

Illustration by Kevin O'Keefe

Bus stop

The original commercial PC, circa 1981, had a reasonable array of input/output (I/O) facilities; its serial and parallel ports were more than adequate for the throughputs required by the peripherals of

the day. But times have changed, and serial and parallel I/O devices fall short of user's needs in a number of important areas:

➤ **Throughput** Serial ports max out at 115.2Kbps, parallel ports (depending on type) at around 500Kbps, but devices such as digital video cameras require vastly more bandwidth.

➤ **Ease of use** Connecting devices to legacy ports can be fiddly and messy, especially daisy-chaining parallel port devices through pass-through ports. And the ports are always inconveniently located at the rear of the PC.

➤ **Hardware resources** Each port requires its own interrupt request line (IRQ). A PC has a total of 16 IRQ lines, most of which are already spoken for. Some PCs have as few as five free IRQs before peripherals are installed. COM ports can 'share' IRQs, but some operating systems such as Windows NT 4.0 won't tolerate this kludge. PCI steering partially overcomes this problem.

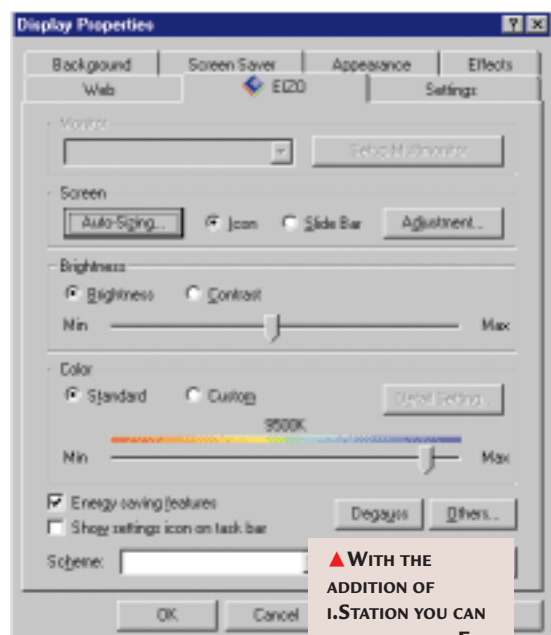
➤ **Limited number of ports** Most PCs have a pair of COM ports and one LPT port. You can add more COM ports and LPT ports, but at the cost of precious IRQs.

Two new I/O ports, Universal Serial Bus (USB) and IEEE 1394, address all of the limitations of the legacy I/O devices in one fell swoop. And they are complementary: USB deals with slower devices and 1394 with high-speed devices. Both support plug-and-play and hot swapping and, together, they cover a broad range of I/O requirements. Soon PCs will routinely be configured with both USB and 1394 and *only* these two, dropping parallel and serial connectors altogether.

Most PCs have had USB ports for a couple of years, but USB peripherals have only just started to arrive in any numbers. The reason? The launch of Windows 98 and the Apple iMac. Windows 95 support of USB was at best wishy-washy and we had to wait until Windows 98 for proper driver support. The iMac, of course, only has USB ports so it's Hobson's choice

ONE DAY, ALL PERIPHERALS WILL BE CONNECTED TO YOUR PC VIA USB AND IEEE 1394 — ROGER GANN EXPLAINS HOW, AND WHY. HE ALSO PRESENTS USB DEVICES CURRENTLY IN USE.

if you want to connect peripherals to it. USB and 1394 also dovetail neatly in with the putative PC99 standard, which envisages, amongst other things, the 'closed' system unit incapable of internal expansion. If you want to connect any sort of peripheral, sbe it a hard disk, DVD-ROM, MPEG decoder or scanner, then you'll use either USB or 1394.



The development of USB

The Universal Serial Bus (USB) specification was originally developed by a group that included Intel, Microsoft, Compaq, Digital Equipment, IBM, NEC and Nortel. It combines the best features of SCSI architecture with an advanced plug-and-play standard. It replaces the antique serial and parallel ports with a single port that is extensible through hubs and devices daisy-chained in a tree arrangement.

