Introduction to How Power Supplies Work

If there is any one component that is absolutely vital to the operation of a computer, it is the power supply. Without it, a computer is just an inert box full of plastic and metal. The power supply converts the alternating current (AC) line from your home to the direct current (DC) needed by the personal computer. In this article, we'll learn how PC power supplies work and what the wattage really ratings mean.

In a personal computer (PC), the power supply is the metal box usually found in a corner of the case. The power supply is visible from the back of many systems because it contains the power-cord receptacle and the cooling fan.

Power supplies, often referred to as "switching power supplies", use switcher technology to convert the AC input to lower DC voltages. The typical voltages supplied are:

- 3.3 volts
- 5 volts
- 12 volts

The 3.3- and 5-volts are typically used by digital circuits, while the 12-volt is used to run motors in disk drives and fans. The main specification of a power supply is in watts. A watt is the product of the voltage in volts and the current in amperes or amps. If you have been around PCs for many years, you probably remember that the original PCs had large red toggle switches that had a good bit of heft to them. When you turned the PC on or off, you knew you were doing it. These switches actually controlled the flow of 120 volt power to the power supply.

Today you turn on the power with a little push button, and you turn off the machine with a menu option. These capabilities were added to standard power supplies several years ago. The operating system can send a signal to the power supply to tell it to turn off. The push button sends a 5-volt signal to the power supply to tell it when to turn on. The power supply also has a circuit that supplies 5 volts, called VSB for "standby voltage" even when it is officially "off", so that the button will work. See the next page to learn more about switcher technology.



Switcher Technology

Prior to 1980 or so, power supplies tended to be heavy and bulky. They used large, heavy transformers and huge capacitors (some as large as soda cans) to convert line voltage at 120 volts and 60 hertz into 5 volts and 12 volts DC.

The switching power supplies used today are much smaller and lighter. They convert the 60-Hertz (Hz, or cycles per second) current to a much higher frequency, meaning more cycles per second. This conversion enables a small, lightweight transformer in the power supply to do the actual voltage step-down from 110 volts (or 220 in certain countries) to the voltage needed by the particular computer component. The higher-frequency AC current provided by a switcher supply is also easier to rectify and filter compared to the original 60-Hz AC line voltage, reducing the variances in voltage for the sensitive electronic components in the computer.

A switcher power supply draws only the power it needs from the AC line. The typical voltages and current provided by a power supply are shown on the label on a power supply.
Switcher technology is also used to make AC from DC, as found in many of the automobile power inverters used to run AC appliances in an automobile and in uninterruptible power supplies. Switcher technology in automotive power inverters changes the direct current from the auto battery into alternating current. The transformer uses alternating current to make the transformer in the inverter step the voltage up to that of household appliances (120 VAC).

Power Supply Standardization

Over time, there have been at least six different standard power supplies for personal computers. Recently, the industry has settled on using ATX-based power supplies. ATX is an industry specification that means the power supply has the physical characteristics to fit a standard ATX case and the electrical characteristics to work with an ATX motherboard.

PC power-supply cables use standardized, keyed connectors that make it difficult to connect the wrong ones. Also, fan manufacturers often use the same connectors as the power cables for disk drives, allowing a fan to easily obtain the 12 volts it needs. Color-coded wires and industry standard connectors make it possible for the consumer to have many choices for a replacement power supply.

Advanced Power Management (APM) offers a set of five different states that your system can be in. It was developed by Microsoft and Intel for PC users who wish to conserve power. Each system component, including the operating system, basic input/output system (BIOS), motherboard and attached devices all need to be APM-compliant to be able to use this feature. Should you wish to disable APM because you suspect it is using up system resources or causing a conflict, the best way to do this is in the BIOS. That way, the operating system won't try to reinstall it, which could happen if it were disabled only in the software.

Power Supply Wattage

A 400-watt switching power supply will not necessarily use more power than a 250-watt supply. A larger supply may be needed if you use every available slot on th motherboard or every available drive bay in the personal computer case. It is not a good idea to have a 250-watt supply if you have 250 watts total in devices, since the supply should not be loaded to 100 percent of its capacity.

Power supplies of the same form factor ("form factor" refers to the actual shape of the motherboard) are typically differentiated by the wattage they supply and the length of the warranty.

