

## Avoiding Design Errors in 1394-Based External Storage Systems

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IEEE 1394, also known as FireWire, has become a standard of choice for storage applications. FireWire is a popular and proven standard, and while it is familiar to many system designers, there is still the potential to make design errors that can compromise performance.

First, a look at the three significant market segments for external FireWire/1394 hard drives. The most common is external storage for computers. These drives are used to provide additional storage for computers, for use in transferring data between computers or for making backups.

Second is external storage for direct connection to camcorders. These drives can accept audio and video directly from the camcorder in lieu of recording to videotape or other storage media inside the camcorder. Additionally, video can be transferred from storage inside the camcorder to the FireWire hard drive without using a computer to manage the transfer. This type of 1394 hard drive is often called an “AV” drive.

Finally, there is external storage for set top boxes or HDTVs. These drives provide additional storage for a set-top box (STB) or HDTV and are similar to the AV drives. This additional storage can be used to increase the storage capacity of the STB for use in recording programming or it could be used for archiving programming already recorded on the STB.

Of these three market segments, the most common is external storage for computers. Drives for direct connect to camcorders tend to sell into the professional Audio/Video market. 1394 drives for STBs and HDTVs are also available, but their use may not be enabled by cable TV suppliers (see <http://redbuttonsoftware.com>).

There are three other storage market segments that have essentially the same architecture. These include flash drives, CD/CDRW drives and DVD/Blu-ray (BD) drives.

FireWire external storage devices follow the same general design.

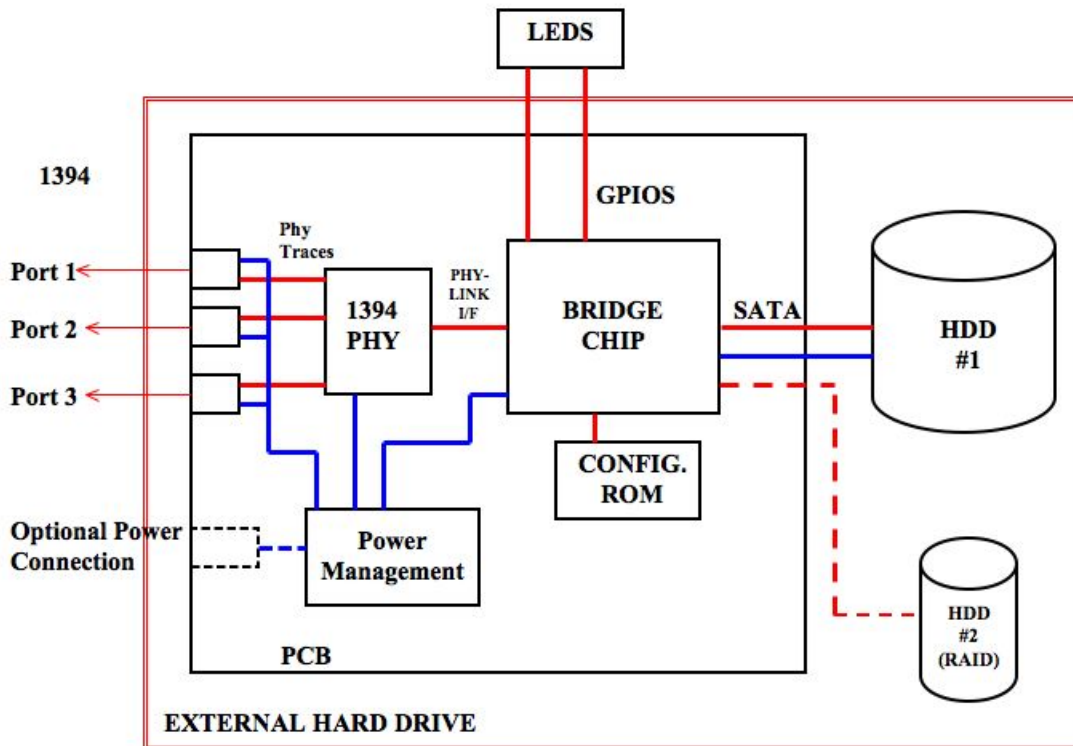


Figure 1

## External Connectors

Most FireWire hard drives for computers combine FireWire and other common interfaces such as USB and eSATA. It is also common for FireWire drives to contain both FireWire 400 and FireWire 800. The 6-pin connector is the most common FireWire 400 connector on hard drives and the 9-pin connector is used on FireWire 800. It is common for smaller drives (2.5 inches and smaller) to be powered over the 1394 bus via a 6-pin or 9-pin connector. Larger drives will require a separate power supply because of the limitations in power that can be provided over the bus.

FireWire flash drives are frequently powered over the 6-pin connector but some form of external power is normally provided for cases where the FireWire 4-pin connector is the only one available for use. The 4-pin connector does not provide power. CD, DVD and BD drives can also be powered over the 6-pin or 9-pin cable.

## Silicon Options and Choices

Communication across the FireWire cable is achieved using an ATAPI, IDE, SATA or ATA bridge chip to 1394. Native 1394 storage silicon, if available could reduce

peripheral cost. The silicon providers for bridge chips include PLX Technology (through its Oxford Semiconductor division), Initio, JMicron, Prolific, and O2Micro.

### **Software support**

FireWire 400 storage has been supported in the Windows OS since Windows 98 Second Edition and in Apple computers since the second-generation iMacs in late 1998.