The system was designed to deliver a data-transfer rate of up to 12Mbit/sec to or from the PC. This is enough to deal with all existing types of peripherals, and most of the new higher-bandwidth mass-market PC

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peripherals in the foreseeable future. It also supports a low-speed mode of 1.5Mbit/sec for devices like keyboards, mice and joysticks. USB support has been built in to Intel's PCI set since the 430VX and many current motherboards feature connector headers for USB socket panels.

The main attractions of USB are its flexibility and its speed. It is cross-platform, hot-pluggable and hot-swappable, making peripherals easy to connect and disconnect from the network. And it offers performance that's faster than serial, parallel and Ethernet technologies.

USB was designed to be user-friendly: it eliminates the need to install expansion cards inside the PC and then reconfigure the system. Instead, peripherals will be automatically configured when they are attached to the system without needing to run a setup program or reboot. Similarly, there should be no more guesswork about which serial or parallel port to choose, and non-technical PC users should not have to worry about IRQ settings, DMA channels and I/O addresses. Finally, USB's hot insertion and removal allows users to attach and detach peripherals without powering down the system first.

overall system performance. In turn, USB system software installed in the operating system manages the host controller.

Data on the USB flows through a bi-directional pipe regulated by the host controller and by subsidiary hub controllers. An improved version of bus mastering allows portions of the total bus bandwidth to be permanently reserved for specific peripherals, a technique called isochronous data transfer. The USB interface contains two main modules: the Serial Interface Engine (SIE), responsible for the bus protocol, and the Root Hub, used to expand the number of USB ports. The USB Host Controller incorporates logic for processing incoming and outgoing data, as well as legacy keyboard support for PS/2 keyboards.

The USB also allows unpowered devices to draw up to 500mA over the connector cable and even allows for unpowered hubs that might have unpowered devices downstream — here the current drawn mustn't exceed 100mA. So you have to exercise some common sense when hooking up multiple USB devices: for example, you shouldn't use ports on the keyboard, a low-power device, to plug in anything other than a mouse. A typical four-port hub

should run on 2.1A (500mA per port plus 100mA for the hub). Half an amp is sufficient to power devices like video cameras, but so far only Logitech/Storm Technologies has managed to drive a scanner on this skimpy amount of power.

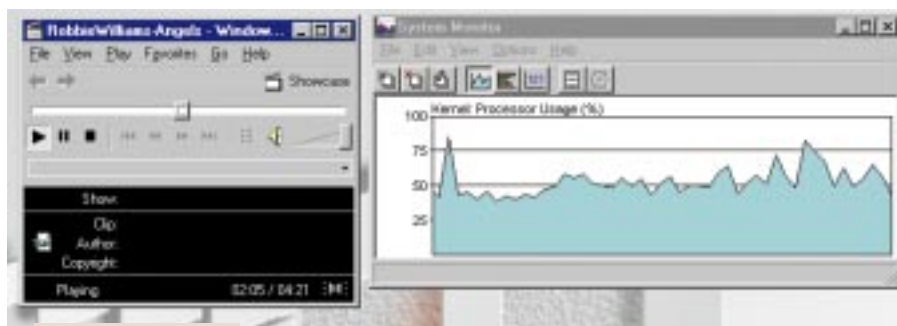
USB isn't without its critics:

there have been complaints that its implementation and architecture

are too complex. US reports indicate that printer manufacturers, with an eye on the booming consumer electronics market, are far more interested in 1394 than USB for the simple reason that digital cameras are more likely to sport a 1394 socket than a USB port. Some have criticised the USB protocol stack which, because it has to support so many different types of peripherals, is unwieldy. Others complain that the hub concept merely shifts expense and complexity from the system unit to the keyboard or monitor.

USB in practice

For my USB test bed I picked a P200MMX with the Intel 440TX chipset and 64Mb of RAM running Windows 98 (of course). This PC had a pair of USB ports which clearly weren't enough, so I installed a couple of hubs: the Entrega Hub 7U seven-port hub, which was hung off an Eizo F57 17in monitor, with the i-Station USB hub slung under the front panel. The latter has four free USB ports. Both hubs had separate power supplies but were not called on to power any



▲ **IF YOU USE USB SPEAKERS, BE PREPARED TO KISS GOODBYE TO A SIGNIFICANT NUMBER OF PROCESSOR CYCLES**

The USB architecture comprises a dedicated master-slave system with a host controller residing at the root of the tree, typically within the PC chipset. Because of its 7-bit address scheme, the USB will allow users to connect up to 127 peripherals using a single standard connector type. That's the theory, but manufacturers discourage this in practice: high-speed USB peripherals, such as backup drives and scanners, should have their 'private' port for optimal performance. Mice, keyboards and other low-speed devices used infrequently can share a port. In addition, some peripherals (notably monitors and keyboards) can act as hubs to provide additional plug-in nodes. This is very convenient, allowing you, for example, to plug your mouse and keyboard into the base of a monitor.

