IEEE1394

AKA 'Firewire' & 'iLink'

Note: Jaycar no longer stock IEEE1394 components.

This document is provided as a service to any customers who might encounter "legacy" IEEE1394 installations.

Around 1986, Apple Computer Inc developed a very fast but relatively low cost serial interface for distributing digital audio and other bulk data between personal computers, and between computers and their peripherals. The new high speed serial interface was designed to replace the relatively expensive SCSI parallel interface, and Apple dubbed it FireWire (which is still an Apple trademark).

Firewire was so successful that other manufacturers soon began using it under licence. In 1995 Sony released its DCR-VX1000 digital video camcorder, which featured essentially the same interface for input and output of digital video. Sony dubbed the interface iLink, and gradually provided the interfaces on all of its digital camcorders and VCRs. (iLink is a Sony trademark.)

It was soon realised that the FireWire/iLink interface was ideal not just for conveying digital video and audio, but for fast transfer of large amounts of any kind of digital data. Because of this the IEEE (Institution of Electrical and Electronics Engineers) established it in 1995 as an industry standard data interface, known as IEEE 1394-1995 — or 'IEEE 1394' for short.

For several years IEEE 1394 interfaces were used on a very wide range of digital equipment, both in the computer and entertainment electronics industries. They were standard on the majority of digital camcorders and VCRs, as well as on video editing workstations and advanced computer graphics systems. They were fitted to many DVD video recorders and were found even inside large workstations and servers, to interface peripherals such large hard disk drives and arrays, CD-writers andscanners.

For a while it looked very much as if IEEE 1394 was going to become the standard high speed interface for the coming era of digital convergence — the merging of computers, communications and entertainment technology.

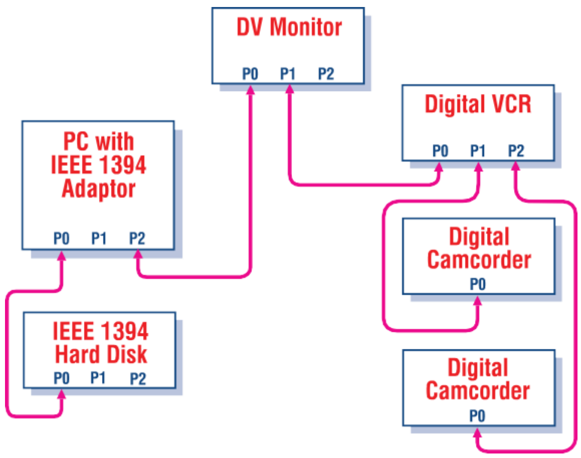


Fig.1: A fairly typical IEEE 1394 network used in a digital video editing studio. The PC would generally take the role of bus manager and isochronous resource manager.

However, no technology stands still for long and some major changes in recent years have seen IEEE1394 pretty much fallen by the wayside.

1. Digital Video cameras have all switched to flash memory for data storage, so there is far less need for serial data access; it is simply a matter of plugging the SD card directly in to the computer in many cases.
2. The performance of the USB interface has been improved enormously, to the point where full HD video can now be played directly from a USB flash drive, or from a camera's internal storage.
3. HDMI has gone from being an expensive "high-end" interface option to almost universal. Many video cameras (and stills cameras which shoot video, that is, most of them) also come equipped with HDMI connection.
4. DVD recorders have disappeared from the marketplace, replaced by much cheaper and more reliable Personal Video Recorders (PVRs). If it is done at all, most DVD recording of home video is now done with PC-Based DVD drives.
5. A major advantage of IEEE1395 was that, once a Firewire card was installed, any attached device effectively became part of the computer and files stored on it could be accessed with relative ease. However USB technology has now advanced to the point where virtually all devices will self-install and simply appear as extra drives on the PC, which is even more convenient.

Note that although there are many similarities between IEEE 1394 and the USB, there are quite a few differences. USB is essentially designed for n e t w o r k s with a single host (the PC), whereas IEEE 1394 can be used for peer-to-peer communication. A digital camcorder can stream video and audio data to both a digital VCR and a DVD-RAM recorder simultaneously via an IEEE 1394 network for example, with no need for assistance from a PC or other network controller device(after it has been allocated an isochronous channel for the transfer — see later).

