Power Supplies

After studying this chapter, you will be able to:

- ✔ Define electrical energy.
- ✔ Describe the terms *ampere, volt,* and *ohm* in relation to electrical energy.
- ✔ Explain the wattage rating of a power supply unit.
- ✔ Determine power supply requirements for a PC.
- ✔ Identify possible commercial power problems.
- ✔ Use a digital multimeter to troubleshoot a power supply.
- ✔ Apply wattage values when selecting the proper power supply and computer devices.
- ✔ Identify various power supply form factors.
- ✔ Explain the use of UPS and power protection devices.

A+ Exam—Key Points

There will be some basic questions about meters and reading resistance of wires and fuses. There will also likely be a basic question about wattage.

A+

Key Words and Terms

The following words and terms will become important pieces of your computer vocabulary. Be sure you can define them.

- Advanced Configuration and Power Interface (ACPI)
- Advanced Power Management (APM)
- alternating current (ac)
- amperes (A)
- backfeed
- continuity
- current
- cycle
- dedicated circuit
- direct current (dc)
- fuse
- metal oxide varistor (MOV)
- mini connector
- Molex connector
- power
- power good signal
- rails
- resistance
- soft power
- standby power connection
- uninterruptible power supply (UPS)
- voltage
- volt-amperes (VA)
- volts (V)
- watts (W)

This unit introduces you to the basic concepts of electrical energy. This chapter is not intended to turn you into an electronics technician. Rather, this chapter will familiarize you with the terminology and basic electrical concepts needed to ensure success as a computer technician and success on the A+ Certification exams.

You will learn how to use a multimeter to test voltage and resistance and to test the standard features of computer power supplies. The basis of this chapter is the discussion and illustration of the PC power supply unit. The power supply is easy to understand and simple to replace, but making a mistake connecting a power supply can damage the motherboard. This would be a very expensive mistake.

What Is Electrical Energy?

Electrical energy is best defined as the flow of electrons. Most people only know that electricity can be supplied from a wall outlet or from a battery. This is fine for what you need to achieve in this unit. In fact, these will likely be the only two areas of concern you will have when working with PCs.

The flow of electrons is described by terms that express electrical values such as voltage, current, resistance, and power. Each term will be explained on an individual basis and in relation to each other. The terminology may seem confusing at first, but it is fairly simple. Familiarity with these terms is essential for A+ certification.

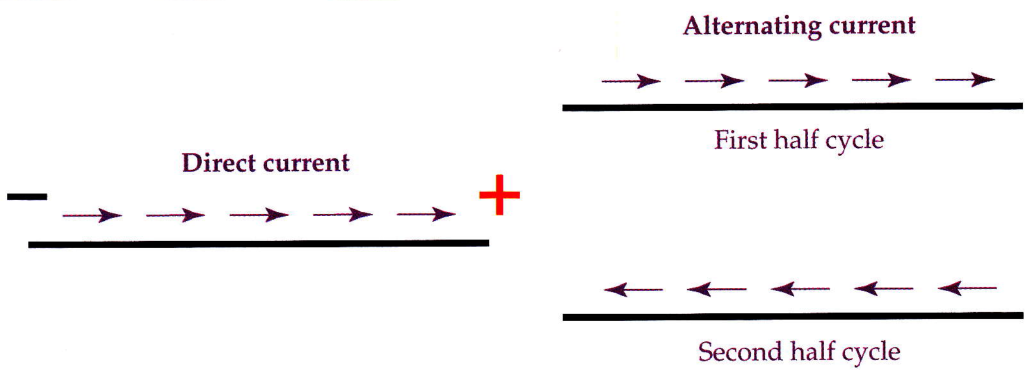


Figure 5-1. Illustrations of ac and dc flow.

AC and DC

Direct current (dc) electrical energy flows from negative to positive. A dc power source has two terminals: one positive and the other negative. The positive terminal is indicated by the color red and a plus (+) sign. The negative terminal is indicated by the color black and a minus (–) sign. DC electrical energy flows in a steady motion from negative to positive. Look at the left side of **Figure 5-1.**

direct current (dc) electrical current that flows in one direction.

Alternating current (ac) has no negative or positive markings because an alternating current system is in a state of constant change or alternating polarities. The current in an ac circuit flows in one direction and then in the opposite direction. Examine the right side of Figure 5-1. The completed sequence of flow, first in one direction and then in the other is called a ***cycle.*** Current flows in one direction during the first half cycle and then in the opposite direction the next half cycle. See **Figure 5-2** for an illustration of one ac cycle.

alternating current (ac) electrical current that reverses direction cyclically.

cycle the completed sequence of flow, first in one direction and then in the other.

This pattern is repeated as long as power is applied to the circuit. The frequency of how often the cycle is repeated is expressed in hertz (Hz) and is based on a time period of one second. Standard household electrical energy is 60 Hz. This means that the direction of the current changes at a rate of 60 times per second, or 60 Hz. See **Figure 5-3.**

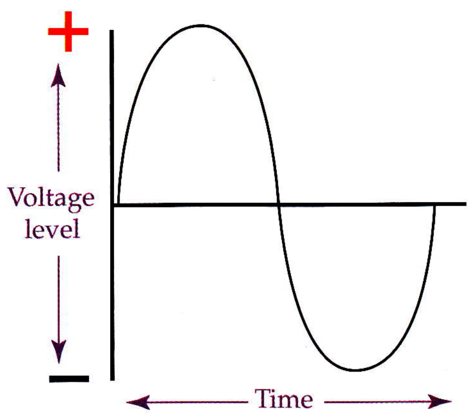
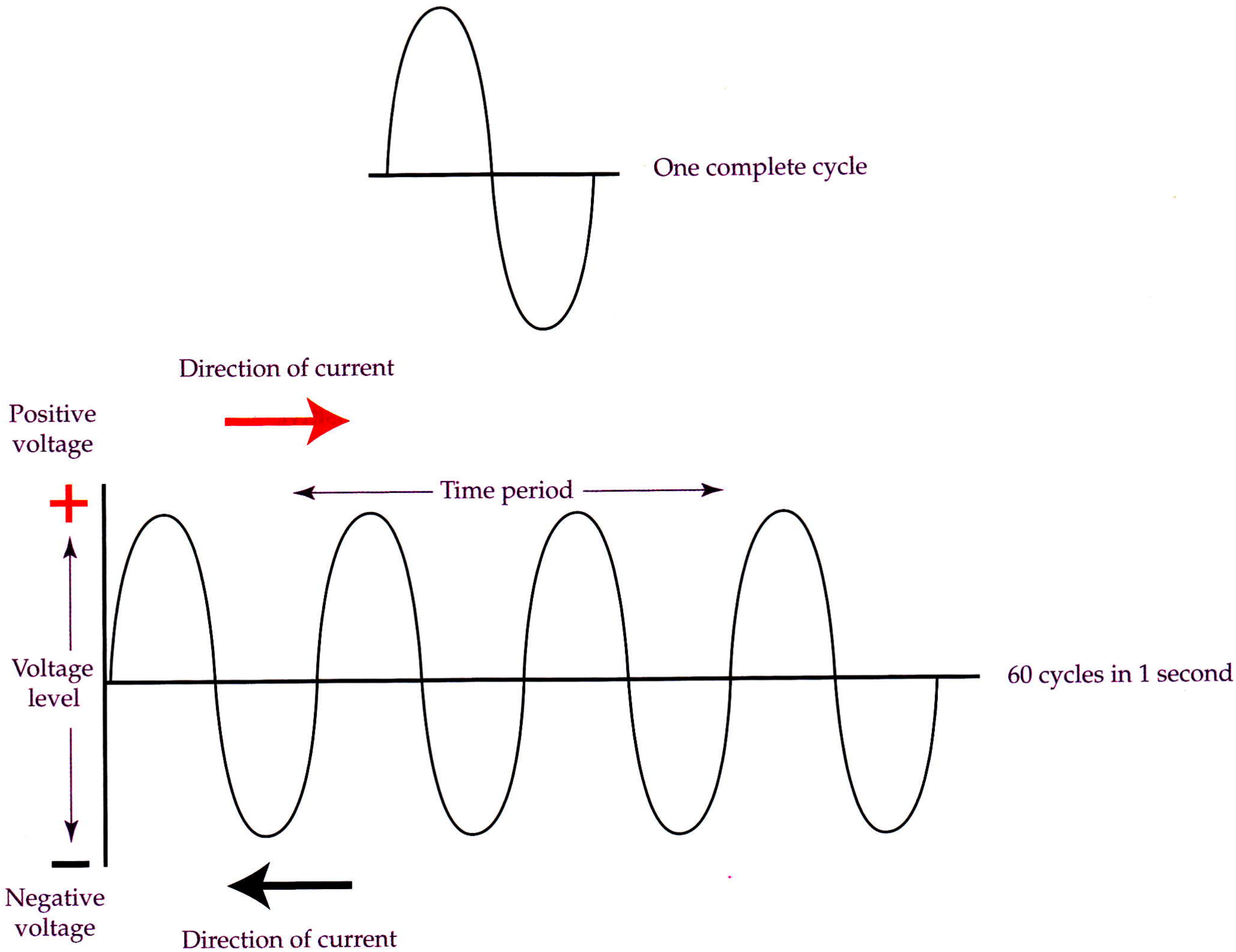


Figure 5-2. An ac voltage is commonly plotted as a graph with the voltage level plotted along the vertical axis and the time plotted along the horizontal axis.

Figure 5-3.
A complete ac cycle is illustrated with a series of ac cycles. The cycle pattern represents the rise and fall of a voltage level. This pattern repeats 60 times in one second (60 Hz) for standard household electrical energy.



Voltage and Current

Voltage and current are two measures of electrical power that are tested by technicians in the diagnosis of problems related to the PC. Measurements are usually taken with a universal multimeter. The multimeter and its operation are covered later in this chapter.

Voltage and current are directly related to each other when measuring electrical quantities. ***Voltage,*** measured in ***volts (V),*** is the amount of electrical pressure present in a circuit or power source. ***Current,*** measured in ***amperes (A),*** is the amount of electron flow. Do not mistake the ampere measurement of electrical energy as speed. It is the measure of volume of electrical energy flowing through the system.

Electrical energy can be compared to water in a pipe. Water flow is measured in gallons per minute (GPM) as well as pounds per square inch (PSI). GPM is the rate of flow or volume of water while PSI is the amount of pressure used to

voltage
the amount of electrical pressure present in a circuit or power source.

volts (V)
a scale used in measuring electrical pressure (electromotive force).

current
the electron flow in a circuit.

amperes (A)
a scale used in measuring the volume of electron flow in a circuit.

produce the flow. Electrical energy is similar. The voltage of the electrical source produces the force for moving the amount of electrical energy, or current, flowing through the wires and devices. The letter *V* represents voltage and the letter *A* or the abbreviation *amp* usually represents amperes.

Resistance

Resistance is the opposition to the flow of electrical energy. The unit of resistance is the ohm and is expressed with the letter symbol *R* or the symbol omega (Ω).

resistance
the opposition to the flow of electrical energy.

Electrical components that manipulate the voltage and current levels in a circuit have measurable resistance values that can be expressed in ohms. Computer technicians very seldom, if ever, are required to take accurate resistance readings. The resistance readings taken by PC technicians are usually to check for electrical continuity. ***Continuity*** is the ability of a device or component to allow an unobstructed flow of electrical energy. Examine **Figure 5-4.**

continuity
a state of connectedness. In electronics, an unbroken circuit is said to have continuity.

In the illustration, there are two electrical wires. These wires are referred to as *conductors* when using electrical terminology. A complete conductor, one that has no breaks, will have a resistance reading of zero. There is no significant resistance to be measured. When a conductor has a break in its path, referred to as an *open,* there is an immeasurable amount of resistance. This extreme condition of high resistance is referred to as *infinity.* As the term *infinity* implies, the reading is so high it is beyond the capability of the multimeter to read it. It is imperative that you learn these two readings, what they mean, and the conditions that cause them. This is the key to using the ohmmeter function to troubleshoot certain PC items.

Now let's look at a switch and a fuse. A ***fuse*** is constructed of two metallic end pieces with a thin strand of wire stretched between them. The wire is engineered to burn open at a predetermined ampere value. The fuse is covered in either a tube of clear glass or opaque ceramic material.

fuse
an inexpensive, passive component that is engineered to burn open at a predetermined amperage, protecting the rest of the circuit from overload.

To check a fuse with a multimeter, the meter function should be set to measure resistance. Place the meter probes across the fuse, one probe on each end of the fuse. The reading should be zero for a good fuse and infinity for a bad fuse. A bad fuse is when the small wire inside the fuse is burnt to an open condition. The path for the electricity no longer exists, **Figure 5-5.**

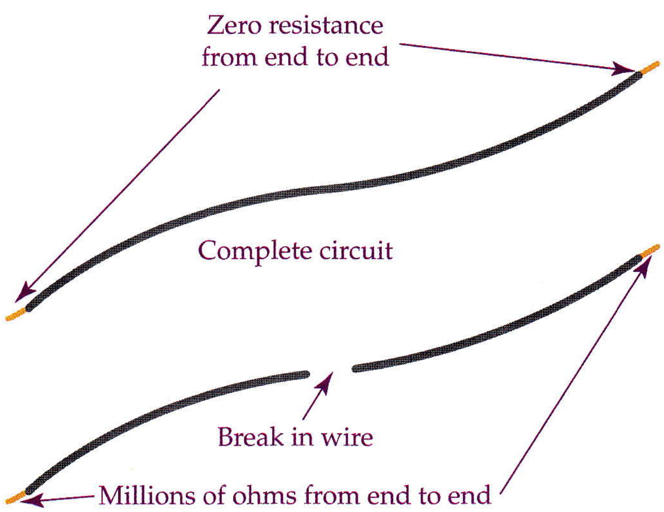


Figure 5-4. Drawing of two wires, one complete and the other open. A complete circuit has (almost) no resistance. An open circuit (like a broken wire) has a very high or infinite resistance.