All peripherals connected via a USB interface are managed by a USB host controller mounted on the PC's motherboard or on a PCI add-in card. The host controller and subsidiary controllers in hubs manage USB peripherals, helping to reduce the load on the PC's CPU time and improving

peripherals. With the exception of the Intel video camera, all the other devices that required power had their own mains transformers. Interestingly, the i-Station used a separate cable to connect to the monitor itself which allowed you to control the display from software rather than using its rather awkward on-screen menu system.

All told, this gave me no less than 11 free USB ports to play with. Inserting multiple USB plugs in the Entrega hub was easy enough, but the resulting mass of cable made the lightweight hub reluctant to 'stay put' on the desktop. Inserting USB plugs in to the Eizo i-Station was awkward: three of the four ports were located on the rear of the unit, which was just about the most inconvenient place you could think of. I then proceeded to fill up as many of the ports as I could. I plugged in eight in all — here's the list: Microsoft Natural Keyboard Elite; Microsoft Precision Pro joystick; Microsoft Digital Sound System 80; Logitech USB Wheel Mouse; Hewlett-Packard ScanJet 4100C; Epson Stylus Color 740; Intel Create and Share video camera; and the DrayTek ISDN Vigor 128 TA.

Overall, I was disappointed. With 119 devices to go in my possible USB 'tree', my P200MMX wasn't a happy bunny with all this extra hardware to look after. By and large, plug-and-play worked pretty much as expected: you'd plug the device in, Windows 98 would automatically detect it and, if the drivers weren't already installed, prompt you for the install disks. Occasionally, a device wouldn't be detected upon

insertion or would take a minute or two before the 'New Hardware Detected' window went away.

There were, however, one or two minor exceptions, notably the keyboard and mouse. The test bed PC was already working with an ordinary keyboard and PS/2 mouse and Windows 98 likes to find these devices as it loads. First-time installation of a USB device is normally done when Windows 98 is up and running. Trying to install the USB keyboard and mouse simultaneously didn't work and I had to plug the old PS/2 keyboard back in to install the mouse. I was then able to install the USB keyboard correctly.

I found it easy to cause Windows 98 to lock up or blue-screen by unplugging USB devices and plugging them back in. Firing up the System Monitor applet and graphing percentage CPU utilisation was instructive too. Plugging in a device would typically send CPU utilisation up to 100% for 10 or 20 seconds, sometimes longer, making the PC feel like a barrel of treacle had been poured into it. Also, as the burden of supporting multiple USB devices gradually mounted, so the PC felt progressively less responsive.

Maybe I was pushing my luck with a P200MMX — it could be that it just isn't powerful enough to keep an eye on all those peripherals on the USB bus. Perhaps a Pentium II 450MHz is a better bet. At the end of the day, there's no escaping the fact that it doesn't matter how many or how few USB ports you've got; there's only one bus, and all your peripheral data has to pass down it.

USB hubs

Although the USB standard permits the daisy-chaining of up to 127 devices, most users will come across a more practical limitation well before they hit double figures: USB sockets to plug things in to! Most PCs have a pair of USB ports, and while a few monitors come equipped with a USB hub, I've not seen any USB devices with a second USB socket, so daisy-chaining is impossible. Even the monitor hubs I've come across aren't a great

solution: the two I've seen have three or four USB ports, but one port has to be used to connect your PC to the hub, so you gain some, you lose one. The solution is simple: the stand-alone USB hub. Anyone who's set up an 10Base-T Ethernet network will be familiar with the concept of the hub. USB hubs simply let you attach more devices to your USB chain. In the UK, only Entrega has released a USB hub, available in four- and seven-port versions. The seven-

port version (£84 ex VAT) is tiny, no more than four inches square. Powered by a mains transformer, this hub has seven red status LEDs on the front, just like a network hub. These turn green when you insert a USB device. If seven ports proves too few then you can buy a second one, stack it on top of the first and daisy-chain one to the other, just like an Ethernet hub. There's no software to install



and you simply use the special USB hub cable to link the hub to a PC USB port. Once you connect a hub to a USB chain, you can then connect several other devices to that hub. For example, you can connect three devices and another hub, and then connect

two devices and two more hubs to the second hub, and so on, adding hubs and devices until you attach your 127th device. In any case, given the lack of self-powered USB devices, you're more likely to run out of mains socket outlets well before then.

