instead of normal PPP); change server type in properties under Dial-Up Networking, not Networks.
Duplicate IP addresses.	Error message indicates "the (TCP/IP) interface has been disabled" during startup.	Duplicate IP addresses will disable both TCP/IP and NetBEUI networking if NetBEUI is being transported over TCP/IP.

Table 11.18 Troubleshooting TCP/IP Connections Continued

Problem	Symptoms	Solution
One user to an IP address.	Can't share the Web.	If you're trying to share your Internet connection, use software such as Artisoft's Ishare or check with your networking hardware vendor for their recommendations. If your LAN uses a proxy server for connection, some sharing products might not work. Windows 98 Second Edition, Windows 2000 Professional, and Windows Me can all be configured as a gateway to enable Internet sharing from a cable modem, dial-up modem, ISDN, or DSL modem connection. For details, see Chapter 6, "Serial Ports and Modems."
Browser can't display Web pages.		To verify that the TCP/IP connection works, open an MS-DOS window and type `PING websitename` (replace `websitename` with a particular IP address or Web site). If `PING` indicates that signals are returning, check the proxy settings in the browser. If `PING` can't connect, recheck your TCP/IP settings for the NIC or modem and retry after making changes.

Direct Cable Connections

Null Modem and Parallel Data-Transfer Cables

A *null modem cable* is a special cable that has its circuits crossed so the transmit data (TD) pin on each serial port connector leads to the receive data (RD) pin on the other. A cable that connects the systems' parallel ports in this way is called a *parallel data-transfer cable*. Cables such as these are usually available at computer stores that sell cables. They are sometimes called *LapLink* cables, after one of the first software products to introduce the concept of the direct cable connection. The cables supplied with FastLynx and other data-transfer programs for MS-DOS and Windows 3.x/9x/Me will also work. A good rule of thumb is this: If the cable works for LapLink or the MS-DOS INTERLNK file transfer utility, you can use it for Direct Cable Connection, as well.

You also can build your own null modem or parallel data-transfer cable using the wiring diagrams that follow. Table 11.19 shows the pins you must connect for a serial cable, using either DB-9 (9-pin) or DB-25 (25-pin) connectors. Table 11.20 shows the connections for a parallel port cable. The parallel cable is slightly harder to build, but is recommended because of its much higher transfer speed and because it will not interfere with existing modems and mouse drivers on computers.

Table 11.19 3-Wire Serial Null Modem Cable Pinouts

PC#1	DB-9	DB-25	DB-25	DB-9	PC#2
TD	3	2 <————>	3	2	RD
RD	2	3 <————>	2	3	TD
SG	5	7 <————>	7	5	SG

Table 11.20 11-Wire Parallel Data-Transfer Cable Pinouts

PC #1	PC #2
2 <————>	15
15 <————>	2
3 <————>	13
13 <————>	3
4 <————>	12
12 <————>	4
5 <————>	10
10 <————>	5
6 <————>	11
11 <————>	6
25 <————>	25

If you plan to use parallel-mode DCC on a frequent basis, consider purchasing a high-speed Direct Parallel Universal Fast Cable from Parallel Technologies, creators of the Direct Cable Connection software for Microsoft (`www.lpt.com`). This cable also works with third-party remote-control and file-transfer programs, such as LapLink 2000 and PCAnywhere. This cable boosts performance significantly, especially on systems using ECP or EPP parallel ports.

Direct Connect Software

After you have the hardware in place, you need the proper software for the two systems to communicate. At one time, you had to purchase a third-party product (such as LapLink) to do this, but the

capability is now part of most operating systems, including DOS 6, Windows 9x, Windows Me, Windows NT 4, and Windows 2000. One computer is designated the host and the other is the guest. The software enables a user, working at the guest machine, to transfer files to and from the host. With Windows, you must specify which folders or drives you will share, and you have the option with Windows 9x and Windows Me to specify a password. Windows NT and Windows 2000 require that you add the guest user to your list of authorized users for the host system.

Setting Up and Using MS-DOS Interlink

In DOS, the software consists of two executable files, called INTERSVR.EXE and INTERLNK.EXE. In the DOS version, you run the INTERSVR program on the host computer. This system can be running a different version of DOS; therefore, you have to copy the INTERSVR.EXE program to it from a DOS 6 machine (using a floppy disk). Select the COM or LPT port to which you have connected the cable. INTERSVR then waits until INTERLNK makes a connection.

On the guest computer, you run the INTERLNK.EXE program from a DOS prompt. As before, you are prompted to select the COM or LPT port to which you have connected the cable. After this is completed, the INTERLNK software establishes the connection with the host computer running INTERSVR. Then, the guest computer mounts the drives from the host in its own file system, assigning them the next available drive letters with Interlink.

Setting Up and Using Windows 9x/Me Direct Cable Connection

On Windows 9x/Me, you click the Start menu and then select Programs, Accessories, Direct Cable Connection (on some systems it might be stored in a Communications folder beneath the Accessories folder). Then, choose the Host option button. You are prompted to select the COM or LPT port to which you have connected the cable.

On the other computer, you select the same Direct Cable Connection menu item in Windows and choose the Guest option button. Again, you are prompted to choose the correct port, after which the software establishes a connection between the two machines. With the Windows Direct Cable Connection, you can either access the shared drive as a folder or map a drive letter to it with Windows Explorer after the connection is established.

Windows 9x and DCC can use parallel, serial, or IR ports. Windows Me can also use a separate IR Link utility for initiating file transfers via the infrared port.

