Motherboards, Power Supplies, and Cases

	NEWBIE	SOME EXPERIENCE	EXPERT
ETA	5 hours	3 hours	2 hours

At the heart of all personal computers live certain core components. The *motherboard* provides the framework upon which every other component builds. The *power supply* provides DC current to feed the hungry motherboard and components and makes everything chug along happily. The *case* or *system unit* holds it all together. Don't think that all cases are created equal, however, as subtle differences between identical-looking cases can influence how difficult it is to upgrade and service the PC. Every good tech needs to understand these basic ingredients of the PC, including their common variants.

Objective 4.01   # Motherboards

Every device in your computer system connects either directly or indirectly to the motherboard. The motherboard, in essence, defines the type of computer you have.

| **Local Lingo** |
| --- |
| **System boards, mobos**   Many PC techs call motherboards *system boards* or *mobos*. |

Manufacturers decide three things when creating a new motherboard. First, they select the set of chips—appropriately called the *chipset*—that provide support for everything that plugs into the motherboard. Second, they select a style of motherboard, the *form factor*, that defines the size and shape, among other things. Finally, manufacturers decide which connectors to include for both internal and external devices.

This section looks at chipsets, form factors, and connections available on motherboards. It wraps with notes on installation and troubleshooting.

Chipsets

Every motherboard has a chipset that determines the type of processor the motherboard accepts, the type and capacity of RAM, and what sort of internal and external devices the motherboard supports. The chips in a PC's chipset serve as electronic interfaces through which the CPU, RAM, and input/output devices interact. Chipsets vary in feature, performance, and stability, so they factor hugely in the purchase or recommendation of a particular motherboard. Most modern chipsets are composed of two primary chips—the *Northbridge* and the *Southbridge* (Figure 4.1).
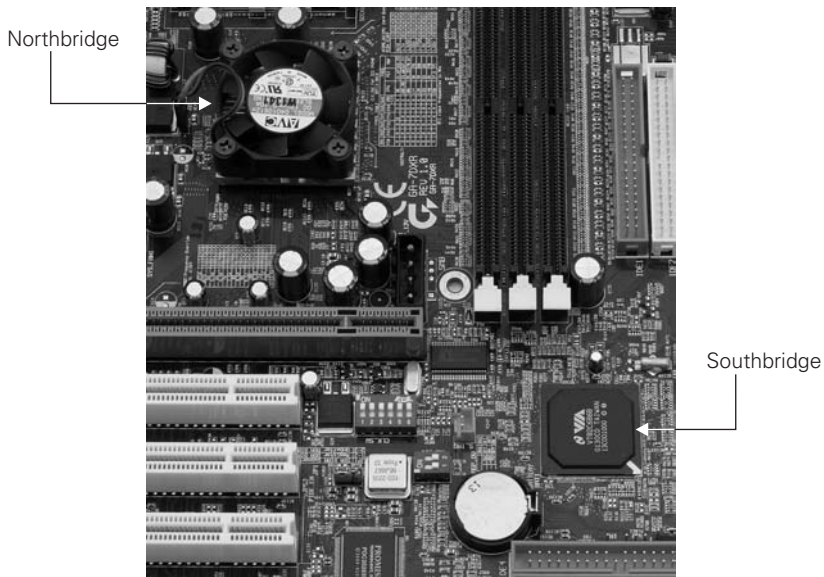
FIGURE 4.1   Northbridge and Southbridge

The Northbridge chip on Intel-based motherboards helps the CPU work with RAM. On AMD-based motherboards, the Northbridge provides the communication with the video card, rather than memory, because the memory controller is built into the CPU. Current Northbridge chips do a lot and thus get pretty hot, so they have their own heat sink and fan assembly (Figure 4.2).
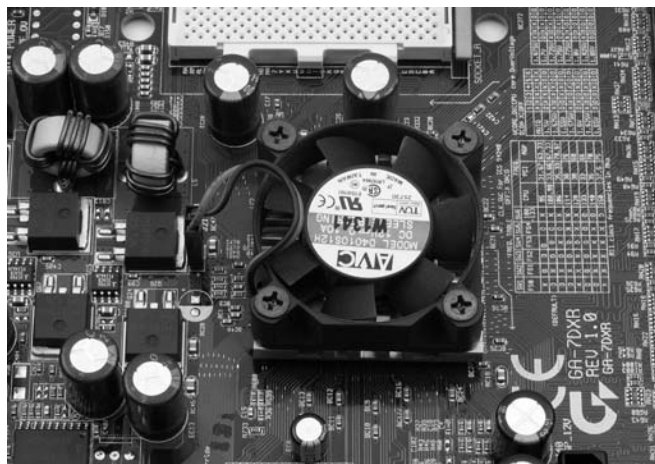
FIGURE 4.2   Heat sink and fan on a Northbridge

Travel Assistance

Chapter 5 covers CPUs in detail.