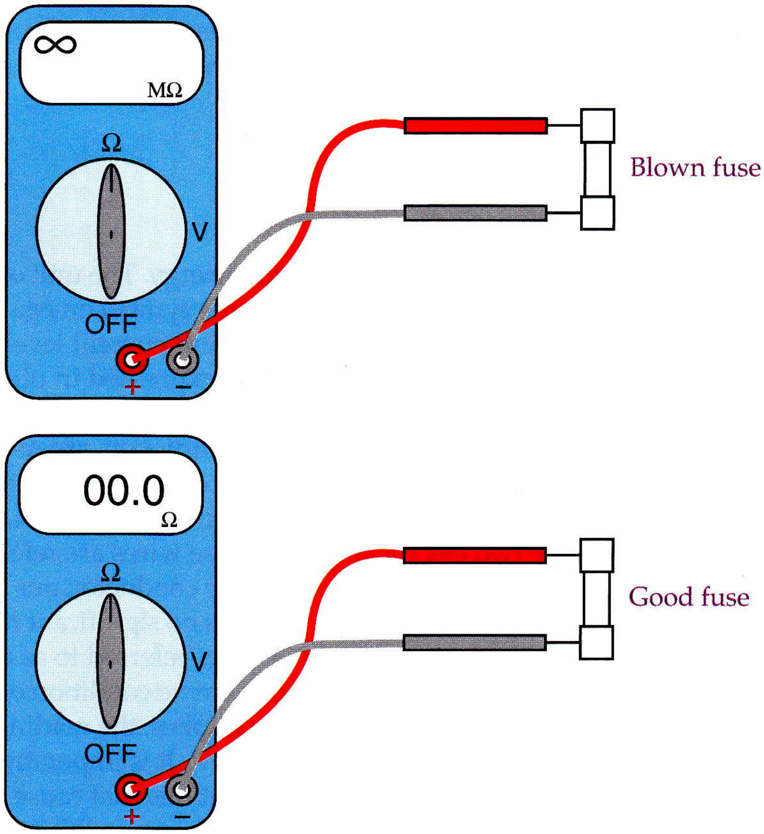


Figure 5-5.
A blown fuse will have a resistance reading too high to be displayed, even in the megaohm range. A good fuse will display zero resistance.

Warning

Be sure the electrical power supplying the fuse is turned off.

Testing switches is very similar to testing fuses. An open switch will show an infinite resistance. A closed switch should show zero ohms of resistance, **Figure 5-6.** As with testing a fuse, *make sure the electrical power to the switch is disconnected.*

Backfeed

Resistance values can fool an untrained electronics technician. There is a situation when a resistance reading taken on a circuit component such as a switch will give false information. An open switch can, in fact, have what appears as a resistance value other than infinity. The meter may be reading through the electronic components mounted in the system and indicate a value anywhere between zero and infinity.

backfeed
a type of ohmmeter reading in which the resistance is measured through the circuit components even though the circuit is open.

Look at the drawing in **Figure 5-7.** In the illustration, the ohmmeter is reading through the circuit components even after the switch is opened. This is referred to as ***backfeed*** and is a very common condition. To avoid backfeed situations, the component to be read should be removed from the circuit whenever possible. This is not always practical. At times, it is more appropriate to take voltage readings to indicate the condition of fuses, breakers, and switches.

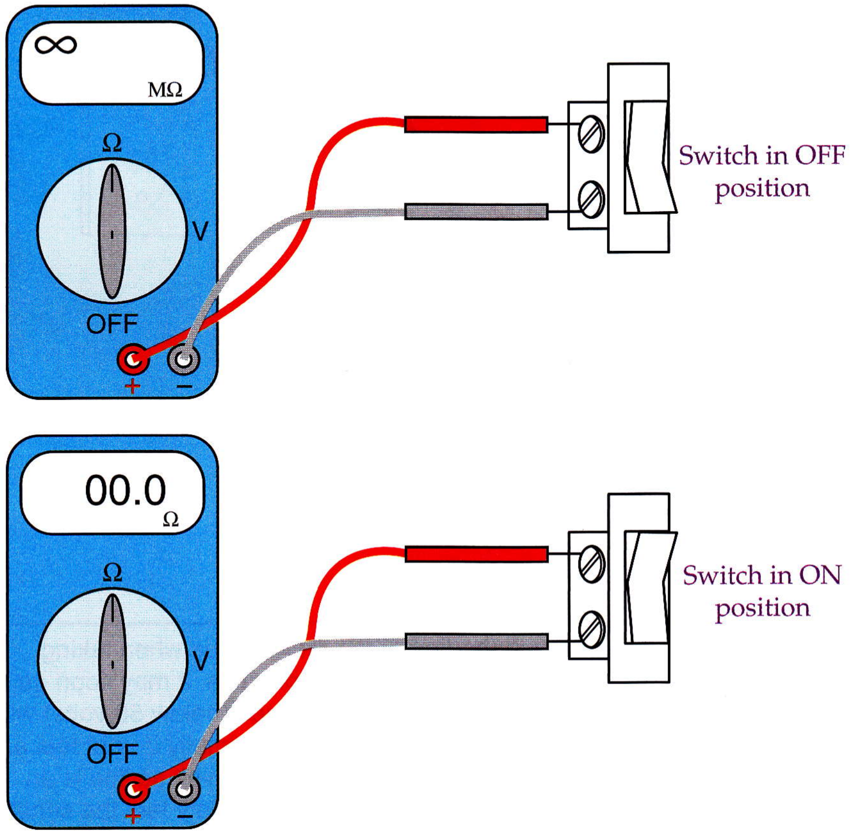


Figure 5-6.
A closed switch has zero resistance while an open switch shows infinite resistance.

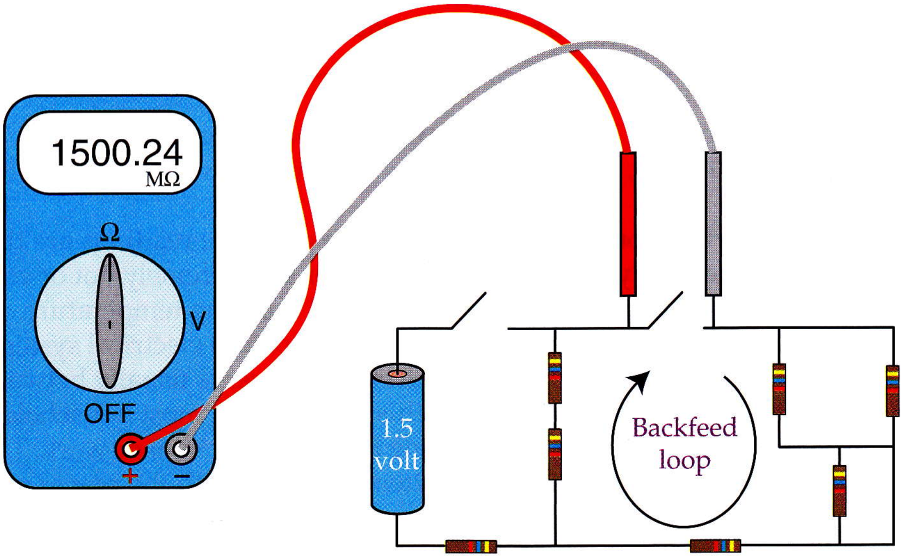


Figure 5-7.
Reading resistance across an open switch can give you a false resistance reading. The ohmmeter reads the resistance through the rest of the circuit instead of the resistance across the open switch.

Checking Power Outlets

Checking a power outlet is a very common task. See **Figure 5-8.** The meter probes are simply inserted into a wall outlet to check for electrical power. There is no polarity when reading ac voltage sources, so the polarity markings on the meter need not be observed.

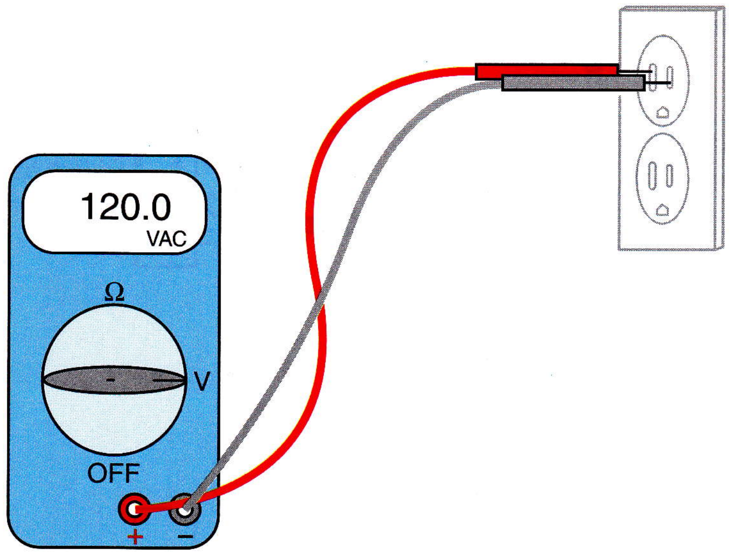


Figure 5-8. Meter connected to a wall outlet. Polarity need not be observed. Be careful when making this test. Keep your fingers away from the exposed probe tips.

Warning !

Never touch the tips of the meter leads when taking readings. Once you start this practice, it may soon develop into a very bad habit. Low voltages (below 50 volts) will not normally harm you, and you normally do not feel any electrical sensation. Touching a 120-volt ac line is an entirely different story. You will definitely feel the sensation of electrical energy. It is possible to incur a permanent injury or even death. Safety is a habit. Develop safe habits when reading low voltages and you will automatically use the same habits when reading a much higher voltage.

A good voltage reading is considered to be plus or minus 10% of the 120-volt rating. In actuality, the voltage can drop or rise considerably more before affecting a PC.

Two other important considerations when taking voltage readings are the weather and the time of day. Low voltage is common on extremely hot or cold days when electrical heat or air conditioning control building temperature. Heating and air conditioning call for a large demand on the electrical system inside a building. The highest demand for electrical power is usually between the hours of 4:00 PM and 6:00 PM. During this time period, most households are actively using power because of those coming home from school or work. The demand for heat or cooling increases and often combines with the power needed for the preparation of the evening meal. During the same time period, many businesses are still operating. This is the time period that most brownouts occur.

Tech Tip:

When checking for low voltage, it is best to have the air conditioning or heating system operating at maximum so that you can see the system under maximum strain. This is especially important when checking an intermittent problem and a low voltage condition is suspect.

Clean Electrical Power

Clean power is a term that means the commercial electrical supply is steady, at the correct voltage level, and does not contain voltage spikes. Clean power can be difficult to obtain without additional equipment being added to the supply system. High voltage power line switching, lightning, cars hitting electric poles, or routine line maintenance can cause voltage spikes. When a spike occurs, an abnormally high level of voltage is sent through the electrical system. See **Figure 5-9** for an illustration of line spike in relation to normal ac voltage pattern.

Line voltage spikes can be reduced or eliminated by the use of line conditioning equipment. A common method of ensuring a constant clean power supply is the use of uninterruptible power supplies (UPS). The UPS system will be discussed later in this chapter.

Power

The amount of electrical energy provided or used by equipment is ***power,*** and it is measured in ***watts (W).*** Wattage is the product of voltage and current. In other words, to determine the amount of power expressed in watts that a dc circuit is using, the electrical pressure measured in volts is multiplied by the electrical current measured in amps.

Watts = Volts × Amps

A computer drawing 3 amps when connected to a 120-volt source would consume *approximately* 360 watts of electrical energy. Notice that the term *approximately* is used here. When calculating wattage values associated with ac power, there are other electrical factors, such as induction, to be taken into account. The power value of an ac circuit is expressed as ***volt-amperes (VA).***

A power supply's output capacity is rated in watts and in VA. Watts and VA are not the same expression. Wattage is considered the "true" power rating of a device. It is measured with a very expensive wattmeter or calculated with a more exact formula. VA is considered the "apparent" power. It is called the apparent power because the voltage and ampere values derived from a multimeter are not true values. These values are distorted from electrical factors in the circuit, such as induction. Look at **Figure 5-10.** Total load is calculated from a group

power
the amount of electrical energy provided or used by equipment.

watts (W)
a scale used in measuring electrical power.

volt-amperes (VA)
an alternative scale for measuring electrical power.

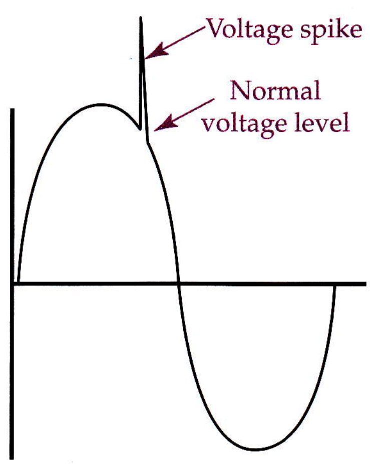


Figure 5-9.
A voltage line spike can be caused by many things (motors, switches, lightning). The increased voltage in the spike damages electronic components by exceeding the voltage limitation of the component.

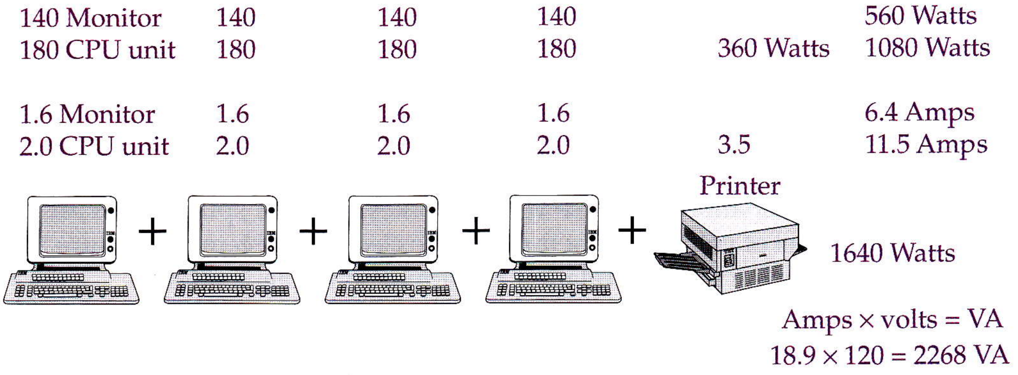


Figure 5-10. The total wattage rating can be quite a bit different than the calculated wattage rating based on the formula of volts × amps. It is not unusual for the calculated wattage using volts and amps to be larger than the wattage totals.

of computers and a printer, which are rated by current, amperes, and wattage. Notice that the calculated power rating derived from the formula V × A is higher than the total power rating derived from adding the individual watt values. The power rating derived from adding the individual watt values is the true power rating. This is a very brief explanation of a very complicated topic. The electronic theory involved for a complete understanding of electronic system loads is beyond the scope of this text. If you have a real desire to know more about electronics, an introductory level course in basic dc and ac circuits is recommended.

