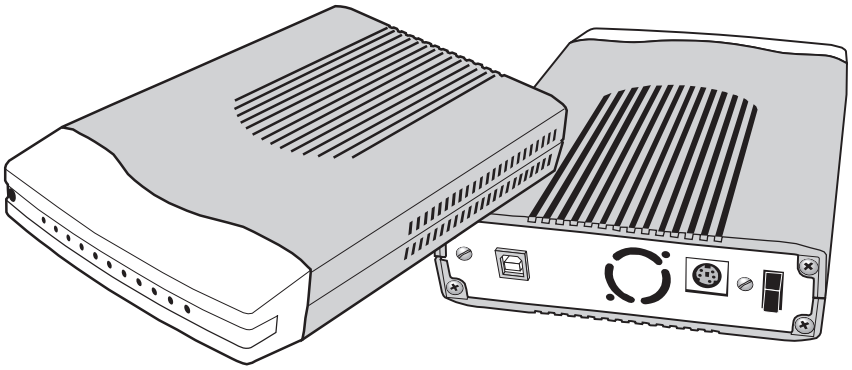
IEEE 1394 and USB 2.0 IDE Drive Enclosures



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IEEE 1394 and USB 2.0 IDE Drive Enclosures

Lava Computer MFG Inc.

This white paper describes IEEE 1394 (FireWire®) and USB 2.0 IDE drive enclosures. It outlines what they are, how they perform, and how they compare to other types of external storage.

What are IDE drive enclosures?

IDE drive enclosures are cases designed to hold a standard IDE hard disk drive, and to permit interfacing that drive to a computer. To accomplish this, IDE drive enclosures contain electronics that bridge the hard disk drive's IDE interface to a high-speed data bus such as USB 2.0 or IEEE 1394 (FireWire®). Depending on the power requirements of the IDE drive and on the need to daisy-chain IDE drive enclosures, a power supply—either external to the case, or internal—may be a part of an IDE drive enclosure package.

Why are these drive enclosures arriving now in the marketplace?

The arrival of IDE drive enclosures results from a combination of factors:

- wide-spread adoption of new I/O interface standards that are well-suited for high-speed data interfacing
- rapidly falling IDE hard disk drive costs for a given combination of speed and capacity
- rapidly increasing storage needs for sound, video, and graphic files
- increased consumer desire for portable storage

Why do IDE drive enclosures use FireWire® and USB 2.0 interfaces?

These interfaces are particularly well-suited to external IDE drive enclosures, for a number of reasons.

1. They provide the speed needed to take advantage of the throughput capabilities of the hard disk drives fitted into the enclosures. Although an IDE drive directly connected to a motherboard IDE controller will be faster than an external drive that must use a bridge, the loss is generally not significant. IDE drive enclosure speed is discussed in detail below.
2. They are simple to set up. FireWire® and USB 2.0 represent good alternatives to SCSI drive interfaces, as they need no terminators or device IDs. They are easy to configure.
3. They are convenient to use. FireWire® drives can daisy-chain directly to other FireWire® peripherals; USB 2.0 drives daisy-chain to USB devices using hubs. Both USB and FireWire® drives can be hot plugged, making it possible to attach or move an external drive without rebooting the system to which it is attached.
4. They are becoming better and better supported across operating systems. Details on operating system support for FireWire® and USB is provided below.
5. IEEE 1394 has support on both PCs and Macintoshes®, so a FireWire® external IDE drive, such as Lava's FireDrive®, can simply and transparently move files between these systems.
6. USB 1.1's wide use, and the fact that USB 2.0 is backwards compatible with USB 1.1, means that many people can use a USB 2.0 external IDE drive, such as Lava's Kazan, right away. To get the full benefit of a USB 2.0 peripheral's speed, however, a USB 2.0 port is needed.

Measuring throughput: understanding the numbers

DATA CAPACITY

When describing data throughput rates to hard drives or across I/O interfaces, the terminology and abbreviations can be confusing. To start, quantities of data are measured in "bits" or "bytes." A byte is simply eight bits. When describing data storage *capacity*, the industry typically speaks of *bytes* of data: a floppy disk has 1440 kilobytes of storage capacity, a hard disk has 20 gigabytes of storage capacity, and so on.

