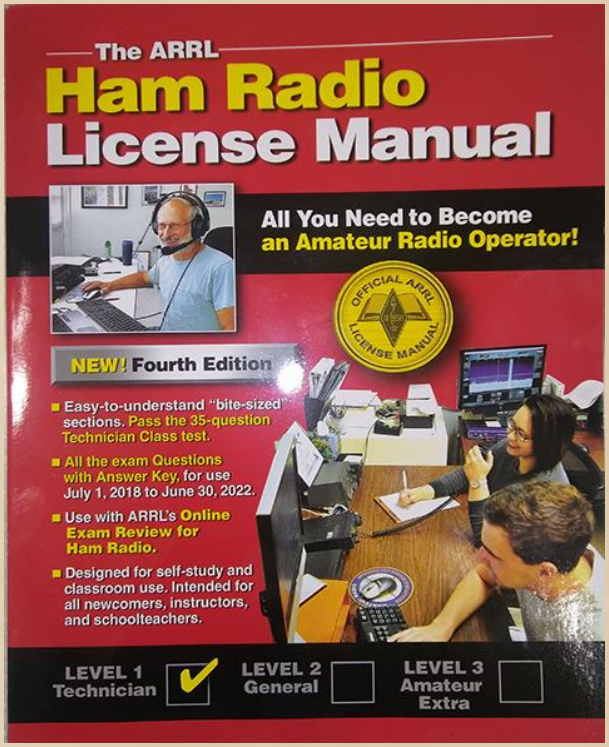
FCC Technician License Course



2018-2022 FCC Element 2 Technician Class Question Pool

Presented by:

Tamiami Amateur Radio Club (TARC)

Tamiami Amateur Radio Club
Venice, Florida

W E L C O M E

- To the Third of 4, 4-hour classes presented by TARC to prepare you for the FCC Technician Class Amateur Radio Service license test.
- Today we will cover Chapters 3 and 9 of the ARRL Ham Radio License Manual, 4rd Edition
- Everything you need to know is in this manual

Meet Your Instructors

Andy Durette

KB1HIP

Extra Class

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KN4BAR

Extra Class

Chet Fennell

KG4IYS

Extra Class

Course Outline

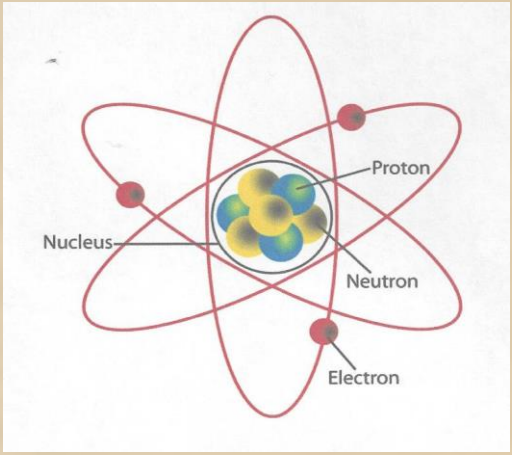
- Welcome to amateur radio
- Radio and Signals Fundamentals
- Amateur Radio Equipment (VHF and UHF)
- Electricity, Components and Circuits
- Amateur Radio Equipment (HF)
- Propagation, Antennas and Feedlines
- Communicating with other hams
- Licensing regulations
- Operating regulations
- Safety
- Test preparation and review

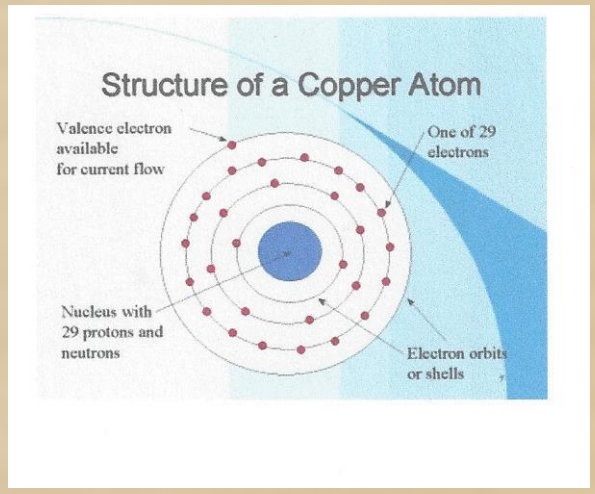
Fundamentals of Electricity-History

- 600-BC- Greeks found mysterious force of attraction/repulsion when amber was rubbed. Greek word for amber is “elektron”
- 1600- William Gilbert wrote the “De Magnete”. He used terms like electric force and electric attraction and is known as the “Father of Electricity”
- 1746- Benjamin Franklin experimented with electric charges, lightning/kites and formulated the fluid theory of electrical current; current flowing from plus to minus (conventional current)
- 1828- Georg Simon Ohm determined the relationship of current, voltage and resistance which is now known as Ohm’s Law.

Electricity, Components and Circuits

- In electronics and radio, we control the flow of electrons to make things happen
- Knowledge of how to control the flow of electrons helps us understand how to operate our radio
- Atoms are the smallest particle that show its chemical and physical properties.



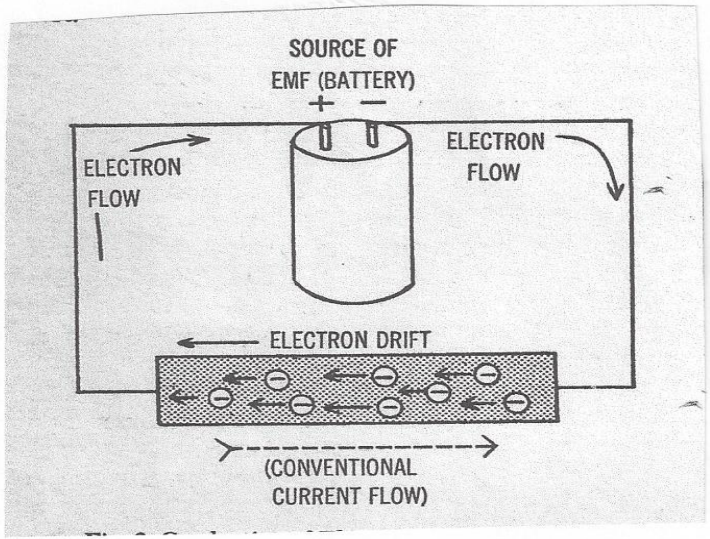


- Atoms consist of a Nucleus (neutron and protons which have a positive charge) and negatively charged particles called electrons that revolve around the Nucleus in fixed orbits.

Electricity, Components and Circuits

- The negatively charged electrons balances the positively charged protons so the atom is electrically neutral.
- When dealing with electricity, what we are referring to is the flow of electrons through a conductor.
- When a voltage is present across a conductor (ie copper) electrons are dislodged from their fixed orbit and move in the conductor towards the positive terminal.

Fundamentals of Electricity

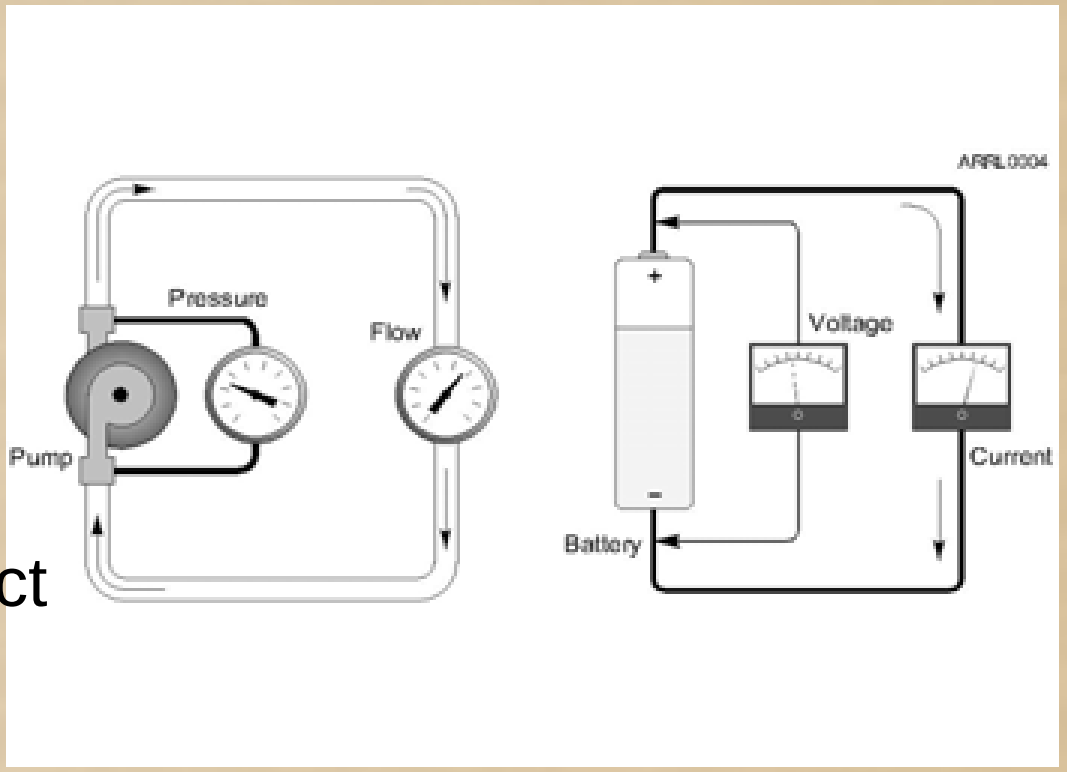


Conductors	Insulators
Silver	Mica
Copper	Quartz
Gold	Glass
Aluminium	Ceramics
Brass	Ebonite
Steel	Plastics
Mercury	Air and other gasses
Carbon	Oil
Solutions of salts or acids in water	Pure water

