# Power Supplies

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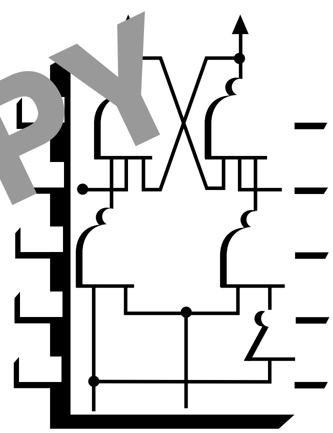
POWER SUPPLIES

Lesson One

# Power Supplies and Power Conditioners





TPC Training Systems

25201

*Lesson*

# 1 Power Supplies and Power Conditioners

## TOPICS

**Functions of Power Supplies and Power Conditioners**
**ac-to-dc Power Supplies**
**ac-to-ac Power Supplies**
**ac-to-dc Power Supplies (Rectifiers)**
**dc-to-ac Power Supplies (Inverters)**
**Inverter Feedback Circuits**
**Power Conditioners**
**Safety Precautions**

## OBJECTIVES

**After studying this Lesson, you should be able to…**

- Discuss the basic functions of power supplies and power conditioners.
- Describe dc-to-dc, ac-to-ac, ac-to-dc, and dc-to-ac power supplies.
- Compare the operation of transformer-driven and oscillator-driven inverters.
- Discuss the functions of filters, voltage regulators, voltage dividers, switching power supplies, and ferroresonant power supplies.
- Explain why low voltages can be dangerous.



## KEY TECHNICAL TERMS

**UPS** 1.04 uninterruptible power supply
**Power supply** 1.05 a circuit or device that converts available power into usable power
**Power conditioner** 1.07 a circuit or device that improves the quality of input power
**Rectifier** 1.19 a circuit that changes alternating current to direct current
**Inverter** 1.21 a circuit that changes direct current to alternating current

**Power supplies can provide electrical power when none is available or convert available power into power that can be used by electronic circuits. Conversion alone does not improve the quality of the input power, so power conditioners are added for sensitive or critical applications. In this Lesson, you will read about different kinds of power supplies and conditioners and how they are used.**

### Functions of Power Supplies and Power Conditioners

1.01 Electronic components and circuits must have electrical power (usually direct current) in order to operate. Components normally use a single low voltage, typically 5 volts, and a single polarity, either positive (+5 V) or negative (-5 V). Circuits often require several voltages and both polarities, typically +5 V, +12 V, and -12 V.

1.02 Power supplies and power conditioners are the circuits or devices that supply the necessary electrical power for the variety of conditions at which electronic equipment operates. Sometimes no power is available, perhaps under normal conditions, perhaps because the operating power is turned off, or perhaps because of main power failure. Sometimes power is available, but one or more of its characteristics—frequency, voltage(s), or polarity—is incorrect for the application.

1.03 When no power is available under normal conditions, the power supply is some kind of stored electrical energy (for example, a battery) or generated electrical energy (for example, from a solar cell, which converts light into electricity). When operating power is off, stored energy from capacitors can supply power for a short time (for example, during battery replacement) and batteries can supply energy for longer periods of time (for example, for maintaining computer memory and clocks).

1.04 Main power failure does not permit normal, orderly shutdown. Computers lose data and industrial process control systems become hazardous. The best defense is an *uninterruptible power supply* (*UPS*), usually consisting of continuously charged batteries with enough capacity to maintain operation while an orderly shutdown, a switch to backup power, or a restoration of main power can be made.

1.05 When main power is available, it seldom has the right characteristics for electronic equipment. Main power almost universally is alternating current (ac) at 50 or 60 Hz (hertz, cycles per second), but electronic devices usually require direct current (dc) or ac at much higher frequencies. Main power usually is available in a range of 100 to 240 V (100 V in Japan, 120 V in the United States, and 220 V in most of the rest of the world), much too high for direct operation of electronic circuits. *Power supplies* provide required conversions:

- ac to dc—conversion
- ac to ac—different frequencies
- dc to dc—different voltages, single to multiple voltages, or different polarities
- dc to ac—inversion.

1.06 Power supplies perform the necessary conversions but do not, by themselves, improve the quality of the main power. For example, household power (in the U.S.) may vary from 100 to 130 V ac, and appliances may be labeled for 110, 115, 117, or 120 V ac. Frequency also varies slightly from 60 Hz.

1.07 Simple power supplies repeat these undesirable input variations at a different output level and also produce *ripple* in their dc output. Ripple appears on an oscilloscope as a wave instead of a straight line. The ripple wave is not alternating current, though—it always has the same polarity. The effect on radios may be negligible, but televisions are seriously affected, and computers may become inoperable if the quality of main power is not improved. Therefore, power supplies for electronic equipment have *power conditioners* either built-in or added to them to provide stable and regulated output from the varying input.

1.08 Power supplies include transformers, fuses, diodes and other rectifiers, transistors, resistors, and capacitors. These may be discrete (individual) components wired together, or the functions of an integrated circuit (IC), or a combination of both.

1.09 Power conditioners are combinations of circuits that provide frequency regulation, voltage regulation, ripple filtering, and current regulation or limiting. Power-conditioning circuits are added to, or incorporated into, power supplies for sensitive or critical applications. Note carefully that the term "power supply" is used for both simple convert-only devices and sophisticated power-conditioning devices. Consult and evaluate the specifications for the device when you select a power supply for an application.

### dc-to-dc Power Supplies

1.10 The simplest dc-to-dc power supply is a resistor in series with a load, as shown in Fig. 1-1. If the current drawn by the load does not change, the voltage across the resistor will be as steady as the source voltage. The series resistor is often called a *voltage dropping resistor* or just a *dropping resistor*. Here's how to determine the voltage supplied to the load:

$$V_{out} = V_{in}\left(\frac{R_L}{R_I + R_L}\right)$$

where $V_{out}$ = voltage across the output

$V_{in}$ = voltage across the input

$R_L$ = resistance of the load.

$R_I$ = resistance of the series resistor

You can calculate the load resistance by using Ohm's law, $E = I \times R$. The current is apt to be at milliampere levels, so remember that $E$ is voltage in volts, $I$ is current in amperes, and $R$ is resistance in ohms. Ohm's law helps show the main disadvantage of using a dropping resistor—it wastes power.