DATA FLOWS

When it comes to data *flows*, however, we tend to speak of *bits* of data: a hard disk has a throughput of 200 megabits per second, a 16550 UART serial port has a speed of 115.2 kilobits per second, a Fast Ethernet connection is a 100 megabit per second connection, etc.

Throughput measurements describe data transferred over a period of time, usually a minute or a second. When comparing products' relative speeds, be aware of inconsistent and overlapping abbreviations for "megabits per second" and "megabytes per second."

The table below lists some of the standard throughput measures and their abbreviations, and highlights a possible area of confusion.

TABLE 1. Throughput terminology and abbreviations

Full Term	Abbreviation	Other Abbreviations Used
kilobits per second	kbps	Kbps
megabits per second	Mbps	mbps; Mb/s; MBps, MB/s
megabytes per second	MB/s	Mb/s; MBps
gigabits per second	Gbps	

For example, Lava's FireDrive® has a maximum sustained throughput of about 15 Mbps. A competing product might claim a maximum sustained throughput of 15 MB/s. Do not be misled; the two drives transfer data at the same speed.

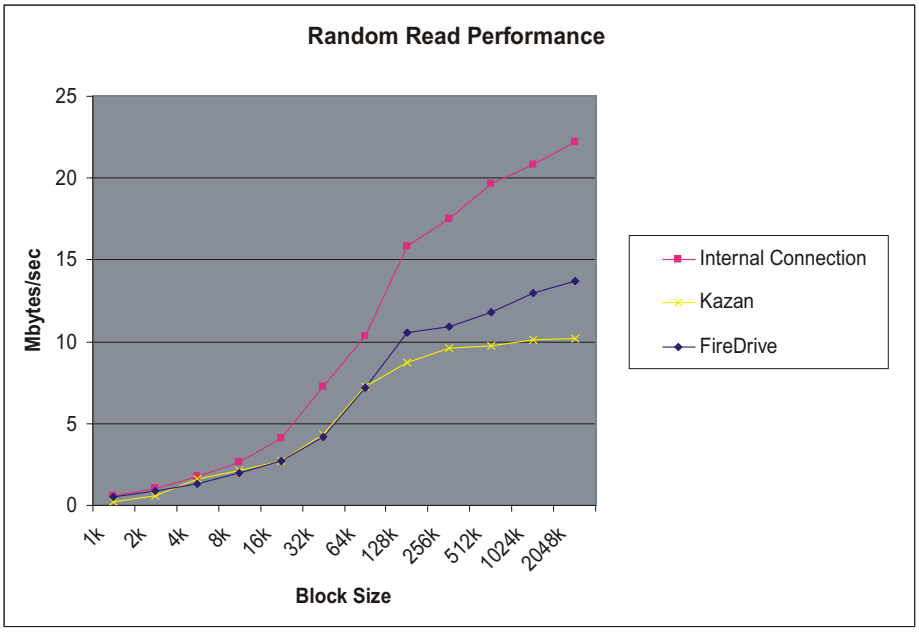
How fast are Kazans and FireDrives?

