FIRE-WIRE
(Physical Description, Applications and Characteristics)

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ABSTRACTS

The emergence of digital video and multimedia applications has brought with it the need to move large amounts of data-quickly-between peripherals and PCs. And as audio/video products migrate to digital technology, understood to benefit from a simple high-speed connection that would make this transmission more efficient.

IEEE 1394 is a Serial BUS standard is the industry-standard implementation of computer industries for digital I/O system. It's a versatile, high-speed, low-cost method of interconnecting a variety of personal computer peripherals and consumer electronics devices. It is designed for use in real-time applications such as sound, video, and animation. This technology was designed by INMOS (now SGS-Thomson Microelectronics) for their TRANSPUTER and then further developed by Apple Computer Inc.

The name FireWire, which was coined by Apple, is still used by a few vendors. Others have adopted the name i.Link, which is trademarked by Sony Corp., and has become a popular moniker for 1394-enabled products and technology in the world.

Keywords

FireWire, i-Link, Universal Serial Bus (USB),

1.0 INTRODUCTION

The *Institute of Electrical and Electronic Engineers* Standards Board introduced IEEE-1394 in late 1995. The number comes from the fact that this happened to be the 1,394th standard they published. It is the result of the large data-moving demands of today's audio and video multimedia devices. The key advantage of 1394 is that it's extremely fast, the current standard supports data transfer rates (data interface) up to an incredible 400 Mbps (and next 1394 about 800 Mbps) and called *FireWire*. It is also known as *i-Link* (a Sony Corporation's name). *FireWire-A* (IEEE 1394a) has been around for many years, and is widely available on both Macintosh and PC computers, as well as many proprietary systems. *FireWire-B* (IEEE 1394b) is a new higher-speed standard which is just appeared on the market in 2003.

The function of FireWire is to connecting PC to PC or PC to Digital Camera, this product bring you all the advantages of this exciting peripheral connectivity standard with easy-to-use plug-in cards and great software for a fantastic value and gives the high-speed serial bus communication.

2.0 BACKGROUND

Designed by *Inmos Ltd.* for their transputer (*Transputers are high performance microprocessors that support parallel processing through on-chip hardware. They can be connected together by their serial links in application-specific ways and can be used as the building blocks for complex parallel processing systems).* and then further developed by APPLE, at which point it was given the name *"FireWire".* Companies that want to

include the FireWire name in a 1394 product first must sign a licensing agreement with *Apple Computer Inc.* (and pay the necessary royalties). The IEEE 1394 signal has an intermediate characteristic between serial and parallel transmission. It transmits serial data and clock signal in parallel, and countermeasures cable skew (propagation velocity difference between two pairs) by not changing the clock signal when the data signal changes. It uses high speed real-time transmission with a cable that can be connected and disconnected without turning off any device. It makes it possible to connect freely between multiple terminals without having to consider termination.

Developed by the industry's leading technology companies, the specification was accepted as an industry standard by the *IEEE Standards* Board on December 12, 1995, with succeeding revisions since then.

3.0 FIREWIRE CHARACTERISTICS

3.1 The Types of FireWire

FireWire IEEE 1394a (400 Mbps), offers several advantages over other technologies. These benefits include:

- Guaranteed delivery of multiple data streams through isochronous data transport.
- The ability to connect up to ***63 devices*** without the need for additional hardware, such as hubs. *(refer Appendix 1)*
- A flexible, six-wire cable.
- Complete plug-and-play operation, including the hot swapping of live devices.
- Acceptance by over 40 leading manufacturers in the computer and electronics consumer industries.

And of course, having the IEEE 1394a than might be named IEEE 1394b.

FireWire IEEE 1394b (800 Mbps) is higher speed, longer distance, more functionality, and a better connectivity experience.