Setting Up Windows NT 4 Direct Connection

Windows NT 4 treats direct connections as a form of dial-up networking that uses a serial cable as a substitute for a modem. Thus, you must use the Modems icon in Control Panel to Install a New Modem: Choose Dial-Up Networking Serial Cable Connection Between 2 PCs from the list of standard modems. Parallel connections are not supported in NT 4.

If you are going to host the connection, you also need to do the following:

- Install and configure NT networking (if not already installed)
- Install and configure remote access services (RAS)
- Install NetBEUI protocol

This process is clumsy and complex. A good visual tutorial for both host and guest setup is available online at J. Helmig's World of Windows Networking Web site:

```
www.helmig.com/j_helmig/dccnt4.htm
```

As an alternative, you might want to use LapLink 2000 or other file-transfer programs with your NT 4 system.

Hosting NT 4 Dial-Up Networking Serial Cable Connections

If you're hosting the connection, log in as Administrator, open the Administrative Tools (common) folder on the Start button, and select Remote Access Administrator.

Open the Server menu and then select Start Remote Access Service. Your server will wait for the connection.

Using NT 4 Dial-Up Networking Serial Cable as Guest

Open the Dial-Up Networking Wizard and create a new connection. For the modem, select the Dial-Up Networking Serial Cable you installed previously. Do not enter a phone number. Click the Server tab and specify PPP: Windows NT as the server type. Next, select NetBEUI as the protocol, select Enable Software Compression, and deselect Enable PPP LCP Extensions.

Enter the username and password required to make the connection to an NT 4 or a Windows 2000 host. If you are connecting to a Windows 9x/Me Direct Cable Connection host instead, you can use any username you want, but enter a password only if the shared resource is using a password for security. After you are connected, you can use the Dial-Up Networking Monitor to check your connection status and speed.

Setting Up and Using Windows 2000 Direct Parallel and Direct Serial Connections

In Windows 2000, you use the same Network Connection Wizard used for other types of network connections to make the link. Most of the network setup work is already done if you also use modem or LAN networking with the computer. Before you start, ensure that the NetBEUI protocol has been installed. Open the Networks icon in the Control Panel, select your current network connection, and view its properties.

To create a connection, click Start, Settings, Network and Dial-Up Connections. Open Make New Connection to start the wizard. If you are prompted for telephone information (area code and outside dialing code), fill in the information before continuing. If you don't fill this in, your connection options are limited.

To set up DCC, click Next on the first screen and then select Connect Directly to Another Computer. On the next screen, select Host or Guest. Then, on the following screen, select the parallel or serial port you want to use (parallel is recommended).

Next, select the user you are granting access to from the list of authorized users. If the user you want to grant access to isn't listed, add him with the Users option in the Control Panel. Click Next and then Finish to complete the connection setup process. The system waits for you to make the connection.

Windows 9x, Me, NT 4, and 2000 systems can use their versions of DCC to connect to each other as either guest or host.

Using DCC

After a connection has been established, you can use the drive letters or folders representing the host system just as though they were local resources. You can copy files back and forth using any standard file management tool, such as the DOS COPY command or Windows Explorer. The only difference is that file transfers will, of course, be slower than local hard drive operations.

DCC is the perfect way to install CD-ROM–based software to older machines lacking such drives. You can install the DCC Host software on a notebook computer with a CD-ROM drive, install the DCC Guest software on a desktop computer, cable them together, and install the software. DCC is also the cheapest network around.

I've also used DCC to run tape backups remotely. I set up the system I wanted to back up as the host and logged in to it as guest with the computer containing the tape backup program. After mapping the remote drive to a drive letter, I was able to back up the files via a parallel LapLink-style cable.

Some users have set up DCC on machines using the TCP/IP protocol and used it for game playing. For other advanced tricks you can perform with DCC, see the following Web site:
`www.tecno.demon.co.uk/dcc/dcc.html`.

Troubleshooting Direct Cable Connections

As Table 11.21 and the following checklist indicate, several places exist where a Direct Cable Connection setup can go wrong. Use this checklist, and Table 11.21, to make this virtually free "network" work best for you:

- Make sure the same networking protocols are installed on both the host and guest machines with Windows 9x, Me, NT, or 2000. The simplest protocol to install is NetBEUI, and that's what Parallel Technologies (creator of DCC) recommends for a basic DCC mini-network. To configure NetBEUI, all you need to supply is the workgroup name (same for both guest and host) and a unique computer name for guest and for host.
- Use the parallel (LPT) ports for DCC when possible; although serial (COM) or IR port transfers will work, they are unbearably slow. Note that Windows Me refers to IR ports by their COM port alias in DCC, not specifically as IR ports.
- Ensure that both host and guest LPT ports are working correctly, with no shared IRQ problems. Use the Windows 9x/Me/2000 Device Manager to check for IRQ conflicts with the parallel port you're using.
- Make sure the person using the guest computer knows the network name of the host computer (set through the Networks icon in Control Panel, Identification tab). With a simple protocol such as NetBEUI, it might be necessary to enter the name to log in to the host machine.

- If the user you want to connect to your Windows 2000 or Windows NT host computer isn't on the list of authorized users, you'll need to add that user before you set up the direct connection.
- Install the Client for Microsoft Networks on the guest computer.
- Don't print to the printer(s) normally connected to the LPT port while you're using DCC; the printer will be set for offline mode and require you to manually release the print jobs after you re-establish the printer(s). Also, allow any print jobs to finish (or hold them or delete them) on any port you want to use for DCC before you set up your cables.
- Make sure that the host computer is sharing a drive, so that the guest computer can copy files from it or move files to it. The sharing is accomplished in the same way that peer-to-peer network sharing is done on Windows 9x/Me systems; on Windows NT/2000, you specify permissions for authorized users.
- If you don't want to unplug your printer to use DCC, you might want to add a second printer port for DCC use if you plan to use this option frequently.
- Download the DCC troubleshooter from the FAQs and troubleshooting page at Parallel Technologies's Web site: `www.lpt.com/faqs1.htm`.

