Broadcasting Towers Operation

WEEK 3 – Review to Fundamentals of Electronics

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Objectives

At the end of the topic students will be able to:

1. Review of the passive and active components
2. Voltage and power calculations by applying Ohm's Law.
3. Volage gain, power gain.

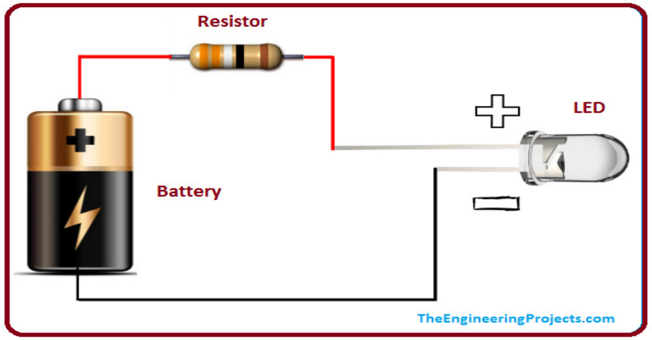
Rationale

- Fundamentals electronics provide a foundation for understanding complex systems. Semiconductor diodes, transistors, and operational amplifiers are essential for modern electronic devices.
- A solid understanding of these basics helps in troubleshooting, design, and innovation across fields like telecommunications and signal processing.
- Highlighting the significance of broadcasting towers, these principles are most utilized to transmit signals over long distances. Therefore, mastering these fundamentals enhances the field activities which an operator needs daily.
- The power consideration is always a master key in the review of the principles related to electronics in broadcasting towers.

3.1 Review of passive components

- **Resistor** is a passive component that resists the flow of electric current, producing a voltage drop. It is an electrical component that limits or regulates the flow of electrical current in an electronic circuit. It can also be used to provide a specific voltage for an active device such as a transistor.
- Resistor’s types include fixed, variable, thermistors, and varistors.
- They are applied in voltage dividers, current limiting, biasing of active components.

(Passive Electronic Component Handbook, Charles A. Harper, McGraw Hill Professi onal, 1997, pp. 69-85).

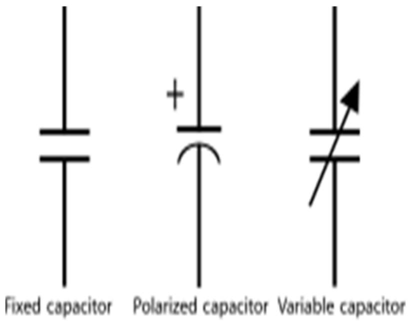


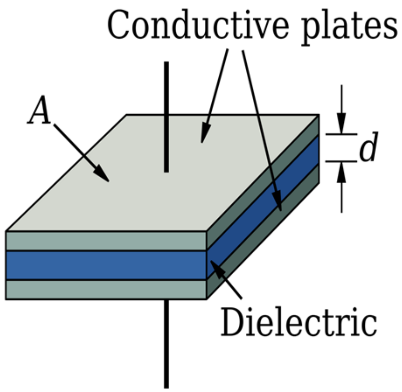
(https://www.theengineeringprojects.com/2018/01/introduction-to-resistors.html)

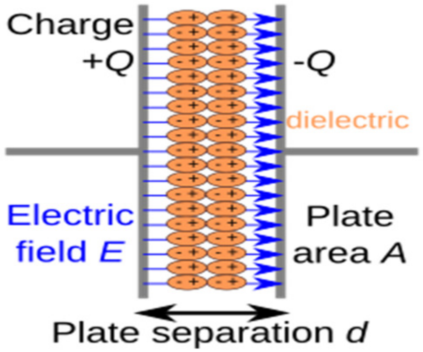
3.1 Review of passive components cont'd

- **Capacitor** is a passive component that stores energy in an electric field. It stores electrical energy by accumulating electric charges on two closely spaced surfaces that are insulated from each other, originally a condenser.
- Their types include ceramic, electrolytic, tantalum, film applied in filtering, coupling, decoupling, energy storage.

(Passive Electronic Component Handbook, Charles A. Harper, McGraw Hill Professional, 1997, pp. 205-220).