The 1394b standard retains all the major features of 1394a, but adds some others that are great improvements:

- A new signaling protocol called *Beta*, which permits operation at higher data rates and at greater distances than the older *Data Signal* protocol used in 1394/1394a.
- Higher data rates of 800 Mbps (S800) and 1600 Mbps (S1600). It also includes *"architectural support"* for 3200 Mbps (S3200) for the future.
- Greater cable distances, using a variety of cabling types, including not only the familiar copper wire of 1394a, but also optical fiber and CAT-5 twisted pair.
- Improved copper cables and connectors (9-pin plugs and sockets) that perform better at the higher speeds and greater distances.
- Speed-ups in arbitration and signaling, higher efficiency, suspend/resume, etc.

Despite of their competitors such as *Universal Serial Bus (USB)* produce revisions specification which is allow higher data rates transfer, the *FireWire* will not stop here, it should soon reach, with the aid of special fibers or wireless communications, speeds from 800 to 3200 Mbps.

3.2 The Features

These FireWires offers the following features:

1. Low attenuation
2. High propagation velocity
3. Low cable skew

FireWire carries data transmission with enough margins to be used for longer runs than the recommended maximum length of 4.5m (14.75Ft.) per cable in the IEEE 1394 standard. Incidentally, the maximum applicable

length of all the connected cables in one FireWire system, excluding a bus bridge on any one bus, is limited to 4.5m × 15 pcs. for a total of 67.5m (14.75Ft × 15 pcs. = 221.25Ft.).

3.3 FireWire Technical Details (IEEE 1394a)

This standard currently exists with three signaling rates:

- 100 Mbps
- 200Mbps
- 400Mbps

The most PC adapter cards support the 200Mbps rate, even though current devices generally operate at only 100Mbps. A maximum of 63 devices can connected to a single IEEE 1394 adapter card by way of daisy-chaining or branching. The FireWire devices (unlike USB devices) can be used a daisy-chain without using hub, although hubs are recommended for devices that will be hot-swapped. FireWire cables devices consist of 6 conductors, which is four wires transmit data, and two wires conduct a power. *Figure 1* shows the FireWire cable, socket, and connector.

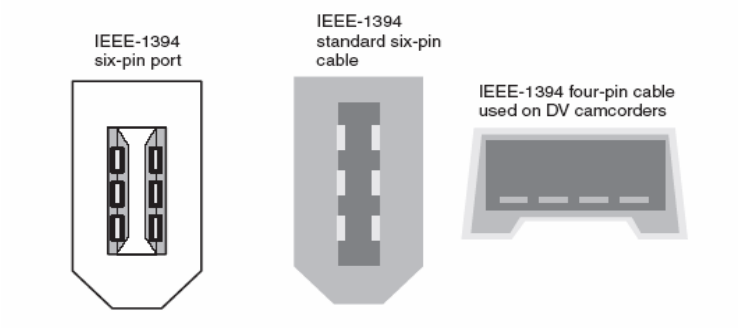

Figure 1, FireWire (IEEE-1394) port, 6-pin cable, and 4-pin cable.

FireWire uses a simple six-wire cable with ***two*** differential pairs of clock and data lines, plus ***two*** power line, the four-wire cables shown in *Figure 1* is used with self-powered devices, such as DV camcorder. Just plug-and-play (PnP), including the capability for hot-plugging (insertion and removal of components without powering down). FireWire does not require complicated termination, and devices connected to the bus can draw up to 1.5 amps of electrical power.

Why 63 devices can connect to the FireWire without additional hardware?
FireWire is built a daisy-chained and branched topology, and it allows up to 63 nodes, with a chain of up to 16 devices on each node. The standard also calls up to 1,023 bridged buses, which can interconnect more than 64,000 nodes. It's also can support devices with various data rates on the same bus.

The types of devices that can be connected to the PC via FireWire mainly include video cameras, editing equipment, and all forms of disk drives, including hard disk, optical, floppy, CD-ROM, and DVD-ROM drives. Also, digital cameras, tape drives, high-resolution scanners, and many other high-speed peripherals that feature FireWire have interface built-in.

3.4 Physical Description

FireWire is supporting data speeds up to 400 megabits per second (Mbps). Some manufacturing companies build this peripheral inclusive with feature by *Sonic MyDVD* software for Windows. This feature is used to capture and edit video, arrange the clips into an easy-to-access menu, and then burn the finished collection onto CD-RW or DVD-R media to share, store, and keep memories alive for a lifetime.