Use Table 11.21 to see whether you are ready to connect your computers via DCC.

Table 11.21 Direct Cable Connection–Type Configuration Requirer

Operating System	Host Program	Guest Program	Network Components Types to Install	Port Supported
MS-DOS 6.x	INTERSVR.EXE	INERLNK.EXE	None	Serial, parallel
Windows 9x Windows Me	Direct Cable Connection (host and guest)		NetBEUI, MS Network Client	Serial, parallel, IR
Windows NT 4	Dial-Up Networking (host and guest)		Modem: direct serial connection, NT Networking, RAS, NetBEUI	Serial
Windows 2000	Direct Parallel or DirectSerial connection (host and guest)		Networking, RAS, NetBEUI	Serial, parallel, IR

Chapter 12

Operating System Installation and Diagnostic Testing

This chapter covers methods for testing and diagnosing systems and the software you'll use. For hardware tools, see Chapter 13, "Tools and Techniques."

Installing an Operating System on an Empty Drive

Use this section for a quick reference for the procedures you'll follow and software you'll need to install an operating system.

Installing MS-DOS

Prerequisites:

Create a bootable disk (containing COMMAND.COM and hidden files). The boot disk also should contain FDISK, FORMAT, SYS, and MSD, along with Help, Qbasic, and Edit files. Create the bootable disk with FORMAT A:/S on a system with the same MS-DOS version. Then, copy files from the \DOS folder.

Follow these steps:

1. Boot the system with the bootable disk.
2. Run FDISK and create the partition(s) desired. The drive must have an active (which will be C: and bootable) partition; it can also have an extended partition (D: and beyond) that can contain one or more drives.
3. Exit FDISK.
4. Reboot the computer with the bootable disk.
5. Run FORMAT to format drive(s) created with FDISK:

   ```
   FORMAT C:/S formats & copies system files to C:
   FORMAT D: formats D: drive if present; repeat for
   E: & others
   ```

6. Remove the bootable floppy and restart the system from the C: drive.
7. Install the remainder of the operating system files from the disk or other storage device (install drivers first if necessary).

Installing Windows 9x

Prerequisites:

You'll need an Emergency System Disk (create it on a computer with the same OS, or use the bootable disk supplied with the full version). The disk must contain at least COMMAND.COM and hidden files, plus FDISK, FORMAT, SYS, and Edit.

Follow these steps:

1. Boot the system with the Emergency System Disk.
2. Run FDISK and select Large Drive Support if you want to exceed 2GB per drive letter with Windows 95 OSR2.x/98/Me. Create the partition(s) desired. The drive must have an active partition (which will be C: and bootable) and can also have an extended partition (D: and beyond) that can contain one or more drives.
3. Exit FDISK.
4. Reboot the computer with the bootable disk.
5. Run FORMAT to format drive(s) created with FDISK:

   ```
   FORMAT C:/S formats & copies system files to C:
   FORMAT D: formats D: drive if present; repeat for
   E: & others
   ```

6. Remove the bootable floppy and restart the system from the C: drive.
7. Install the remainder of the operating system files from the CD-ROM or Windows 95 disc; install CD-ROM drivers and restart the system. You must provide proof of a previous OS purchase (old Windows disks or CD-ROM) when prompted if you are installing an upgrade version onto a blank drive.

Note

You can also use OEMSETUP from a CD-ROM (called by the setup program on disk) if you want to automate the process with the full (non-upgrade) version.

Installing Windows Me

Prerequisites:

- An Emergency Startup (boot) Disk (EBD) created from another Windows Me or Windows 98 installation

- Hardware drivers (for Me or Windows 98) for any hardware not supported by the drivers on the Windows Me CD-ROM
- The Windows Me CD-ROM drive

Follow these steps:

1. Boot the system with the Emergency Startup Disk.
2. Run FDISK and select Large Drive Support if you want to exceed 2GB per drive letter *and* if any other OS you might install can also use FAT-32. Create the partition(s) desired. The drive must have an active partition (which will be C: and bootable); it can also have an extended partition that can contain one or more drives (D: and beyond).
3. Exit FDISK.
4. Reboot the computer with the Emergency Startup Disk.
5. Run FORMAT to format drive(s) created with FDISK:

```
FORMAT C: formats C: drive
FORMAT D: formats D: drive if present; repeat for
E: & others
```

6. Restart the system with the EBD; boot files will be installed on the hard disk during step 7.
7. Install the remainder of the operating system files from the Windows Me CD-ROM as prompted. Restart the system when prompted. You must provide proof of a previous OS purchase (such as old Windows disks or a CD-ROM) when prompted if you are installing an upgrade version onto a blank drive.

Installing Windows NT 4.0 or Windows 2000

Prerequisites:

You will need to create setup disks (three or four—it varies with each version) by running WINNT32 from the \I386 folder of the Windows NT 4.0 or Windows 2000 CD-ROM. The computer you use to create these disks doesn't need to be running Windows NT 4.0 or Windows 2000.

Follow these steps:

1. Start the installation process on the target computer by putting Setup disk 1 into the A: drive and restarting the computer; follow the prompts for each additional disk.

2. Put the Windows NT 4.0 or Windows 2000 CD-ROM into the CD-ROM drive on the target computer when prompted and follow the prompts to complete the installation process.

