MOTHERBOARDS

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OBJECTIVES

- Explain how motherboards work
- Recognize modern expansion buses
- Upgrade motherboards
- Troubleshoot mother boards

WHAT IS A MOTHERBOARD?

The motherboard provides the foundation for the personal computer. Every piece of hardware from the CPU to the expansion card, directly or indirectly plugs into the motherboard.

HOW MOTHERBOARDS WORK

Three variables and interrelated characteristics define modern motherboards

- *Form factor* – **determines the physical size of the motherboard as well as the general location of components and ports**
- *Chipset* – **defines the type of processor and RAM the motherboard requires and determines the built-in devices supported, including expansion slots**
- *Components* – **determines the core functionality of the system**

FORM FACTORS

…are industry-standardized shapes and layoutws that enable motherborads to work with cases and power supplies. All motherboards come in basic rectangular or square shapes but vary in overall size and layout.

Figure 7-2
Typical motherboard

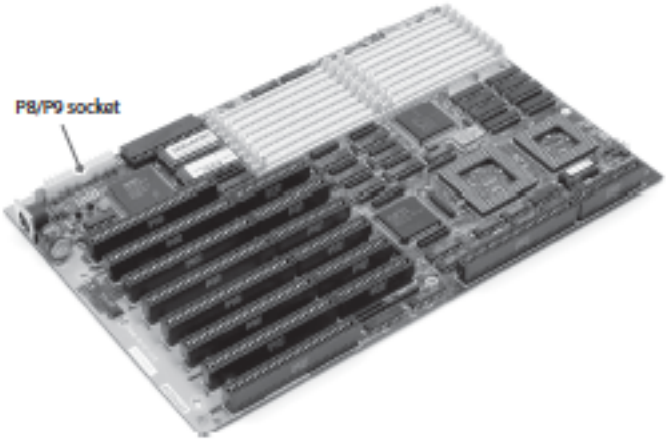
FORM FACTOR

- The power supply and the motherboard need matching connections.
- And different form factors define different connections.
- The term “from factor” applies to the case, motherboard and power supply.

AT FORM FACTOR

The AT form factor was invented by IBM in the early 80s and was dominant until the mid 90s and is now obsolete.

Figure 7-3
AT-style motherboard



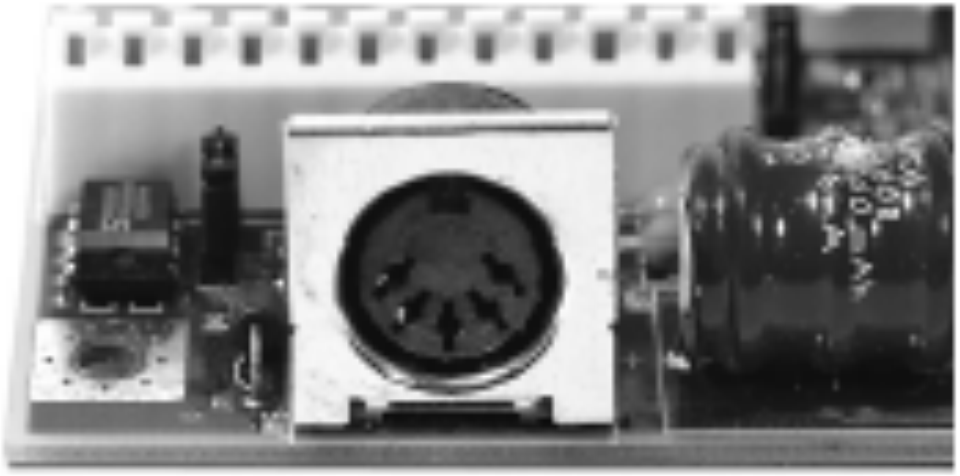
AT MOTHERBOARDS

AT motherboards ranged in size large to very large. (12 x 13 inches). PCs were in their early stage and needed space for various chips. They lacked external ports; only designed for keyboard and monitor.

Figure 7-4
AT motherboard (bottom) and Baby AT motherboard (top)

AT FORM FACTOR

The only ports the AT was designed to handle were the monitor and keyboard. The only dedicated connector on an AT motherboard was the keyboard port.



AXT FORM FACTOR

A demand for a new form factor that had more standard connections and was flexible for change was needed. That led to the creation of the ATX form factor in 1995