The Southbridge handles some expansion devices and mass storage drives, such as hard drives. Most Southbridge chips don't need extra cooling, leaving the chip exposed or passively cooled with only a heat sink. This makes the Southbridge a great place to see the manufacturer of the chipset, such as Intel Corporation (Figure 4.3).

Most motherboards support old technologies such as floppy drives, parallel ports, and serial ports. Although supporting these old devices was once part of the Southbridge's job, hardly any modern chipsets still support these devices. Motherboard manufacturers add a third chip called the *Super I/O chip* to handle these chores. Figure 4.4 shows a typical Super I/O chip.

Travel Advisory

Super I/O chips work with chipsets but are not part of the chipset. Motherboard makers purchase them separately from chipsets.
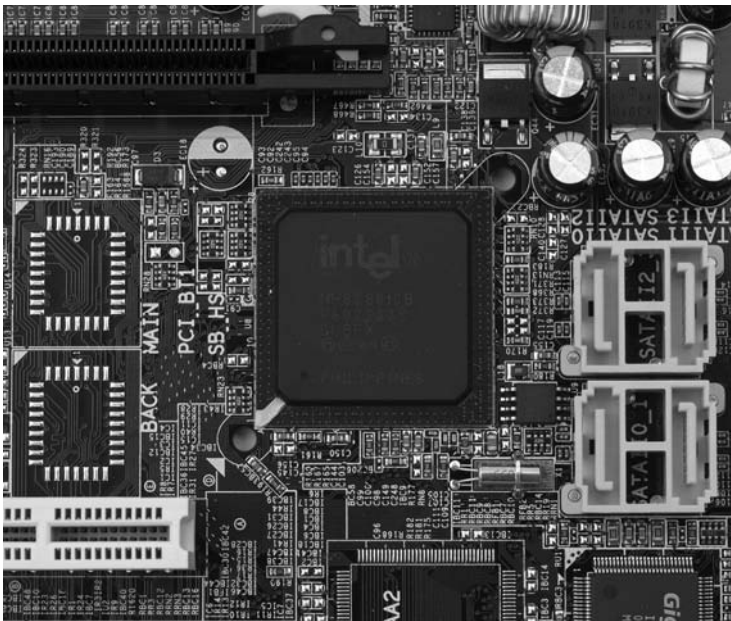
FIGURE 4.3   An Intel Southbridge chip on a motherboard

FIGURE 4.4 Super I/O chip on ASUS motherboard

The system ROM chip provides part of the BIOS for the chipset, but only a barebones, generic level of support. The chipset still needs support for the rest of the things it can do, so it requires drivers loaded from a CD or downloaded from the manufacturer.

Travel Assistance

Chapter 7 covers the system BIOS and system ROM chip in detail.

Four companies make the vast majority of chipsets for PCs: Intel, VIA, NVIDIA, and AMD through its ATI brand. With the exception of Intel, every chipset maker has chipsets for Intel and AMD processors, so you need to pay attention when purchasing or recommending a particular motherboard. You can buy an NVIDIA nForce 590-based motherboard that supports an AMD Athlon 64, for example, or an NVIDIA nForce 590-based motherboard that supports an Intel Core 2 Duo processor. They're not interchangeable!

Travel Advisory

Just like most devices, motherboards ship with dated drivers. Smart techs download the updated drivers from the manufacturer's Web site.
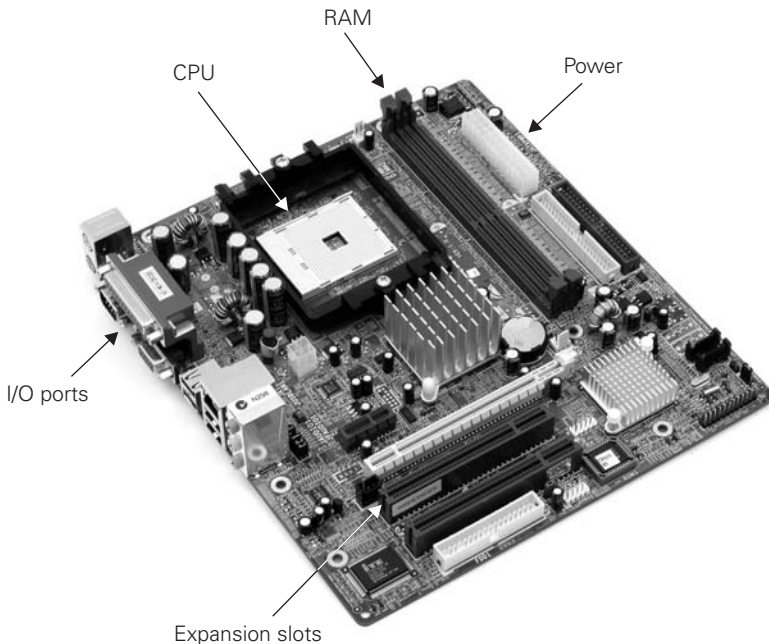
Motherboard Form Factors

Most motherboards come in one of two form factors, ATX or BTX, plus you'll see a sprinkling of proprietary and other form factor motherboards out there as well. Each form factor has several varieties.

