CHAPTER 7

Power Supplies

In this chapter, you will learn how to

- Explain the basics of electricity
- Describe the details of powering the PC
- Install and maintain power supplies
- Explain power supply troubleshooting and fire safety

Computers need electricity to run. Where this electricity comes from depends on the device. Mobile devices use batteries (covered in great detail in Chapter 23, "Portable Computing"). Desktop computers need a special box—the *power supply unit* (*PSU*)—that takes electricity from the wall socket and transforms it into electricity your computer can use. Figure 7-1 shows a typical power supply.

Figure 7-1 Power supply about to be mounted inside a system unit

As simple as this appears on the surface, power supply issues are of critical importance for techs. Problems with power can create system instability, crashes, and data loss—all things most computer users would rather avoid! Good techs therefore know an awful lot about powering the PC, from understanding the basic principles of electricity to knowing the many variations of PC power supplies. Plus, you need to know how to recognize power problems and implement the proper solutions. Too many techs fall into the “just plug it in” camp and never learn how to deal with power, much to their clients’ unhappiness.

EXAM TIP Some questions on the CompTIA A+ 220-1001 certification exam refer to a power supply as a *PSU*, for *power supply unit*. A power supply also falls into the category of *field replaceable unit* (*FRU*), which refers to the typical parts a tech should carry, such as RAM and a hard drive.

Historical/Conceptual

Understanding Electricity

Electricity is a flow of negatively charged particles, called electrons, through matter. All matter enables the flow of electrons to some extent. This flow of electrons is very similar to the flow of water through pipes; so similar that the best way to learn about electricity is by comparing it to how water flows through pipes. So let's talk about water for a moment.

Water comes from the ground, through wells, aquifers, rivers, and so forth. In a typical city, water comes to you through pipes from the water supply company that took it from the ground. What do you pay for when you pay your water bill each month? You pay for the water you use, certainly, but built into the price of the water you use is the surety that when you turn the spigot, water will flow at a more or less constant rate. The water sits in the pipes under pressure from the water company, waiting for you to turn the spigot.

Electricity works essentially the same way as water. Electric companies gather or generate electricity and then push it to your house under pressure through wires. Just like water, the electricity sits in the wires, waiting for you to plug something into the wall socket, at which time it'll flow at a more or less constant rate. You plug a lamp into an electrical outlet and flip the switch, electricity flows, and you have light. You pay for reliability, electrical pressure, and electricity used.

The pressure of the electrons in the wire is called *voltage* and is measured in units called *volts* (*V*). See Figure 7-2.

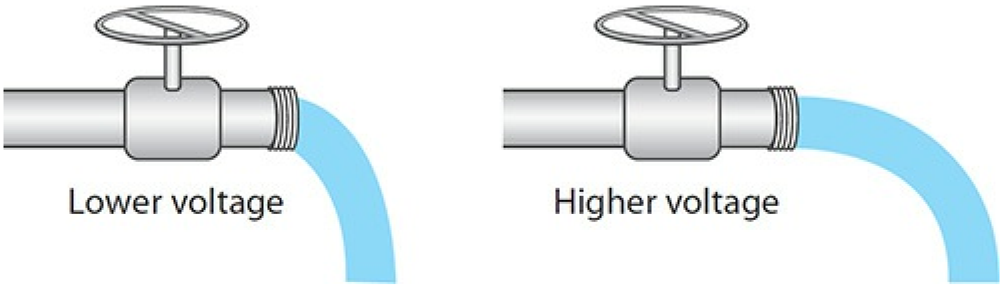

Figure 7-2 Electrical voltage as water pressure

The amount of electrons moving past a certain point on a wire is called the *current* (or *amperage*), which is measured in units called *amperes* (*amps* or *A*). See Figure 7-3.

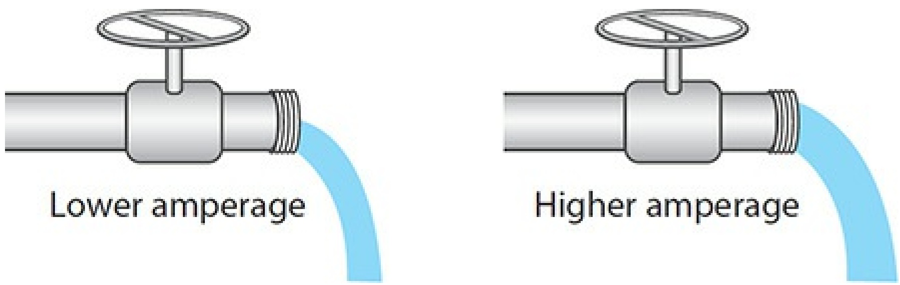

Figure 7-3 Electrical amperage as amount of water flowing

The amps and volts needed so that a particular device will function is expressed as how much *wattage* (*watts* or *W*) that device needs. The correlation between the three is very simple math: V × A = W. You'll learn more about wattage a little later in this chapter.

Wires of all sorts—whether copper, tin, gold, or platinum—have a slight *resistance* to the flow of electrons, just as water pipes have a slight amount of friction that resists the flow of water. Resistance to the flow of electrons is measured in *ohms* (Ω).

- Pressure = voltage (V)
- Volume flowing = amperes (A)
- Work = wattage (W)
- Resistance = ohms (Ω)

A particular thickness of wire only handles so much current at a time. If you push too much through, the wire will overheat and break, much as an overloaded water pipe will burst. To make sure you use the right wire for the right job, all electrical wires have an amperage rating, such as 20 amps. If you try to push 30 amps through a 20-amp wire, the wire will break, and electrons will seek a way to return into the ground. Not a good thing, especially if the path back to ground is through you!

Circuit breakers and ground wires provide the basic protection from accidental overflow. A circuit breaker is a heat-sensitive or electromagnetically operated electrical switch rated for a specified amperage. If you push too much amperage through the circuit breaker, the wiring inside detects the increase in heat or current and automatically opens, stopping the flow of electricity before the wiring overheats and breaks. You reset the circuit breaker to reestablish the circuit, and electricity flows once more through the wires. A ground wire provides a path of least resistance for electrons to flow back to ground in case of an accidental overflow.

Many years ago, your home and building electrical supply used fuses instead of circuit breakers. Fuses are small devices with a tiny filament designed to break if subjected to too much current. Unfortunately, fuses had to be replaced every time they blew, making circuit breakers much more convenient. Even though you no longer see fuses in a building’s electrical circuits, many electrical devices—such as a PC’s power supply—often still use fuses for their own internal protection. Once blown, these fuses are not replaceable by users or technicians without special training and tools.

EXAM TIP An electrical outlet must have a ground wire to be suitable for PC use.

Electricity comes in two flavors: *direct current* (*DC*), in which the electrons flow in one direction around a continuous circuit, and *alternating current* (*AC*), in which the flow of electrons alternates direction back and forth in a circuit (see Figure 7-4). Most electronic devices use DC power, but all power companies supply AC power because AC travels long distances much more efficiently than DC.

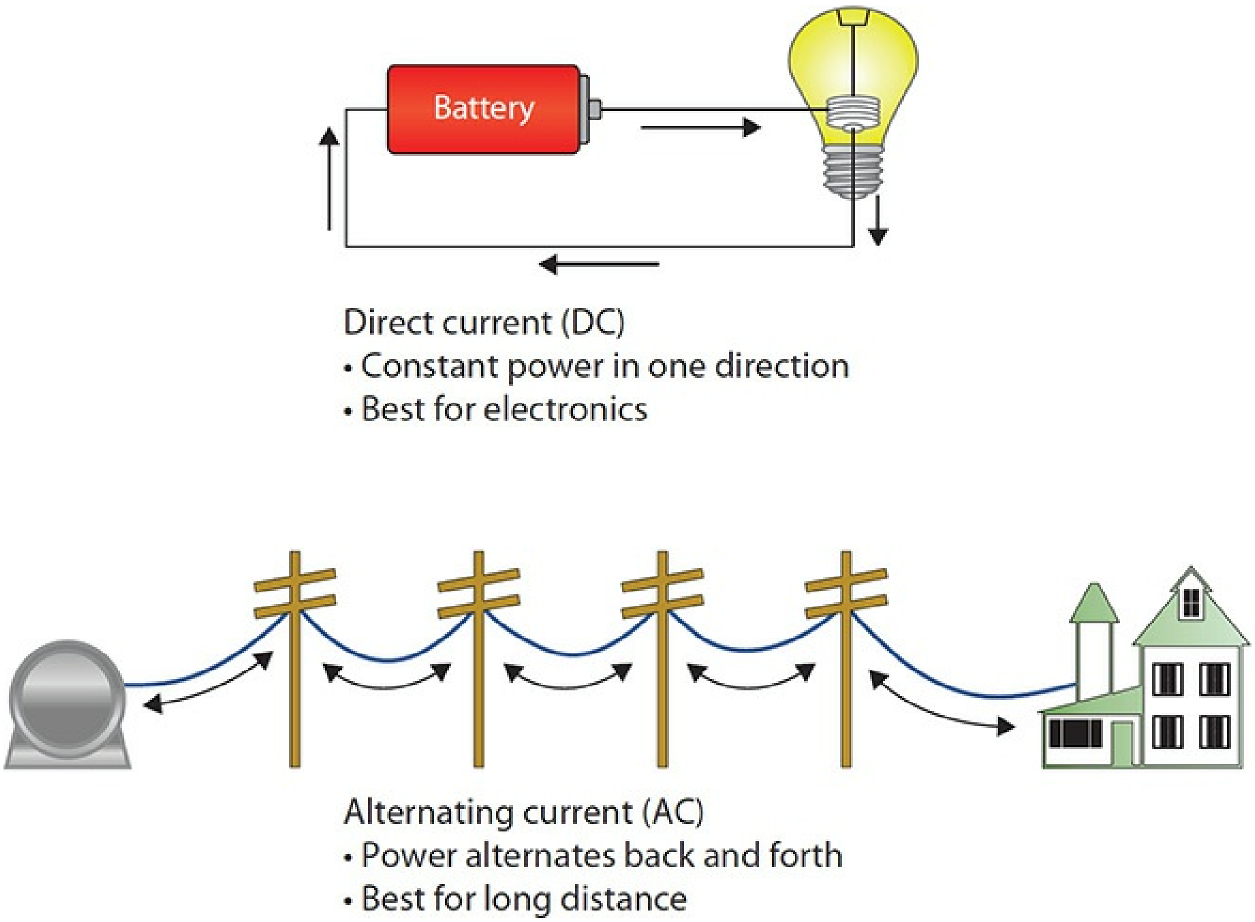

Figure 7-4 Diagrams showing DC and AC flow

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Powering the PC

Your PC uses DC voltage, so some conversion process must take place before the PC can use AC power from the power company. The power supply in a computer converts high-voltage AC power from the wall socket to low-voltage DC. The first step in powering the PC, therefore, is to get and maintain a good supply of AC power. Second, you need a power supply to convert AC to the proper voltage and amperage of DC power for the motherboard and peripherals. Finally, you need to control the byproduct of electricity use—namely, heat. Let's look at the specifics of powering the PC.

Supplying AC

Every PC power supply must have standard AC power from the power company, supplied steadily rather than in fits and spurts, and protection against accidental blurps in the supply. The power supply connects to the power cord (and thus to an electrical outlet) via a standard *IEC-320* connector. In the United States, standard AC comes in somewhere between 110 and 120 V, often written as ~115 VAC (volts of alternating current). Most of the rest of the world uses 220–240 VAC, so power supplies are available with *dual-voltage options*, making them compatible with either standard. Power supplies with voltage-selection switches are referred to as fixed-input. Power supplies that you do not have to manually switch for different voltages are known as auto-switching. Figure 7-5 shows the back of a power supply. Note the three components, from top to bottom: the hard on/off switch, the 115/230 switch, and the IEC-320 connector.

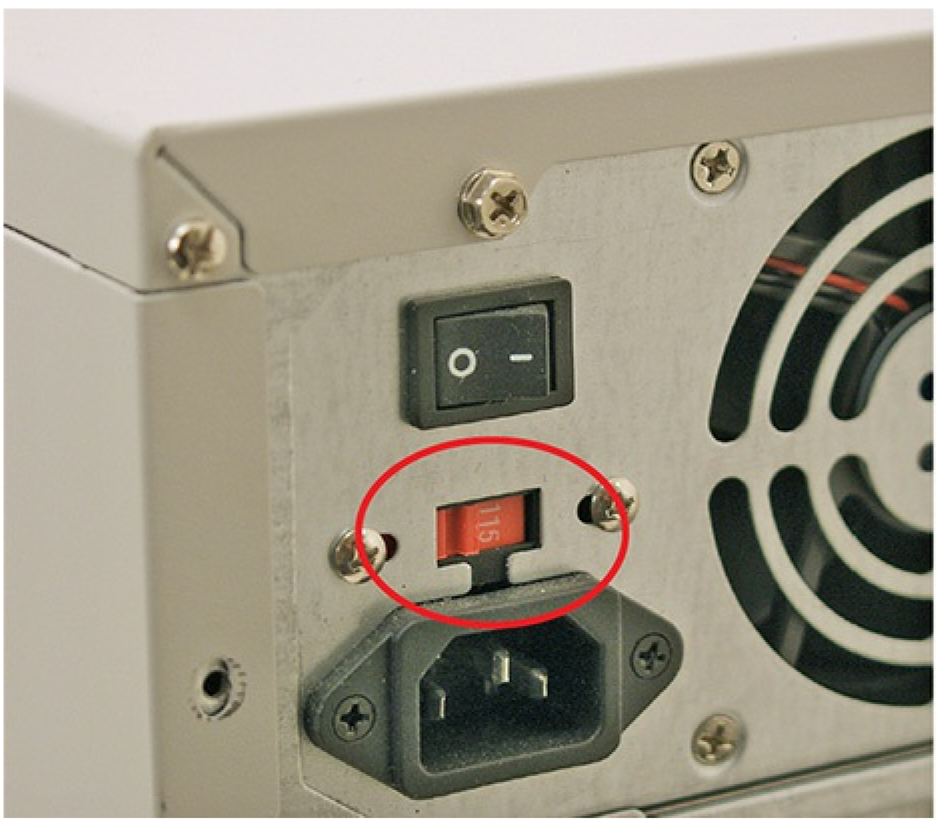

Figure 7-5 Back of fixed-input power supply, showing typical switches and power connection

Although the higher voltage differs among the many countries that use it, the CompTIA A+ 1001 exam objectives refer to it only as *220V*, not the range (220–240 VAC) that this chapter uses. That’s what they mean, though.

