



FireWire 800

Next-generation high-speed serial interface

Key Features

- Data transfer speeds up to 800 Mbps
- Distances up to 100 meters
- Plug-and-play connectivity
- Highly efficient architecture
- Compatibility with current FireWire products
- Real-time data delivery
- On-bus power
- More advanced than USB 2.0
- Support for a wide range of devices

FireWire is a high-speed serial input/output (I/O) technology for connecting peripheral devices to a computer or to each other. It's one of the fastest peripheral standards ever developed—and now, at 800 megabits per second (Mbps), it's even faster.

Based on Apple-developed technology, FireWire was adopted in 1995 as an official industry standard (IEEE 1394) for cross-platform peripheral connectivity. By providing a high-bandwidth, easy-to-use I/O technology, FireWire inspired a new generation of consumer electronics devices from many companies, including Canon, Epson, HP, Iomega, JVC, LaCie, Maxtor, Mitsubishi, Matsushita (Panasonic), Pioneer, Samsung, Sony, and Texas Instruments. Products such as DV camcorders, portable external disk drives, and MP3 players like the Apple iPod would not be as popular as they are today without FireWire.

FireWire has also been a boon to professional users because of the high-speed connectivity it has brought to audio and video production systems. In 2001, the Academy of Television Arts & Sciences presented Apple with an Emmy award in recognition of the contributions made by FireWire to the television industry.

Now FireWire 800, the next generation of FireWire technology, promises to spur the development of more innovative high-performance devices and applications. FireWire 800 (an implementation of the IEEE 1394b standard approved in 2002) doubles the throughput of the original technology, dramatically increases the maximum distance of FireWire connections, and supports many new types of cabling. This technology brief describes the advantages of FireWire 800 and some of the applications for which it is ideally suited.



USB versus FireWire

Bus	Theoretical maximum speed in Mbps
USB 1.1	12
FireWire 400	400
USB 2.0	480
FireWire 800	800

Due to the speed and efficiencies of FireWire 800, in many cases the effective bandwidth is more than twice that of USB 2.0.

Data Transfer Speeds Up to 800 Mbps

FireWire 800 is capable of transferring data at 800 Mbps—twice the speed of the original FireWire. This performance increase has been achieved primarily by using the same highly efficient encoding scheme used by Gigabit Ethernet and Fibre Channel.

In fact, the FireWire roadmap outlined in the IEEE 1394b standard will eventually take the theoretical bit rate to 1600 Mbps and then up to a staggering 3200 Mbps. That's 3.2 *gigabits* per second, which will make FireWire indispensable for transferring massive data files and for even the most demanding video applications, such as working with uncompressed high-definition (HD) video or multiple standard-definition (SD) video streams.

Distances Up to 100 Meters

Not only is FireWire 800 twice as fast as before, but it can be used over much longer distances. The 1394b specification allows the use of various types of cabling, each offering different speed/distance capabilities, as shown in the following table.

IEEE 1394b media speeds and distances

Cable type	100 Mbps	200 Mbps	400 Mbps	800 Mbps	1600 Mbps	3200 Mbps
9-pin shielded twisted pair copper	4.5 m	4.5 m	4.5 m	4.5 m	4.5 m	4.5 m
CAT-5 unshielded twisted-pair copper (standard Ethernet cable)	100 m	—	—	—	—	—
Step-index plastic optical fiber	50 m	50 m	—	—	—	—
Hard polymer-clad plastic optical fiber	100 m	100 m	—	—	—	—
Glass optical fiber	100 m	100 m	100 m	100 m	100 m	100 m

FireWire 800 (1394b) hubs even make it possible to connect FireWire 400 (1394a) devices up to 100 meters apart. Neither the computer nor the remote devices need to support FireWire 800, because the new hubs and their associated cables work with FireWire 400 equipment. New FireWire 800 (and other 1394b) devices can, of course, communicate over long connections directly through their own FireWire 800 ports; no hub is required to gain this distance benefit in a pure-FireWire 800 connection.

Plug-and-Play Connectivity

FireWire allows for true hot-swappable, plug-and-play connection of peripheral devices. There is no need to shut down the computer before adding or removing a FireWire device. Nor do you need to install drivers, assign unique ID numbers, or connect terminators.