Microsoft Natural Keyboard Elite ▷

This is a 'dual purpose' USB device in that it's a PS/2 keyboard with a short female PS/2-to-USB adapter lead. The Elite is a slightly more compact version of the original curved Microsoft Natural Keyboard; some space is regained by rearranging the cursor and editing keys. The keyboard is supplied *sans* software — it doesn't need any. Windows 98 recognises it as a standard 101/102 or Natural Keyboard. It has some quirks, notably the erratic behaviour of the the Caps Lock and Num Lock status LEDs

Price £40 (£34.05 ex VAT) **Contact** Microsoft 0870 601 0100 www.microsoft.com



◁ Logitech USB Wheel Mouse

This particular Wheel Mouse offers much the same functionality as the Microsoft Wheel Mouse: it's a two-button mouse with a wheel that can function as a third button or as an adjunct to scrolling. The Logitech comes with slightly more sophisticated software than Microsoft IntelliPoint and gives you more programming options for button combinations. This is a USB-only device — there is no PS/2 or COM port adapter. Detection was automatic, but installing the driver software was a drawn-out affair. Moving the mouse to a different USB port on a hub could confuse it to the point that at the next reboot, Windows 98 won't detect a mouse at all.

Price £29.38 (£25 ex VAT) **Contact** Logitech UK 0181 308 6582 www.logitech.com



▽ Eizo Flexscan F57 and i-Station hub

Another great monitor from Eizo: the picture quality on this 17in display is very easy on the eye. What makes it particularly interesting is the addition of the i-Station four-port USB hub that clips to the underside of the front bezel, blending in with the existing design. It has one easy-access USB port at the side and three well-nigh impossible to access ports at the rear. The i-Station doesn't draw its power from the monitor but from a separate mains supply — oh dear! It also has a 'maintenance' lead that links the two units together, and this allows display driver software to control the image.

Price Monitor £480.58 (£409 ex VAT),
Hub £104.58 (£89 ex VAT) **Contact** PDS
01483 719500 www.eizo.com



Microsoft SideWinder Precision Pro ▷

The only difference between the USB and the ordinary version of the SideWinder Precision Pro is the small joystick port-to-USB adapter lead included in the box. Like most of the other USB devices, the SPP was a doddle to install — you don't, for example, need a sound-card joystick port to plug this in to. The SPP is a good-quality joystick, certainly on a par with the likes of the Logitech Wingman Extreme Digital. Sadly, the force-feedback version of the SPP isn't available in USB format.

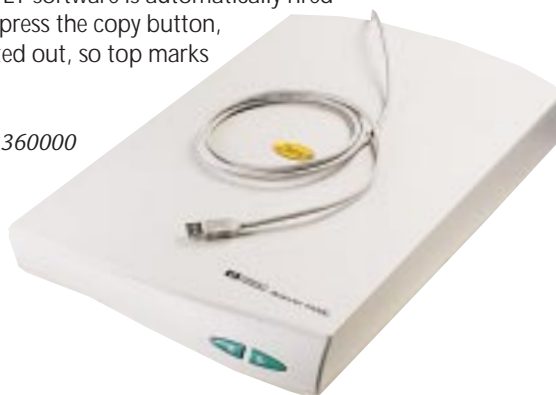
Price £50 (£42.55 ex VAT) **Contact** Microsoft
0870 601 0100 www.microsoft.com



▽ Hewlett-Packard ScanJet 4100C

The ScanJet 4100C is the new entry-level ScanJet, although it's still relatively expensive. It's an A4 flatbed 36-bit colour scanner with an optical resolution of 600dpi, only modestly extendable to 1200dpi by interpolation. These scanners ship with HP's Precision Scan LT for one-step scanning, with automated OCR courtesy of Caere OmniPage, plus Adobe PhotoDeluxe and HP's ScanJet Colour Copy Utility — an excellent software bundle. The 4100C was one of the first scanners to feature a USB interface, making installation truly painless. The scanner also has two large, green buttons on its front panel: press the scan button and the Precision Scan LT software is automatically fired up and a scan initiated. If you press the copy button, the image is scanned and printed out, so top marks for convenience here.