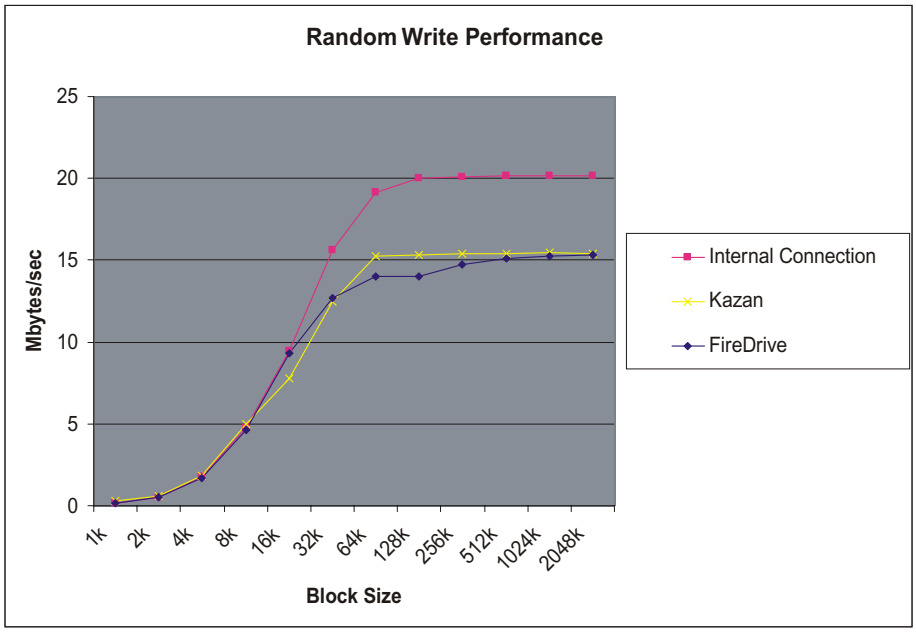
Assessing IDE drive enclosure speed is slightly complicated. A number of factors contribute to external drive speed. To start with, the faster the drive you put into the enclosure, the faster the overall result. At the same time, because external drives must communicate with the system across a bridging hardware interface, some overhead is introduced. In no case will any external drive -- Lava's or any other type -- be as fast as the same hard drive with a direct motherboard IDE connection. That said, in most cases a user will see no difference between a hard disk directly connected, and a hard disk in a FireDrive® or Kazan drive enclosure.

The graphs below show the performance of a typical 7200 rpm, 20 gigabyte hard drive in three scenarios: directly attached to the computer's motherboard, installed in a Kazan USB 2.0 IDE drive enclosure, and installed in a FireDrive® IEEE 1394 drive enclosure. In each case, the drive's read and write speeds were tested in two ways: random access testing and sequential access testing. Lava tested each drive with various sizes of data transfer (block sizes) to gain the fullest possible picture of the performance of its drive enclosures.

RANDOM ACCESS TESTING

Random access testing evaluates how well a drive writes or retrieves data randomly located on a drive. Random access speed is important for applications such as databases where the drive needs to process a large number of small transfer demands.