FireWire 800 is supported in Apple's OSX and is supported in Microsoft's Win7. Linux supports both FireWire 400 and FireWire 800.

### **Common Design Mistakes**

Frequently seen design mistakes that often impact interoperability or performance fall into four categories: power management; configuration ROM contents; board layout; and Late-VG protection.

The first category is providing insufficient power for the external storage device. This includes power for the board electronics, the storage device and the correct bus power indicated by the Power Class of the devices.

- Bus power needs to match the Power Class included in the Self-ID packet. See figures 9-25 and 9-26 from the IEEE 1394-2008 specification.
  - Power Class 0 – Self-Powered Device where cable power is never used
  - Power Class 1 – Primary Power Provider where PHY is always self powered
  - Power Class 2 – Primary Power Provider where PHY is powered by cable in Power off state (30 watts)
  - Power Class 3 – Primary Power Provider where PHY is powered by cable in Power off state (45 watts)
  - Power Class 4 – Alternate Power provider or powered from cable (3 watts)
  - Power Class 5 – Reserved for future standardization
  - Power Class 6 – Cable Power is always used (3 to 6 watts)
  - Power Class 7 – Cable Power is always used (3 to 10 watts)
  
- Devices should be designed to withstand full bus voltages. 1394 cables can deliver as much as 33 volts and 1.5 Amps of current (45 watts). Be sure to use components with suitable ratings such as capacitors, diodes, PCB traces, wire gauge, etc.

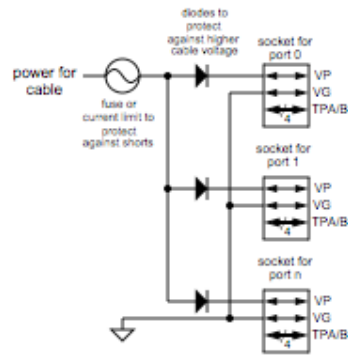


Figure 9-25—Node power interface for POWER\_CLASS one, two, or three

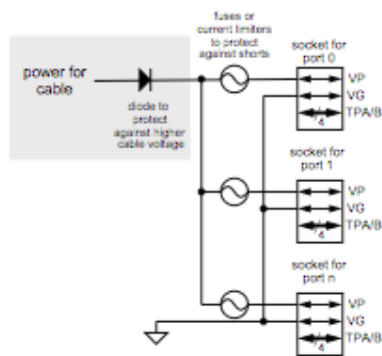


Figure 9-26—Node power interface for POWER\_CLASS four (three or more ports)

Figure 2. Node power interface figures from the IEEE 1394-2008 standard

The second category is having the required information in the configuration ROM. Configuration ROM (see figure 1) errors lead to misinformation in the Self-ID packet, which is transmitted every time the external storage product is connected to the FireWire bus. The configuration ROM supplies values for these parts of the Self-ID packet: Vendor ID; unique serial number (GUID); checksum; and power class. Having a unique GUID is particularly important because some operating systems will only recognize one external storage device if two devices are connected with the same GUID.

The third category of common design mistakes is circuit board layout. Using non-impedance matched traces (see figure 1) and skew matched traces should be avoided. TPA+/A- and TPB+/B- traces between the PHY and the connectors should be 110 ohms +/- 10% differential impedance.

Other requirements include the following:

- Differential traces need to be the same length to avoid introducing skew with termination close to the PHY. Four-layer boards are recommended.

- Power planes need to be included. Lack of power planes makes it difficult to meet the required trace impedance and may increase EMI issues. Again, four-layer boards should be used.

Finally, design choices such as the use of common mode chokes in the TPA+/A- and TPB+/B- traces to reduce electromagnetic interference (EMI) can impact 1394 signal quality and introduce interoperability or performance issues.

The fourth category of common design mistakes concerns susceptibility to a type of electrical overstress (EOS) that is unique to FireWire called Late-VG. Late-VG occurs when the cable ground connection,  $V_g$  fails to connect before cable power,  $V_P$ . This can damage the PHY because TPA/TPB temporarily become used as a path for return currents. To avoid this, there should be a DC connection between  $V_g$  and the connector shield, and the connector should be designed to resist cables being plugged in upside down or at an angle

- Avoid the use of 6-pin sockets where the mechanical seam is on the narrow end of the socket (these sockets tend to allow easier upside down cable insertion)
- Use back-to-back diode protection, for example BAL99 type products, on the TPA/TPB signal pairs
- Use over-voltage detection on the TPA/TPB signal pairs to disconnect  $V_P$

Additional design tips are available on the 1394 TA web page at this URL:  
<http://www.1394ta.org/developers/DevelopersTips.html>

### **Recommend Standard Compliance Testing**

Both FireWire 400 and FireWire 800 external storage devices are eligible to earn the 1394 TA compliance logo by being submitted for testing at a 1394 TA certified test lab or at a 1394 TA plugfest. Testing includes the following suites:

- a) Base 1394 Test Suite
- b) Point-to-Point Test Suite
- c) Network Test Suite
- d) Functional Test Suite

Many potential customer interoperability issues -- which may be easily fixed in product firmware -- can be identified by submitting a storage device for testing at a 1394 TA Compliance Workshop. More information is available on the 1394 TA web page, [www.1394ta.org](http://www.1394ta.org)