Amateur Radio Technician Exam Preparation Course

ARRL
The National Association for Amateur Radio®

Amateur Radio Technician Exam Prep Course

Module 3

Electricity, Components, and Circuits

3.1 Electricity
3.2 Components and Units
3.3 Radio Circuits

Fundamentals of Electricity

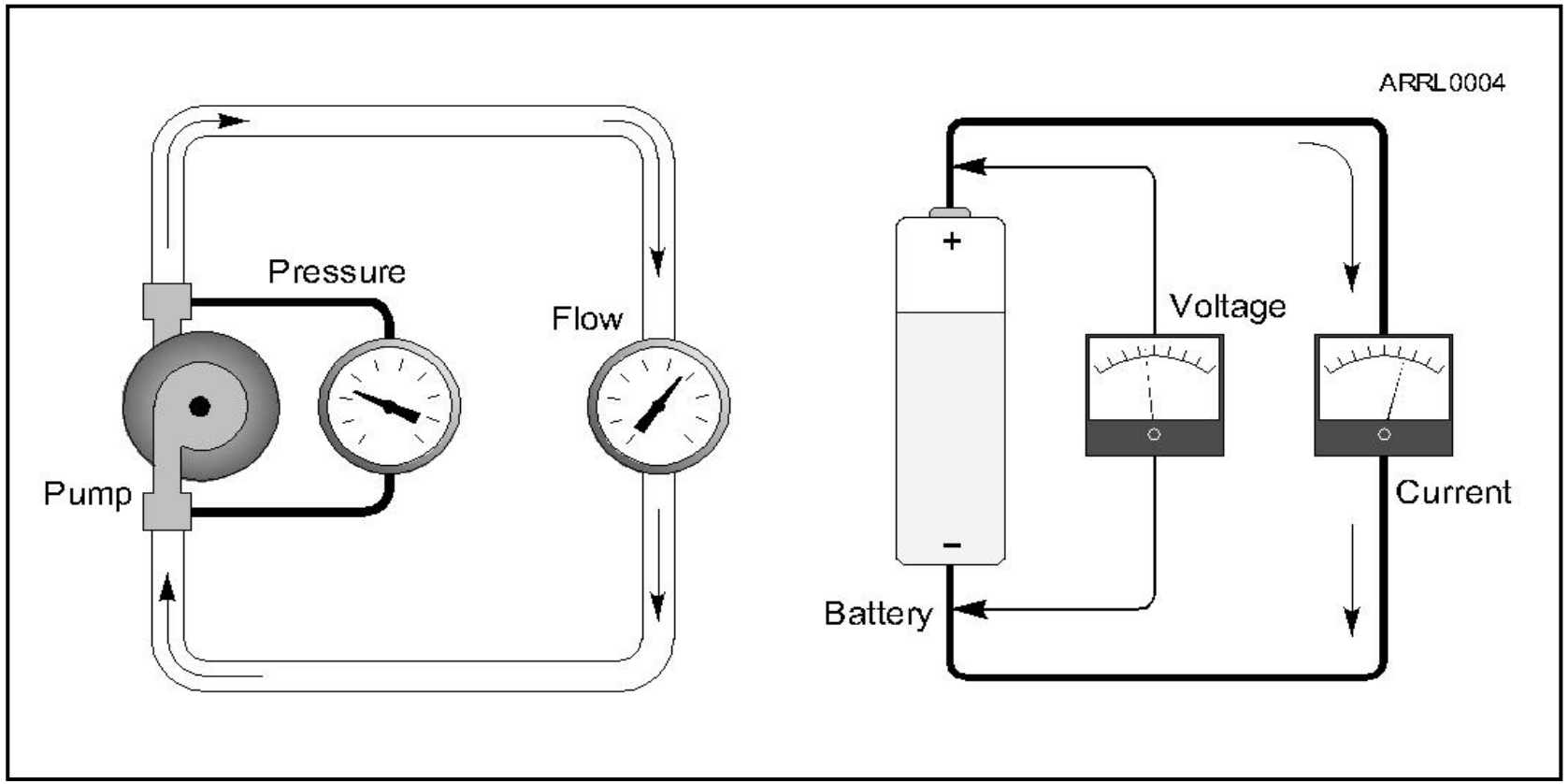
- Radios are powered by electricity and radio signals are a form of electrical energy
- A basic understanding of how we control electricity allows you to better install and operate your radio
- Electrical charge can be positive or negative
  - Opposite charges attract each other (like charges repel)
- Electrical current is the flow of ***electrons***
  - Electrons are negatively-charged atomic particles, usually surrounding an atom's positively-charged nucleus of protons (positive) and neutrons (neutral – no charge)
  - Electrons move in response to an ***electromotive force*** and can move independently of atoms

Basic Electrical Concepts

- Current: the movement of electrons, measured in *amperes* (***A***) by an *ammeter*, and represented by ***I*** (capital letter “i”) in formulas
- Voltage: the amount of electromotive force (emf), also called electrical potential, measured in *volts* (***V***) by a *voltmeter*, represented by ***E*** or ***V*** in formulas
- Resistance: the opposition to the movement of electrons, measured in *ohms* (***Ω***) by an *ohmmeter* and represented by ***R*** (sometimes Ω in scientific publications) in formulas
- Resistance is like friction and turns electrical energy into heat when current flows
- *Conductors* permit current flow (low resistance) and *insulators* block current flow (high resistance)

Basic Electrical Concepts (cont.)

- The flow of water through a pipe is a good analogy to understand the three characteristics of electricity and how they are related



Basic Electrical Concepts (cont.)

- *Polarity* refers to the convention that determines which voltages are positive and negative
- Voltage from a *source* of electrical energy causes current to flow
- *Resistance* is a material's opposition to the flow of current
- Voltage, current, and resistance affect each other
  - For example, higher voltage (bigger push) causes more current (more flow)

PRACTICE QUESTIONS

Electrical current is measured in which of the following units?

A. Volts
B. Watts
C. Ohms
D. Amperes

T5A01 D 3-1

What is the name for the flow of electrons in an electric circuit?

A. Voltage
B. Resistance
C. Capacitance
D. Current

T5A03 D 3-1

What is the electrical term for the force that causes electron flow?

A. Voltage
B. Ampere-hours
C. Capacitance
D. Inductance

T5A05 A 3-1

Which of the following describes alternating current?

A. Current that alternates between a positive direction and zero
B. Current that alternates between a negative direction and zero
C. Current that alternates between positive and negative directions
D. All these answers are correct

T5A09 C 3-1

Which instrument would you use to measure electric potential?

A. An ammeter
B. A voltmeter
C. A wavemeter
D. An ohmmeter

T7D01 B 3-1

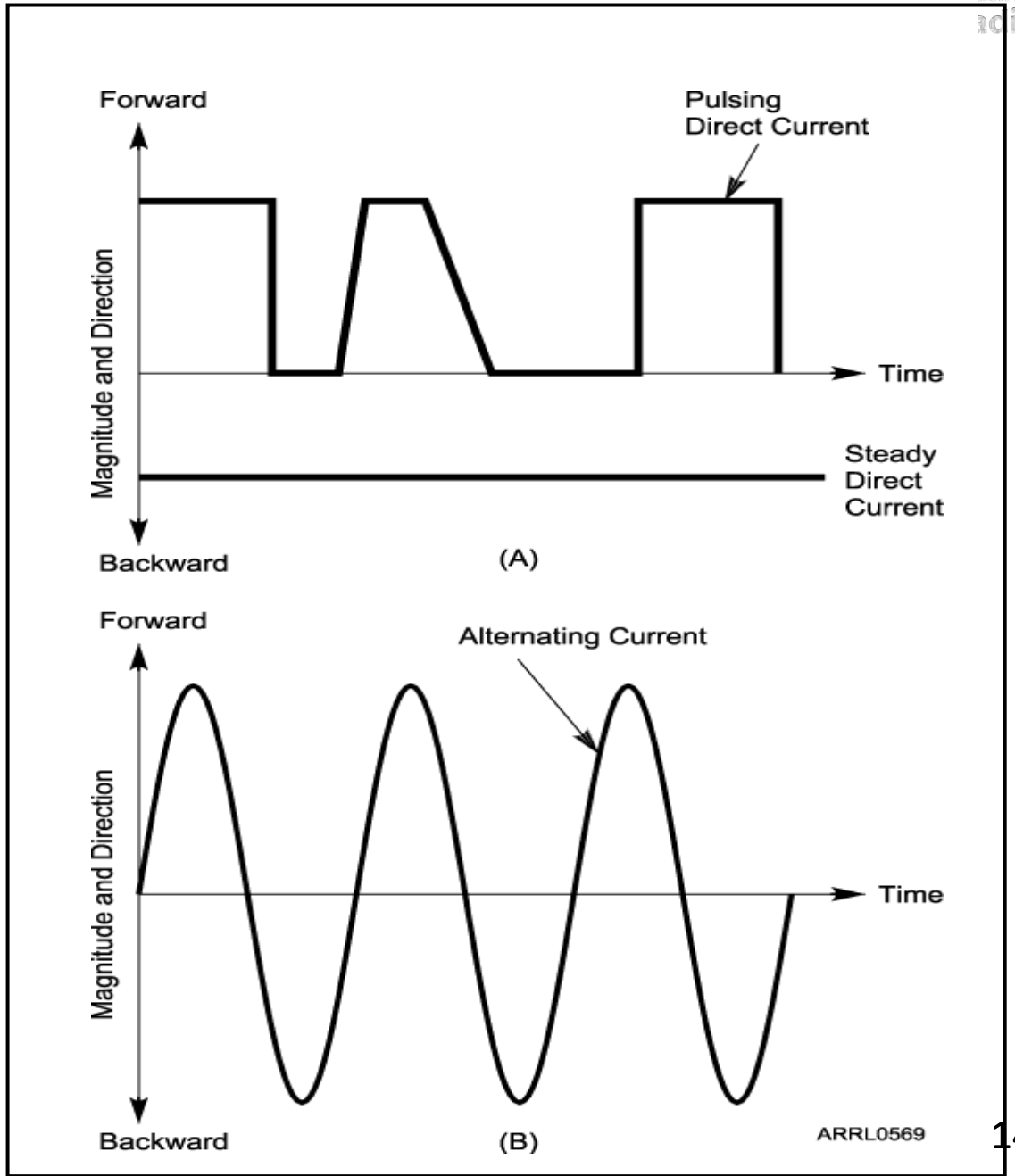
Which instrument is used to measure electric current?

A. An ohmmeter
B. An electrometer
C. A voltmeter
D. An ammeter

T7D04 D 3-1

The Two Kinds of Current

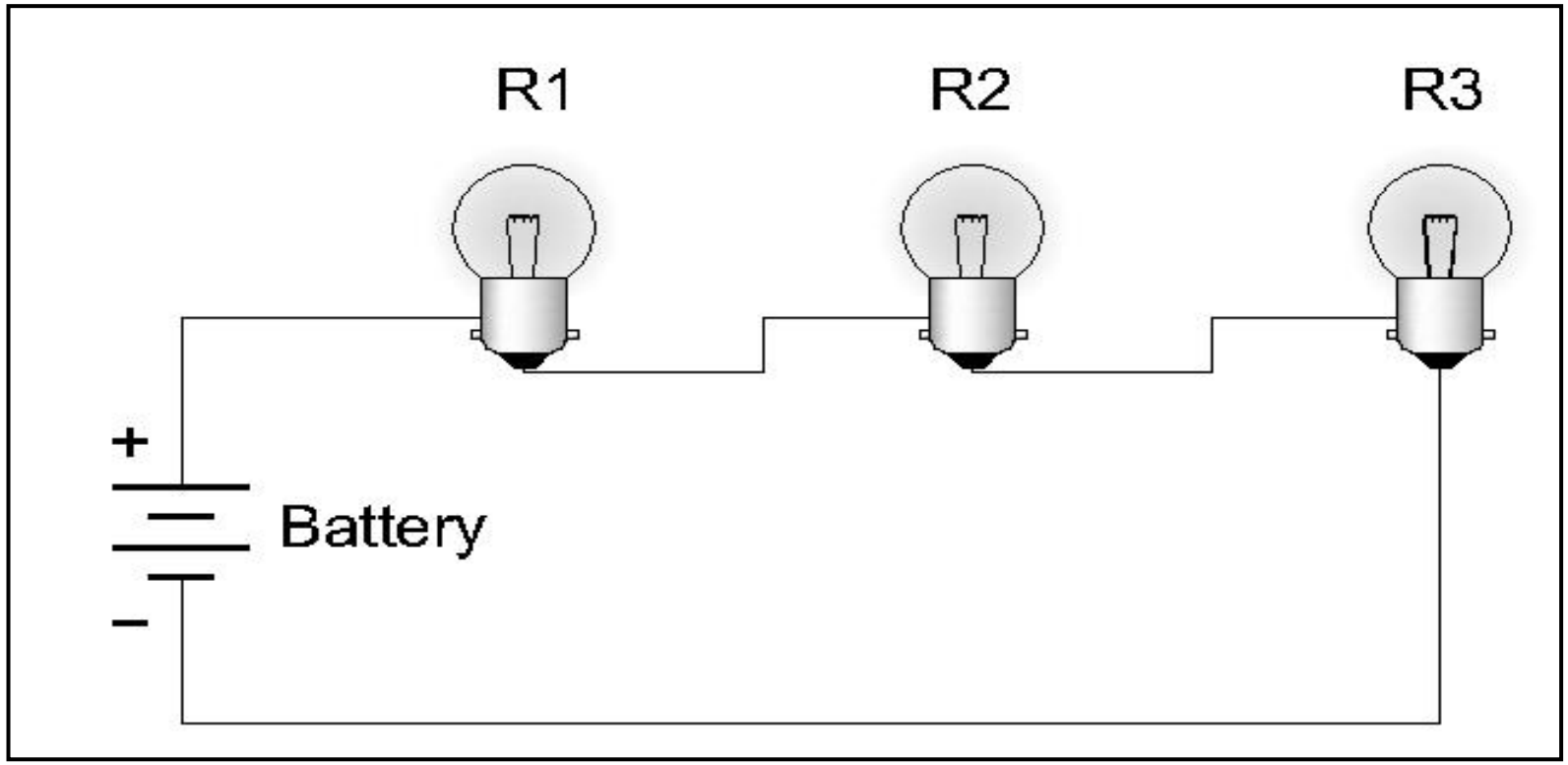
- Current that flows in only one direction, is called *direct current* (DC)
  - Batteries are a common source of DC
- Current that flows in one direction then in the opposite direction is called *alternating current* (AC)
  - Household current is AC
- AC current reverses direction on a regular basis
  - Each process of reversing is a *cycle*
  - The number of cycles per second is *frequency*, measured in hertz (Hz)
- 1 Hz = 1 cycle per second



Current Flow

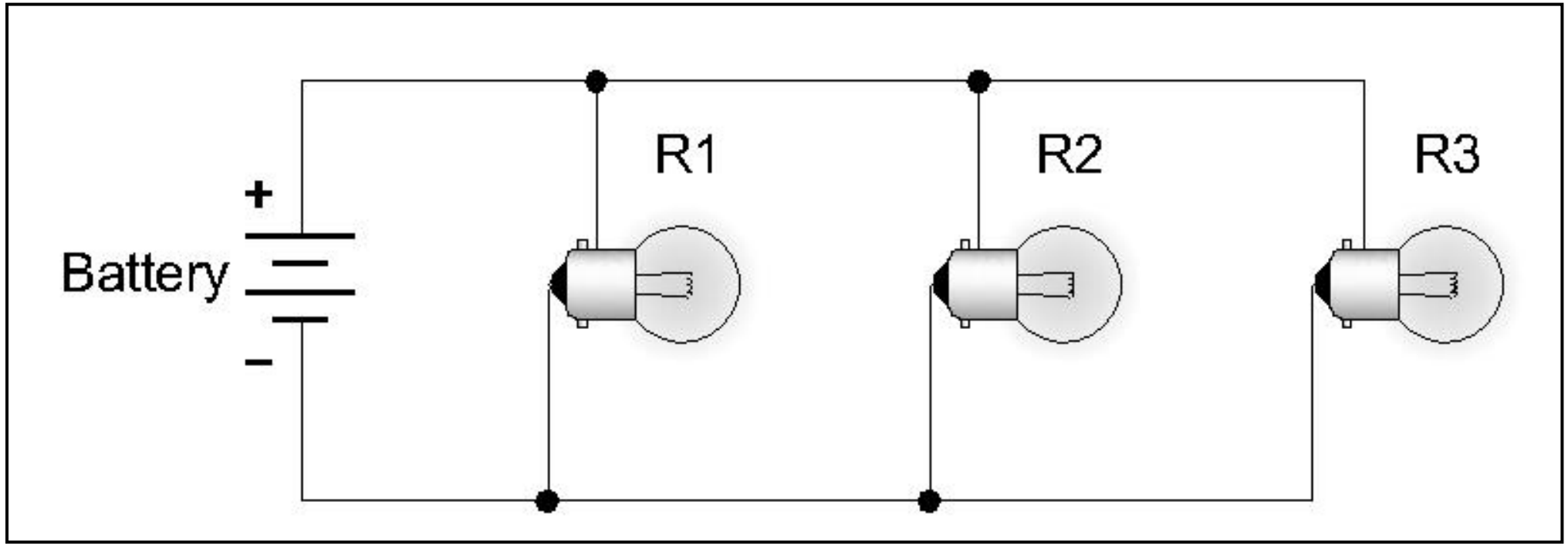
- A *circuit* is any path through which current can flow
- Electrical circuits are made from *components* and the connections between them
- If two or more components are connected in a circuit so that the same current must flow through all of them, that is a *series* circuit
- A *short circuit* is a direct connection between two points in a circuit
- An *open circuit* is made by breaking a current path in a circuit

Series Circuit



*Same **CURRENT** at all points in the circuit. Series circuits provide one and only one path for current flow.*

Parallel Circuit



*Same **VOLTAGE** at all parts of the circuit. Parallel circuits provide multiple paths for current flow.*

PRACTICE QUESTIONS

In which type of circuit is DC current the same through all components?