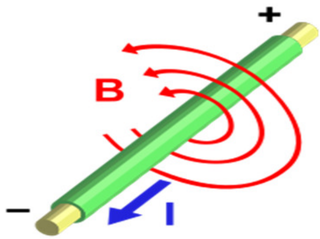
(https://en.wikipedia.org/wiki/Capacitor)

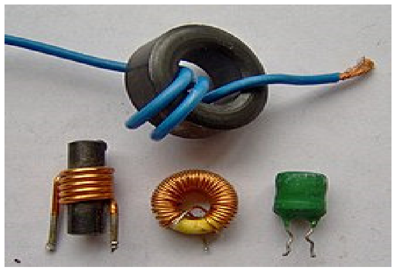
3.1 Review of passive components cont’d

- **Inductor** is a passive component that stores energy in a magnetic field. They are key electronic component that consist of a coil of wire wrapped around a central core.
- The electric current flowing through the coil induces a magnetic field around the inductor, storing the electric energy as magnetic energy and creating a voltage across it. An inductor typically consists of an insulated wire wound into a coil. Their types include air core, iron core, ferrite core.
- They are applied in filters, transformers, energy storage.

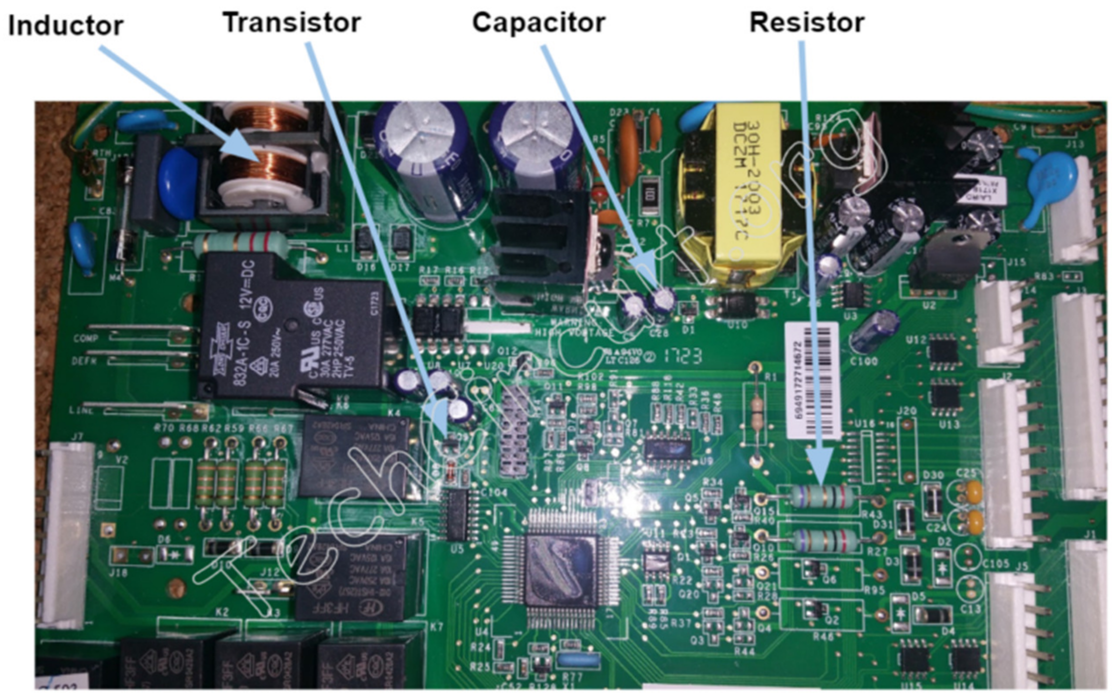
(Passive Electronic Component Handbook, Charles A. Harper, McGraw Hill Professional, 1997, pp. 221-240).

(https://en.wikipedia.org/wiki/Inductor)





3.1 Review of passive components cont'd



The Tech Circuit
TechCircuit.org

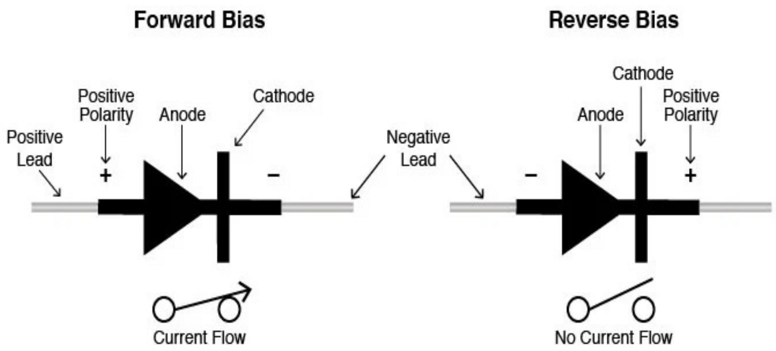
(https://techcircuit.org/resistors-capacitors-inductors-and-transistors-what-are-they-for/)