- A **conductor** is a material that allows electrons to move with relative freedom
- Copper is a good conductor
- **Insulators** are materials that DO NOT easily allow the flow of electrons
- Glass or plastic are good insulators

Fundamentals of Electricity

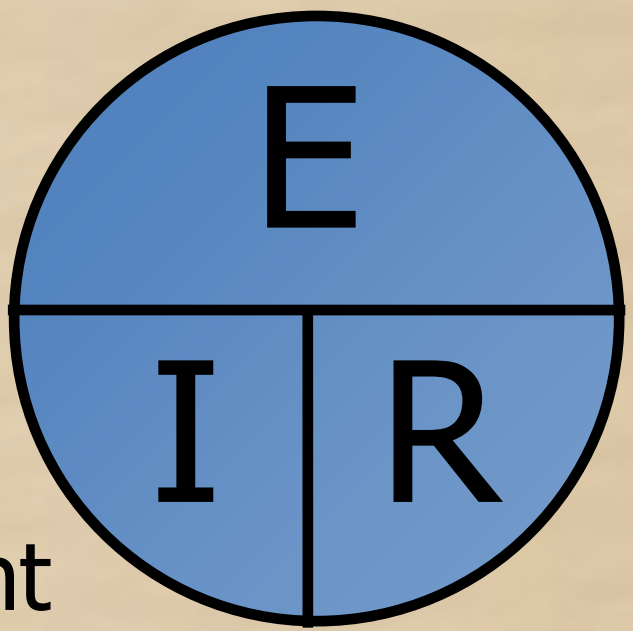
- Voltage and a conductor (resistance/load) must be present to have a current flow
- Just like water flowing through a hose, changes in voltage and resistance affect the current flowing
- That effect is mathematically expressed as Ohm's Law



Fundamentals of Electricity

Electromotive Force = **VOLTS**

Measured with a Voltmeter



E = I x R

The flow of electrons-current (**AMPERES**)

Measured with an Ammeter

Resistance to current flow (**OHMS**)

Measured with an Ohmmeter

Ohms Law

Digital Multimeter –VOM or DVM

- These modern multimeters are easier to use and harder to break than older analog meters.
- Measures dc/ac voltages, current or resistance
- The higher input impedance makes them more accurate.
- Many include extra features like capacitance, inductance, diode and transistor test functions.

Fundamentals of Electricity

Which instrument would you use to measure electric potential or electromotive force? (T7D01)

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

Fundamentals of Electricity

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A. An ammeter
B. A voltmeter
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Fundamentals of Electricity

What is the correct way to connect a voltmeter to a circuit? (T7D02)

A. In series with the circuit
B. In parallel with the circuit
C. In quadrature with the circuit
D. In phase with the circuit

Fundamentals of Electricity

What is the correct way to connect a voltmeter to a circuit? (T7D02)

A. In series with the circuit
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C. In quadrature with the circuit
D. In phase with the circuit

Fundamentals of Electricity

Which instrument would you use to measure electric current? (T7D04)

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

Fundamentals of Electricity

Which instrument would you use to measure electric current? (T7D04)

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

Fundamentals of Electricity

How is an ammeter usually connected to a circuit? (T7D03)

A. In series with the circuit
B. In parallel with the circuit
C. In quadrature with the circuit
D. In phase with the circuit

Fundamentals of Electricity

How is an ammeter usually connected to a circuit? (T7D03)

A. In series with the circuit
B. In parallel with the circuit
C. In quadrature with the circuit
D. In phase with the circuit

Fundamentals of Electricity

Which of the following might damage a multimeter? (T7D06)

A. Measuring a voltage too small for the chosen scale

B. Leaving the meter in the milliamps position overnight

C. Attempting to measure voltage when using the resistance setting

D. Not allowing it to warm up properly

Fundamentals of Electricity

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Fundamentals of Electricity

What is probably happening when an ohmmeter, connected across a circuit, initially indicates a low resistance and then shows increasing resistance with time? (T7D10)

A. The ohmmeter is defective
B. The circuit contains a large capacitor
C. The circuit contains a large inductor
D. The circuit is a relaxation oscillator

Fundamentals of Electricity

What is probably happening when an ohmmeter, connected across a circuit, initially indicates a low resistance and then shows increasing resistance with time? (T7D10)

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Fundamentals of Electricity

Which of the following precautions should be taken when measuring circuit resistance with an ohmmeter? (T7D11)

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

Fundamentals of Electricity

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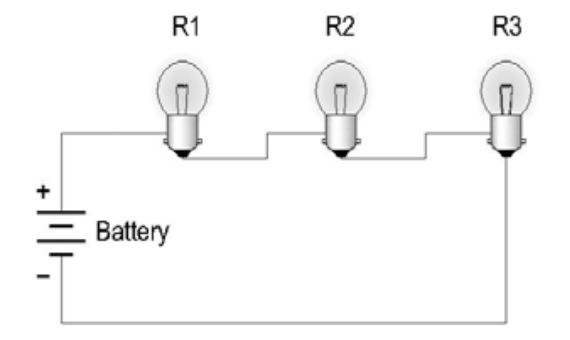
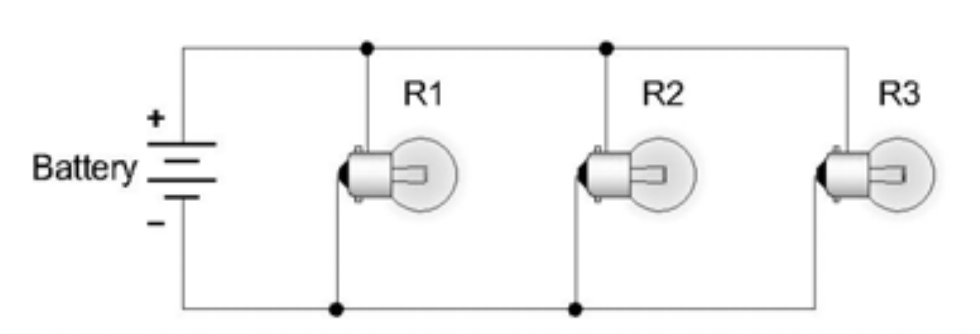
Electrical Circuits

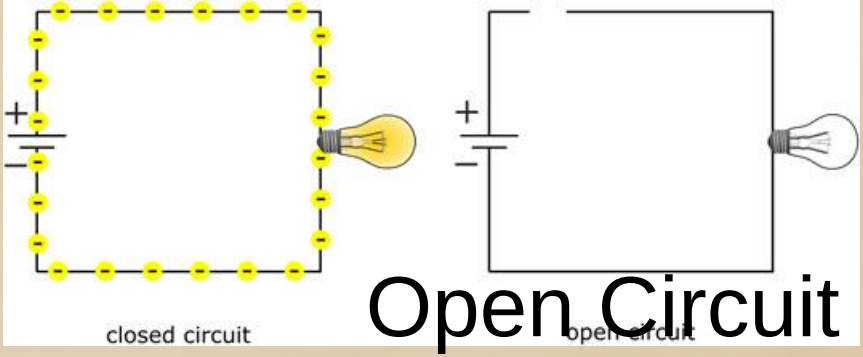
A **circuit** is a path through which current can flow