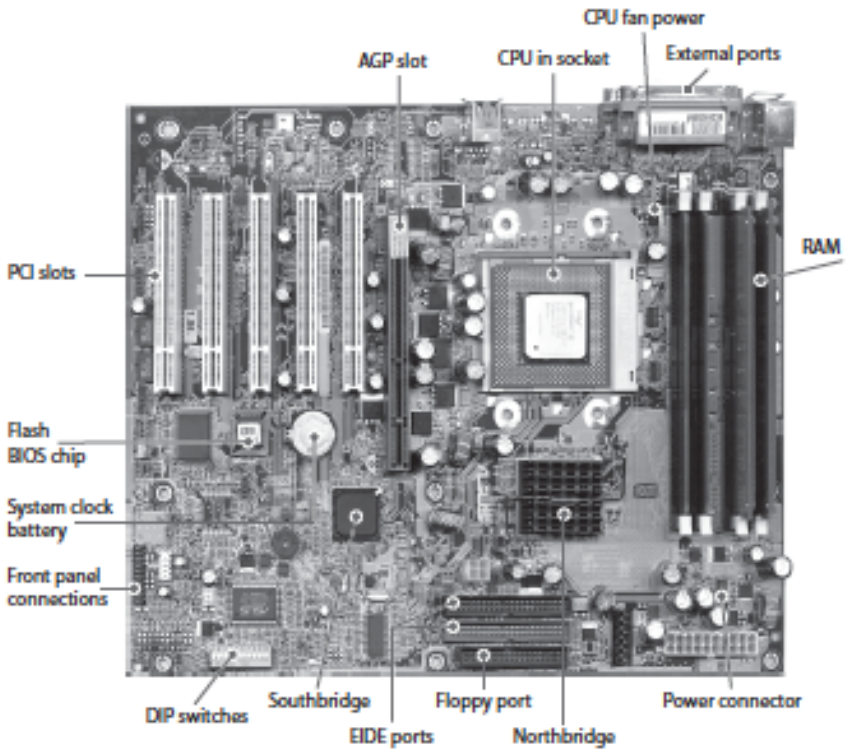


Figure 7-6 Early ATX motherboard

ATX FORM FACTOR

ATX lacks the AT keyboard port. It was replaced with a rear-board panel that has all the necessary ports built in.

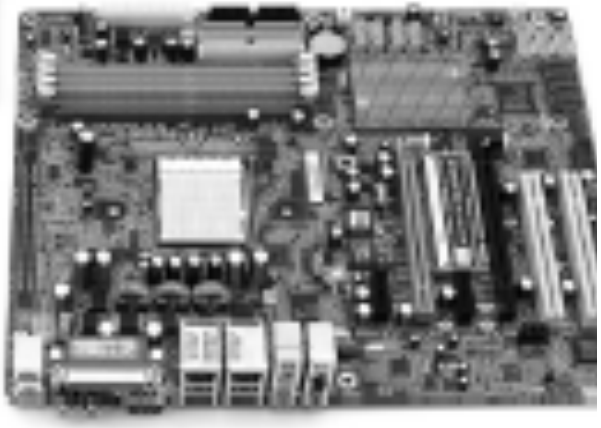
Figure 7-7
ATX ports

ATX FORM FACTOR

Improvements

- **Position of power supply creates better air movement**
- **CPU and RAM are placed to provide easier access**
- **Rearrangement of components prevents long expansion cards from colliding with CPU or Northbridge**
- **RAM is placed closer to Northbridge and CPU**

ATX AND AT COMPARISON



ATX HAS 3 VARIATIONS

- **Full sized ATX (12 by 9.6 inches)**
- **Micro ATX (9.6 by 9.6) *See below***
- **FlexATX (9 by 7.7 inches) are the smallest motherboards**

Figure 7-9 A microATX motherboard

ITX (SMALL FORM MOTHERBOARDS)

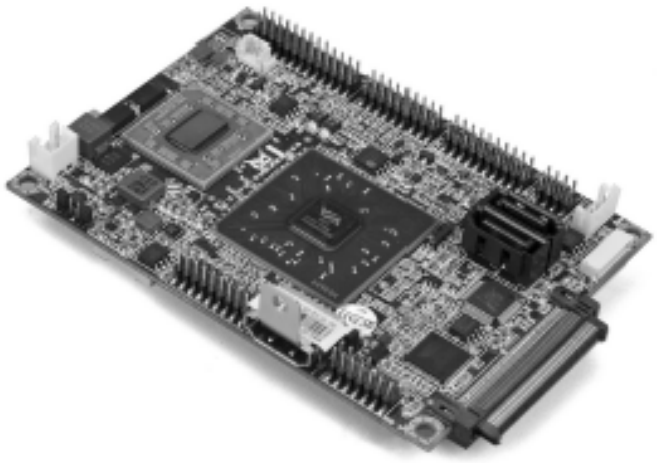
Mini IXTs are the largest and most popular of the form factors and are 6.7 inches square.

Figure 7-10
Mini-ITX

FORM FACTORS

- A Nano-ITX is 4.7 inches square
- A Pico-ITX is 3.8 by 2.8 inches.
- Both of these systems are used in embedded systems. They have lower power usage, produce less heat and this enables passive cooling systems.

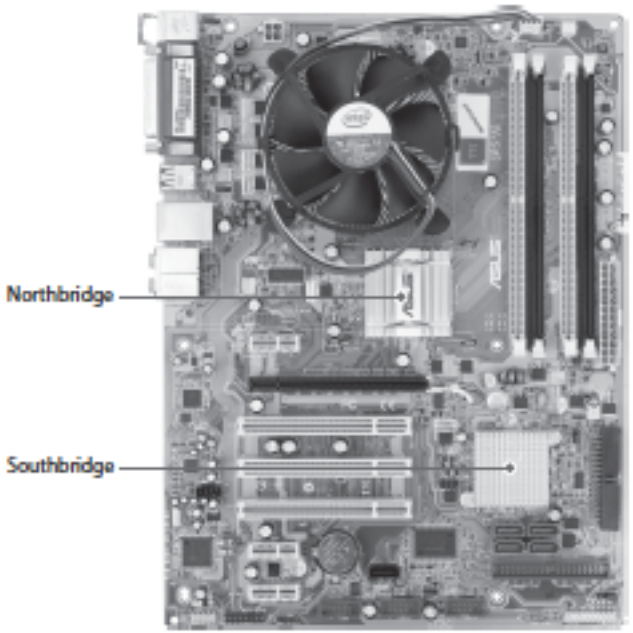
Figure 7-11
Pico-ITX (photo courtesy of VIA Technologies, Inc.)