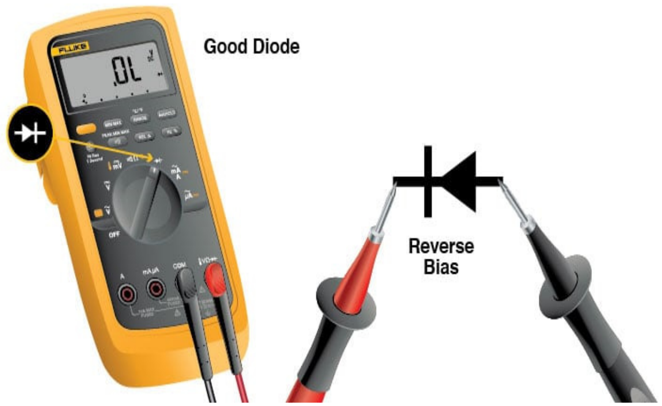
3.1 Review of active components

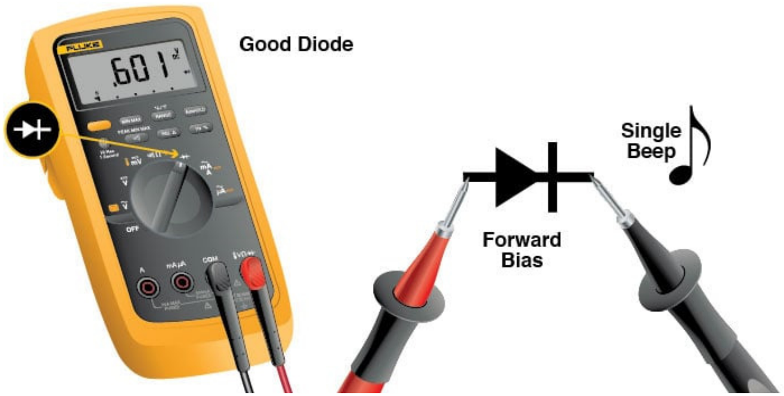
- **Diode** is an active component that allows current to flow in one direction only but severely restricts current from flowing in the opposite direction, a semiconductor acting as one way switch for current.
- They are also known as **rectifiers** because they change alternating current (ac) into pulsating direct current (dc). Diodes are rated according to their type, voltage, and current capacity, polarities are determined by an **anode** (positive lead) and **cathode** (negative lead).
- The types include PN junction, Schottky, Zener, LED.
- They are applied in rectification, voltage regulation, signal demodulation.

(Active Electronic Component Handbook, Charles A. Harper, McGraw Hill Professional,1997, pp. 101-120).

3.1 Review of active components cont’d





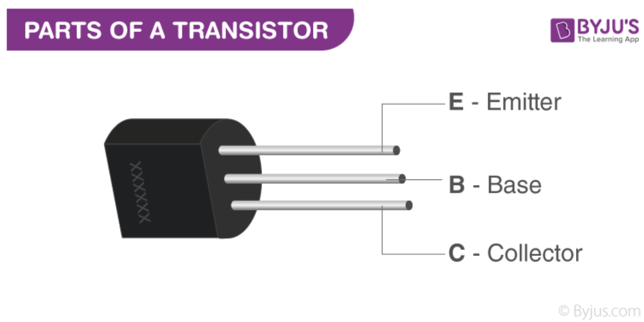


(https://www.fluke.com/en/learn/blog/electrical/what-is-a-diode#:~:text=A%20diode%20is%20a%20semiconductor,flowing%20in%20the%20opposite%20direction)