When sizing the load capacity of a computer configuration, there are two choices. All the watt values can be added together to arrive at the total load in watts, or all the ampere loads can be added together and then compared to the amperage rating of the power supply.

Wattage measurements are used in two primary ways: power consumption and power supplied. The amount of power consumed by devices such as monitors or hard drives is expressed in watts. When wattage is written on a device that uses or consumes electrical power, the watts label is used to express the amount of power used or consumed by that device. When watts is used as a label on a device that supplies electrical energy such as a generator or power supply, it represents the amount of power that can be provided safely from that unit. Power supplies and generators can actually supply more power than they are rated for. However, when excess amounts of power are taken from a power supply, excessive heating occurs. This can permanently damage the power supply.

When changing power supplies, a power supply with equal or greater wattage marked on the label must be used. A power supply with less wattage capability may work for a while, but it will surely burn up after a period of time.

To determine how much equipment can be connected to a power strip, the wattage ratings of each piece of equipment should be added together. A typical power strip should not connect to a total of over 1600 watts of equipment. Also, *never* daisy chain (string in series) power strips, **Figure 5-11.** When daisy chained together, the first strip carries the total load of both strips.

Another consideration when using extension cords is wire size. A cord with less than number 16-gauge wire should not be used. Wire smaller than 16 gauge can pose a fire hazard. Wire gauge is used to indicate the size of wire and also how much current it can safely handle without excessive heat. Remember, the larger the number, the smaller the wire. **Figure 5-12** shows a wire size chart with current ratings.

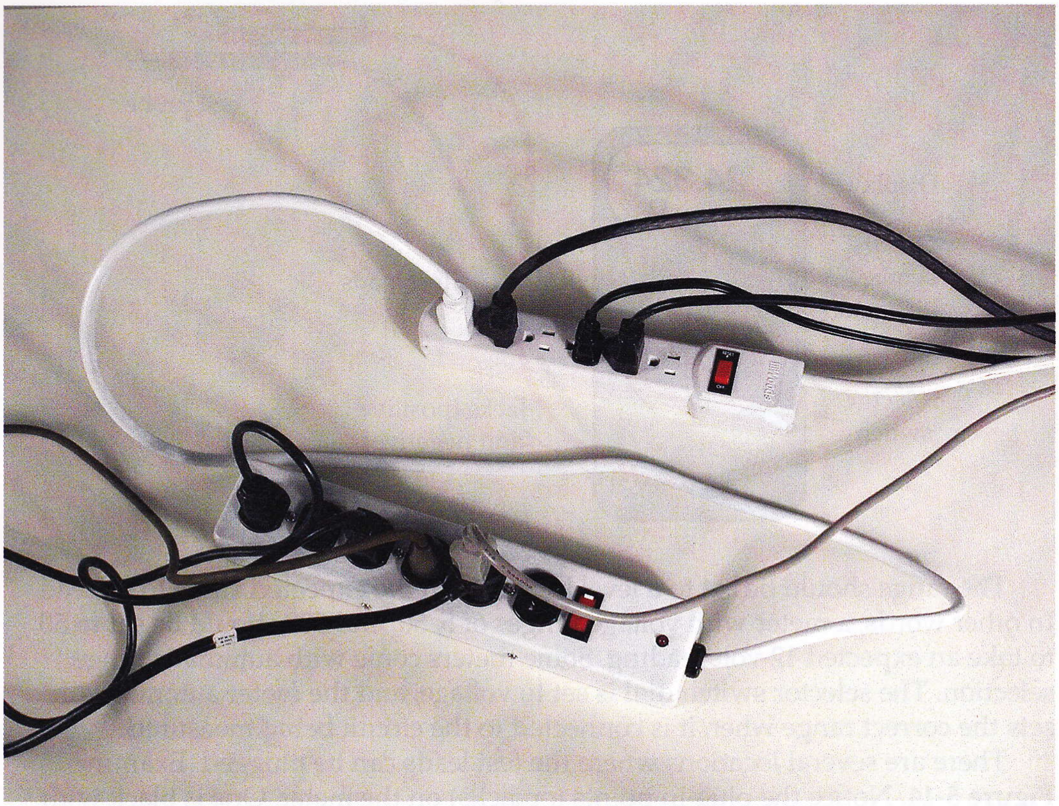


Figure 5-11. Daisy chaining power strips is very unwise.

Wire Size	Ampere Rating
12	20
14	15
16	7
18	5

Figure 5-12. Wire size chart with current ratings. Note that this chart reflects current carrying capacities of typical conductors. It does not take into consideration the type of insulation or the application, which can change the current rating for the listed conductors.

Parts of a Digital Multimeter

A digital multimeter is used to measure current, resistance, and voltage values. As the name implies, the meter is constructed from digital circuits, and it is used in place of multiple meters. The multimeter replaces the use of individual volt, ohm, and amp meters. It is an all-in-one type of meter. Look at **Figure 5-13.** Shown is a typical digital multimeter with major parts labeled.

The display area displays a numeric value of the electrical quality being measured such as voltage, current, or resistance. The numeric display expresses the value with a decimal point when appropriate. The numeric value displayed in the meter window is coordinated with the range dial setting and with the location of where the meter leads are plugged.

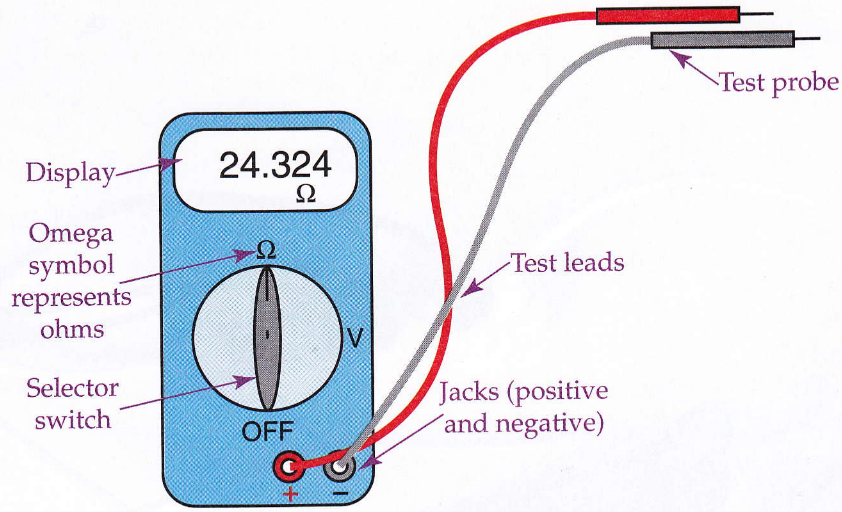


Figure 5-13. A typical auto-range meter is very simple in design. You simply select the function you wish (volts or resistance), and then touch the parts with the probe tips.

The range should be set to a level higher than the expected value to be read. In other words, a meter with voltage ranges of 5, 50, and 500 should be set to 50 to take an expected 12-volt reading. Some meters come with automatic range selection. The selector switch dial is set to voltage, and the meter automatically sets the correct range when it is connected to the circuit being measured.

There are several locations where the test leads can be plugged. Examine **Figure 5-14.** Notice the plug-in points (or jacks) on the meter. One is black with a negative (–) symbol beside it and the other is red with a plus (+) sign beside it. These identify the appropriate polarity position of the electrical input. The

Figure 5-14. Meters come with multiple jacks for the test probes. Be sure to place the test probes in the proper jacks. (Fluke Corp. Reproduced with permission.)

test leads correspond in the colors red and black, which represent positive and negative power respectively. Also, take special note of the ac marking on some of the meter jacks. Be sure the test leads are plugged into the appropriate jacks when taking current readings.

Probes

The meter is equipped with two test leads with probes at the end of each. The probes are for touching test points. One test lead is black and the other is red. This color combination is universal. The black lead is for the negative side of a reading. It plugs into the meter at the jack that is marked in black, has a negative sign, or both. The red lead plugs into the jack with the red marking or the plus sign for voltage and resistance readings. For current readings, there is usually a different position in which to be plugged. As a PC technician, you typically never need to take a current reading. Current readings are much more complicated and require knowledge of electronic components to correctly connect the meter. Voltage readings and occasionally resistance readings are required.

Never touch the probes with your fingertips when taking readings even when the voltage is low. Make electrical safety a habit. Forming safe habits is essential. If you touch the bare tip of the probe during routine checks of low voltage where there is not sufficient voltage to harm you, you may create a bad habit. This can lead to touching the tips when reading dangerously high voltages.

Display Area

The display area is where the measured value is displayed. For example, when reading voltage, the display will give a numeric value of the voltage and possibly indicate if it is an ac or dc voltage value. It may also indicate if you are out of the correct range selection value.

Range Selection

The range selector is used to choose the appropriate value to be read: voltage, current, or resistance. The dial indicator should be placed in the lowest range that is greater than the value to be read. If it is placed higher than the next highest value, an accurate reading will not be obtained. The reading will be a rounded-off value, rather than an accurate reading. If you go below the desired level, you will probably not get a reading at all. In fact, a warning will appear in the display area of most good meters.

Some meters are equipped with an auto-range feature. It will automatically select the correct range for the reading you are taking. I highly recommend this type of meter for anyone not familiar with basic electronics.

Procedures for Reading Voltage

Before taking any readings, you should have some idea of the level of voltage you expect to read. For example, a common wall outlet is 120 volts ac. A power supply unit might be 12, 5, or 3.3 volts dc depending on the exact power supply connection.

Warning

Never wear an anti-static or ground strap while taking meter readings. The ground strap makes you an excellent conductor of electricity, which is a dangerous situation when taking meter readings.

To read ac or dc voltages:

1. Insert the meter leads into the appropriate jacks on the face of the meter. The red lead is inserted into the jack marked with the letter "V" or a "+" symbol. (Generally, you will never use the jacks marked with an "A" or a "mA" as they are used for current readings.)
2. Insert the black lead into the jack marked "COM" or with the "–" symbol. The common is usually black and the input voltage jack is usually red.
3. Turn the selector switch to voltage AC. On some meters this can require the use of two separate switches. One switch selects ac or dc voltage and the other switch selects the voltage range. If you do not have an auto-range meter, set the range selector to the next highest voltage level over what you expect to read. (This is where an auto-range meter is handy.)
4. Touch the test locations with the probes. Keep your fingers away from the tips of the probes.
5. Read the display and record the voltage. It should be within 10% of the expected voltage level.

Procedures for Reading Resistance

To read resistance:

1. Insert the meter leads into the appropriate jacks on the face of the meter. The red lead is inserted into the jack marked with the letter "V" or a "+" symbol.
2. Insert the black lead into the jack marked with "COM" or with a "–" symbol. The common is usually black.
3. Be absolutely sure the power is OFF before attempting to read resistance.

Warning

Electrical voltage can damage a meter if the meter is set up to read resistance.

4. Set the selector switch to the *highest* value of resistance.
5. Touch the test probes together to see if the meter is working properly. The reading should be zero. If not, the battery inside the unit could be weak. The ohmmeter portion of a multimeter depends on battery power to take a resistance reading.
6. Touch the probes to the part (fuse or cable) to be tested.
7. When doing a resistance check on a fuse or a cable, you should read either zero resistance or infinity. A good fuse will cause a reading of zero resistance as will a good cable. A bad fuse will cause a reading of infinity as will a cable that is not complete from end to end.

Checking Fuses, Cables, and Switches

When checking fuses, cables, and switches there are only two resistance values that are typically displayed on a digital meter display: zero ohms and infinity. A typical low ampere value fuse found in electronic equipment is simple in construction. The fuse is a cylinder shape of glass or ceramic with a metal cap on each end. Inside the cylinder is the fuse link. The fuse link is a thin metal wire that burns and splits into two parts at a predetermined ampere value.

The easiest way to tell if the fuse is good (or not) is to remove it from the fuse holder and take a resistance reading across the fuse. Since the fuse is made of a small metal wire, it will have very low resistance. When tested with the ohmmeter, the meter will indicate zero resistance. If the fuse is burned open, it will have a resistance value too high to read. You would be trying to read through the air or space inside the tube. This reading is known as infinity. This means the resistance reading is beyond the capabilities of the meter range.

The same principle applies to a cable and switches. Before reading a switch or cable with an ohmmeter, they must be removed from the PC. A cable should read zero resistance from one end to the other. A cable with a broken wire will read infinity. See **Figure 5-15** for an illustration of a cable with a meter attached, illustrating both a good reading and a bad cable reading.

A switch can be difficult to remove from the circuit and the type of switch present must be identified. Some switches used today are capacitor-type switches. These switches cannot be adequately diagnosed with an ohmmeter. Capacitor switches are usually very small in comparison to the physical size of mechanical

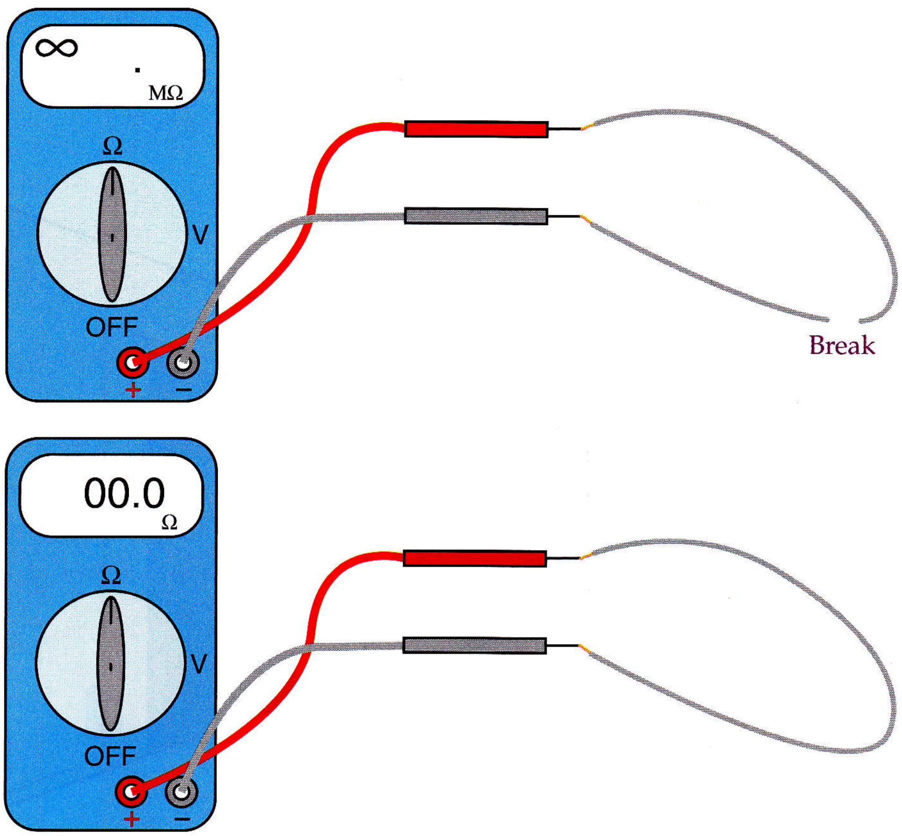


Figure 5-15. A good conductor will read zero resistance. A conductor with a break (or open) will read infinity, the highest possible resistance reading.

switches. If a switch is suspected as the problem, it may be best to simply replace the switch with a known good switch rather than attempting to diagnose it with a meter.