CHIPSET

Chipsets are comprised of primarily of two chips, the Northbridge and Southbridge

Figure 7-12
Northbridge and Southbridge



CHIPSET

The Northbridge handled the RAM, while the Southbridge handled expansion devices, and mass storage devices (such as hard drives). A third chip is called super I/O chip handles both those jobs. See below

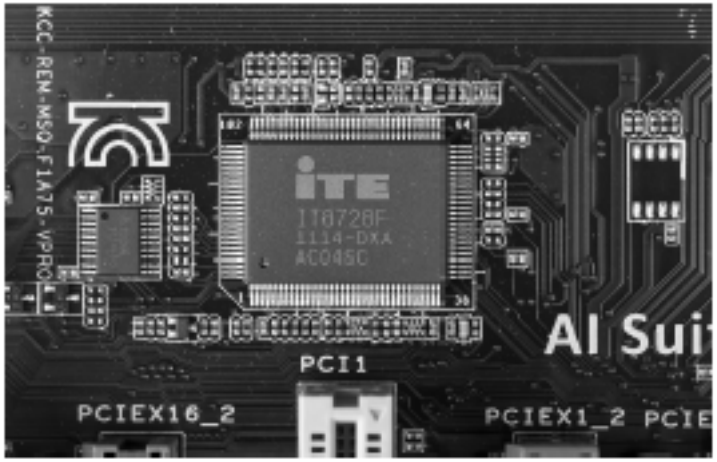


Figure 7-13
Super I/O chip on ASUS motherboard

SYSTEM ROM

Provides part of the BIOS for the chipset. Software drivers are needed to create a fully functional PC. Most motherboards ship with optical disc with drivers and support programs.

Figure 7-14
Driver disc for ASUS motherboard

Typical Chipset chores for an X99 chipset

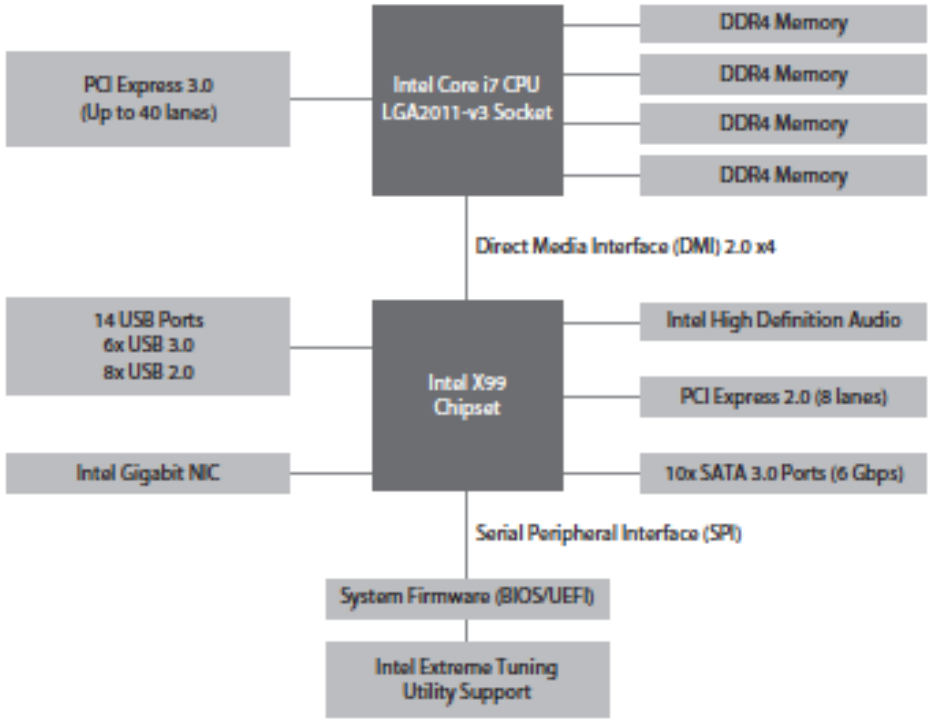


Figure 7-15 Schematic of a modern chipset

MOTHERBOARD COMPONENTS

Some motherboards come with dongles that you will need to connect
Extra USB and FireWire ports

Figure 7-16
USB/FireWire dongle

MOTHERBOARD COMPONENTS

You can also buy add-on front USB and FireWire devices that go into 3.5 inch drive bay.

Figure 7-17
Front USB and FireWire drive bay device

RAID

RAID stands for *redundant array for independent (or inexpensive)* disk and is very common on mother boards.

There are mirroring RAIDS (using two drives to hold the same data)

We'll learn more in chapter 9 *"Hard Drive Technologies"*

CASE FAN SUPPORT

- Every motherboard has a CPU fan power connector
- Some motherboards offer one or more fan power connectors for case fans, which are almost always only three-wire connectors
- The case fans plugged into the motherboard can be monitored and controlled by Windows, unlike case fans connected straight to the power supply.