The form factor defines the motherboard's size, its orientation, the location of built-in sockets and expansion slots, and so on. The motherboard's form factor determines the type of power supply and case a PC can use. Form factors are not interchangeable. That means that ATX motherboards fit into ATX cases, and BTX motherboards fit into BTX cases.

ATX

ATX motherboards, as shown in Figure 4.5, have a central Northbridge chip encircled by the CPU, RAM, drive, and power connections; expansion slots; and connections for external devices. ATX motherboards use mini-DIN (PS/2) connectors for the keyboard and mouse, and most have integrated USB ports. Many also feature onboard modem and NIC ports, FireWire ports, sound, and video. ATX motherboards dominate the PC market.

Two popular variations of the ATX form factor are *microATX* and *FlexATX*. These use the same power connections and have the same basic layout as ATX but are scaled to fit into much smaller ATX cases. Full-sized ATX motherboards will not fit into microATX or FlexATX cases, although most full-sized cases support the smaller motherboards.
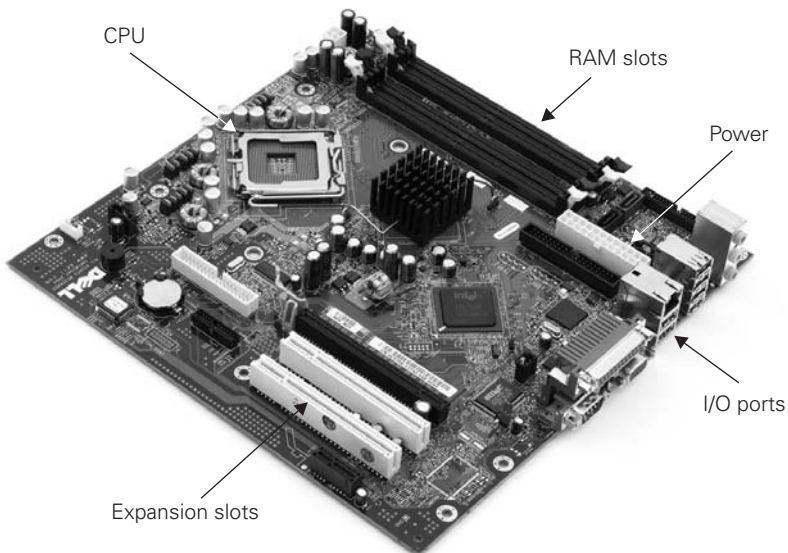

FIGURE 4.5 microATX motherboard

BTX

Fast CPUs and powerful graphics cards in today's PCs create phenomenal amounts of heat, which motivated the PC industry to create the "coolest" form factor used today—the Balanced Technology eXtended (BTX) form factor (Figure 4.6). BTX defines three subtypes: standard BTX, microBTX, and picoBTX, designed to replace ATX, microATX, and FlexATX, respectively. At first glance, BTX looks like ATX, but notice that the I/O ports and the expansion slots have switched sides.

Everything in the BTX standard is designed to improve cooling. BTX cases vent in cool air from the front and vent out warm air in the back. CPUs are moved to the front of the motherboard so they benefit from the cool air entering the front of the case. BTX defines a special heat sink and fan assembly called the *thermal unit.* The thermal unit's fan blows the hot CPU air directly out the back of the case, as opposed to the ATX method of just blowing the air into the case and letting the power supply and case fans pull air out.

The BTX standard offers better cooling than ATX, but the PC industry tends to take its time when making big changes like moving to a new form factor. As a result, BTX has not yet made much of an impact in the industry, and BTX motherboards, cases, and thermal units are still fairly rare.

FIGURE 4.6   microBTX motherboard

Proprietary Form Factors

Several major PC makers, including Dell and Sony, make motherboards that work only with their cases. These *proprietary* motherboards enable these companies to create systems that stand out from the generic ones and, not coincidently, push you to get service and upgrades from their authorized dealers. Some of the features you'll see in proprietary systems are riser boards like you see with the NLX form factor—part of a motherboard separate from the main one, but connected by a cable of some sort—and unique power connections. Proprietary motherboards drive techs crazy as replacement parts tend to cost more and are not readily available.