CAUTION Flipping the voltage-selection switch on the back of a power supply can wreak all kinds of havoc on a PC. Moving the switch to ~230 V in the United States makes for a great practical joke (as long as the PC is off when you do it)—the PC might try to boot up but probably won’t get far. You don’t risk damaging anything by running at half the AC the power supply is expecting. In countries that run ~230 standard, on the other hand, firing up the PC with this switch set to ~115 can cause the power supply to die a horrid, smoking death. Watch that switch!

Before plugging any critical components into an AC outlet, take a moment to test the outlet first by using a multimeter or a device designed exclusively to test outlets. Failure to test AC outlets properly can result in inoperable or destroyed equipment, as well as possible electrocution. The IEC-320 plug has three holes, called hot, neutral, and ground. These names describe the function of the wires that connect to them behind the wall plate. The hot wire carries electrical voltage, much like a pipe that delivers water. The neutral wire carries no voltage, but instead acts like a water drain, completing the circuit by returning electricity to the local source, normally a breaker panel. The ground wire makes it possible for excess electricity to return safely to the ground, such as in a short-circuit condition.

When testing AC power, you want to check for three things: that the hot outputs approximately 115 V (or whatever the proper voltage is for your part of the world), that the neutral connects to ground (0 V output), and that the ground connects to ground (again, 0 V). Figure 7-6 shows the voltages at an outlet. You can use a *multimeter*—often also referred to as a *volt-ohm meter* (*VOM*) or *digital multimeter* (*DMM*)—to measure a number of aspects of electrical current. A multimeter consists of two probes, an analog or digital meter, and a dial to set the type of test you want to perform. Refer to Figure 7-7 to become familiar with the components of the multimeter.

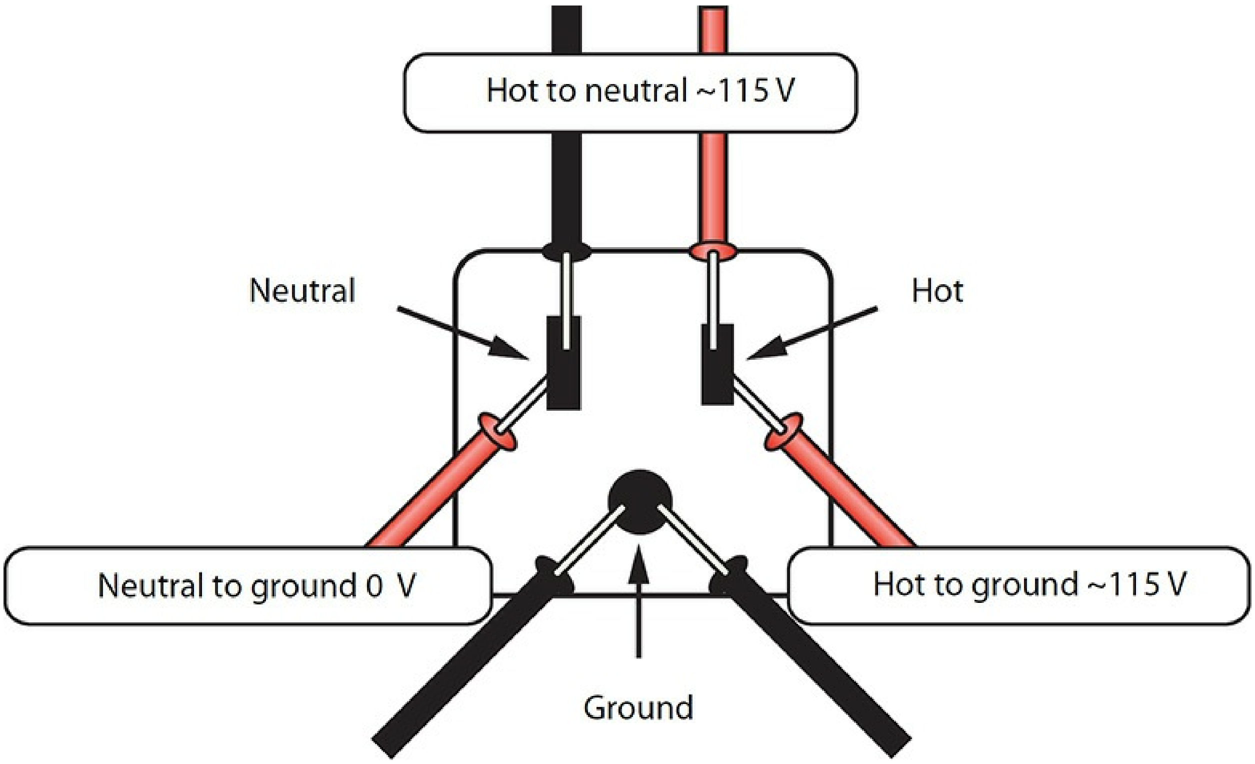

Figure 7-6 Outlet voltages

Figure 7-7 Author's ancient but reliable digital multimeter

Note that some multimeters use symbols rather than letters to describe AC and DC settings. For example, the *V* with the solid line above a dashed line in Figure 7-8 refers to direct current. The *V*~ stands for alternating current.

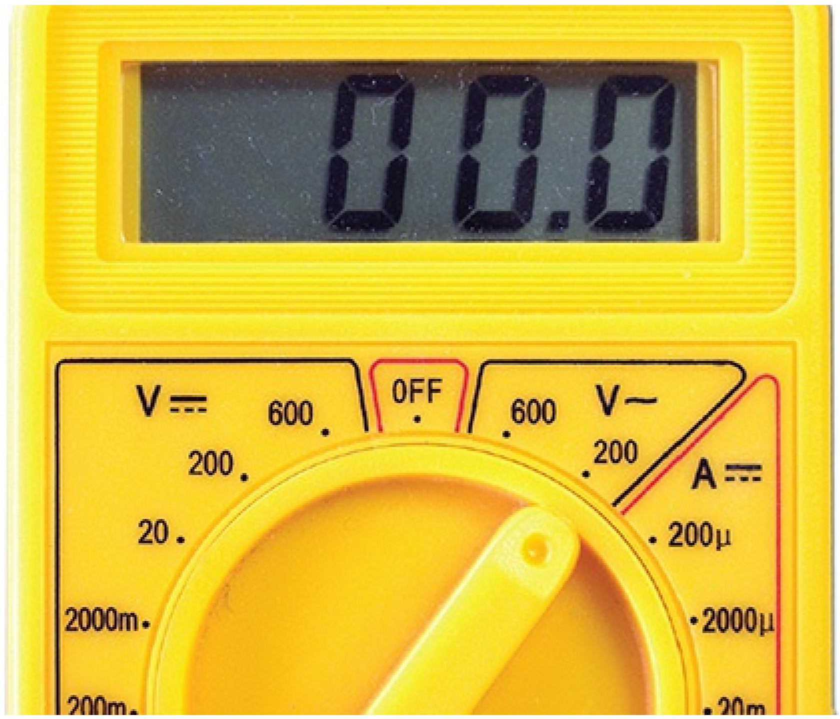

Figure 7-8 Multimeter featuring DC and AC symbols

Most multimeters offer at least four types of electrical tests: continuity, resistance, AC voltage (VAC), and DC voltage (VDC). Continuity tests whether electrons can flow from one end of a wire to the other end. If so, you have continuity; if not, you don't. You can use this setting to determine if a fuse is good or to check for breaks in wires. If your multimeter doesn't have a continuity tester (many cheaper multimeters do not), you can use the resistance tester. A broken wire or fuse will show infinite resistance, while a good wire or fuse will show no resistance. Testing AC and DC voltages is a matter of making sure the measured voltage is what it should be.

Try This! Using a Multimeter to Test AC Outlets

Every competent technician knows how to use a multimeter, so if you haven't used one in the past, get hold of one and work through this scenario. Your boss tasks you with checking the existing electrical outlets in a new satellite location for the company. Caution: During this exercise, do *not* physically touch any of the metal parts of the probes or sockets!

First you need to set up the meter for measuring AC. Follow these steps:

1. Move the selector switch to the AC V (usually red). If multiple settings are available, put it into the first scale higher than 120 V (usually 200 V). *Auto-range* meters set their own range; they don't need any selection except AC V.
2. Place the black lead in the common (–) hole. If the black lead is permanently attached, ignore this step.
3. Place the red lead in the V-Ohm-A (+) hole. If the red lead is permanently attached, ignore this step.

Once you have the meter set up for AC, go through the process of testing the various wires on an AC socket. Just don't put your fingers on the metal parts of the leads when you stick them into the socket! Follow these steps:

1. Put either lead in hot, the other in neutral. You should read 110 to 120 V AC.
2. Put either lead in hot, the other in ground. You should read 110 to 120 V AC.
3. Put either lead in neutral, the other in ground. You should read 0 V AC.

If any of these readings is different from what is described here, it's time to call an electrician.

Using Special Equipment to Test AC Voltage

A number of good AC-only testing devices are available. With these devices, you can test all voltages for an AC outlet by simply inserting them into the outlet. Be sure to test all of the outlets the computer system uses: power supply, external devices, and monitor. Although convenient, these devices aren't as accurate as a multimeter. My favorite tester is a seemingly simple tool available from a number of manufacturers (see Figure 7-9). This handy device provides three light-emitting diodes (LEDs) that describe everything that can go wrong with a plug.

Figure 7-9 Circuit tester

AC Adapters

Many computing devices use an AC adapter 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 internal 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, these adapters are not necessarily interchangeable. In other words, 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 either 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 a battery in a flashlight backward. If either the voltage or amperage—especially the former—is too high, on the other hand, you can very 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.

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Equipment Grounding

Computer equipment safety starts with proper grounding. The ground wire functions as an emergency outlet for excess current in case of any short or malfunction of a device. Don’t assume that a convenient three-prong outlet has proper grounding, especially in older buildings. Use a multimeter to check that ground wire.

Protecting the PC from Spikes and Sags in AC Power

If all power companies could supply electricity in smooth, continuous flows with no dips or spikes in pressure, the next two sections of this chapter would be irrelevant. Unfortunately, no matter how clean the AC supply appears to a multimeter, the truth is that voltage from the power company tends to drop well below (sag) and shoot far above (surge or spike) the standard 115 V (in the United States). These sags and spikes usually don’t affect lamps and refrigerators in such scenarios, but they can keep your PC from running or can even destroy a PC or peripheral device. Two essential devices handle spikes and sags in the supply of AC: surge suppressors and uninterruptible power supplies.

EXAM TIP Large sags in electricity are also known as *brownouts*. When the power cuts out completely, it’s called a *blackout*.

Surge Suppressors Surges or spikes are far more dangerous than sags. Even a strong sag only shuts off or reboots your PC; any surge can harm your computer, and a strong surge destroys components. Given the seriousness of surges, every PC should use a *surge suppressor* device that absorbs the extra voltage from a surge to protect the PC. The power supply does a good job of surge suppression and can handle many of the smaller surges that take place fairly often. But the power supply takes a lot of damage from this and will eventually fail. To protect your power supply, a dedicated surge suppressor works between the power supply and the outlet to protect the system from power surges (see Figure 7-10).

Figure 7-10 Surge suppressor

Most people tend to spend a lot of money on their PC and for some reason suddenly get cheap on the surge suppressor. Don’t do that! Make sure your surge suppressor has the Underwriters Laboratories UL 1449 for 330-V rating to ensure substantial protection for your system. Underwriters Laboratories (www.ul.com) is a U.S.-based, not-for-profit, widely recognized industry testing laboratory whose testing standards are very important to the consumer electronics industry. Additionally, check the joules rating before buying a new surge suppressor. A *joule* is a unit of electrical energy. How much energy a surge suppressor can handle before it fails is described in joules. Most authorities agree that your surge suppressor should rate at a minimum of 2000 joules—and the more joules, the better the protection. My surge suppressor rates at 3500 joules.