Branch Circuits

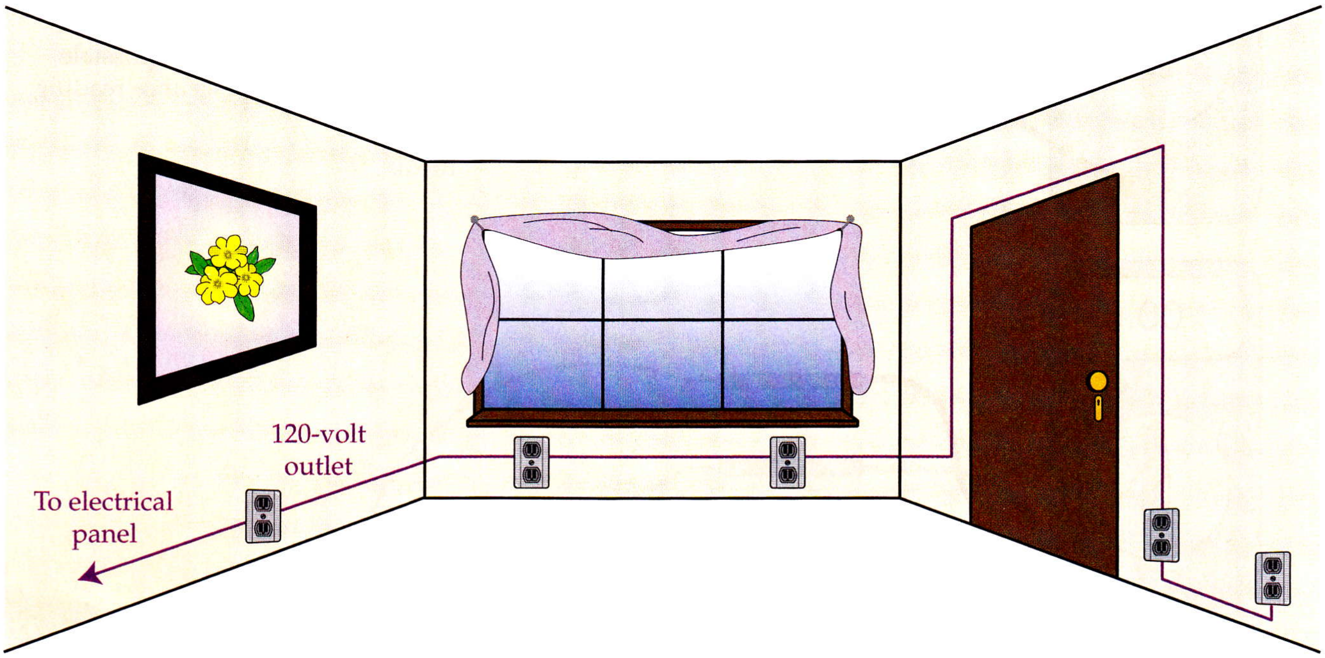
Many computer problems can be generated by the electrical system inside the residential home or small business. A typical electrical panel distributes electricity to electrical circuits throughout a home. The electrical power in home settings and some businesses all tie back to the same electrical panel. Electrical equipment running anywhere in that environment can cause a power problem for the computer system.

For example, the operation of a vacuum cleaner or a power tool can generate voltage spikes that can disrupt the computer process. The computer can be damaged, develop a glitch, or simply lock up. It is imperative that a surge protector of some sort be installed at the computer location. See **Figure 5-16** for a drawing of a typical home distribution system.

A branch circuit is the technical name for the wiring from an electrical panel to the final outlet on that circuit. A typical commercial installation uses two electrical distribution panels: one panel for lighting and the other panel for distributing power to equipment. **Figure 5-17** is an illustration showing side-by-side panels. One panel is for lighting and the other is for power.

Computers are located in every type of business location from small travel agency offices to heavy manufacturing operations. It is important to know the type of equipment that a company operates from the same electrical distribution panel that serves the computer station.

Figure 5-16.
Typical home distribution.



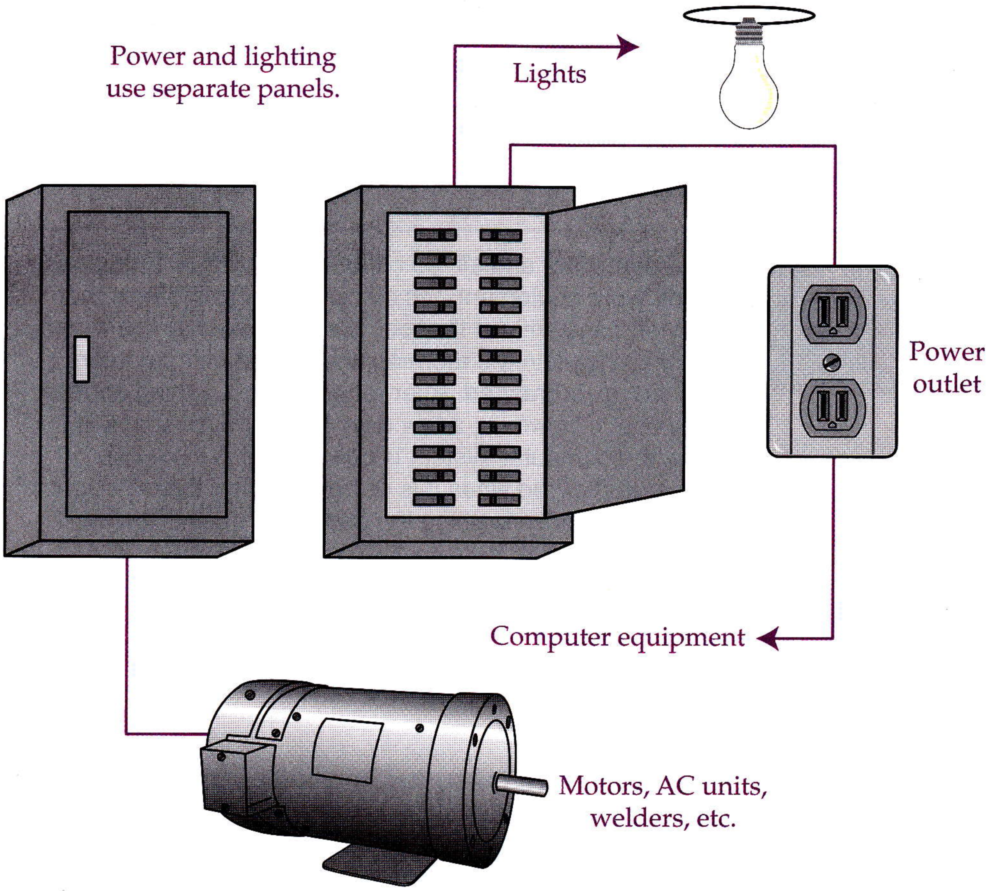


Figure 5-17. Heavy machinery should have its own electrical panel. It should not be on the same panel as computer equipment.

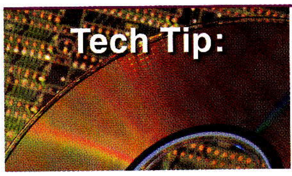
The type of electrical distribution and the equipment connected to that electrical system is of major concern to reliable computer operation. An office location in the form of a large industrial building can be misleading to a technician. While the immediate environment may look like a typical office setting, the same electrical circuits in the office environment can be serving heavy printing press equipment directly behind the office wall. A surge protector power strip may not be adequate in this type of location. A more reliable approach to ensure dependable operation of this computer system would be the installation of a quality uninterruptible power source (UPS) system. UPS systems are covered later in this chapter.

Dedicated Circuit

A ***dedicated circuit*** is one that is installed in an electrical power distribution system that is designed to serve *only* computer equipment. A dedicated circuit is wired separately from other electrical circuits. A typical installation uses an isolation transformer to separate the computer electrical power from other power circuits. An isolation transformer converts electrical energy to magnetic energy and then back to electrical energy again. The transformer helps to buffer the circuit against voltage spikes generated outside the building as well as from inside the building.

dedicated circuit
a circuit installed in an electrical power distribution system that is designed to serve only computer equipment.

A separate electrical panel is used strictly for the computers in the building. No additional equipment should ever be plugged into the dedicated circuit outlets. If computers connected to dedicated circuits suddenly develop problems that appear to be power related, the technician should look for some type of equipment that may have been plugged into the dedicated outlets. Any non-computer type equipment that is found should be removed.



An interesting, and all too common, occurrence happens to network equipment and office computer systems that are left constantly in the "on" position. When office workers return to work in the morning, they find their computers locked up or crashed. After rebooting, everything appears fine again. However, a few days later, or even the next day, the computer system is down again. This problem is usually solved when it is discovered that the overnight cleaning service is using the dedicated circuits to power their vacuum cleaners.

Grounding

Improper grounding conditions can cause serious problems to computer equipment. After all other attempts to solve a power problem have been exhausted, the technician should investigate the grounding system. An improperly installed or damaged grounding system can cause problems that appear as voltage problems.

To check out the grounding system, a certified electrician or power company technician should make the inspection. There is specialized equipment used to perform grounding tests. It is expensive and special training is needed to use it. This is one time when the computer tech must call on another specialist.

The PC Power Supply

The power supply is responsible for converting standard 120-volt ac power from the wall outlet to dc voltage levels appropriate for the electronics systems of the computer. Typical dc voltage levels are +12, +5, +3.3, –12, and –5. These voltages are provided to the motherboard, which, in turn, distributes these voltage levels to motherboard components and expansion slots. The expansion slots provide the voltage levels required by adapter card electronic parts. Voltages are also distributed to peripherals inside the computer, such as the hard drive and DVD drive.

Power supplies have form factors just as motherboards do. The power supply must fit into the case and also allow room for the motherboard. Some of the standard form factors are named after the motherboard form factors such as AT, Baby AT, LPX, ATX, ATX12V and NLX. In addition, they can be broken down further to tower or desktop models. You should be aware of a variety of nonstandard power supplies that are proprietary. The color coding on the wiring for these types of power supplies are not truly standard. You must be careful. As a matter of fact, any implied standardization should not be taken for granted. Always check with the manufacturer's specifications for definitive information about color and voltages.

Main Power Connectors

To assist in making the proper voltage level connections, power plugs have a special shape that matches the voltage level required by the motherboard or peripheral. **Figure 5-18** illustrates two styles of motherboard main power connection. Figure 5-18A shows the ATX and Figure 5-18B shows the newer style of ATX power connection, the ATX12V. Notice that both connectors in Figures 5-18 have a PWR_OK connection. This refers to the power good signal. This signal is transmitted from the power supply to the motherboard and on to the CPU. The ***power good signal*** is used to verify the power supply is working properly during POST.

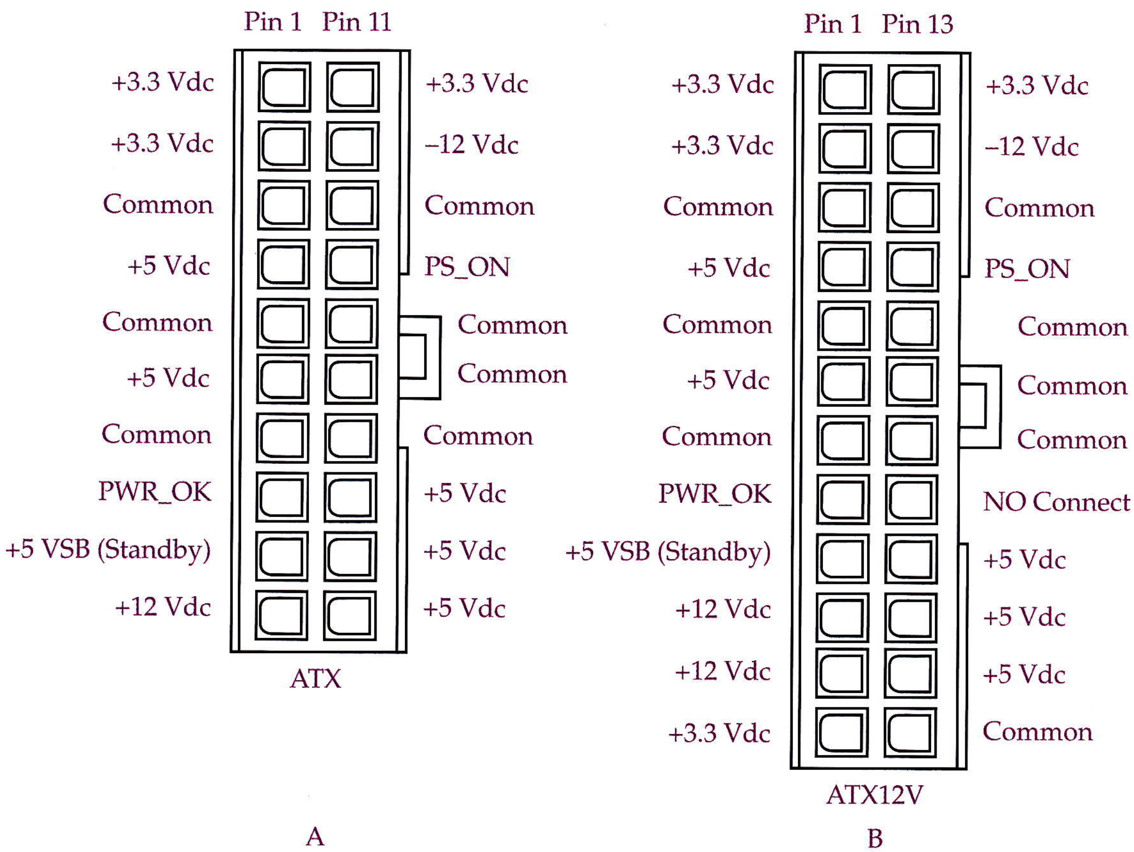
The +5VSB (standby) connection provides voltage even when the power switch is set to off. The computer is said to "wake up" on an event. The exception is when the AC plug is physically unplugged from the wall outlet or the power supply. ***Standby power connection,*** also called ***soft power,*** provides power to the keyboard when the computer system is in sleep mode. Power is reduced to the entire system, but some power must remain on to reactivate or wake up the system. This is the purpose of the standby power connection. The power on and

power good signal
a signal sent from the power supply to the motherboard that verifies the power supply is working properly.

standby power connection
provides power to reactivate or wake up a system in standby mode.

soft power
another term for the features provided by a standby power connection.