Motherboard Connections

Motherboards today come with connectors to support literally dozens of devices, from the core components of CPU and memory, to sophisticated high-speed networking. You've already seen the most common integrated I/O ports in Chapter 2, which covered serial, parallel, keyboard, mouse, video, audio, multimedia, MIDI/joystick, modem, network, USB, FireWire, and SCSI ports. Six of the next seven chapters of this book cover the rest: CPU, RAM, hard drives, removable drives, and expansion slots. (There's no reason to go through any of these in any detail in this chapter.)

When you upgrade or recommend an upgrade, you must address one question: Can the hardware do the job desired by your client? If your client wants to play the latest and greatest games, for example, you need to look at his or her machine and determine its capability. Can it handle a powerful enough CPU? Does the motherboard have enough RAM slots to install 2+ GB of memory? Does the chipset support that much? Look at the expansion slot for the video card. Is it AGP or PCI Express? Does it have the number and type of expansion slots needed for future growth (Figure 4.7)?

If your client wants to get a new, high-speed scanner—a more mundane example—you need to weigh several factors. If the motherboard has a FireWire port, just recommend a FireWire-capable scanner and the client is set. If the motherboard has USB but not FireWire, on the other hand, you need to determine whether the USB is Hi-Speed or plain vanilla USB. If the latter, buying a Hi-Speed USB–capable scanner and plugging it into the lower speed connection would work, but would the client be getting his money's worth? Of course not! So a good recommendation to overcome this motherboard limitation would be to go for the Hi-Speed scanner and install a Hi-Speed USB controller into an expansion slot. By examining the capabilities and limitations of specific motherboards, you can provide the right experience for your clients.

PCI
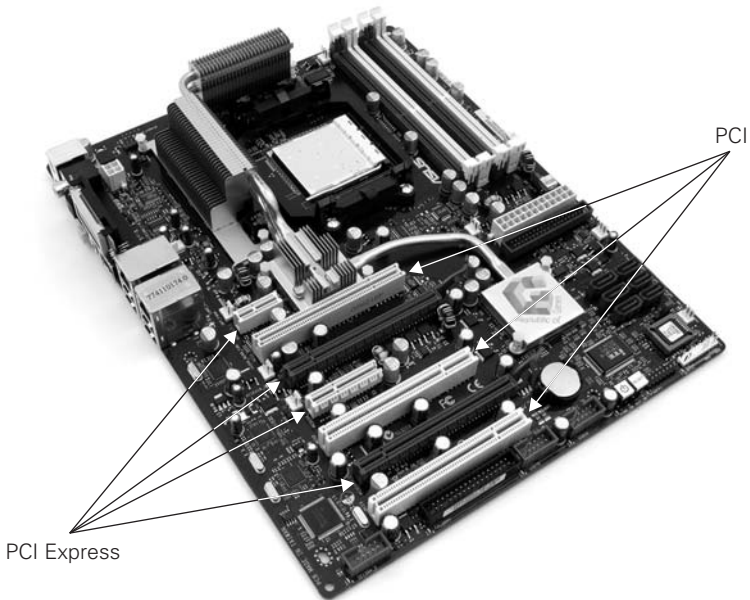
PCI Express

Sweet! A mobo with both PCI Express and PCI!

Installing a Motherboard

Installing or replacing a motherboard requires you to go through a couple of simple steps. First, install the motherboard into a case designed for the motherboard. Most system boards come with an I/O shield that matches the external I/O connectors on the motherboard, so you might have to replace the one that's in the case before you can insert the new motherboard. Second, adjust the standouts on the case to align with the mounting holes in the motherboard. Third, angle the motherboard into the I/O shield (Figure 4.8) and screw it down snugly. Plug in power, CPU, RAM, fans, and video, and you're ready to go.

Troubleshooting Motherboards

Motherboards can go bad over time because of external factors such as power spikes and sags, electrostatic discharge, or excessive heat. A motherboard can be faulty right out of the box, so if you run into a new system that you have trouble getting to work, you can add the new motherboard to the list as a possible culprit.

FIGURE 4.8   Installing a motherboard (note spare I/O shield)

Troubleshooting motherboards—even in a new installation—can drive a tech to distraction, because the symptoms of a failing motherboard range from devices not working to intermittent lockups. What would you suspect first if a network card that worked before a storm didn't work after a storm? The card seems the logical suspect and that's what you'd check first, but the motherboard could have taken a hit from the storm and have a few electrons jangling loose. This is especially true in motherboards with built-in NICs.

> **Travel Advisory**
>
> You can update a motherboard's internal drivers through a process called *flashing the BIOS*. You can also turn a motherboard into an inert piece of wall art easily by flashing the BIOS incorrectly or having an error occur during the flashing process. *There's no recovery* from a flashing failure, so be careful! See Chapter 7, "BIOS and CMOS," for the scoop on flashing the BIOS.