Upgrading an Operating System

Installing to the Same Folder

Installing the new version of an operating system (such as Windows 9x, Me, or 2000) to the same folder as the existing version of Windows upgrades your current copy. You will not need to reinstall applications to use them.

Installing to a Different Folder

Installing the new version of an operating system to a different folder can enable you to *dual-boot* (select which operating system to use at each system startup) your computer. If you want to use your existing applications with the new operating system, you must reinstall your applications to the new folder.

> **Note**
>
> If you are interested in building a computer with more than one bootable operating system, I recommend picking up a copy of *The Multi-Boot Configuration Handbook*, published by Que.

Installing to a Different Partition

Installing the new version of an operating system to a different partition is similar to installing to a different folder, plus it enables you to use a more efficient partitioning method than if you install to the same folder or different folder on the same drive. See information on FAT-32 and NTFS in Chapter 4, "SCSI and IDE Hard Drives and Optical Drives," for details.

Checking for IRQ, DMA, I/O, and Memory Usage

MS-DOS Using MSD

Follow these steps:

1. Start MSD from the \DOS or \Windows folder, or from the CD-ROM if you are using a version of Windows 9x that includes it.
2. To see IRQ usage, select Q from the main menu.

3. View the IRQ listing; items listed as "reserved" are *allegedly* available, unless you see a device driver or device name listed in the right column. Standard IRQs are also listed; however, if the device (serial, parallel, or other port) is absent, the IRQ listed for the device is also free.

Note

MSD is unreliable for detecting IRQ usage by non-standard peripherals, such as sound cards and network cards. If you run MSD within an MS-DOS window under Windows 9x, you will see memory and other information assigned to your DOS session, rather than the full amount of memory and so on.

As an alternative that's also more accurate, use the IRQ detection features in Norton Diagnostics (part of the Norton Utilities or System Works), CheckIt, QA Plus, or AMIDiag (the latest versions are best).

4. To see the I/O Port address usage for serial and parallel ports only, select C(om) for serial ports or L(pt) for parallel ports.
5. To see the conventional memory usage (BIOS chips and UMBs), select M from the main menu. The display on the left shows a visual map of usage; the display on the right lists memory managers in use and memory created by HIMEM.SYS, EMM386.EXE, or equivalents.

Windows 9x/2000/Me

1. Right-click My Computer.
2. Select Properties.
3. Select the Device Manager tab.
4. Double-click the Computer icon at the top of the list of device categories.
5. Select Interrupt Request (IRQ) from the list of choices.
6. The IRQs in use (0–15) are listed along with the devices using them; IRQs not listed are free. A yellow (!) icon indicates devices with conflicts or other problems. A blue (I) icon indicates a PnP (Plug and Play) device that has been set manually.

Note

Use the same procedure for DMA, I/O port address, and memory address detection.

Windows NT 4.0

1. Click the Start button, Programs, Administrative Tools (common), Windows NT Diagnostics.
2. Select the Resources tab.
3. Click IRQ to see the IRQs in use, along with the devices using them; IRQs not listed are available.
4. Click I/O Port to see I/O port addresses in use.
5. Click DMA to see DMA channels in use.
6. Click Memory to see memory addresses in use.

Software Toolkit

Tables 12.1–12.3 list the software tools you should have to perform important tests.

Tip

If you have a CD-R or CD-RW drive and licenses permit, create a CD-R with an entire collection of tools you can take with you.

Table 12.1 Operating System Software and Drivers

Item	Purpose	Notes
Your operating system files on CD	Allows fast reloading to fix numerous problems	Verify exact operating system on computer before reloading.
Bootable disk with CD-ROM driver(s) for each operating system supported	Allows operating system reload when Windows isn't working	Verify exact operating system on computer before reloading.
Standard system image on bootable CD-R	Can be restored in minutes to a system with a standard hardware configuration	Create with Drive Image, Norton Ghost, PowerQuest EasyRestore, or ImageCast plus bootable option in CD-R creation software. Bootable CD-ROM requires boot files onboard, boot CD-ROM first setting in BIOS, and boot-compatible drive.

Table 12.1 Operating System Software and Drivers Continued

Item	Purpose	Notes
Windows 98/Me Emergency disk	Has drivers for most CD-ROM drives	Can be used to "cheat" by making a CD-ROM drive available for a Windows 95 installation.
Network card software	Including drivers, test, and diagnostic software	Use to verify proper operation and test network communication.

Table 12.2 includes the most popular testing, maintenance, and reference programs and files found in Microsoft Windows and MS-DOS.

Table 12.2 Testing, Maintenance, and Reference Software Included in Major Operating Systems

Item	Name	Notes
MSD.EXE	Microsoft Diagnostics	Found in MS-DOS and Windows 3.1 standard installations and on some versions of the Windows 95 CD-ROM. Provides useful information, especially on COM and LPT ports, BIOS and video data, and mouse testing. Offers printer testing that works for laser, inkjet, and even PostScript printers. Inaccurate IRQ listings are a major limitation.
WINMSD.EXE	Microsoft Diagnostics	Standard Windows NT system reporting tool.
HWDIAG.EXE	Hardware Diagnostics	Found on OEM CD-ROM versions of Windows 95 OSR2.x. Can be downloaded from `User.aol.com/AXCEL216/osr2.htm` (the Tricks + Secrets Files database) for Win95 users who don't have it on their CD-ROMs. More thorough and accurate than the Windows 95 Device Manager information about hardware drivers and resources. Also lists INF files and Registry keys. Works with all releases of Windows 95.
HWINFO.EXE	System Diagnostics	Similar to HWDIAG.EXE, but for Windows 98.
MSIE32.EXE	System Information	Standard part of Windows 98 and Office 97. Provides information superior to Device Manager reports in Windows 95. Office 97 and newer versions can be used with Windows 95/98/NT4. Maintains history of device drivers and links to other repair tools.