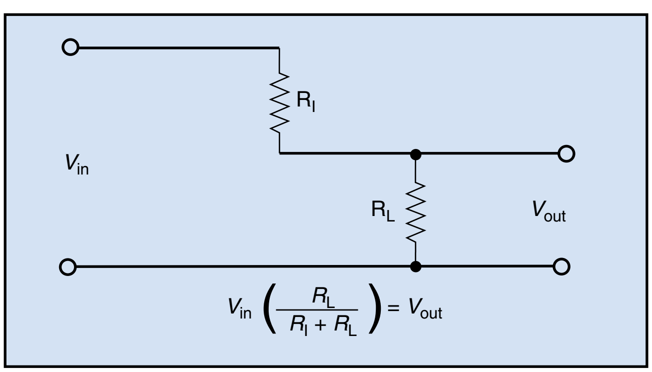
1.11 A circuit that has a dc-to-ac inverter plus an ac-to-dc power supply and filter provides an output voltage *greater* than the voltage applied by the power source. Figure 1-2 shows this kind of circuit.

**Application 1-1**

Despite what Disney people might say, Herb's car, Herbie, a 1952 Volkswagen, wore out its motor after 40 years and half a million miles. Herb got a new motor instead of a new car. The new motor was easy enough to find and install. Its ignition, starter, and alternator required 12 V, and a new battery solved that problem. But Herb didn't want to change Herbie's lights, horn, radio (AM only), and wipers, which operated on 6 V. Fortunately, all the electrical equipment was powered by one heavy wire from the battery, divided into circuits at the dashboard.

Herb turned everything on at the same time and then measured the current ($I$) drawn from the 6-V ($E$) battery. Using Ohm's law, he calculated the resistance ($R$) needed to reduce the voltage to zero—this was the dropping resistance needed to reduce 12 V to 6 V. Also, by multiplying $E$ times $I$, he knew the power rating the resistor would need. Herb installed the dropping resistor in the feed wire to the dashboard, and Herb and Herbie started out with lights blazing and radio blaring to make a million.

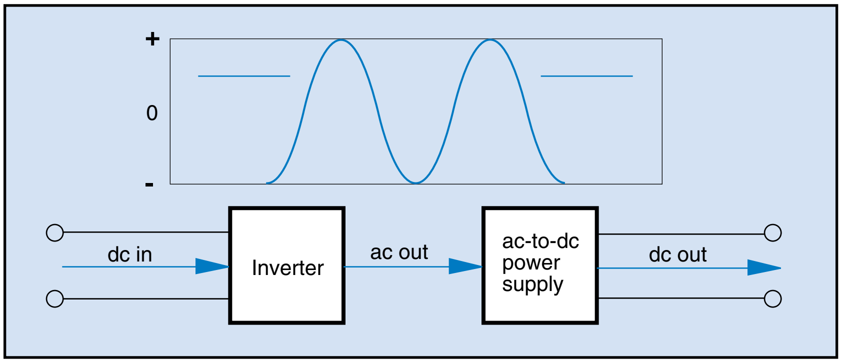
**Fig. 1-1. Simple dc-to-dc power supply**




### ac-to-ac Power Supplies

1.12 The dropping resistor used in dc-to-dc power supplies also can be used for ac-to-ac power supplies. However, the most common way to convert ac voltage levels is with a transformer. A *transformer* is made from two or more coils of wire wound around a core of magnetic material (usually iron), as shown in Fig. 1-3. The function of the transformer is to deliver an output voltage that is higher or lower than the input voltage. One coil, called the *primary*, is connected across the ac voltage source. The alternating current in the primary creates an alternating magnetic field which,

**Fig. 1-2. dc-to-dc power supply with inverter**




in turn, induces an ac voltage across the secondary coil.

1.13 The relationship between input and output voltages depends on the number of turns of wire in the primary and secondary coils. If the primary coil has half as many turns as the secondary coil, the voltage across the primary is half the voltage across the secondary (ignoring small losses).

1.14 If a transformer delivers current to a load connected across the secondary coil, the transformer must draw current from the source. If the primary has half as many turns as the secondary, the current in the primary is twice the current in the secondary. The ratio of input current to output current always equals the reciprocal of the ratio of the number of turns in the primary to the number of turns in the secondary.

1.15 A transformer's input and output power are nearly equal. There is no gain or loss of power, except for slight losses due to resistance in the coils and certain conditions in the core. If a transformer primary is connected across a 120-V ac source and has ten times as many turns as the secondary, the transformer output is 12 V ac. If a load draws 5 A (amperes) from the secondary, the primary draws 0.5 A from the 120-V source. The power into the transformer is 60 watts (120 V × 0.5 A) and the power out is 60 watts (12 V × 5 A). Allowing for the slight losses mentioned above, output power might actually be about 59.9 watts.

1.16 Figure 1-4 on following page shows a schematic of a transformer with two secondaries. The core concentrates the magnetic field for maximum coupling of each secondary to the primary. Several secondaries, with different numbers of turns, can be wound on one core.

1.17 A transformer has several advantages over a dropping resistor. It is very efficient due to a very low power loss, even with a large voltage difference between the primary and the secondary. The voltage can be different across each of several secondary coils. The voltage across any secondary is determined by the primary-to-secondary turns ratio. No electrical connection is needed between the primary and the secondary, because power is transferred by the magnetic field. This electrically isolates the transformer input from its output.