When you suspect a motherboard has gone or is going bad, replace it. A computer must have a rock-solid foundation, and a buggy motherboard is simply not acceptable.

Objective 4.02 Power Supplies

The PC's power supply (Figure 4.9) converts high-voltage alternating current (AC) power into the lower voltage direct current (DC) power that your motherboard and drives need. Its internal fan also provides essential cooling for the PC components and drives. In the United States, standard AC comes in somewhere between 110 and 120 volts, often written as ~115 VAC. Most of the rest of the world uses 220–240 VAC, so many power supplies have a little switch in the back so you can use them anywhere.

Exam Tip

Remember that the power connector for the AC plug on the back of a power supply is called an *IEC 320* connector.
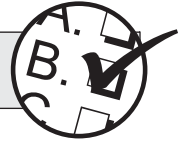
Power supplies come in various form factors that determine the physical size and shape, as well as the types of connectors you'll find. Power supplies vary in output and efficiency.

Cooling fan

Power switch

Port for power cord

Cables to deliver power to the system
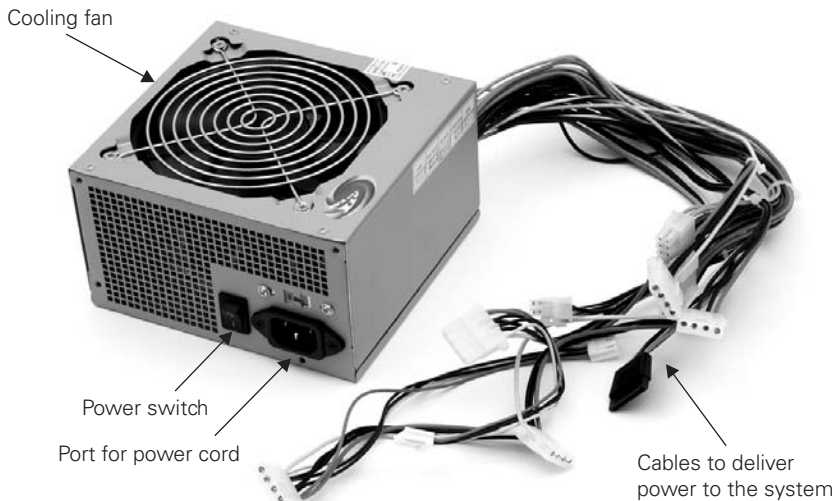
FIGURE 4.9 Power supply

> **Exam Tip**
>
> Look for the acronym *PSU*, for *power supply unit*, on the CompTIA A+ exams. Most techs refer to power supplies using the full words rather than the acronym.
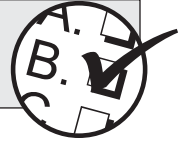
Power Supply Form Factors

Power supply form factors more or less mirror motherboard form factors. ATX power supplies are the most common, and they plug into all sizes of ATX and BTX motherboards. You can find smaller power supplies that fit microATX, FlexATX, and microBTX motherboards as well. Finally, manufacturers have created all sorts of proprietary power supplies that come in all shapes and sizes (Figure 4.10).

Power Supply Connectors

Power supplies offer several connectors for the motherboard and drives. All have four-wire *mini* and Molex connectors for floppy, parallel ATA (PATA), and small computer system interface (SCSI) drives, and most have serial ATA

FIGURE 4.10   Proprietary power supply

FIGURE 4.11   Mini, Molex, and SATA power connectors (left to right)

(SATA) connectors for SATA drives (Figure 4.11). Better power supplies have a dedicated six-wire *PCIe* connector for PCI Express video cards (Figure 4.12).

Power supplies connect to the motherboard with up to four connectors: the 20- or 24-wire *P1* connector, the primary power circuit; a 4-wire *P4* connector to add another 12-volt circuit (or *rail*, as techs say) to the motherboard to add stability; and a 6-wire auxiliary connector (referred to as an *AUX* connector) that very few motherboards use (Figure 4.13). Table 4.1 lists the common connectors of the *ATX12V* power supplies—the current standard—with their voltages and uses.

Exam Tip

The 5-volt orange wire on the P1 connector is called *power good* and is used in the initial boot sequence. See Chapter 7 for the boot sequence.