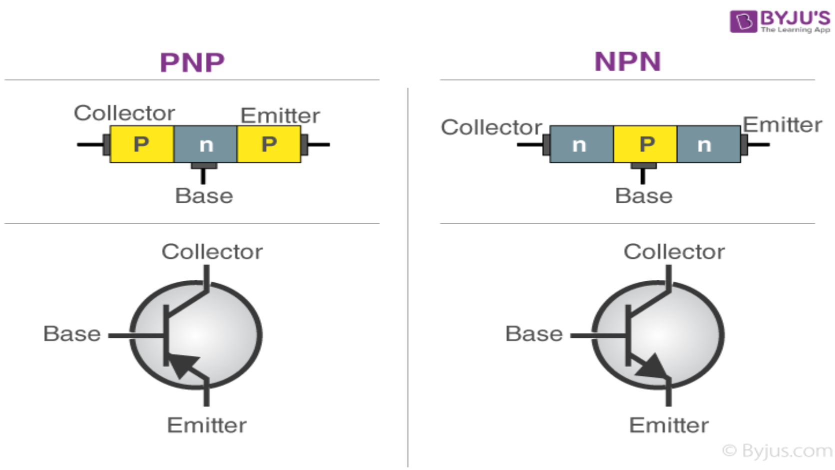
3.1 Review of active components cont'd

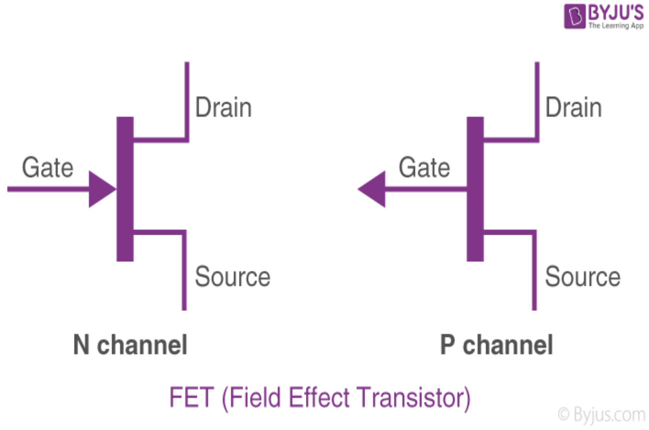
- **Transistor** is an active component used to amplify or switch electronic signal, a semiconductor device that can be used to conduct and insulate electric current or voltage.
- It acts as a switch and an amplifier which makes it a miniature device that is used to control or regulate the flow of electronic signals.
- Types include Bipolar Junction Transistor (BJT), Field Effect Transistor (FET).
- They are applied in amplification, switching, signal modulation.

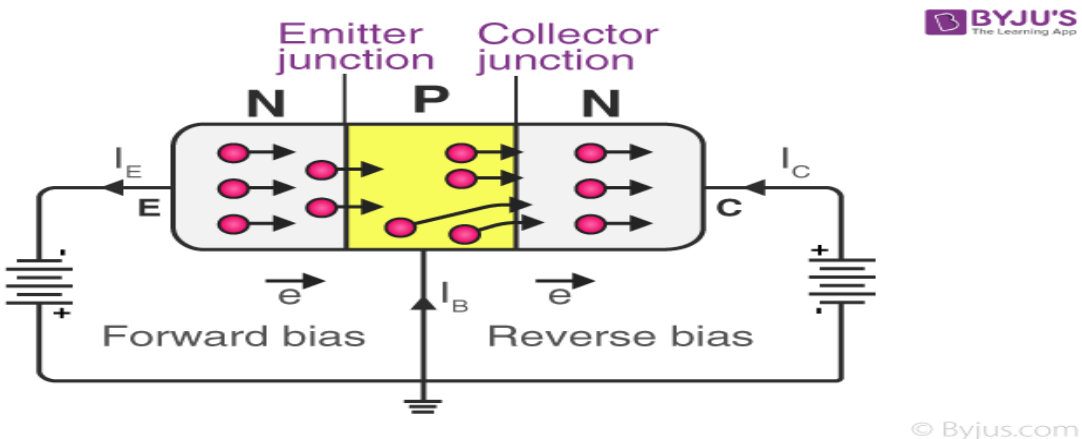
(Active Electronic Component Handbook, Charles A. Harper, McGraw Hill Profes sional, 1997, pp. 121-150).