You can connect a few devices in a simple chain or add hubs to attach as many as 63 devices to a single FireWire bus. The number of available FireWire buses can be increased via PCI and CardBus cards.

FireWire is a true peer-to-peer technology. Using a FireWire hub, multiple computers and FireWire peripherals can be connected at the same time. Such an arrangement would, for instance, enable two computers to share a single FireWire camera.

A brief history of FireWire

Three versions of the IEEE 1394 standard “FireWire” have been approved so far by the Institute of Electrical and Electronics Engineers (IEEE):

- 1394-1995 was the original standard. Driven by Apple and based largely on Apple-developed technology, 1394-1995 supported data transfer rates up to 400 Mbps and distances up to 4.5 meters, and introduced the concept of self-managing, peer-to-peer multimedia interconnect.
- 1394a, adopted in 2000, added and clarified specifications for performance optimization and power management on FireWire buses.
- 1394b, adopted in 2002, raises maximum FireWire speeds with architectural specifications up to 3.2 Gbps and distances to 100 meters. It also allows more types of media (including optical fiber cabling) to be used for FireWire connections.

Highly Efficient Architecture

The added speed and longer cable distance of FireWire 800 come from two major improvements to the underlying technology.

First is a new, highly efficient arbitration scheme for all the devices sharing a given FireWire bus. For data to be sent and received successfully (such as from a camcorder to a computer, or from a computer to a disk drive), the various FireWire devices must determine which device gets to transmit when. Otherwise, the data packets would collide and reduce the data transfer rate.

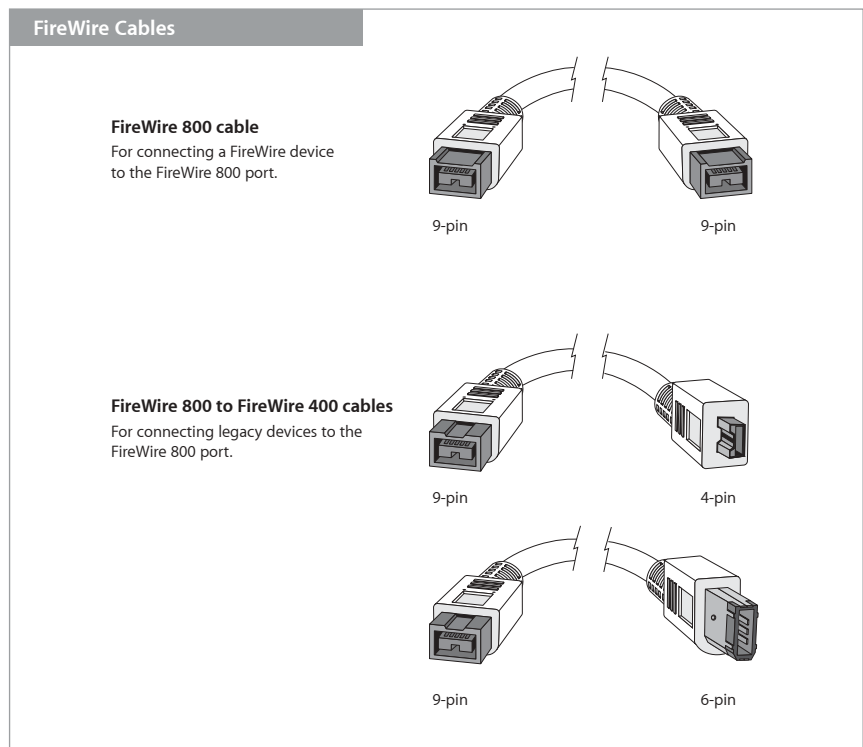
In FireWire 400, arbitration is performed after each transaction, so there’s a delay before a device wins the arbitration and is allowed to start sending its data. In FireWire 800, the arbitration for the next transaction is done while the current data packet is being sent. This way, the device chosen by the arbitration is ready to send its data as soon as the current transmission is completed.