FIGURE 4.12   PCIe power connector
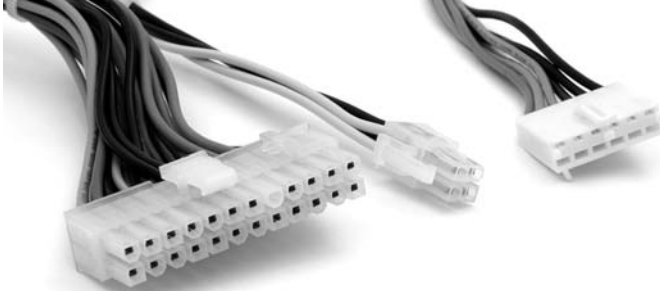
P1, P4, and AUX connectors (left to right)

Travel Advisory

All power connectors are keyed so you can't easily plug them in backward. The mini socket keying on floppy drives is often flimsy, though, so you need to take care with them. Reversing the power on a device will destroy that device, because you're plugging a 12-volt wire into a 5-volt circuit. That's a bad thing!

TABLE 4.1   Power Connectors and Voltages

Connector	Voltages	Common Use
Molex	5 V, 12 V	PATA and SCSI hard drives and optical drives; some PCIe video cards; some PCIe motherboards
Mini	5 V, 12 V	Floppy drives
SATA	5 V, 12 V	SATA drives
PCIe	12 V	PCIe video cards
P1 (20-wire)	3.3 V, 5 V, 12 V	Primary power for older ATX motherboards
P1 (24-wire)	3.3 V, 5 V, 12 V	Primary power for current ATX motherboards
P4	12 V	Secondary power for current ATX motherboards
AUX	3.3 V, 5 V, 12 V	Auxiliary power for motherboards

Output—Wattage and Harmonics

Power supplies provide a certain amount of *wattage* that the motherboard, drives, and fans draw on to run. That's the desired output. Power supplies also produce *harmonics*, the hum you hear when the power supply runs, that can cause problems if not controlled.

Local Lingo
Wattage   Wattage is the amount of amperage flowing at a specific voltage, usually written as W=VA.

A PC requires sufficient wattage to run properly. Every device in a PC also requires a certain amount of wattage in order to function. A typical hard drive draws 15 watts of power when accessed, for example, whereas some Athlon 64 X2 CPUs draw a whopping 110 watts at peak usage—with average usage around 70 watts. The total wattage of all devices combined is the minimum you need the power supply to provide.

If the power supply cannot produce the wattage needed by a system, that PC won't work properly. Because most devices in the PC require maximum wattage when first starting, the most common result of insufficient wattage is a paperweight that looks like a PC. The only fixes for this problem are to remove a device from the PC—such as the new hard drive you just plugged in—or get a power supply with more wattage. Today's PCs require 400+ watt power supplies to function.

Good PC power supplies come with *active power factor correction (active PFC),* extra circuitry that smoothes out the way the power supply takes power from the power company and eliminates harmonics. Older and poorer power supplies don't have this circuitry and should not be used if at all possible.

Most active PFC power supplies are *auto-sensing*, meaning they can detect the voltage coming from the wall and adjust accordingly. You can use an auto-sensing power supply anywhere in the world, from the ~115 VAC in New York City to the ~230 in Hong Kong. This is especially important with portable computers!

Troubleshooting Power Supplies

Power supplies fail in two ways: sudden death and slowly over time. When they die suddenly, the computer will not start and the fan in the power supply will not turn. In this case, verify that electricity is getting to the power supply before you do anything else. Assuming that the system has electricity, the best way to

verify that a power supply is working or not working is to check the voltages coming out of the power supply with a multimeter (Figure 4.14).

The voltages supplied by most PC power supplies can safely vary by as much as ±10 percent of their stated values. This means that the 12-volt line can vary from roughly 10.5 to 12.9 volts without exceeding the tolerance of the various systems in the PC. The 5.0- and 3.3-volt lines offer similar tolerances.

If the power supply fails to provide power, throw it into the recycling bin and get a new one. Do *not* open a power supply and try to service it yourself, because it contains dangerously high-voltage capacitors.

When power supplies die slowly, bad things begin to happen to the computer intermittently. The computer locks up every once in a while, for example, or it takes two tries before it boots up in the morning. Because a Blue Screen of Death (BSoD) in Windows can be caused by a lot of things, diagnosing a lockup as a power supply problem is tough to do. The key is the word *intermittent*. If you run into phantom problems, switch out the power supply to see if that makes a difference. Every tech should have a known-good power supply as a *field replaceable unit* (*FRU*).

Many devices in the computing world use an AC adapter (Figure 4.15) rather than an internal power supply. Even though it sits outside a device, an AC adapter converts AC current to DC, just like a power supply. Unlike power supplies, AC adapters are rarely interchangeable. Although manufacturers of different devices often use the same kind of plug on the end of the AC adapter cable,

FIGURE 4.14   Testing one of the 5-volt DC connections

FIGURE 4.15 AC adapter

these adapters are not necessarily interchangeable. Just because you can plug an AC adapter from your friend's laptop into your laptop does not mean it's going to work!