A. Series
B. Parallel
C. Resonant
D. Branch

T5D13 A 3-2

In which type of circuit is voltage the same across all components?

A. Series
B. Parallel
C. Resonant
D. Branch

T5D14 B 3-2

How is a voltmeter connected to a component to measure applied voltage?

A. In series
B. In parallel
C. In quadrature
D. In phase

T7D02 B 3-2

When configured to measure current, how is a multimeter connected to a component?

A. In series
B. In parallel
C. In quadrature
D. In phase

T7D03 A 3-2

Multimeters

- The basic electrical test instruments are simple meters: voltmeters, ammeters, and ohmmeters
- So that a separate meter isn't needed for each parameter, the *multimeter* was invented
  - Short for "multifunction meter"
  - Measures all three electrical values of voltage, current, and resistance
  - Other names: *VOM* (volt-ohm meter) or *DVM* (digital volt meter)
- Ways meters are damaged …
  - Measuring voltage of an energized circuit when the meter is set to measure resistance
  - Exceeding meter's voltage rating … voltmeter and leads not rated for use at the voltages to be measured

PRACTICE QUESTIONS

Which of the following can damage a multimeter?

A. Attempting to measure resistance using the voltage setting
B. Failing to connect one of the probes to ground
C. Attempting to measure voltage when using the resistance setting
D. Not allowing it to warm up properly

T7D06 C 3-4

Which of the following measurements are made using a multimeter?

A. Signal strength and noise
B. Impedance and reactance
C. Voltage and resistance
D. All these choices are correct

T7D07 C 3-4

What reading indicates that an ohmmeter is connected across a large, discharged capacitor?

A. Increasing resistance with time
B. Decreasing resistance with time
C. Steady full-scale reading
D. Alternating between open and short circuit

T7D10 A 3-4

Which of the following precautions should be taken when measuring in-circuit resistance with an ohmmeter?

A. Ensure that the applied voltages are correct
B. Ensure that the circuit is not powered
C. Ensure that the circuit is grounded
D. Ensure that the circuit is operating at the correct frequency

T7D11 B 3-4

Which of the following precautions should be taken when measuring high voltages with a voltmeter?

A. Ensure that the voltmeter has very low impedance
B. Ensure that the voltmeter and leads are rated for use at the voltages to be measured
C. Ensure that the circuit is grounded through the voltmeter
D. Ensure that the voltmeter is set to the correct frequency

T0A12 B 3-4

Ohm's Law

- E represents voltage
  - Units – volts (V)
- I represents current
  - Units – amperes (A)
- R represents resistance
  - Units – ohms (Ω)

$$R = E / I$$
$$I = E / R$$
$$E = I \times R$$

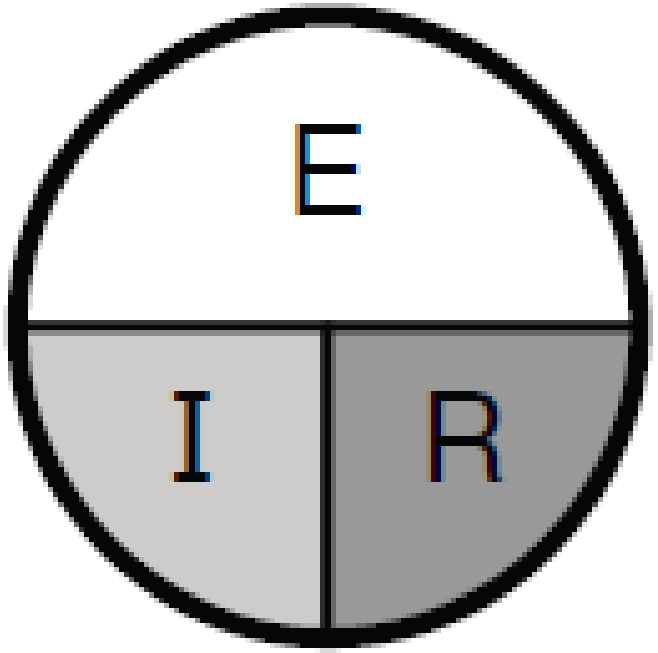
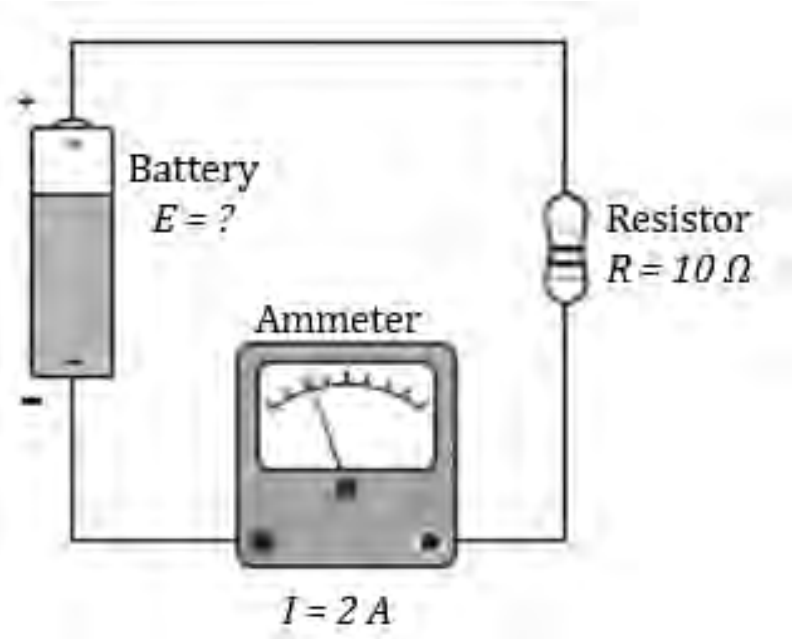


Figure 3.5A — Simple diagram to help remember the Ohm's Law. If you know any two of the quantities, the equation to find the third — just cover up the unknown quantity. The positions of the remaining two symbols show if you have to multiply (side-by-side) or divide (one above the other).

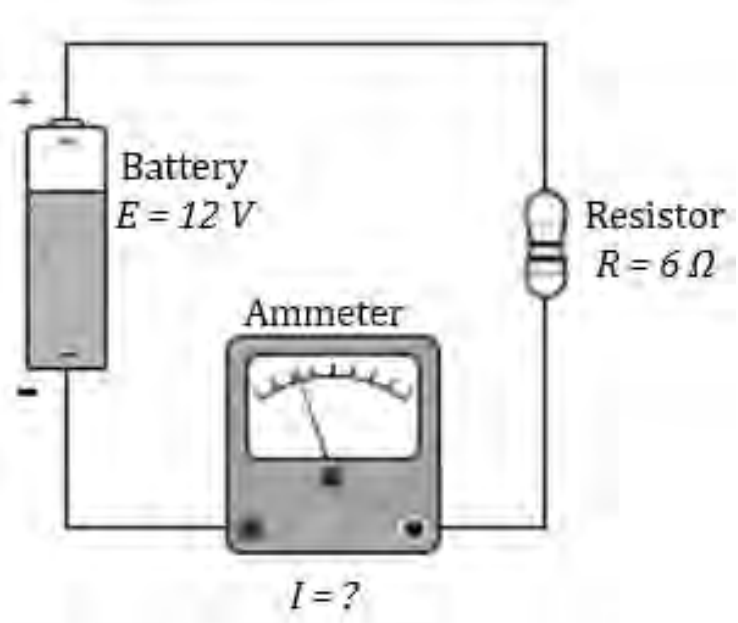
Examples of how to use Ohm's Law



Given I = 2 Amperes
R = 10 Ohms

Find: E (voltage)

E = I × R = 2 × 10 = 20 Volts
Voltage Equals 20 Volts



Given E = 12 Volts
R = 6 Ohms

Find: I (current)

I = E / R = 12 6 = 2 Amps

Current Equals 2 Amperes

More Ohm's Law Examples

What is the resistance of a circuit in which a current of 3 amperes flows when connected to 90 volts?

$$R = E / I = 90\ V / 3\ A = 30\ \Omega$$

What is the current in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms?

$$I = E / R = 120\ V / 80\ \Omega = 1.5\ A$$

What is the voltage across a 2-ohm resistor if a current of 0.5 amperes flows through it?

$$E = I \times R = 0.5\ A \times 2\ \Omega = 1\ V$$

PRACTICE QUESTIONS

What are the units of electrical resistance?

A. Siemens
B. Mhos
C. Ohms
D. Coulombs

T5A04 C 3-5

Why are metals generally good conductors of electricity?

A. They have relatively high density
B. They have many free electrons
C. They have many free protons
D. All these choices are correct

T5A07 B 3-5

Which of the following is a good electrical insulator?

A. Copper
B. Glass
C. Aluminum
D. Mercury

T5A08 B 3-5

What formula is used to calculate current in a circuit?

A. I = E × R

B. I = E / R

C. I = E + R

D. I = E – R

T5D01 B 3-5

What formula is used to calculate voltage in a circuit?

A. E = I x R

B. E = I / R

C. E = I + R

D. E = I – R

T5D02 A 3-5

What formula is used to calculate resistance in a circuit?

A. R = E x I

B. R = E / I

C. R = E + I

D. R = E – I

T5D03 B 3-5

What is the resistance of a circuit in which a current of 3 amperes flows when connected to 90 volts?

A. 3 ohms
B. 30 ohms
C. 93 ohms
D. 270 ohms

T5D04 B 3-6

What is the resistance of a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes?

A. 18 ohms
B. 0.125 ohms
C. 8 ohms
D. 13.5 ohms

T5D05 C 3-6

What is the resistance of a circuit that draws 4 amperes from a 12-volt source?

A. 3 ohms
B. 16 ohms
C. 48 ohms
D. 8 ohms

T5D06 A 3-6

What is the current in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms?

A. 9600 amperes

B. 200 amperes

C. 0.667 amperes

D. 1.5 amperes

T5D07 D 3-6

What is the current through a 100-ohm resistor connected across 200 volts?

A. 20,000 amperes
B. 0.5 amperes
C. 2 amperes
D. 100 amperes

T5D08 C 3-6

What is the current through a 24-ohm resistor connected across 240 volts?

A. 24,000 amperes
B. 0.1 amperes
C. 10 amperes
D. 216 amperes

T5D09 C 3-6

What is the voltage across a 2-ohm resistor if a current of 0.5 amperes flows through it?

A. 1 volt
B. 0.25 volts
C. 2.5 volts
D. 1.5 volts

T5D10 A 3-6

What is the voltage across a 10-ohm resistor if a current of 1 ampere flows through it?

A. 1 volt
B. 10 volts
C. 11 volts
D. 9 volts

T5D11 B 3-7

What is the voltage across a 10-ohm resistor if a current of 2 amperes flows through it?

A. 8 volts
B. 0.2 volts
C. 12 volts
D. 20 volts

T5D12 D 3-7

Power

- *Power*, represented by the symbol P, is the rate at which electrical energy is used
  - Measured in *watts* (W)
- A device that consumes or dissipates power is referred to as a *load*

$$P = I \times E$$
$$E = P / I$$
$$I = P / E$$

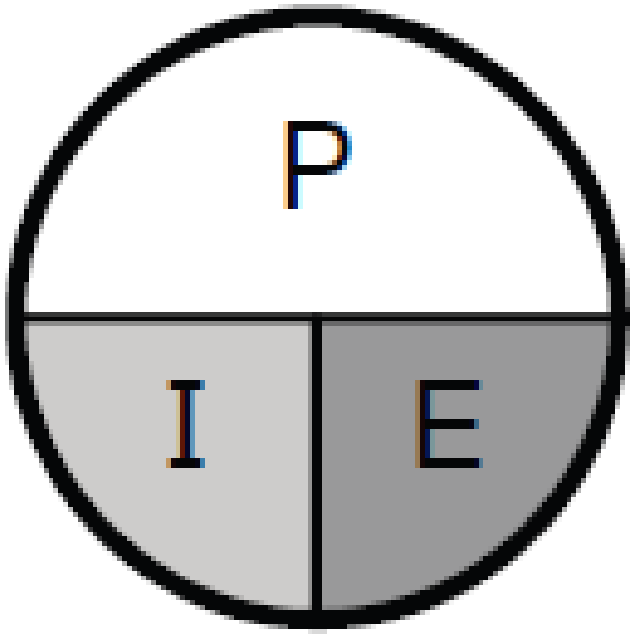


Figure 3.5B — Simple diagram to help remember the Ohm's Law. If you know any two of the quantities, the equation to find the third — just cover up the unknown quantity. The positions of the remaining two symbols show if you have to multiply (side-by-side) or divide (one above the other).

Example Power Calculations

How much power is delivered by a voltage of 13.8 volts DC and a current of 10 amperes?

$$P = E \times I = 13.8\ V \times 10\ A = 138\ W$$

How much current is required to deliver 120 watts at a voltage of 12 volts DC?

$$I = P / E = 120\ W / 12\ V = 10\ A$$

PRACTICE QUESTIONS

Electrical power is measured in which of the following units?

A. Volts
B. Watts
C. Watt-hours
D. Amperes

T5A02 B 3-7

Which term describes the rate at which electrical energy is used?

A. Resistance
B. Current
C. Power
D. Voltage

T5A10 C 3-7

What is the formula used to calculate electrical power (P) in a DC circuit?

A. $P = I \times E$

B. $P = E / I$

C. $P = E - I$

D. $P = I + E$

T5C08 A 3-7

How much power is delivered by a voltage of 13.8 volts DC and a current of 10 amperes?

A. 138 watts

B. 0.7 watts

C. 23.8 watts

D. 3.8 watts

T5C09 A 3-7

How much power is delivered by a voltage of 12 volts DC and a current of 2.5 amperes?

A. 4.8 watts

B. 30 watts

C. 14.5 watts

D. 0.208 watts

T5C10 B 3-7

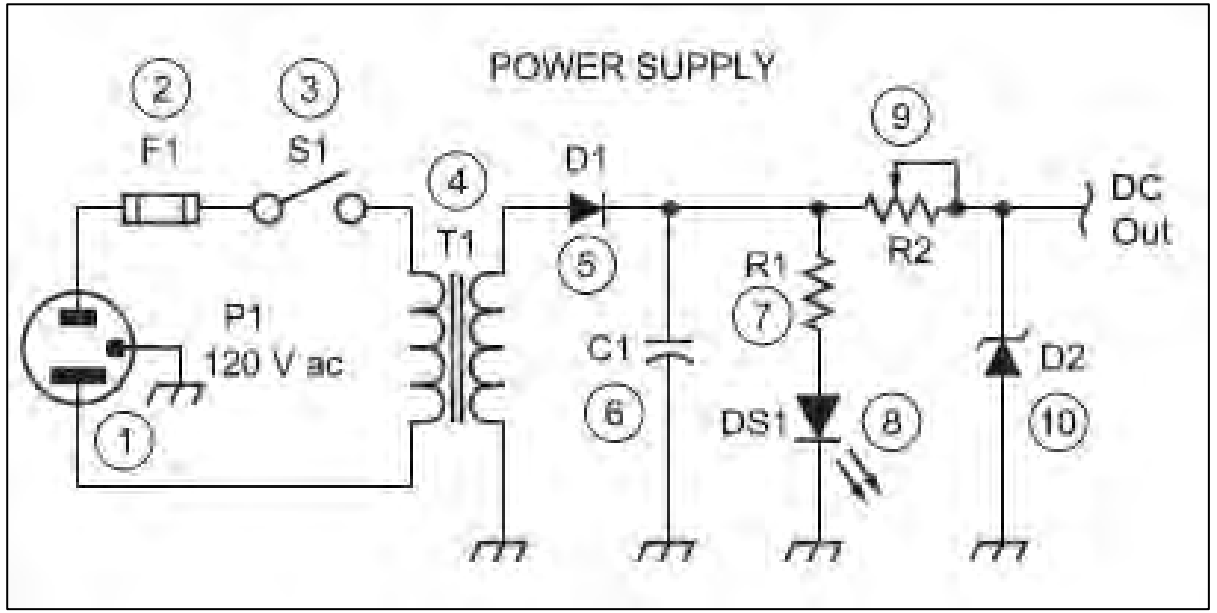
How much current is required to deliver 120 watts at a voltage of 12 volts DC?