- Six wire - 4 signal - transfer rates to 400Mbps (1394b) - to 800 Mbps (1394a).
- 30-micron gold plated contacts on 2 mm centers.
- Durability Connections: beyond 1500 cycles, P&P.
- Signal Attenuation: <5.8 dB at 400 MHz
- Signal Velocity of Propagation: ≤ 5.05 nanosec/m.
- Signal pairs of propagation skew: ≤ 400 p/s
- Crosstalk: ≤ -26 dB
- Cable assemblies in standard lengths: 1m, 2m, 3m and 4.5m. Custom lengths from 0.2 m (6 in.).
- 6 wire = 4 signal (plus ground & power)
  4 wire = 4 signal (dual twisted pair)

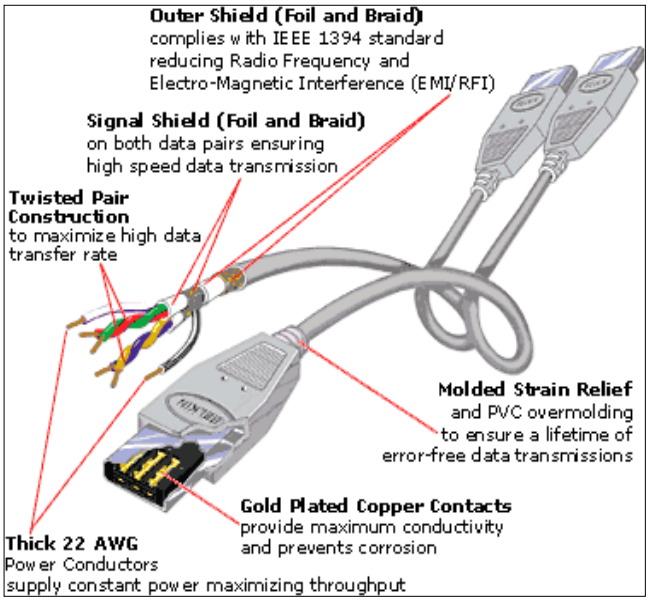

Figure 2, Physical view of FireWire (IEEE 1394®)

3.4.1 FireWire (4-pin to 4 pin Cable)

Features:
Connectors: 4-pin Male to 4-pin Male
Data Transfer Speeds: 100/200/400 Mbps
Features: Supports Plug n Play operation Hot Pluggable Molded strain relief protects ensures years of trouble-free data transmissions IEEE-1394a compliant.
Application: Video presentation and editing, desktop and commercial publishing, document imaging, home multimedia, personal computing
Designed for: Digital camcorders, scanners, printers, storage devices and other Firewire devices.

Figure 3, 3ft or 6 ft FireWire 4 pin to 4 pin Cable.

3.4.2 FireWire (6 pin to 4 pin Cable)

Features:
Connectors: 6-pin Male to 4-pin Male
Data Transfer Speeds: 100/200/400 Mbps
Features: Supports Plug n Play operation Hot Pluggable Molded strain relief protects ensures years of trouble-free data transmissions IEEE-1394-1995 compliant.
Application: Video presentation and editing, desktop and commercial publishing, document imaging, home multimedia, personal computing
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Figure 4, 3ft or 6 ft FireWire 6 pin to 4 pin Cable.

3.4.3 Firewire (6 pin to 6 pin Cable)

Features:
Connectors: 6-pin Male to 6-pin Male
Data Transfer Speeds: 100/200/400 Mbps
Features: Supports Plug n Play operation Hot Pluggable Molded strain relief protects ensures years of trouble-free data transmissions IEEE-1394-1995 compliant.
Application: Video presentation and editing, desktop and commercial publishing, document imaging, home multimedia, personal computing
Designed for: Digital camcorders, scanners, printers, storage devices and other FireWire devices.

Figure 5, 3ft or 6ft FireWire 6 pin to 6 pin Cable.