While you’re protecting your system, don’t forget that surges also come from telephone and cable connections. If you use a modem, DSL, or cable modem, make sure to get a surge suppressor that includes support for these types of connections. Many manufacturers make surge suppressors with telephone line protection (see Figure 7-11).

Figure 7-11 Surge suppressor with cable and telephone line protection

CAUTION No surge suppressor in the world can handle the ultimate surge, the electrical discharge of a lightning strike. If your electrical system takes such a hit, you can kiss your PC and any other electronic devices goodbye if they were plugged in at the time. Always unplug electronics during electrical storms!

No surge suppressor works forever. Make sure your surge suppressor has a test/reset button so you’ll know when the device has—as we say in the business—turned into an extension cord. If your system takes a hit and you have a surge suppressor, call the company! Many companies provide cash guarantees against system failure due to surges, but only if you follow their guidelines.

NOTE Surge suppression isn’t just about joules. Surge suppressors are also rated in clamping voltage, in which an overvoltage condition is “clamped” to a more manageable voltage for a certain amount of time. Good consumer suppressors can clamp 600 volts down to 180 volts or less for at least 50 microseconds and can do so on either the hot line or neutral line.

If you want really great surge suppression, you need to move up to *power conditioning*. Your power lines take in all kinds of strange signals that have no business being in there, such as electromagnetic interference (EMI) and radio frequency interference (RFI). Most of the time, this line noise is so minimal it’s not worth addressing, but occasionally events (such as lightning) generate enough line noise to cause weird things to happen to your PC (keyboard lockups, messed-up data). All better surge suppressors add power conditioning to filter out EMI and RFI.

UPS An *uninterruptible power supply* (*UPS*) protects your computer (and, more importantly, your data) in the event of a power sag or power outage. Figure 7-12 shows a typical UPS. A UPS essentially contains a big battery that provides AC power to your computer regardless of the power coming from the AC outlet.

Figure 7-12 Uninterruptible power supply

All uninterruptible power supplies are measured in both watts (the true amount of power they supply in the event of a power outage) and in *volt-amps* (*VA*). Volt-amps is the amount of power the UPS could supply if the devices took power from the UPS in a perfect way. Your UPS provides perfect AC power, moving current smoothly back and forth 60 times a second (or 50 in other parts of the world). Power supplies, monitors, and other devices, however, may not take all of the power the UPS has to offer at every point as the AC power moves back and forth, resulting in inefficiencies. If your devices took all of the power the UPS offered at every point as the power moved back and forth, VA would equal watts.

EXAM TIP You'll want to be familiar with the technology and use of surge suppressors and battery backup systems (UPSs) for the CompTIA A+ 220-1002 exam.

If the UPS makers knew ahead of time exactly what devices you planned to plug into their UPS, they could tell you the exact watts, but different devices have different efficiencies, forcing the UPS makers to go by what they can offer (VAs), not what your devices will take (watts). The watts value they give is a guess, and it's never as high as the VAs. The VA rating is always higher than the watt rating.

Because you have no way to calculate the exact efficiency of every device you'll plug into the UPS, go with the wattage rating. You add up the total wattage of every component in your PC and buy a UPS with a higher wattage. You'll spend a lot of time and mental energy figuring precisely how much wattage your computer, monitor, drives, and so on require to get the proper UPS for your system. But you're still not finished! Remember that the UPS is a battery with a limited amount of power, so you then need to figure out how long you want the UPS to run when you lose power.

NOTE There are two main types of UPS: online, where devices are constantly powered through the UPS's battery, and standby, where devices connected to the UPS receive battery power only when the AC sags below ~80–90 V. Another type of UPS is called line-interactive, which is similar to a standby UPS but has special circuitry to handle moderate AC sags and surges without the need to switch to battery power.

The quicker and far better method to use for determining the UPS you need is to go to any of the major surge suppressor/UPS makers' Web sites and use their handy power calculators. My personal favorite is on the APC by Schneider Electric (formerly known as American Power Conversion Corporation) Web site: www.apc.com (type **UPS selector** in the search field). APC makes great surge suppressors and UPSs, and the company's online calculator will show you the true wattage you need—and teach you about whatever new thing is happening in power at the same time.

Try This! Shopping for a UPS

When it comes to getting a UPS for yourself or a client, nothing quite cuts through the hype and marketing terms like a trip to the local computer store to see for yourself. You need excuses to go to the computer store, so here's a valid one for you.

1. Go to your local computer store—or visit an online computer site if no stores are nearby—and find out what's available.
2. Answer this question: How can you tell the difference between an online UPS and a standby UPS

Every UPS also has surge suppression and power conditioning, so look for the joule and UL 1449 ratings. Also look for replacement battery costs—some UPS replacement batteries are very expensive. Last, look for a UPS with a USB or Ethernet (RJ-45) connection. These handy UPSs come with monitoring and maintenance software (see Figure 7-13) that tells you the status of your system and the amount of battery power available, logs power events, and provides other handy options.

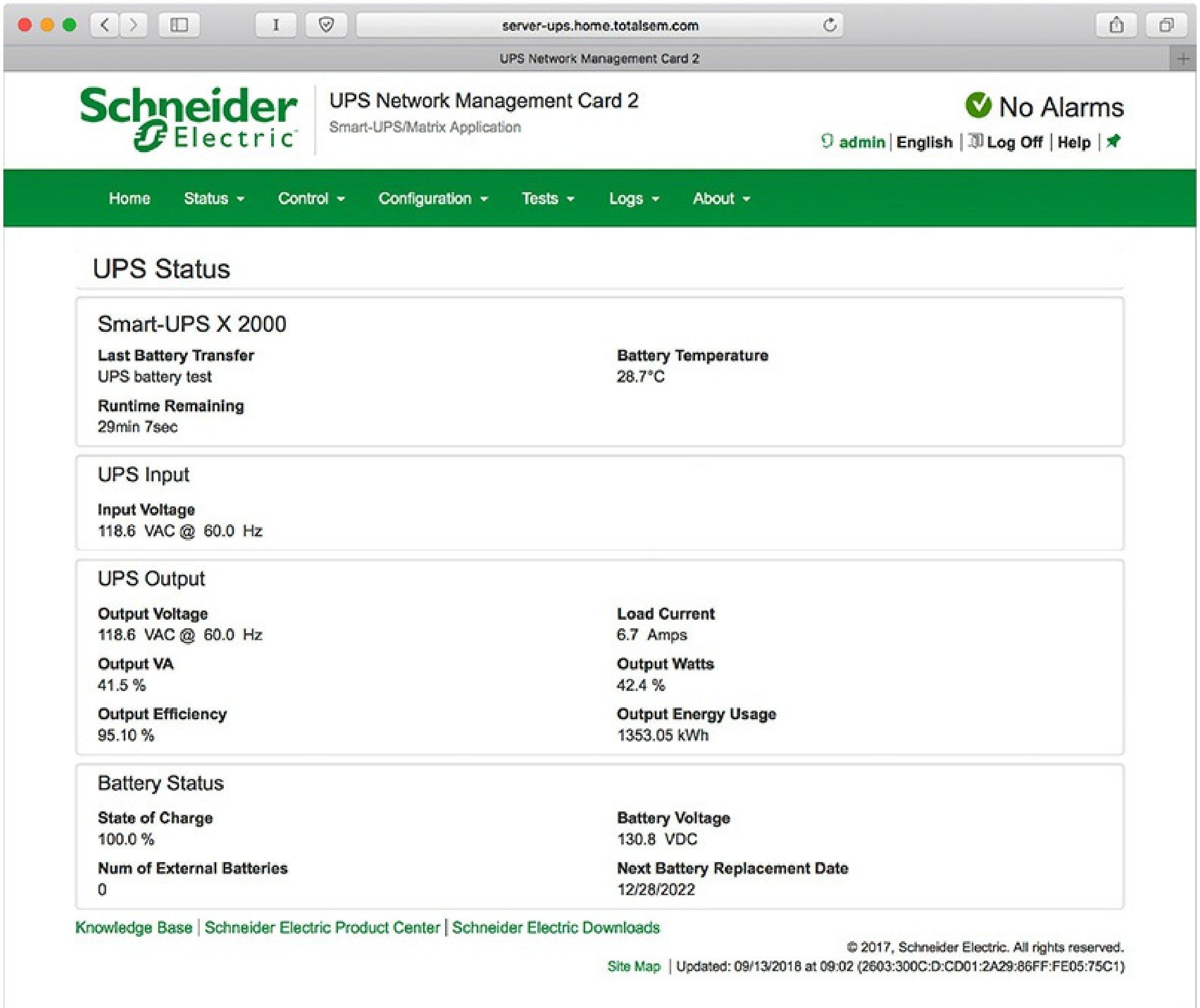

Figure 7-13 UPS management application

Table 7-1 gives you a quick look at the low end and the very high end of UPS products.

Brand	Model	Outlets Protected	Backup Time	Price	Type
APC	BE425M	3 @ 120 V	3 min @ 200 W, 10 min @ 100 W	$49.99	Standby
APC	Pro BR 1000MS	4 @ 120 V	4 min @ 600 W, 64 min @ 100 W	$184.99	Standby
CyberPower	CPS1500AVR	6 @ 120 V	18 min @ 950 W, 6 min @ 475 W	$379.99	Line-interactive

Table 7-1 Typical UPS Devices

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Supplying DC

After you've ensured the supply of good AC electricity for the PC, the power supply unit takes over, converting public utility voltage AC (115/120 V in the United States, 230 V in many other countries) into several DC voltages (notably, 3.3, 5.0, and 12.0 V) usable by the delicate interior components. Power supplies come in a large number of shapes and sizes, but the most common size by far is the standard 150 mm × 140 mm × 86 mm desktop PSU shown in Figure 7-14.

Figure 7-14 Desktop PSU

EXAM TIP The CompTIA A+ objectives list “Output 5.5V vs. 12V.” I’m pretty sure it’s a typo because power supplies offer 3.3-, 5-, and 12-VDC. Assume the “5.5V” means power to the electronics.

The PC uses the 12-V current to power motors on devices such as hard drives and optical drives, and it uses the 3.3- and 5-V current for support of onboard electronics. Manufacturers may use these voltages any way they wish, however, and may deviate from these assumptions. Power supplies also come with standard connectors for the motherboard and interior devices.

Power to the Motherboard

Modern motherboards use a 20- or 24-pin *P1 power connector*. Some motherboards may require special 4-, 6-, or 8-pin connectors to supply extra power (see Figure 7-15). We'll talk about each of these connectors in the form factor standards discussion later in this chapter.

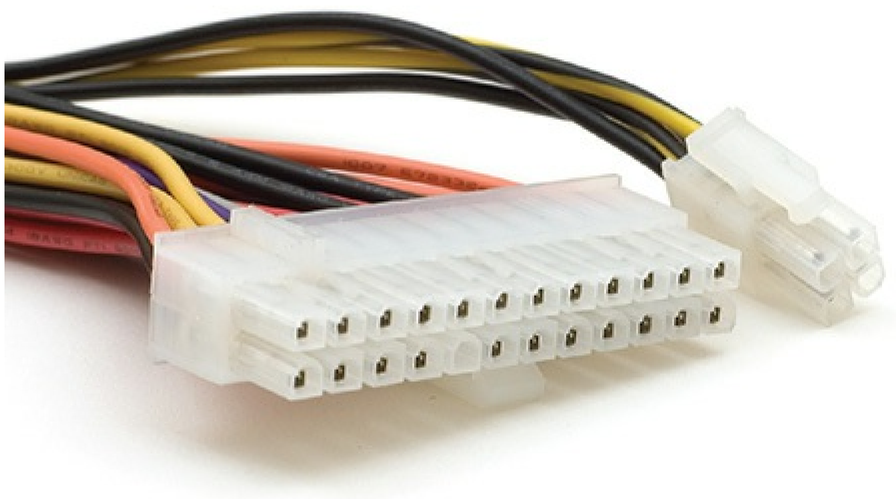


Figure 7-15 Motherboard power connectors

Power to Peripherals: Molex, Mini, and SATA

Many devices inside the PC require power. These include hard drives, solid-state drives, optical drives, and fans. The typical PC power supply has at least three types of connectors that plug into peripherals: Molex, mini, and SATA. (Higher-end video cards get their own connector(s) as well, covered a little later in this chapter.)

Molex Connectors The *Molex connector* supplies 5-V and 12-V current for fans and older drives (see Figure 7-16). The Molex connector has notches, called *chamfers*, that guide its installation. The tricky part is that Molex connectors require a firm push to plug in properly, and a strong person can defeat the chamfers, plugging a Molex in upside down. Not a good thing. *Always* check for proper orientation before you push it in!