Price £149 (£126.80 ex VAT)
Contact Hewlett-Packard 01344 360000
www.hp.com





◁ Entrega Hub 7U

I've already discussed the hub elsewhere, but if you want to use more than two USB devices, you're going to want something like this. The Hub7U is a passive device, like an Ethernet hub, which is mains-powered, so it can support USB devices that need power. It requires no software support and is automatically recognised by the PC's chipset as a hub. Seven LEDs on the front indicate use — they're red if unused, green if used. Like its Ethernet relatives, the Hub7U is stackable and you can daisy-chain additional hubs together to expand the number of USB ports available.

Price £98.70 (£84 ex VAT) **Contact** Entrega 0118 951 9549 www.entrega.com

DrayTek ISDN Vigor 128 ▷

The Vigor 128 is a fairly conventional ISDN terminal adapter that connects to a USB rather than a serial port. Even though it's capable of channel aggregation, its maximum 128Kbps throughput won't really stress the USB bus. It's fairly easy to install, although it falls short of true Plug-and-Play. Betraying its 'Euro' design origins, it's well specified with EuroFile Transfer, Group 3 faxing and voicemail. The Kiosk utility provides useful low-level information on calls, such as CLI, and a real-time protocol analyser.

Price £175.08 (£149 ex VAT) **Contact** Electronic Frontier 0118 981 0600 www.elecfron.com



◁ Traveling Software LapLink Pro

To hook two standalone PCs together to transfer data between them, you'd use the serial or parallel cables supplied. Parallel isn't a bad option, but USB's 12Mbps takes some beating. Accordingly, this version of LapLink doesn't come with the familiar blue or yellow cables of yore, but a single USB cable. Once LapLink is installed at both ends, it turns the USB link into a simple 12Mbps network link, offering similar performance to a 10Mbps Etherlink network connection.

Price £149.99 (£127.65 ex VAT) **Contact** Traveling Software 01344 409056 www.travsoft.com

Intel Create & Share ▷

The USB version of the Intel Create & Share Camera Pack is the easiest to install and use. It's also the cheapest — the PCI version costs about £50 more, simply because you're paying for a video capture card. This Konica-made video camera is perfect for USB because it draws its power from the USB bus and so doesn't require a mains transformer. Once plugged in, Windows 98 detects the camera and installs the drivers for it from the accompanying CD-ROM. And that's it. If only more USB devices had this 'one cable' approach.

Price £117.50 (£100 ex VAT) **Contact** Intel 01793 403000 www.intel.com



◁ Epson Stylus Color 740

This is one of the better colour inkjets money can buy and it's encouraging to at long last see a USB port alongside the Centronics port on the back of a new printer. Installation is a little convoluted because Windows 98 has to install a special printer port, USBLPT, to print to. However, once installed, printing to the USB port is noticeably nippier than using the parallel port, particularly when printing large true-colour, photorealistic images which involve a lot of data. **Price** £223.25 (£190 ex VAT)

Contact Epson UK 0800 220546 www.epson.co.uk

Microsoft Digital Sound System 80 ▷

The new Digital Sound System 80 comprises a hefty sub-woofer and two satellite speakers based on Philips technology. These speakers not only deliver some awesome sound, but can also do it at extreme volumes. These are perhaps the best PC speakers I've heard to date. Note that if the CPU is busy, the sound data stream can get interrupted, which is a pain. Another thing to remember is that USB audio is playback-only, so you can't record. Another gotcha — not all CD-ROMs can deliver digital audio to USB speakers.