Table 12.2 Testing, Maintenance, and Reference Software Included in Major Operating Systems Continued

Item	Name	Notes
Win95rk.hlp	Windows 95 Resource Kit	The entire 1,200+ page text of Windows 95 Resource Kit book is stored on the Windows 95 CD-ROM as a help file in \Admin\Reskit\Helpfile. Windows 98 Resource Kit Online is a similar product stored in Tools\Reskit\Help on the Windows 98 CD. Both provide large amounts of technical references and troubleshooters not found in the standard help system.
Help.exe	MS-DOS 6.x Help file	Standard part of the MS-DOS 6.x installation. Contained on some CD-ROM versions of Windows 95. Lists all internal and external MS-DOS 6.x commands along with syntax and usage notes. Most command-line utilities in Windows 9x are similar, so it's still useful to refer to. Limited help is available with most DOS or Windows command-line utilities by typing /? after the command.
Scandisk.exe	Scandisk	Standard utility in MS-DOS 6.x, Windows 9x/Me, and Windows NT/2000. Performs a check of disk structures and (optional) surface testing. Runs automatically in Windows 95 OSR2.x and Windows 98/Me if Windows isn't shut down properly. Best used from drive properties sheet in Windows 9x/Me/NT/2000 because it tracks last use. Run before defrag or backup.
Defrag.exe	Defrag	Standard utility in MS-DOS 6.x and Windows 9x/Me/2000. Realigns all files into contiguous clusters in full defrag mode. Windows 98/Me offers enhanced options for faster program loading. Run program from the Start button to adjust properties. Windows NT 4.0 and earlier must use a third-party defragmenter, such as Diskeeper. Windows 2000 contains a defragger based on Diskeeper.

Table 12.3 lists third-party diagnostic and testing utilities, most of which go beyond what can be done with built-in operating system utilities. Web sites are listed for products that aren't widely found at retail locations.

Table 12.3 Third-Party Test and Diagnostic Utilities

Program	Uses	Notes
Norton Utilities	Hardware testing, data protection, data recovery, system information, system speedups, anti-virus; defragment and disk testing routines significantly better than standard Microsoft utilities	Best buy when purchased as part of System Works Professional, which includes many other programs; loopback plugs are available for serial and parallel port testing.
AMIDiag (`www.ami.com`)	Hardware testing, system information; burn-in test routines included for stress testing of new equipment	From the makers of the AMI BIOS; are loopback plugs available for serial and parallel port testing.
Win CheckIt 6.5 (`www.checkit.com`)	Hardware testing, system information; burn-in test routines included for stress test of new equipment; for Windows 9x/Me/NT	Can be used to gather information from multiple PCs and analyze reports at a single PC; loopback plugs are available for serial and parallel port testing.
TestDrive (`www.msd.com`)	Floppy drive testing and diagnostic utility	Provides thorough information, especially when used with the appropriate Accuride Digital Diagnostic Disk.
SpinRite (`www.grc.com`)	Hard disk testing and data recovery	Dynastat Data Recovery, extremely accurate at recovering data from damaged drives; same vendor offers Trouble in Paradise tester for Zip drive media.
AntiVirus Available from Trend Micro, Norton, DrSolomon, McAfee, and others	Detect, clean, and prevent viruses and attacks	Use against program, macro, data, and Web-based viruses; use more than one for maximum protection.

Chapter 13

Tools and Techniqu

General Infor

Use this chapter as a che
you need to solve compu
Most of the items in the
other chapters. Use these
Chapter 12, "Operating S
you get ready for battle w

Hardware To

Compare your toolbox's
if you are missing some i
them. Add them now. Th
you to customize the too
cally perform.

Table 13.1 Basic Hardw

Item	Purp
Phillips-head and flat-blade screwdrivers #2 size for most jobs	Open cases
Hex-head drivers (assorted sizes)	Open cases Tighte conne
Needle-nose pliers	Remo jumpe cables straig
3-claw parts retrieval tool	Grabb as jun from
Tweezers	Remo jumpe parts retriev parts

Table 13.1 Basic Hardw

Item	Purpo
Small flashlight	Illumina in case
File	Gently drive fa
Wire cutter or stripper	Fixing cables connec
ESD (electrostatic discharge) protection kit	Attach cable t system inside
Soldering iron	Used o soldere mounte have ba
Toothpick or thin wire	Probing screw h

Tools of the Trade—D

Table 13.2 provides a list disk drives.

Table 13.2 Disk Drive In

Item	Purpose
Floppy drive cable	Used as rep for suspect
IDE hard drive cable (40-pin)	Used as rep suspected f

Table 13.2 Disk Drive I	
Item	**Purpose**
IDE hard drive cable with blue end (40-pin, 80-wire)	Used as re for suspec
SCSI ribbon and SCSI external cables	Used as re for suspec
Mounting screws	Used to a to drive b
Y-cable power splitters	Enables si connector
Mounting frame	Puts 3.5" in 5.25" b
Digital Multimeter (DMM)	Tests pow to drive a
Spare battery for DMM	Keeps tes
Jumper blocks	Used to a configura slave
Rails	Used for m 5.25" driv cases

Tools of the Trade— Installation

Table 13.3 provides a list boards and expansion ca

Table 13.3 Motherboa	
Item	**Purpose**
Stand-off connectors	Holds mo bottom o
Slot covers	Covers re openings slots with