You need to make sure that three things match before you plug an AC adapter into a device: voltage, amperage, and polarity. If the voltage or amperage output is too low, the device won't run. If the polarity is reversed, it won't work—just like putting in a battery backward in a flashlight. If the voltage or amperage—especially the latter—is too high, on the other hand, you can quickly toast your device. Don't do it! Always check the voltage, amperage, and polarity of a replacement AC adapter before you plug it into a device.

Objective 4.03 Cases

Cases come in six basic sizes: slimline, desktop, mini-tower, mid-tower, tower, and cube. Slimline and desktop models generally sit on the desk, beneath the monitor. The various tower cases usually occupy a bit of floor space next to the desk. The mini-tower and mid-tower cases are the most popular choices. Make sure you get a case that will fit your motherboard—many microATX and all FlexATX cases are too small for a regular ATX motherboard. Cube cases generally require a specific motherboard, so be prepared to buy both pieces at once. A quick test fit before you buy saves a lot of return trips to the supplier.

> ### Exam Tip
>
> The six case sizes listed here apply only to consumer or workstation PCs. Server PCs come in several different varieties, such as huge dual-power supply behemoths and rack-mounted systems too svelte to handle a normal expansion card. The CompTIA A+ certification exams test you only on the consumer or workstation models.
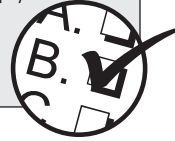
The typical case has four screws on the back, two of which you remove with a Phillips-head screwdriver. This releases the side panel and enables access to the interior of the case. Panels slide into a slot so they should fit snugly.

Vendors such as Alienware offer myriad colors and exotic body styling. More important, these cases are outfitted with detailing that enhances the PC's function, such as additional cooling fans or liquid cooling systems, high-output power supplies, cable management systems, roomier interiors, screwless body panels (these require no tools to remove), and such welcome touches as front-mounted USB, FireWire, and sound ports.

Other design features that separate better PC cases from lower-quality models are finished edges (these prevent nasty scrapes both to your knuckles and to cables), quick-release drive bays (Figure 4.16), a detachable motherboard mount tray, and a removable front *bezel,* or faceplate. The more you work on PCs, the more you'll appreciate how these small features make it easier for you to service them.

If you're looking for pure aesthetic flash, case modification (mod) kits are available to trick out your boring beige box with neon and fiber-optic lighting, see-through acrylic panels, special LED speed and temperature displays, and fancy multimedia control panels. These do nothing to enhance a PC's perfor-
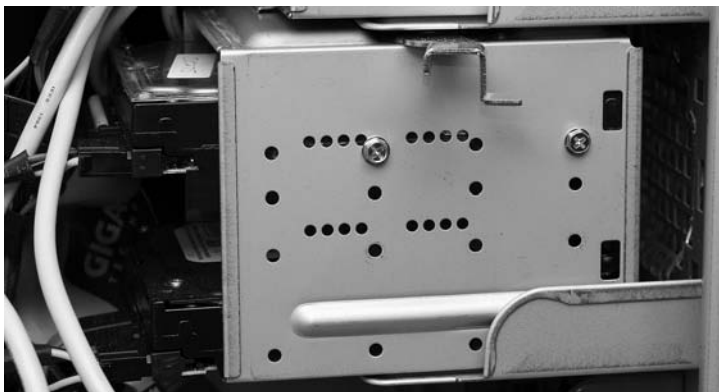
FIGURE 4.16 PC case with quick-release drive bays

mance or reliability, nor do they make them easier for techs to service, but they sure are cool to look at!

CHECKPOINT

✔ **Objective 4.01: Motherboards**   All motherboards have a chipset—North-bridge and Southbridge, plus Super I/O—to provide support for everything that plugs into the motherboard, including the CPU, RAM, drives, and inte-grated I/O devices. The ATX form factor—including full-sized, microATX, and FlexATX—dominates the PC market, but BTX is on the horizon. Moth-erboards support literally dozens of device types through integrated I/O and expansion slots. Installing is a matter of placing standouts properly and screwing down the motherboard. Troubleshooting is tough, though, be-cause of all the variables in the computer, but the fix for a bad motherboard is simple: replace it.

✔ **Objective 4.02: Power Supplies**   The PSU converts AC power into the DC power that your motherboard and drives need. Its internal fan also provides essential cooling for the PC components and drives. ATX power supplies dominate the market and plug into all three ATX and both BTX form factor motherboards. You'll find up to seven connectors on power sup-plies—Molex, mini, SATA, PCIe, P1, P4, and AUX—for drives, video cards, and motherboards. Power supplies are rated in wattage, such as 400-watt or 1-kilowatt; plus better PSUs employ active PFC to stop harmonics. Power supplies die suddenly or slowly over time. With the latter, the clue is inter-mittent problems. Replace, don't try to fix, a dead or dying power supply.