Australia
www.jaycar.com.au
techstore@jaycar.com.au
1800 022 888

New Zealand
www.jaycar.co.nz
techstore@jaycar.co.nz
0800 452 922

Data Rates

IEEE 1394 can transmit data at three rates: 98.304, 196.608 and 393.216Mb/s (megabits per second), which are usually rounded to 100Mb/s, 200Mb/s and 400Mb/s — and officially labelled ‘S100’, ‘S200’ and ‘S400’ respectively.

Most consumer equipment like digital camcorders, VCRs and DVD-RAM recorders used the S100 rate, which was more than capable of handling a compressed video-and-audio data stream. The majority of PCI/IEEE 1394 interface adaptor cards for PCs will also support S200, while some can also support S400.

Like USB, IEEE 1394 is designed to allow ‘hot swapping’. Devices can be connected and/or disconnected without turning off the power or resetting, etc. The device whichis performing the bus manager role constantly monitors bus status, and reconfigures it dynamically whenever nodes are added or disconnected.

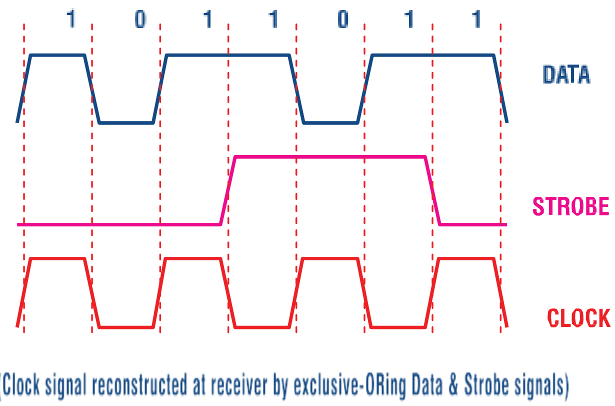


Fig.2: How the DS coding works. The strobe signal is produced at the transmitting port, by exclsuive-ORing the Data and Clock. Then at the receiving end the Clock is reconstructed by exclusive-ORing the Data and Strobe signals.

Data is transferred on the IEEE 1394 bus in addressed packets, and is transaction-based. The transfers can be asynchronous or isochronous. Asynchronous transfers are used mainly for bus configuration, setting up transfers and handshaking, but are also used for bulk data transfer to and from hard disk drives, etc. Isochronous transfers are used for transporting time-sensitive data like digital video and audio.

IEEE 1394 data packets have a 64-bit address header, which is divided into a 10-bit network address, a 6-bit node address and the remaining 48 bits for data (or mode control) memory addresses at the receiving node. This gives IEEE 1394 the ability to address 1023 networks of 63 nodes, each with up to 281TB (terabytes) of data addresses.

In practical terms this tends to mean up to 63 devices can be hooked up via IEEE 1394 cables as a network, with each device able to have tens or hundreds of gigabytes of memory.

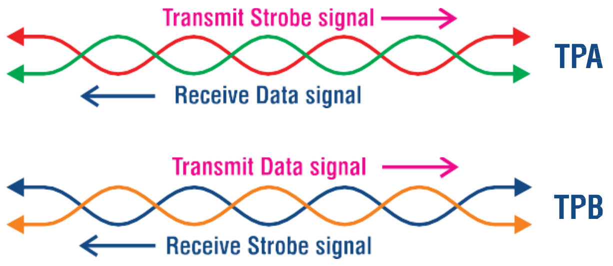


Fig.3: The Strobe and Data signals are sent along the IEEE 1394 bus via two shielded twisted-wire pairs, TPA and TPB.

Typically devices have three IEEE 1394 ports, but they can have up to 27. This allows networks to be as simple as a DV camcorder connected to a digital VCR, or more complicated like the setup shown in Fig.1. As you can see this shows a 'tree' topology, taking advantage of the ability of each device to act as a bus repeater or 'mini hub'.