Figure 5-18.
ATX and ATX12V main power connections.



the standby power connections are also used jointly by Windows 9x software to turn the computer off using software commands rather than a physical switch. For example, the +5VSB connection can provide electrical power to a network card so that the computer can be activated when a network event occurs. The BIOS Setup program is used to configure the computer to "wakeup on LAN," which means network activity can wake up or start up the computer system. This is a common feature of all modern computer systems.

The ATX and ATX12V form factors also have 3.3-volt power connectors. The addition of 3.3 volts at the power connection has eliminated the need for a voltage regulator located at the CPU. The regulator was used to convert the 5 volts from the power supply to the lower voltage required by the new CPU units. ATX is one of the most popular power supply form factors on the market.

The ATX12V power supply is a redesign of the ATX power supply. Changes in the design were made to accommodate new power requirements such as that for PCIe devices and power-hungry video cards. The ATX motherboard main power connection has 20 pins. The newer ATX12V motherboard main power connection has 24 pins. Look closely at Figure 5-18 and you can see the main difference between the 20-pin and 24-pin connection is the bottom four pins. These four additional pins on the ATX12V are used to supply additional electrical power required by the more modern motherboards.

Most ATX motherboard designs will accept the new 24-pin ATX12V. The standard is intended to ensure a backward compatibility with older motherboards when purchasing the newer power supply to replace a defective ATX type power supply. Conversion kits are available to change a 20-pin connector into a 24-pin connector and also the opposite, change a 24-pin to a 20-pin connector. Many motherboards have no problem with a pin conversion kit. The conversion kit is simply two connections, one 24-pin and one 20-pin joined by wires. If you study the pin assignments carefully in Figure 5-18, you will see that the first set of 20 pins of an ATX power supply connector closely match the first 20-pins or the 24-pin ATX12V power supply.

Also, be aware that there are power connectors designed to connect directly from the power supply to a PCIe card. For example, video cards with high-performance processors require a separate power supply connected directly to the card. There will be more about this in Chapter 8—Video Display and Audio Systems.

Figure 5-19 and **Figure 5-20** show the ATX and ATX12V power connectors respectively. The plastic of these plugs are molded to permit the connector to connect to the motherboard in only one way. This prevents an improper connection that will destroy the motherboard. Do keep in mind that nothing along these lines is truly impossible. If sufficient force is applied, it can be plugged in backward. The connector should attach easily. If it does not, do not force it.

Other Power Connectors

There is a wide assortment of power connectors besides the main motherboard power connectors that can be used with a computer power system. **Figure 5-21** shows four of the more common you will encounter. The +12-volt power connector, Figure 5-21A, is also referred to as a 2 × 2, 12-volt connector. The designation 2 × 2 represents the pin configuration as two pins in two rows. The 2 × 2 designation is a way to differentiate the 4-pin power connector from the

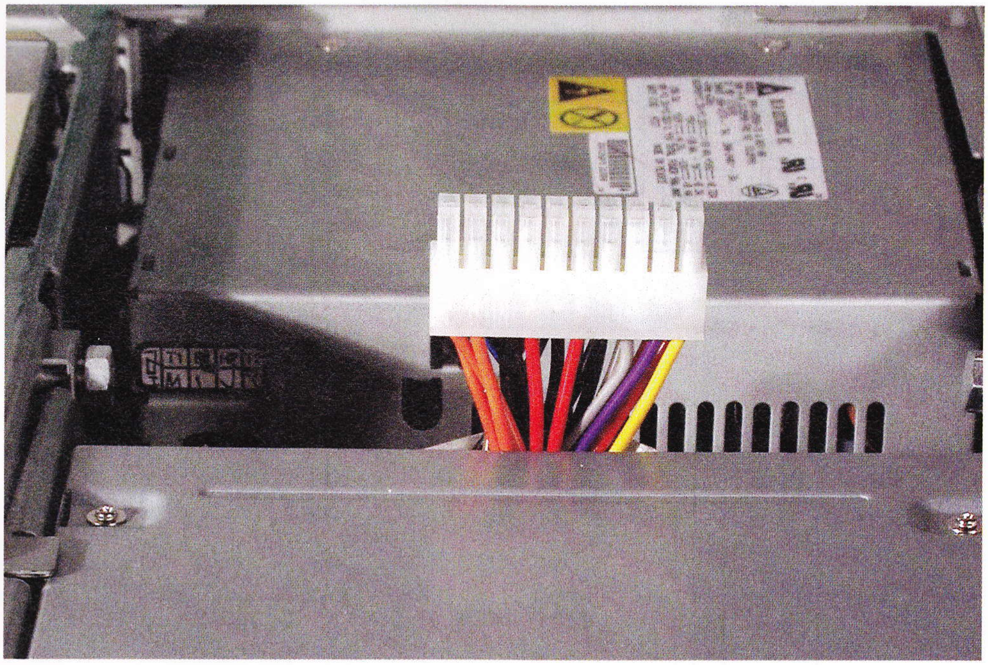


Figure 5-19. ATX motherboard power connector.

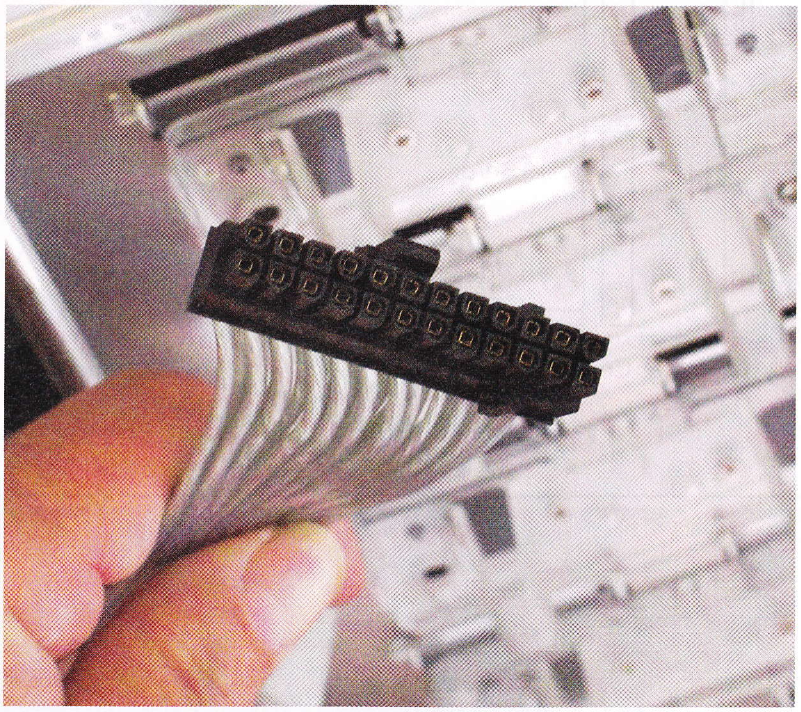


Figure 5-20. ATX12V main motherboard power connector. Most motherboards designed to work with a 20-pin ATX power supply will work with a 24-pin ATX12V power supply.

4-pin peripheral power connector. The 4-pin peripheral power connector would be designated as 1 × 4. There are also 2 × 3, 12-volt power connectors, **Figure 5-22**, and 2 × 4, 12-volt power connectors on many power supplies. You will often see power supply main motherboard connectors referred to in the same fashion. For example, a 20-pin ATX connector is referred to as a 2 × 10 connector, while the 24-pin ATX12V connector is referred to as a 2 × 12 connector.

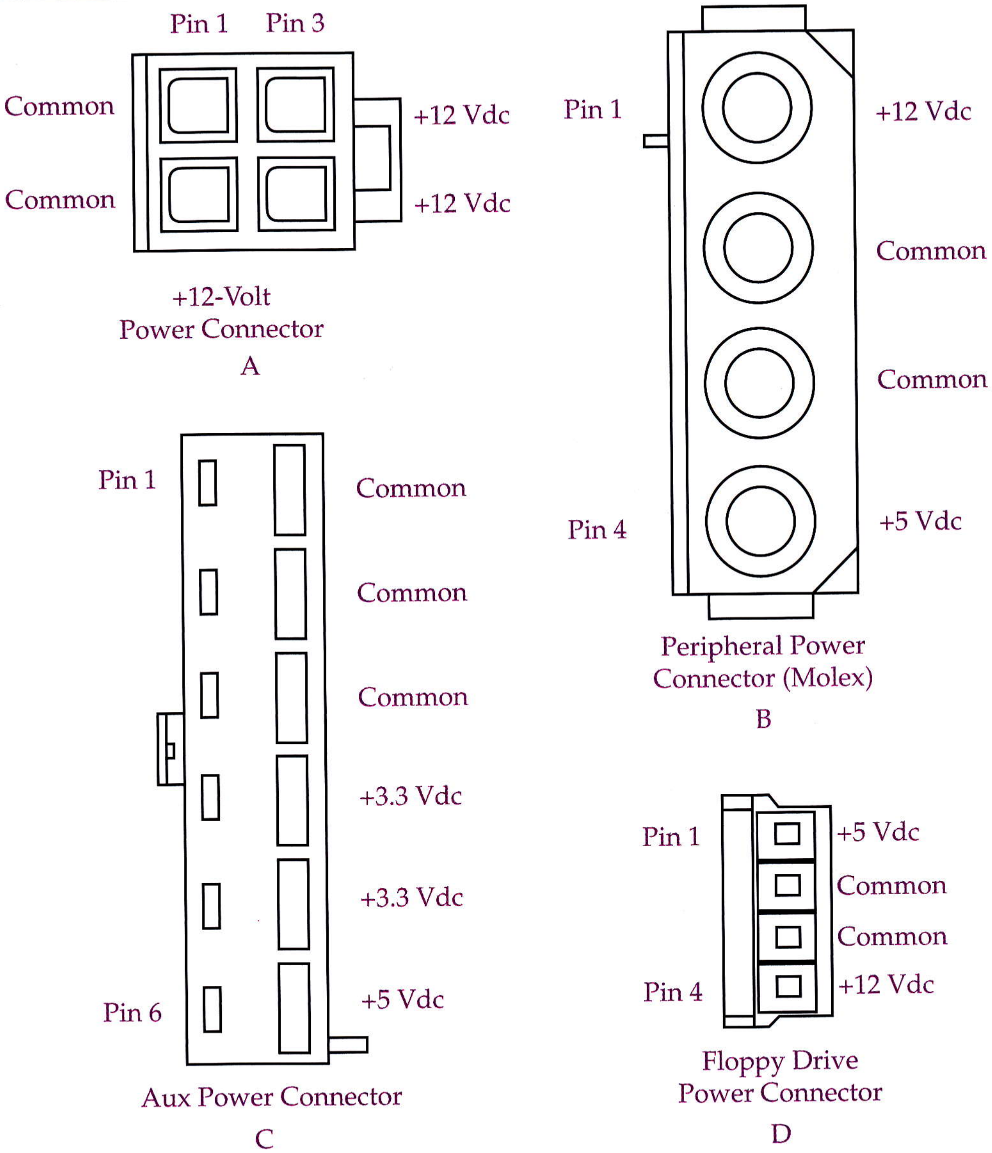


Figure 5-21. Assorted power connectors.

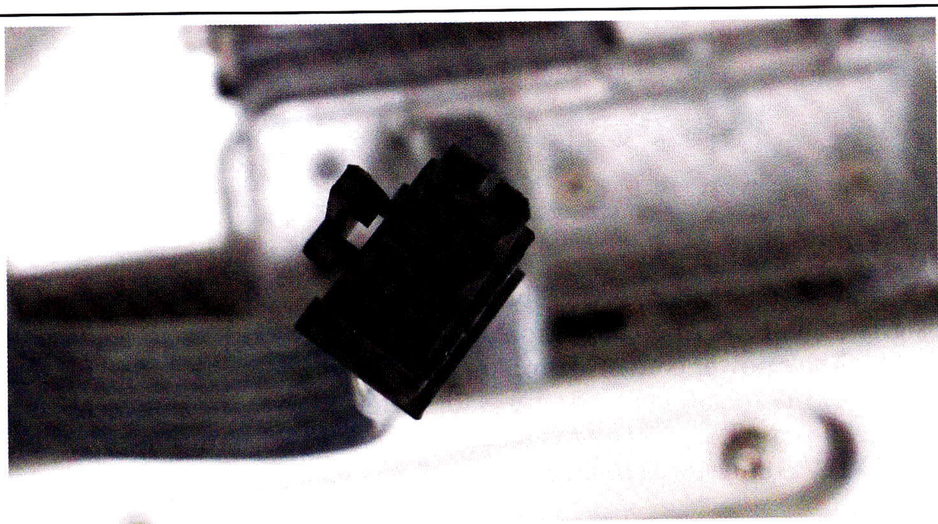
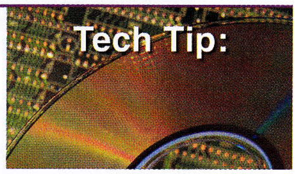


Figure 5-22. Two by six (2 × 3) 12-volt power connector.