A. 0.1 amperes
B. 10 amperes
C. 12 amperes
D. 132 amperes

T5C11 B 3-7

Components and Units

- Components in electrical circuits performs functions such as storing or using energy, routing current, or amplifying signals
- The three most basic types of electronic components are resistors, capacitors and inductors
- We could use actual drawings to show how components are arranged in circuits, but this would be too cumbersome for most circuitry. Instead, we use *schematic diagrams* …



More on schematics later …

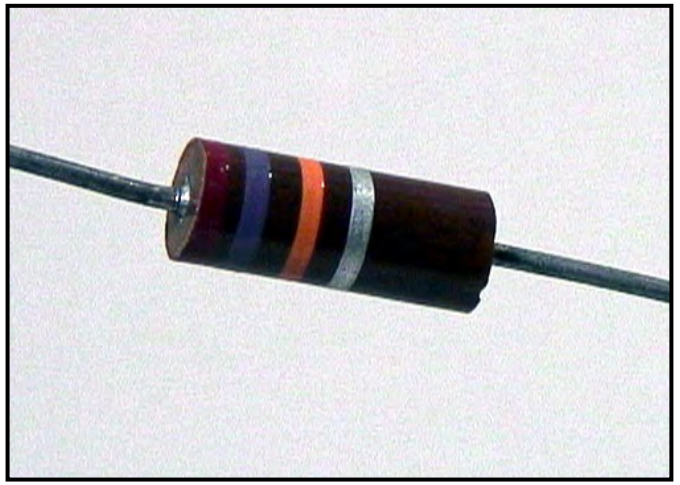
Resistors

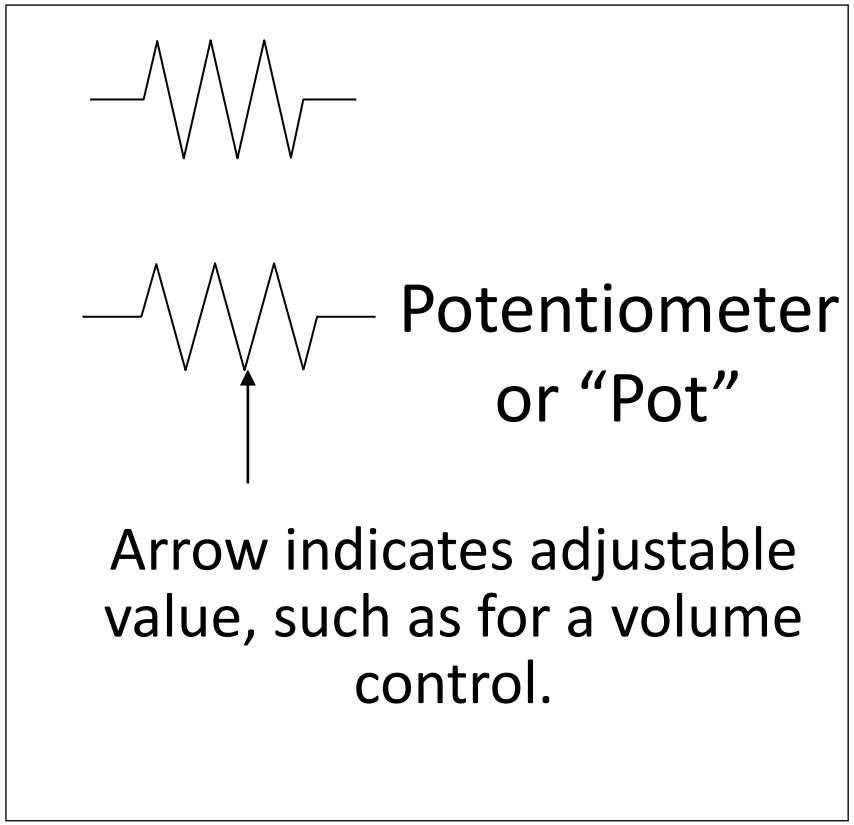
- Function: To restrict the flow of current, just as a valve in a water pipe restricts the flow through the pipe
- Resistance measured in ohms (**Ω**)
- Remember Ohm's Law
- Schematic
- Picture

$$I = E / R$$

$$E = I \times R$$

$$R = E / I$$



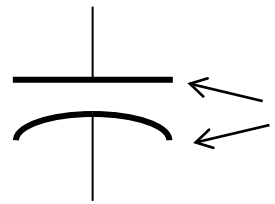


Resistor Schematic

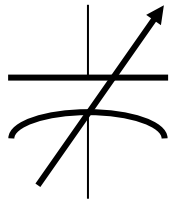
Large Variety of Resistors!

Capacitors

- The function of a capacitor is to store electrical energy – called *capacitance*
- Schematic symbol
- Acts like a battery
- Picture

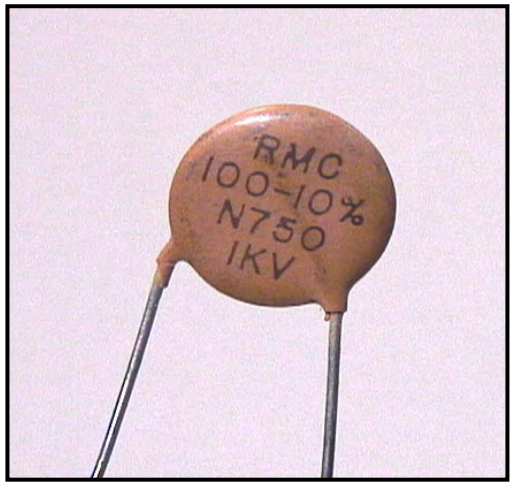


Electrodes



Schematic

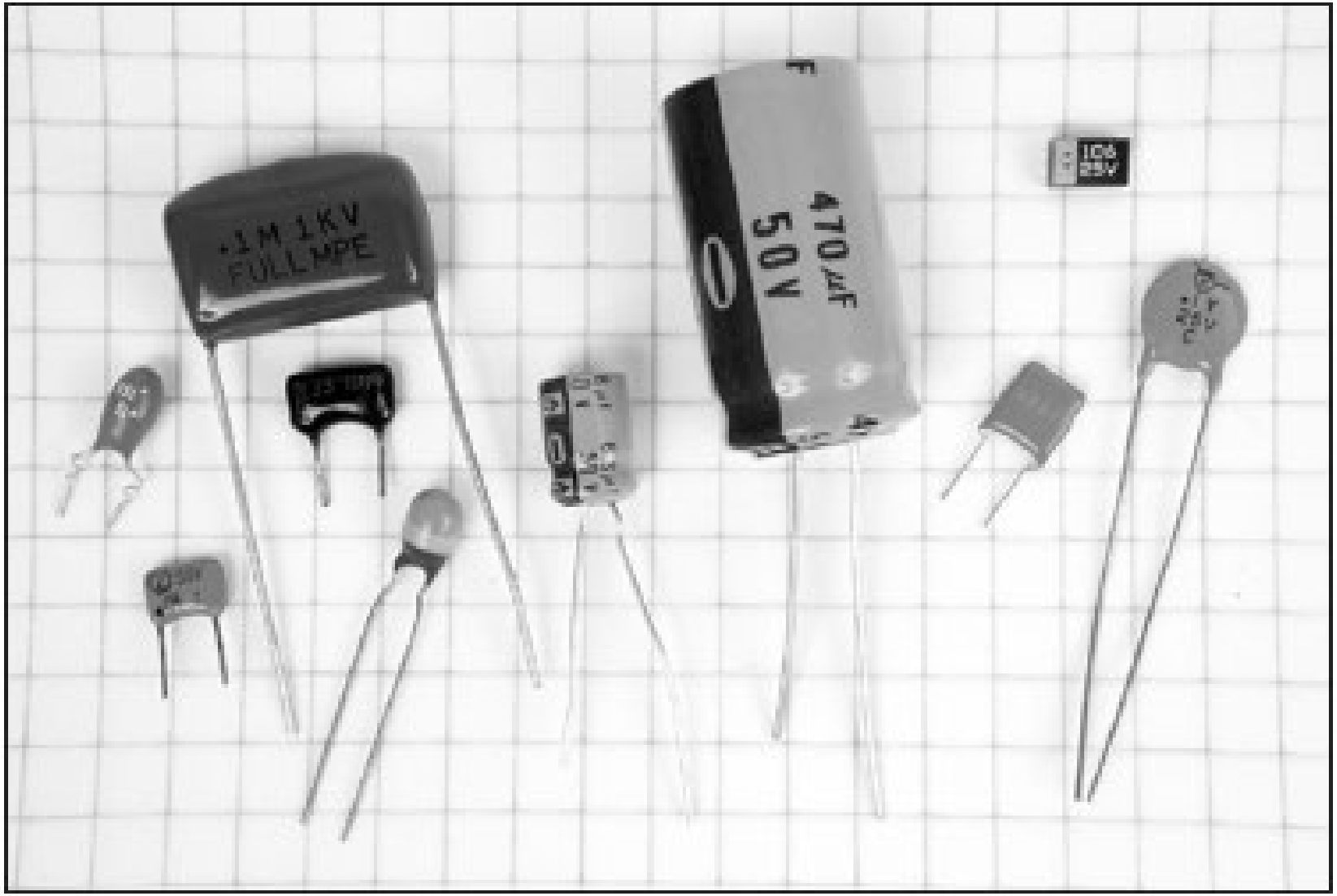
Stores energy in an electric field created by voltage between the electrodes with insulating dielectric material between them



Capacitors (cont.)

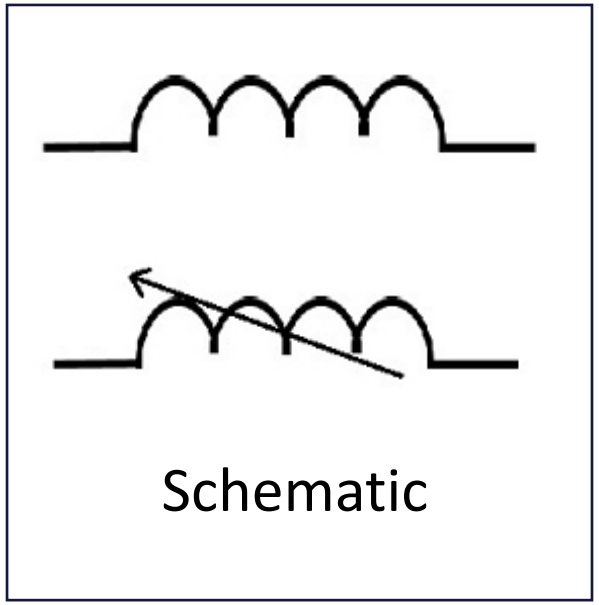
- Store electrical energy in the *electric field* created by a voltage between two conducting surfaces or *electrodes*
- Electrodes are separated by an insulator or *dielectric*
- Storing energy this way is called *capacitance*, and it is measured in *farads* (F)

Large Variety of Capacitors!



Inductors

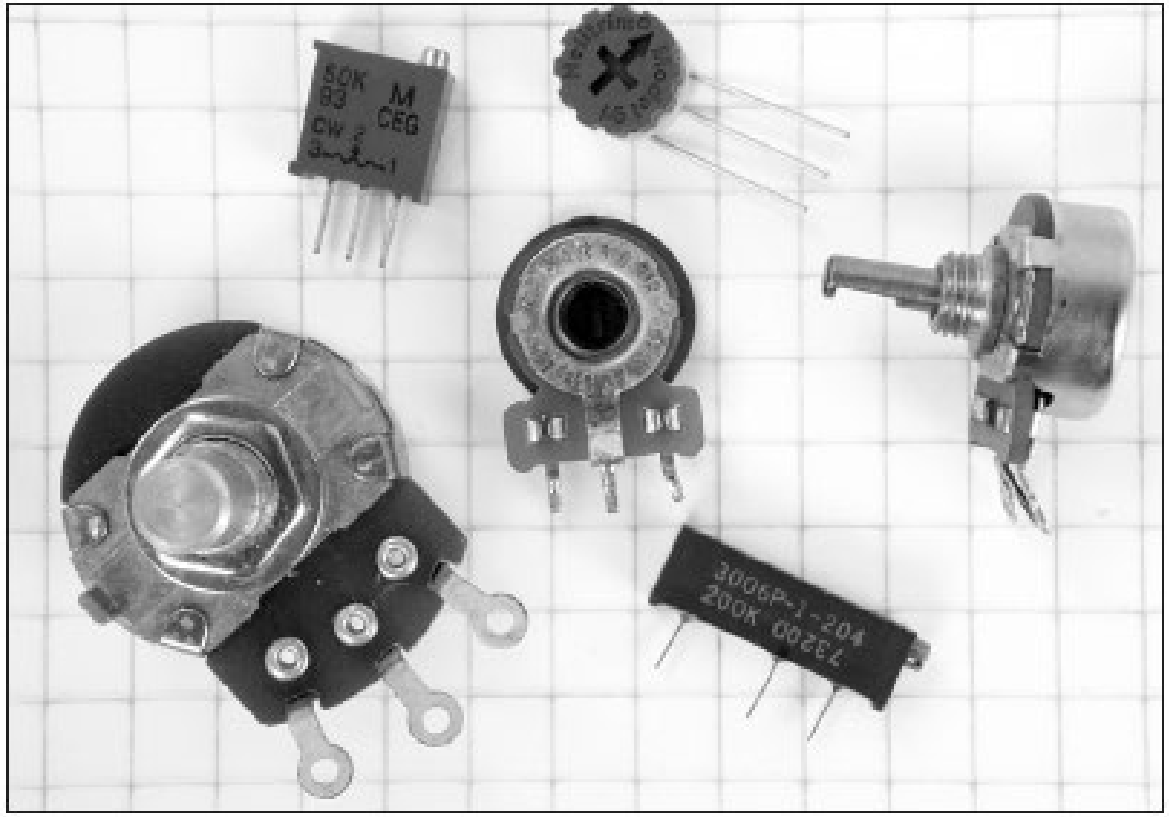
- Function: To store energy in the magnetic field created by current flowing in a wire
- Called *inductance*, measured in *henrys* (H)
- Made from wire wound in a coil, sometimes around a core of magnetic material that concentrates the magnetic energy
- Schematic
- Picture



Schematic

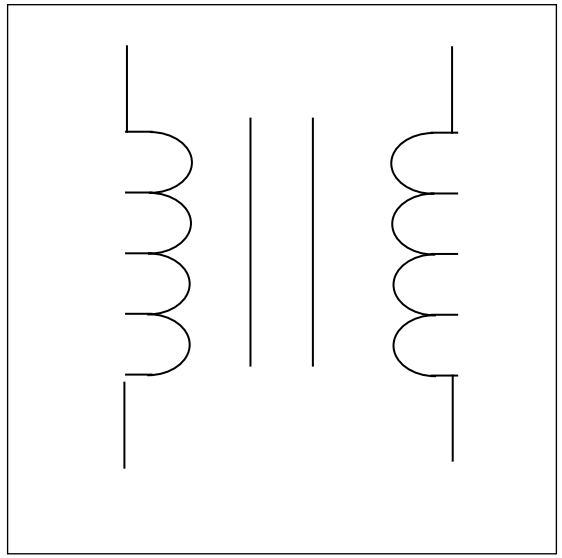
Variable Components

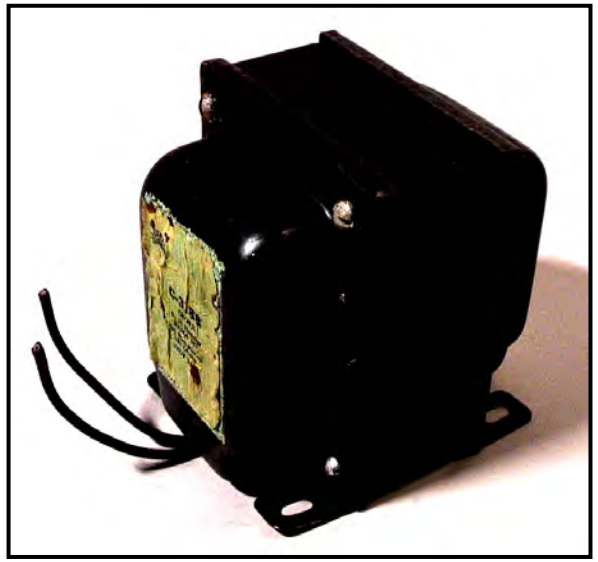
- All three types of basic components are also available as adjustable or variable models
- A variable resistor is also called a *potentiometer*, frequently used to adjust voltage or potential, such as for a volume control



Transformers

- Made from two or more inductors that share their stored energy
- Allows energy to be transferred from one inductor to another while changing the combination of voltage and current
- Example: A transformer is used to transfer energy from household 120 V AC voltage to a lower voltage for other uses such as in electronic equipment





PRACTICE QUESTIONS

What describes the ability to store energy in an electric field?

A. Inductance
B. Resistance
C. Tolerance
D. Capacitance

T5C01 D 3-8

What is the unit of capacitance?

A. The farad
B. The ohm
C. The volt
D. The henry

T5C02 A 3-8

What describes the ability to store energy in a magnetic field?

A. Admittance
B. Capacitance
C. Resistance
D. Inductance

T5C03 D 3-8

What is the unit of inductance?

A. The coulomb
B. The farad
C. The henry
D. The ohm

T5C04 C 3-8

What electrical component opposes the flow of current in a DC circuit?

A. Inductor
B. Resistor
C. Inverter
D. Transformer

T6A01 B 3-8

What type of component is often used as an adjustable volume control?

A. Fixed resistor
B. Power resistor
C. Potentiometer
D. Transformer

T6A02 C 3-8

What electrical parameter is controlled by a potentiometer?

A. Inductance
B. Resistance
C. Capacitance
D. Field strength

T6A03 B 3-8

What electrical component stores energy in an electric field?

A. Varistor
B. Capacitor
C. Inductor
D. Diode

T6A04 B 3-8

What type of electrical component consists of conductive surfaces separated by an insulator?

A. Resistor
B. Potentiometer
C. Oscillator
D. Capacitor

T6A05 D 3-8

What type of electrical component stores energy in a magnetic field?

A. Varistor
B. Capacitor
C. Inductor
D. Diode

T6A06 C 3-8

What electrical component is typically constructed as a coil of wire?