Series Circuit



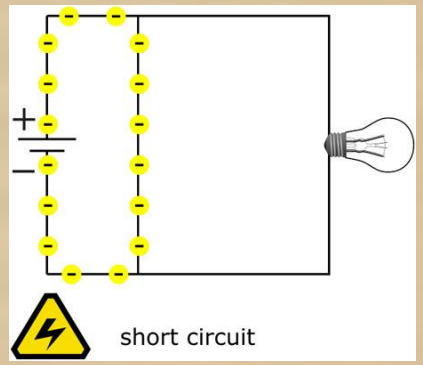
Parallel Circuit





Open Circuit

Short Circuit

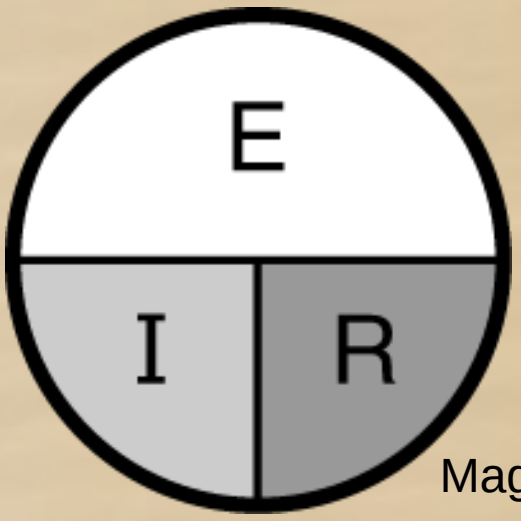


Resistance

- All materials impede the flow of electrons to some degree
- Measured in **Ohms (Ω)** with an **ohmmeter**. (T7D05)
- **Insulators** resist or prevent the flow of electrons

Characteristics of Electricity

- **Three characteristics of Electricity**
  - **Voltage**
  - **Current**
  - **Resistance**
- **Each can be measured**



Magic Circle

- **E is voltage, Unit is Volt**
- **I is current, Unit is Ampere**
- **R is resistance, Unit is Ohm**

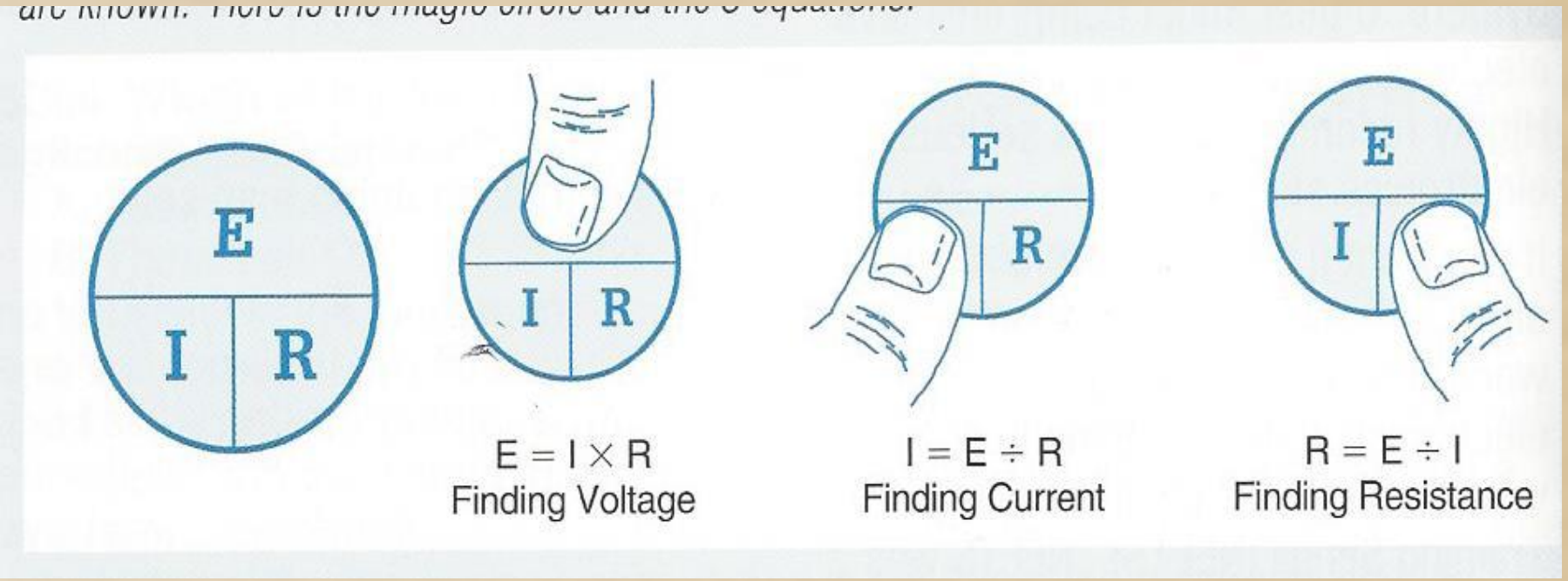
OHM'S LAW

E = I x R (Unit is Volt)

I = E / R (Unit is Ampere)

R = E / I (Unit is Ohm)

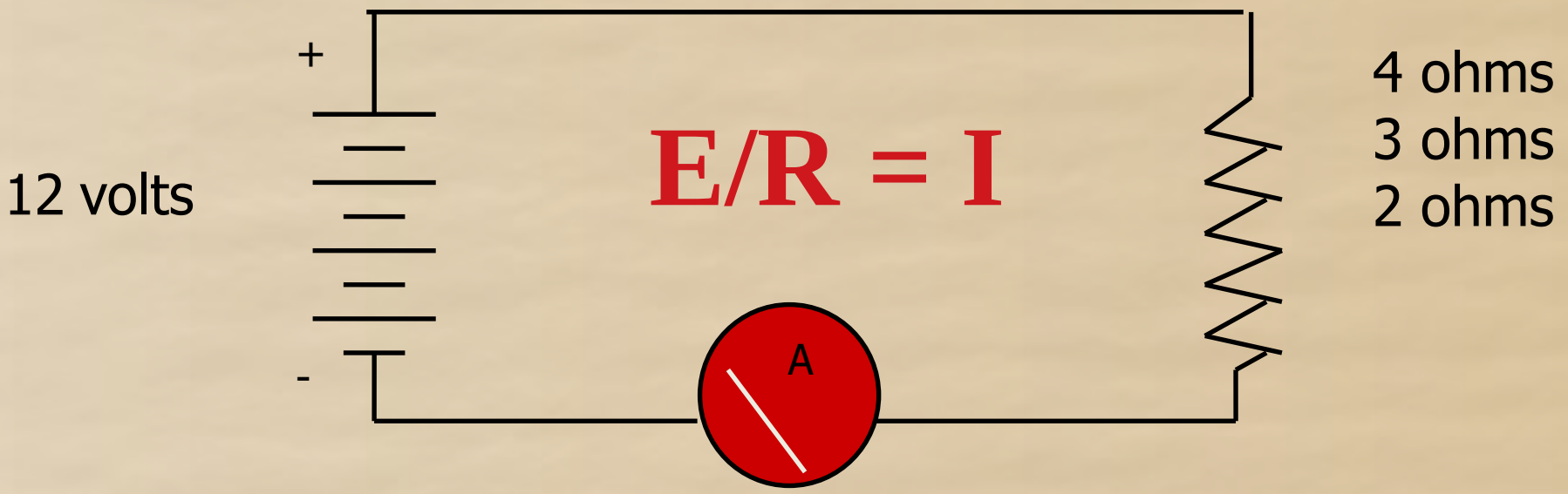
Characteristics of Electricity
Ohms Law



Magic Circle

Gordon West

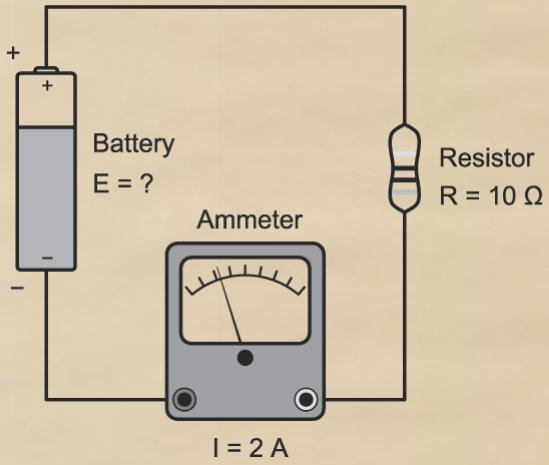
Ohms Law-Example



As we substitute the values shown, what happens to the current flow in the circuit?