1.18 However, at the slow cycle speeds of 50 and 60 Hz, transformers are relatively large and heavy. They produce heat, vibration, and, frequently, a hum or other noticeable sound because large amounts of power are being transferred during each cycle. These disadvantages can be overcome by adding frequency-increasing circuitry ahead of the transformer and using a high-frequency transformer, which is smaller,



**Fig. 1-3. Transformer**

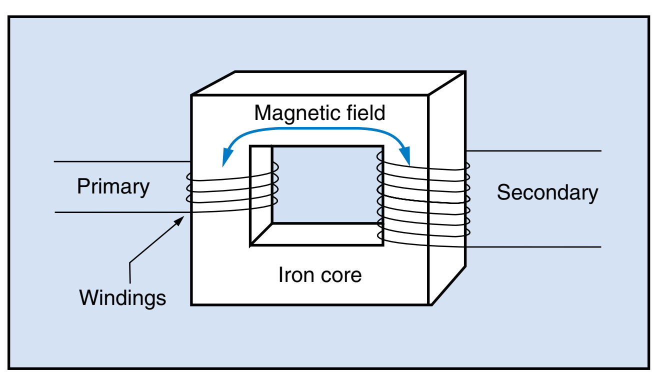
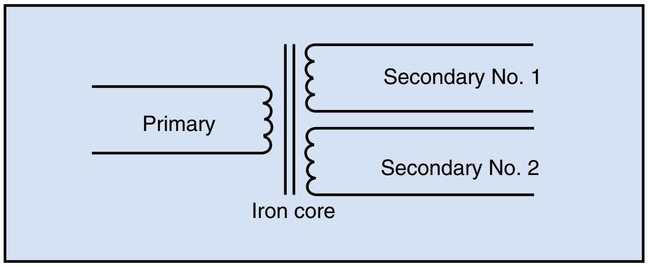


**Fig. 1-4. Transformer schematic**




lighter, and quieter because less power is transferred during each cycle. The output voltage and current are the same both for low-frequency (few high-power pulses) and for high-frequency (many low-power pulses) transformers.

**Application 1-2**

An engineer and a technician were designing a test box to check out company equipment in remote weather stations. A technician would have to carry the test box quite a distance on foot to some of the sites. The test box already weighed 20 lb with just the circuit boards and other needed equipment—and the box did not yet contain a power supply. The technician began to research power supplies. The best he found in looking through his catalogs was a power supply that weighed 9 lb. He knew that 9 lb added to the existing 20-lb test box would be a real problem for the unlucky technician—maybe him—who had to carry the box from the vehicle to the weather station.

The new engineer was something of a power supply expert, so the technician asked him for suggestions. He gave the technician a high-frequency power supply catalog. One device met all the requirements, weighed only 1.5 lb, and took up just half the space of a regular power supply, leaving plenty of room for the necessary frequency-increasing circuit. The high-frequency power supply was ordered and the test box completed. And the technician was relieved that he wouldn't have to carry a 29 lb test box into the back country!

### ac-to-dc Power Supplies (Rectifiers)

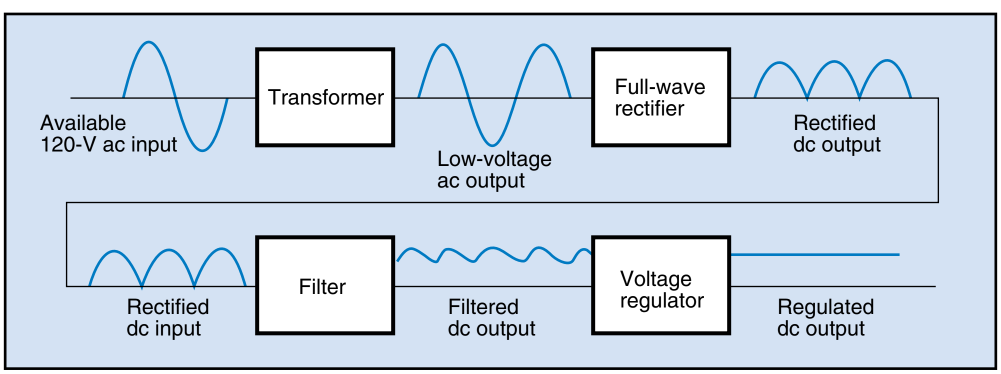
1.19 The most common power supply is ac-to-dc. This arrangement uses a *rectifier*, which conducts current in one direction but not the other. When used with an ac voltage source, the rectifier converts the ac input to pulsating dc output.

1.20 Figure 1-5 is a block diagram of a typical ac-to-dc power supply. Voltage (typically 120 V ac) from a utility line is applied across the primary of a transformer. The transformer isolates the power supply from the utility's system ground and reduces the voltage of the ac output from the secondary. The transformer output is the input to the rectifier, which delivers a pulsating dc output. The rectifier output is the input to the filter, which smooths out the pulses from the rectifier. The filter output is the input to the voltage regulator, which maintains a constant voltage output, even if the power drawn by the load changes.

**The Programmed Exercises on the next page will tell you how well you understand the material you have just read. Before starting the exercises, remove the Reveal Key from the back of your Book. Read the instructions printed on the Reveal Key. Follow these instructions as you work through the Programmed Exercises.**