A. Switch
B. Capacitor
C. Diode
D. Inductor

T6A07 D 3-8

What component changes 120 V AC power to a lower AC voltage for other uses?

A. Variable capacitor
B. Transformer
C. Transistor
D. Diode

T6D06 B 3-8

Reactance and Impedance

- In a resistor, AC voltages and currents are exactly in step, or *in phase*
- In capacitors and inductors, voltage and current have a *phase difference*
- Capacitors and inductors store energy, rather than dissipating it like resistors
- Energy storage creates an effect called *reactance* (symbol *X*) that acts like a resistance in opposing the flow of AC current
  - Capacitors create capacitive reactance (X_C)
  - Inductors create inductive reactance (X_L)
  - The effects of each are complementary

Reactance and Impedance (cont.)

- The combination of *resistance* (R) and *reactance* (X) is called *impedance*, represented by the symbol Z
- Impedance represents a circuit's *opposition* to both AC and DC currents
- Radio circuits almost always have both resistance and reactance, so impedance is often used as a general term to mean the circuit's opposition to AC current flow

PRACTICE QUESTIONS

What is the unit of impedance?

A. The volt
B. The ampere
C. The coulomb
D. The ohm

T5C05 D 3-10

What is impedance?

A. The opposition to AC current flow
B. The inverse of resistance
C. The Q or Quality Factor of a component
D. The power handling capability of a component

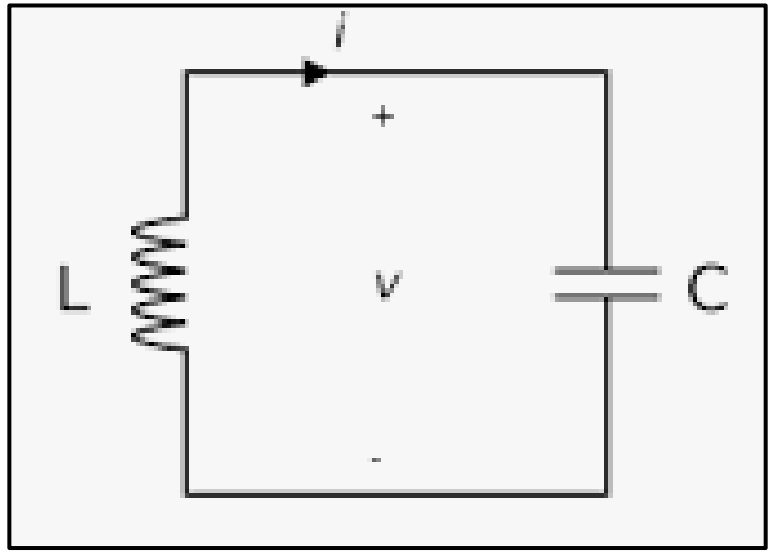
T5C12 A 3-10

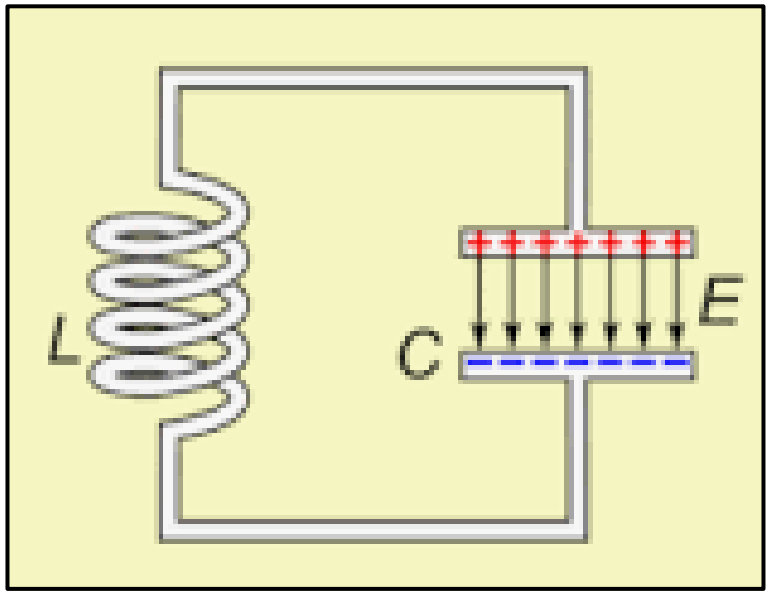
Resonance

- Circuits that contain both a capacitor and an inductor are called *resonant* circuits or *tuned* circuits
- A component's reactance depends on frequency
  - X_L increases with frequency while X_C decreases
- At the frequency for which a circuit's X_L and X_C are *equal*, their effects cancel
  - This is the circuit's *resonant frequency*
- At *resonance*, a circuit has *only resistance*, which affects AC and DC current equally
- A tuned circuit acts as a *filter*, passing or rejecting signals at its resonant frequency

Resonant or Tuned Circuit

- *Capacitors* and *inductors* connected together create a tuned circuit
- When X_L and X_C are equal, the circuit is resonant
- If C or L are adjustable, the resonant frequency can be varied or *tuned*





PRACTICE QUESTIONS

Which of the following is combined with an inductor to make a resonant circuit?

A. Resistor
B. Zener diode
C. Potentiometer
D. Capacitor

T6D08 D 3-10

Which of the following is a resonant or tuned circuit?

A. An inductor and a capacitor in series or parallel
B. A linear voltage regulator
C. A resistor circuit used for reducing standing wave ratio
D. A circuit designed to provide high-fidelity audio

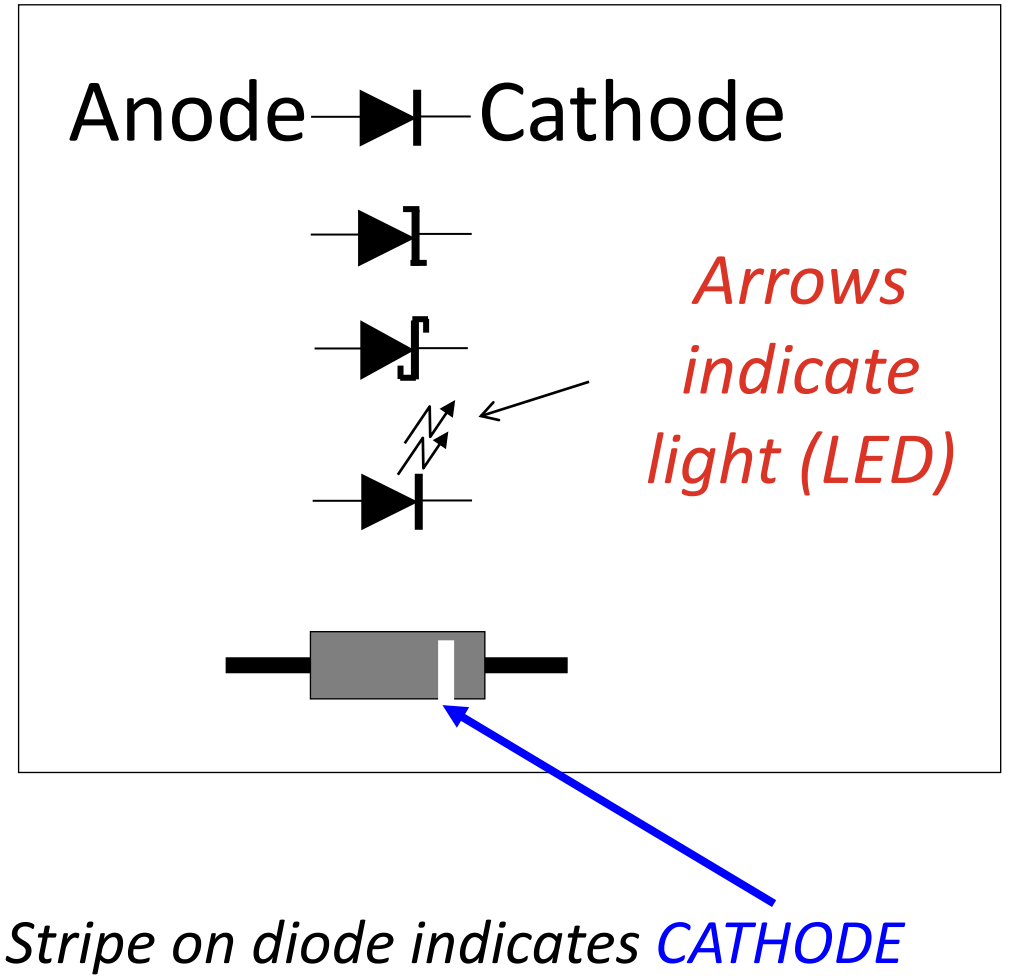
T6D11 A 3-10

Diodes, Transistors and Integrated Circuits
(Semiconductors)

- Made of material like silicon that are “OK” conductors but not as good as metals
- Impurities added to semiconductors create material with more than usual electrons (*N-type*) and fewer than usual electrons (*P-type*)
- Structures of N and P material can control current flow through the semiconductor
- When N- and P-type material are placed in contact with each other, the result is a *PN junction* that conducts better in one direction than the other

Diodes

- Allows current to flow in only one direction
  - Two electrodes (Anode, Cathode)
  - AC current is changed to varying pulses of DC (called *rectification*)
  - Diodes used to change AC power to DC power are called *rectifiers* (heavy-duty diodes)
- Schematic
- Designator (D or CR)
- If AC voltage is applied to a diode, the result is a pulsing DC current because current is blocked when the voltage tries to push electrons in the wrong direction

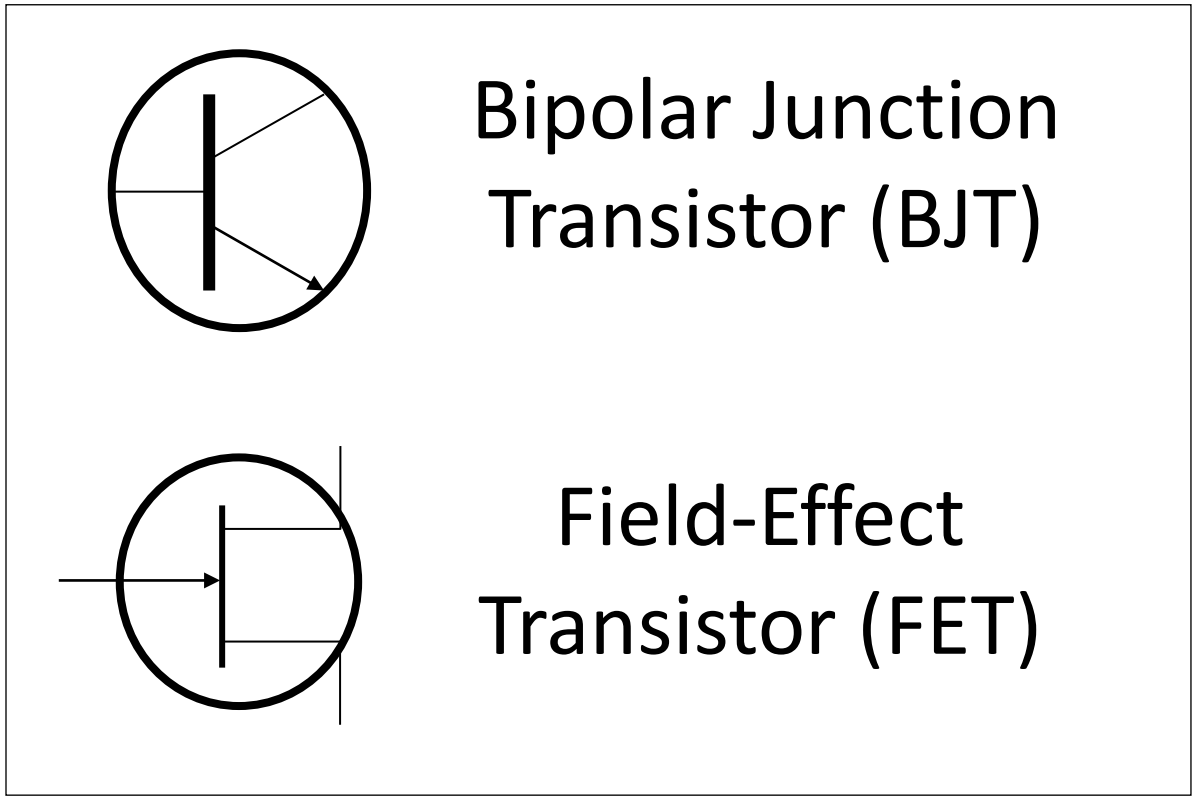


Diodes (cont.)

- When current flows through a diode, a small positive voltage develops from the anode to the cathode
  - Called *forward voltage drop*, usually less than 1 V
  - Voltage depends on the type of diode and the materials it's made from
- Light-emitting diode or *LED* gives off light when current flows through it in the forward direction from anode to cathode
  - Used as visual indicators (use less power than incandescent bulbs/lamps)
  - Material from which the LED is made determines the color of light emitted

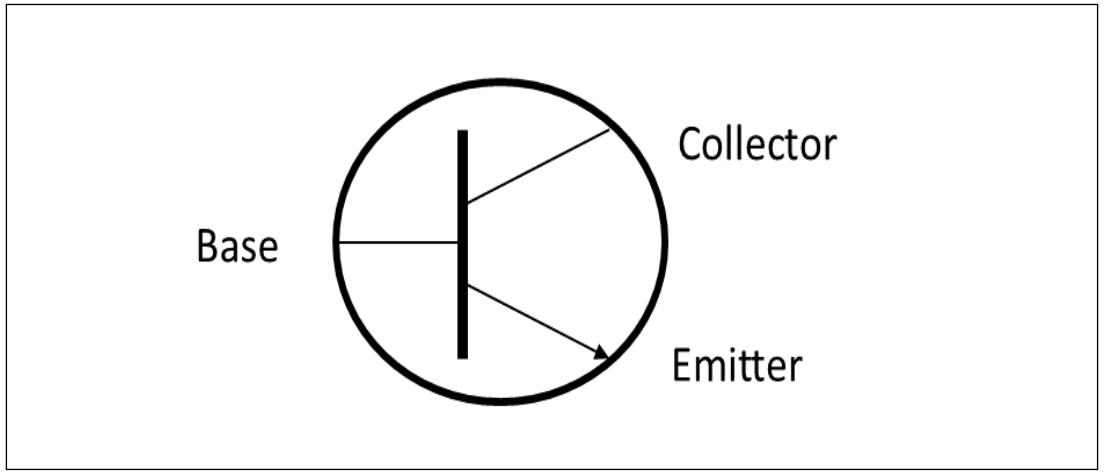
Transistors

- The function of a transistor is to *control* large signals with small ones
  - An “electronically controlled current valve”
  - When used as an amplifier, a transistor produces *gain*
  - Transistors can also be used as a *switch*
- Schematic
- Designator (Q)



Transistors (cont.)

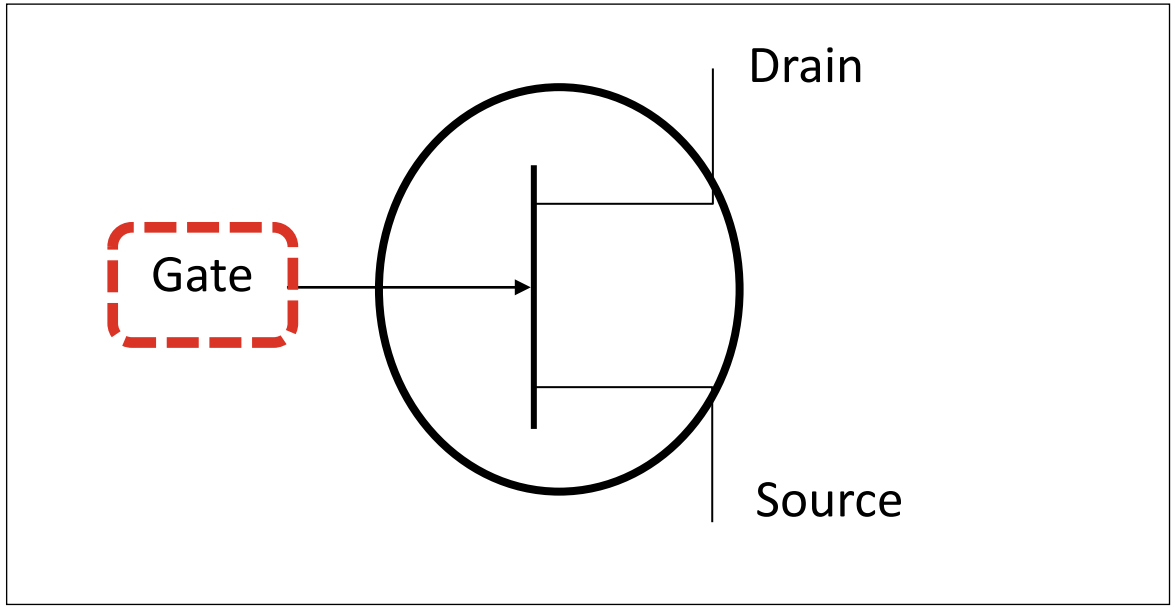
- Two common types of transistors: *bipolar junction transistors* (BJT) and *field effect transistors* (FET)
- The Bipolar Junction Transistor (BJT) has three layers of N or P material connected to electrodes
- Depending on the arrangement of layers, a BJT is either an NPN or PNP transistor
- The three electrodes of an FET are the *gate*, *drain*, and *source*
- RF power transistors are used as the primary gain-producing component in RF power amplifiers



Bipolar Junction Transistor Schematic (showing the 3 electrodes)

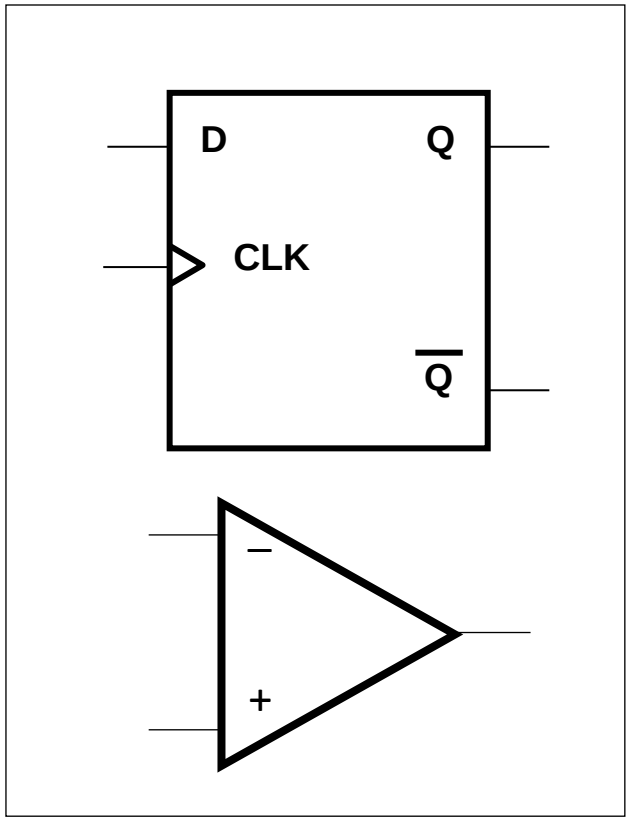
Transistors (cont.)