- **12 V/4 ohms = 3 amperes**
- **12/3 = 4 amperes**
- **12/2 = 6 amperes**

Examples of Ohm's Law



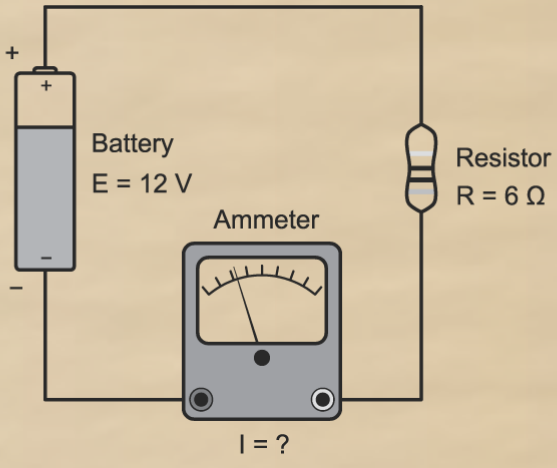
Given: I = 2 Amperes
R = 10 Ohms

Find: E (voltage)

$E = I \times R = 2 \times 10 = 20$ Volts

Voltage Equals 20 Volts

ARRL0006

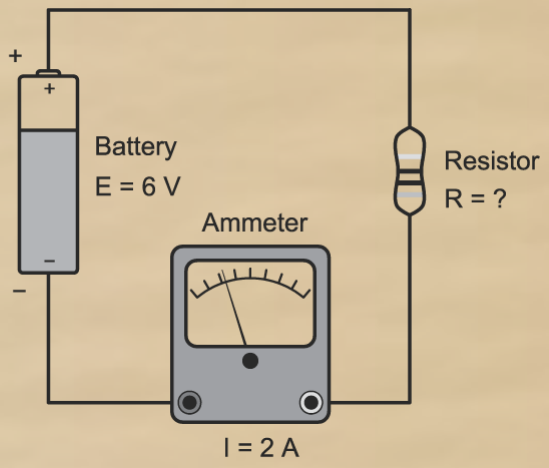


Given: E = 12 Volts
R = 6 Ohms

Find: I (current)

$I = \frac{E}{R} = \frac{12}{6} = 2$ Amps

Current Equals
2 Amperes



Given: E = 6 Volts
I = 2 Amperes

Find: R (resistance)

$R = \frac{E}{I} = \frac{6}{2} = 3$ Ohms

Resistance Equals
3 Ohms

T5D04 What is the resistance of a circuit in which a current of 3 amperes flows through a resistor connected to 90 volts?

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

Be careful – they list current first which would go in the bottom of your magic circle, and voltage at the top. Keystrokes: ***90 ÷ 3 = 30***. **ANSWER B.**

T5D05 What is the resistance in 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.

In this problem, they list voltage first, which is 12, on the top divided by 1.5 amps on the bottom. ***12 ÷ 1.5 = 8***. Read each question carefully because they switch around voltage and current, yet your magic circle always says to put voltage on the top and current on the bottom when solving for resistance.

ANSWER C.

T5D06 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.

On most Technician Class questions, you divide the larger number by the smaller number, and presto, you end up with the correct answer. ***12 divided by 4 equals 3.*** Ohm's Law – simple! **ANSWER A.**

T5D07 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.

Here they want to know current, so it is voltage (120 volts) divided by resistance (80 ohms). Here are your calculator keystrokes: Clear Clear 120 ÷ 80 = ***1.5***.
ANSWER D.

T5D08 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.

Be careful on this question – they reversed the order of resistance and voltage that was in the previous question. In your magic circle, I = 200 ÷ 100. Calculator keystrokes: Clear Clear 200 (volts on the top) ÷ 100 ohms (on the bottom) = ***2 amperes***.
ANSWER C.

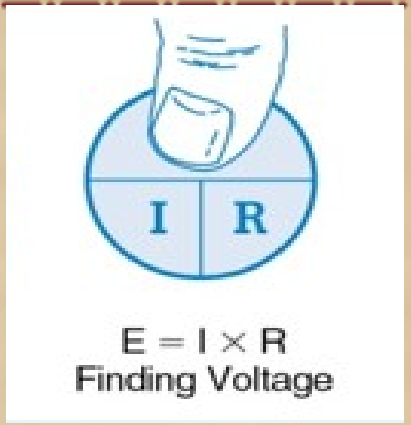
T5D09 What is the current through a 24-ohm resistor connected across 240 volts?

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

Do the calculator keystrokes: Clear Clear ***240*** ÷ ***24 =*** ***10***. Remember, to calculate current, it is voltage on top divided by resistance on the bottom. **ANSWER C.**

T5D10 What is the voltage across a 2-ohm resistor if a current of 0.5 amperes flows through it?

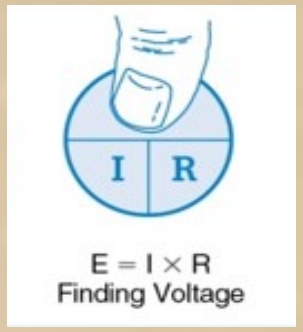
A. 1 volt.
B. 0.25 volts.
C. 2.5 volts.
D. 1.5 volts.



Since we are looking for E in this question, the voltage across a resistor, cover E with your finger, and you now have I (0.5 amps) times R (2 ohms). Simply multiple these two values to obtain your answer: 0.5 X 2 = and the answer is ***1 volt***. Commit the magic circle of success to your memory now! **ANSWER A.**

T5D11 What is the voltage across a 10-ohm resistor if a current of 1 ampere flows through it?

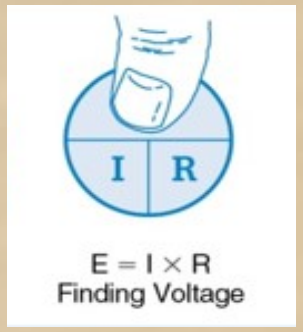
A. 1 volt.
B. 10 volts.
C. 11 volts.
D. 9 volts.



The question starts out, “What is the voltage across…” so put your finger across E and see that the current in this question is 1 amp through a 10 ohm resistor. One multiplied by 10 is… ***10 volts***. You can do this one in your head. **ANSWER B.**

T5D12 What is the voltage across a 10-ohm resistor if a current of 2 amperes flows through it?

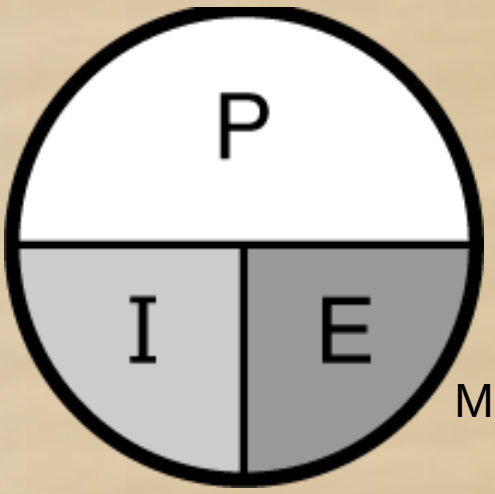
A. 8 volts.
B. 0.2 volts.
C. 12 volts.
D. 20 volts.



This question is looking for voltage, so we know it's going to be a simple multiplication of 2 amperes through a 10-ohm resistor, with ***20 volts*** as the correct answer. **ANSWER D.**

What is Power

- **Anytime energy is expended to do something work is performed**
- **Power is the amount of energy that is pushed through a conductor to a load or device to do that work**



Magic Circle

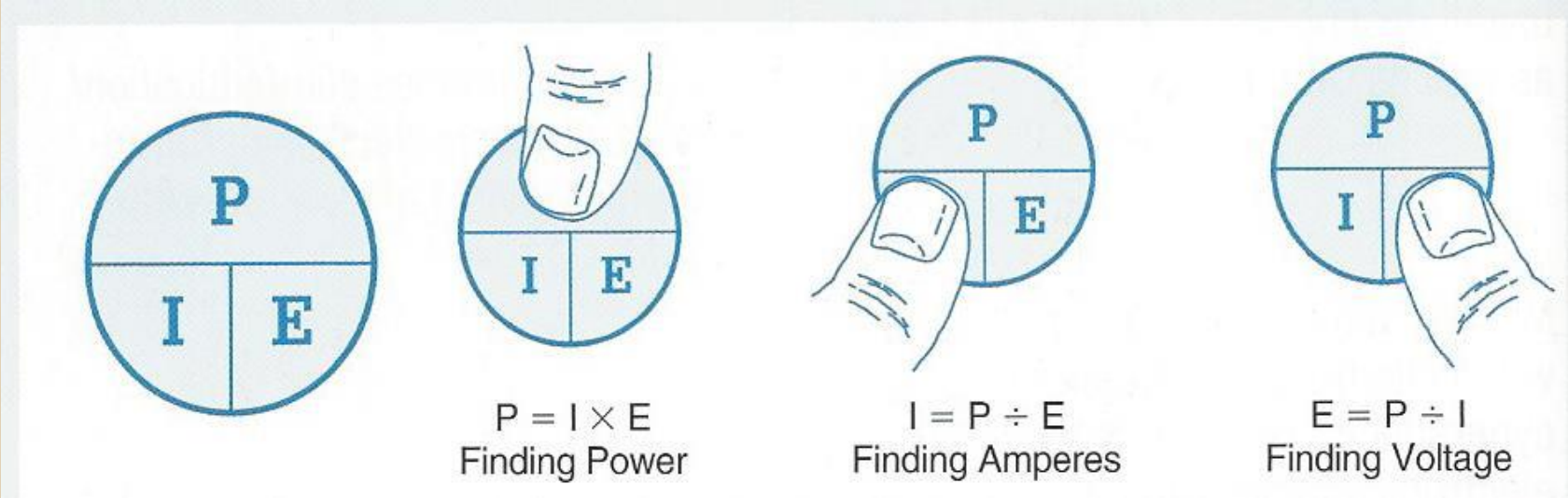
Power

Power is measured in watts

P = I x E, or

Watts = amps x volts

What is Power?