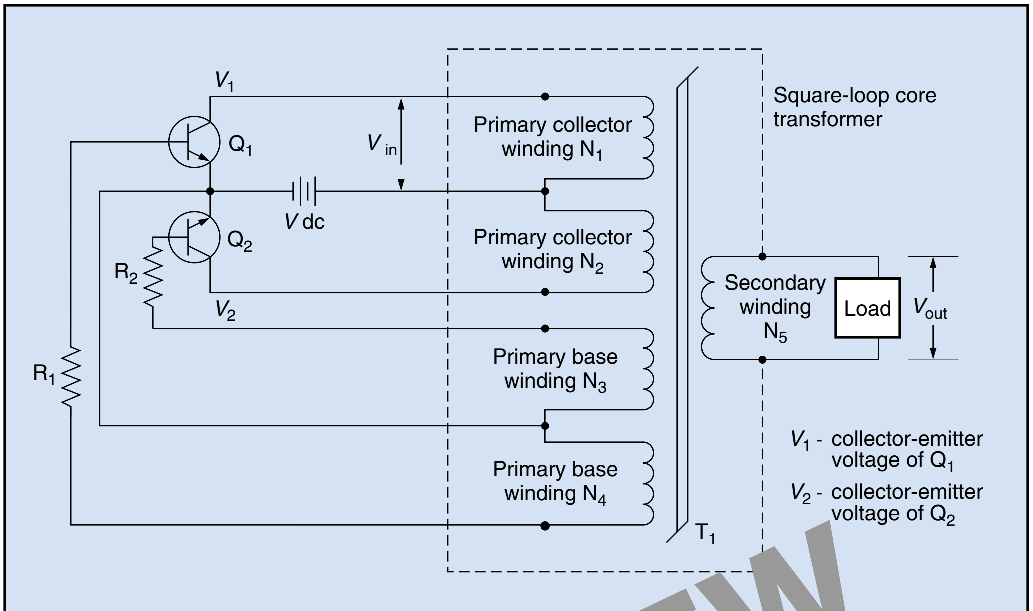


**Fig. 1-5. ac-to-dc power supply**



| | |
|---|---|
| 1-1. Electronic components and circuits usually need ________ current to operate. | 1-1. DIRECT<br><br>Ref: 1.01 |
| 1-2. A(n) ________ provides backup power during main power failures. | 1-2. UNINTERRUPTIBLE POWER SUPPLY (UPS)<br><br>Ref: 1.04 |
| 1-3. Main power almost always is ________ current at ________ Hz. | 1-3. ALTERNATING; 50 or 60<br><br>Ref: 1.05 |
| 1-4. Power supplies include ________ to provide stable and regulated output from varying input. | 1-4. POWER CONDITIONERS<br><br>Ref: 1.07 |
| 1-5. The simplest dc-to-dc power supply is a(n) ________ in series with a load. | 1-5. DROPPING RESISTOR<br><br>Ref: 1.10 |
| 1-6. The most common ac-to-ac power supply uses a(n) ________. | 1-6. TRANSFORMER<br><br>Ref: 1.12 |
| 1-7. If a transformer primary has half as many turns as the secondary, the current in the primary is ________ the current in the secondary. | 1-7. TWICE<br><br>Ref: 1.14 |
| 1-8. A(n) ________ converts ac power to dc power. | 1-8. RECTIFIER<br><br>Ref: 1.19 |

**Fig. 1-6. Single-transformer inverter circuit**



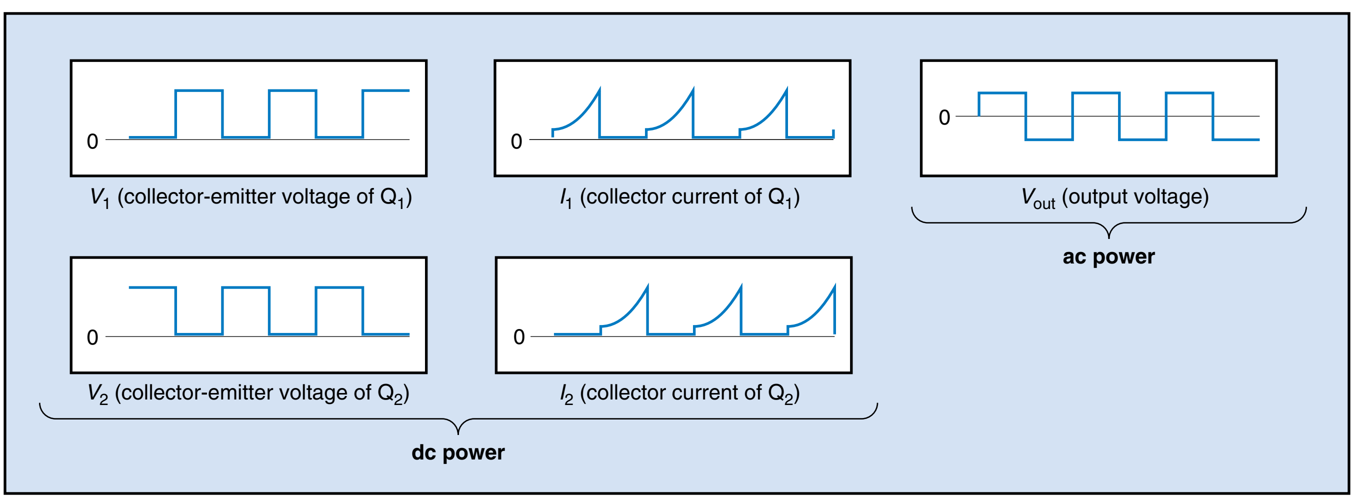

## dc-to-ac Power Supplies (Inverters)

1.21 Circuits that change direct current to alternating current are called *inverters*. Inverters are used if an ac voltage is needed and only dc is available. For example, they are sometimes used for operating ac devices in automobiles, boats, and airplanes. Any device, from a simple electric shaver to a complex computer, can be operated from inverters. Inverters deliver from 60 Hz up to 400 Hz ac power, usually at 115 V ac. High-frequency inverters use smaller, lighter, and less expensive transformers in the power supply. Waveform and frequency regulation are important measures of inverter quality.

1.22 **Single-transformer inverter.** The simplest kind of inverter is the magnetic inverter. A single-transformer magnetic inverter, shown in Fig. 1-6, is made of transistors, resistors, a battery, and a transformer. The transformer core is shown with a "tail" at top and bottom to indicate a *square-loop core*, so-called because its magnetizing pattern is squared off compared to ordinary transformers. Square-loop cores are quite expensive and sometimes hard to locate.



**Fig. 1-7. Inverter waveforms**



1.23 If a battery is connected to the circuit shown in Fig. 1-6, the collector circuit of one transistor begins to conduct. Which transistor turns on first depends on transistor gain and base resistor values. Assume that transistor $Q_1$ turns on first. The potential difference across the collector winding ($N_1$) causes a potential across $N_2$, $N_3$, and $N_4$. The magnetic field produced by $N_1$ causes current in the same direction through all the windings. Base winding $N_4$ sends current to $Q_1$. The direction of the current forward biases $Q_1$ and reverse biases $Q_2$, blocking current through $N_2$ and $N_3$. Therefore, only transistor $Q_1$ is turned on.

1.24 The current increases (*ramps*) until the core reaches its maximum magnetic level. Now base winding $N_4$ cannot provide current to $Q_1$, which turns off. In turn, the potentials across primary windings $N_3$ and $N_4$ and secondary winding $N_5$ drop to zero. The battery then produces a potential of opposite polarity through the circuit. This causes $Q_2$ to be forward biased and $Q_1$ to be reverse biased, so $Q_2$ turns on and $Q_1$ remains off.

1.25 The current increases until the core again reaches it maximum magnetic level and $Q_2$ turns off. The cycle starts over and continues to turn $Q_1$ and $Q_2$ on and off. The reversing magnetism and current direction make the output of secondary winding $N_5$ an alternating current in the shape of a square wave, as shown in Fig. 1-7.