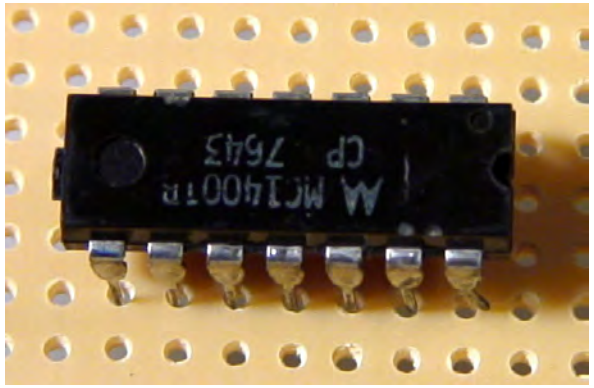
- The Field-Effect Transistor (FET) has a conducting path or channel of N and P material connected to the drain and source electrodes
- Voltage applied to the gate electrode controls current through the channel



Integrated Circuits

- An integrated circuit (IC or chip) is made of many components connected together as a useful circuit and packaged as a single component
- Schematic symbol
- Designator (IC or U)





PRACTICE QUESTIONS

Which is true about forward voltage drop in a diode?

A. It is lower in some diode types than in others
B. It is proportional to peak inverse voltage
C. It indicates that the diode is defective
D. It has no impact on the voltage delivered to the load

T6B01 A 3-10

What electronic component allows current to flow in only one direction?

A. Resistor
B. Fuse
C. Diode
D. Driven element

T6B02 C 3-10

Which of these components can be used as an electronic switch?

A. Varistor
B. Potentiometer
C. Transistor
D. Thermistor

T6B03 C 3-10

Which of the following components can consist of three regions of semiconductor material?

A. Alternator
B. Transistor
C. Triode
D. Pentagrid converter

T6B04 B 3-10

What type of transistor has a gate, drain, and source?

A. Varistor
B. Field-effect
C. Tesla-effect
D. Bipolar junction

T6B05 B 3-10

How is the cathode lead of a semiconductor diode often marked on the package?

A. With the word “cathode”
B. With a stripe
C. With the letter C
D. With the letter K

T6B06 B 3-10

What causes a light-emitting diode (LED) to emit light?

A. Forward current
B. Reverse current
C. Capacitively-coupled RF signal
D. Inductively-coupled RF signal

T6B07 A 3-10

What does the abbreviation FET stand for?

A. Frequency Emission Transmitter
B. Fast Electron Transistor
C. Free Electron Transmitter
D. Field Effect Transistor

T6B08 D 3-10

What are the names for the electrodes of a diode?

A. Plus and minus
B. Source and drain
C. Anode and cathode
D. Gate and base

T6B09 C 3-10

Which of the following can provide power gain?

A. Transformer
B. Transistor
C. Reactor
D. Resistor

T6B10 B 3-11

What is the term that describes a device's ability to amplify a signal?

A. Gain
B. Forward resistance
C. Forward voltage drop
D. On resistance

T6B11 A 3-11

What are the names of the electrodes of a bipolar junction transistor?

A. Signal, bias, power
B. Emitter, base, collector
C. Input, output, supply
D. Pole one, pole two, output

T6B12 B 3-11

Which of the following devices or circuits changes an alternating current into a varying direct current signal?

A. Transformer
B. Rectifier
C. Amplifier
D. Reflector

T6D01 B 3-11

Which of the following is commonly used as a visual indicator?

A. LED
B. FET
C. Zener diode
D. Bipolar transistor

T6D07 A 3-11

What is the name of a device that combines several semiconductors and other components into one package?

A. Transducer
B. Multi-pole relay
C. Integrated circuit
D. Transformer

T6D09 C 3-11

What is the function of component 2 in figure T-1?

A. Give off light when current flows through it

B. Supply electrical energy

C. Control the flow of current

D. Convert electrical energy into radio waves

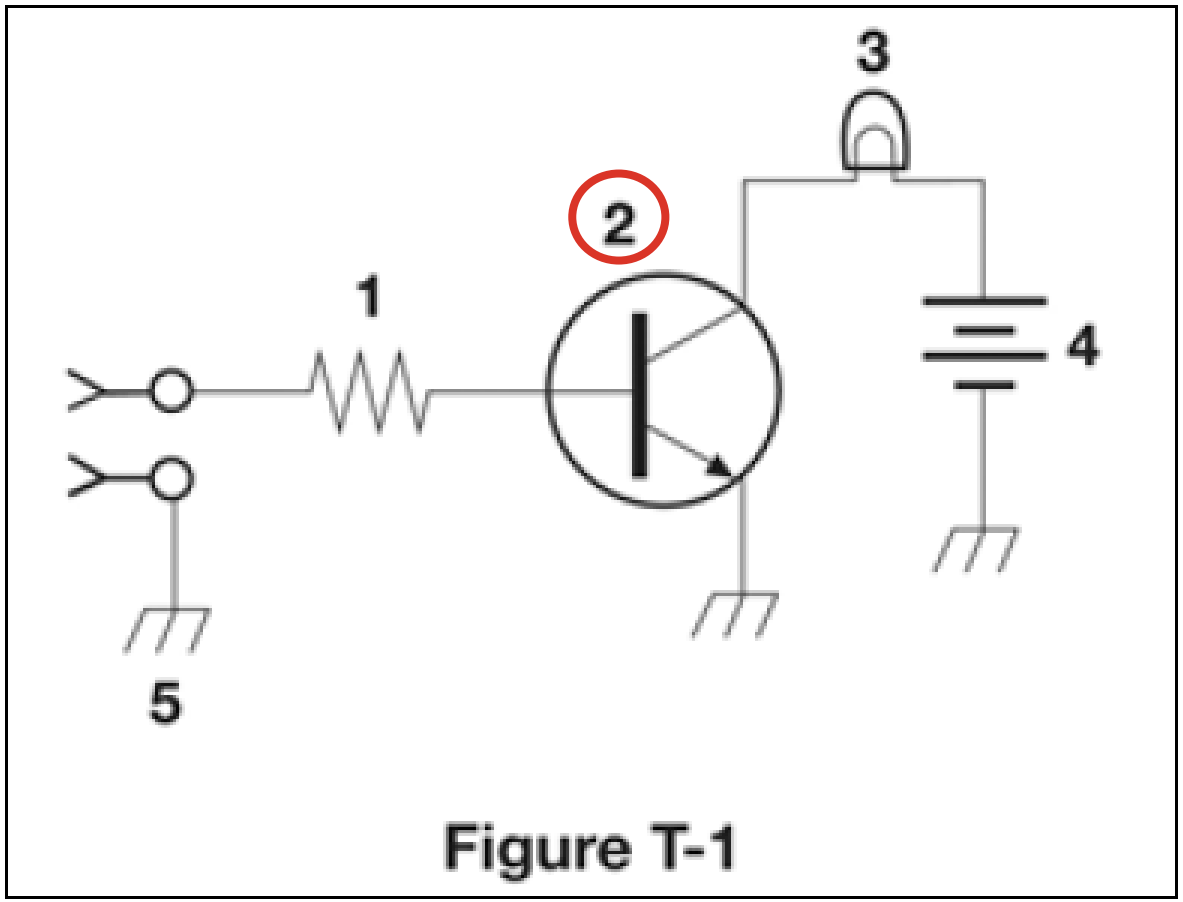
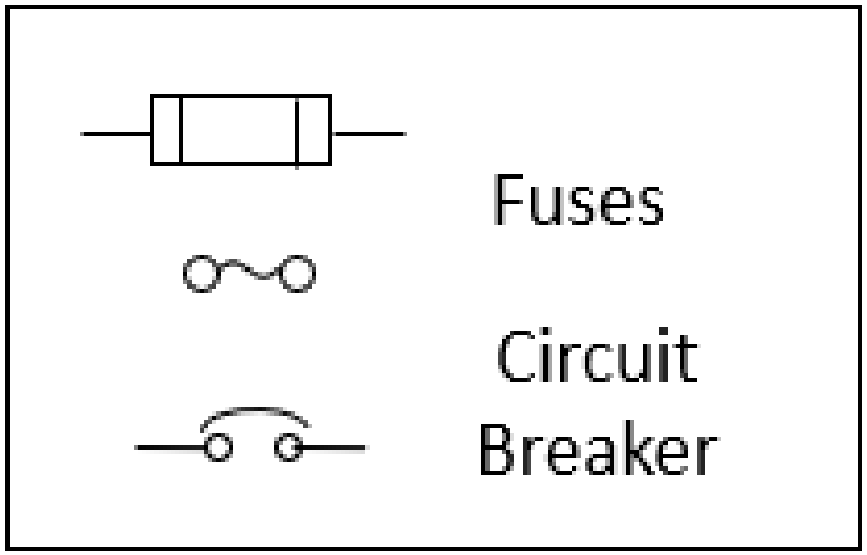


Figure T-1

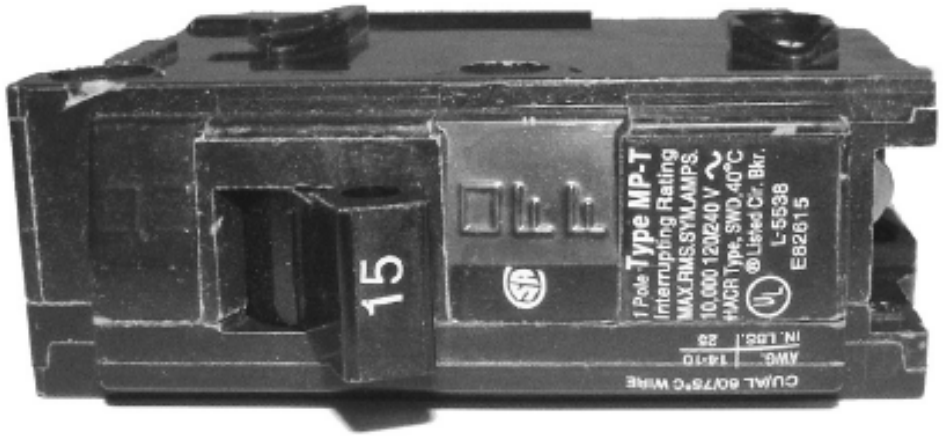
T6D10 C 3-11

Protective Components

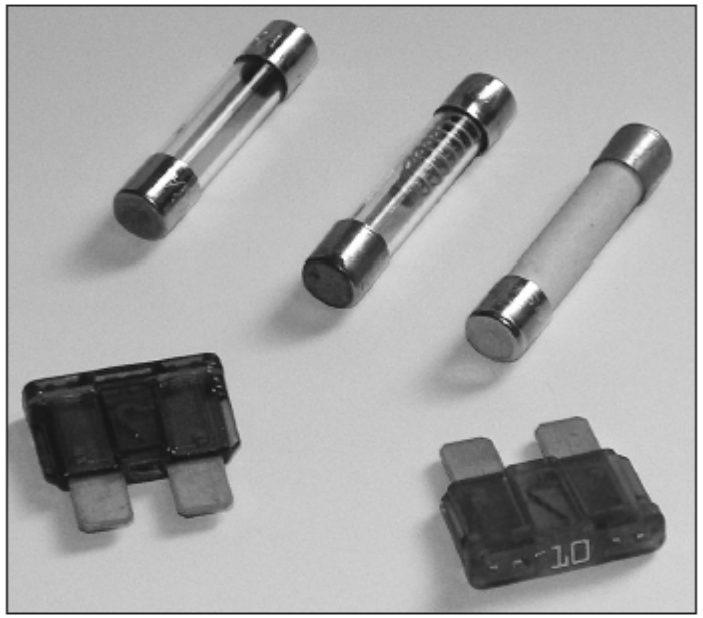
- Protective components (such as *fuses* and *circuit breakers*) are used to prevent equipment damage or safety hazards such as fire or electrical shock
- Designed to remove power in case of a circuit *overload*
  - Fuses blow – one time protection
  - Circuit breakers trip – can be reset and reused
- Fuses interrupt current overloads by melting a short length of metal – when the metal melts, the current path is broken and power is removed from circuits
- Replacing a fuse or circuit breaker with one with a higher current rating could allow the fault to permanently damage the equipment or start a fire



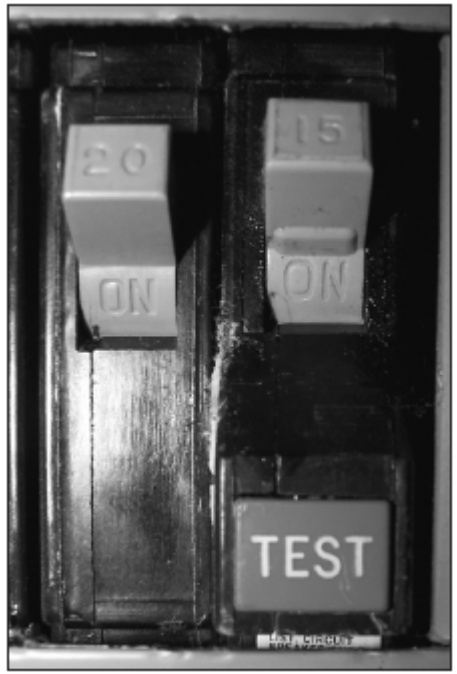
Schematics



Circuit Breaker



Fuses



Ground Fault Circuit Interrupter (GFCI) circuit breaker

PRACTICE QUESTIONS

What electrical component is used to protect other circuit components from current overloads?

A. Fuse
B. Thyratron
C. Varactor
D. All these choices are correct

T6A09 A 3-12

What is the purpose of a fuse in an electrical circuit?

A. To prevent power supply ripple from damaging a component
B. To remove power in case of overload
C. To limit current to prevent shocks
D. All these choices are correct

T0A04 B 3-12

Why should a 5-ampere fuse never be replaced with a 20-ampere fuse?