EXPANSION BUS

Expansion slots have always been a part of the PCs. Expansion slots are used for adding expansion cards and thus new functions to the PC.

The slots and accompanying wires and support chips on the first PC and on the latest PCs are called expansion bus.

STRUCTURE AND FUNCTION OF THE EXPANSION BUS

Every device in the computer connects to the external data bus and the address bus. This is true whether it is soldered to the motherboard or snapped into a socket.

STRUCTURE AND FUNCTION OF THE EXPANSION BUS

On some systems, the expansion slots connect to the Southbridge

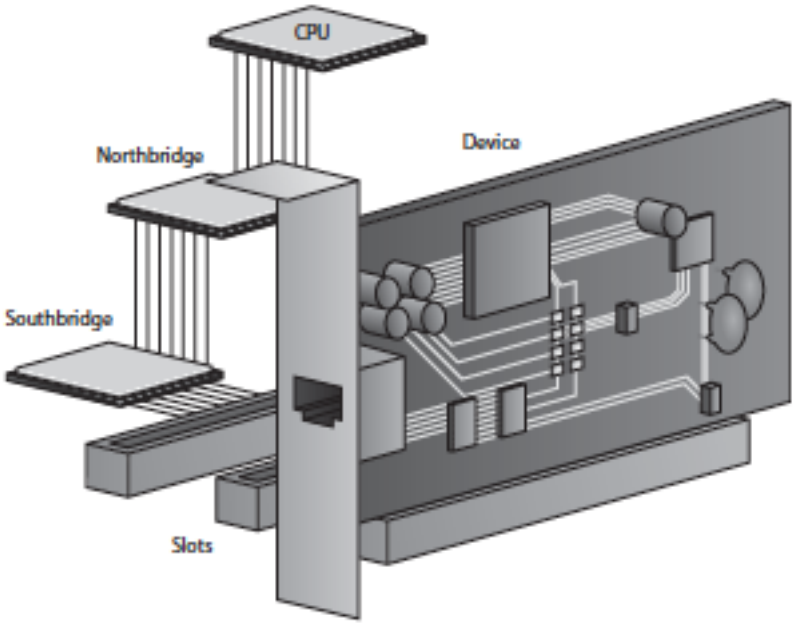


Figure 7-18 Expansion slots connecting to Southbridge

STRUCTURE AND FUNCTION OF THE EXPANSION BUS

On other systems, the expansion slot connects to the Northbridge.

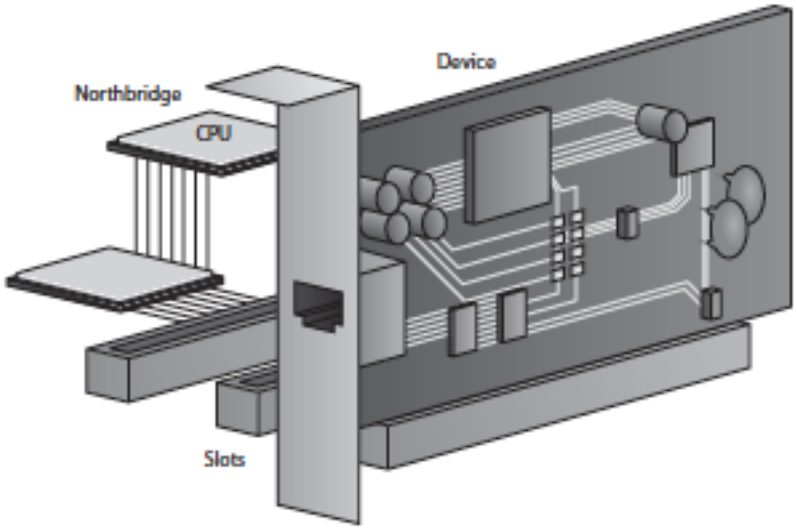


Figure 7-19 Expansion slots connecting to Northbridge

STRUCTURE AND FUNCTION OF THE EXPANSION BUS

Many systems have more than one type of expansion bus, with slots of one type connecting to the Northbridge and slots of another type connecting the Southbridge.

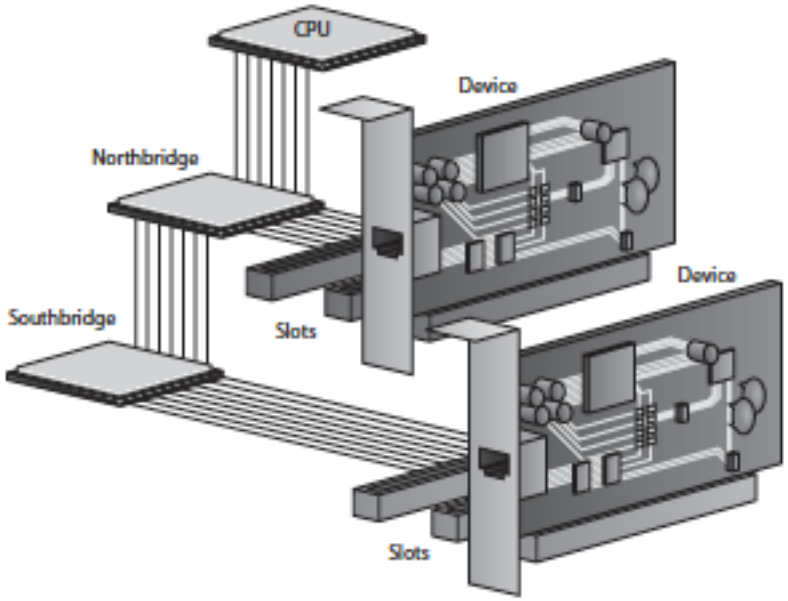


Figure 7-20 Expansion slots connecting to both Northbridge and Southbridge

STRUCTURE AND FUNCTION OF THE EXPANSION BUS

Every device soldered to the motherboard is designed to run at the speed of the system crystal. A 200 MHz motherboard for example, has its chipset chips all timed by a 200-MHz crystal

Every device soldered to the motherboard is designed to run at the speed of the system crystal. A 200-MHz motherboard, for example, has its chipset chips all timed by a 200-MHz crystal (see Figure 7-21).