The 4-pin peripheral power connector, Figure 5-21B, is also called a ***Molex connector.*** It is used to connect to ATA hard drives, CD-ROM drives, and DVD drives. These devices typically use the +12 volt level from the connector. The floppy drive power connector, Figure 5-21D, is also called a ***mini connector.*** This connector is used for 3½″ floppy drives. **Figure 5-23** shows a picture of the Molex connector, and **Figure 5-24** shows the mini connector.

Molex connector
a four-wire, D-shaped connector that delivers +12-volt and +5-volt signals from the power supply.

mini connector
a two-pin connector that delivers a +5 volt signal from the power supply. A variation of this connector has four wires and delivers both +12-volt and +5-volt signals.



The term *Molex* is commonly used and universally accepted to identify the large four-connector peripheral power connection. This is incorrect. Molex is the name of the company who designed and markets this type of connection.

An auxiliary power connection, Figure 5-21A, is used to supply 12 volts to newer high-performance CPUs. The voltage applied to the processor was raised from 5 Vdc to 12 Vdc. Therefore, the ATX12V power supply uses a 4-pin or more power connector attached directly to the motherboard near the processor rather than through the main motherboard power connector. **Figure 5-25** shows an auxiliary power connector.

The ATX style could only carry voltage and higher current to the CPU through the very thin conductors on the motherboard referred to as traces. Traces are very limited in the amount of current that they can carry. Power connections made directly to location on the motherboard as well as directly to devices overcome the current limitations of motherboard traces. The power connection near the CPU is critical on motherboards with high-performance processors. Without the direct connection, the computer will not boot.

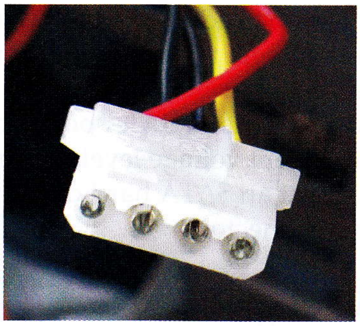


Figure 5-23.
Peripheral power connector. This connector is typically used to power ATA hard drives, CD-ROM drives, and DVD drives.

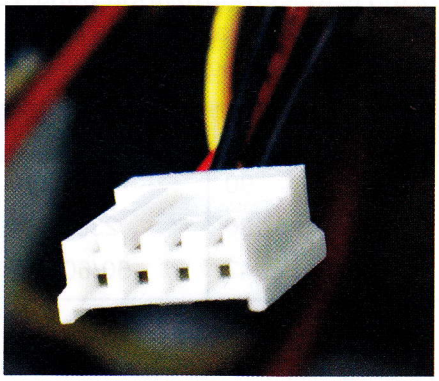


Figure 5-24.
Mini connector. This connector is used to power 3½^2 floppy drives.

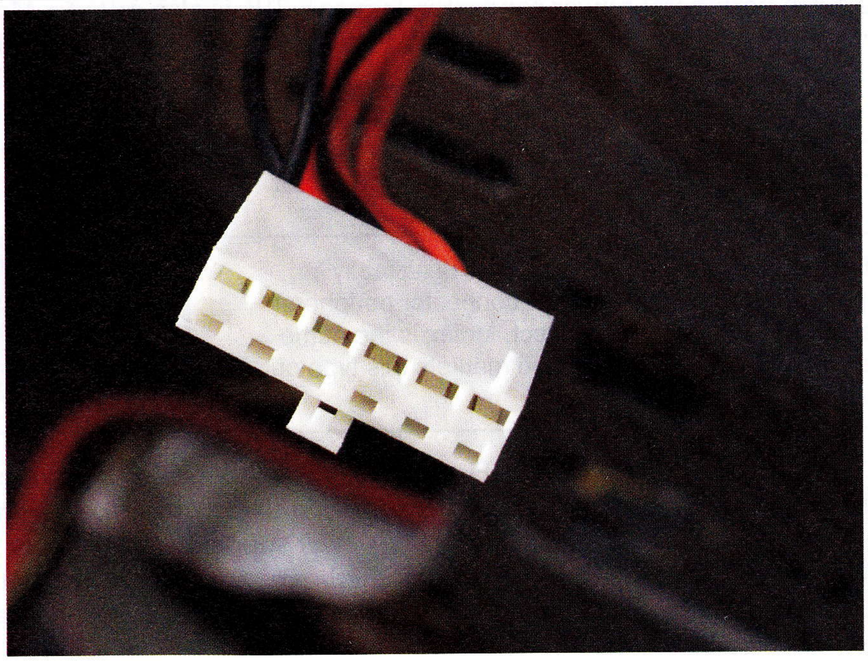


Figure 5-25. Auxiliary power connector.

Tech Tip: Always check your motherboard manual or support documentation to determine the location of and type of power connections to use.

The four-pin connector is also used to provide power directly to many high performance video cards. There will be more about video card power requirements later in the textbook.

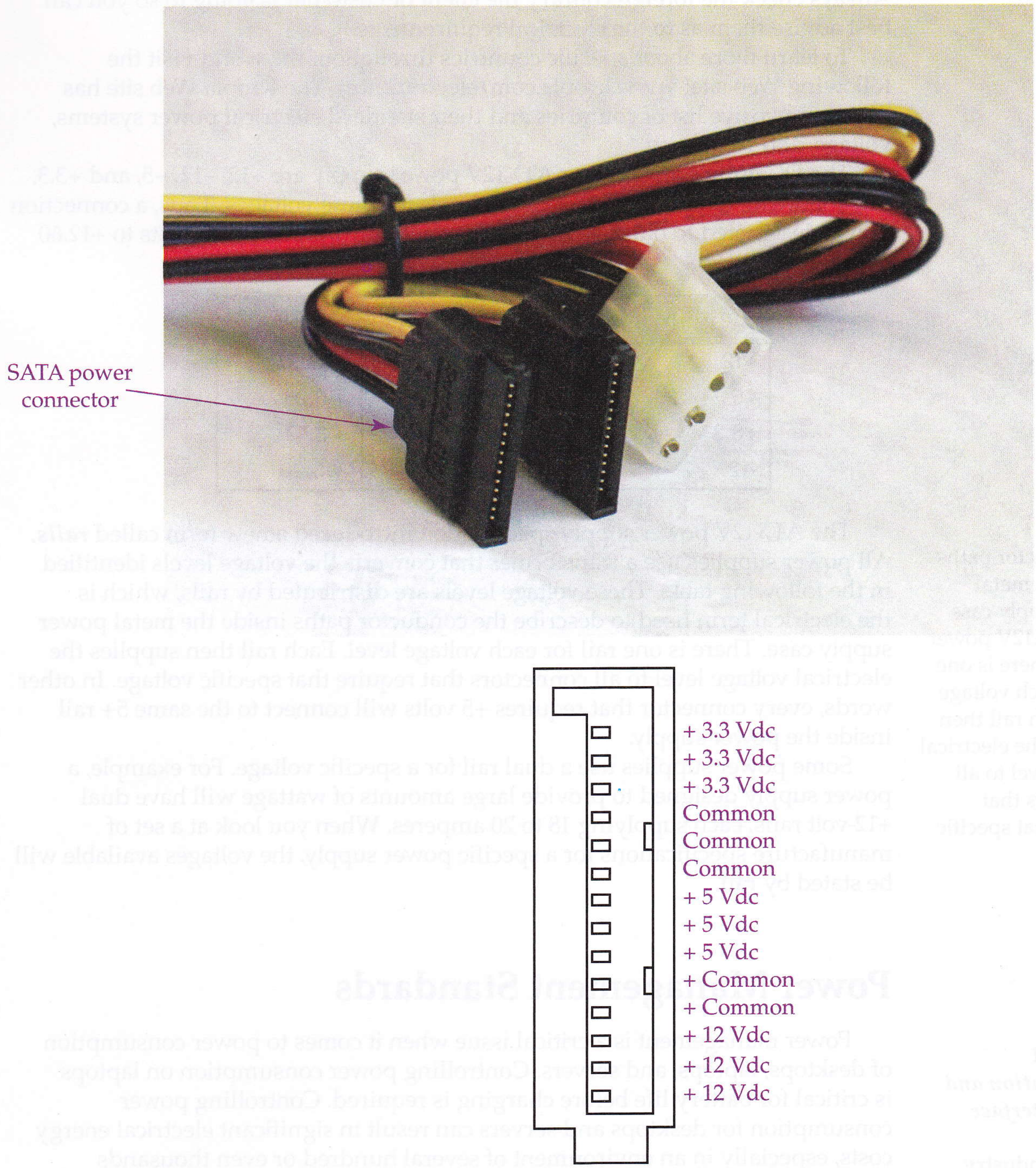
Serial ATA (SATA) hard drives use a SATA power connector, **Figure 5-26,** which has 14 pins at three different voltage levels. There are adapter wiring kits available so that you can connect an SATA hard disk drive to a power supply that does not have a SATA power connector.

Input and Output Voltage Levels

Input voltage levels specified by Form Factors Organization located at www.formfactors.org. Form Factors Organization makes a set of recommended nonbinding specifications that are used as a guideline for power supply manufacturers, as shown in the following table.

Input	Minimum VAC	Nominal VAC	Maximum VAC
115 Vac	90	115	135
230 Vac	180	230	265
Frequency (Hz)	47	50/60	63

Figure 5-26.
SATA power connector and pin outs.



Computers are used worldwide, and as a result, they are typically designed with two voltage levels available either through use of a switch or by automatic electrical sensing and switching circuitry. Most countries in the world use 50-Hz electrical power rated at 230 volts. Some use 115 volts at 50 Hz. The USA is one of the few countries that use a 115/230-volt 60-Hz electrical system. While a computer will run on 230 volts at 50 Hz, the 120-volt 60 Hz standard USA electrical plug will not fit physically into the 230-volt 50-Hz wall outlet. A special adapter must be used to make the computer power supply physically compatible. Always check the foreign country the client or customer is going to so you can best advise them as to the electrical requirements.

To learn more about specific countries throughout the world visit the following Web site: www.kropla.com/electric2.htm. The Kropla Web site has a comprehensive list of countries and their standard electrical power systems, voltage, and frequency.

The DC output levels of an ATX12V power supply are +12, –12, +5, and +3.3. The following table lists the tolerance levels for these voltages. Thus, a connection that is designated to output +12 volts may actually output +11.40 volts to +12.60 volts.

Output Vdc	Range	Minimum	Maximum
+12	± 5%	+11.40	+12.60
+5	± 5%	+ 4.75	+ 5.25
+3.3	± 5%	+ 3.14	+ 3.47
-12	± 10%	–10.80	–13.20

rails
the conductor paths inside the metal power supply case of an ATX12V power supply. There is one rail for each voltage level. Each rail then supplies the electrical voltage level to all connectors that require that specific voltage.

The ATX12V power supply specification introduced a new term called ***rails.*** All power supplies use a transformer that converts the voltage levels identified in the following table. These voltage levels are distributed by rails, which is the electrical term used to describe the conductor paths inside the metal power supply case. There is one rail for each voltage level. Each rail then supplies the electrical voltage level to all connectors that require that specific voltage. In other words, every connector that requires +5 volts will connect to the same 5+ rail inside the power supply.

Some power supplies use a dual rail for a specific voltage. For example, a power supply designed to provide large amounts of wattage will have dual +12-volt rails, each supplying 18 to 20 amperes. When you look at a set of manufacture specifications for a specific power supply, the voltages available will be stated by rail.

Power Management Standards

Advanced Configuration and Power Interface (ACPI)
an open industry power management standard for desktops, laptops, and servers. ACPI allows the operating system to control the power management features.

Power management is a critical issue when it comes to power consumption of desktops, laptops, and servers. Controlling power consumption on laptops is critical for battery life before charging is required. Controlling power consumption for desktops and servers can result in significant electrical energy costs, especially in an environment of several hundred or even thousands of computers. Turning off computer displays and putting the computer into hibernation can save thousands of dollars in energy costs. The savings are not just directly related to electrical energy consumed by the computer system, but also to electrical energy consumed by air conditioning. Computers and displays generate a lot of heat, especially CRT displays.

Advanced Configuration and Power Interface (ACPI) is an open industry power management standard for desktops, laptops, and servers. ACPI allows the operating system to control the power management features. The original implementation of computer power management was ***Advanced Power Management (APM).*** APM was designed for the BIOS to control power management features of the computer system, **Figure 5-27.** APM was configured in the BIOS setup and determined the amount of time before the display screen and hard disk drive would be turned off. It was later replaced by Advanced Configuration and Power Interface (ACPI).

ACPI is enabled by the BIOS but not controlled or configured by the BIOS Setup program. ACPI is configured through the operating system and determines when to implement the energy saving features. Look at the Windows XP power options in **Figure 5-28** and the Windows Vista power options in **Figure 5-29.**

Windows Vista provides three general options for power savings: **Balanced**, **Power saver**, and **High performance**. To the right of each option, you can see the relationship of energy savings to computer performance. For example, the **Power saver** option would be the best choice for the maximum life of a laptop

Advanced Power Management (APM) power management standard that allows the BIOS to control power management features of the computer system. APM is configured in the BIOS Setup program and determines the amount of time before the display and hard disk drive are turned off.

Full On	The system is at full power.
APM Enabled	The APM power system is on and unused devices are powered down.
APM Standby	The system appears asleep. Most devices are shut down but can be powered back up almost instantly.
APM Suspend	The system is not operating and is in a state of suspended animation. Operation parameters have been saved to disk. The system can be brought back to the APM enabled state but with some delay.
Off	The power supply is off. The system is completely shut down.

Figure 5-27. Chart of the five conditions possible with APM technology.

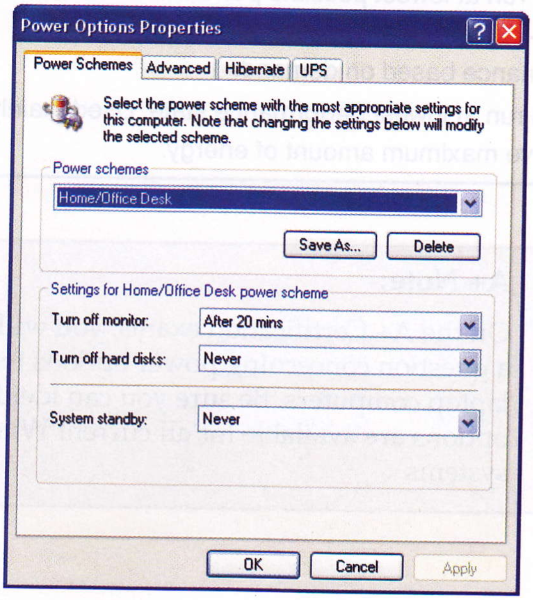


Figure 5-28. Windows XP power options.