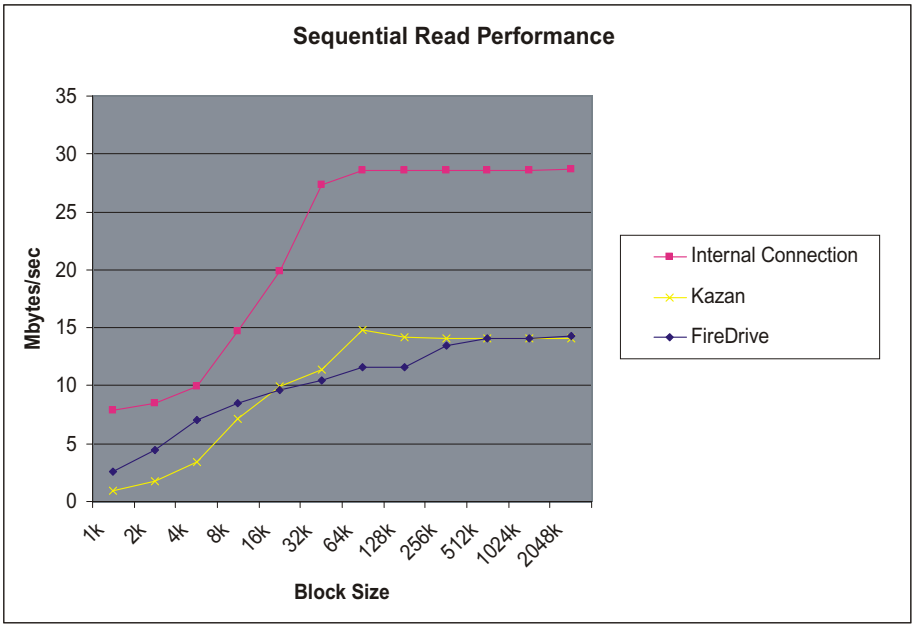


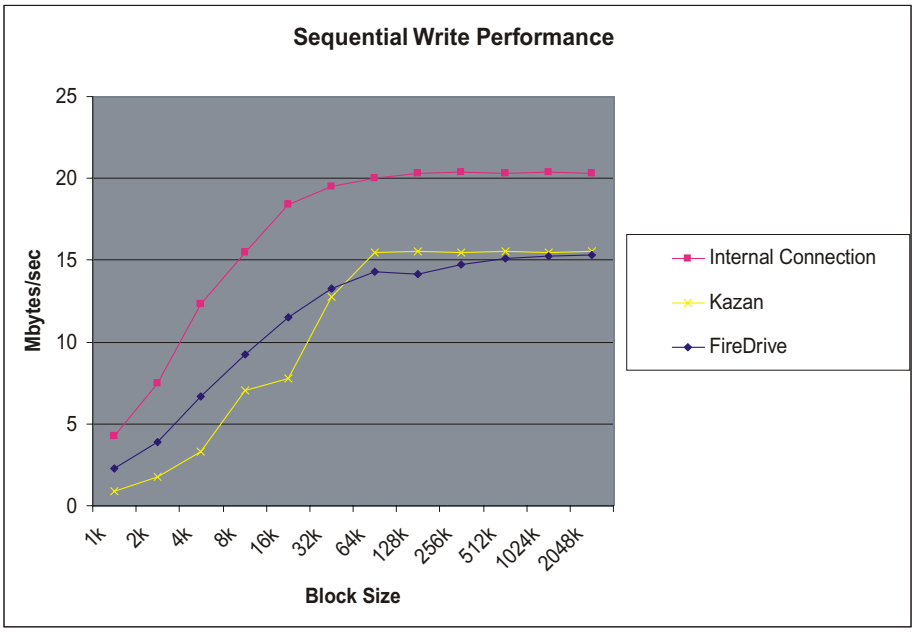


SEQUENTIAL ACCESS TESTING

Sequential access performance is important for graphical and video applications, when file data accesses are relatively few, but files can be large. Sequential access testing mea-

sures how quickly a drive will read or write a file located in a single physical area of a hard disk.





CONCLUSIONS

The basic conclusions from testing these drives are:

1. The FireDrive® IEEE 1394 and the Kazan USB 2.0 are similar in performance.

2. Both the FireDrive® and the Kazan move data at between 50% and 75% of the speed of a direct motherboard connection.
3. With the FireDrive® and Kazan IDE drive enclosures, you can have speed that is generally not distinguishable from an internal hard disk.

How fast are IDE drive enclosures compared to other types of external storage?

In terms of throughput, IDE drives are superior to most other forms of external storage. Compared to ZIP™ drives, tape drives, CD-RW drives, and other external drive technologies, IEEE 1394 and USB 2.0 drive enclosures' throughput capabilities are far ahead.

TABLE 2. Comparative device throughputs

Device	Throughput rate
Parallel port ZIP™ drives	800 kbps
IDE tape drives	1 Mbps
USB ZIP™ drives	1.2 Mbps
CD-RW IDE drives	4.8 Mbps
FireDrive® & Kazan	15 Mbps

