FireWire

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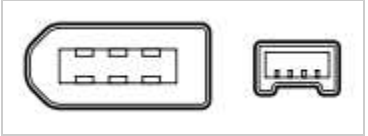
(Redirected from Firewire)

FireWire	
Year created:	1990
Created by:	Apple
Width:	1 bit
Number of devices:	63
Capacity	400/800 Mbit/s
Style:	Serial
Hotplugging?	Yes
External?	Yes

FireWire is Apple Inc.'s brand name for the **IEEE 1394** interface (although the 1394 standard also defines a backplane interface). It is also known as **i.Link** (Sony's name). It is a personal computer (and digital audio/digital video) serial bus interface standard, offering high-speed communications and isochronous real-time data services. FireWire has replaced Parallel SCSI in many applications, due to lower implementation costs and a simplified, more adaptable cabling system. IEEE 1394 has been adopted as the High Definition Audio-Video Network Alliance (HANA) standard connection interface for A/V (audio/visual) component communication and control[1]. FireWire is also available in wireless, fibre optic and coaxial versions using the isochronous protocols. Wireless FireWire is being integrated into the WiMedia Alliance's WiMedia Ultra-Wideband (UWB) standard.



The 6-pin and 4-pin FireWire Connectors

Almost all modern digital camcorders have included this connection since 1995. Many computers intended for home or professional audio/video use have built-in FireWire ports including all Apple, Sony laptop computers and most Dell and HP models currently produced. It is also widely available on retail motherboards for do-it-yourself PCs, alongside USB. FireWire was used with initial models of Apple's iPod, but later models eliminated FireWire support in favor of USB due to space constraints and for wider compatibility.

The alternative ethernet-style cabling used by 1394c

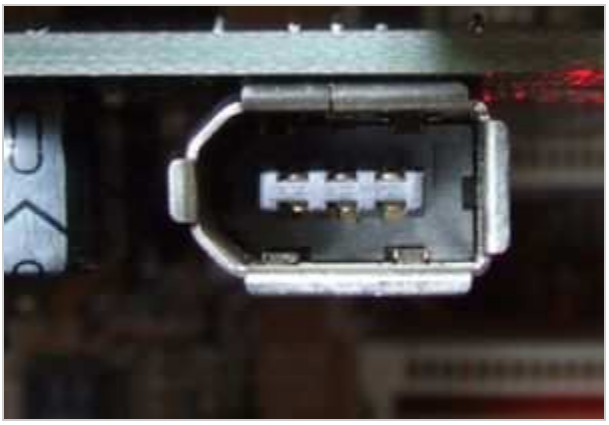
Contents

History and development

FireWire is Apple Inc.'s name for the IEEE 1394 High Speed Serial Bus. It was initiated by Apple and developed by the IEEE P1394 Working Group, largely driven by contributors from Apple, although major contributions were also made by engineers from Texas Instruments, Sony, Digital Equipment Corporation, IBM (International Business Machines Corporation) and INMOS/SGS Thomson (now STMicroelectronics).

4-pin (left) and 6-pin (right) FireWire connectors

Apple intended FireWire to be a serial replacement for the parallel SCSI (Small Computer System Interface) bus while also providing connectivity for digital audio and video equipment. Apple's development was completed in 1995. As of 2007, IEEE 1394 is currently a composite of three documents: the original IEEE Std. 1394-1995, the IEEE Std. 1394a-2000 amendment, and the IEEE Std. 1394b-2002 amendment (there is a 1394c amendment that provides support for 1 Gbit/s operation over 100 m of Category 5 unshielded twisted pair cable that will be published soon).



6-pin FireWire connector on the edge of an expansion card

Sony's implementation of the system is known as i.Link, and uses only the four signal pins, discarding the two pins that provide power to the device in favor of a separate power connector on Sony's i.Link products.

The system is commonly used for connection of data storage devices and DV (digital video) cameras, but is also popular in industrial systems for machine vision and professional audio systems. It is used instead of the more common USB due to its faster effective speed, higher power-distribution capabilities, and because it does not need a computer host. Perhaps more importantly, FireWire makes full use of all SCSI capabilities and, compared to USB 2.0 Hi-Speed, has higher sustained data transfer rates, especially on Apple Mac OS X (with more varied results on Windows, presumably since USB2 is Intel's answer to Firewire on Windows machines)[2][3], a feature especially important for audio and video editors.