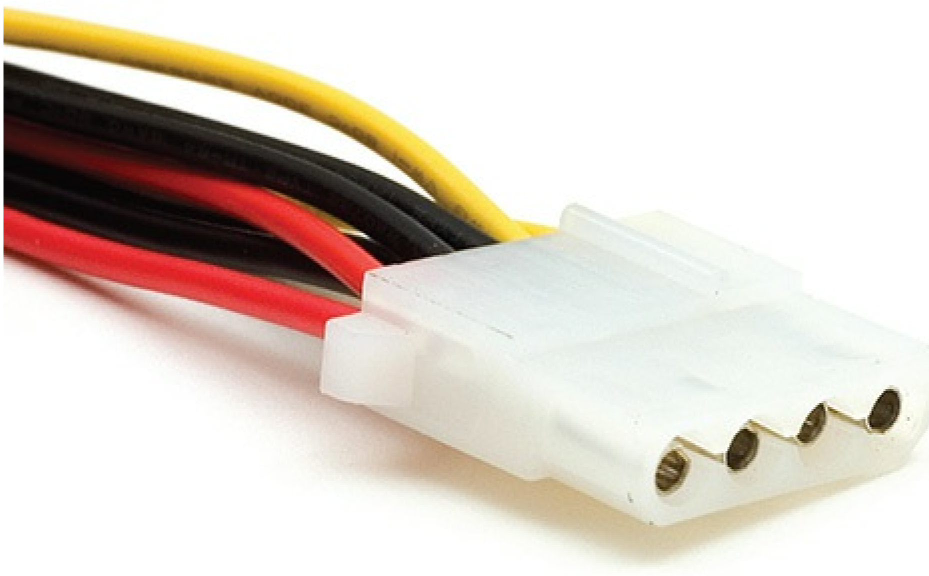


Figure 7-16 Molex connector

Mini Connectors A few power supplies still support the *mini connector* or *Berg connector* (see Figure 7-17). The mini supplies 5 V and 12 V to peripherals. Originally adopted as the standard connector on 3.5-inch floppy disk drives, you'll still see the occasional device needing this connector.

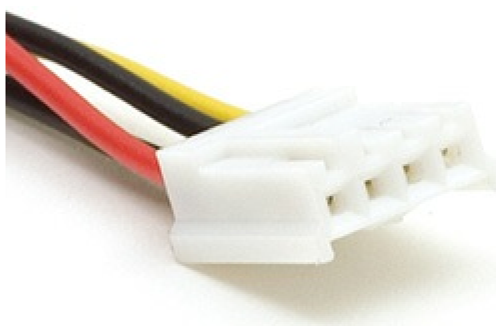


Figure 7-17 Mini connector

Try This! Testing DC

A common practice for techs troubleshooting a system is to test the DC voltages coming out of the power supply. Even with good AC, a bad power supply can fail to transform AC to DC at voltages needed by the motherboard and peripherals. The best way to learn how to perform this common technique is to try it yourself, so grab your trusty multimeter and walk through the following steps on a powered-up PC with the side cover removed. Note that you must have P1 connected to the motherboard and the system must be running (you don't have to be in Windows or Linux, of course).

1. Switch your multimeter to DC, somewhere around 20 V DC if you need to make that choice. Make sure your leads are plugged into the multimeter properly: red to hot, black to ground. The key to testing DC is that which lead you touch to which wire matters. Red goes to hot wires of all colors; black *always* goes to ground.
2. Plug the red lead into the red wire socket of a free Molex connector and plug the black lead into one of the two black wire sockets. You should get a reading of ~5 V. What do you have?
3. Now move the red lead to the yellow socket. What voltage do you get?
4. Testing the P1 connector is a little more complicated. You push the red and black leads into the top of P1, sliding in alongside the wires until you bottom out. Leave the black lead in one of the black wire ground sockets. Move the red lead through all of the colored wire sockets. What voltages do you find?

CAUTION As with any power connector, plugging a mini connector into a device the wrong way will almost certainly destroy the device. Check twice before you plug one in!

SATA Power Connectors Serial ATA (SATA) drives need a 15-pin *SATA power connector* (see Figure 7-18). The larger pin count supports the SATA hot-swappable feature and 3.3-, 5-, and 12-V devices. The 3.3-V pins are not used in any current iteration of SATA drives and are reserved for possible future use. All three generations of SATA use the same power connectors. SATA power connectors are L shaped, making it almost impossible to insert one incorrectly into a SATA drive. No other device on a computer uses the SATA power connector. For more information about SATA drives, see

Chapter 8, “Mass Storage Technologies.”

Figure 7-18 SATA power connector

Splitters and Adapters You may occasionally find yourself without enough connectors to power all of the devices inside your PC. In this case, you can purchase splitters to create more connections (see Figure 7-19). You might also run into the phenomenon of needing a SATA connector but having only a spare Molex. Because the voltages on the wires are the same, a simple adapter will take care of the problem nicely.

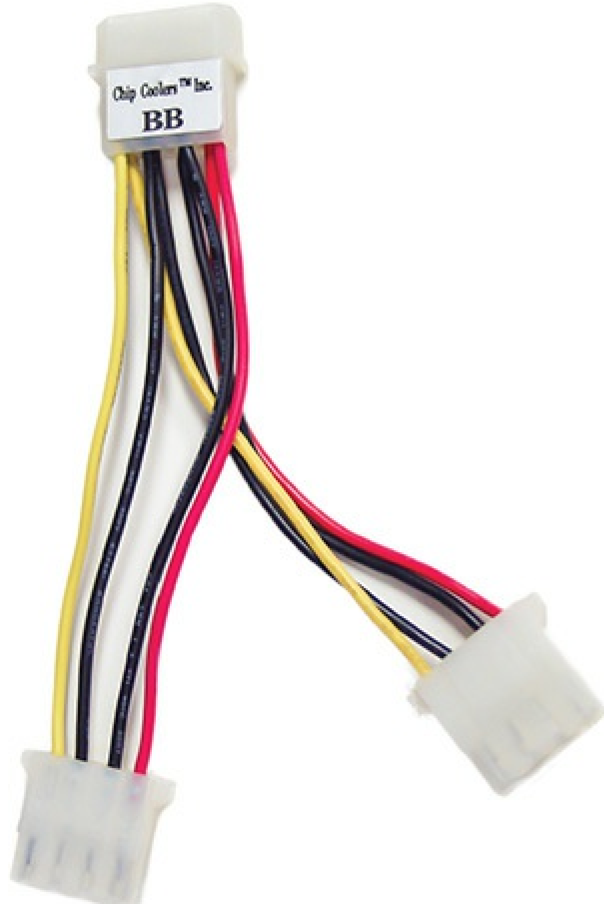


Figure 7-19 Molex splitter

ATX

The original ATX power supplies had two distinguishing physical features: the motherboard power connector and soft power. Motherboard power came from a single cable with a 20-pin P1 motherboard power connector. ATX power supplies also had at least two other cables, each populated with two or more Molex or mini connectors for peripheral power.

When plugged in, ATX systems have 5 V running to the motherboard. They're always "on," even when powered down. The power switch you press to power up the PC isn't a true power switch like the light switch on the wall in your bedroom. The power switch on an ATX system simply tells the computer whether it has been pressed. The BIOS or operating system takes over from there and handles the chore of turning the PC on or off. This is called *soft power*.

Using soft power instead of a physical switch has a number of important benefits. Soft power prevents a user from turning off a system before the operating system has been shut down. It enables the PC to use power-saving modes that put the system to sleep and then wake it up when you press a key, move a mouse, or receive an e-mail (or other network traffic). (See Chapter 23, “Portable Computing,” for more details on sleep mode.)

All of the most important settings for ATX soft power reside in CMOS setup. Boot into CMOS and look for a Power Management section. Take a look at the Power Button Function option in Figure 7-20. This determines the function of the on/off switch. You may set this switch to turn off the computer, or you may set it to the more common *4-second delay*.

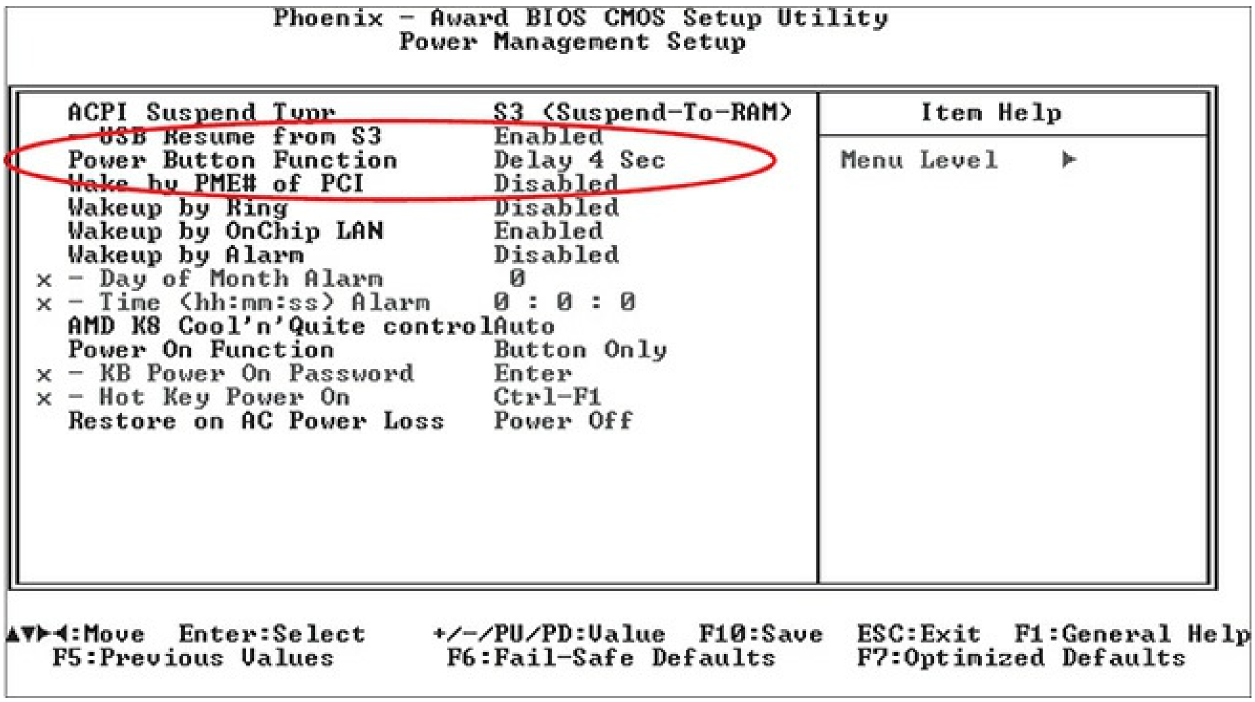
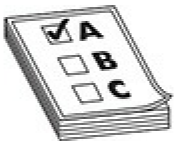


Figure 7-20 Soft power setting in CMOS

ATX did a great job supplying power for more than a decade, but over time more powerful CPUs, multiple CPUs, video cards, and other components began to need more current than the original ATX provided. This motivated the industry to introduce a number of updates to the ATX power standards: ATX12V 1.3, EPS12V, multiple rails, ATX12V 2.0, other form factors, and active PFC.

ATX12V 1.3 The first widespread update to the ATX standard, ATX12V 1.3, came out in 2003. This introduced a 4-pin motherboard power connector, unofficially but commonly called the *P4 power connector*, that provides more 12-V power to assist the 20/24-pin P1 motherboard power connector. Any power supply that provides a P4 connector is called an ATX12V power supply. The term “ATX” was dropped from the ATX power standard, so if you want to get really nerdy you can say—accurately—that there’s no such thing as an ATX power supply. All power supplies—assuming they have a P4 connector—are ATX12V or one of the later standards.



EXAM TIP SATA also supports a slimline connector that has a 6-pin power segment and a micro connector that has a 9-pin power segment.

The ATX12V 1.3 standard also introduced a 6-pin auxiliary connector—commonly called an *AUX* connector—to supply increased 3.3- and 5-V current to the motherboard (see Figure 7-21). This connector was based on the motherboard power connector from the precursor of ATX, called *AT*.

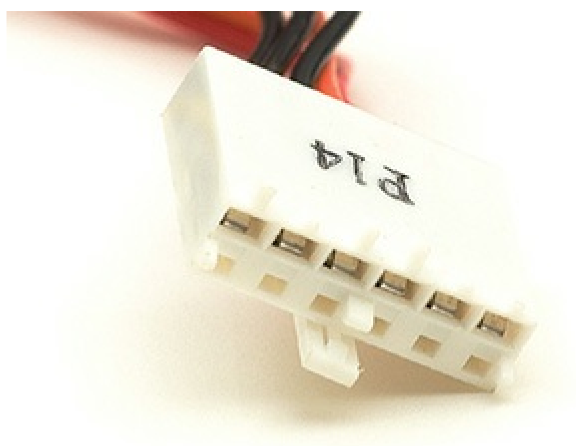


Figure 7-21 Auxiliary power connector

The introduction of these two extra power connectors caused the industry some teething problems. In particular, motherboards using AMD CPUs tended to need the AUX connector, while motherboards using Intel CPUs needed only the P4. As a result, many power supplies came with only a P4 or only an AUX connector to save money. The biggest problem with the

ATX12V standard was the lack of enforcement—it made a lot of recommendations but few requirements, giving PSU makers too much choice (such as choosing or not choosing to add AUX and P4 connectors) that weren't fixed until later versions.

EPS12V Server motherboards are thirsty for power, and sometimes ATX12V 1.3 just didn't cut it. An industry group called the Server System Infrastructure (SSI) developed a non-ATX standard motherboard and power supply called EPS12V. An EPS12V power supply came with a 24-pin main motherboard power connector that resembled a 20-pin ATX connector, but it offered more current and thus more stability for motherboards. It also came with an AUX connector, an ATX12V P4 connector, and a unique 8-pin connector. That's a lot of connectors! EPS12V power supplies were not interchangeable with ATX12V power supplies.