One device on the bus acts as bus manager, and can also act as isochronous resource manager. The latter allocates bus bandwidth for isochronous data transfers when devices request them. When there's a PC in the network, it usually performs the roles of bus manager and isochronous resource manager.

As the IEEE 1394 bus uses time-domain multiplexing (TDM), the isochronous resource manager allocates each isochronous transfer a 'channel' consisting of so many 'bandwidth allocation units' (i.e., a guaranteed proportion of the total time slots). A bandwidth allocation unit is 20.3ns, so there are 6144 of them in a IEEE 1394 'basic cycle' of 125us. However 25us of every cycle is always reserved for asynchronous control data transfers, so a maximum of 4195 units is available for isochronous transfers. Typically a stream from a DV camcorder to a PC or digital VCR might need to be allocated a channel of say 1800 bandwidth units, for about 30Mb/s.

Only one data packet can occur every basic cycle for a particular isochronous transfer channel, using that channel's allocated bandwidth units. However multiple isochronous transfers can take place at the same time, providing there's enough bandwidth available. The transfers can even be at different rates — say one at S100 and another at S200. If there isn't enough bandwidth available when a device requests it, it waits until the bandwidth does become available.

Asynchronous transfers can have multiple data packets per basic cycle, within the 25us reserved for this type of signalling.

Data-Strobe coding

All data is sent along the IEEE 1394 bus in serial four byte (32-bit) words, called quadlets. And the quadlets are encoded together with their clock signal onto two NRZ (non return to zero) bus signals, using a technique known as Data-Strobe (DS) coding. This improves transmission reliability by ensuring that only one of the two signals changes in each data bit period.

Fig.2 shows how DS coding works. The top waveform shows the Data bits being sent, while the bottom waveform shows the Clock signal. At the transmitting node these two are fed to an exclusive-OR gate to generate the Strobe signal, shown in the centre. It's this signal and the Data signal which are sent along the bus,

and as you can see there's only one change in the pair every bit period.

At the receiving device, though, the Data and Strobe signals are again fed to an exclusive-OR gate. The output of this gate effectively reconstructs the Clock signal again, with its timing still accurately locked to the Data. The DS coding therefore avoids the need for IEEE 1394 receivers to have a PLL (phase-locked loop).

Twisted pairs

The IEEE 1394 Data and Strobe signals are sent on cables with two separately shielded twisted-wire pairs, called TPA (twisted pair A) and TPB (twisted pair B). Transfers in one direction have the Strobe signal on TPA and the Data signal on TPB, while those in the opposite direction have the Data signal on TPA and the Strobe signal on TPB. Fig.3 shows the idea.

There are two different kinds of IEEE 1394 cable, with matching connectors. The primary type of cable has not only the two separately shielded wire pairs TPA and TPB, but also two DC power conductors — the negative being grounded. A cross-section of this type of cable is shown in Fig.4, and as you can see there's also an outer shield and sleeve.

The IEEE 1394 standard allows nodes to be supplied with DC power via the two power conductors. The power can be supplied at a voltage between 8V and 33V, and the current can be up to 1.5 amps.

The type of cable shown in Fig.4 is used for most

Australia
www.jaycar.com.au
techstore@jaycar.com.au
1800 022 888

New Zealand
www.jaycar.co.nz
techstore@jaycar.co.nz
0800 452 922

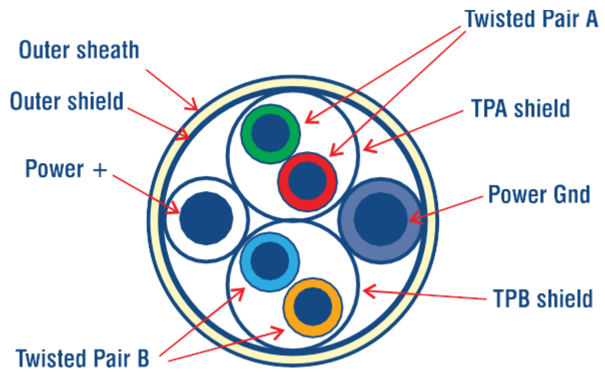


Fig.4: The primary type of IEEE 1394 cable has a pair of power conductors as well as the two shielded signal pairs TPA and TPB.