3.1 Review of active components cont'd

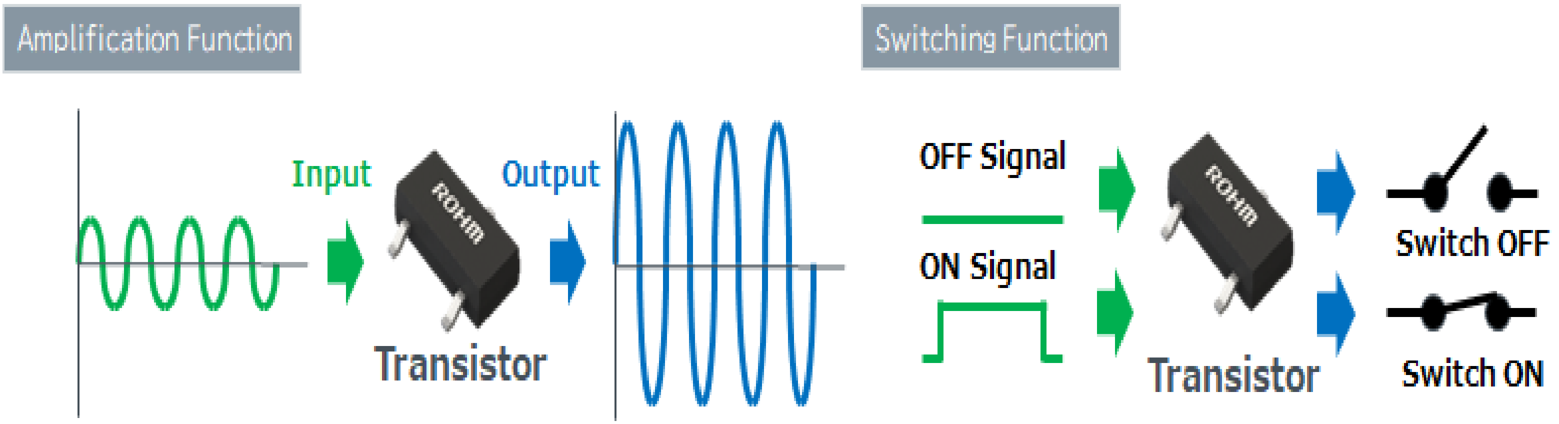


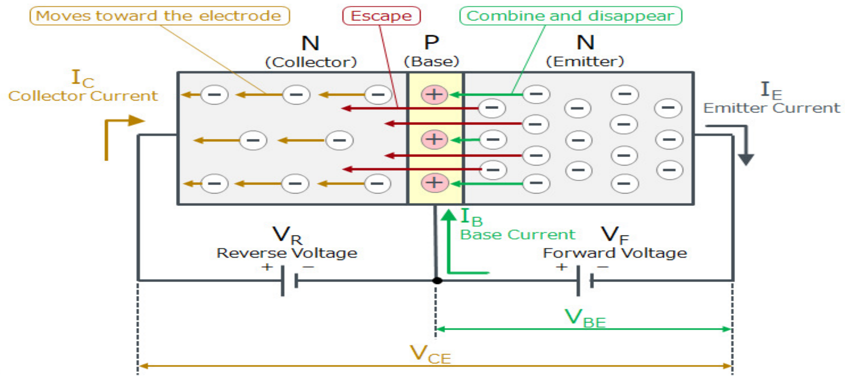




(https://byjus.com/jee/transistor/)

3.1 Review of active components cont'd





(https://www.rohm.com/electronics-basics/transistors/tr_what1)

3.1 Review of active components cont'd

- **Rectifier** converts alternating current (AC) to direct current (DC).
- Their types include half-wave, full-wave, bridge, They are applied in power supplies, signal demodulation.
- (Power Electronics: Converters, Applications, and Design, Ned Mohan, Tore M. Undeland, William P. Robbins, John Wiley & Sons, 2002, pp. 150-170).
- **Amplifier** is an active component that increases the power of a signal.
- Their types include operational amplifiers, power amplifiers, RF amplifiers. They are applied audio systems, signal processing, communication systems.
- (Operational Amplifiers and Linear Integrated Circuits, Robert F. Coughlin, Frederick F. Driscoll, Prentice Hall, 2001, pp. 200-220).

3.1 Review of active components cont’d

- **Regulator** maintains a constant output voltage regardless of changes in input voltage or load conditions.
- Their types include linear regulators, switching regulators. They are applied in power supplies, battery chargers.

(Power Electronics: Converters, Applications, and Design, Ned Mohan, Tore M. Undeland, William P. Robbins, John Wiley & Sons, 2002, pp. 220-240).

- **Filter** is a circuit that removes unwanted components or features from a signal.
- Their types include low-pass, high-pass, band-pass, band-stop. They are applied signal processing, communication systems, audio electronics.

(Analog Filter Design, M. E. Van Valkenburg, Holt, Rinehart & Winston, 1982, pp. 50-70).

In session reflection

- What do you keep in mind when you hear about:

1. A resistor
2. A capacitor
3. An inductor
4. A diode
5. A transistor

- What are the components used for:

1. Rectification
2. Amplification
3. Switching
4. Filtering

In session reflection cont’d

- What do you keep in mind when you hear about:

1. A resistor: resists to the flow of current
2. A capacitor: stores energy in an electric field
3. An inductor: stores energy in magnetic field
4. A diode: a one-way switch of the current, allowing flow in one direction only
5. A transistor: controls or regulates the flow of electronic signals

- What are the components used for:

1. Rectification: diode
2. Amplification: transistor
3. Switching: transistor
4. Filtering: capacitor and inductor

Homework

- Which of the following components used in a circuit stores energy?