4.0 FIREWIRE SPESIFICATION

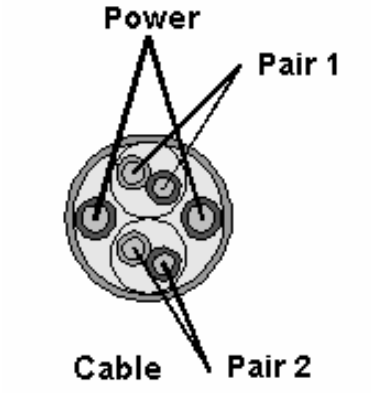

Figure 6, Cross-view & Connector of FireWire.

4.1 Pin Structures (6 Pin)

Pin No.	Signal	Comment
1	Y P	Cable Power
	V G	Cable Ground
3	TPB	Strobe on receive, Data on transmit (differential pair)
4	TPB	
5	TPA	Data on receive , Strobe on transmit (differential pair)
6	TPA	

Table 1, 6 Pin Connector Pin Assignment

4.2 Detailed Specification

Core Configuration			2×Balanced Signal Pair 2×Power Conductor
Balanced Signal Pair	Conductor Size (mm²)		0.0886mm² (#28AWG)
	Insulation	Ov. Dia.(mm)	1.0Ø (0.0394"Ø)
		Material	CPP
		Colors	Red/Green, Blue/Orange
	Shield	1st Shield	Aluminum Tape Shield
		2nd Shield	Copper Braid Shield
Power Conductor	Conductor Size (mm²)		0.341mm² (#22AWG)
	Insulation	Ov. Dia.(mm)	1.2Ø (0.0472"Ø)
		Material	PVC
		Colors	Black/White
Insulation Taping between two individual core braided shields and overall aluminum tape shielding			Twofold Polyester Tape
Ov. Shield	1st Shield		Aluminum Tape Shield
	2nd Shield		Copper Braid Shield
Ov. Jacket	Ov. Dia.(mm)		6.1Ø (0.240"Ø)
	Material		Flexible PVC
	Color		Dark Gray

***Table 2*,** FireWire Insulator Structures.

4.3 Electrical & Mechanical Characteristics

Signal Pair	Impedance	Differential	110W±6W
		Common Mode	33W±6W
	Attenuation (at 4.5m)		100MHz: 1.3dB
			200MHz: 1.9dB
			400MHz: 3.1dB
	Propagation Velocity		4.35nS/m
	Relative Propagation Skew (at 4.5m)		76ps
Power Pair	Characteristic Impedance (Differential)		53W
	DC Resistance at 20°C (at 4.5m)		0.235W
Crosstalk (at 1MHz~500MHz)			-52dB
Tensile Strength			882 N
Emigration			Non–emigrant to ABS resin
Applicable Temperature			-10°C~ +60°C(-14°F~ +140°F)
Standard			IEEE 1394, UL 2560 AWM 60°C 30V VW-1

***Table 3*,** Mechanical & Electrical Characteristics.

5.0 CONCLUSIONS

FireWire has satisfied the definition of a good bus design—it has expanded far beyond its original intent. As consumer multimedia and computing applications continue to merge, the peer-to-peer flexibility and the serial bus advantages of the IEEE 1394 standard will become increasingly popular. As demonstrated by the increasing bandwidth of 1394b, there's no immediate end in sight to the amount of performance that can be extracted from this protocol. With backward compatibility in mind, contributors to the evolving standard are opening up a new way of computing that will provide increasing flexibility and portability of applications

A lot is being said about the FireWire. The first thing is its acceptability on the market. In fact, that is not a polemic point, due to the fact that its creation has practically happened by *"industry order",* mainly the appliances and great performance computers.