Price £180 (£153.20 ex VAT) **Contact** Microsoft 0870 601 0100 www.microsoft.com



IEEE 1394

Originally designed by Apple in the late eighties under the 'FireWire' moniker, the concept behind the 1394 bus was simple: that a fast serial bus, with sufficiently clever physical-layer design, could be both fast enough to handle a rich mix of audio, video and data traffic and yet simple enough to be affordable. By supporting hot insertion and a plug-and-play protocol, FireWire could simplify the lives of Mac users who were putting together multimedia systems. The idea was good enough to spread beyond the shrinking confines of Apple, and emerged into the consumer-electronics and PC worlds as the IEEE (Institute of Electrical and Electronic Engineers) 1394 bus.

By providing an inexpensive, non-proprietary, high-speed method of interconnecting digital devices, 1394 offers a universal I/O connection. Its scalable architecture and flexible peer-to-peer topology make it ideal for connecting high-speed devices: everything from computers and hard drives, to digital audio and video hardware.

You can mix 100, 200 and 400Mbps devices on a single bus. The current 1394 specification data transfer rate currently tops out at 400Mbps: the 1394b specification aims to adopt a different coding and data-transfer scheme that will scale to 800Mbps, 1.6Gbps and beyond. Even at its lowest speed of 100Mbps, 1394 supports two simultaneous channels of full motion (30fps), high-quality video and stereo audio, with enough bandwidth left over to issue commands to control the digital devices transmitting the audio and video.

As a peer-to-peer technology, there is no need to have a computer in the chain to control the data transfer. The 1394 cable consists of two pairs of wires for data transport, and one pair for device power. A unique feature of the 1394 cable is the distribution of power through the cable for operation of the transceiver's repeating functions, even if the node power is off.

1394 supports a guaranteed data path bandwidth called 'isochronous data transfers' and allows for real-time transmission of data to/from 1394 devices. This is important for audio and video applications such as MPEG and DV. Isochronous data transfers operate in a broadcast manner, where one or many 1394 devices can 'listen' to the data being transmitted. The emphasis of isochronous data transfers is placed on guaranteed data timing rather than guaranteed delivery, obviating the need for buffering. Multiple channels (up to 63) of

isochronous data can be transferred simultaneously on the 1394 bus. Since isochronous transfers can only take up a maximum of 80 percent of the 1394 bus bandwidth, there is enough bandwidth left over for additional asynchronous transfers.

Asynchronous data transmission includes receipt datagrams that indicate the data was transmitted reliably to the 1394 device. Asynchronous data transfers place emphasis on delivery rather than timing. The data transmission is guaranteed, and retries are supported.

As a transaction-based packet technology, 1394 can be organised as if it were memory space interconnected between devices. Memory-based addressing, rather than channel addressing, views resources as registers or memory that can be accessed with processor-to-memory transactions. In basic terms, all this means easy networking. 1394 devices can be connected via branching or daisy-chaining, so it is very easy for consumers to connect 1394 devices. For example, a digital camera can easily send pictures directly to a digital printer without a computer in the middle. In addition, up to 63 1394 devices can be connected together. With bus-bridging technology, up to 64,000 1394 devices can be connected — in theory!

This is bad news for the PC, which may well lose its position of dominance in the interconnectivity environment and may well be relegated to being a very intelligent peer. 1394 is going to be the interface for connecting handy-cams and VCRs, set-top boxes and televisions, although thus far its implementation has been largely in digital camcorders, where it is known as iLink. If a computer is needed later, it would involve nothing more than adding a 1394 cable to the computer — it's that easy. USB, although it is the current interface of choice, will never be a mainstream consumer electronics interface.

With all these advantages, it is surprising more manufacturers have not adopted 1394 in consumer devices. It's a digital interface, so there is no need to convert digital data into analogue, which causes a loss of data integrity — excellent for digital photography and video.

But most of all, for the consumer it is very easy to put together, with no need for