a. Resistors
b. Inductors
c. Capacitors
d. Diodes
e. Transistors

- Which of the following components used in a circuit allows the current to flow one way

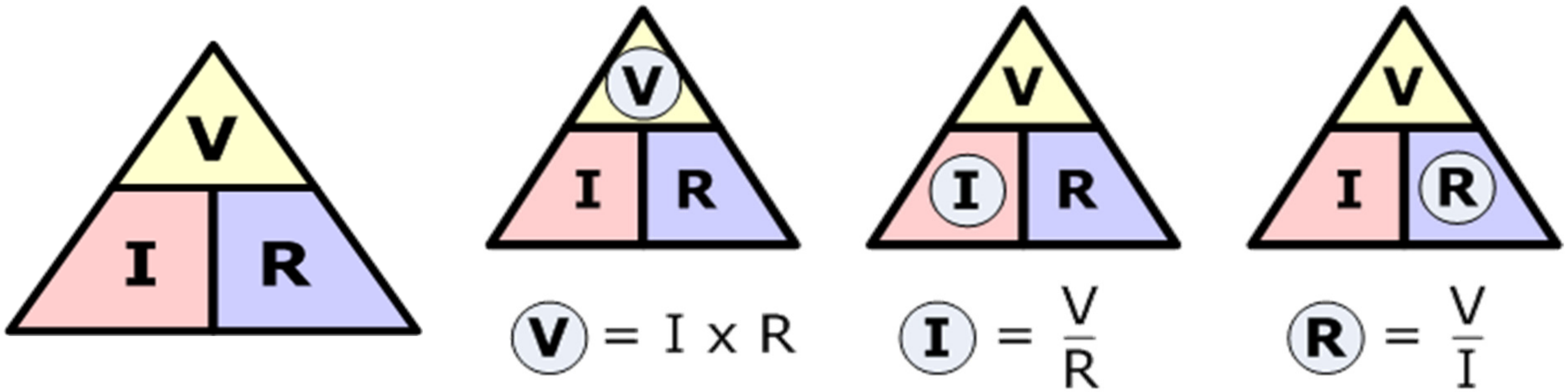
a. Resistors
b. Inductors
c. Capacitors
d. Diodes
e. Fuses

3.2 Ohm's law

- **Ohm's Law:** states that the current through a conductor between two points is directly proportional to the voltage across the two points.

Formula: (V=IR). (Basic Circuit Theory, Charles A. Desoer, Ernest S. Kuh, McGraw -Hill, 1969, pp. 45-50).

- **Ohms Law Triangle**



(https://www.electronics-tutorials.ws/dccircuits/dcp_2.html)

3.2 Ohm's law cont'd

- Then by using Ohms Law we can see that a voltage of 1V applied to a resistor of 1Ω will cause a current of 1A to flow and the greater the resistance value, the less current that will flow for a given applied voltage.
- Any Electrical device or component that obeys "Ohms Law" that is, the current flowing through it is proportional to the voltage across it ($I \alpha V$), such as resistors or cables, are said to be **"Ohmic"** in nature, and devices that do not, such as transistors or diodes, are said to be **"Non-ohmic"** devices.

- To find the Voltage, (V)
  - [$V = I \times R$] V (volts) = I (amps) x R (Ω)
- To find the Current, (I)
  - [$I = V \div R$] I (amps) = V (volts) ÷ R (Ω)
- To find the Resistance, (R)
  - [$R = V \div I$] R (Ω) = V (volts) ÷ I (amps)

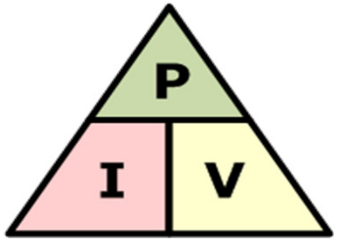
(https://www.electronics-tutorials.ws/dccircuits/dcp_2.html)