1.26 The frequency of the inverter shown in Fig. 1-6 depends not only on the battery voltage, but also on the transformer windings and the core magnetizing pattern. It can operate at 60 Hz up to 400 Hz. However, the frequency is difficult to control because it varies according to the resistance of the load. For applications that do not require precise frequency control, this kind of inverter is a good choice because it has few components and is relatively easy to build.

1.27 **Dual-transformer inverter.** Another kind of magnetic inverter uses two transformers, as shown in Fig. 1-8. Only the base circuit transformer ($T_1$) requires a square-loop core—the power transformer ($T_2$) contains ordinary core material. Because the base circuit requires only a small amount of power, a very small square-loop core can be used. This kind of inverter also produces a square wave.

1.28 **Oscillator-driven inverter.** A third kind of magnetic inverter, shown in Fig. 1-9, uses an oscillator to drive the transistors. This inverter is the most common for modern electronic devices because it uses inexpensive integrated circuits (ICs) and provides precise frequency control.

1.29 Another advantage of the oscillator-driven inverter is that it can control the output waveform. This is important because many circuits do not work well with square-wave power. The oscillator turns the transistors on and off in short pulses, producing a waveform more like a sine wave than a square wave.

1.30 The *stepped-wave inverter*, shown in Fig. 1-10 on the following page, also controls the output



**Fig. 1-8. Dual-transformer inverter circuit**

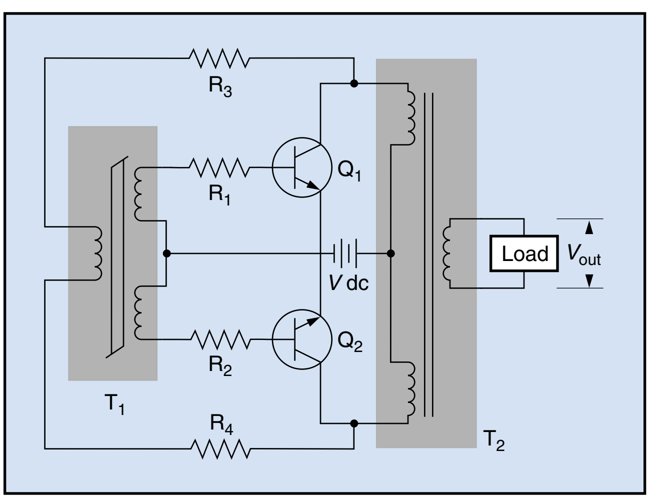



**Fig. 1-9. Oscillator-driven inverter circuit**

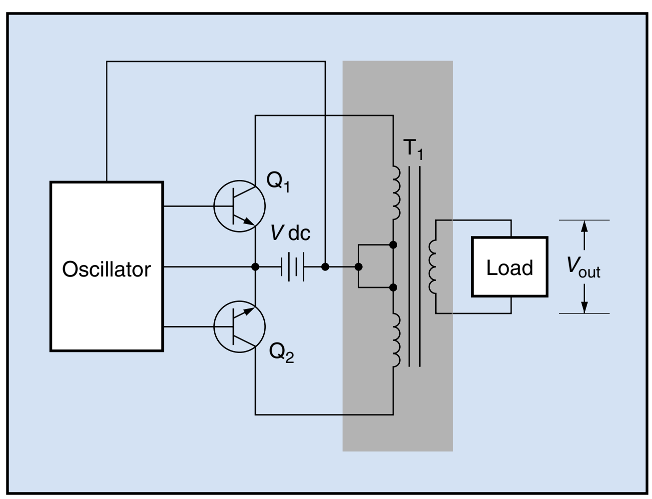


**Fig. 1-10. Stepped-wave inverter**

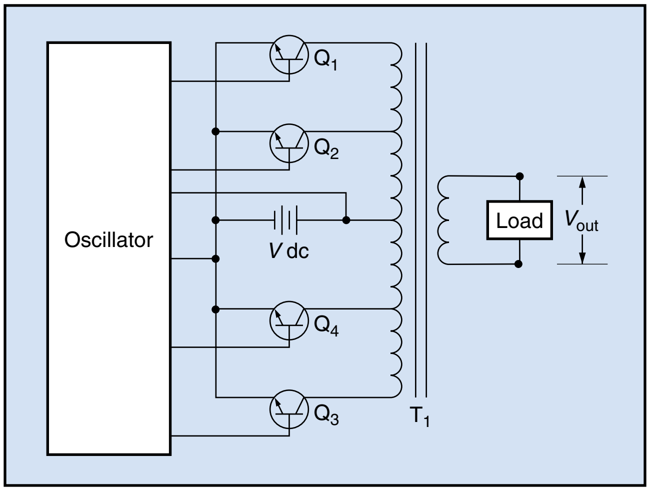
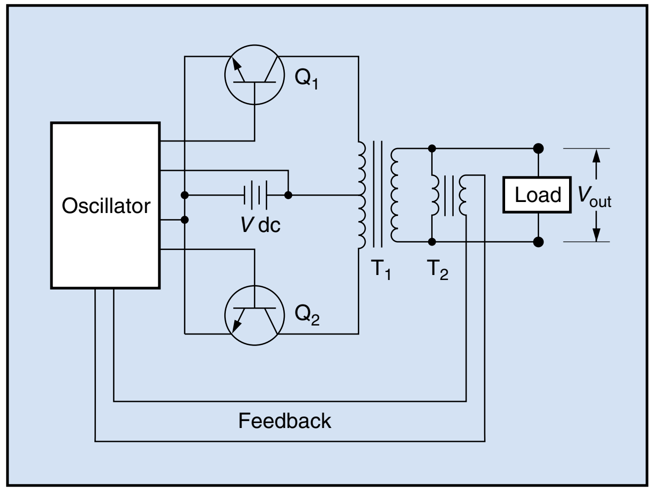



**Fig. 1-11. Inverter with transformer feedback**




waveform. This inverter uses four transistors in series. The oscillator keeps all transistors off for the first part of the cycle, then turns on transistor $Q_1$. Next it turns $Q_1$ off and $Q_2$ on, and then turns all transistors off. Next it repeats the cycle with transistors $Q_3$ and $Q_4$. When $Q_1$ or $Q_3$ is turned on, the input voltage is across more turns of the primary so that the output voltage is smaller than when $Q_2$ or $Q_4$ is turned on. This inverter produces a stepped wave, which approaches a sine wave when filtered.