The second improvement brings even greater efficiency. FireWire 800 uses advanced data encoding based on codes used by Gigabit Ethernet and Fibre Channel. This encoding, which is called 8B10B, results in less signal distortion than the original FireWire data/strobe (D/S) encoding.

Together, these arbitration and data encoding improvements are called the “beta mode” of FireWire operation. Beta mode distinguishes FireWire 800 (1394b) from the 1394-1995 and 1394a “legacy modes.”

Compatibility with Current FireWire Products

FireWire 800 provides two modes of transmission: the pure beta mode (1394b) and the backward-compatible legacy mode that works with FireWire 400 devices (1394-1995 and 1394a).



FireWire 400 devices use a 6-pin or 4-pin connector; FireWire 800 devices use a 9-pin connector. The FireWire 400 ports on Apple systems have 6 pins, while the FireWire 800 ports have 9 pins. Existing FireWire 400 devices can be plugged into either type of port, although in some cases an adapter cable (4-pin to 6-pin, 6-pin to 9-pin, and so on) is required. FireWire 800 devices can achieve FireWire 800 speeds only on the FireWire 800 port.

Real-Time Data Delivery

Unlike many other data transfer technologies, FireWire can guarantee real-time delivery of data. This is critical for streaming media applications such as audio and video, where delayed or out-of-order frames are unacceptable.

The data traffic between FireWire nodes is divided into isochronous and asynchronous transfers. Isochronous transfers provide guaranteed transmission opportunities at defined intervals; if a packet is not received successfully, it is not resent. In asynchronous transfers, the intervals between transmissions can vary, and data can be resent if it's missed.

For example, sending a live TV broadcast requires isochronous transmission to ensure that each frame arrives on time and in the correct order. By contrast, storing data on a hard disk drive can be done asynchronously. It's okay for dropped data to be resent, and it doesn't matter in what order the data arrives, because each packet is tagged with an address or sequence number to reliably identify it.

FireWire is one of very few interfaces that combine both isochronous and asynchronous capabilities. FireWire can reserve up to 80 percent of its bandwidth for one or more isochronous channels, making it an excellent interface for applications that require real-time data transmission.

On-Bus Power

Like its predecessor, FireWire 800 provides significant amounts of power on its bus (up to 45 watts, with a maximum of 1.5 amps and 30 volts). This means that many devices can be powered through the FireWire cable and will not need their own power cables and adapters. For example, Apple's iPod digital music player uses FireWire as its sole data and power connection. The player can recharge its built-in battery while it's downloading new music from your computer.

(Note that some manufacturers offer products that use 4-pin FireWire connectors; these devices cannot receive power from a FireWire bus and must be powered separately. The 9-pin and 6-pin connectors do carry power.)

FireWire also includes an aggressive power management scheme; power is used only when actually needed.

More Advanced Than USB 2.0

FireWire and USB have both found their place in the computer and consumer electronics industries. USB is the technology of choice for most computer mice, keyboards, and other lower-bandwidth input devices. FireWire—with its higher bandwidth, longer distances, and much higher-powered bus—is more suitable for devices such as high-speed external disk drives, digital video (DV), professional audio, high-end digital still cameras, and home entertainment components.

The extra speed of FireWire 800 compared with USB 2.0 makes FireWire much more suitable for bandwidth-intensive applications like video and graphics, which often consume hundreds or even thousands of megabytes of data per file. The short cable distance of USB 2.0 (about five meters) limits its usefulness in deployments that require long-haul cabling and multiple sources of data, such as sound stages and studios. Another differentiator of FireWire is that it is a true peer-to-peer technology. USB 2.0 works in a master/slave arrangement, meaning that data must be copied to a central computer, then back again. Because FireWire does not require a central host, two or more FireWire peripherals can communicate with each other directly as peers, sending each piece of data across the bus only once, directly to its destination. So at the same speed in Mbps, FireWire can be used to move data much faster than USB. This feature makes FireWire suitable for connecting home entertainment components such as game consoles, home stereos, and TVs.

Finally, FireWire is designed to transport useful amounts of power as well as data, so it's possible to power—and even charge the battery of—many FireWire peripherals directly from your computer. While USB 2.0 allows at most 2.5W of power, enough for a simple device like a mouse, FireWire devices can provide or consume up to 45W of power, plenty for high-performance disk drives and rapid battery charging. This feature is of special benefit to users of portable computers, who can take important peripherals on the road without carrying a lot of wall-mount power adapters.