Technical Terms Glossary

Ambient Temperature	The temperature of an environment in which power supply operates.
Burn-in	In power supplies, a period during which a supply is energized and loaded to peak output, with the intent of finding potentially weak components. Typical burn-in tests can include temperature cycling, input cycling, and/or load cycling.
Class I Power Supply	Protection against electric shock is achieved by basic insulation and protective earth groud to the device.
Class II Power Supply	Since there is no protective earth ground, protection against electric shock is achieved by double insulation or reinforced insulation.
Dielectric Withstanding Voltage	The maximum DC Voltage applied within a specified time period between two isolated points without causing breakdown of its insulation. (See Hi-Pot Test)
Efficiency	Ratio of output power to input power, generally measured at full load with nominal line conditions.
EMI (Electromagnetic Interference)	Unwanted energy, generally emitted from switching power supplies, which may be conducted or radiated.
Hi-Pot Test (High Potential Test)	A test to determine if the breakdown voltage of a transformer or power supply exceeds the minimum requirement. It is performed by applying a high voltage between two isolated test points.
Hold-up Time	The time during which a power supply's output voltage remains within specification following the loss of input power.
Impedance	The ratio of voltage to current in AC circuits, containing both resistance and reactance terms, usually expressed as ohms.
Input Voltage (AC)	Normally it is the sinusoidal input from AC source to the power supply, normally specified in volts RMS. The minimum and maximum voltage and frequency limits must be specified for proper performance of the power supply. Different countries have different AC Inputs and Frequencies.
Inrush Current	The peak instantaneous input current drawn by a power supply at turn-on.
Isolation Resistance	The electrical resistance, normally in Megaohms, between the input and output of a power supply, isolated electrically by means of the power transformer. The isolation resistance is generally specified as a function of materials and spacings

	employed throughout the power supply.
Leakage Current	The AC or DC current flowing from input to output and/or chassis of an isolated power supply at a specified voltage.
Line Regulation	The change in value of DC output voltage resulting from a change in AC input voltage over a specified range, or from low line to high line or from high line to low line. Normally specified as the + or - change from the nominal DC output voltage.
Load Regulation	The change in value of DC output voltage resulting from a change in load resistance from open circuit to a value that yields maximum rated output current, or from full load to open circuit.
Minimum Loading	Minimum current required for voltages to be in specified range. Generally in multiple output power supplies, a minimum load is required on the main output to ensure regulation of auxiliary outputs.
MTBF (Mean Time Between Failure)	The failure rate of a power supply, expressed in hours, established by the actual operation or calculation from a known standard such as MIL-HDBK-217.
Output Current Limiting	An output protection feature which limits the output current to a predetermined value in order to prevent damage to the power supply or the load under overload conditions. The supply is automatically restored to normal operation following removal of the overload.
Output Voltage (DC)	The nominal value of the DC voltage at the output terminals of a power supply.
Overcurrent (Overload) Protection	Protection of the power supply and associated equipment against excessive output current, including short-circuit current. Protection circuitry is electronic with automatic recovery. Current characteristic is normally foldback type.
Overshoot	A transient change in output voltage in excess of specified output regulation limits that can occur when a power supply is turned on/off, or when there is a step change in line or load.
Overvoltage Protection	A power supply feature which shuts down the supply, or crowbars or clamps the output, when its voltage exceeds a preset level.
PARD (Periodic and Random Deviation)	A term used for the sum of all ripple and noise components measured over a specified band width and stated in either peak-to-peak or RMS values.

Power Factor (input)	Ratio of true input power to the apparent power (rms voltage x rms current) in AC circuits. This power is generally considered to be wasted, but can be corrected for.
Ripple and Noise	The magnitude of AC voltage on the output of a power supply, expressed in millivolts peak-topeak or RMS, at a specified bandwidth. This is the result of feed through of the rectified line frequency, internal switching transients, and other random noise.
Shock and Vibration	A specification requirement for which a power supply is designed or tested to withstand, such as 20 G shock for 11 milliseconds and 10 G random vibration for 2 hours over a 2 - 2000 Hz bandwidth.
Short-circuit Protection	A feature which limits the output current of a power supply under short-circuit conditions so that the supply will not be damaged.
Start-Up Time	Time required for the output of a power supply to reach its full load after input power is turned on.
Switching Frequency	The rate at which the DC voltage is switched in a DC-DC converter or switching power supply.
Temperature Coefficient	A ratio by which the changes in power supply output voltage caused by temperature changes can be calculated. Usually output decreases as ambient temperature rises.
Temperature (Range), Operating	The range of ambient or case temperatures within which a power supply may be safely operated and meet its specifications.
Temperature (Range), Storage	The range of ambient temperatures within which a power supply may be safely stored, non-operating, with no degradation in its subsequent operation.
Thermal Protection	An internal safeguard circuit in a power supply that shuts down the unit in the event of excessive internal temperature.
Transient Response	Time required for output voltage to return to regulated value after a step change of output current, usually specified in microseconds for a specified percentage of load change.