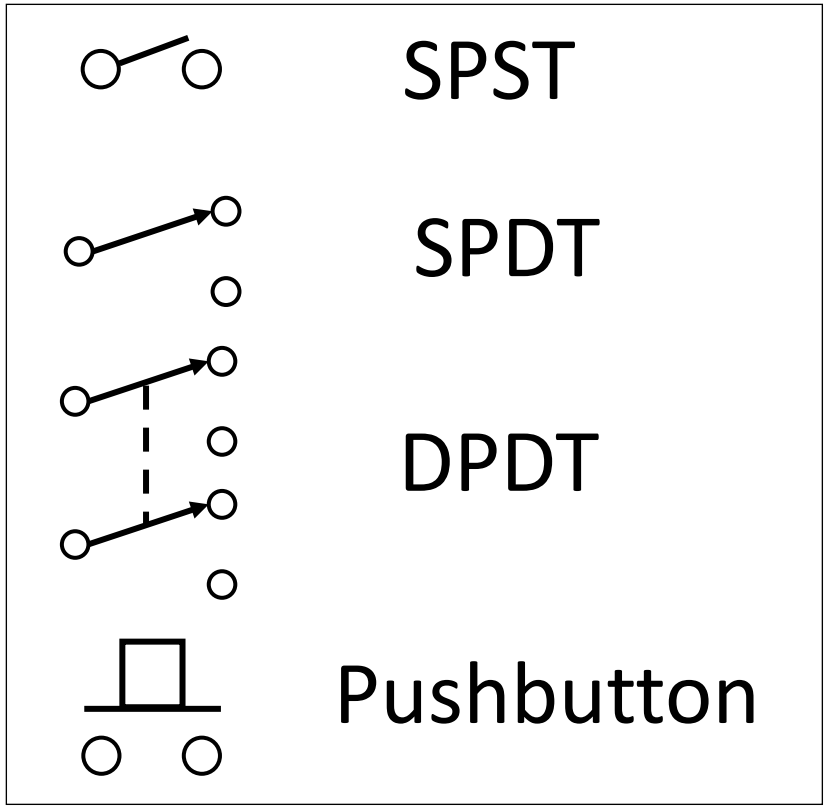
A. The larger fuse would be likely to blow because it is rated for higher current
B. The power supply ripple would greatly increase
C. Excessive current could cause a fire
D. All these choices are correct

T0A05 C 3-12

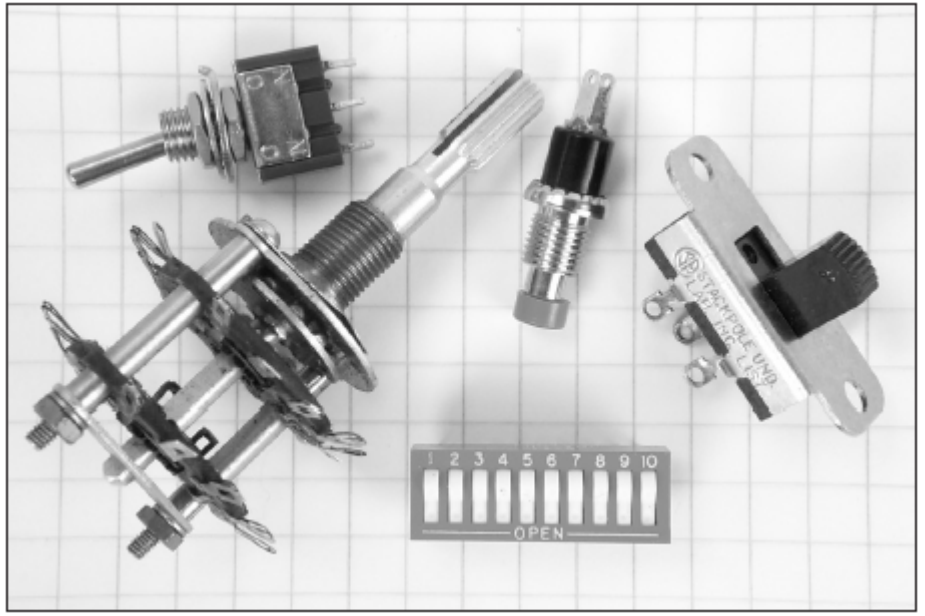
Circuit Gatekeepers … Switches & Relays

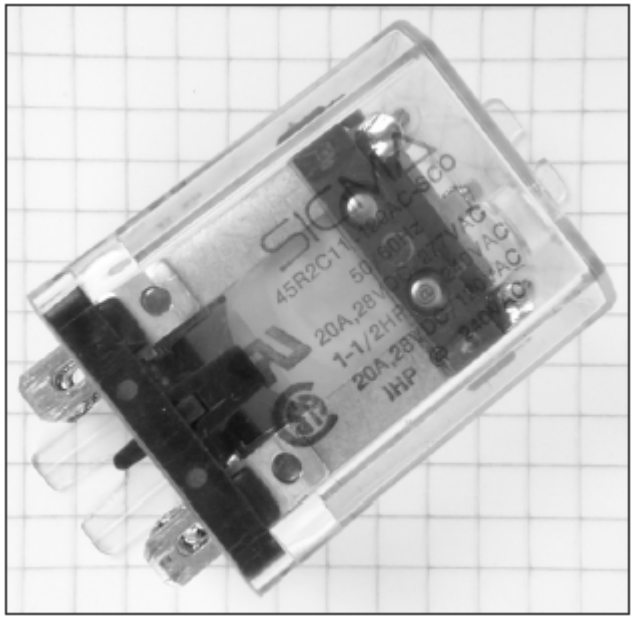
- *Switches* and *relays* control current through a circuit by connecting and disconnecting paths for current to follow
- Switches and relays are described by their number of poles and the number of throws
  - The combination of poles and throws describes the switch
  - Each circuit controlled by the switch is a *pole*
  - Each position is called a *throw*
- A switch is operated manually while a relay is a switch controlled by an electromagnet

Switch Configurations



Switches





Relay

Indicator, Meters and Displays

- Indicators and displays are important components for radio equipment
  - An *indicator* is either ON or OFF
- A *meter* provides information as a value in the form of numbers or on a numeric scale
- A *display* combines indicators, numbers, and labels
  - A *liquid crystal display* or **LCD** is used on the front panel of many radios and test instruments

PRACTICE QUESTIONS

What is the function of an SPDT switch?

A. A single circuit is opened or closed
B. Two circuits are opened or closed
C. A single circuit is switched between one of two other circuits
D. Two circuits are each switched between one of two other circuits

T6A08 C 3-13

What type of switch is represented by component 3 in figure T-2?

A. Single-pole single-throw
B. Single-pole double-throw
C. Double-pole single-throw
D. Double-pole double-throw

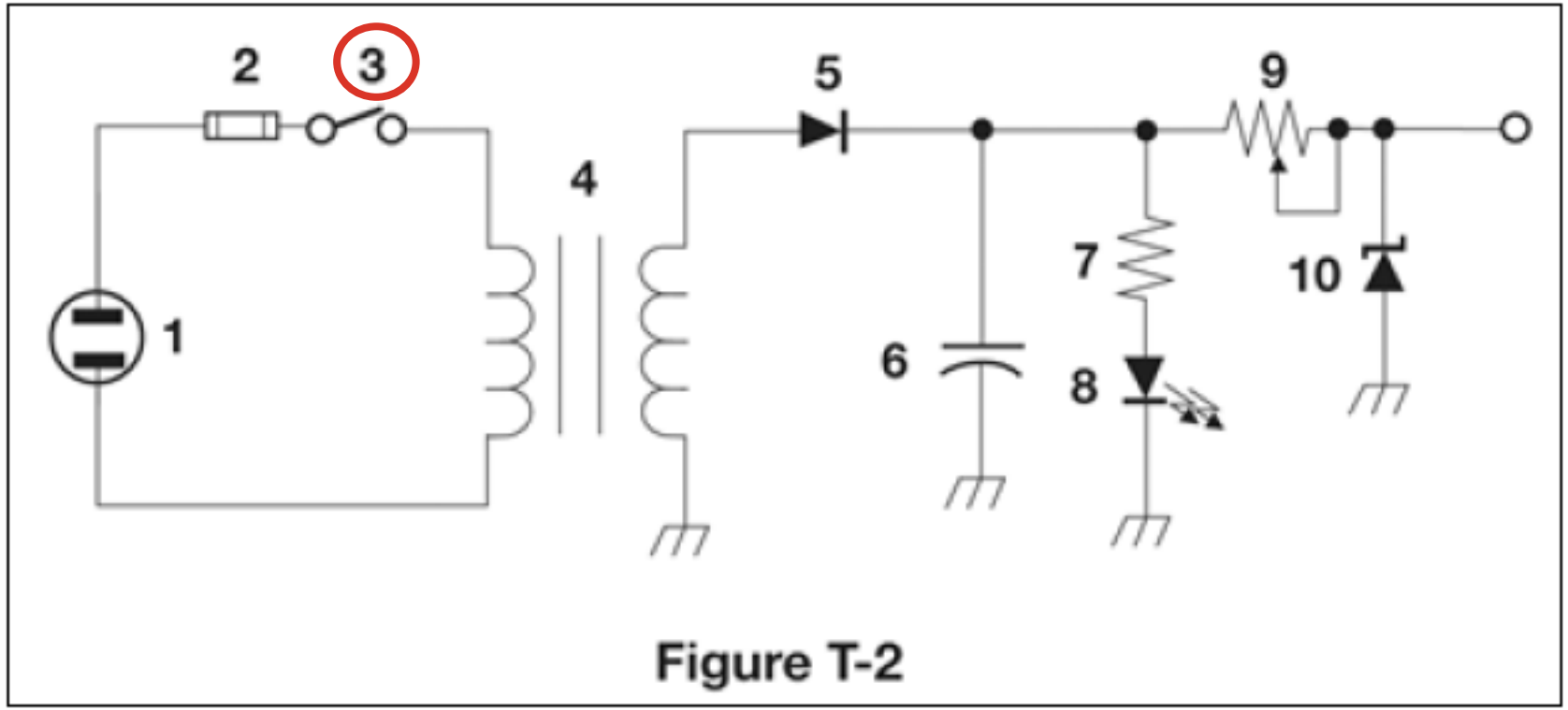


Figure T-2

T6A12 A 3-13

What is a relay?

A. An electrically-controlled switch
B. A current controlled amplifier
C. An inverting amplifier
D. A pass transistor

T6D02 A 3-13

Which of the following displays an electrical quantity as a numeric value?

A. Potentiometer
B. Transistor
C. Meter
D. Relay

T6D04 C 3-14

Fig 3.15 – Schematic Symbols (see text)

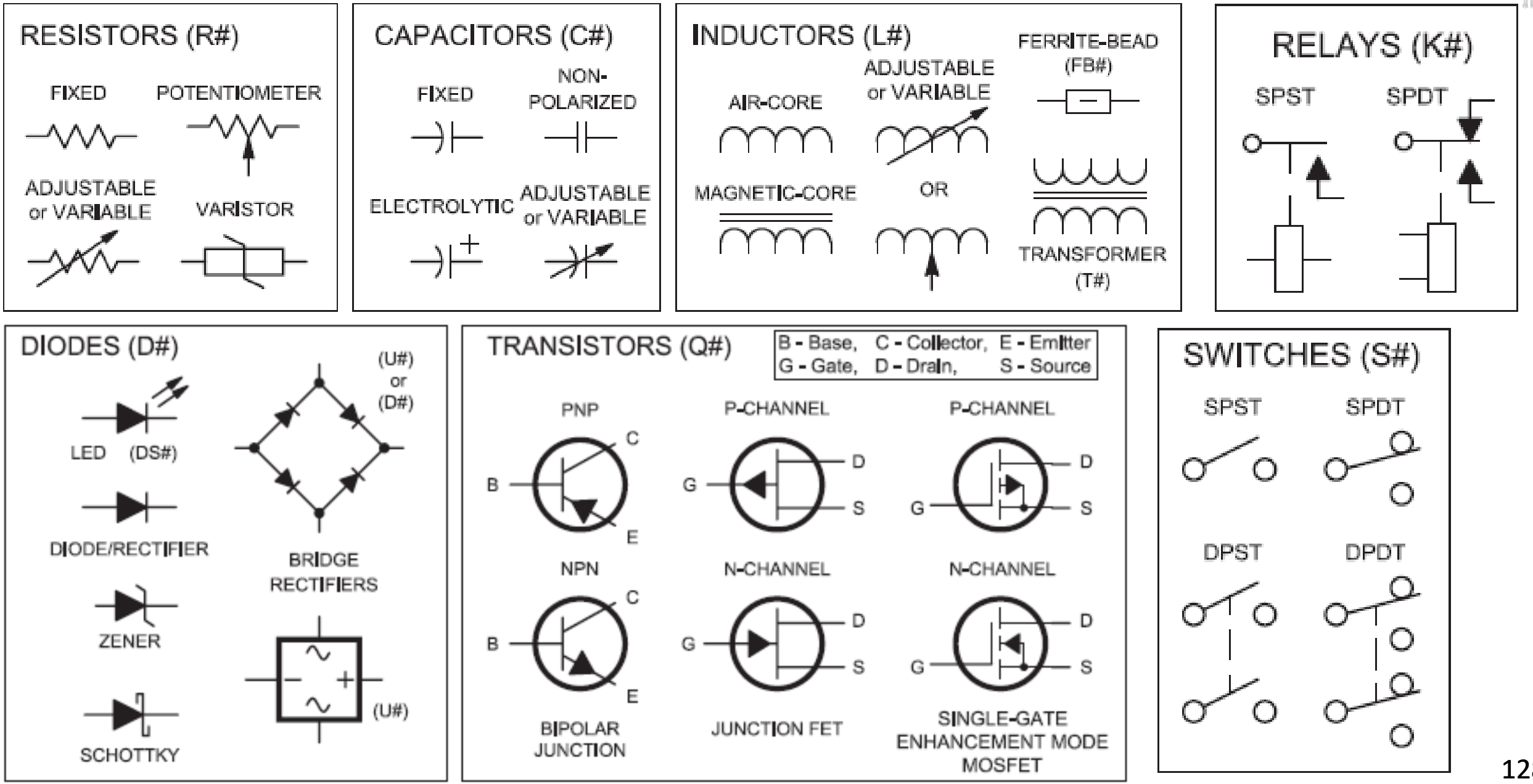
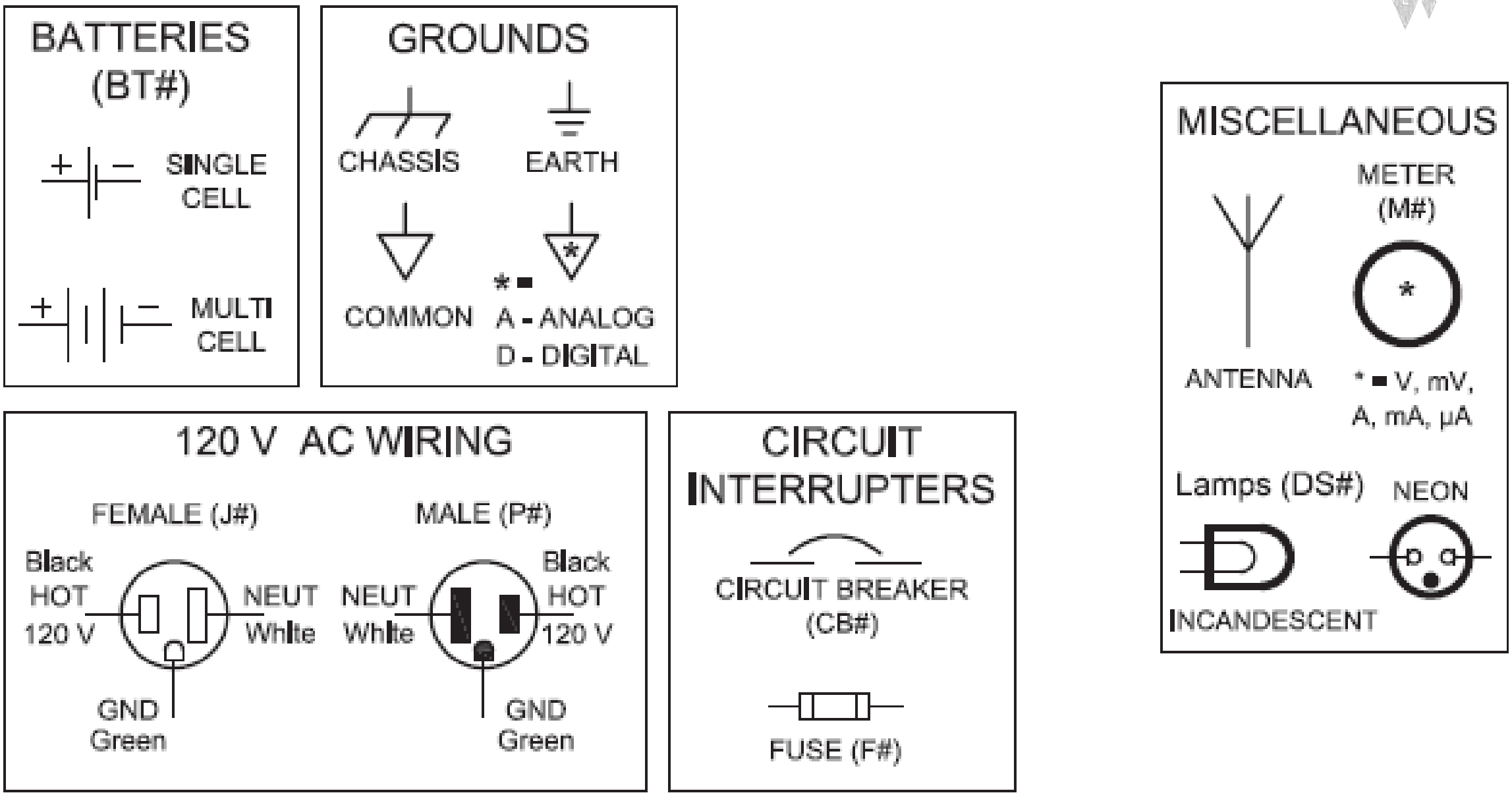


Fig 3.15 – Schematic Symbols (cont., see text)



Schematic Diagrams and Symbols

- *Symbols* are used when drawing a circuit because there are so many types of components
- *Schematic diagrams* are a visual description of a circuit and its components that uses standardized drawings called *circuit symbols*
  - Shows how the components are connected electrically

PRACTICE QUESTIONS

What is the name of an electrical wiring diagram that uses standard component symbols?

A. Bill of materials
B. Connector pinout
C. Schematic
D. Flow chart

T6C01 C 3-14

What is component 1 in figure T-1?