Magic Circle

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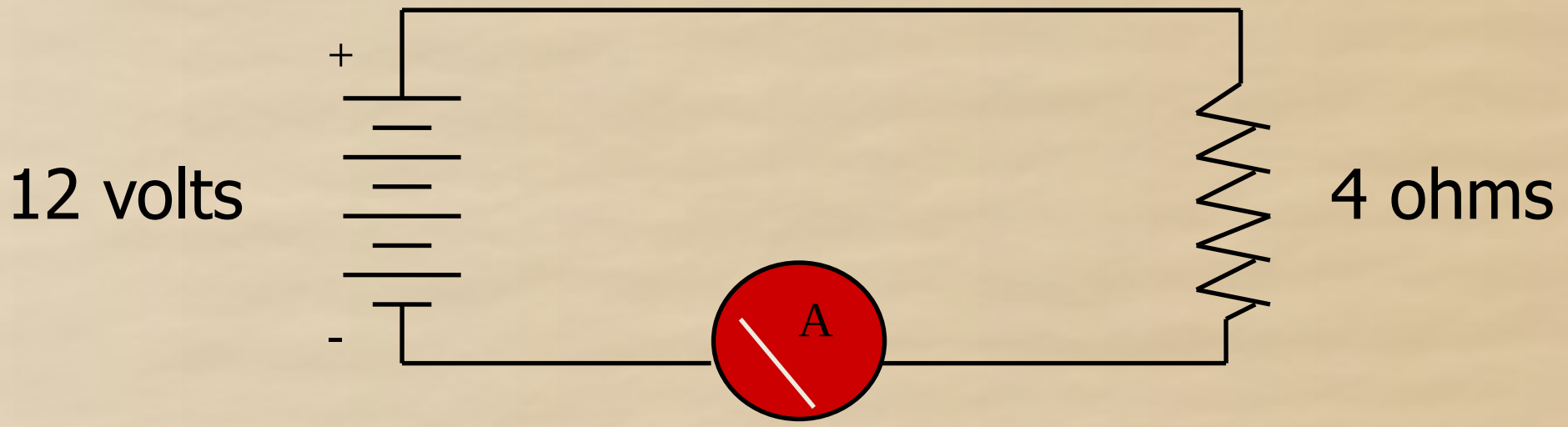
Volts, Amps and Watts



The current in this circuit = 3 Amps

The power in this circuit = 36 Watts

T5C09 How much power is being used in a circuit when the applied voltage is 13.8 volts DC and the current is 10 amperes?

A. 138 watts.
B. 0.7 watts.
C. 23.8 watts.
D. 3.8 watts.

Power is equal to volts times amps. In this problem, multiple 13.8 volts by 10 amps, and you end up with ***138 watts***. You can do this one in your head. Easy as PIE! **ANSWER A.**

T5C10 How much power is being used in a circuit when the applied voltage is 12 volts DC and the current is 2.5 amperes?

A. 4.8 watts.
B. 30 watts.
C. 14.5 watts.
D. 0.208 watts.

Power is equal to volts times amps. Multipe 12 volts by 2.5 amps, and you end up with ***30 watts,*** **ANSWER B**.

T5C11 How many amperes are flowing in a circuit when the applied voltage is 12 volts DC and the load is 120 watts?

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

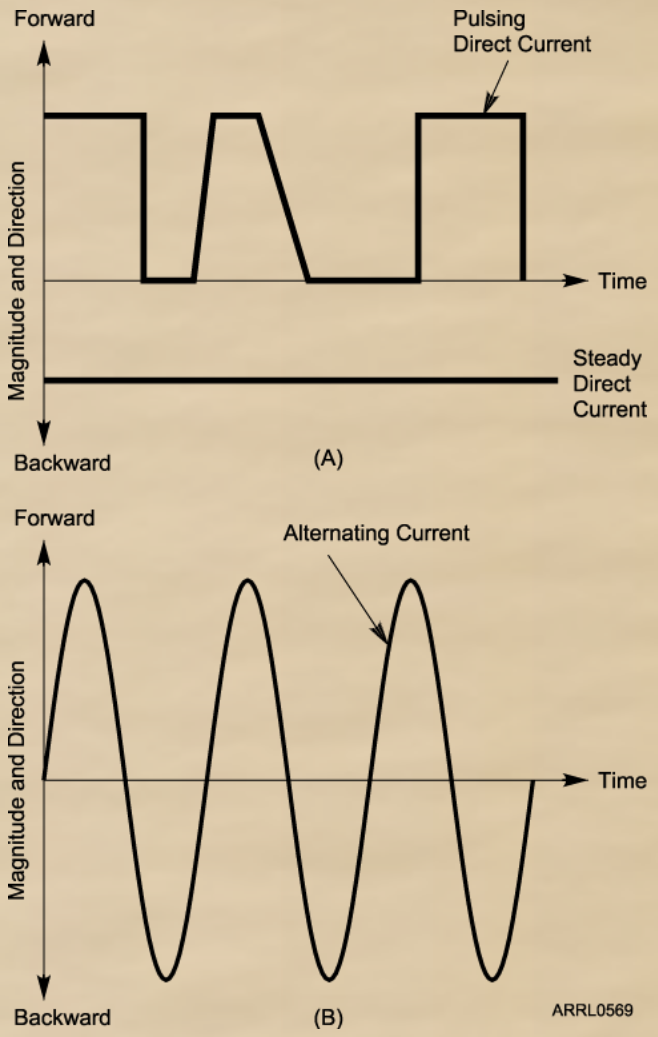
This time we are calculating for amps, so it is power (120) divided by voltage (12). ***120 ÷ 12 = 10***.
ANSWER B.

AC and DC Current

- **When current flows alternatively in one direction then in the opposite direction, it is called Alternating Current (AC)**
- **Your household current is AC. Cross country power lines use AC.**
- **Radio waves are created by AC**

- **When current flows in only one direction, it is called Direct Current (DC)**
- **Most electronic devices are powered by DC**
- **Batteries are a source of DC**
- **Batteries are in flashlights and are used to start your car**