Table 13.3 Motherboard

Continued

Item	Purpose
Jumper blocks	Used to ad motherboa add-on car configurati
Digital Multimeter (DMM)	Tests powe to motherb expansion
Outlet tester	Quick plug bad ground wiring fault
POST testing card	Used to dia bootup pro
IRQ/DMA testing card	Used to dia IRQ and DI and proble
Spare Pentium, Pentium II, K6, other CPUs	Used to tes motherboa no POST c
Spare memory modules	Used to tes motherboa produces n errors durin

1. POST codes (also called hex codes)
supplied with Upgrading and Rep
Web sites of BIOS, system, and m

Tools of the Trade—E Installation

Table 13.4 provides a list external devices and netw

Table 13.4 External Dev

Item	Pur
Loopback plug for serial port	Use port

Table 13.4 External De

Item	Pu
Loopback plug for parallel port	Us po
IEEE-1284 parallel cable	Kn sp pa
"Silver satin" phone cable	Kn fo in-
RJ-45 network cable Category 5	Kn fo an
5-Port Ethernet hub 10/100 speed	Kn co RJ-
USB cables and hub	Kn fo
RS-232 breakout box	An fo an
Device-specific cables	RS pa sw

Tools of the Trade—

Use Table 13.5 to prepare

Table 13.5 Data-Transf

Item	Pu
Parallel data-cable (LapLink or Interlink type)	Use Cab to net
Null-modem serial cable (LapLink or Interlink type)	Use Dir or wit

Table 13.5 Data-Transfe

Item	Purp
Drives and media	
Tape backup cartridges	Carry devic optic for u data.

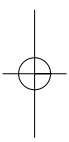
Tools of the Trade—C

Table 13.6 provides a list cleaning and maintaining

Table 13.6 Cleaning and

Item	Purpose
Floppy drive cleaning kit	Removes gun write heads
SuperDisk LS-120 Cleaning kit	Removes gun write heads of SuperDisk/ drives only
Tape drive cleaning kit	Removes gun write heads
Endust for Electronics	Effective surfa for monitor ca monitor glass and other PC

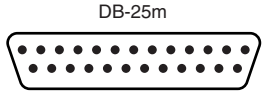
Table 13.6 Cleaning ar	
Item	**Purpose**
Electronic contact cleaner	Stabilant 22 ProGold, CA MCL (conta for product
ESD-safe vacuum cleaner	Eliminates d gunk instead it around
Canned air	Used to clea dust from p supplies, key and cases
Foam or chamois cleaning swabs	Used for dri and contact
Silicone sprays	Lubricates m



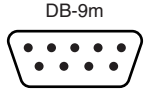
Chapter 14

Connector Quick Reference

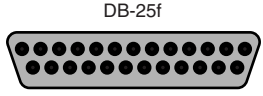
Serial Ports and Cables



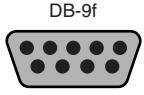
DB-25M 25-pin serial port.



DB-9m 9-pin serial port.

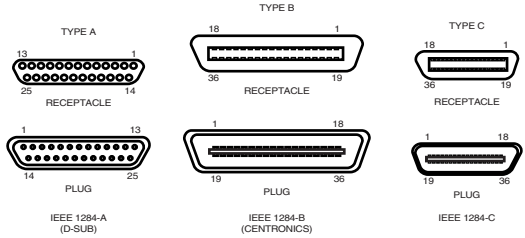


DB-25f 25-pin serial cable.



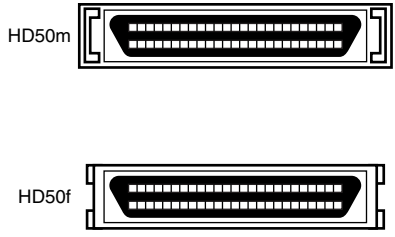
DB-9f 9-pin serial cable.

Parallel Ports

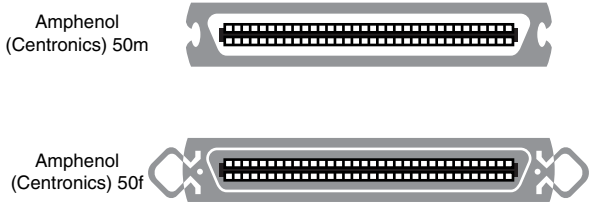


The three different types of IEEE-1284 parallel port connections. Type A receptacle (DB-25m) is used on computers; Type B receptacle is used on most printers. Some HP LaserJet printers use both Type B and Type C receptacles.

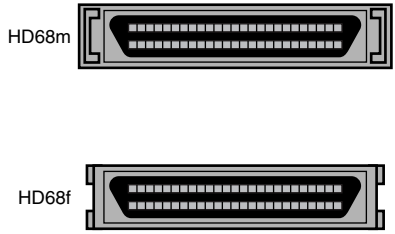
SCSI Ports



The SCSI HD-50m cable connector (top) and HD-50f receptacle (bottom) are the most common types of external SCSI ports used today.

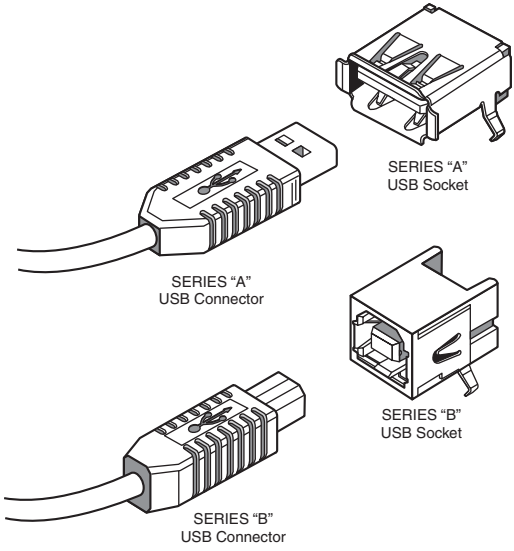


The traditional (Amphenol/Centronics) 50m cable connector (top) and 50f receptacle (bottom) are still widely used for external SCSI devices.