However, the small royalty that Apple Inc. and other patent holders have initially demanded from users of FireWire (US$0.25 per end-user system) and the more expensive hardware needed to implement it (US$1–$2) has prevented FireWire from displacing USB in low-end mass-market computer peripherals where cost of product is a major constraint.

According to Michael Johas Teener, original chair and editor of the IEEE 1394 standards document, and technical lead for Apple's FireWire team from 1990 until 1996:

> The original FireWire project name was "Chefcat", the name of Michael Teener's favorite coffee cup. The standard connectors used for FireWire are related to the connectors on the venerable Nintendo Game Boy. While not especially glamorous, the Game Boy connectors have proven reliable, solid, easy to use and immune to assault by small children.
>
> FireWire is a trademark of Apple Computer, Inc. The trademark was filed in 1993. The "FireWire" name was chosen by a group of engineers socializing before Comdex 1993, just before the project was about to go public. IBM,

> Apple, Texas Instruments, Western Digital, Maxtor and Seagate were all showing drives, systems and other various FireWire support technology. The marketing forces behind the FireWire project had originally considered a name like "Performa".
>
> FireWire won the "most significant new technology" award from *Byte Magazine* at the Comdex 1993 show.
>
> During the period they participated with the IEEE p1394 working group, Apple proposed licensing all of their blocking patents for US$3,000, a one time fee only for "the point of first use" or the integrated circuits that implement the protocols. Furthermore, there was a discount if a contribution was made to the IEEE undergraduate scholarship fund. Under that agreement, the IEEE agreed to include the appropriate patents in the standard.
>
> Apple never intended to charge for the use of the name "FireWire". It could be used by any party signing an agreement to use the name for a product that was compliant with IEEE 1394-1995, the original version of the standard. Steve Jobs was convinced that Apple should ask for US$1 per port for the patents that became part of the standard. The argument was that it was consistent with the MPEG patent fees.
>
> The fallout from charging US$1 per FireWire port was significant, particularly from Intel. Intel had sunk a great deal of effort into the standard with the improved 1394a-2000 standard being partially based on work contributed by Intel. A group within Intel used this as a reason to drop 1394 support and bring out the improved USB 2.0 instead.
>
> Simultaneously, Sony and the other backers of the technology noted to Apple that they all had patents too and were entitled to per-port royalties. Under circumstances, Apple would have to pay roughly US$15 per port to the other FireWire technology developers. The end result was the creation of the "1394 Licensing Authority", a body which charges everyone US$0.25 per end-user system (like a car or computer) that uses any 1394 technology.
>
> —Micheal Teener, Apple's lead on the IEEE 1394 standards body, [4]

Technical specifications

FireWire can connect together up to 63 peripherals in an acyclic topology (as opposed to Parallel SCSI's Electrical bus topology). It allows peer-to-peer device communication, such as communication between a scanner and a printer, to take place without using system memory or the CPU. FireWire also supports multiple hosts per bus. It is designed to support Plug-and-play and hot swapping. Its six-wire cable is more flexible than most Parallel SCSI cables and can supply up to 45 watts of power per port at up to 30 volts, allowing moderate-consumption devices to operate without a separate power supply. As noted earlier, the Sony-branded i.Link usually omits the power wiring of the cables and uses a 4-pin connector. Power is provided by a separate power adapter for each device.

FireWire devices implement the ISO/IEC 13213 "configuration ROM" model for device configuration and identification, to provide plug-and-play capability. All FireWire devices are identified by an IEEE EUI-64 unique identifier (an extension of the 48-bit Ethernet MAC address format) in addition to well-known codes indicating the type of device and protocols it supports.

Operating system support

Full support for IEEE 1394a and 1394b is available for FreeBSD, Linux, Haiku OS and Apple Mac OS 8.6 through Mac OS X operating systems.[5] Microsoft Windows XP supports 1394a and 1394b, but as of Service Pack 2, every FireWire device will only run at S100 (100 Mbit/second) speed. A hotfix download is available from Microsoft that, with a simple registry modification, enables devices that run at S400 or S800 speeds to operate at their rated speed.[6] Some FireWire hardware manufacturers also provide custom device drivers that replace the Microsoft OHCI host adapter driver stack, enabling S800-capable devices to run at full 800Mb/s transfer rates. Microsoft Windows Vista currently supports only 1394a, with 1394b support coming later in a service pack.[7]

Cable system support

Cable TV providers (in the US, with digital systems) must, upon request of a customer, provide a high-definition capable cable box with a functional FireWire interface. This applies only to customers leasing high-definition capable cable boxes from said cable provider after April 1, 2004. The relevant law is CFR 76.640 Section 4 Subsections i and ii.[8] The interface can be used to display or record Cable TV, including HDTV programming.[9]

Node hierarchy

FireWire devices are organized at the bus in a tree topology. Each device has a unique self-id. One of the nodes is elected root node and always has the highest id. The self-ids are assigned during the self-id process that happens after each bus-reset. The order in which the self-ids are assigned is equivalent to traversing the tree in a depth-first, post-order manner.