### Inverter Feedback Circuits

1.31 Another advantage of using oscillator-driven inverters is that they can use feedback to control the voltage output. In the example shown in Fig. 1-11, transformer $T_2$ is connected with its primary across the secondary winding of power transformer $T_1$. The secondary of $T_2$ is filtered and rectified to produce a dc voltage that can be compared to a reference voltage. Transformer $T_2$ also provides electrical isolation of the oscillator from the load by means of its air gaps.

1.32 Sometimes a special feedback winding on the power transformer is used. If the output voltage of $T_1$ is too high, the oscillator output is decreased. If the output voltage of $T_1$ is too low, the oscillator output is increased. The output voltage can be controlled for normal variations in input frequency.

1.33 Feedback circuits sometimes make use of *optocouplers* to relay the signals from the output circuit to the input, as shown in Fig. 1-12. The power transformer output is connected through a resistor to a light-emitting diode (LED). The light output of the diode is picked up by a light-sensitive transistor that sends a feedback signal to the oscillator control circuit. The LED and the light-sensitive transistor usually are contained in the same 8-pin IC package. The term *optocoupler* refers to the whole package. The air gap of the optocoupler provides electrical isolation in this circuit.



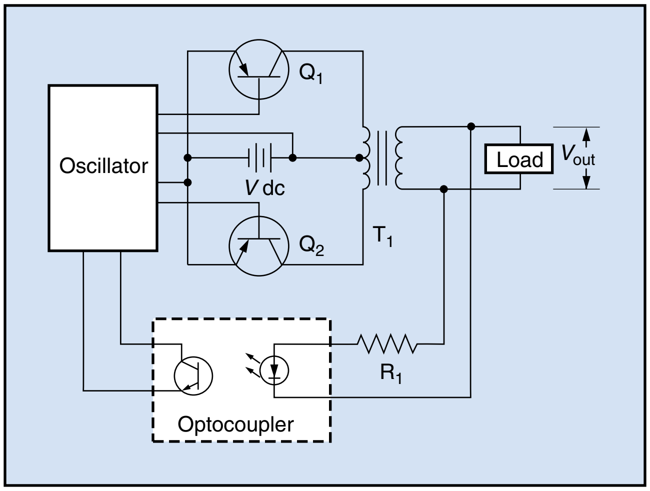
### Power Conditioners

1.34 **Filters.** Filters can be used in dc output power supplies (both ac-to-dc and dc-to-dc) and in ac output power supplies. In dc output power supplies, filters help smooth out the rectifier output pulses. However, filters are not capable of smoothing out the pulses completely—the output has a *ripple*, as shown in Fig. 1-13. In ac output power supplies, filters are used to shape the waveforms. That is, they remove the undesired parts of the waveform.

1.35 **Voltage regulators.** Loads can be connected directly to the output of the filter in an ac-to-dc power supply. However, any variations in input power can cause variations in the voltage supplied to the load, because power supplies have internal resistance. This resistance causes a voltage drop across components if the circuit carries a current. A voltage regulator eliminates these variations in voltage.

1.36 The regulator acts as a variable resistor and changes resistance automatically in response to changes

**Fig. 1-12. Inverter with optocoupler feedback**




in the power drawn by the load. This action maintains a constant voltage output from the power supply, as shown in Fig. 1-14. Changes in the ac input to the power supply also can cause the output to change. In this case, a voltage regulator at the input of the power supply can maintain a constant output voltage.

1.37 **Voltage dividers.** A voltage divider is used if several different voltages are required from one power supply and the loads are not excessive. For ac, a transformer with several outputs combined with separate rectifiers and filters could do the same job, but a voltage divider is less expensive and has fewer parts.

1.38 The voltage divider shown in Fig. 1-15 on the following page splits the incoming 20 V dc into three output voltages—20, 12, and 5 V dc. Resistors $R_1$, $R_2$, and $R_3$ are selected to provide the desired output voltages. This kind of circuit can produce any voltage between 0 V dc and the full input voltage. Variable (adjustable) resistors make selectable output voltages available to the user.

1.39 If voltage regulation is critical, the voltage divider can be connected between the filter and several voltage regulators, as shown in the top part of Fig. 1-16 on the following page. With this circuit, the filter output goes directly to the voltage divider. The input voltage is divided and fed to the voltage regulators. The voltage regulators then maintain each of the three voltages at a constant level.

1.40 If voltage regulation is not critical, the voltage divider can be connected to the output of a single regulator, as shown in the bottom part of Fig. 1-16. Changes in the current drawn by the load directly affect the three outputs of the voltage divider. Therefore, the resistors in the voltage divider must be chosen according to the current required by the load as well as the voltage requirements.

1.41 **Switching power supplies.** If component size and weight are a problem, you can use a switching power supply. In this circuit, the high-frequency output of an inverter permits the use of a high-frequency transformer, which is smaller and lighter than a low-frequency transformer. Inputs and outputs are shown in Fig. 1-17 on page 15:

- The rectifier converts the alternating current input to a direct current output.
- The filter smooths out the output pulses of the rectifier.
- The voltage regulator keeps the dc voltage at a constant level.
- The inverter changes dc input voltage to high-frequency ac output voltage.