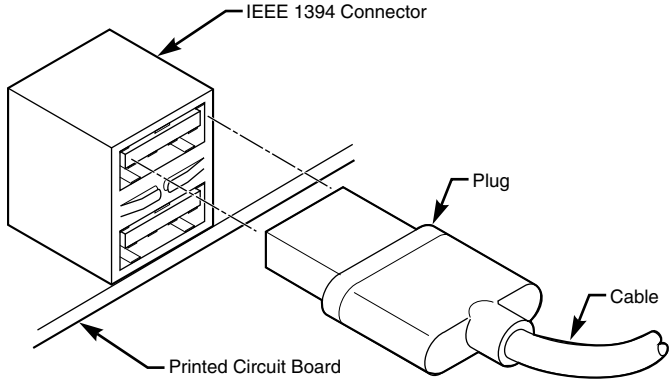


Wide SCSI HD-68m cable connector (top) and HD-68f receptacle (bottom) are used for Wide SCSI external devices.

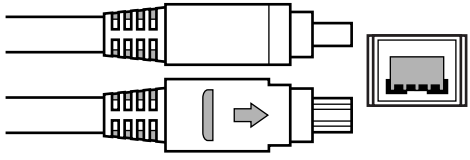
USB and IEEE-1394 (FireWire)



USB Type A and Type B ports and cables. Use a Type A to Type B cable to run between USB hubs and most USB devices.



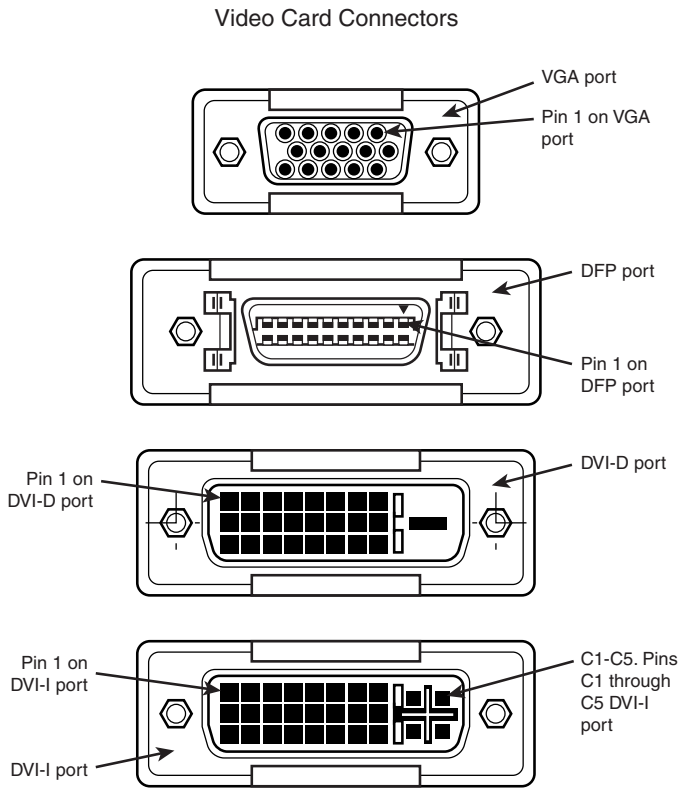
The standard 6-wire IEEE-1394 (FireWire, i.Link) connector, receptacle, and cable.



Some IEEE-1394 devices use a four-wire cable and receptacle instead, omitting the power lines.

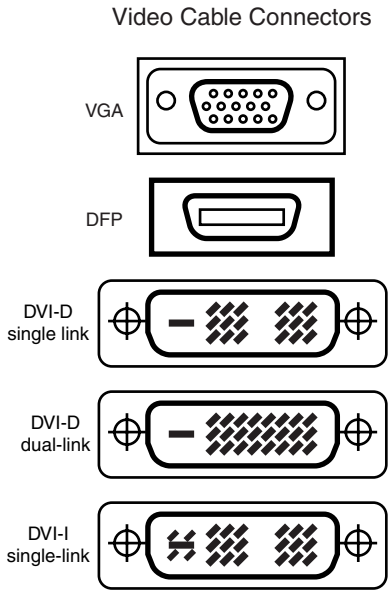
Video Connectors

Video Ports



VGA, DFP, DVI-D, and DVI-I video receptacles (top to bottom).