✔ **Objective 4.03: Cases**   PC cases come in six basic sizes: slimline, desktop, mini-tower, mid-tower, tower, and cube. Make sure you get a case that will fit your motherboard—many microATX and all FlexATX cases are too small for a regular ATX motherboard. Cube cases generally require a specific motherboard, so be prepared to buy both pieces at once.

REVIEW QUESTIONS

1. What part of the PC is the framework on which everything builds?
   A. I/O buses
   B. Expansion slots

    C. CPU

    D. Motherboard

2. Which of the following motherboards are you most likely to see in modern PCs? (Select two.)

    A. AT

    B. ATX

    C. Baby ATX

    D. microATX

3. If you have a PC with an ATX motherboard and case and you decide you would like to upgrade the motherboard, can you replace it with a BTX motherboard?

    A. No

    B. Yes, if you reset the jumpers

    C. Yes, if you add more screw holes

    D. Yes, if you remove the integrated ports

4. If you have a PC with a full-sized ATX motherboard and case and you decide you would like to upgrade the motherboard, can you replace it with a microATX motherboard? (Select the best answer.)

    A. No

    B. Yes, if you reset the jumpers

    C. Yes, if you add more screw holes

    D. Most likely, if you move the standouts

5. What types of connector attach the ATX power supply to a modern ATX motherboard? (Select two.)

    A. P1

    B. P2

    C. P4

    D. P8

6. What advantage do BTX form factor systems have over ATX systems?

    A. Better device support

    B. Better CPU support

    C. Better sound

    D. Better cooling

7. Mario bought a PCI Express video card. What type of connector might he need to plug into the card? (Select two.)

   A. Molex

   B. P1

   C. P4

   D. PCIe

8. Which motherboard type uses a riser card?

   A. ATX

   B. BTX

   C. microATX

   D. NLX

9. Molex connectors supply electricity to which devices? (Select two.)

   A. Floppy drives

   B. Hard drives

   C. Optical drives

   D. Thumb drives

10. A client notices the 115/230 switch on the back of a power supply you're installing. What's the switch used for?

    A. Powering computers in countries that run at a higher standard voltage than that used in the United States

    B. Powering computers in countries that run a lower standard voltage than that used in the United States

    C. Powering server computers that need double the normal voltage

    D. Overclocking

11. In what circumstance should you open a power supply?

    A. You open a power supply for routine cleaning.

    B. If the computer suddenly won't start up, you can check and replace the fuse inside the power supply.

    C. If you see a flash of light or see smoke coming out, you should open the power supply.

    D. Never open a power supply. It's not safe.

12. Which voltages does a power supply provide through a mini connector?

    A. 3.3 V, 5 V

    B. 5 V, 12 V

C. 3.3 V, 12 V

D. 115 V, 230 V

13. After installing an additional drive into a working computer, the computer won't power up at all—no lights, no spinning drives, nothing. What's most likely the problem?

A. Dead hard drive

B. Dead power supply

C. Insufficient DC wattage provided by the power supply

D. Insufficient AC wattage provided by the electrical outlet

14. What's another name for a computer case?

A. Brick

B. Bucket

C. System unit

D. System support

15. What feature do you find on better power supplies that eliminates harmonics?

A. Active PFC

B. Active scan

C. Passive PFC

D. Passive scan

REVIEW ANSWERS

1. **D**   The motherboard can be considered the cornerstone of the PC. All your system devices are either directly or indirectly attached to the motherboard, making it the most important part of your PC.

2. **B** **D**   You'll find primarily ATX and microATX motherboards in modern systems. AT motherboards are old and baby ATX motherboards don't exist.

3. **A**   You cannot replace an ATX motherboard with a BTX motherboard using the same case. ATX motherboards go into ATX cases, and BTX motherboards go into BTX cases.

4. **D**   Most full-sized ATX cases support microATX motherboards.

5. **A** **C**   Modern ATX motherboards use P1 for primary power and P4 for secondary power.

6. **D**   BTX systems offer better cooling than ATX systems. Both offer similar device, CPU, and sound support.

7. **A** **D**   Some PCIe video cards use a Molex connector, although most require a PCIe connector.

8. **D**   NLX motherboards use a riser card.

9. **B** **C**   Molex connectors supply power for hard drives and optical drives.

10. **A**   When powering up computers in countries that use ~230 VAC, you simply flip the switch from ~115 to ~230.

11. **D**   Don't open that power supply as the capacitors can bite. Hard.

12. **B**   Mini connectors provide 5 V and 12 V.

13. **C**   If a power supply does not have enough DC wattage to power up the computer, you'll get a completely inert computer.

14. **C**   Many techs call computer cases "system units."

15. **A**   Active power factor correction (PFC) helps smooth out those nasty harmonics.