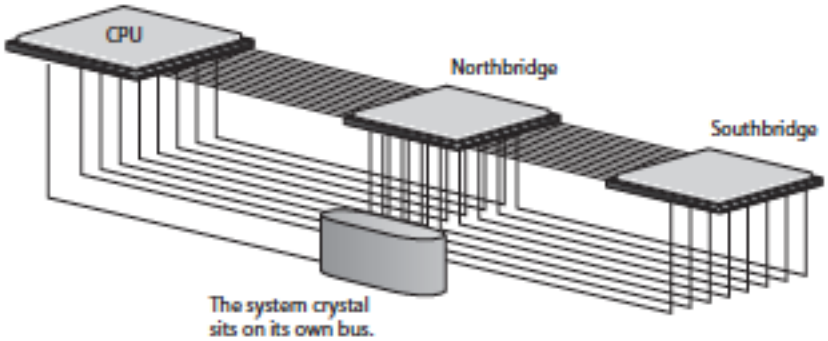


Figure 7-21 The system crystal sets the speed.

Clock crystals aren't just for CPUs and chipsets. Pretty much every chip in your computer has a CLK wire and needs to be pushed by a clock chip, including the chips on your expansion cards. Suppose you buy a device that did not come with your computer—say,

STRUCTURE AND FUNCTION OF THE EXPANSION BUS

Clock crystals aren’t just for CPUs and chipsets. Every chip in the computer has a CLK wire and needs to be pushed by the clock chip, including the chips on the expansion cards.

STRUCTURE AND FUNCTION OF THE EXPANSION BUS

An *extension* external data bus is used that runs on it's own standardized speed. A different crystal is used, the expansion slot crystal and controls the part of the external bus that is connected to the expansion slots.

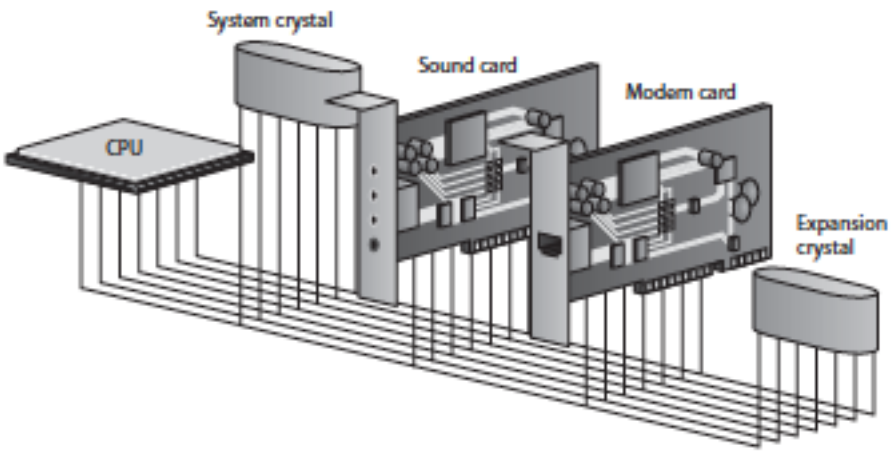


Figure 7-22 Function of system and expansion bus crystals

STRUCTURE AND FUNCTION OF THE EXPANSION BUS

The expansion slots runs at a slower speed than the frontside bus. The chipset acts as the divider between the two buses, compensating for the speed difference with wait states and special buffering areas

PERIPHERAL COMPONENT INTERCONNECT (PCI)

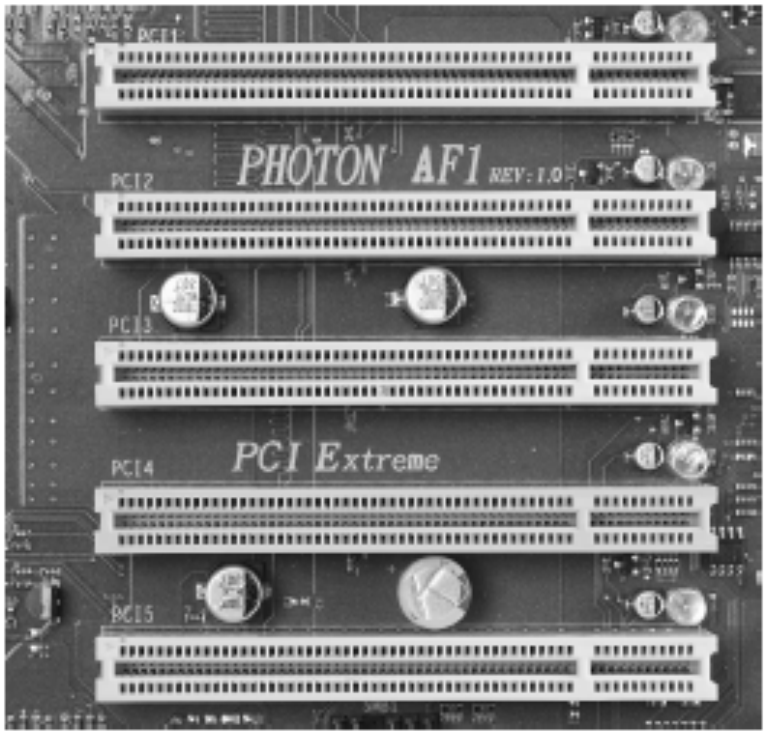
PCI provided a wider, faster, more flexible alternative than any previous expansion bus.