'mainstream' IEEE 1394 applications, such as interfacing large hard disk arrays to DV editing workstations.

The second type of cable used for IEEE 1394 has only the two shielded twisted pairs TPA and TPB, and can therefore only be used for signal transfer. This is the type of cable first used in Sony's iLink, and is now commonly used for digital video applications. Most DV camcorders and VCRs use this type of cable.

Due to the high speed at which IEEE 1394 works, cables between device nodes should be no longer than 5m long to limit signal attenuation. There should also be no more than 16 cable 'hops' separating any two nodes in an IEEE 1394 network.

Connectors

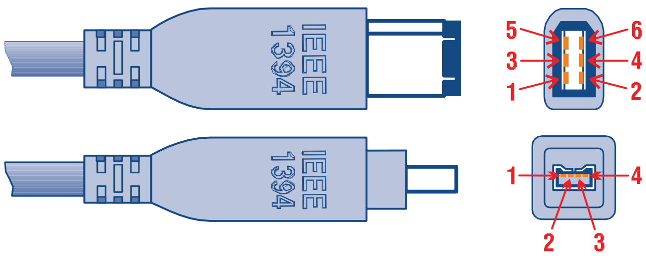
Just as there are two types of cable, there are two types of IEEE 1394 connector to match. Not surprisingly one type provides six connections and the other only four. Both of the plugs are shown in Fig.5, together with their pinouts. The corresponding sockets and their pinouts are complementary, of course.

As you can see both plugs are polarized and fairly compact. But the inserting section of the primary 6-pin plug is much larger (11.3 x 6.2mm) than that of the 4-pin plug, which is very small indeed (6.45 x 3.5mm). The larger plug is polarized by a pair of chamfers at one narrow end, while the smaller one has an indent in the centre of one side.

Normally all devices with IEEE 1394 ports are fitted with sockets, and the cables have plugs at each end. Adapter cables are available to allow data transfer between devices with 6-pin and 4-pin sockets, with appropriate plugs at each end. (There are also short adaptor cables with a plug and a socket, to mate with a standard like-to-like cable.)

NOTE: In all standard IEEE 1394 cables, the connections to the two signal 'twisted pairs' are transposed between the two ends. That is, in a 6-pin to 6-pin cable pins 4 and 3 at each end connect to pins 6 and 5 at the other, respectively. Similarly in a 4-pin to 4-pin cable pins 2 and 1 at each end connect to pins 4 and 3 at the other, respectively.

Because of their complex construction and the small size and precision of their connectors, IEEE 1394 cables can be quite expensive. Because of this and the tiny size of the 4-pin connectors in particular, they should be treated with care to ensure that they provide reliable communication at the fast data rates involved.



IEEE 1394 PLUG PINOUTS

Signal	6-pin Plug Pin	4-pin Plug Pin
Power +	1	–
Power Gnd	2	–
TPB –	3	1
TPB +	4	2
TPA –	5	3
TPA +	6	4

Fig.5: The two different types of IEEE 1394 plug, and their basic pin connections. But note that the TPA and TPB connections are transposed in all standard IEEE 1394 cables.

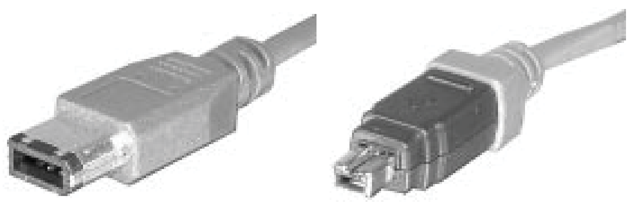


Fig.6: The two different types of IEEE 1394 plug. The 6-pin plug is on the left and the 4-pin plug is on the right.

Australia
www.jaycar.com.au
techstore@jaycar.com.au
1800 022 888

New Zealand
www.jaycar.co.nz
techstore@jaycar.co.nz
0800 452 922