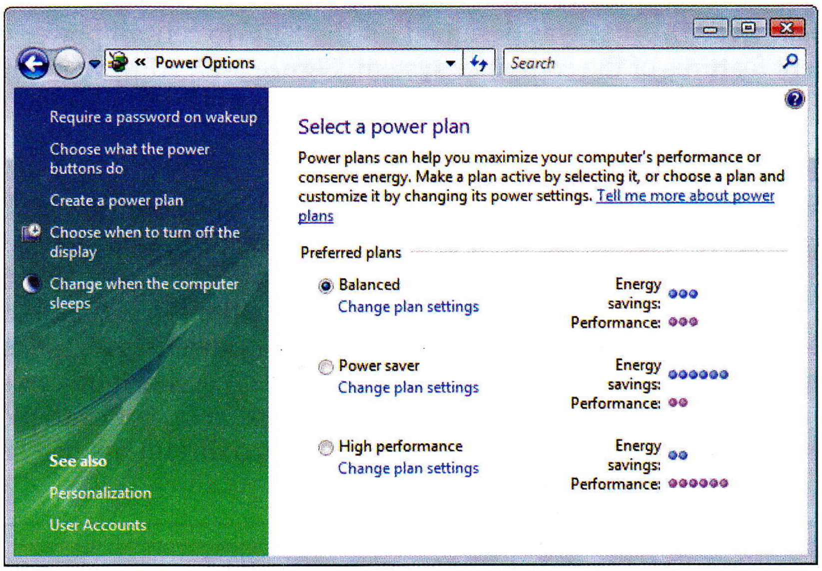


Figure 5-29. Windows Vista power options.

battery charge. There will be much more about power saving and laptops later in Chapter 12—Portable PCs. The **Power Options** dialog box accessed through **Control Panel | Performance and Maintenance** in Windows XP, and **Control Panel | System and Maintenance** in Windows Vista. If your folders are set up to use the classic view, the **Power Options** dialog box is accessed through **Control Panel | Power Options** in both Windows XP and Windows Vista.

Windows uses dynamic processor throttling to control the processor when in certain processor management modes. The Windows operating system can automatically throttle CPU performance to conserve electrical energy. The following table lists the various modes.

Mode	Description
None	Run at highest performance possible.
Constant	Always run at lowest possible performance to conserve maximum energy.
Adaptive	Performance based on demand.
Degrade	Always run at lowest performance state. Used mainly for laptops to conserve maximum amount of energy.

A+ Note:

On the A+ Certification exams, you will most likely see a question concerning power options for desktop and laptop computers. Be sure you can identify which power options are available for all current Windows operating systems.

Troubleshooting the Power Supply

See **Figure 5-30** for a picture of the inside of a power supply. A power supply is usually sealed to make it difficult to open. In general, there are no serviceable parts inside the power supply. It is considered a field replacement unit. Although it is possible to repair a power supply, it is not cost effective. The cost of most power supplies does not come near the cost of having an electronic technician repair the unit.

The bulleted list that follows contains signs that a power supply might be bad. Although some of the indicators can be caused by other system components, it is most likely that the power supply has caused the occurrence. Power supply failure is quite frequent when compared to the failure of other computer components.

These common signs of a defective power supply include the following:

- ✔ **Inoperable cooling fans:** Cooling fans that are not running are a fairly consistent sign that the power supply has failed. (Cooling fans receive their power directly from the power supply.)
- ✔ **Smoke:** Smoke coming from the power supply is an indicator of electronic component or circuit board damage. Electronic components usually burn up from an overload condition. This almost always results in excessive heat, which generates the smoke.

  The distinctive smell of burnt electrical device in proximity of a failed computer is also a very common indication that the power supply is defective. The smell can linger for hours after a system failure.
- ✔ **Circuit breaker tripping:** If a circuit breaker is tripped, it is most likely caused by the power supply unit in the computer. With the exception of the monitor, no other component will generate a condition to trip the breaker. To verify that the problem is with the power supply, unplug the monitor to isolate the computer power supply.

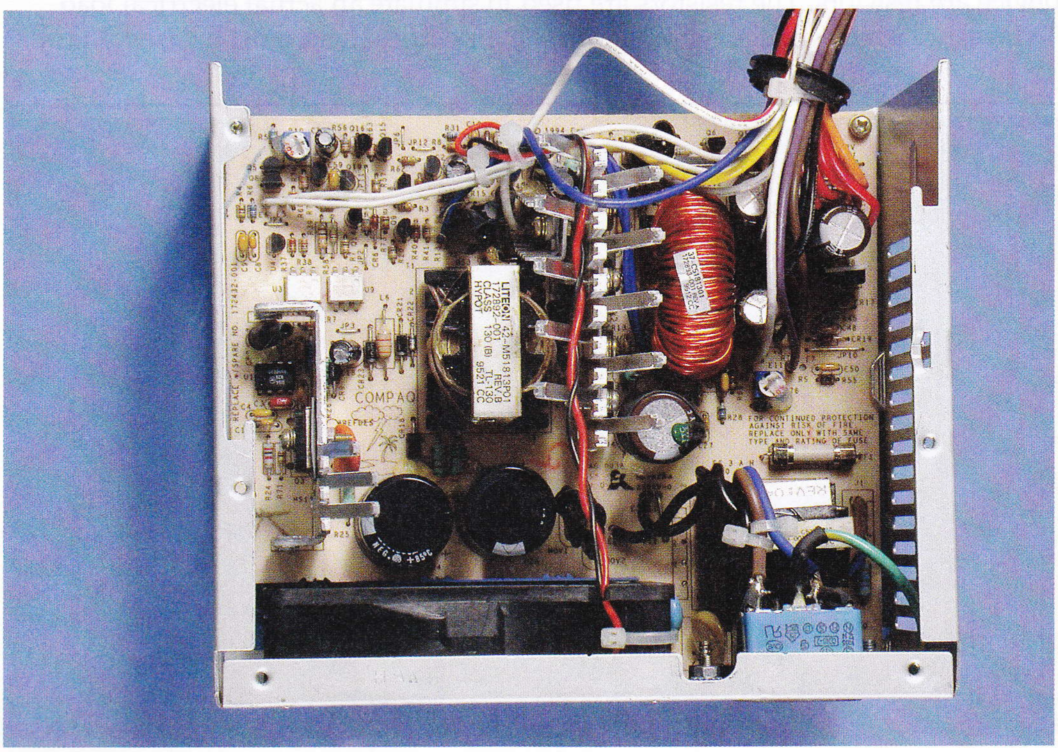


Figure 5-30. Inside a power supply. Power supplies are field replacement units.

- ✔ **Automatic rebooting:** If the computer reboots itself while on standby or during normal operation, it is a good indication of a bad power supply. The power level dropping and rising is a common occurrence as the power supply breaks down. This fluctuating voltage level causes the computer system to reboot for no apparent reason.
- ✔ **Electric shock:** Any electric shock received from the computer case is a sign of a bad power supply or one that is breaking down. *Always use extreme caution when troubleshooting a suspected power supply unit. Remember that 120-volt ac power can be deadly.*
- ✔ **Excessive heat:** This troubleshooting diagnosis is made through experience. Even a normally functioning power supply will produce a certain amount of heat. Heat is a normal by-product of electrical equipment. However, excessive heat is a sure sign that complete failure of an electronic component is imminent. The excessive heat in combination with the other signs can leave little doubt that the power supply is failing. If the power supply is too hot to touch, it has excessive heat. Electronic components usually start to break down at 160°F (71°C).

Electronic technicians can repair power supplies, but it is usually not cost effective. The time taken to diagnose the power supply, locate the component, and replace the defective component is simply cost prohibitive. It's much quicker and more economical to replace rather than repair. Power supplies are very low cost components. The cost of labor and availability of replacement parts are the major factors that determine when a unit is repaired or replaced.

Figure 5-31 shows a typical ATX power checker with the cover removed to better expose the LED indicators. The LEDs light up to indicate the presence of +12, –5, +5, –12, and +3.3 voltage levels corresponding to the ATX main motherboard connection. This is the preferred method of checking power. Also, notice that the two large white rectangular areas at the top corners of the device are resistors. The resistors are used to simulate an actual electrical load. To measure a true voltage output level, some electrical load must be used. Many

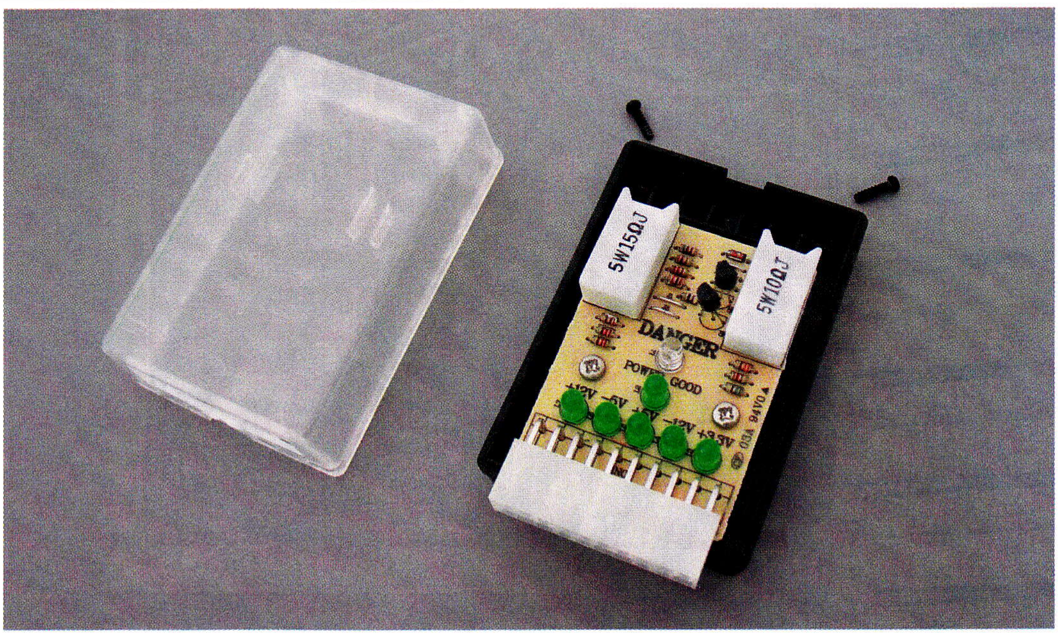


Figure 5-31. A typical power supply check device.

times a false good reading is indicated on a voltage power supply output when there is no electrical load. This is one of the short comings of using a digital voltmeter to check the power supply output voltage.

Replacing a Power Supply

Replacing a power supply is an easy task. You must make sure the replacement is an acceptable form factor to match the case and motherboard. You must also make sure there is an adequate watt capacity provided by the replacement unit. *The watts capacity should either match or exceed the unit being replaced.*

Steps for power supply replacement:

1. Be absolutely sure the power is off. (Do not use an anti-static wrist strap for this operation.)
2. Sketch of all the connections between the old power supply unit and the other computer components. (This will save you a great deal of time later.)
3. Remove the power connections carefully. Try not to disturb other cable connections on the motherboard or other devices. Also, remove the power cord attached to the power supply.
4. Remove retaining/mounting screws from the case that secure the power supply in place.
5. Place the new power supply into the case and secure the retaining/mounting screws.
6. Reconnect the power connections to the motherboard and devices using your sketch as a map.
7. Place any extra connections from the power supply in a neat bundle. Keep the loose connectors away from the motherboard. A loose connector could easily slip over a motherboard bare jumper causing destruction during power on or can catch in the fan blades thus stopping the fan and causing the CPU to overheat.
8. Take one last look around at the connections. Verify that they are all secure, and then power on the computer before replacing the case cover. The cover should be left off until you are satisfied the PC is working properly. Any error messages at this time could be generated by a loose or improper connection during installation.
9. If everything is fine, replace the case cover and power on the PC once more. When replacing the case cover, be careful not to pinch any of the cables between the case frame and cover.

Surge Protection Devices

An electrical surge, brownout, or blackout can happen at any time. A surge is when a higher voltage than desired is present in the electrical system. A brownout is when low voltage is present. In a blackout condition, there is no voltage present. A momentary blackout can happen at any time and go completely unnoticed by the human eye. All that is required is the absence of one electrical cycle of power, or less, to cause a computer crash or lockup. **Figure 5-32** shows a series of cycles with one flatlined. Below it is a series of digital signals with a large group of flat digital pulses in relation to the one cycle.

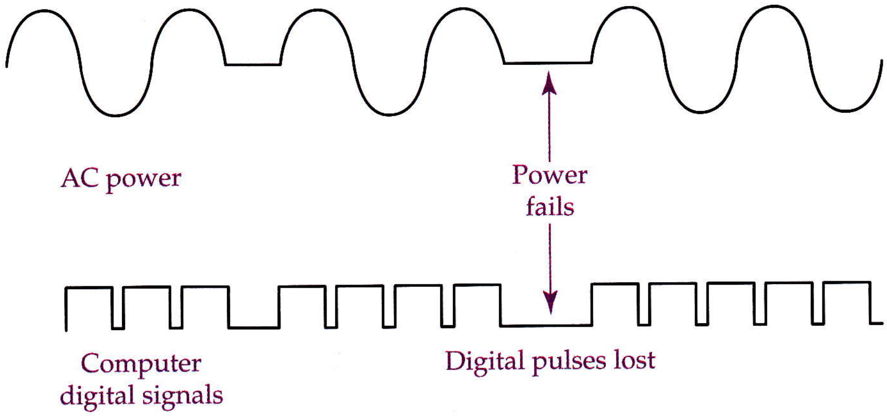


Figure 5-32. Series of cycles with a few cycles flatlined. Below it is a series of digital signals with a large group of flat digital pulses. A few lost cycles can eliminate many digital pulses.

Surge protection devices are designed to protect computer and other electronic devices against harmful surges of electrical energy. Two of the most common methods of providing protection are the use of power strips and UPS systems. UPS systems also protect against brownouts and blackouts.

UPS System

uninterruptible power supply (UPS) a power supply that ensures a constant supply of quality electrical power to the computer system.