- **Provided a wider faster, more flexible alternative than any other expansion bus.**
- **A great price tag made manufacturers drop older buses**
- **The original PCI was 32 bits wide and ran at 33 MHz.**
- **It had the capability to co-exist with other expansion bus.**

PERIPHERAL COMPONENT INTERCONNECT (PCI)

- Users could keep their old expansion cards and slowly migrate to PCI
- They were self configuring, and this became know as plug and play (PnP)

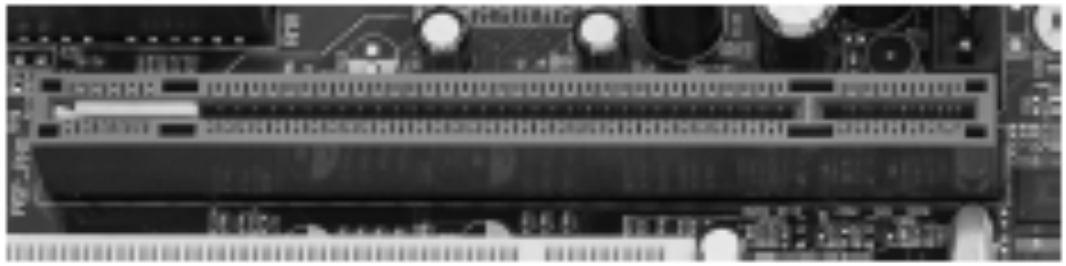
Figure 7-23
PCI expansion bus slots



AGP

Intel presented a specialized video only version of PCI called Accelerated Graphics Port (AGP). It had a direct connection to the Northbridge. AGI slots were only for video cards.

Figure 7-24
AGP slot



PCI-X

The PCI Extended (PCI-X) offered a high speed alternative to PCI (and AGP). The 64 bit AGP slots supported 32 bit PCI cards for backward compatibility and easy upgrade.

Figure 7-25
PCI-X slot

MINI-PCI

PCI made it into laptops in the specialty Mini-PCI format. It was designed to use low power and to lie flat, good for a laptop expansion slot.

Figure 7-26
Tiny card in Mini-PCI slot. See the contacts at the bottom of the picture?

PCI EXPRESS

PCI express is the latest, fastest and most popular expansion bus in use today. It is a PCI but uses a point-to-point serial connection instead of a PCIs shared parallel communication.

PCI EXPRESS

The most common PCIe slot is the 16-lane (x16) most commonly uses for video calls.

Figure 7-27 PCIe x16 slot (center) with PCI slots (top and bottom)

PCI EXPRESS

The bandwidth generated by a x16 slot is for more than anything other than a video card would need.. So PCI motherboards also contain slots with fewer lanes. PCI x1 is the most common general purpose PCIe slot.

The bandwidth generated by a ×16 slot is far more than anything other than a video card would need, so most PCIe motherboards also contain slots with fewer lanes. Currently ×1 is the most common general-purpose PCIe slot (see Figure 7-28).

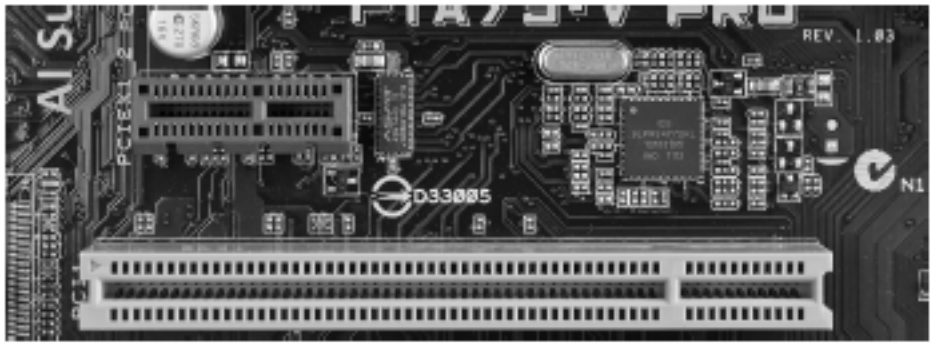


Figure 7-28 PCIe ×1 slot (top)

PCI EXPRESS

Never insert or remove a card at an extreme angle. A slight angle is acceptable and necessary when removing the card.