**Fig. 1-13. Ripple in filter output**

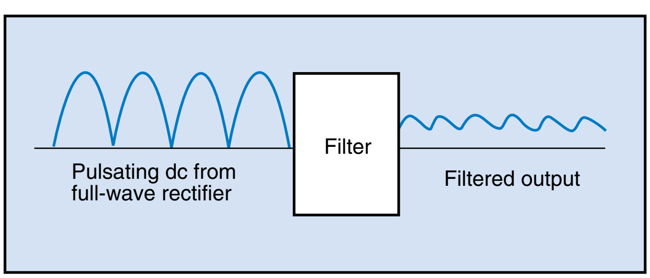



**Fig. 1-14. Effect of voltage regulator**

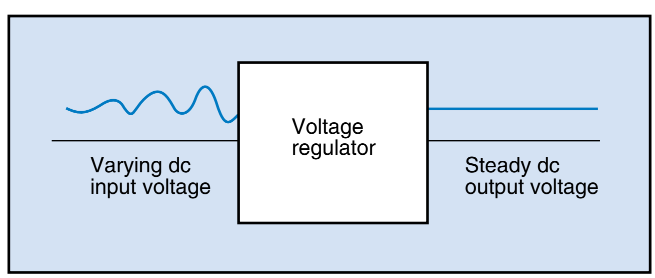
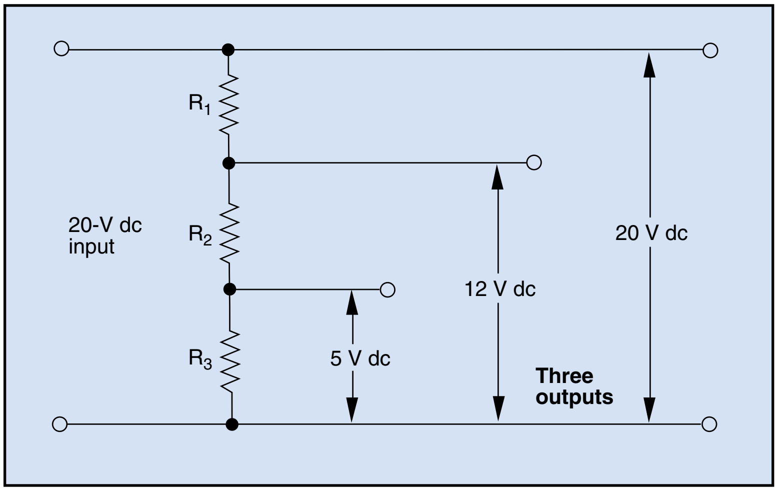


Fig. 1-15. Three-level voltage divider




- The transformer produces the proper voltage.
- Rectifiers and filters produce steady dc outputs from the transformer secondaries.

1.42 **Ferroresonant power supplies.** Some partially regulated supplies use an additional transformer winding with a capacitor to form an inductor-capacitor circuit that saturates the transformer core for a part of each cycle. These *ferroresonant power supplies* are slightly heavier than other power supplies, but the cost is low, regulation is improved, and reliability is high. Because the additional winding is tuned to a specific line frequency, different ferroresonant transformers are required for 50- and 60-Hz applications.



### Safety Precautions

**WARNING:**

**Even low voltages can be dangerous!**

1.43 When you are working with power supplies, it is important to remember that *electricity can kill you!* The current does the damage, not the voltage, but even low voltages provide enough current to be dangerous, especially if your hands or feet are wet. Also remember that transformer outputs can be much higher than their inputs.

Fig. 1-16. Voltage divider connections

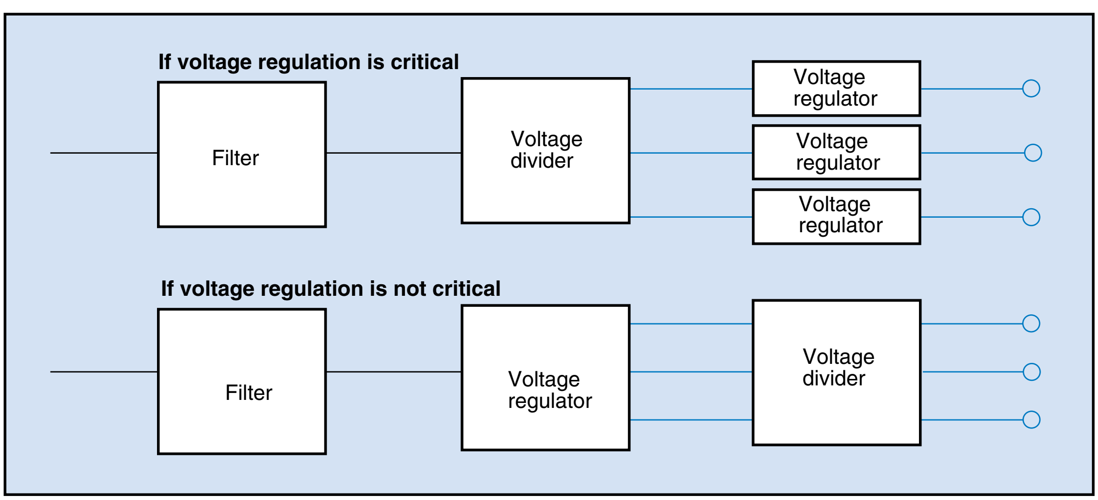
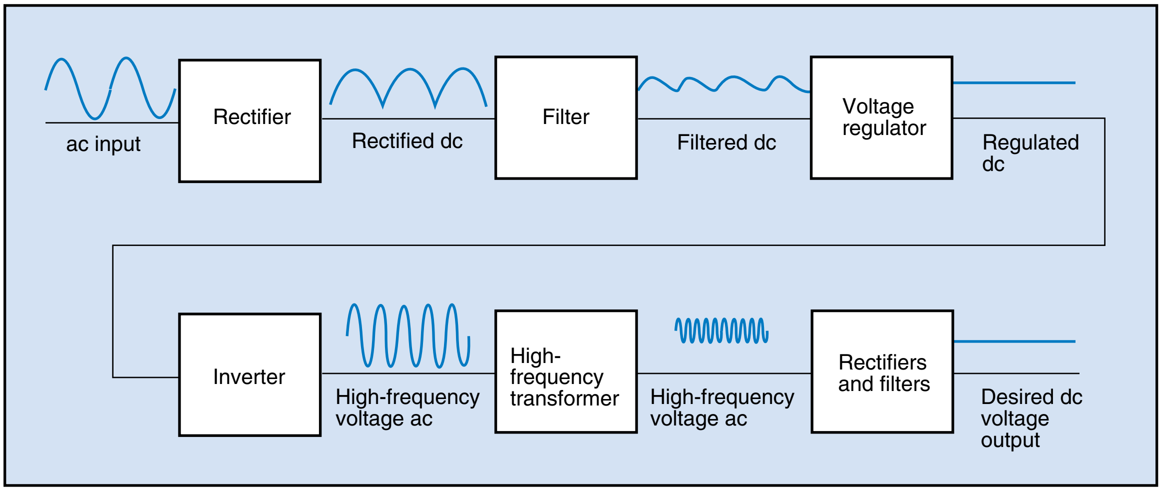


**Fig. 1-17. Switching power supply**




1.44 Low-voltage power supplies can be dangerous if they are connected to the power line. For safety reasons, all ac lines from the power company have one wire connected to the ground. The other wires may be at 120 V, 240 V, or some other voltage ac to ground.