An ***uninterruptible power supply (UPS)*** is designed to ensure a constant supply of quality electrical power to the computer system. Quality power means a power supply that eliminates surges and low voltage as well as complete power outage conditions. **Figure 5-33** illustrates a typical UPS system showing outlets, surge protection, batteries, and charger. **Figure 5-34** shows two typical UPS systems.

A UPS system monitors the power input to the computer while maintaining a fully charged battery. The AC/DC inverter is used to convert some of the 120 Vac from the outlet to 12 Vdc used to keep the batteries fully charged. When commercial power fails, the inverter changes the 12 Vdc from the battery back into 120 Vac. The 120 Vac is then used to maintain power to the computer until the PC can be properly shut down, preventing the loss of data. Without the UPS system, the PC would crash when the power failed, and all data in RAM would be lost.

Low voltage situations and brownouts are common occurrences in electrical distribution systems. Some low voltage occurrences last only a few milliseconds and go completely unnoticed by the users. Even low voltage levels of a few milliseconds can cause a computer crash. Remember that the digital traffic in a computer is traveling at megahertz values. Many commands can be issued in a few milliseconds or thousands of bits of data can be sent. All of it could be lost during the momentary voltage loss. Many computer system lockups are caused by momentary low voltage conditions. This condition can be prevented by using a UPS. A power strip does not provide protection against blackout or brownout conditions.

metal oxide varistor (MOV) a gate in a surge suppressor that becomes conductive at a given voltage, causing current to bypass the equipment plugged into the suppressor.

Power Strips

Not all power strips provide protection against power surges. Some are designed as a strip of convenient outlets to plug equipment into. Power strips that are designed for power surge protection have a ***metal oxide varistor (MOV)*** connected across the internal electrical line.

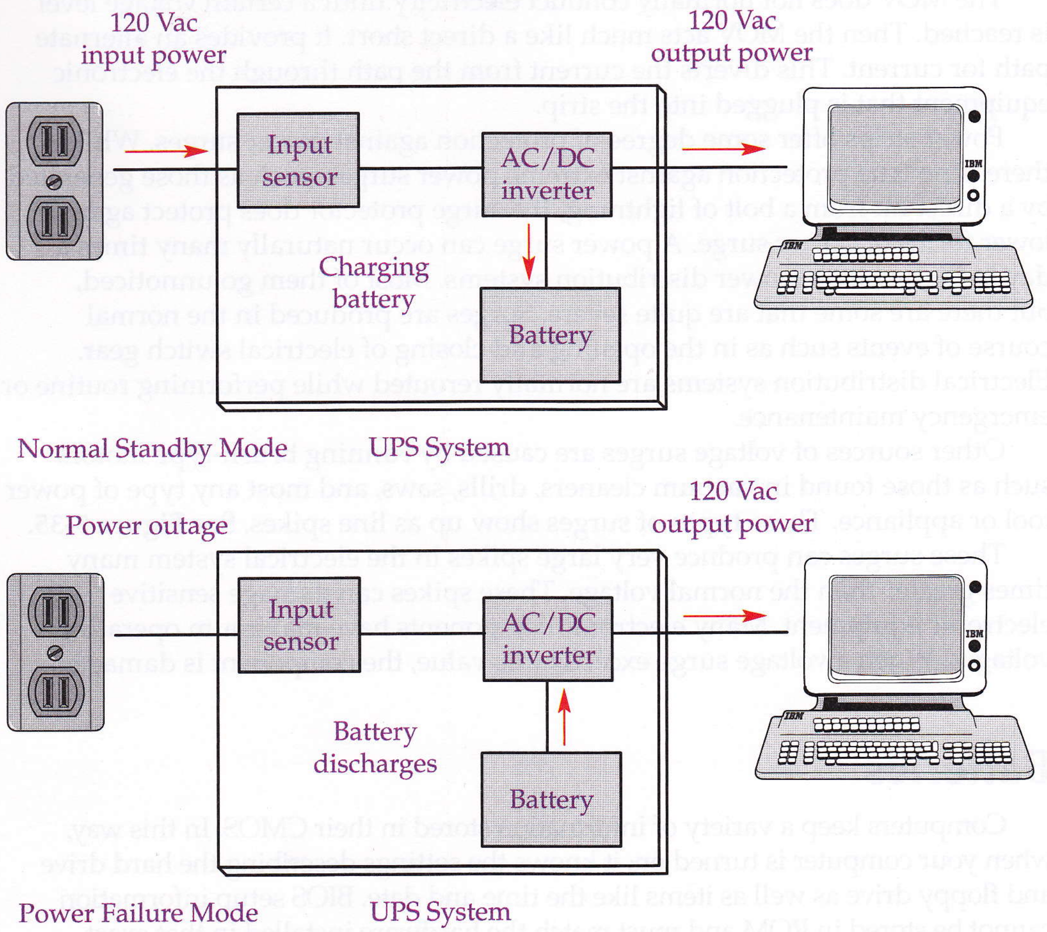


Figure 5-33. A typical UPS monitors the 120 Vac input. When power is normal, the battery is kept fully charged and ac power is supplied to the computer. When the 120 Vac input fails, the battery discharges through the inverter to create 120 Vac for the computer.

Figure 5-34. Uninterruptible power supply systems protect PCs and servers from power loss and power surges. All critical PC systems should be protected by a UPS. (APC)

The MOV does not normally conduct electricity until a certain voltage level is reached. Then the MOV acts much like a direct short. It provides an alternate path for current. This diverts the current from the path through the electronic equipment that is plugged into the strip.

Power strips offer some degree of protection against power surges. While there is no true protection against extreme power surges, such as those generated by a direct hit from a bolt of lightning, the surge protector does protect against lower forms of power surge. A power surge can occur naturally many times a day in high-voltage power distribution systems. Most of them go unnoticed, but there are some that are quite severe. Surges are produced in the normal course of events such as in the opening and closing of electrical switch gear. Electrical distribution systems are normally rerouted while performing routine or emergency maintenance.

Other sources of voltage surges are caused by running brush-type motors such as those found in vacuum cleaners, drills, saws, and most any type of power tool or appliance. These types of surges show up as line spikes. See **Figure 5-35.**

These surges can produce very large spikes in the electrical system many times greater than the normal voltage. These spikes can damage sensitive electronic equipment. Many electronic components have maximum operating voltages. When a voltage surge exceeds this value, the component is damaged.

Batteries

Computers keep a variety of information stored in their CMOS. In this way, when your computer is turned on, it knows the settings describing the hard drive and floppy drive as well as items like the time and date. BIOS setup information cannot be stored in ROM and must match the hardware installed in that exact computer. BIOS setup information is saved to the CMOS chip and maintained by a battery so that the setup information remains intact even when the computer power is disconnected or turned off. Thus, a battery is used to power the CMOS chip when the main power supply to the computer is shut down. Look at **Figure 5-36.**

Batteries are constructed in a simple manner. When two dissimilar metals are placed in contact with a chemical solution, called an electrolyte, a voltage is produced. See **Figure 5-37** for an illustration of the principles behind a battery. It shows two metal plates and an electrolyte with a lightbulb as the load.

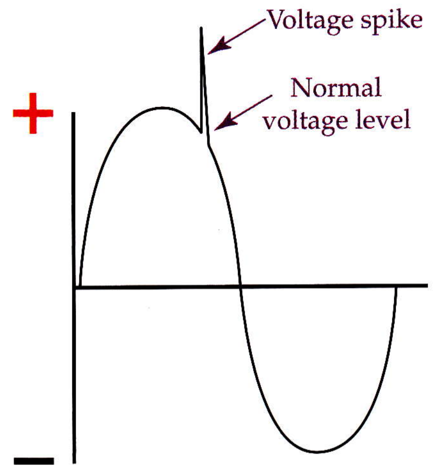


Figure 5-35. Voltage spikes can be caused by many things. The increased voltage in the spike damages electronic components by exceeding the voltage limitation of the component.

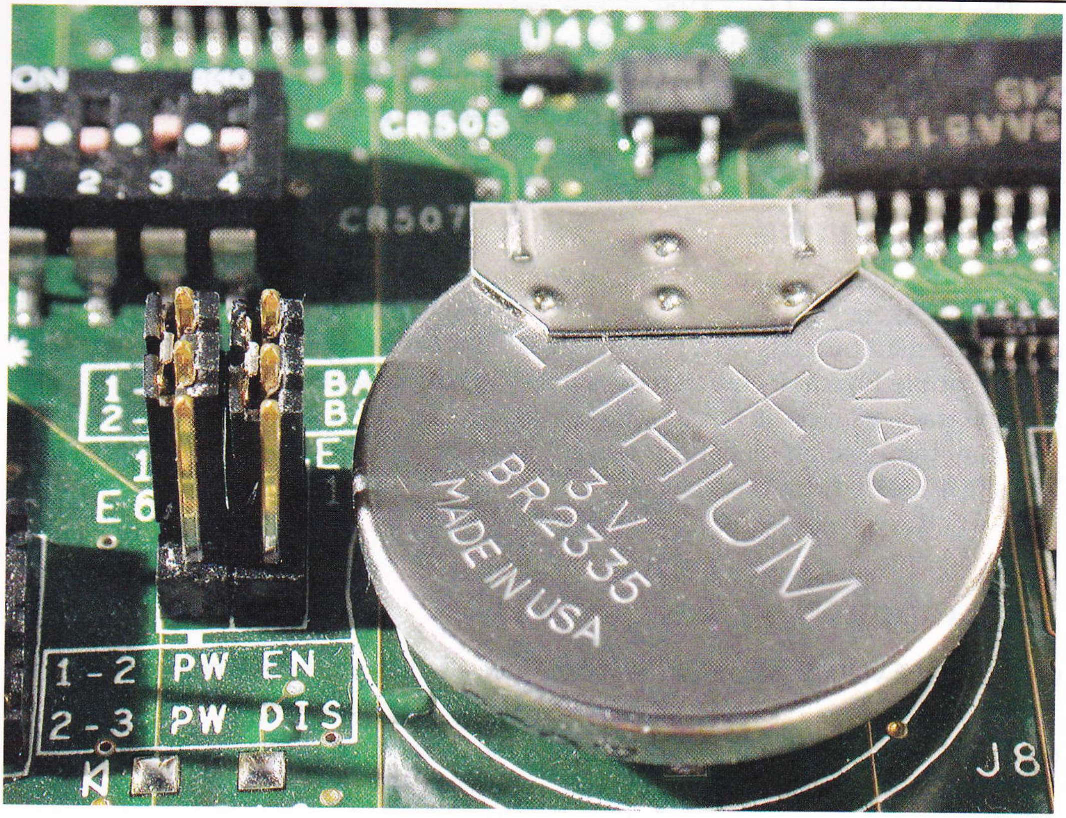


Figure 5-36. Typical motherboard battery.

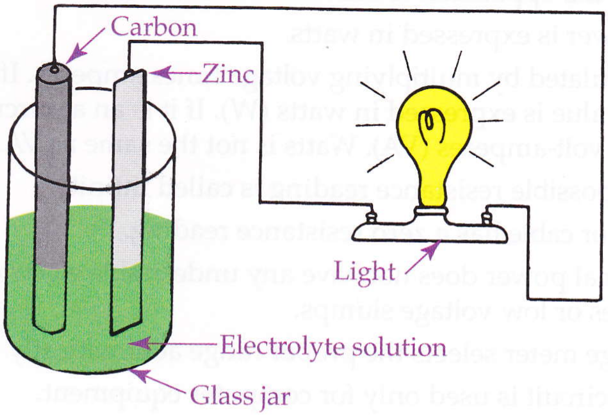


Figure 5-37. Illustration of the battery principles. Two metal plates in an electrolyte solution producing energy to power a light.

The most common types of batteries used for motherboards are alkaline, nickel metal hydride, nickel cadmium (also called NiCad), and lithium. All are rechargeable batteries. The charge on a lithium battery lasts longer than the other three types of battery. This is why lithium is also the preferred choice for laptop computers.

A sure sign of failure of the CMOS battery is the PC's failure to correctly keep the date and time. Battery failure can also cause the system to fail to recognize the hard drive and other devices that store information about themselves in the CMOS settings. A typical PC battery should last five to seven years, but they have been known to fail sooner. You can usually reset the CMOS settings and use the computer as normal until the battery is replaced.

The batteries used for a UPS system are usually lead-acid or a jell-type. These batteries can provide power for a substantial period of time. The biggest advantage of jell-type is the lack of regular maintenance required as compared to lead-acid. Newer lead-acid batteries should also be maintenance free. Both types should be periodically inspected for corrosion on the battery terminals.

Battery Disposal

Batteries must be disposed of in the manner outlined by the Environmental Protection Agency (EPA). Most manufacturers will readily accept the old battery in return when purchasing a new one. They have the proper means of disposal at hand that the typical technician does not. You simply do not throw an old battery into the trash, especially large UPS batteries.

More information on battery recycling can be found on the EPA's Web site. The site is located at www.epa.gov.

Summary

- ✔ Electrical voltage provides the pressure needed to push electrons through a circuit.
- ✔ Amperes or current is used to express the amount or volume of electrical energy flowing through the circuit.
- ✔ Electrical current is expressed in amperes.
- ✔ Resistance is the opposition to current and is measured in ohms.
- ✔ Electrical power is expressed in watts.
- ✔ Power is calculated by multiplying voltage times amperes. If the circuit is a dc circuit, this value is expressed in watts (W). If it is an ac circuit, this value is expressed in volt-amperes (VA). Watts is not the same as VA.
- ✔ The highest possible resistance reading is called infinity.
- ✔ A good fuse or cable has a zero resistance reading.
- ✔ Clean electrical power does not have any undesirable electrical characteristics such as spikes or low voltage slumps.
- ✔ An auto-range meter selects the proper range automatically.
- ✔ A dedicated circuit is used only for computer equipment.
- ✔ Computer systems must be properly grounded.
- ✔ PC power supplies have form factors to match cases and motherboards.
- ✔ The ATX power supply uses a 20-pin connector while the ATX12V uses a 24-pin connector.
- ✔ The ATX12V power supply is compatible with a motherboard designed for an ATX 20-pin connector.
- ✔ Power management standards are designed to conserve electrical energy consumed by desktop, laptop and server computer systems.
- ✔ Windows operating systems use dynamic processor throttling to control the performance of the CPU to conserve electrical energy.