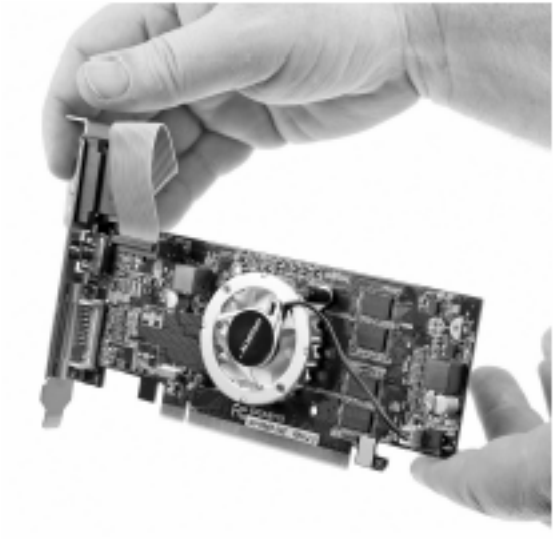


Figure 7-30
Where to handle a card

PCI EXPRESS

Many cords use the screw connection to ground the card.

Figure 7-31
Always secure all cards properly.

PCI EXPRESS

A fully inserted expansion card sits flush against the back of the PD case with no gap between the mounting brackers on the card and the screw hole on the case.

Figure 7-32
Properly seated expansion card; note the tight fit between case and mounting bracket and the evenness of the card in the slot.

DEVICE DRIVERS

All devices, whether built into the motherboard or added along the way, require BIOS. For all expansion slots the BIOS comes in the form of device drivers – software support programs –loaded from the CD/DVD drive.

GETTING CORRECT DRIVERS

Many driver disc have an AutoRun screen that advertises the version. If nothing is on the pop-up screen, look for a Readme file.

Figure 7-33 Part of a Readme file showing the driver version

DRIVER OR DEVICE

In most cases, you should install the device drive *after* you install the device. If not, the the driver installation will not find the device and errors will occur. For USB and FireWire, install the driver first.

REMOVING OLD DRIVERS

Some cards require you to remove old drivers before you install a new device. Locate device manager and right click on the device driver you want to uninstall.

Figure 7-34
Uninstalling a device

REMOVING OLD DRIVERS

Many devices come with a lot of applications will have an uninstall option in the programs and features applet in the Control Panel.

Figure 7-35 The Uninstall/Change option in Programs and Features

UNASSIGNED DRIVERS

Microsoft provides a program for hardware manufacturers called the Windows Hardware Certification Program. The drivers get a digital signature that says Microsoft has tested and found all is well.

UNASSIGNED DRIVERS

The last of the 32-bit version of Windows had support for unassigned drivers. These were drivers that did not go through the certification program. On newer machines, Windows would bring up this screen:

Figure 7-36
Unsigned driver warning

INSTALLING THE NEW DRIVER

There are two ways to install a new driver;

- **By using the installation disc (Vista only)**
- **Or using the Add Hardware Wizard in the Control Panel**

Figure 7-37 Installation menu

DRIVER ROLLBACK

To roll back to an earlier version of a device driver, open Device Manager and access the properties for the device you want to adjust. On the driver tab, you'll see the rollback button.

Figure 7-38
Driver rollback feature

VERIFY

After installing the driver, open Device Manager and verify that Windows sees the device.

Figure 7-39
Device Manager shows the device working properly.

TROUBLESHOOTING CARDS

The first sign that your card is improperly installed is that the card is not doing what it is supposed to do. After checking the *Device Manager*, the next step is to reinstall.

TROUBLESHOOTING CARDS

Sometimes Device Manager may not show your device. First make sure device is properly inserted and it has power (if needed). Run the Add Hardware Wizard and see if Windows recognizes the device.

TROUBLESHOOTING CARDS

Device Manager hardly ever fails to see a device. A black *"!"* on a triangle indicates that a device is missing or that Windows is not recognizing that there's a device driver problem

Figure 7-40
An "!" in Device Manager, indicating a problem with the selected device

TROUBLESHOOTING CARDS

For the "!" symbol:

- **Double check the device connections**
- **Try reinstalling the driver with the Update Driver button**

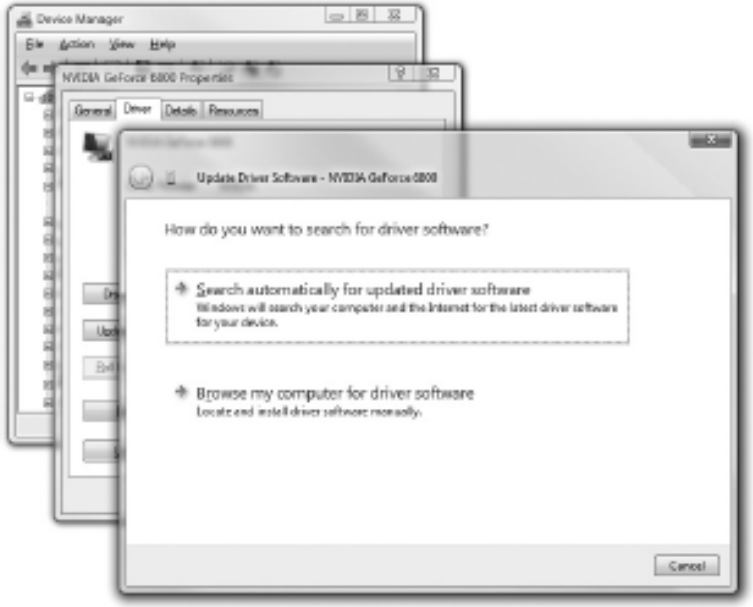


Figure 7-41 Updating the driver

UPGRADING AND INSTALLING

Make sure you are getting a form factor that works with your case. Don't put a regular ATX motherborad into a microATX case! Additionally, Make sure you have the motherboard (technical manual) book.