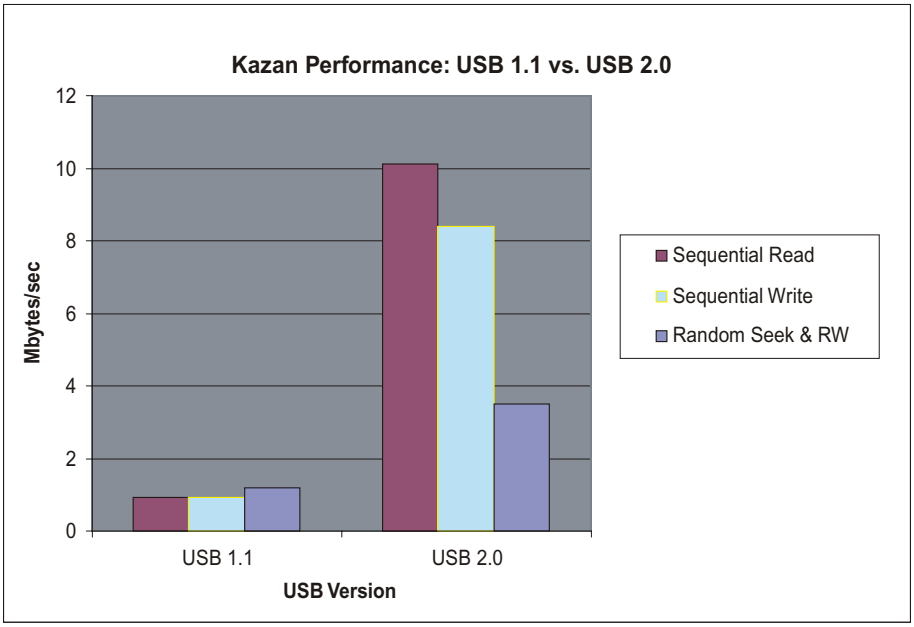
Comparing the Kazan's speed when used with USB 2.0 and USB 1.1 ports

One of the reasons USB 2.0 is rapidly gaining popularity is that it builds on the existing infrastructure of USB 1.1 ports and peripherals. Most motherboards today have USB 1.1 ports built-in. The Kazan, like USB 2.0 peripherals generally, can use them.

This backwards compatibility highlights a major benefit of USB 2.0: using USB 2.0 peripherals will not force a user to upgrade their system to include USB 2.0 ports. With a Kazan, users can continue with their USB 1.1 ports and upgrade to USB 2.0 when they see it fit. There is, however, one very clear reason to use a USB 2.0 interface as soon as possible: to take full advantage of the Kazan's blazing USB 2.0 speed.

The chart below compares the Kazan's performance when used with USB 2.0 and USB 1.1 ports. The same Kazan was tested for speed when attached to a USB 1.1 port and

when attached to a USB 2.0 port. With USB 2.0, the improvement is extremely impressive.



Of course, as USB 2.0 is still new, most motherboards will not have USB 2.0 ports built-in. To get USB 2.0 ports, users will need to add a USB 2.0 interface to their systems with a USB 2.0 host adapter, such as Lava's two-port USB 2.0 Host Adapter.

What about drive capacity?

CAPACITY

When looking at IDE drive enclosures, assessing capacity is simple: the capacity of a hard drive does not change when you put it into the Lava enclosure. Using a 60 gigabyte hard drive will give you a 60 gigabyte external drive enclosure.

Compared to other forms of external storage, IDE drive enclosures generally provide superior storage capacity.

SIZE LIMITS

The limit on drive size for an IDE drive enclosure is set by the limit of addressability in the industry-standard ATA specification for hard drives generally. In the case of the ATA interface implemented in the drive enclosure, 28 bits are given to the sector number interface between the operating system, the BIOS, and the hard disk. A hard disk can therefore have at most 2^{28} or 268,435,456 sectors of 512 bytes. The ATA interface, and the drive enclosure as a result, has a maximum capacity of approximately 137.4 GB.

Physical characteristics

EXTERNAL POWER

External IDE drive enclosures can power their system boards and hard drives through their interface cables. Both USB and FireWire® have this capability. This power is usually sufficient for interface boards and small hard disk drives (2.5”), but is not recommended for 3.5” drives. In no case is it likely to be adequate when the external drive is part of a daisy-chain of peripherals.

In addition, in the case of FireWire®, cables can have either four or six wires. Only six-wire FireWire® cables carry power, so a bus-powered drive enclosure will not work with a four-wire cable.

Lava’s IDE drive enclosures come complete with external switching power supplies. This ensures that they will always have sufficient power, regardless of the hard drive that has been installed or the daisy-chaining configuration being used.

ELECTRICAL ISOLATION

Lava’s FireDrive® and Kazan are designed to supply power to their interface boards through their external power supplies, rather than through their interface cables. As a consequence, these external IDE drives are isolated from the computers to which they connect. This design affords greater security from electrical spikes and surges than that afforded by bus-powered external IDE drive enclosures.