A. Resistor
B. Transistor
C. Battery
D. Connector

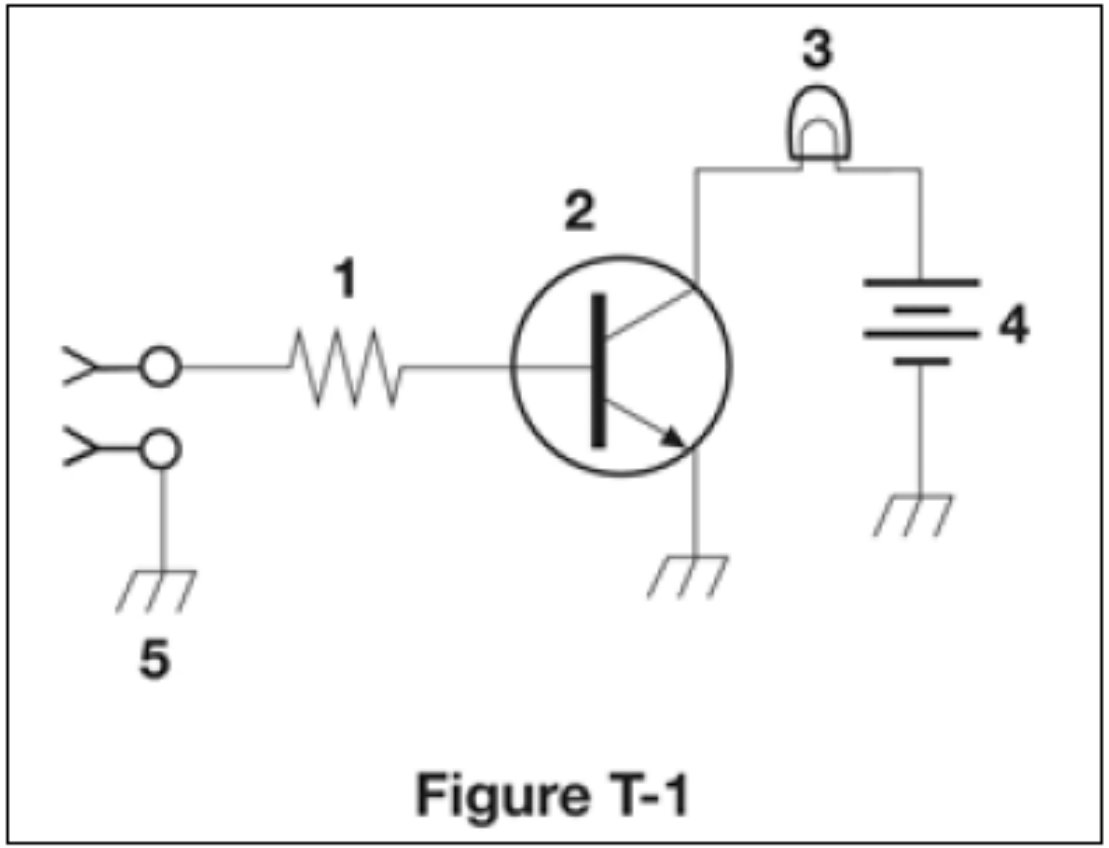


Figure T-1

T6C02 A 3-14

What is component 2 in figure T-1?

A. Resistor
B. Transistor
C. Indicator lamp
D. Connector

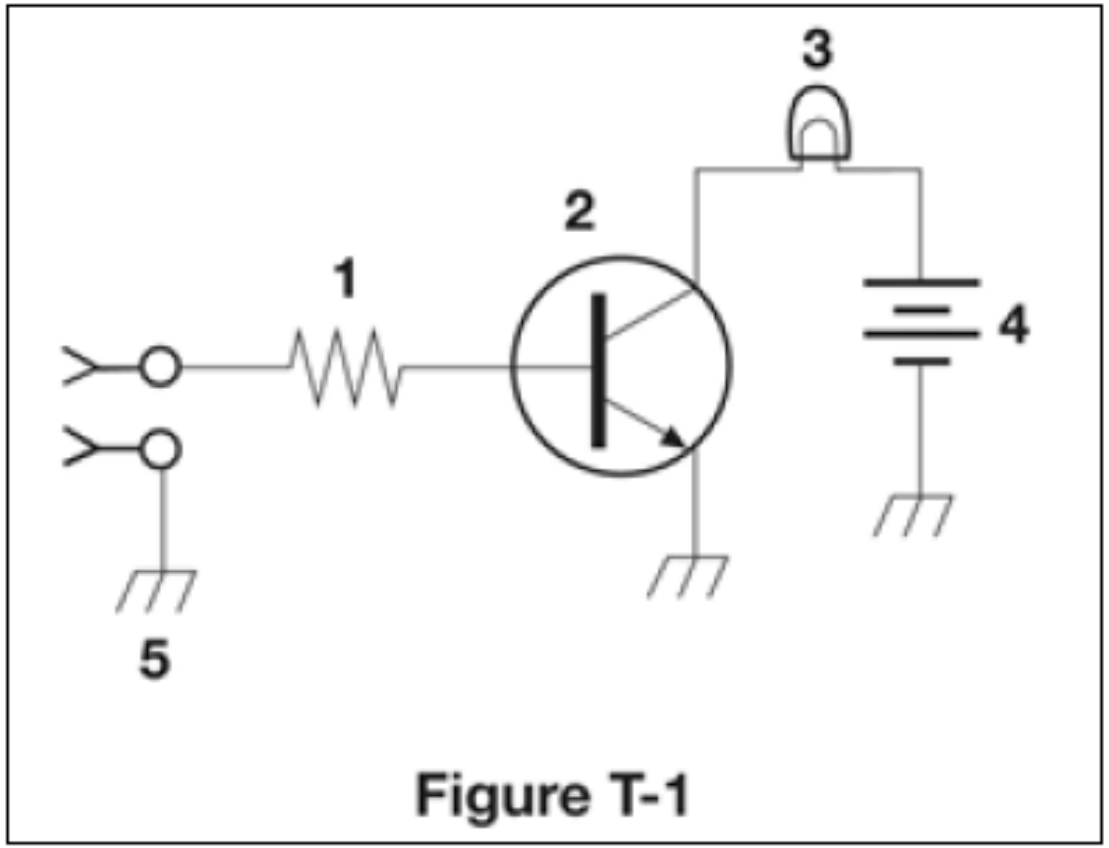


Figure T-1

T6C03 B 3-14

What is component 3 in figure T-1?

A. Resistor
B. Transistor
C. Lamp
D. Ground symbol

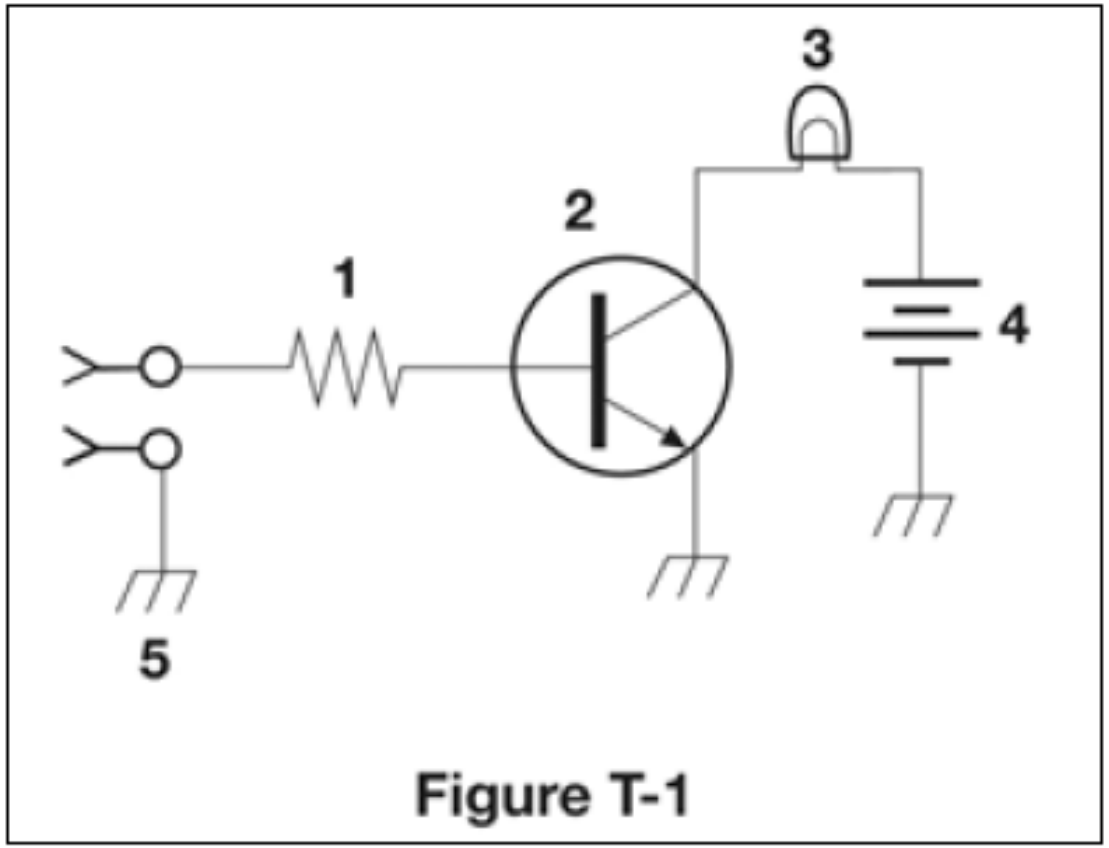


Figure T-1

T6C04 C 3-14

What is component 4 in figure T-1?

A. Resistor
B. Transistor
C. Ground symbol
D. Battery

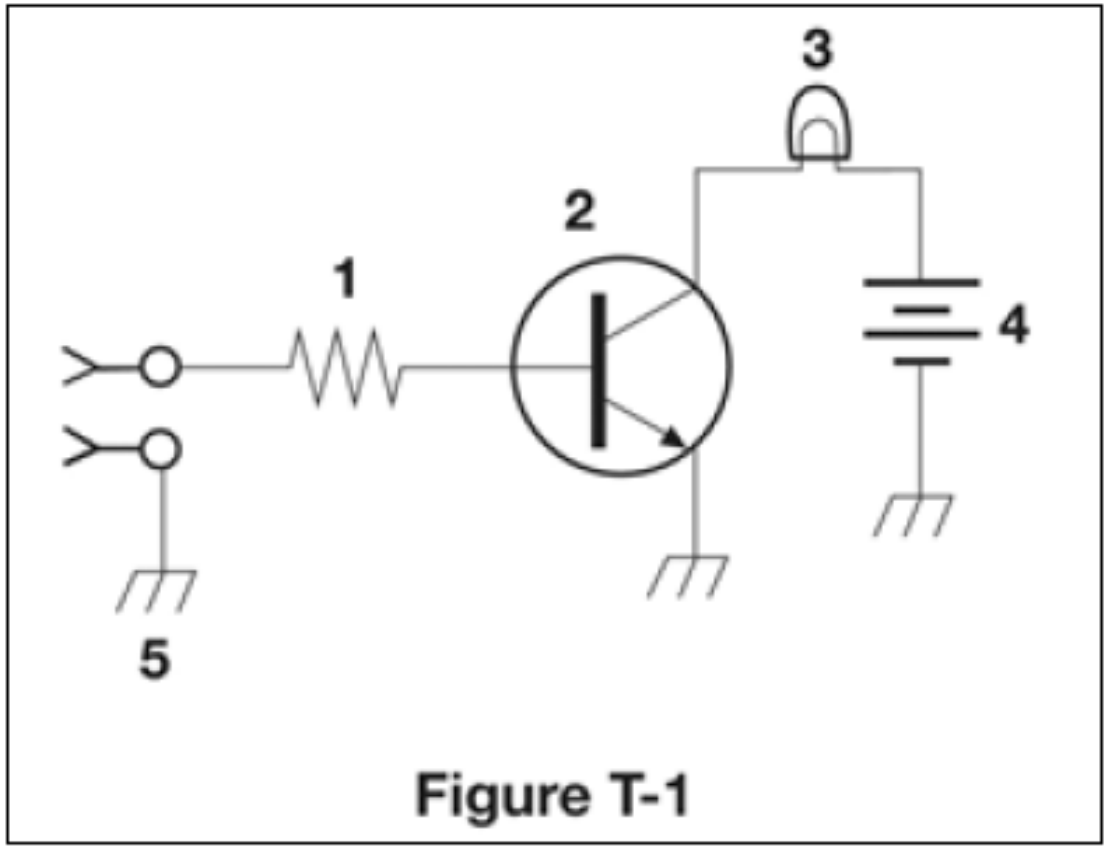


Figure T-1

T6C05 D 3-14

What is component 6 in figure T-2?

A. Resistor
B. Capacitor
C. Regulator IC
D. Transistor

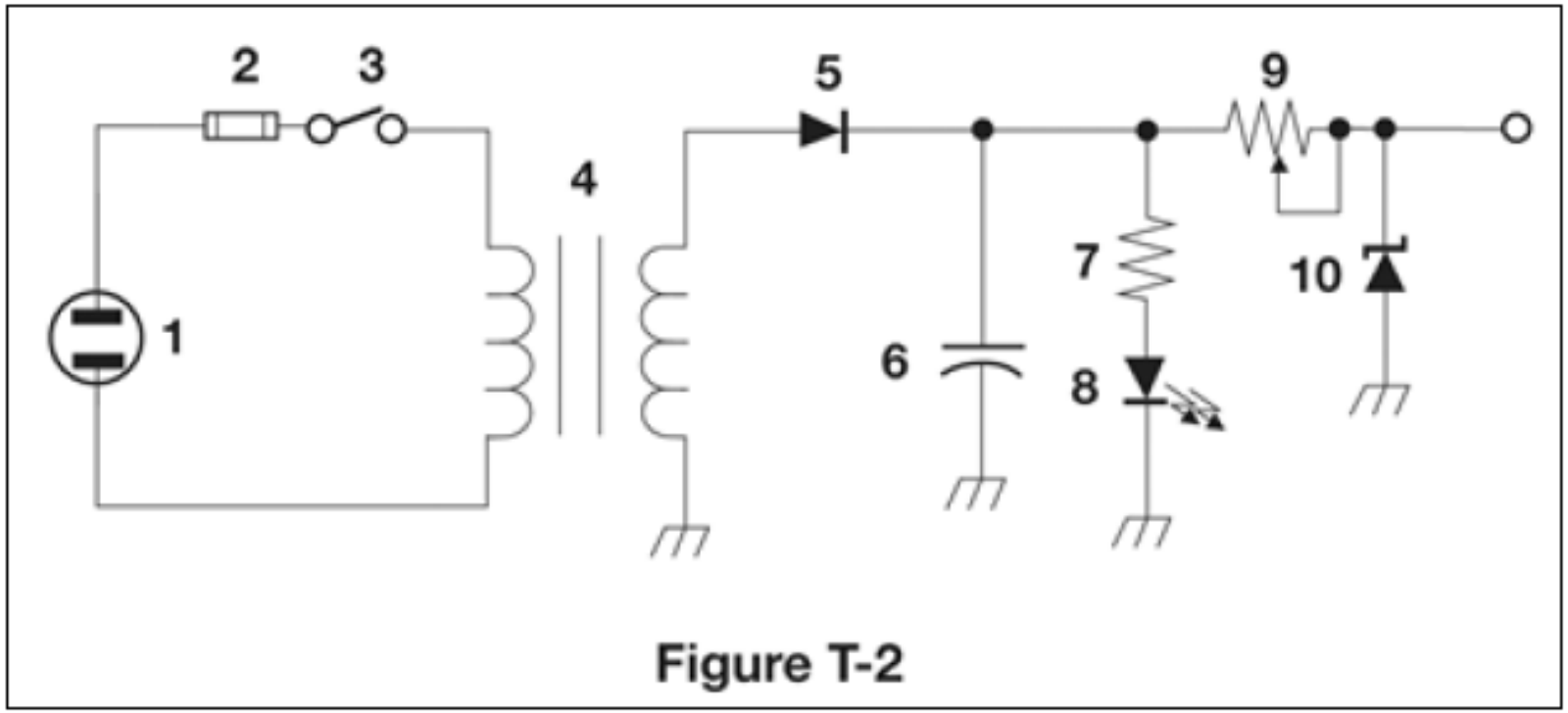


Figure T-2

T6C06 B 3-14

What is component 8 in figure T-2?

A. Resistor
B. Inductor
C. Regulator IC
D. Light emitting diode

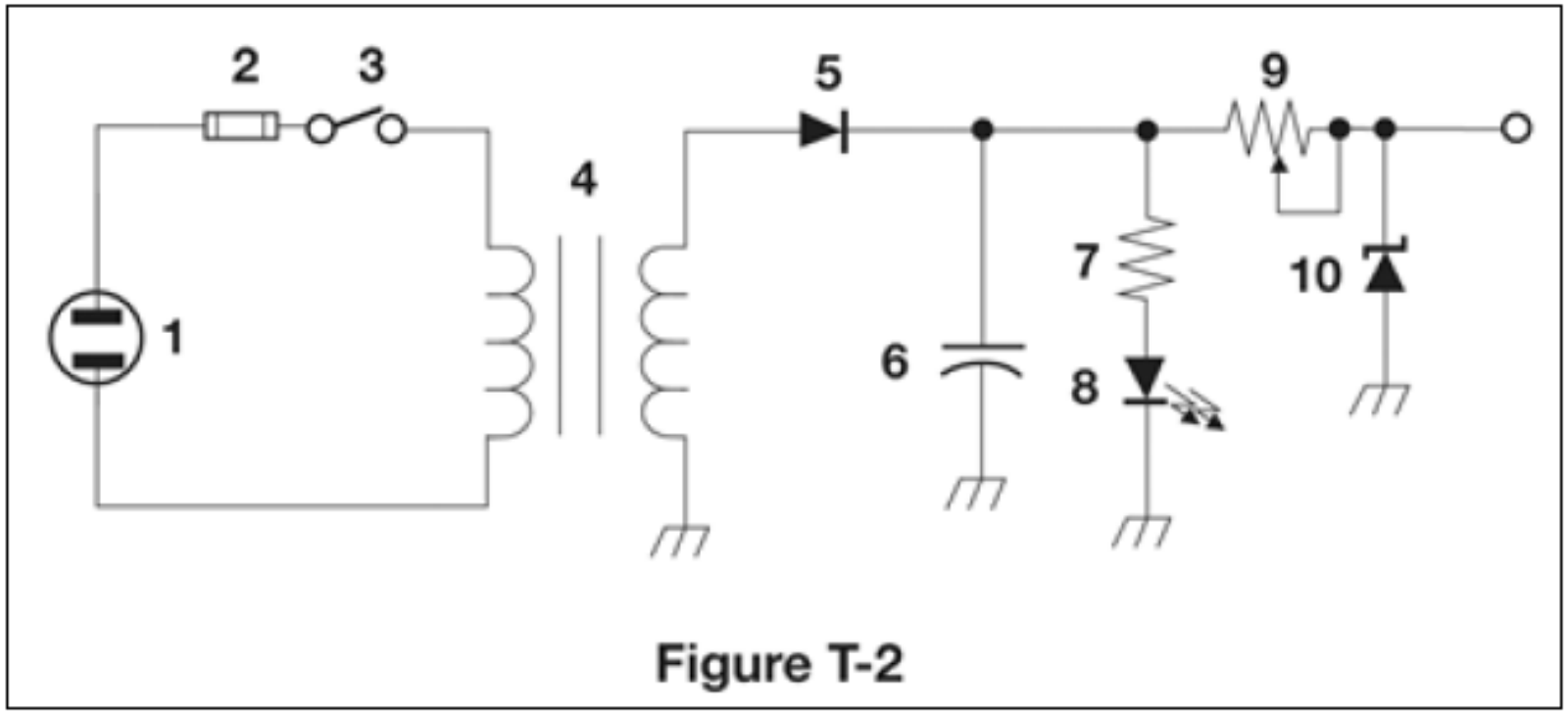


Figure T-2

T6C07 D 3-14

What is component 9 in figure T-2?