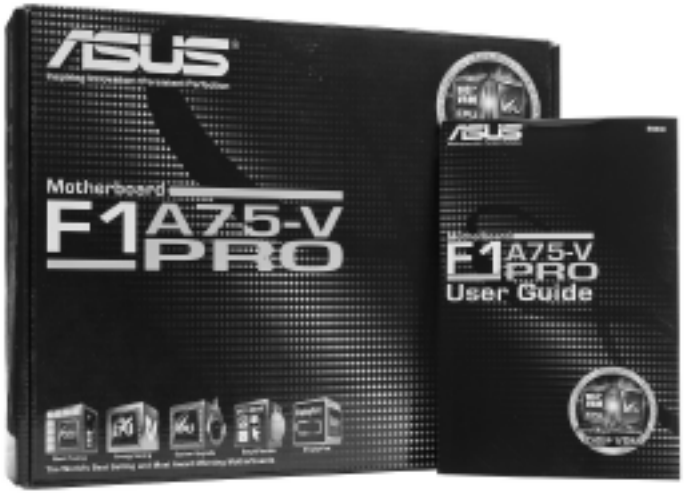


Figure 7-42
Motherboard box and book

UPGRADING AND INSTALLING

Pick your case carefully. You can get specialized cases such as tiny cases for entertainment systems or ones that fit the same format as a stereo receiver or DVD player – such as the home theater PC case (HTPC) shown here.

Figure 7-43
An HTPC

UPGRADING AND INSTALLING

The motherboard mounts to the case via small connections called *standouts* that slide into keyed slots or screw into the bottom of the case.

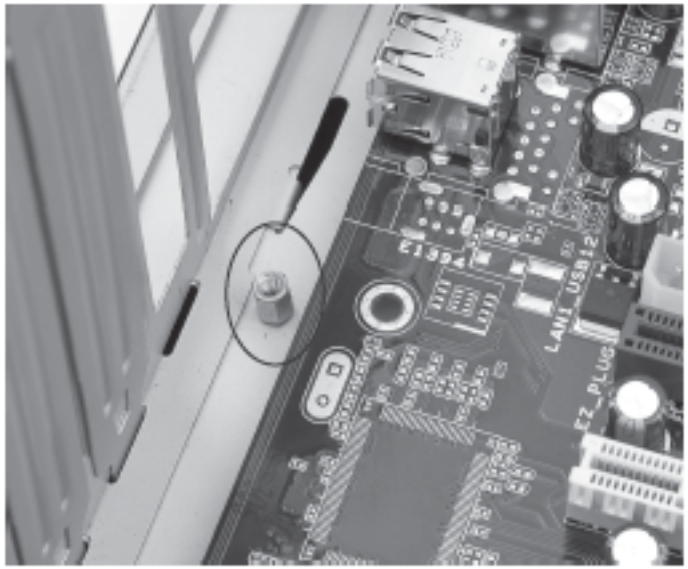


Figure 7-44
Standout in a case, ready for the motherboard

UPGRADING AND INSTALLING

You can trace the wire leads from the front of the case to the appropriate standouts of the motherboard. Wires have specific pin connections to the motherboard. Refer to the book.

Figure 7-45
Motherboard wire connections labeled on the motherboard

UPGRADING AND INSTALLING

There's no sure way for determining the function of each wire. Often the function is printed on the connector. If not, track each wire to the LED or switch to determine its function.

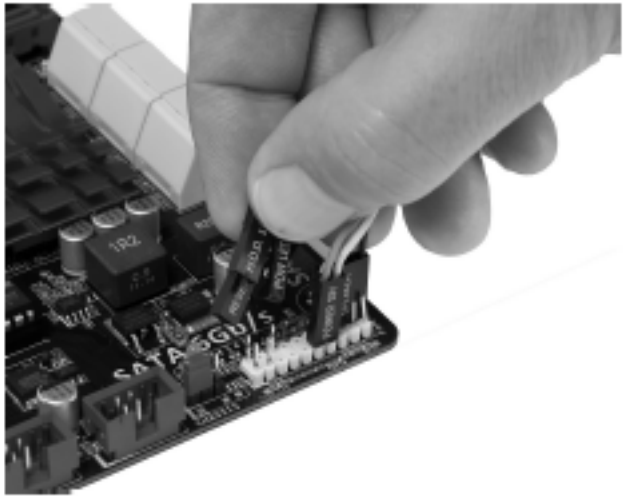


Figure 7-46
Sample of case wires

TROUBLESHOOTING MOTHERBOARDS

Use a modern POST Card with a good diagnostic screen. A POST card monitors the POST (Power-On Self Test) and identifies what piece of hardware is causing the problem.

Figure 7-47
USB POST card (left) and PCI POST card (right)

TROUBLESHOOTING MOTHERBOARDS

If you have a component failure, you can replace it with an add-on that would be just as good or better.

Figure 7-48
Adaptec PCIe SATA card

THE END

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