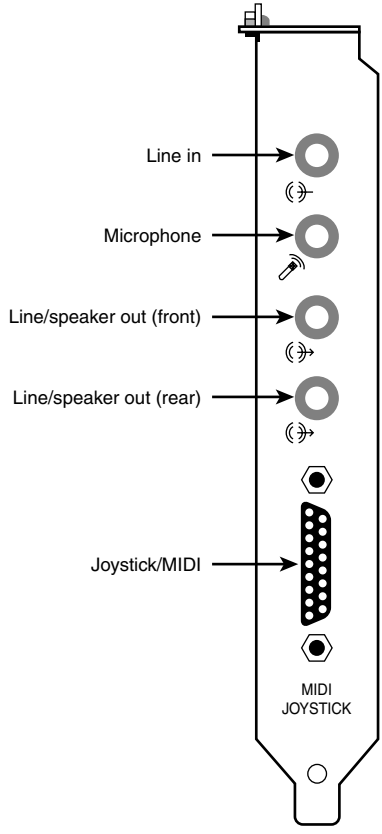
Video Cables



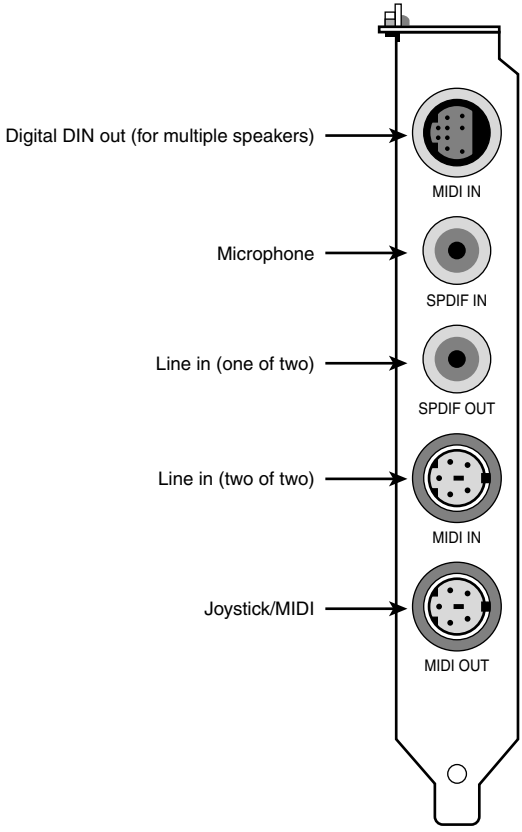
VGA, DFP, DVI-D single link, DVI-D dual link, and DVI-I video cable connectors (top to bottom).

Sound Card Ports

Sound Card External Ports

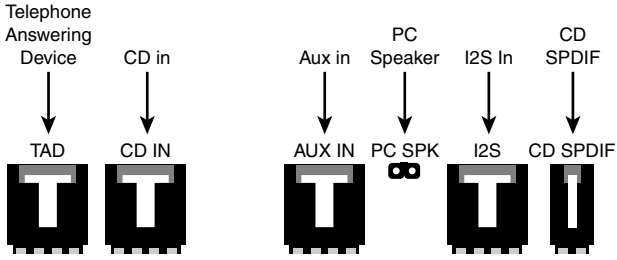


Speaker out, microphone, dual line-in, and MIDI/Joystick port (top to bottom) are found on typical sound cards of all types.



Some or all of these ports—digital DIN, SPDIF in, SPDIF out, MIDI in, and MIDI out (top to bottom)—can be found in various combinations on advanced sound cards. They can be mounted on a daughtercard bracket (shown here), attached to the rear of the sound card itself, or mounted on a box connected to the outside of the computer.

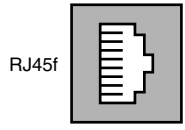
Sound Card Internal Connectors



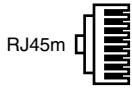
Typical internal sound card ports include, from left to right, TAD (telephone answering device for use with modems), CD in (for playing music CDs through the sound card speakers), Aux in (for connecting other devices), PC SPK (for playing PC speaker beeps through the sound card's speakers), I2S in (for playing DVD audio), and CD SPDIF (for playing digital audio from CD-ROM drives with SPDIF output).

Network and Modem Ports and Cables

RJ-45 Port and Cable

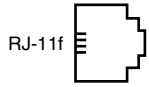


An RJ-45 port, typically used for UTP Ethernet/Fast Ethernet.



An RJ-45 cable connector, typically used for UTP Ethernet/Fast Ethernet.

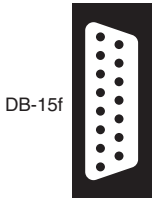
RJ-11 Port and Cable Connector



An RJ-11 port, used for modems and other telephone-wire applications. Often found in pairs (one connecting to the telephone network, the other acting as a pass-through to a normal telephone).

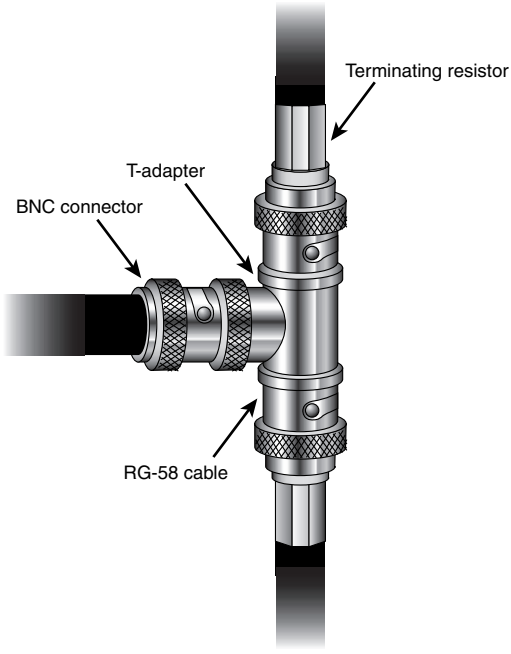
An RJ-11 cable, used to connect modems and other telephone-based devices.

Older Network Connectors



A DB-15 connector used for Thick Ethernet (10BASE-5) networks; usually found on the rear of a network card along with an RJ-45 or a BNC connector.

The BNC connector, used by Thin Ethernet along with a T-adapter. The adapter is used to connect the cable to the network card.



The BNC connector with T-adapter, resistor, and BNC (RG-58 Thin Ethernet) cable.

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