EPS12V may not have seen much life beyond servers, but it introduced a number of power features, some of which eventually became part of the ATX12V standard. The most important issue was something called *rails*.

Rails Generally, all of the PC's power comes from a single transformer that takes the AC current from a wall socket and converts it into DC current that is split into three primary DC voltage rails: 12 V, 5 V, and 3.3 V. Groups of wires run from each of these voltage rails to the various connectors.

Each rail has a maximum amount of power it can supply. Normal computer use rarely approaches this ceiling, but powerful computers with advanced processors and graphics cards require more power than some rails can provide. In the past, 12-V rails only supplied about 18 amps, which wasn't enough to power all that high-end equipment.

The most popular solution was to include multiple 12-V rails in the power supply. This worked fine, but you needed to make sure that you weren't drawing all of your power from the same 12-V rail. The key circuitry that monitors the amount of amperage going through each rail, called the over-current protection (OCP), will shut down the power supply if the current goes beyond its cap. In a *single-rail system*, a single OCP circuit monitors all the pathways. In a *multi-rail system*, each pathway gets its own OCP circuit.

When first implemented, multi-rail power supplies didn't do a great job balancing the circuitry, so enthusiasts still ran into problems with systems shutting down under heavy load. This has been fixed since 2008 or so, so any multi-rail PSU you buy today can handle whatever you throw at it.

Today's power supply manufacturers produce single- and multi-rail, high-amperage PSUs. You can find power supplies now with 12-V rails pushing 70 amps or more!

ATX12V 2.0 The ATX12V 2.0 standard incorporated many of the good ideas of EPS12V, starting with the 24-pin connector. This 24-pin motherboard power connector is backward compatible with the older 20-pin connector, so users don't have to buy a new motherboard if they use an ATX12V 2.0 power supply. ATX12V 2.0 requires two 12-V rails for any power supply rated higher than 230 W. ATX12V 2.0 dropped the AUX connector and requires SATA hard drive connectors.

Many ATX12V 2.0 power supplies have a convertible *24-to-20-pin motherboard adapter*. These are handy if you want to make a nice "clean" connection, because many 20-pin connectors have interfaces that prevent plugging in a 24-pin connector. You'll also see many 24-pin connectors constructed in such a way that you can slide off the extra four pins. Figure 7-22 shows 20-pin and 24-pin connectors; Figure 7-23 shows a convertible adapter. Although they look similar, those extra four pins won't replace the P4 connector. They are incompatible!

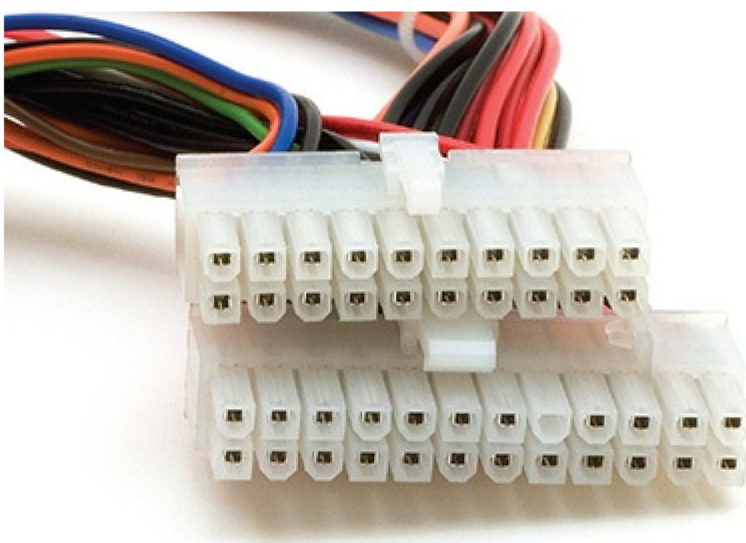


Figure 7-22 20- and 24-pin connectors

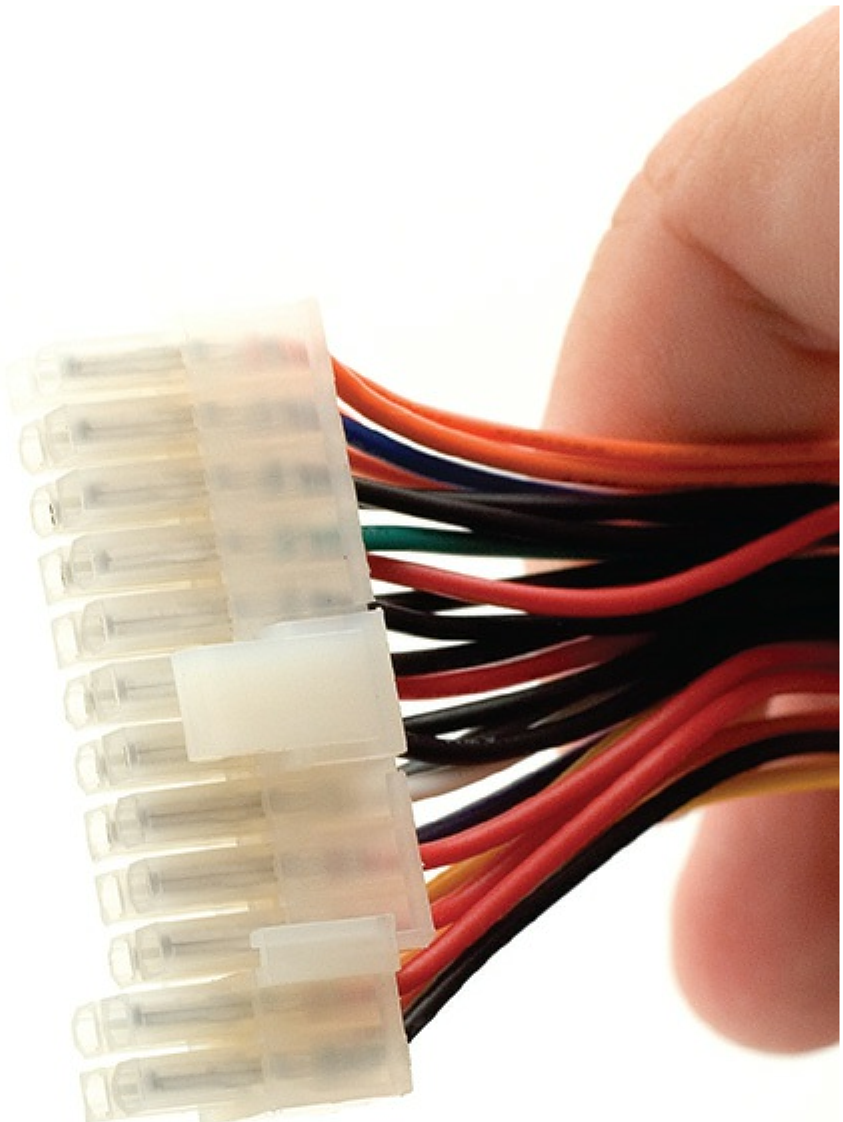


Figure 7-23 Convertible motherboard power connector

Many modern ATX motherboards feature an 8-pin CPU power connector like the one found in the EPS12V standard to help support high-end CPUs that demand a lot of power. This connector is referred to by several names, including EPS12V, EATX12V, and ATX12V 2x4. One half of this connector will be pin compatible with the P4 power connector, and the other half may be under a protective cap. Be sure to check the motherboard installation manuals for recommendations on when to use the full 8 pins. For backward compatibility, some power supplies provide an 8-pin power connector that can split into two 4-pin sets, one of which is the P4 connector.

Another notable connector is the auxiliary PCI Express (PCIe) power connector. Figure 7-24 shows the 6-pin PCIe power connector. Some motherboards add a Molex socket for PCIe, and some cards come with a Molex socket as well. Higher-end video cards have one or two sockets that require specific *6-pin or 8-pin PCIe power connectors*. The 8-pin PCIe connector should not be confused with the EPS12V connector, as they are not compatible. Some PCIe devices with the 8-pin connector will accept a 6-pin PCIe power connection instead, but this may put limits on their performance. Often you'll find that 8-pin PCIe power cables have two pins at the end that you can detach for easy compatibility with 6-pin devices.

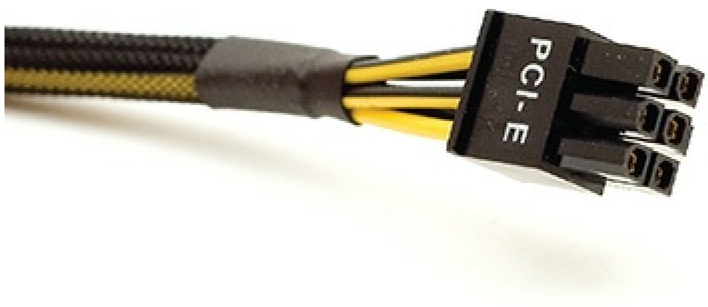


Figure 7-24 PCI Express 6-pin power connector

SIM Check out the Chapter 7 Challenge! sim, "ID PSU Connector," over at http://totalsem.com/100x. It'll help you identify and memorize the standard power supply connectors.

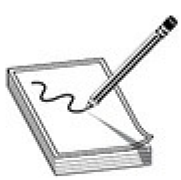
Niche-Market Power Supply Form Factors The demand for smaller and quieter PCs led to the development of a number of niche-market power supply form factors. All use standard ATX connectors but differ in size and shape from standard ATX power supplies.

Here are some of the more common specialty power supply types:

- **Mini-ITX** and **microATX** Smaller power supply form factors designed specifically for mini-ITX and microATX cases, respectively

- **TFX12V** A small power supply form factor optimized for low-profile ATX systems
- **SFX12V** A small power supply form factor optimized for systems using FlexATX motherboards (see Figure 7-25)

Figure 7-25 SFX power supply



NOTE You'll commonly find niche-market power supplies bundled with computer cases (and often motherboards as well). These form factors are rarely sold alone.

Active PFC Visualize the AC current coming from the power company as water in a pipe, smoothly moving back and forth, 50 or 60 times each second. A PC's power supply, simply due to the process of changing this AC current into DC current, is like a person sucking on a straw on the end of this pipe. It takes gulps only when the current is fully pushing or pulling at the top and bottom of each cycle and creating an electrical phenomena—sort of a back pressure—that's called *harmonics* in the power industry. These harmonics create the humming sound you hear from electrical components. Over time, harmonics damage electrical equipment, causing serious problems with the power supply and other electrical devices on the circuit. Once you put a few thousand PCs with power supplies in the same local area, harmonics can even damage the electrical power supplier's equipment!

Good PC power supplies come with *active power factor correction* (*active PFC*), extra circuitry that smooths out power coming from the wall before passing it to the main power supply circuits. This smoothing process eliminates any harmonics (see Figure 7-26). Never buy a power supply that does not have active PFC—all power supplies with active PFC will announce it on the box.

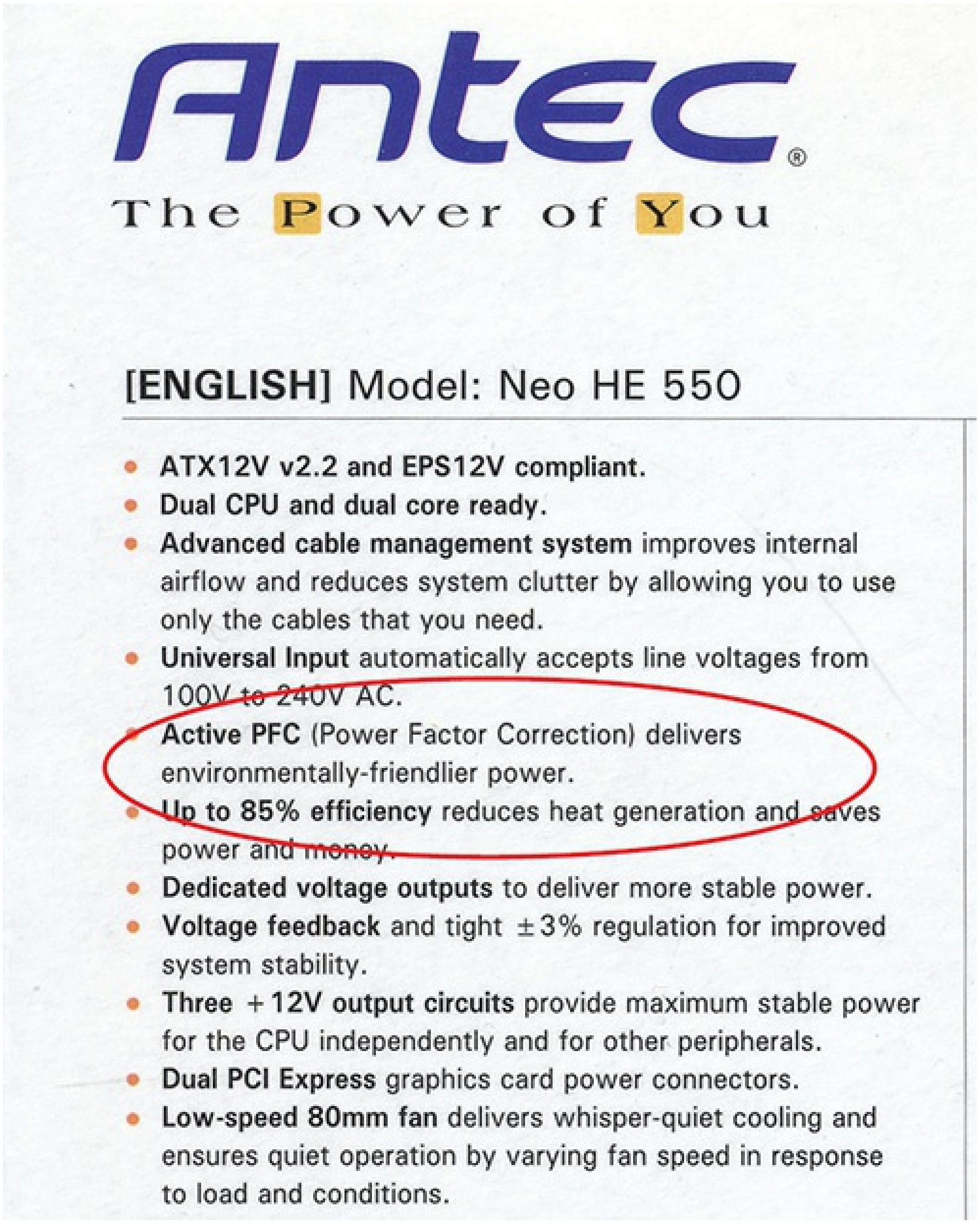


Figure 7-26 Power supply advertising active PFC

Wattage Requirements

Every device in a PC requires a certain wattage to function. A typical hard drive draws about 15 W of power when accessed, for example, whereas a quad-core Intel i7-4790K draws a whopping 151 W at peak usage. The total wattage of all devices combined is the minimum you need the power supply to provide.