A. Variable capacitor
B. Variable inductor
C. Variable resistor
D. Variable transformer

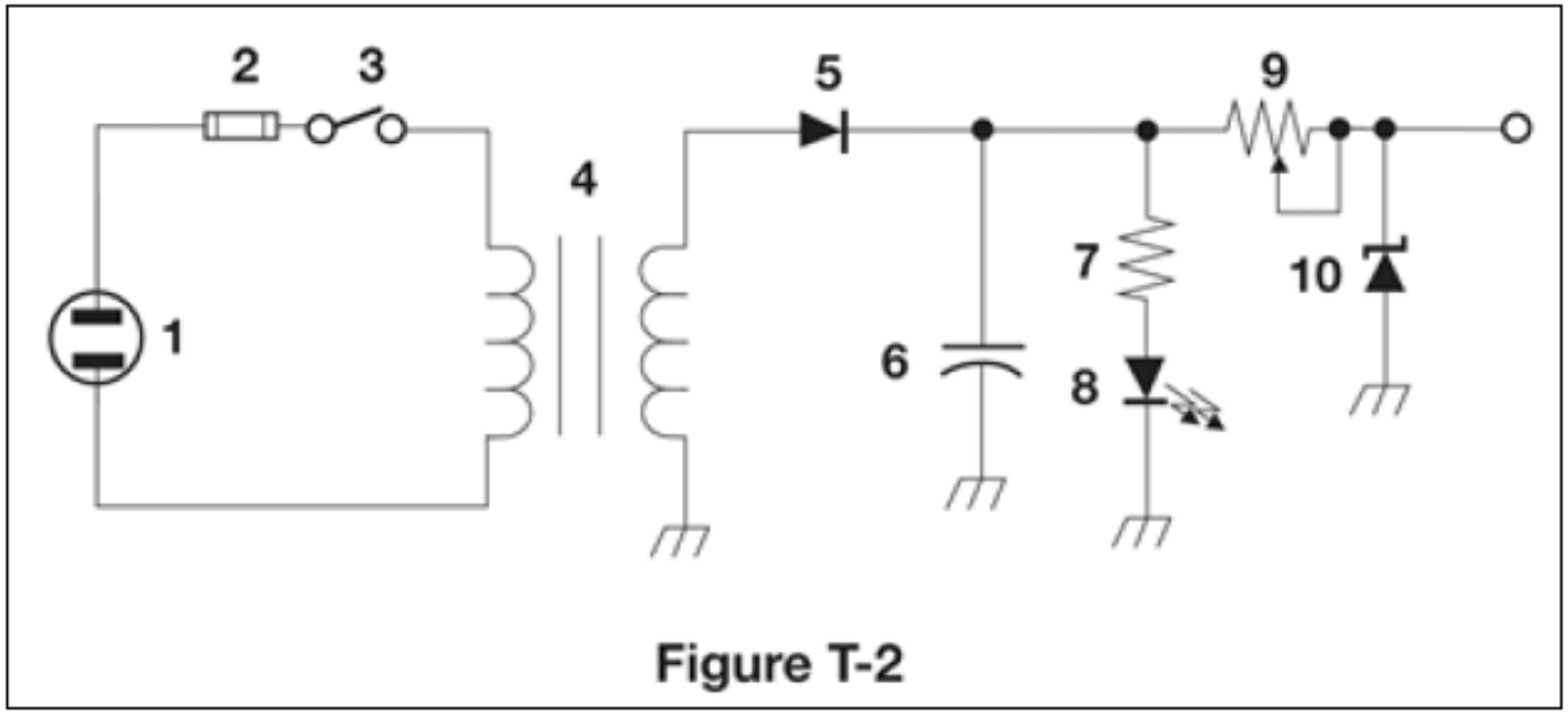


Figure T-2

T6C08 C 3-14

What is component 4 in figure T-2?

A. Variable inductor
B. Double-pole switch
C. Potentiometer
D. Transformer

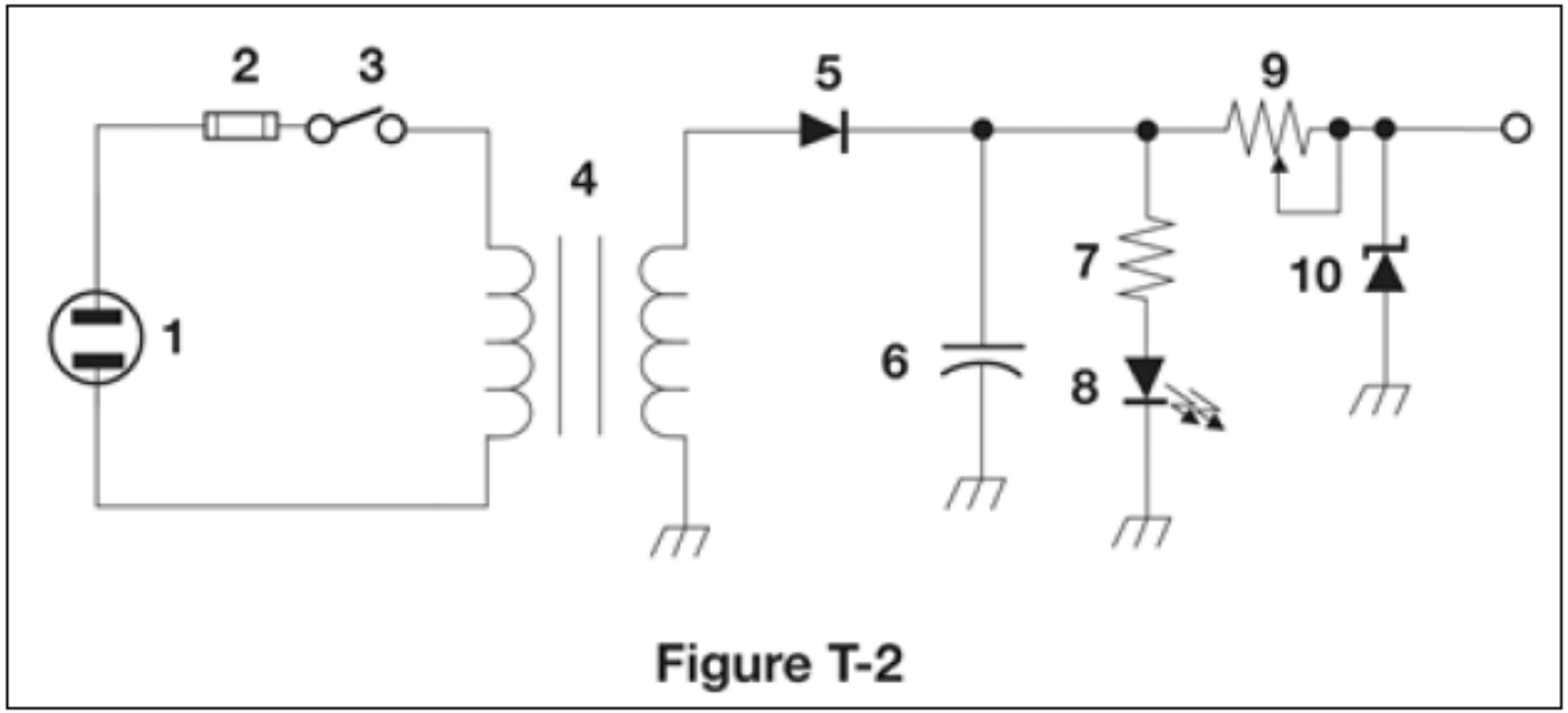


Figure T-2

T6C09 D 3-14

What is component 3 in figure T-3?

A. Connector
B. Meter
C. Variable capacitor
D. Variable inductor

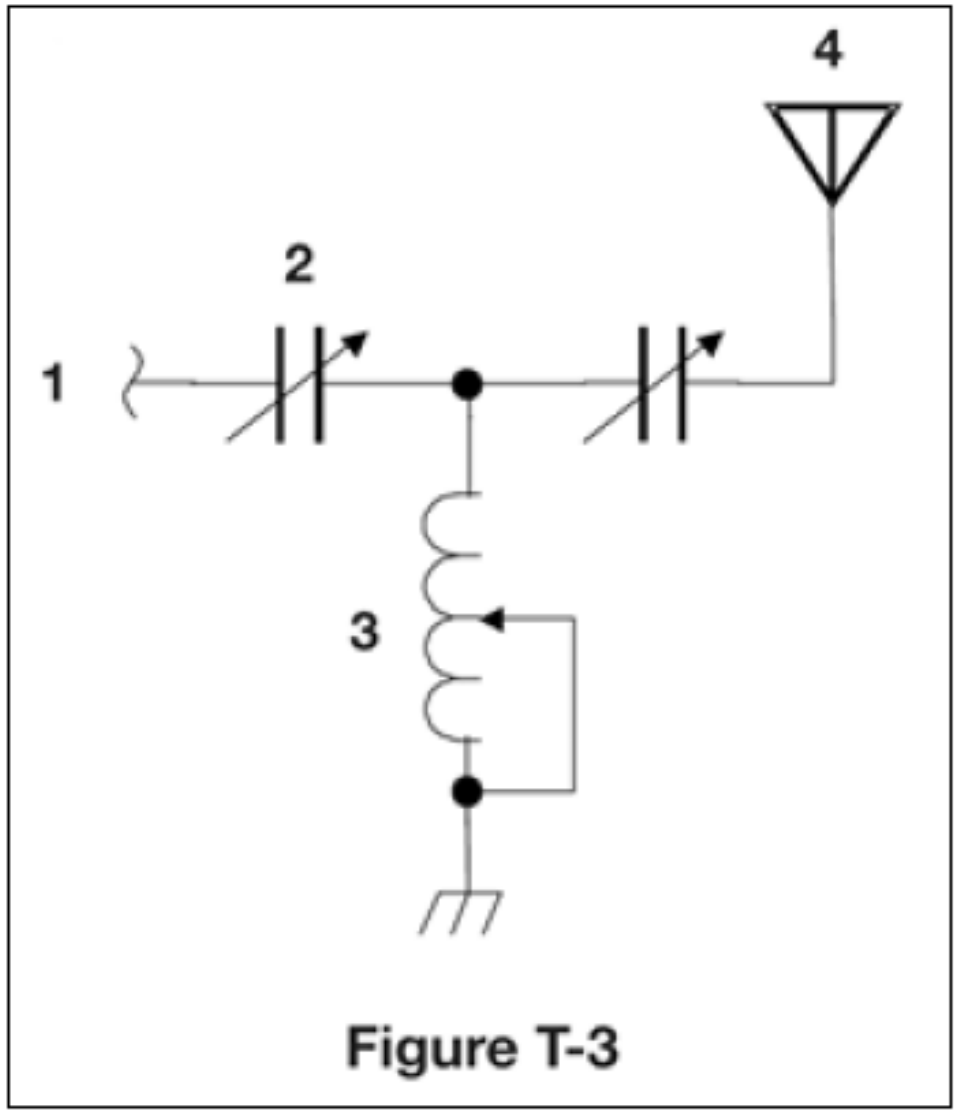


Figure T-3

T6C10 D 3-14

What is component 4 in figure T-3?

A. Antenna
B. Transmitter
C. Dummy load
D. Ground

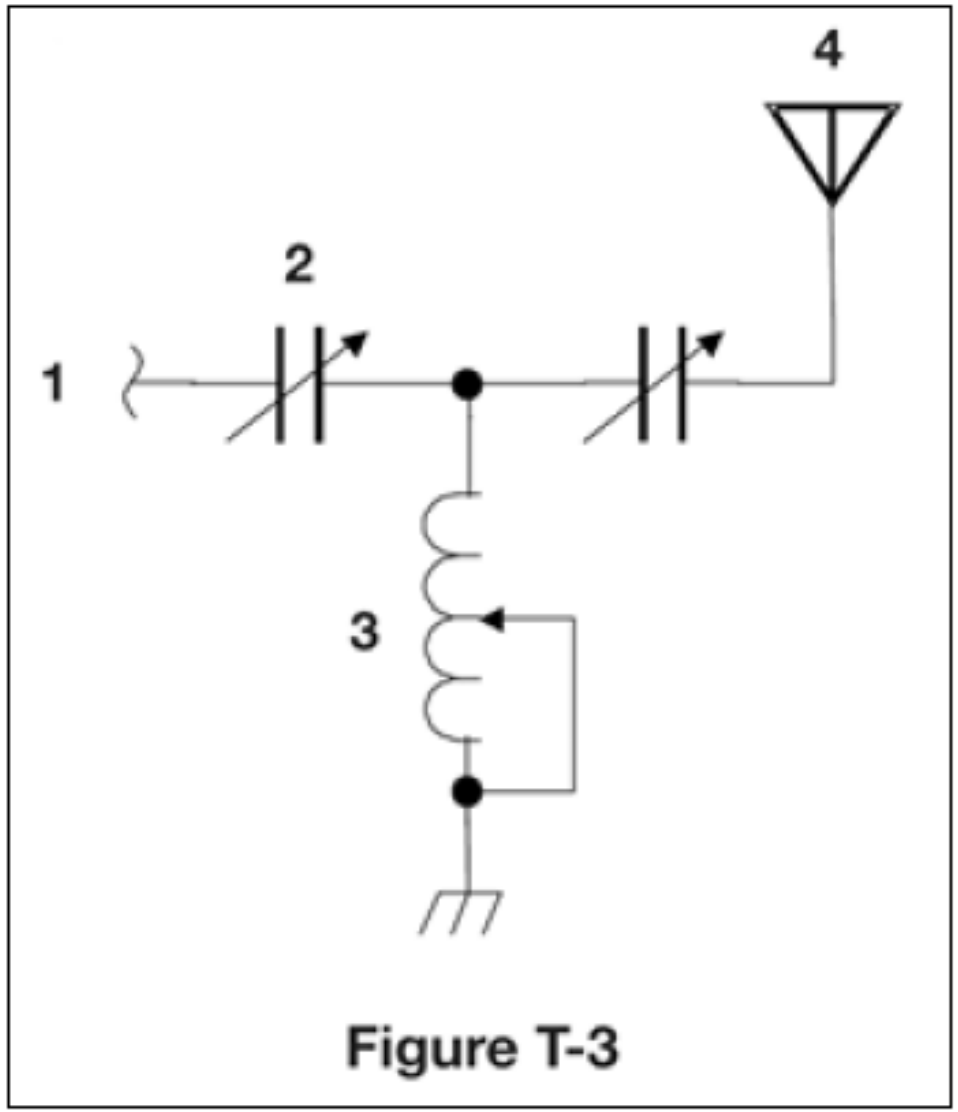


Figure T-3

T6C11 A 3-14

Which of the following is accurately represented in electrical schematics?

A. Wire lengths
B. Physical appearance of components
C. Component connections
D. All these choices are correct

T6C12 C 3-14

Radio Circuits

- An *oscillator* produces a steady signal at one frequency
  - Used in both receivers and transmitters to determine the operating frequency
- The process of combining data or voice signals with an RF signal is *modulation*
- Modulators add the data or voice signal to an RF signal or carrier
  - A *demodulator* circuit extracts the information from a modulated signal
- *Mixers* combine two RF signals and shift one of them to a third frequency (closely related to a modulator)

PRACTICE QUESTIONS

What is the name of a circuit that generates a signal at a specific frequency?

A. Reactance modulator
B. Phase modulator
C. Low-pass filter
D. Oscillator

T7A05 D 3-17

Which of the following describes combining speech with an RF carrier signal?

A. Impedance matching
B. Oscillation
C. Modulation
D. Low-pass filtering

T7A08 C 3-17

Which of the following is used to convert a signal from one frequency to another?

A. Phase splitter
B. Mixer
C. Inverter
D. Amplifier

T7A03 B 3-18

END OF MODULE 3