Standards and versions

FireWire 400 (IEEE 1394a)

FireWire 400 can transfer data between devices at 100, 200, or 400 Mbit/s data rates (the actual transfer rates are 98.304, 196.608, and 393.216 Mbit/s, i.e. 12.288, 24.576 and 49.152 MBytes per second respectively). These different transfer modes are commonly referred to as S100, S200, and S400. Although USB 2.0 can theoretically operate at 480 Mbit/s, tests indicate that this speed is rarely attained. This may be due to the peer-to-peer network architecture of FireWire (as opposed to the client-server architecture of USB), as well as its support for memory-mapped devices (which allows high-level protocols to run without loading the host CPU with interrupts and buffer-copy operations).[10]


A 6-Pin FireWire 400 connector

Cable length is limited to 4.5 meters (about 15 ft), although up to 16 cables can be daisy chained using active repeaters, external hubs, or internal hubs often present in FireWire equipment. The S400 standard limits any configuration's maximum cable length to 72 meters. The 6-pin connector is commonly found on desktop computers, and can supply the connected device with power. A 4-pin version is used on many laptops (although some use the 6-pin powered connector, particularly those made by Apple) and small FireWire devices and does not have any power connectors, although it is fully compatible with 6-pin interfaces.

The 6-pin powered connector adds power output to support external devices. Typically a device can pull about 7 to 8 watts from the port ; however, the voltage varies significantly from different devices.[11] Voltage is specified as unregulated and should nominally be about 25 Volts (range 24 to 30). Apple's implementation on laptops is typically related to battery power and can be as low as 9V and more likely about 12 Volts.

FireWire 800 (IEEE 1394b)

FireWire 800 (Apple's name for the 9-pin "S800 bilingual" version of the IEEE 1394b standard) was introduced commercially by Apple in 2003. This newer 1394 specification (1394b) and corresponding products allow a transfer rate of 786.432 Mbit/s with backwards compatibility to the slower rates and 6-pin connectors of FireWire 400. However, while the IEEE 1394a and IEEE 1394b standards are compatible, FireWire 800's connector is different from FireWire 400's connector, making the physical male and female (both 4 and 6pin) connectors and cables incompatible. An adapter is necessary to take advantage of the 800's backward compatibility.

A 9-pin FireWire 800 (IEEE 1394b) connector.

The full IEEE 1394b specification supports optical connections up to 100 metres in length and data rates up to 3.2 Gbit/s. Standard category-5 unshielded twisted pair supports 100 metres at S100, and the new p1394c technology goes all the way to S800. The original 1394 and 1394a standards used data/strobe (D/S) encoding (called *legacy mode*) on the signal wires, while 1394b adds a data encoding scheme called 8B10B (also referred to as *beta mode*). With this new technology, FireWire, which was already slightly faster,[12] is now substantially faster than Hi-Speed USB.

FireWire S800T (IEEE 1394c)

IEEE 1394c-2006 was published on June 8, 2007.

It provides the following improvements

- A new port specification that provides the same ubiquitous RJ45 connectors with Category 5 cable used by the physical layer specified in IEEE 802.3 clause 40 (gigabit ethernet over copper twisted pair)
- Automatic negotiation that allows a port to connect using either the IEEE Std 1394 or IEEE 802.3 (ethernet) higher layers
- Various minor updates to IEEE 1394b

Firewire is enhanced to use Category 5 cable

Though the potential for a combined Ethernet and Firewire RJ45 port is intriguing, as of July 2007, there are no products or chipsets that include this capability.

Alternative Uses for IEEE 1394

Military Aircraft

IEEE 1394b is utilized for military aircraft, where weight savings are desired; even four pairs of wires, to permit multiple redundancy, are far lighter than hundreds of discrete wires. Developed for use as the data bus on the F-22 Raptor, it is also used on the F-35 Lightning II.[13] NASA's Space Shuttle also uses IEEE 1394b to monitor debris (foam, ice) which may hit the vehicle during launch.[13]. This standard should not be confused with the unrelated MIL-STD-1394B.