When selecting a power supply for a system, in other words, make sure the power supply provides enough wattage to run the number of devices in the system. Also, the power supply needs to be able to support all the *types* of devices to be powered in the system. I updated the video card in a system the other day, for example, from a card that required a single 6-wire power cable to one that required two 8-wire power cables (see Figure 7-27). The power supply clearly had to have the latter capability.

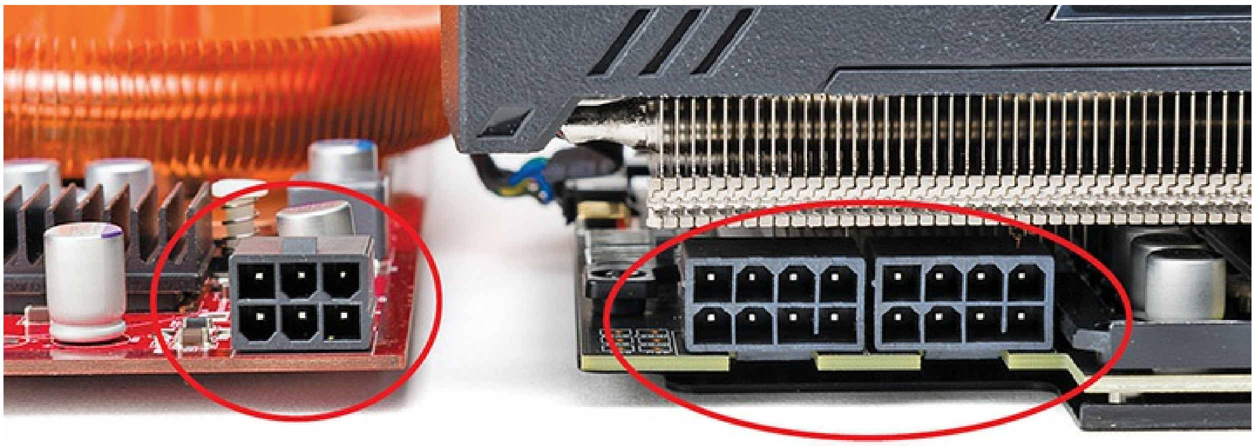
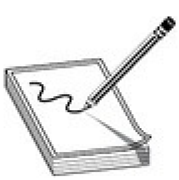


Figure 7-27 Big jump in power requirements!

If the power supply cannot produce the wattage a system needs, that PC won't work properly or at all. 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. This can lead to some embarrassing moments. You might plug in a new hard drive for a client, push the power button on the case, and nothing happens—a dead PC! Eek! You can quickly determine if insufficient wattage is the problem. Unplug the drive and power up the system. If the system boots up, the power supply is a likely suspect. The only fix for this problem is to replace the power supply with one that provides more wattage (or leave the new drive out—a less-than-ideal solution).



NOTE An undersized power supply may not necessarily result in a complete paperweight. Some graphics cards that are dependent on additional rail power from a PSU may continue to operate but will do so at reduced frame rates. That means your games won't play well, but the computer will function in other capacities. See Chapter 17, "Display Technologies," for the scoop on power-hungry video cards.

No power supply can turn 100 percent of the AC power coming from the power company into DC current, so all power supplies provide less power to the system than the wattage that they draw from the wall. The difference is lost in heat generation. The amount of this differential is advertised on the box. ATX12V 2.0 standards require a power supply to be at least 70 percent efficient, but many power supplies operate with better than 80 percent efficiency.

Power supplies are typically graded for their efficiency under a voluntary standards program called *80 Plus*. Under 80 Plus, power supplies are rated from 80 percent to 94 percent efficiency for a given load and badged with "metal labels" such as Bronze (85 percent), Gold (90 percent), or Titanium (94 percent) levels. These levels are achieved within a narrow range of watts provided, while lower levels of efficiency are achieved at higher and lower power draw. Power and efficiency curves are usually provided in the power supply documentation. More efficiency can tell you how many watts the system draws to supply sufficient power to the PC in actual use. The added efficiency means the power supply wastes less power, saving you money.

EXAM TIP The CompTIA A+ 1001 exam does not require you to figure precise wattage needs for a particular system. When building a PC for a client, however, you do need to know this stuff!

One common argument these days is that people buy power supplies that provide far more wattage than a system needs and therefore waste power. This is untrue. A power supply provides only the amount of power your system needs. If you put a 1500-W power supply into a system that needs only 250 W, that big power supply will put out only 250 W to the system. So buying an efficient, higher-wattage power supply gives you two benefits.

First, running a power supply at less than 100 percent load helps it live longer. Second, you'll have plenty of extra power when adding new components.

Don't cut the specifications too tightly for power supplies. All power supplies produce less wattage over time, simply because of wear and tear on the internal components. If you build a system that runs with only a few watts of extra power available from the power supply initially, that system will most likely start causing problems within a year or less. Do yourself or your clients a favor and get a power supply that has more wattage than you need.

As a general recommendation for a new system, use at least a 500-W power supply. This is a common wattage and gives you plenty of extra power for booting as well as for whatever other components you might add to the system in the future.

Try This! Calculating Power Needs

The Internet has some great tools to help you determine power needs for specific computer systems. As noted earlier in the chapter, I recently upgraded from a decent video card to a high-end gaming card (and added another solid-state drive for more storage), and needed to determine whether I needed to upgrade the power supply for a stable system. You will find yourself in similar situations as a tech, so try this!

Open a Web browser and check out the OuterVision Power Supply Calculator here:

https://outervision.com/power-supply-calculator

Put in the details on your desired systems and let their amazing tool do the math for you. Note the calculator puts in efficiency information and even makes a recommended purchase for you (and not from OuterVision). It's a very slick, very convenient tool. Bookmark it!

Installing and Maintaining Power Supplies

Although installing and maintaining power supplies takes a little less math than selecting the proper power supply for a system, they remain essential skills for any tech. Installing takes but a moment, and maintaining is almost as simple. Let's take a look.

Installing

The typical power supply connects to the PC with four standard computer screws, mounted in the back of the case (see Figure 7-28). Unscrew the four screws and the power supply lifts out easily (see Figure 7-29). Insert a new power supply that fits the case and attach it by using the same four screws.

Figure 7-28 Mounting screws for power supply

Figure 7-29 Removing power supply from system unit

Handling ATX power supplies requires special consideration. Understand that an ATX power supply *never turns off*. As long as that power supply stays connected to a power outlet, the power supply will continue to supply 5 V to the motherboard. Always unplug an ATX system before you do any work! For years, techs bickered about the merits of leaving a PC plugged in or unplugged when servicing it. ATX settled this issue forever. Many ATX power supplies provide a real on/off switch on the back of the PSU (see Figure 7-30). If you really need the system shut down with no power to the motherboard, use this switch.

Figure 7-30 On/off switch for an ATX system

When working on an ATX system, you may find using the power button inconvenient because you're not using a case or you haven't bothered to plug the power button's leads into the motherboard. That means there is no power button. One trick when in that situation is to use a metal key or a screwdriver to contact the two wires to start and stop the system (see Figure 7-31).

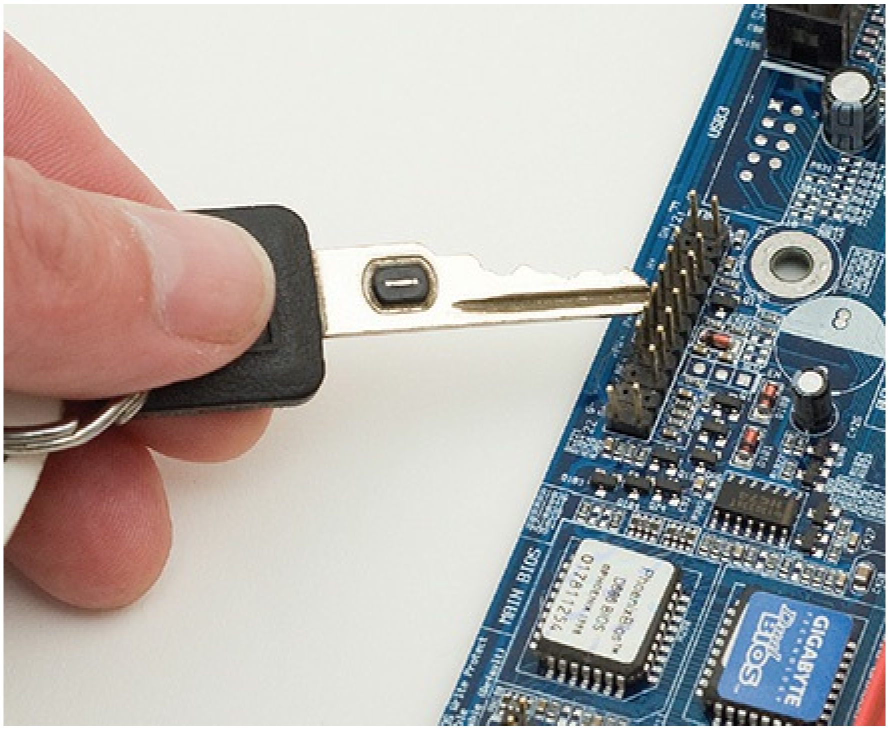


Figure 7-31 Shorting the soft on/off jumpers

Your first task after acquiring a new power supply is simply making sure it works. Insert the motherboard power connectors before starting the system. If you have video cards with power connectors, plug them in too. Other connectors such as hard drives can wait until you have one successful boot—or if you're cocky, just plug everything in!

Cooling

Heat and computers are not the best of friends. Cooling is therefore a vital consideration when building a computer. Electricity equals heat. Computers, being electrical devices, generate heat as they operate, and too much heat can seriously damage a computer's internal components.

The *power supply fan* provides the basic cooling for the PC (see Figure 7-32). It not only cools the voltage regulator circuits *within* the power supply but also provides a constant flow of outside air throughout the interior of the computer case. A dead power supply fan can rapidly cause tremendous problems, even equipment failure. If you ever turn on a computer and it boots just fine but you notice that it seems unusually quiet, check to see if the power supply fan has died. If it has, quickly turn off the PC and replace the power supply.

Figure 7-32 Power supply fan

Some power supplies come with a built-in sensor to help regulate the airflow. If the system gets too hot, the power supply fan spins faster (see Figure 7-33).

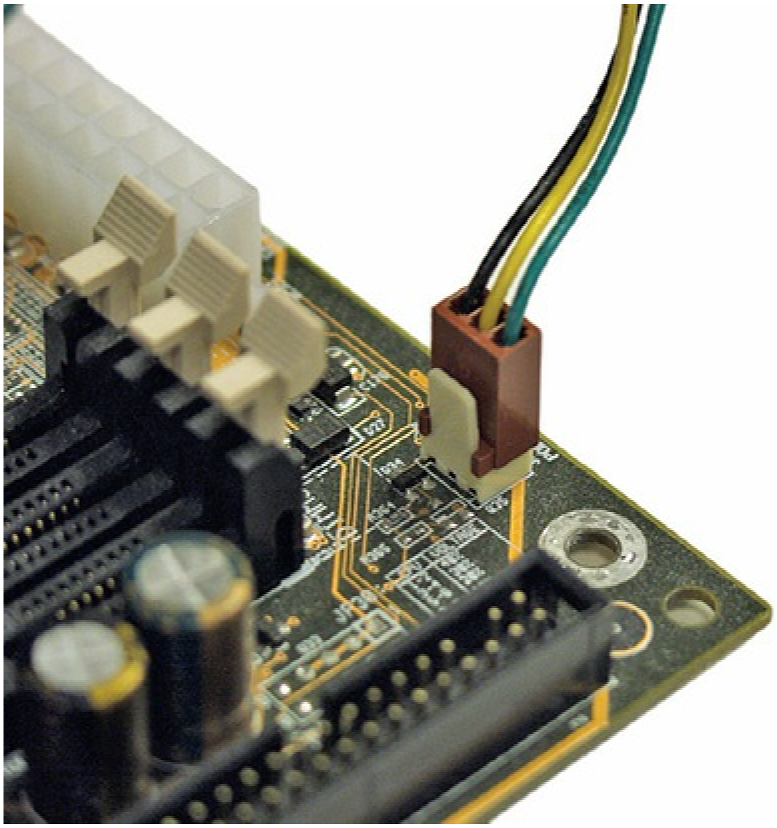


Figure 7-33 3-wire fan sensor connector

Case fans are large, square fans that snap into special brackets on the case or screw directly to the case, providing extra cooling for key components (see Figure 7-34). Most cases come with a case fan, and no modern computer should really be without one or two.