Support for a Wide Range of Devices

What can you use FireWire for? Here's a sampling of the FireWire devices currently in use or on the horizon.

Mass storage

Storage devices—especially portable ones—are being radically transformed by the adoption of FireWire. Not only does FireWire permit an external hard disk drive to be mounted by simply connecting a single plug, it can even provide enough electricity to power the drive. FireWire mass storage devices include hard disk drives, magneto-optical drives, high-capacity removable drives, tape drives, and CD/DVD products, including both read-only and read/write drives.

Video

Digital video (DV) camcorders capture video and audio and can send a perfect copy to a computer for editing, adding special effects, and making other modifications to create a finished video. FireWire provides the high-speed connection required to download digital video quickly. FireWire 800 even has the necessary throughput for bandwidth-intensive applications that were not possible over the original FireWire, such as multiple-stream, uncompressed, standard-definition video. The long-distance capability of FireWire 800 also gives production studios and similar businesses more flexibility to locate each piece of equipment where it's most appropriate, rather than having to put everything adjacent to the computer.

Digital audio

FireWire delivers the bandwidth required for high-quality digital audio. Even FireWire 400 has enough bandwidth over a single connector for hundreds of channels of noise-free, high-resolution digital audio and up to 256 channels of MIDI. FireWire 800 can handle twice as many simultaneous real-time streams. Support for cabling up to 100 meters gives you more configuration options with FireWire 800 than solutions such as USB, enabling you to use a Macintosh system as a virtual patch bay that connects audio devices in situations ranging from a personal studio to a huge multiroom production facility. You can even hot-swap devices in and out of the audio processing chain as your needs change.

Digital recording, processing, and storage bring many advantages to today's musicians, producers, engineers—and, of course, listeners. These advantages include clean transmission and audio integrity even with multiple generations of copying. FireWire offers a high-speed, flexible bridge between professional digital audio components. In addition, because FireWire has been widely embraced by consumer electronics manufacturers, you can easily integrate video cameras, receivers, and other consumer gear with professional audio equipment.

Digital still cameras

Digital cameras are one of the fastest-growing peripheral segments in computing. They allow you to capture high-quality still images and transfer them digitally to your Macintosh system, eliminating the need for traditional film developing and scanning.

FireWire provides a means for transferring images from the camera to the computer that is much faster and more convenient than serial, parallel, or even USB connections—especially for high-resolution images that can be hundreds of megabytes in size. The high bandwidth of FireWire 800 will be increasingly important as consumer-product manufacturers offer cameras with higher and higher megapixel ratings.

Printers and scanners

The benefits of FireWire printers and scanners include faster direct connections for high-quality imaging applications and the ability to free up Ethernet bandwidth by sharing printers within small FireWire-equipped workgroups.

Printers and scanners also benefit from the built-in power capabilities of FireWire. Portable printers don't need a separate battery, and consumer and film scanners don't need wall-mounted power supplies.

Home entertainment

Set-top boxes, personal video recorders (PVRs), game consoles, home stereo equipment, DVD players, digital TVs, interactive TVs, and computers all have a need to communicate using a common plug-and-play, high-speed interconnection that's capable of efficiently transmitting video, audio, graphics, and Internet data. More and more of these devices are already available with FireWire ports, so they can easily be integrated into the modern home entertainment system.

Networking

Workgroup computers that have FireWire or other 1394 ports can be linked via FireWire and communicate using standard IP networking protocols. FireWire can also be used to cost-effectively share a printer, scanner, camera, or other device.

Networking with FireWire offers several advantages over Ethernet. FireWire 400 is faster than 100BASE-T, the most common Ethernet speed, and FireWire 800 comes close to the speed of 1000BASE-T. FireWire 800, with its ability to guarantee the timing interval of data packets, can also deliver smooth real-time video.

For More Information

For more information about FireWire, please visit www.apple.com/firewire. For more information about specific FireWire products, visit guide.apple.com.