In addition, if these external drives are connected to the Lava FireHost IEEE 1394 Host Adapter or the Lava USB 2.0 Host Adapter, they will have additional isolation, as these host adapters have PTC fuses and directional diodes built-in.

COOLING

Since hard disk drive and interface electronics generate heat in operation, cooling is a consideration when using an IDE drive enclosure such as the Kazan or FireDrive®. While Lava’s enclosures are designed with sufficient ventilation for normal applications, it is important to ensure good air circulation around the drive enclosure case.

If more cooling is desired, Lava’s enclosures are designed to accommodate a user-installed fan. The interface board has a pin connector to supply power to the fan, and the casing itself has an opening and holes for fan mounting.

SHOCK RESISTANCE

External drives are by their nature subject to movement and occasional jarring. The casing used for the Kazan and FireDrive® enclosures is designed to withstand normal bumping and dropping.

Operating system support

IEEE 1394/FIREWIRE®

IEEE 1394 is currently supported in Windows® 98SE/Me/2000/XP, Macintosh® OS 8.6+, and Linux kernel 2.4+.

IEEE 1394 support for external drives varies from operating system to operating system, and within versions of a single operating system. The main areas of variation include support for using IEEE 1394 drives as bootable drives, and for handling the “surprise removal” of an external drive from a running system.

IEEE 1394 AND WINDOWS® SYSTEM AND BOOT PARTITIONS

Using IEEE 1394 external drives as system or bootable drives depends on both the operating system and the system’s BIOS support for IEEE 1394. Windows® 98SE and Me do not support IEEE 1394 bootable drives.

Windows® 2000 and XP support using IEEE 1394 drives for system and boot partitions, as well as for normal storage. To use an IEEE 1394 drive for a system or boot partition, the computer’s BIOS must have IEEE 1394 boot support. If the BIOS des not have IEEE 1394 support, you will not be able to install the operating system because although the drive and partitions will appear in Setup, they will be listed as an “unknown controller.”

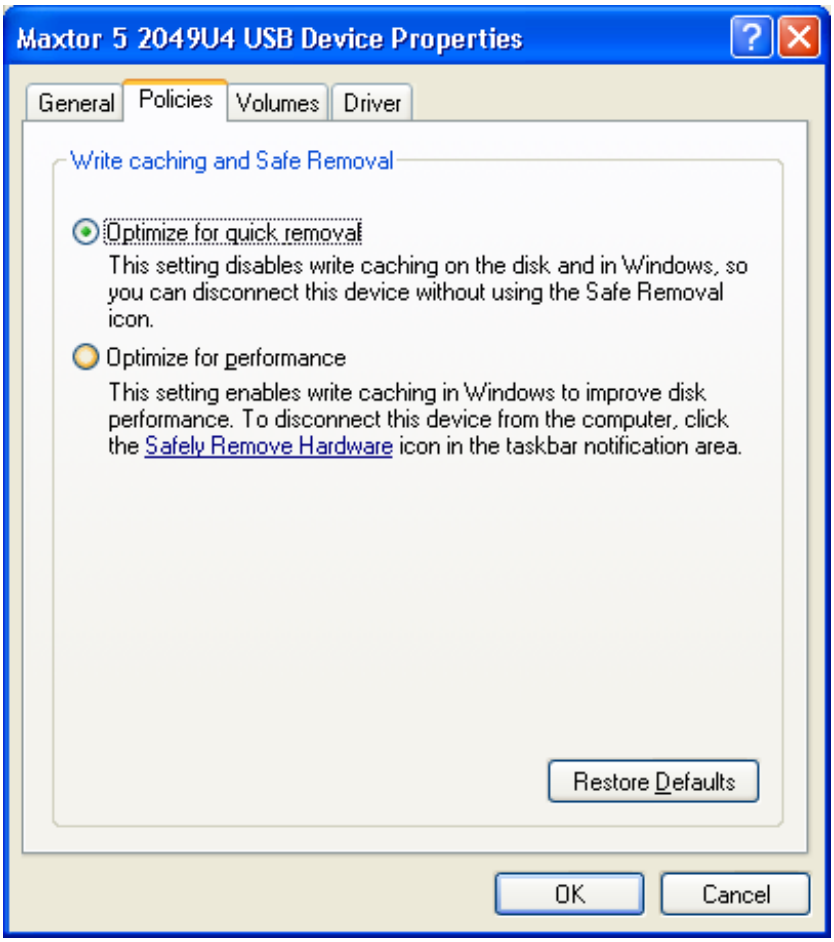
WINDOWS® AND EXTERNAL HARD DRIVE ENCLOSURE “SURPRISE REMOVAL”