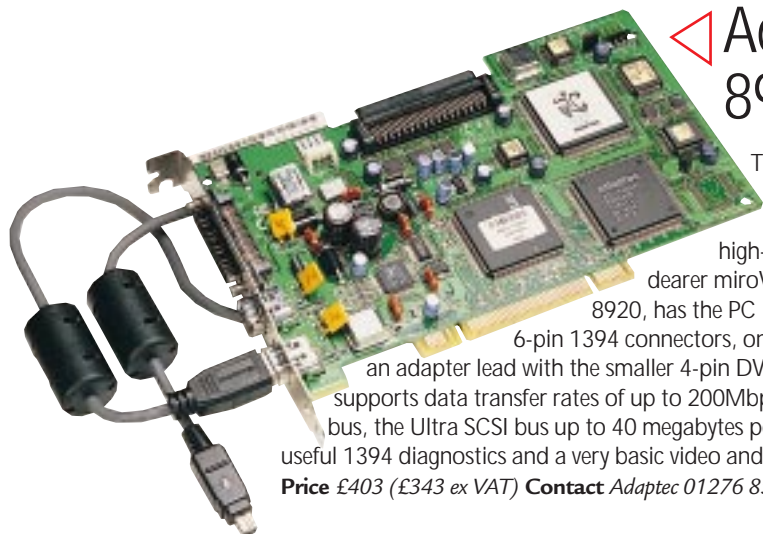
▲ THE ADAPTEC
HOTCONNECT
ULTRA 8945 COMES
WITH A SIMPLE
DIGITAL VIDEO
RECORDER
[SEE PAGE 141]

terminators, device IDs, or elaborate setup. It represents true plug-and-play as 1394 devices can be connected to the computer or to one another at any time, with the power on or off and without rebooting and reconfiguring. In some cases, 1394 devices can even power themselves from the 1394 bus. The 1394 connector is tiny but very rugged — it was derived from Nintendo's GameBoy, so it is fully 'kid' tested! Unlike SCSI, terminators aren't needed for 1394 devices.

Microsoft Windows 98 does include support for 1394 but Intel declined to include 1394 support in its 1998 PC chipsets. It makes the point: 'How many people really want to plug their camcorders and digital VCRs into their PC?' However, sources indicate that Intel plans to come to market in early 1999 with its first 1394 silicon.

Traditional computer devices support 1394. 'Soon' there will be 1394 fixed-disk drives,

1394 printers, 1394 scanners and 1394 CD-ROM/DVD devices. Consequently, a computer with a 1394 port will be able to connect to a potentially huge number of 1394 computer devices, as well as to all of the available 1394 consumer electronics devices.



◁ Adaptec HotConnect Ultra 8945

This pricey expansion card has most high-speed options covered. Not only does it offer support for 1394, but it also supports Ultra SCSI; this is important if you want to run high-quality video off an AV-quality hard disk. Apart from the even dearer microVideo MV300, Adaptec, with its 8945 and the down-spec'd 8920, has the PC 1394 market to itself. The card comes with three of the large, 6-pin 1394 connectors, one of which is internal. It comes with a 6-pin 1394 lead plus an adapter lead with the smaller 4-pin DV/GameBoy-style 1394 connector. The HotConnect Ultra supports data transfer rates of up to 200Mbps (or 25 megabytes per second) on the 1394 bus, the Ultra SCSI bus up to 40 megabytes per second. The card comes with some useful 1394 diagnostics and a very basic video and stills capture utility, DV Deck.

Price £403 (£343 ex VAT) **Contact** Adaptec 01276 854500 www.adaptec.com

Sony DCR PC-1E ▷

This is a gorgeous piece of AV kit, exquisitely designed in the Sony house-style. It's a 40X digital zoom DV camera with autofocus and a choice of small LCD display or a traditional viewfinder to frame your images. The PC-1E is well equipped with video ports: concealed under a tethered pull-off flap at the front is a GameBoy-style 4-pin 1394 (i.LINK in Sony-speak) port, while a cap at the side conceals a conventional S-VHS mini-DIN port.

Price £1,400 (£1,191.50 ex VAT)

Contact Sony Consumer Products 01932 816000 www.sony.com



▽ JVC GR-DVL9000

This is a larger DV camcorder with a better spec than the Sony: it has a higher 500x560 resolution plus a much larger 4in hinged LCD display-cum-viewfinder and features 100X digital zoom. It's not quite as easy to use as the PC-1E or as neatly designed, but it has a similar array of video ports: an S-VHS mini-DIN port plus a small 4-pin DV/1394 output port. Note that this is an output port only — you can't, for example, record video from another 1394 source. This DV camera wasn't recognised by the Adaptec card and so I was unable to record images straight to disk. **Price** £1,798.93 (£1,531 ex VAT) **Contact** JVC 0181 208 7654 www.jvc.com