AC and DC Current



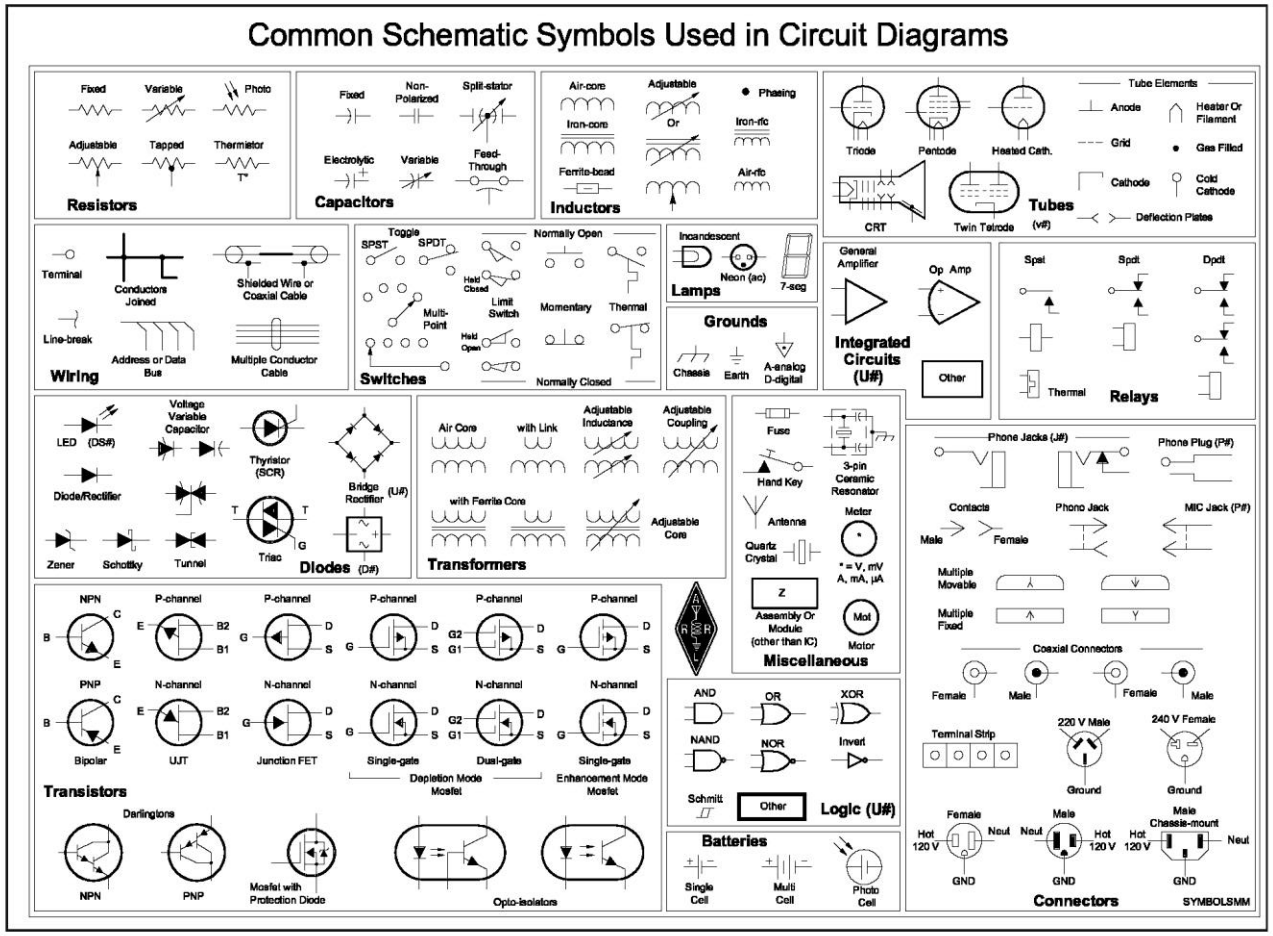
Electrical Components

- Controlling the Flow of Current
- To make an electronic device (like a radio) do something useful (like a receiver), we need to control and manipulate the flow of current
- There are a number of different electronic components that we use to do this

Basic Components

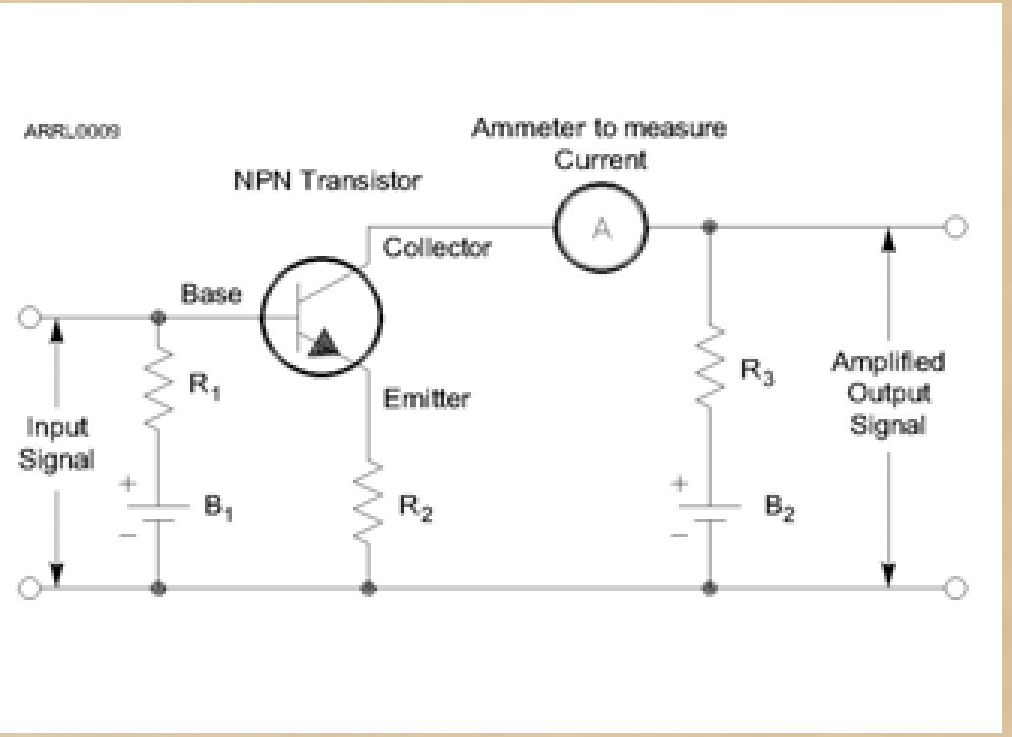
- Resistors
- Capacitors
- Inductors
- Transformers
- Semiconductors
  - Transistors and Integrated Circuits
  - Diodes
- Switches
- Fuses

Component Symbols



A Circuit Diagram

- Called a "**schematic diagram**"
- Shows the electrical connections of a circuit or device
- Uses industry standard **circuit symbols**
- It is NOT the physical arrangement of components



A Circuit Diagram

What is the name of an electrical wiring diagram that uses standard component symbols? (T6C01)

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

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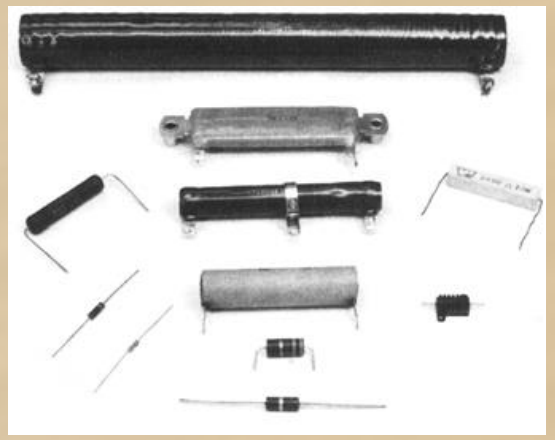
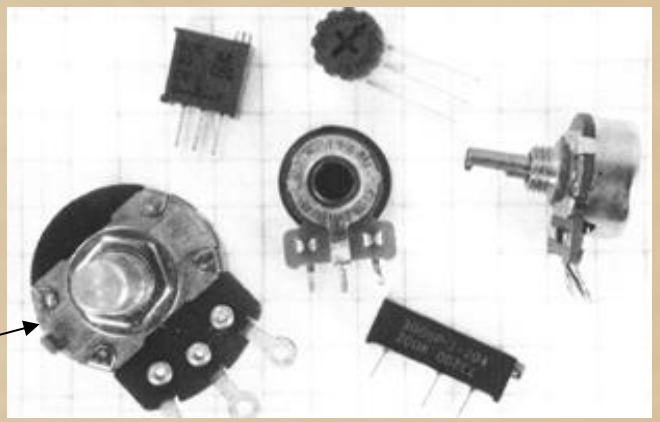
Resistors

- **The function of the resistor is to restrict (limit) the flow of current through it**
- **Measured in Ohms**
- **Can be fixed value or variable**

- **Resistors dissipate energy as heat**

Schematic Symbol

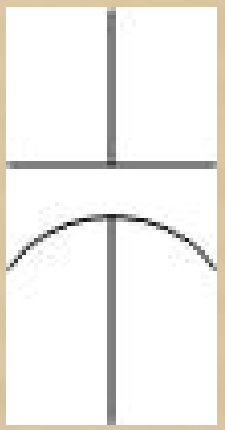




Potentiometer

Capacitors

- **The function of the capacitor is to temporarily store electric current**
- **Like a very temporary storage battery**
- **Stores energy in an electrostatic field**



Schematic Symbol

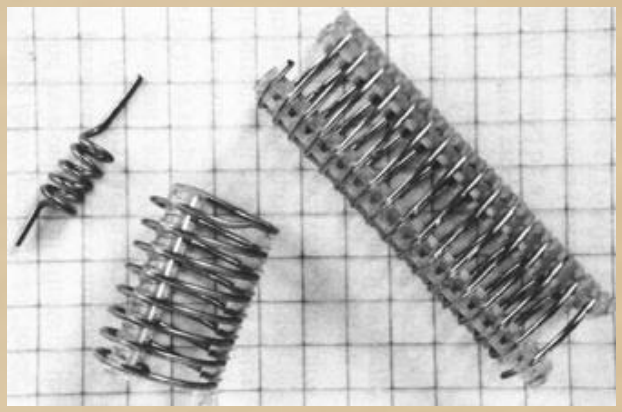
Capacitors

- **Measured in pico, nano or micro farads (pF, nF, or µF)**
- **Can be fixed value or variable**
- **Have “electrodes” separated by a “dielectric” material**

Inductors

- **The function of the inductor is to temporarily store electric current**
- **It is basically a** coil of wire that stores or releases energy in a magnetic field
- Measured in henrys (H). Can be nano, micro, or millihenrys.
- Can be fixed value or variable

Schematic Symbol



Impedance

- **Impedance** is a measure of a circuits resistance to the AC flow of electricity
- Measured in Ohms as “Z”
- **Reactance** is caused by a phase shift of voltage and current in AC circuits
- Reactance and resistance combine to produce impedance as follows:
  - **Capacitive reactance**
  - **Inductive reactance**
  - **and resistance**
-

What is impedance? (T5C12)

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

What is impedance? (T5C12)

A. A measure of the opposition to AC current flow in a circuit

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C. The Q or Quality Factor of a component

D. The power handling capability of a component

What formula is used to calculate current in a circuit? (T5D01)

A. Current (I) equals voltage (E) multiplied by resistance (R)
B. Current (I) equals voltage (E) divided by resistance (R)
C. Current (I) equals voltage (E) added to resistance (R)
D. Current (I) equals voltage (E) minus resistance (R)

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D. Current (I) equals voltage (E) minus resistance (R)

Questions

T6C06 (B)

What is component 6?