Networking over FireWire

FireWire can be used for ad-hoc (terminals only, no routers) computer networks. Specifically, RFC 2734 specifies how to run IPv4 over the FireWire interface, and RFC 3146 specifies how to run IPv6.

Mac OS X, Linux, FreeBSD, and Windows XP include support for networking over FireWire. A network can be set up between two computers using a single standard FireWire cable, or by multiple computers through use of a hub. This is similar with Ethernet networks with the major

differences being transfer speed, wire length and that standard Firewire cables can be used for point to point communication (Ethernet needs crossover cables for p2p connections).

Note that this feature is not supported in Windows Vista.[14]

The PlayStation 2 console had an iLink-branded 1394 connector. This was used for networking until the release of an ethernet adapter late in the console's lifespan, but was poorly supported by software.

IIDC

IIDC (Instrumentation & Industrial Digital Camera) is the FireWire data format standard for live video, and what Apple's iSight A/V camera uses. The system was designed for machine vision systems,[15] but is also used for other computer vision applications and for some webcams. Although they are easily confused since they both run over FireWire, IIDC is different from, and incompatible with, the ordinary DV (Digital Video) camcorder protocol.

DV

Digital Video (DV) is a standard protocol that is used by nearly all digital camcorders. Nearly all DV cameras have a FireWire interface (usually a 4-pin). Labeling of the port varies by manufacturer, with Sony always using its i.Link trademark. Many digital video recorders have a "DV-input" FireWire connector (usually a 6-pin connector) that can be used to record video from a directly-connected DV camcorder ("computer-free").

The protocol also allows remote control (play, rewind, etc.) of connected devices.

Security issues

Devices on a FireWire bus can communicate by direct memory access, where a device can use hardware to map internal memory to FireWire's "Physical Memory Space". The SBP-2 (Serial Bus Protocol 2) used by FireWire disk drives use this capability to minimize interrupts and buffer copies. In SBP-2, the initiator (controlling device) sends a request by remotely writing a command into a specified area of the target's FireWire address space. This command usually includes buffer addresses in the initiator's FireWire "Physical Address Space", which the target is supposed to use for moving I/O data to and from the initiator.

On many implementations, particularly those like PCs and Macintoshes using the popular OHCI, the mapping between the FireWire "Physical Memory Space" and device physical memory is done in hardware, without operating system intervention. While this enables high-speed and low-latency communication between data sources and sinks without unnecessary copying (such as between a video camera and a software video recording application, or between a disk drive and the application buffers), this can also be a security risk if untrustworthy devices are attached to the bus. For this reason, high-security installations will typically either purchase newer machines that map a virtual memory space to the FireWire "Physical Memory Space" (such as a Power Macintosh G5, or any Sun workstation), disable the OHCI hardware mapping between FireWire and device memory, physically disable the entire FireWire interface, or do not have FireWire at all.

This feature can also be used to debug a machine whose operating system has crashed, and in some systems for remote-console operations. On FreeBSD, the dcons driver provides both, with using gdb as debugger. Under Linux, firescope[16] and fireproxy[17] exist.

Hot plugging guidelines

Many electronic and computer systems should not be connected or disconnected while powered, as this may damage them. FireWire and other hot swappable devices however, have connectors

and circuits which are designed to make this safe. Despite this, there have been a few reports of cameras being damaged if the pins of the FireWire port are accidentally shorted while swapping. This was especially true for some early FireWire devices, but modern devices appear to have eliminated this problem. Furthermore, FireWire 800 ensures even greater safety when hot-swapping.

See also

- HAVI, FireWire to control Audio and Video hardware.
- Universal Serial Bus (USB)
- mLAN Yamaha's FireWire-based music networking system
- List of device bandwidths

References

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- IEEE p1394a Working Group (2000-06-30). *IEEE Std 1394a-2000 High Performance Serial Bus - Amendment 1 (http://shop.ieee.org/ieeestore/Product.aspx?product_no=SH94821)* . IEEE. ISBN 0-7381-1958-X.
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- Anderson, Don (1999). *FireWire System Architecture*. MindShare, Inc.. ISBN 0-201-48535-4.

External links

- High Definition Audio-Video Network Alliance (HANA) (http://www.hanaalliance.org/) Standard using IEEE 1394 FireWire for interconnecting A/V components
- Apple FireWire Technology (http://www.apple.com/firewire/)

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