How they do what they do

In the linear or series-pass supply (a), the ac line voltage is stepped down through a transformer. The low-voltage alternating current is rectified to give an unregulated direct-current voltage about 5 volts higher than the desired output. The extra voltage is dropped in a variable dissipating element (the series-pass element).

This dissipating element is shown in the sketch as a variable resistor, but it actually is one or more power transistors operating in the linear mode; hence the term linear power supply. A control circuit continuously senses the output voltage and adjusts the transistors to maintain the desired level.

The linear supply provides excellent regulation, is reliable, and does not generate electrical noise. But the line-voltage transformer makes it large and heavy, and the heat sink for the pass transistor adds to the bulk. Also, the dissipative mode of regulation makes the linear supply inefficient—about 60% of the input power is wasted in low-voltage supplies—and requires cooling provisions.

If the ac line-voltage goes too high, the output voltage is unaffected. The series transistor merely dissipates extra power. If the input ac line voltage drops below the design value even momentarily, the output voltage drops too, because the low-voltage capacitor that holds the unregulated dc cannot store enough energy to maintain the output against a momentary line-voltage dip.

The switching power supply (b) rectifies the ac line voltage directly, storing energy in a high-voltage capacitor. The high dc voltage is switched at high frequency (around 20 kilohertz) across a transformer and then is rectified to provide the regulated dc output voltage desired. The switches used in the dc-to-dc conversion are actually power transistors, operating in the highly efficient switching mode; hence the term switching power supply.

A control circuit senses the output voltage and provides regulation by adjusting the duty cycle of the transistors—the length of time that the switches are closed to charge the output capacitor. Because this charging is done in pulses and correction for a voltage change may require several pulses, the regulation response is not as fast as in the linear supply—resulting in reduced regulation.

The on-off switching in these supplies can generate electrical noise that may be radiated and conducted to other parts of the system unless special precautions are taken. The operation at high voltage and the greater number of components required make the switching supply more susceptible to failure than a linear supply. But it is lighter, smaller, and cooler, as well as less expensive to operate because of its greater efficiency. Also, the energy storage at high voltage provides some protection against brief drop-off of line power.

The ferroresonant supply (c) is the simplest and most reliable of the three types of regulated power supply. The input ac line voltage is applied to the primary of a transformer, exciting flux in the iron. A resonant secondary circuit causes part of the iron to saturate. A magnetic shunt provides a flux path for the secondary so that the primary flux remains unsaturated. The output secondary coil is across the saturated core, so the output voltage has a square waveform. Therefore the rectified output is fairly well regulated without the need for any external control circuitry. Inherently a current-limiting device, the supply automatically protects against overload.

The resonant circuit also provides protection against dips in line voltage, but is very sensitive to line frequency. So line-frequency stability must be assured.