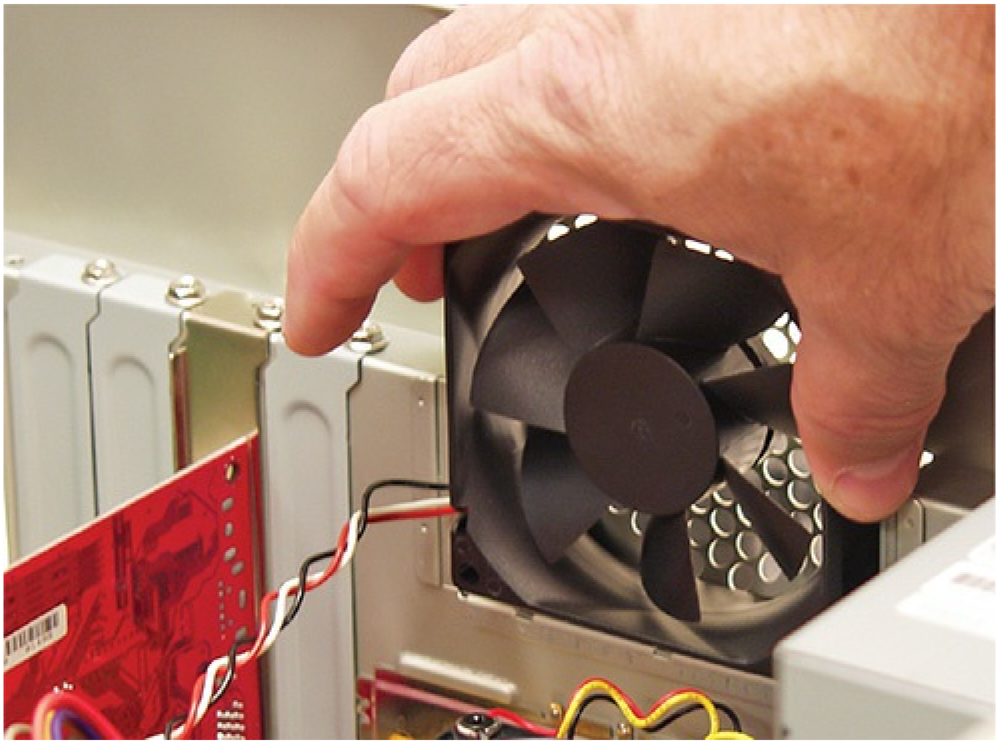


Figure 7-34 Case fan

The single biggest issue related to case fans is where to plug them in. Case fans may come with standard Molex connectors, which are easy to plug in, or they may come with special three-pronged power connectors that need to connect to the motherboard. You can get adapters to plug three-pronged connectors into Molex connectors or vice versa.

Maintaining Airflow

A computer is an enclosed system, and computer cases help the fans keep things cool: everything is inside a box. Although many tech types like to run their systems with the side panel of the case open for easy access to the components, in the end they are cheating themselves. Why? A closed case enables the fans to create airflow. This airflow substantially cools off interior components. When the side of the case is open, you ruin the airflow of the system, and you lose a lot of cooling efficiency.

An important point to remember when implementing good airflow inside your computer case is that hot air rises. Warm air always rises above cold air, and you can use this principle to your advantage in keeping your computer cool.

In the typical layout of case fans for a computer case, an intake fan is located near the bottom of the front bezel of the case. This fan draws cool air in from outside the case and blows it over the components inside the case. Near the top and rear of the case (usually near the power supply), you'll usually find an exhaust fan. This fan works the opposite of the intake fan: it takes the warm air from inside the case and sends it to the outside.

Another important part of maintaining proper airflow inside the case is ensuring that *slot covers* are covering all empty expansion bays (see Figure 7-35). To maintain good airflow inside your case, you shouldn't provide too many opportunities for air to escape. Slot covers not only assist in maintaining a steady airflow; they also help keep dust and smoke out of your case.

Figure 7-35 Slot covers

EXAM TIP Missing slot covers can cause the PC to overheat!

Reducing Fan Noise

Fans generate noise. In an effort to ensure proper cooling, many techs put several high-speed fans into a case, making the PC sound like a jet engine. You can reduce fan noise by using manually adjustable fans, larger fans, or specialty "quiet" fans. Many motherboards enable you to control fans through software.

Manually adjustable fans have a little knob you can turn to speed up or slow down the fan (see Figure 7-36). This kind of fan can reduce some of the noise, but you run the risk of slowing down the fan too much and thus letting the interior of the case heat up. A better solution is to get quieter fans.

Figure 7-36 Manual fan adjustment device

Larger fans that spin more slowly are another way to reduce noise while maintaining good airflow. Fans sizes are measured in millimeters (mm) or centimeters (cm). Traditionally, the industry used 80-mm power supply and cooling fans, but today you'll find 100-mm, 120-mm, and even larger fans in power supplies and cases.

Many companies manufacture and sell higher-end low-noise fans. The fans have better bearings than run-of-the-mill fans, so they cost a little more, but they're definitely worth it. They market these fans as "quiet" or "silencer" or other similar adjectives. If you run into a PC that sounds like a jet, try swapping out the case fans for a low-decibel fan from Cooler Master or

NZXT. Just check the decibel rating to decide which one to get. Lower, of course, is better. Also, note that the type of bearing makes a difference. Sleeve-bearing fans get a lot louder as they age; ball-bearing fans don’t. The price difference is minimal, so go with ball-bearing fans every time.

Because the temperature inside a PC changes depending on the load put on the PC, the best solution for noise reduction combines a good set of fans with temperature sensors to speed up or slow down the fans automatically. A PC at rest uses less than half of the power of a PC running a video-intensive computer game and therefore makes a lot less heat. Virtually all modern systems support three fans through three 3-pin fan connectors on the motherboard. The CPU fan uses one of these connectors, and the other two are for system fans or the power supply fan.

Most CMOS setup utilities provide a little control over fans plugged into the motherboard. Figure 7-37 shows typical CMOS settings for the fans. Note that you can’t use CMOS settings to tell the fans when to turn on or off—only to set off an alarm if they reach a certain temperature or fall below a certain speed.

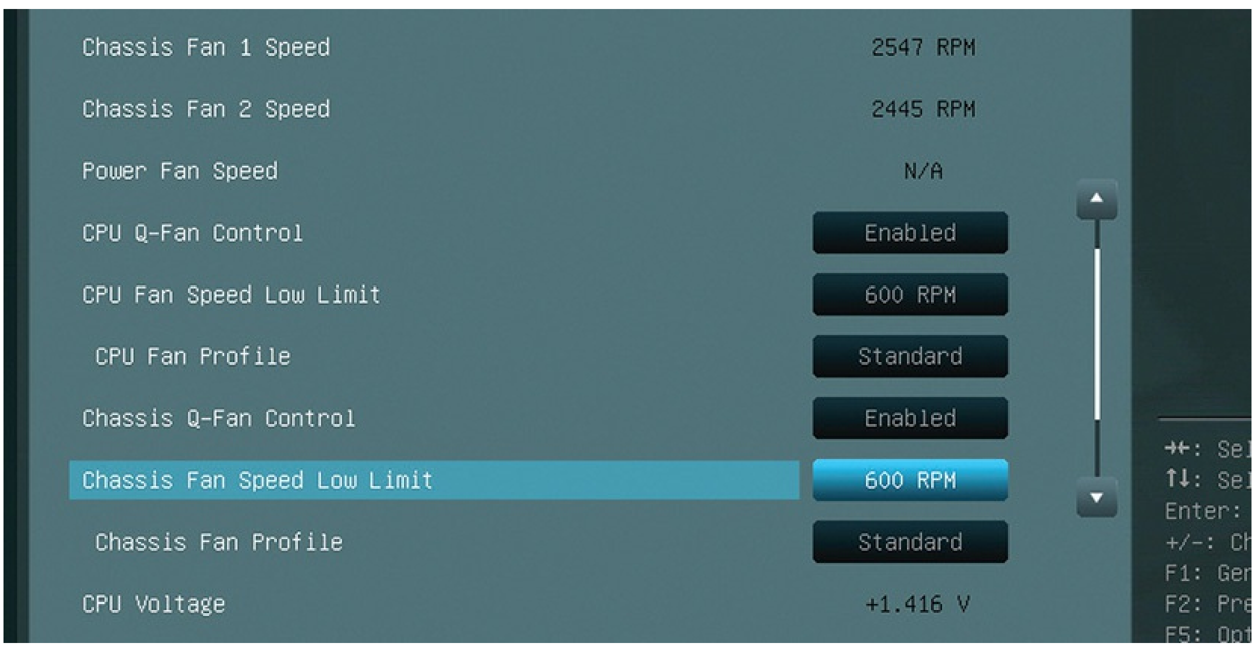


Figure 7-37 CMOS fan options

Software is the best way to control your fans. Some motherboards come with system-monitoring software that enables you to set the temperature at which you want the fans to turn on and off. If no program came with your motherboard, and the manufacturer's Web site doesn't offer one for download, try the freeware SpeedFan utility (see Figure 7-38). Written by Alfredo Milani Comparetti, SpeedFan monitors voltages, fan speeds, and temperatures in computers with hardware monitor chips. SpeedFan can even access S.M.A.R.T. information (see Chapter 8) for hard disks that support this feature and show hard disk temperatures, too. You can find SpeedFan at www.almico.com/speedfan.php.

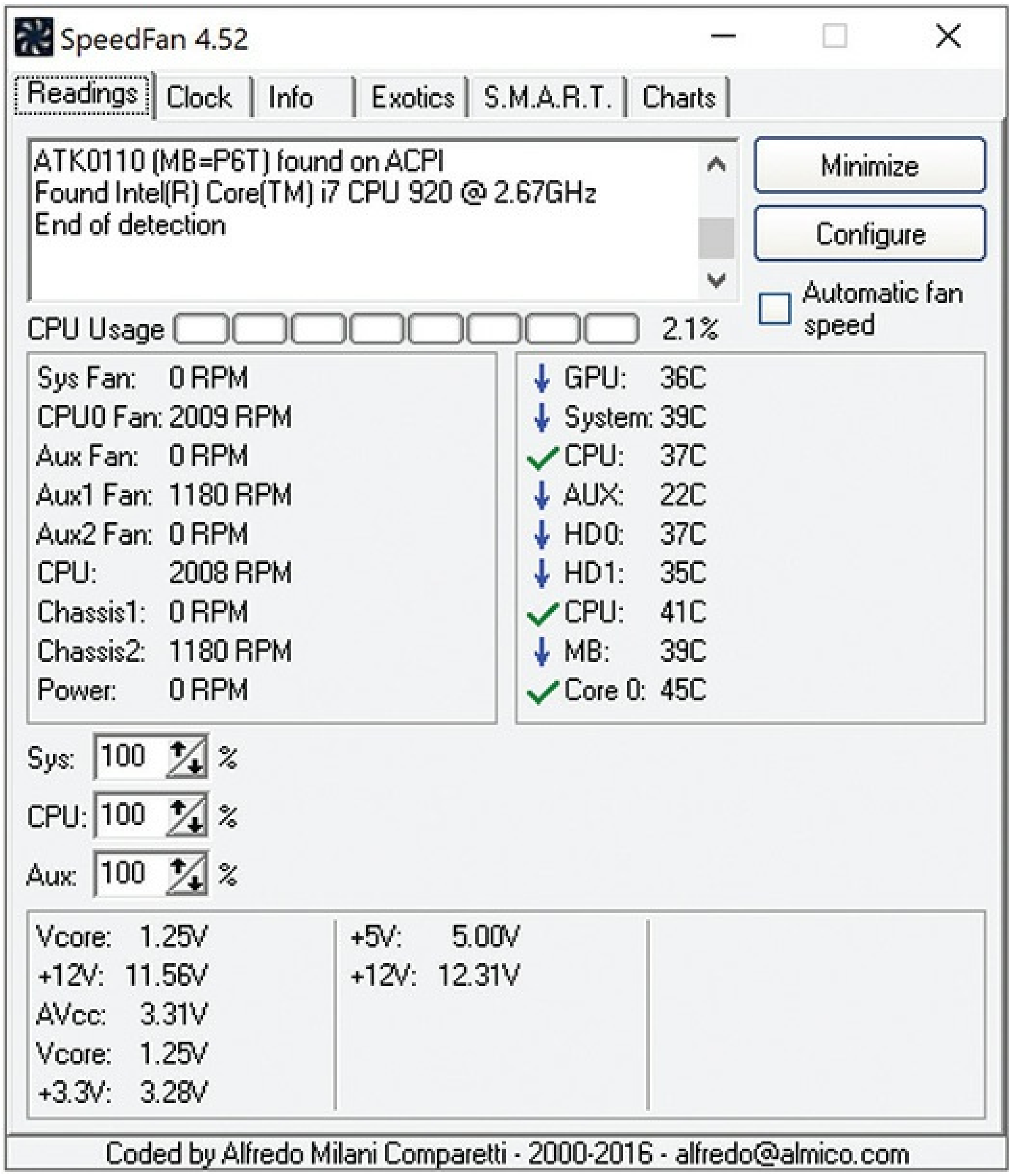


Figure 7-38 SpeedFan

NOTE When shopping for fans, remember your metric system: 80 mm = 8 cm; 120 mm = 12 cm; 200 mm = 20 cm. You'll find fans marketed both ways.