1.45 Leakage current paths can connect the low-voltage power supply to the hot wire of the power source. If you must work on the power supply while it is connected, always remember that it might be connected to a high-voltage wire and that *you* can become the path to the ground if you touch it. Also remember that many power supplies include large capacitors that store energy, creating a hazard even when power is disconnected.

1.46 Ground connections are everywhere. Metal workbench frames, equipment cabinets, and even bare concrete floors can carry enough current to ground to cause severe burns, injuries, and death. The green wire connected to the ground connector on a power plug is a safety connection. Always make sure that the green wire is connected to the metal shell or cabinet surrounding the electronic equipment. This way, if there is a short circuit or a leakage path to the metal cabinet, the green wire—rather than the person who touches the equipment—will carry the current to ground.



**WARNING:**

**Electricity can kill you!**

| | |
|---|---|
| 1-9. A dc-to-ac power supply is called a(n) ________. | 1-9. INVERTER<br>Ref: 1.21 |
| 1-10. Transformer-driven inverters require a(n) ________ core. | 1-10. SQUARE-LOOP<br>Ref: 1.22 |
| 1-11. Single-transformer inverters can operate at a frequency range of ________. | 1-11. 60 to 400 Hz<br>Ref: 1.26 |
| 1-12. An optocoupler is sometimes used in an inverter ________ circuit. | 1-12. FEEDBACK<br>Ref: 1.33 |
| 1-13. A(n) ________ maintains the output of a power supply at a constant voltage. | 1-13. VOLTAGE REGULATOR<br>Ref: 1.35 |
| 1-14. A voltage divider can provide several voltages from one power supply if the loads require only ________ currents. | 1-14. LOW<br>Ref: 1.37 |
| 1-15. Small size and light weight are advantages of using a(n) ________ power supply. | 1-15. SWITCHING<br>Ref: 1.41 |
| 1-16. Leakage current paths can connect a low-voltage power supply to the ________ of the power source. | 1-16. HOT WIRE<br>Ref: 1.45 |

**Answer the following questions by marking an "X" in the box next to the best answer.**

1-1. If failure of main power could cause hazards or loss of critical data, the system requires a(n)

- ☐ a. converter
- ☐ b. inverter
- ☐ c. transformer
- ☐ d. UPS

1-2. The use of a resistor in series with a load is a common means of providing a simple ________ power supply.

- ☐ a. ac-to-ac
- ☐ b. ac-to-dc
- ☐ c. dc-to-ac
- ☐ d. dc-to-dc

1-3. If a transformer primary has 20 turns and the secondary has ten, the voltage across the primary is ________ the voltage across the secondary.

- ☐ a. half
- ☐ b. the same as
- ☐ c. twice
- ☐ d. ten times

1-4. The part of an ac-to-dc power supply that converts ac voltage to pulsating dc voltage is the

- ☐ a. filter
- ☐ b. rectifier
- ☐ c. transformer
- ☐ d. voltage regulator

1-5. In a typical ac-to-dc power supply, the output from the rectifier is the input to the

- ☐ a. filter
- ☐ b. optocoupler
- ☐ c. voltage divider
- ☐ d. voltage regulator

1-6. Transformers and optocouplers are used in oscillator-driven inverter power supplies to provide

- ☐ a. feedback
- ☐ b. filtering
- ☐ c. frequency regulation
- ☐ d. sine wave outputs

1-7. The power conditioner that adjusts output voltage to compensate for load changes is the

- ☐ a. filter
- ☐ b. rectifier
- ☐ c. voltage divider
- ☐ d. voltage regulator

1-8. Where should a voltage divider be connected if voltage regulation is critical?

- ☐ a. At the output of the rectifier
- ☐ b. At the output of the voltage regulator
- ☐ c. Between the filter and voltage regulators
- ☐ d. Between the rectifier and the filter

1-9. Different transformers are required for 50- and 60-Hz applications of ________ power supplies.

- ☐ a. ferroresonant
- ☐ b. inverter
- ☐ c. rectifier
- ☐ d. switching

1-10. The green wire in a power cord is

- ☐ a. a safety ground connection
- ☐ b. connected to the hot side of the power line
- ☐ c. connected to the load
- ☐ d. used only for backup

## SUMMARY

**Power supplies are needed to provide power or to convert available power into usable power. Power supplies may be divided into four groups: dc-to-dc, ac-to-ac, ac-to-dc, and dc-to-ac. The most common power supply is ac-to-dc. Rectifiers convert ac power to dc, and inverters changed dc power to ac. Inverters may be driven by transformers or oscillators. Oscillator-driven inverters use feedback to control the voltage output.**

**Power conditioners are built into or added to power supplies to regulate and stabilize the power supply. They include filters, voltage regulators, voltage dividers, switching power supplies, and ferroresonant power supplies. The filter smoothes out rectifier output pulses, and the voltage regulator maintains a constant voltage level.**

**The voltage divider provides different voltages from one power supply. Switching power supplies make use of high-frequency transformers to conserve space and weight. Ferroresonant power supplies provide an inductor-capacitor circuit that saturates the transformer core for a part of each cycle.**

**When working with power supplies, always remember that *electricity can kill you!* Even low voltages can be dangerous, especially if they are from a power supply connected to the power line. Always make sure that the green(grounding wire is connected to the metal cabinet surrounding electronic equipment so that *you* don't become the ground connection.**



### Answers to Self-Check Quiz

1-1. d. UPS. Ref: 1.04

1-2. d. dc-to-dc. Ref: 1.10

1-3. c. Twice. Ref: 1.14

1-4. b. Rectifier. Ref: 1.19

1-5. a. Filter. Ref: 1.20

1-6. a. Feedback. Ref: 1.31, 1.33

1-7. d. Voltage regulator. Ref: 1.35

1-8. c. Between the filter and voltage regulators. Ref: 1.39, Fig. 1-16

1-9. a. Ferroresonant. Ref: 1.42

1-10. a. A safety ground connection. Ref: 1.46