Surprise removal of a device occurs when a user simply removes the device from the system without indicating to the operating system that such a removal will occur. When a device is removed by surprise, the operating system has no opportunity to prepare for the event by doing such things as stopping writing to the device, removing power from the device, and any other tasks to allow the device to be removed without damage to the system or loss of data. From the operating system’s perspective, a surprise removal is the same as a hardware failure.

Surprise removal contrasts with “orderly removal,” where the user opens the Safely Remove Hardware applet on the task bar, indicates that a particular device will be removed, and awaits a confirmation that the device can be safely removed.

Microsoft has been gradually increasing and improving the operating system support for the so-called “surprise removal” of external drive enclosures. Windows 98SE and 2000 initially lacked provision for the surprise removal of external drives. The operating system would issue a warning when a drive was removed, and a risk of data loss existed. However, users of these operating systems can now download a patch to update these operating systems with a safe removal applet that will prepare the system for a drive enclosure removal.

Windows® XP includes improved support for surprise removal of external drives. As the screen capture below shows, it can be optimized for either quick device removal or for improved performance



When optimized for quick removal, an external drive has write caching disabled. The added security comes with a performance hit: while the risk of data loss is less, throughput fell from 13 Mbps to 8.3 Mbps in Microsoft's testing of a Windows® XP system with an IEEE 1394 hard drive.

USB 2.0 AND USB 1.1

USB 2.0 is currently supported in Windows® 2000 and Windows® XP.

Windows® 2000 USB 2.0 support is not native to the operating system or its service packs, but is available as a driver package available on Windows Update.

Windows® XP support is native to the operating system, but the initial release of Windows® XP supports only a couple of hardware IDs, belonging to the NEC USB 2.0 EHCI controller, as this was the only certified contoller in the mrketplace at the time of the XP development effort for Windows® XP. Support for other EHCI silicon vendors'

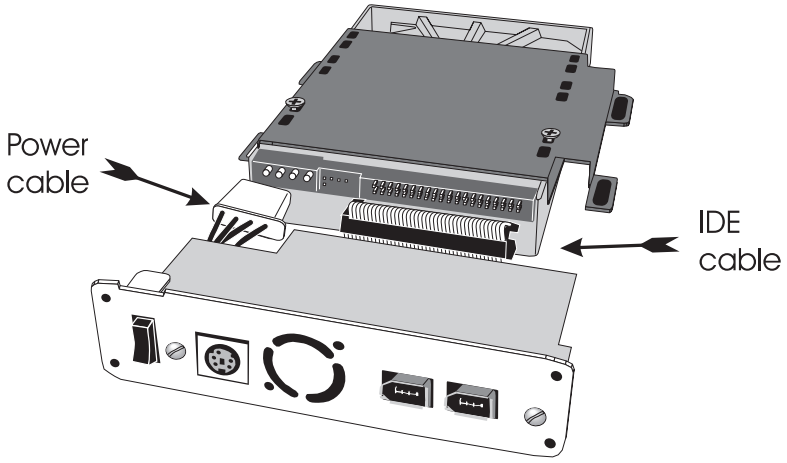
products will be made available periodically from Microsoft. The Lava USB 2.0 Host Adapter PCI card works with Microsoft drivers already released.

Microsoft will not provide support for USB 2.0 in the Windows® 9x or Windows NT® 4.0 platforms.