Even if you don't want to mess with your fans, always make a point to turn on your temperature alarms in CMOS. If the system gets too hot, an alarm will warn you. There's no way to know if a fan dies other than to have an alarm.

CAUTION SpeedFan is a powerful tool that does far more than work with fans. Don't tweak any settings you don't understand!

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. Avoid the embarrassment of trying to repair a power supply when the only problem is a bad outlet or an extension cord that is not plugged in. Assuming that the system has electricity, the best way to verify that a power supply is working or not working is to use a multimeter to check the voltages coming out of the power supply (see Figure 7-39).

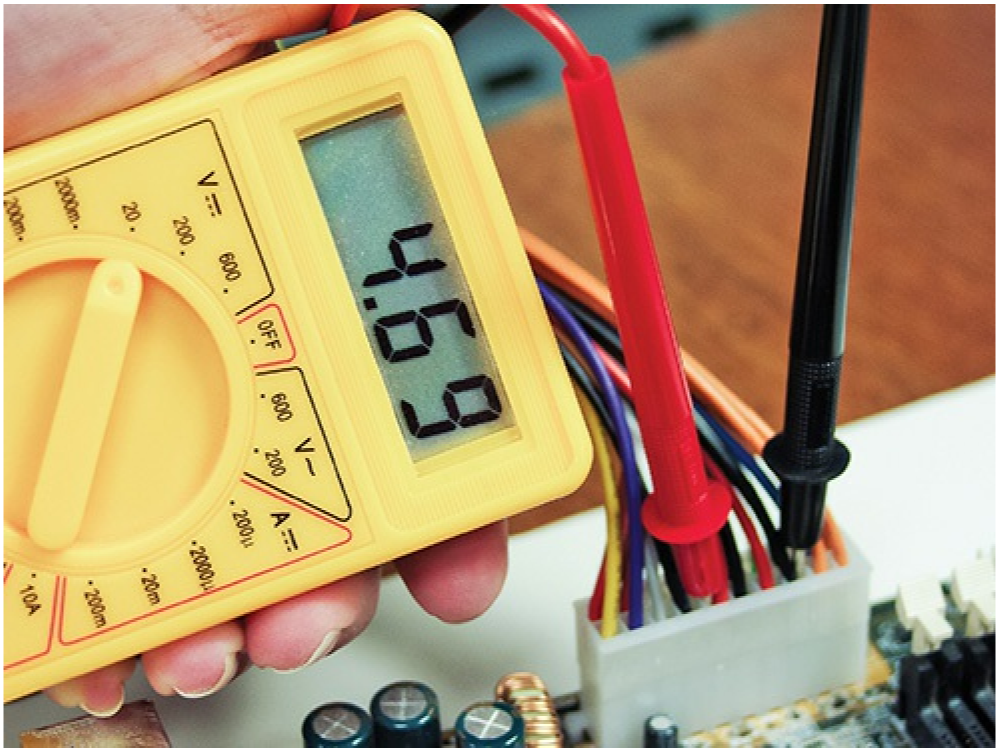


Figure 7-39 Testing one of the 5-V DC connections

Do not panic if your power supply puts out slightly more or less voltage than its nominal value. 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 12.0-V line can vary from roughly 10.8 to 13.2 V without exceeding the tolerance of the various systems in the PC. The 5.0- and 3.3-V lines offer similar tolerances.

Be sure to test every connection on the power supply—that means every connection on your main power as well as every Molex and mini. Because all voltages are between –20 and +20 VDC, simply set the multimeter to the 20-V DC setting for everything. If the power supply fails to provide power, dispose of it properly and get a new one—even if you're a component expert and a whiz with a soldering iron. Don't waste your time or your company's time; the price of new power supplies makes replacement the obvious way to go.

No Motherboard

Power supplies will not start unless they're connected to a motherboard, so what do you do if you don't have a motherboard you trust to test? First, try an ATX tester. Many companies make these devices. Look for one that supports both 20- and 24-pin motherboard connectors as well as all of the other connectors on your power supply. Figure 7-40 shows a power supply tester.

Figure 7-40 ATX power supply tester

NOTE Many CMOS utilities and software programs monitor voltage, saving you the hassle of using a multimeter. Of course, you have to have enough functionality to get into the CMOS utilities!

Switches

Broken power switches form an occasional source of problems for power supplies that fail to start. The power switch is behind the on/off button on every PC. It is usually secured to the front cover or inside front frame on your

PC, making it a rather challenging part to access. To test, try shorting the soft power jumpers as described earlier. A key or screwdriver will do the trick.

EXAM TIP Be sure you are familiar with power-testing tools such as multimeters and power supply testers.

When Power Supplies Die Slowly

If all power supplies died suddenly, this would be a much shorter chapter. Unfortunately, the majority of PC problems occur when power supplies die slowly over time. This means that one of the internal electronics of the power supply has begun to fail. The failures are *always* intermittent and tend to cause some of the most difficult to diagnose problems in PC repair. The secret to discovering that a power supply is dying lies in one word: intermittent. Whenever you experience intermittent problems, your first guess should be that the power supply is bad. Here are some other clues you may hear from users:

- “Whenever I start my computer in the morning, it starts to boot, and then locks up. If I press CTRL-ALT-DEL two or three times, it will boot up fine.”
- “Sometimes when I start my PC, I get an error code. If I reboot, it goes away. Sometimes I get different errors.”
- “My computer will run fine for an hour or so. Then it locks up, sometimes once or twice an hour.”
- “It takes a couple of tries—plugging and unplugging—with a new USB device before my system recognizes it.”

Sometimes something bad happens and sometimes it does not. That’s the clue for replacing the power supply. And don’t bother with the multimeter; the voltages will show up within tolerances, but only *once in a while* they will spike and sag (far more quickly than your multimeter can measure) and cause these intermittent errors. When in doubt, change the power supply.

Power supplies break in computers more often than any other part of the PC except components with moving parts. You might choose to keep extra power supplies on hand for swapping and testing.

Fuses and Fire

Inside every power supply resides a simple fuse. If your power supply simply pops and stops working, you might be tempted to go inside the power supply and check the fuse. This is not a good idea. First off, the capacitors in most power supplies carry high-voltage charges that can hurt a lot if you touch them. Second, fuses blow for a reason. If a power supply is malfunctioning inside, you want that fuse to blow because the alternative is much less desirable.

Failure to respect the power of electricity will eventually result in the most catastrophic of all situations: an electrical fire. Don’t think it can’t happen to you! Keep a fire extinguisher handy. Every computer workbench needs a fire extinguisher, but make sure you have the right one. The fire prevention industry has divided fire extinguishers into five fire classes:

- **Class A** Ordinary free-burning combustible, such as wood or paper
- **Class B** Flammable liquids, such as gasoline, solvents, or paint
- **Class C** Live electrical equipment
- **Class D** Combustible metals such as titanium or magnesium
- **Class K** Cooking oils, trans-fats, or fats

As you might expect, you should use only a Class C fire extinguisher on a burning computing device. All fire extinguishers are required to have their type labeled prominently on them. Many fire extinguishers are multiclass in that they can handle more than one type of fire. The most common fire extinguisher is type ABC—it works on all common types of fires, though it can leave residue on computing equipment.

EXAM TIP If your power supply is smoking or you smell something burning inside of it, stop using it now. Replace it with a new power supply.

Beyond A+

Power supplies provide essential services for the PC, creating DC out of AC and cooling the system, but that utilitarian role does not stop the power supply from being an enthusiast’s plaything. Plus, servers and high-end workstations have somewhat different needs than more typical systems, so naturally they need a boost in power. Let’s take a look Beyond A+ at these issues.

Modular Power Supplies

It’s getting more and more popular to make PCs look good on both the inside and the outside. Unused power cables dangling around inside PCs creates a not-so-pretty picture and can impede airflow. To help stylish people, manufacturers created power supplies with modular cables (see Figure 7-41).

Figure 7-41 Modular-cable power supply

Modular cables are pretty cool, because you add only the lines you need for your system. On the other hand, some techs claim that modular cables hurt efficiency because the modular connectors add resistance to the lines. You make the choice: Is a slight reduction in efficiency worth a clean look?

Temperature and Efficiency

Watch out for power supplies that list their operating temperature at 25º C—about room temperature. A power supply that provides 500 W at 25º C will supply substantially less in warmer temperatures, and the inside of your PC is usually 15º C (59º F) warmer than the outside air. Sadly, many power supply makers—even those who make good power supplies—fudge this fact.

Chapter Review

Questions

1. What is the proper voltage for a U.S. electrical outlet?
   - **A.** 120 V
   - **B.** 60 V
   - **C.** 0 V
   - **D.** –120 V
2. What voltages does an ATX12V P1 connector provide for the motherboard?
   - **A.** 3.3 V, 5 V
   - **B.** 3.3 V, 12 V
   - **C.** 5 V, 12 V
   - **D.** 3.3 V, 5 V, 12 V
3. What sort of power connector do better video cards require?
   - **A.** Molex
   - **B.** Mini
   - **C.** PCIe
   - **D.** SATA
4. Joachim ordered a new power supply but was surprised when it arrived because it had an extra 4-wire connector. What is that connector?
   - **A.** P2 connector for plugging in auxiliary components
   - **B.** P3 connector for plugging in case fans
   - **C.** P4 connector for plugging into modern motherboards
   - **D.** Aux connector for plugging into a secondary power supply
5. What should you keep in mind when testing DC connectors?
   - **A.** DC has polarity. The red lead should always touch the hot wire; the black lead should touch a ground wire.

B. DC has polarity. The red lead should always touch the ground wire; the black lead should always touch the hot wire.

C. DC has no polarity, so you can touch the red lead to either hot or ground.

D. DC has no polarity, so you can touch the black lead to either hot or neutral but not ground.

6. What voltages should the two hot wires on a Molex connector read?

A. Red = 3.3 V; Yellow = 5 V

B. Red = 5 V; Yellow = 12 V

C. Red = 12 V; Yellow = 5 V

D. Red = 5 V; Yellow = 3.3 V

7. Why is it a good idea to ensure that the slot covers on your computer case are all covered?

A. To maintain good airflow inside your case.

B. To help keep dust and smoke out of your case.

C. Both A and B are correct reasons.

D. Trick question! Leaving a slot uncovered doesn't hurt anything.

8. A PC's power supply provides DC power in what standard configuration?

A. Two primary voltage rails, 12 volts and 5 volts, and an auxiliary 3.3-volt connector

B. Three primary voltage rails, one each for 12-volt, 5-volt, and 3.3-volt connectors

C. One primary DC voltage rail for 12-volt, 5-volt, and 3.3-volt connectors

D. One voltage rail with a 12-volt connector for the motherboard, a second voltage rail with a 12-volt connector for the CPU, and a third voltage rail for the 5-volt and 3.3-volt connectors

9. What feature of ATX systems prevents a user from turning off a system before the operating system has been shut down?

A. Motherboard power connector

B. CMOS setup

C. Sleep mode

D. Soft power

10. How many pins does a SATA power connector have?

A. 6

B. 9

C. 12

D. 15

Answers

1. **A.** U.S. outlets run at 120 V.
2. **D.** An ATX12V power supply P1 connector provides 3.3, 5, and 12 volts to the motherboard.
3. **C.** Better video cards require one or two 6- or 8-pin PCIe connectors.
4. **C.** The P4 connector goes into the motherboard to support more power-hungry chips.
5. **A.** DC has polarity. The red lead should always touch the hot wire; the black lead should touch a ground wire.
6. **B.** A Molex connector's red wires should be at 5 volts; the yellow wire should be at 12 volts.
7. **C.** Both A and B are correct reasons. Keeping the slots covered helps keep a good airflow in your case and keeps the dust and smoke away from all those sensitive internal components.
8. **B.** The standard PC power supply configuration has three primary voltage rails, one each for 12-volt, 5-volt, and 3.3-volt connectors.
9. **D.** The soft power feature of ATX systems prevents a user from turning off a system before the operating system has been shut down.
10. **D.** SATA power connectors have 15 pins.