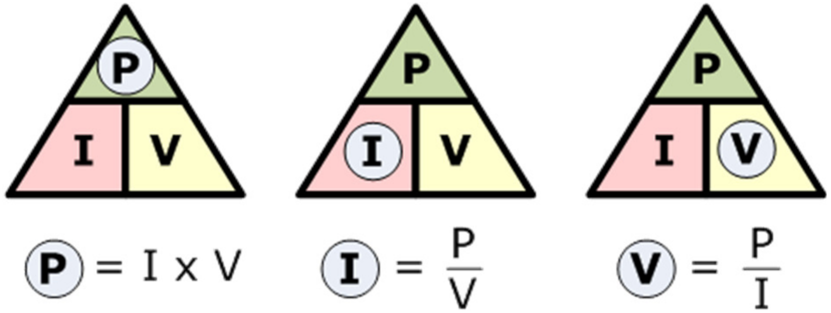
3.2 Ohm's law cont'd

- Electrical Power in Circuits (P) in a circuit is the rate at which electrical energy is absorbed or produced within a circuit. A source of energy such as a voltage will produce or deliver power while the connected load absorbs it.
- Light bulbs and heaters for example, absorb electrical power and convert it into either heat, or light, or both. The higher their value or rating in watts the more electrical power they are likely to consume.
- The quantity symbol for power is "P". It is the product of voltage multiplied by the current with the standard electrical units of measurement being the Watt (W). Prefixes are used to denote the various multiples or sub-multiples of a watt, such as: milliwatts (mW = 10-3W) or kilowatts (kW = 103W).

3.2 Ohm’s law cont’d

- **The Power Triangle:**





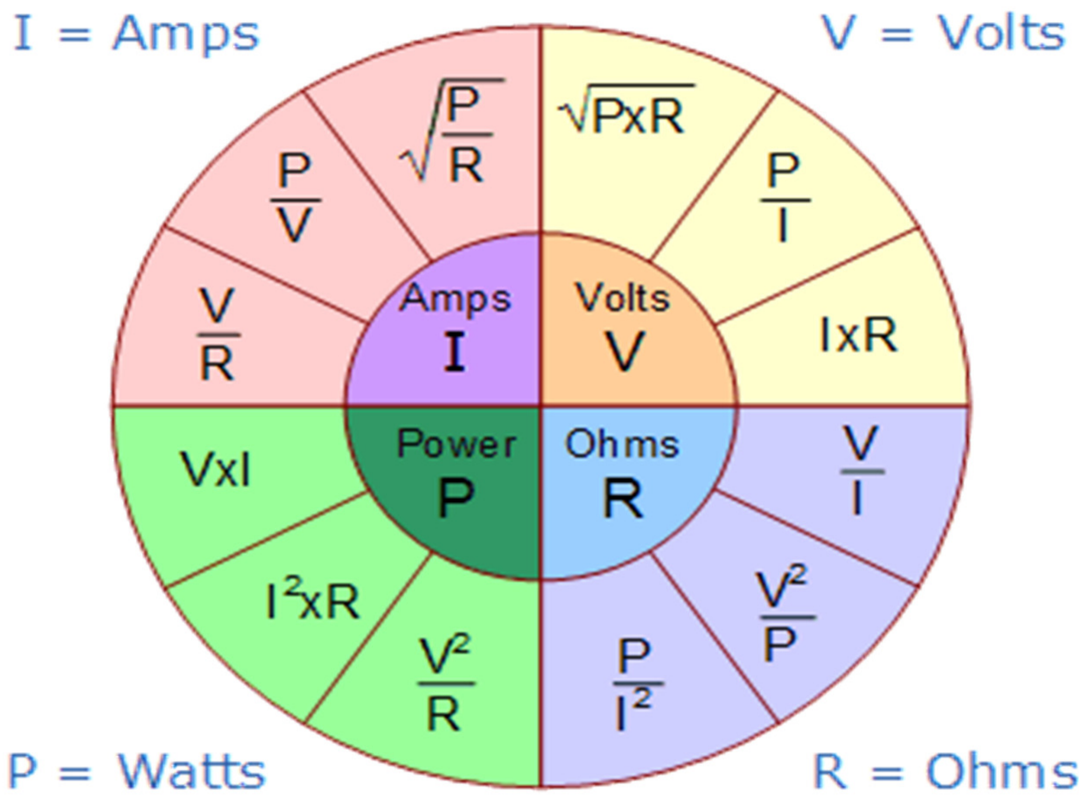
- By using the Ohm’s law equation and substituting for the values of V, I and R the electrical power formula can be found as:

- To find the Electrical Power (P)
  - [P = V x I] P (watts) = V (volts) x I (amps)
- Also:
  - [P = V^2 ÷ R] P (watts) = V^2 (volts) ÷ R (Ω)
- Also:
  - [P = I^2 x R] P (watts) = I^2 (amps) x R (Ω)

(https://www.electronics-tutorials.ws/dccircuits/dcp_2.html)

3.2 Ohm's law cont'd

- **The Ohms Law Pie Chart**



(https://www.electronics-tutorials.ws/dccircuits/dcp_2.html)