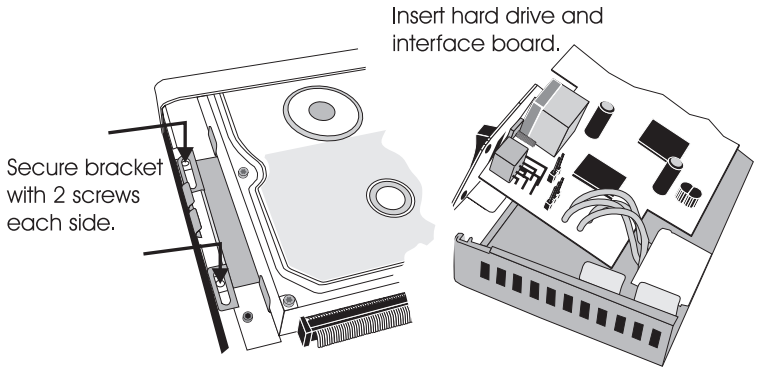
USB 1.1 has support in Windows® 98SE/Me/2000/XP, Macintosh® OS 8.6+, and Linux kernel 2.4+.

How do I hook up a FireDrive® or Kazan drive enclosure?

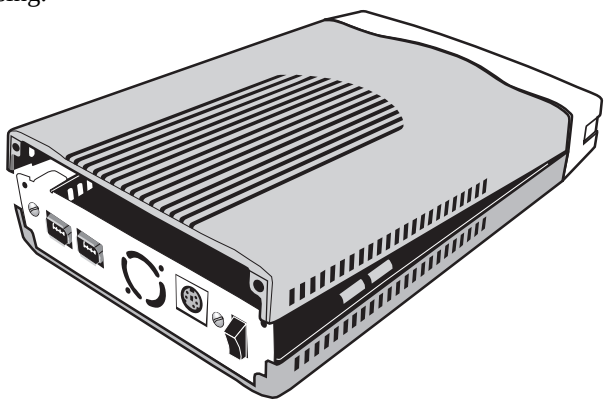
1. Connect the hard disk drive to the interface board with the IDE cable and internal power cable.



2. Insert the IDE hard drive and interface board into the casing, and secure drive bracket.



3. Close the casing.



4. Connect the power supply to the assembled enclosure.
5. Connect the IEEE 1394 or USB cable to a PC or Mac®.

Uses and benefits

IDE drive enclosures have benefits for both resellers and end users. Resellers can bundle IDE drive enclosures with hard drive sales. Doing so can add value to low-margin hard drive sales. Also, IDE drive enclosures are often easier to install, configure, and maintain than other external storage devices.

End users can benefit from IDE drive enclosures in the following ways:

TABLE 3. IDE drive enclosure uses and benefits

Use	Benefit
Adding external/portable drive capability for MPEGs, AVIs, DTP files	Adds fast high-capacity external storage
Backing up data fast	Faster than tape or Zip™ drives
Working directly on the FireDrive® or Kazan, as if they were internal drives	Eliminates need to work on internal drives and then copy to external drives for transport
Expanding the drive capacity of notebook computers	Permits convenient and cost-effective expansion
Making existing hard drives IEEE 1394 or USB 2.0 compatible	Adds convenience of hot-plugging and daisy-chaining
Carrying work between office and home	Facilitates coordination of data files between systems
Securely storing sensitive materials	Enables easy off-site storage for greater security
Taking advantage of the Kazan's backward compatibility with USB 1.1	Allows use of existing USB interfaces and peripherals
Converting smoothly from USB 1.1 to high-speed USB 2.0	Makes interface upgrading painless

Summary

Hard drive enclosures are the best way for most people to add fast external data storage to a computer system. Drive enclosures give high-speed throughput and convenient portability.

Lava's FireDrive® and Kazan are good examples. They come in sturdy cases and ship complete with either IEEE 1394-to-IDE or USB 2.0-to-IDE internal interface boards, switching power supplies, and all necessary cables. Both the FireDrive® and Kazan hold 3½" IDE hard drives.

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