6.0 REFERENCES

1. *Scott Mueller*, Upgrading & Repairing PCs 14th Edition 2003; ISBN 0-7897-2745-5, Que Publishing Indianapolis, USA.
2. Website: http://www.ieee.org
3. Website: http://www.1394a.org

Appendix 1

FireWire Equipment Arrangements

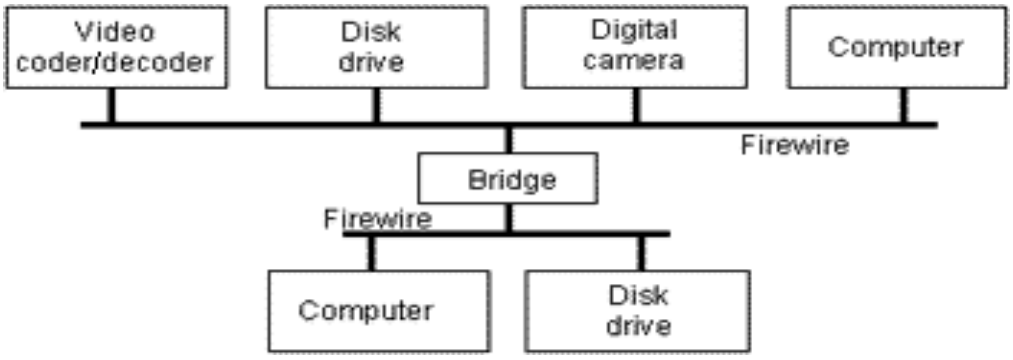

Figure 1: Example of equipment arrangements with FireWire.

Examples of FireWire Buses

- Node "N1" transmits a request packet through FireWire of portal "b"
- Portal "b", implemented in bridge "a-b", detects a request and verifies that it is needed to retransmit the packet through "a" portal for it to be able to reach its destination (inbound operation);
- Packet travels through bridge "a-b" and arrives at portal "a";
- Portal "a" retransmits the packet through the FireWire bus that unites "a" and "c" (outbound operation);
- Portal "c", implemented on bridge "d-c-e", detects a request and verifies that it is need to retransmit the packet through portal "e", for it to be able to reach its destiny (inbound operation);
- Packet travels over the bridge "c-e" and arrives at portal "e";
- Portal "e" retransmits the packet through the FireWire bus, where node "N2" is connected (outbound operation);
- Node "N2" receives packet;
- Node "N2" starts the opposite process, that is, sends response packet to request.

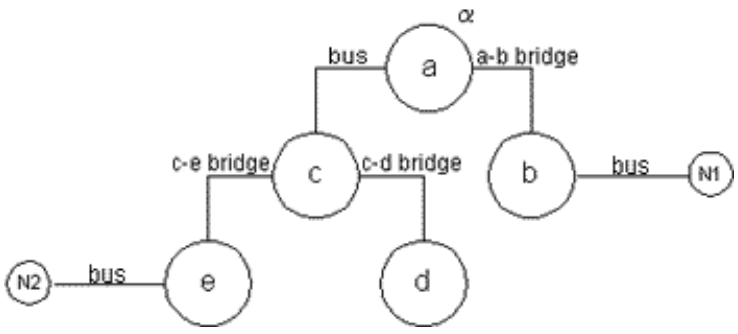

Figure 3: Example of topology with FireWire buses, portals, bridges and nodes.

Appendix 2

FireWire characteristics

- Hot-pluggable — you don't have to turn off your storage system or computer to connect or disconnect it, and you don't even need to restart your computer.
- FireWire-A max raw data rate is 400Mbps (50MB/sec); typical sustained transfer rate is about 40MB/sec. FireWire-B doubles these rates.
- FireWire-A is about 30 times faster than USB 1.1 (Universal Serial Bus), and about the same speed as USB 2.0 Hi-Speed. FireWire-B is about 60 times faster than USB 1.1, and about twice as fast as USB 2.0 HS.
- Supports up to 63 devices per bus. A typical bus will have between two and perhaps a dozen devices.
- Hubs are available to provide "tree" layouts in addition to the more common "daisy-chain".
- Cable lengths can extend up to 14 feet (4.5 meters) between devices.
- Cables are easy to connect and you don't need device IDs or terminators.

FireWire-A vs. USB 2.0 Hi-Speed

Even though USB 2.0 Hi-Speed has a theoretical max raw data rate slightly higher than FireWire (480 Mbps vs. 400 Mbps), the typical sustained transfer rates are about the same, because FireWire is a more efficient protocol to use in audio and video environments. In fact, in most cases, FireWire beats USB 2.0 Hi-Speed, albeit by a small margin. Very often it will be the computer or hard drive mechanism which limits the system performance more than the interface, so you might see about the same performance using FireWire-A or USB 2.0.