A. Resistor

B. Capacitor

C. Regulator IC

D. Transistor

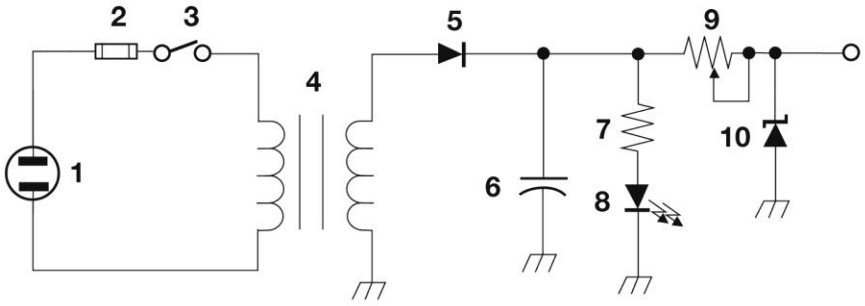


Figure T-2

T6C08 (C)

What is component 9?

A. Variable capacitor

B. Variable inductor

C. Variable resistor

D. Variable transformer

Questions

T6C06 (B)

What is component 6?

A. Resistor

B. Capacitor

C. Regulator IC

D. Transistor

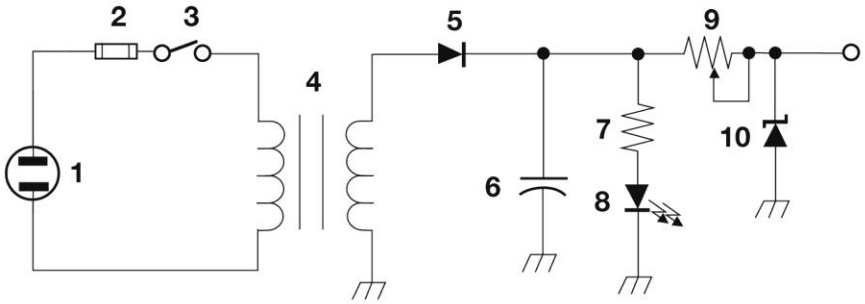


Figure T-2

T6C08 (C)

What is component 9?

A. Variable capacitor

B. Variable inductor

C. Variable resistor

D. Variable transformer

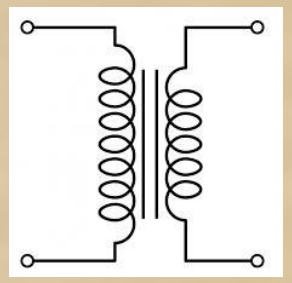
Resonance

- Circuits that contain capacitors and inductors will have one “**resonant frequency**”
- It is the point where inductive reactance and capacitive reactance exactly cancel each other out
- The AC current and voltage are back in phase
- When canceled you have a **resonant or tuned circuit**

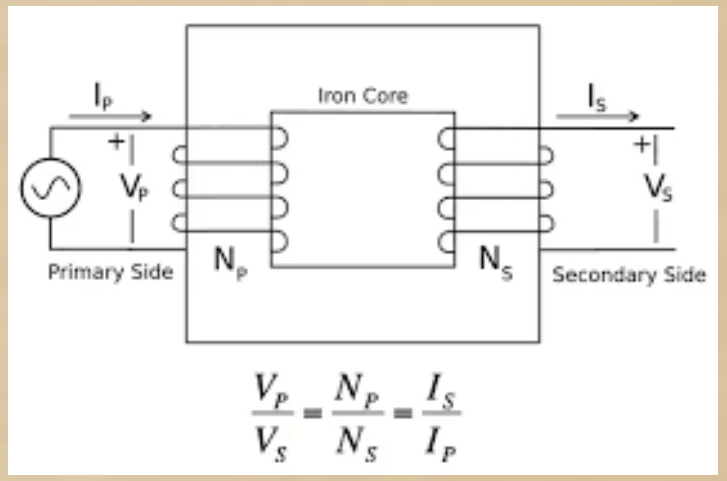
- Acts like a “**filter**” either passing or rejecting signals at its resonant frequency

Transformers

- Made from two or more inductors that share their stored energy
- Changes the combination of voltage and current
- Example: the wall charger for your cell phone has a transformer

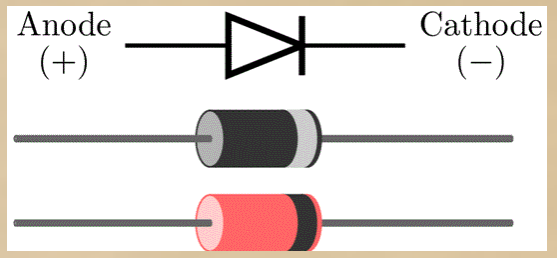


Schematic Symbol



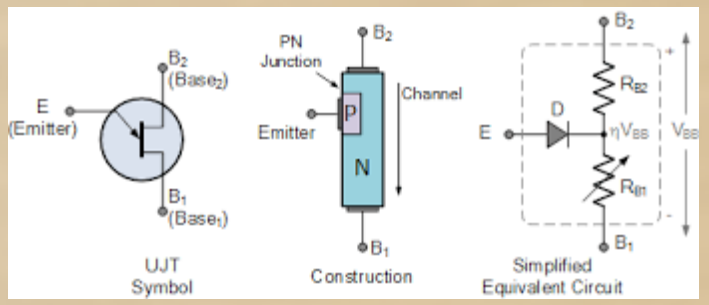
Diodes

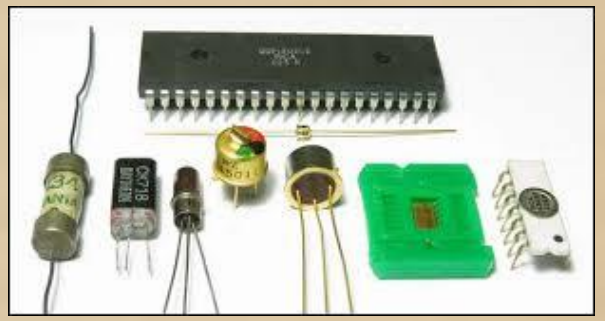
- Welcome to the world of semiconductors
- **Diodes only allow current to flow in one direction**
- Two electrodes: anode and cathode
- Cathode end has a “stripe” to ID it
- Special kind of diode is the LED or light emitting diode
- LEDs require less power than incandescent lights and produce less heat.



Transistors

- Use to amplify or switch voltages & current
- Made from layers of N and P-type doped semiconductor materials





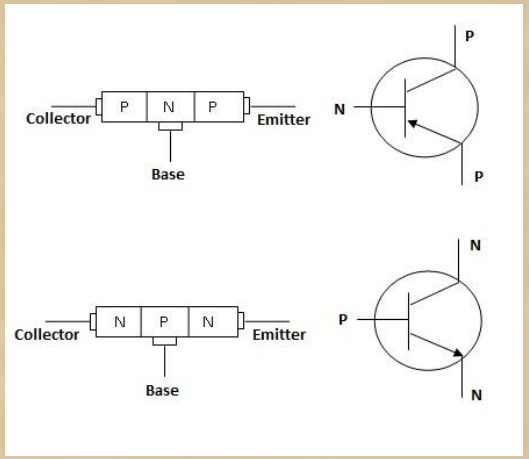
- **Two common types of transistor**
  - Bipolar Junction Transistor or BJT
  - Field Effect Transistors FET
    Junction FET--- JFET
    Metal Oxide Semiconductor FET-- MOSFET

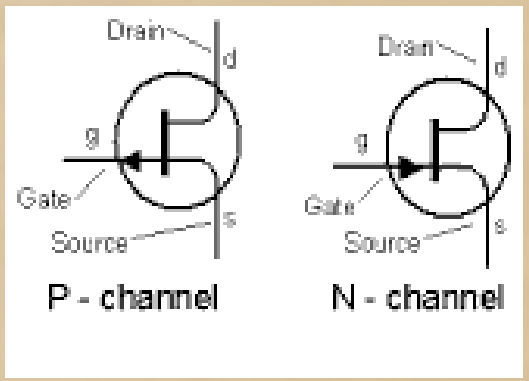
Transistors

- Bipolar junction or BJT has electrode names of: **base, emitter, and collector**