FireWire Bridge

Figure 2 illustrates a very simple bridge model. As you can see, the 2 portals represented can exchange information synchronized by a single clock (notice the synchronism clock and the isochronal queues) or in asynchronous way (notice the request and response queues). Also by Figure 2, it is clear that the transactions of packets can occur bi-directionally, that is, from 0 to portal 1 or vice-versa. The choosing of the kind of communication (isochronal or asynchronous), as well as the communication rates, it is made by data structures contained on the Routing Control Table.

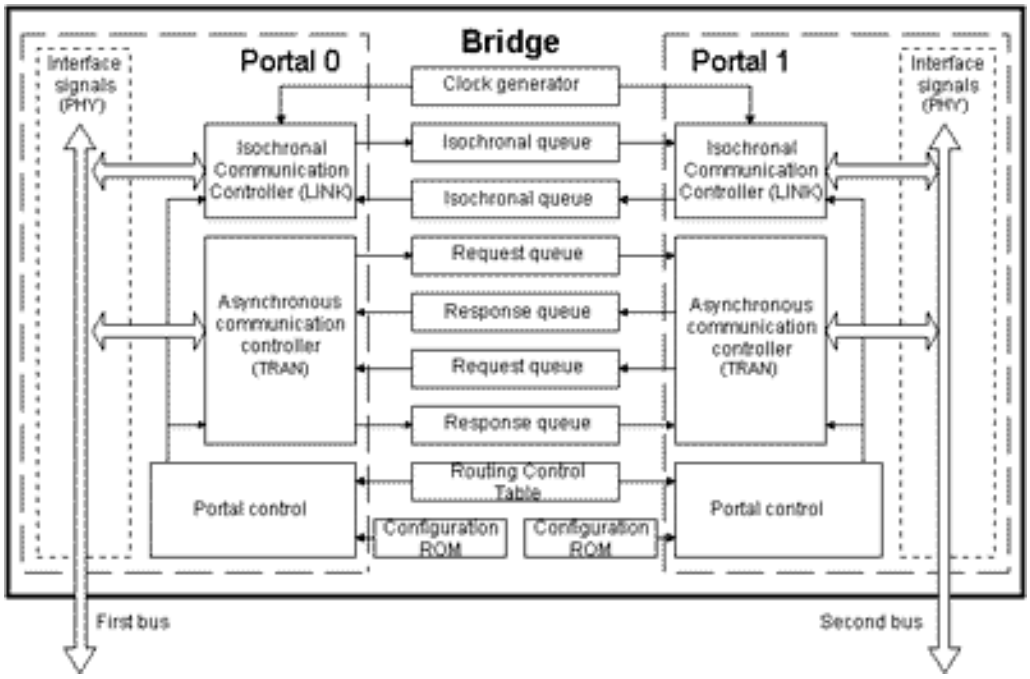

Figure 2: Simplified model of FireWire bridge, with only 2 portals.

Virtual Node ID

In a FireWire bus network, the node (connected devices) IDs have some interesting characteristics. One of them is stability in reset operation in the buses and stability in the path (it depends on the topology of the bus connection) used by the information packet. One and only one portal, is the responsible for managing the designation of virtual nodes. Portal A is chosen, during a bus auto-identification phase (on the network initialization), as being, by simplicity, the one that has higher physical ID value. The auto-identification process works like this: each portal transmits at least 2 packets with information about itself to the other portals, including the physical ID used to choose. So, after this process, all the portals can easily calculate the topology of the implemented network and internally keep registrations of this topology's information.

When a node is removed or added in some bus, a bus reset process is automatically initiated, starting a new bus and node auto-identification procedure. Connected devices easily detect the adding or removal of nodes, just by comparing the topology calculated after this reset with the topology calculated after the previous reset. There is also a periodical operation that serves to update the topological IDs, that is called refresh.