- Field Effect or FET has electrode names of: **gate, source, drain**.
- Gate or base electrode controls current flow through the transistor

Schematic Symbol

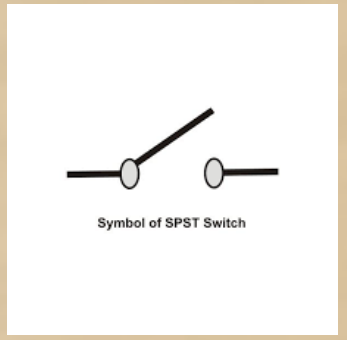


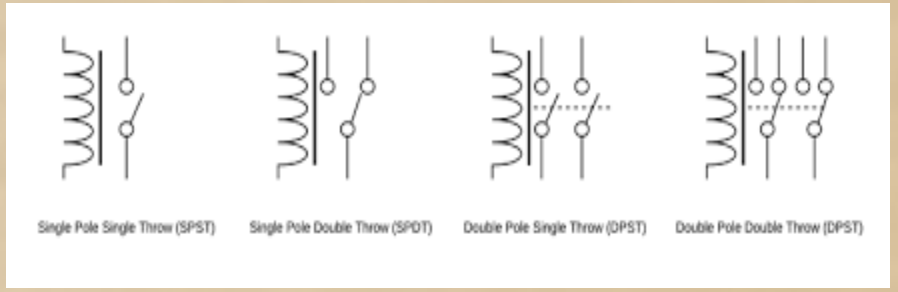


Circuit Gatekeepers

- Fuses and circuit breakers are designed to interrupt the flow of current if the current becomes uncontrolled
- Switches manually open or close a circuit
- Relays uses an electromagnet
- Described by number of of poles & throws
  - SPST
  - DPDT

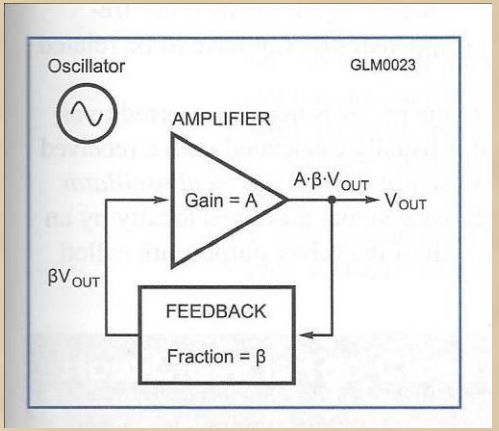
Schematic Symbols





Circuits-Building Blocks

- **Oscillators** produce steady signal at one frequency

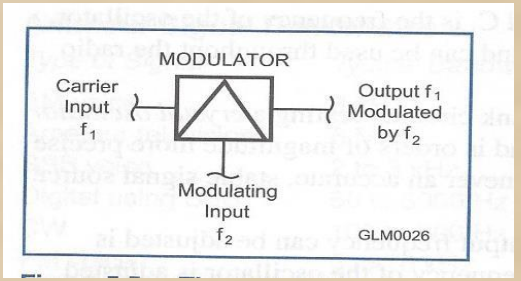


Oscillator circuits must include a filter so that feedback is present at only the intended frequency. The filter of an LC oscillator is a resonant circuit made from inductors and capacitors. It sets the oscillator's frequency

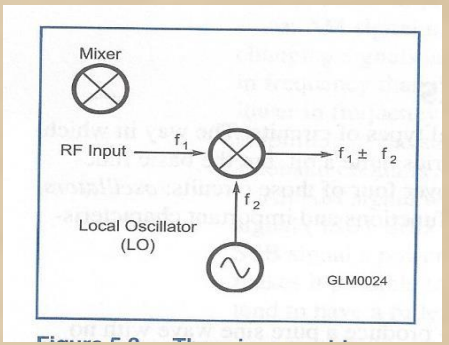
Filters are used to pass or reject a signal

Circuits-Building Blocks

- **Modulators** combine voice or data signals with an RF signal (modulation)

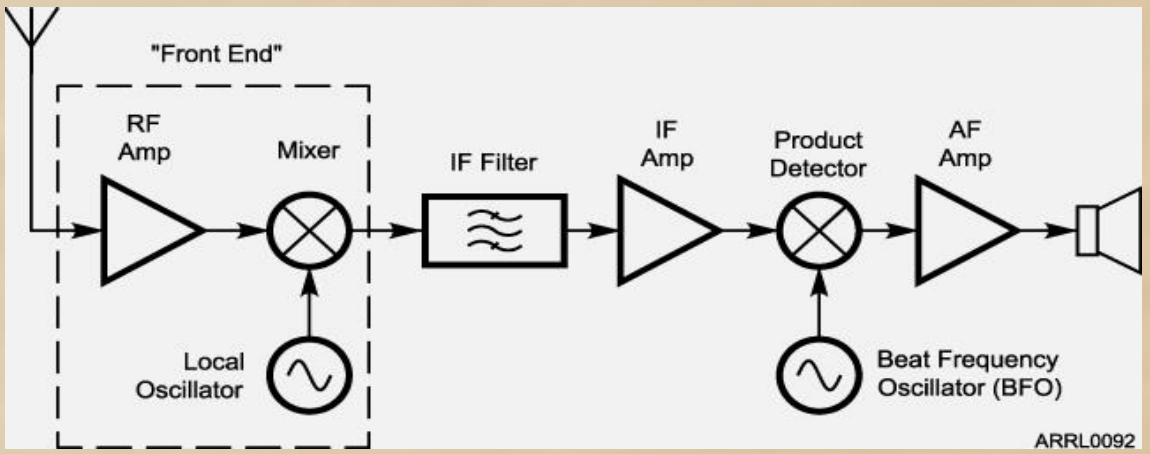


- **Mixers** combine two signals and shift one of them to a third signal



Radio Receiver

- **Receivers** convert a modulated signal back to voice or data



Superheterodyne Receiver

- **Sensitivity** is ability to detect a signal
- **Selectivity** is ability to retrieve information in presence of strong signals on nearby frequencies

Questions

T6C11

What is component 4?

A. Antenna

B. Transmitter

C. Dummy load

D. Ground

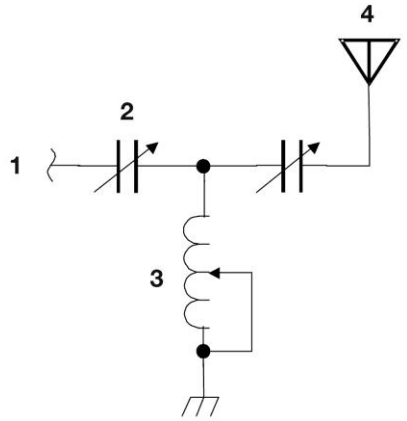


Figure T-3

T6C10

What is component 3?

A. Connector

B. Meter

C. Variable capacitor

D. Variable inductor

Questions

T6C11

What is component 4?

A. Antenna

B. Transmitter

C. Dummy load

D. Ground

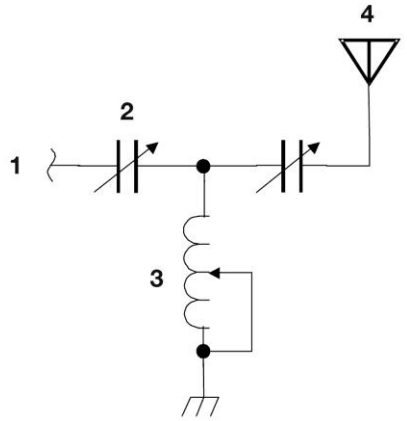


Figure T-3

T6C10

What is component 3?

A. Connector

B. Meter

C. Variable capacitor

D. Variable inductor

What is a relay? (T6D02)

A. An electrically controlled switch
B. A current controlled amplifier
C. An optical sensor
D. A pass transistor

What is a relay? (T6D02)

A. An electrically controlled switch
B. A current controlled amplifier
C. An optical sensor
D. A pass transistor

Which of the following displays an electrical quantity as a numeric value? (T6D04)

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

Which of the following displays an electrical quantity as a numeric value? (T6D04)

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

Which of the following devices or circuits changes an alternating current into a varying direct current signal? (T6D01)

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

Which of the following devices or circuits changes an alternating current into a varying direct current signal? (T6D01)

A. Transformer
B. Rectifier (Diode)
C. Amplifier
D. Reflector

What is the name of a circuit that generates a signal of a desired frequency? (T7A05)

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

What is the name of a circuit that generates a signal of a desired frequency? (T7A05)

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

Which of the following is used to convert a radio signal from one frequency to another? (T7A03)

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

Which of the following is used to convert a radio signal from one frequency to another? (T7A03)

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

End of Introduction

Q U E S T I O N S ?