3.2 Ohm's law cont'd

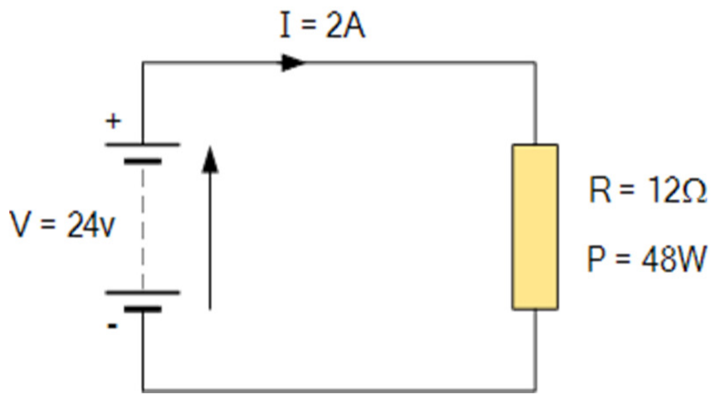
- From the Ohm's Law Pie Chart, let us extract individual Ohm's Law equations into a simple matrix table to ease the calculations of unknown values.
- **Ohms Law Matrix Table**

Ohms Law Formulas				
Known Values	Resistance (R)	Current (I)	Voltage (V)	Power (P)
Current & Resistance	---	---	$V = I \times R$	$P = I^2 \times R$
Voltage & Current	$R = \frac{V}{I}$	---	---	$P = V \times I$
Power & Current	$R = \frac{P}{I^2}$	---	$V = \frac{P}{I}$	---
Voltage & Resistance	---	$I = \frac{V}{R}$	---	$P = \frac{V^2}{R}$
Power & Resistance	---	$I = \sqrt{\frac{P}{R}}$	$V = \sqrt{P \times R}$	---
Voltage & Power	$R = \frac{V^2}{P}$	$I = \frac{P}{V}$	---	---

(https://www.electronics-tutorials.ws/dccircuits/dcp_2.html)

Exercises

1. Consider the circuit with a battery of 6V connected to a 60 Ohms load. What is the current that flows in the circuit? What is the power generated?
2. For the circuit shown below, use Ohms law to find the Voltage (V), the Current (I), the Resistance (R) and the Power (P) around the circuit. You are required to interpret the circuit by using the formulas taking the known quantities to find unknown quantities.

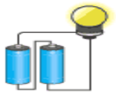
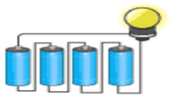
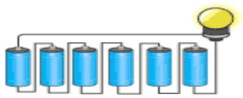
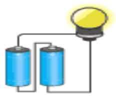
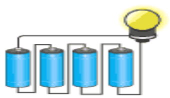
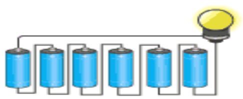


Assignment

1. If the resistance of an electric iron is 50 Ω and a current of 3.2 A flows through the resistance. Find the voltage between two points.
2. An EMF source of 8.0 V is connected to a purely resistive electrical appliance (a light bulb). An electric current of 2.0 A flows through it. Consider the conducting wires to be resistance-free. Calculate the resistance offered by the electrical appliance.
3. What is the voltage if a resistance of 25 Ω produces a current of 250 amperes?
4. What resistance would produce a current of 120 A from a 6-V battery?
5. What is the current produced with a 9-V battery through a resistance of 100 Ω?

Review

BYJU'S The Learning App

Circuit diagram	Battery voltage	Total resistance	Current
	3 V	6 Ω	0.5 A
	6 V	6 Ω	1 A
	9 V	6 Ω	1.5 A
	3 V	12 Ω	0.25 A
	6 V	12 Ω	0.5 A
	9 V	12 Ω	0.75 A

(https://byjus.com/physics/ohms-law/)

3.3 Voltage and power gains

- Because amplifiers can increase the magnitude of an input signal, it is useful to be able to rate an amplifier's amplifying ability in terms of an output/input ratio. The technical term for an amplifier's output/input magnitude ratio is gain. As a ratio of equal units (power out / power in, voltage out / voltage in, or current out / current in), gain is naturally a unitless measurement.
- Mathematically, gain is symbolized by the capital letter "A".
- Mostly power gain is expressed in deciBel or dB.

3.3 Voltage and power gains

- Because amplifiers can increase the magnitude of an input signal, it is useful to be able to rate an amplifier's amplifying ability in terms of an output/input ratio. The technical term for an amplifier's output/input magnitude ratio is gain. As a ratio of equal units (power out / power in, voltage out / voltage in, or current out / current in), gain is naturally a unitless measurement.
- Mathematically, gain is symbolized by the capital letter "A".
- Mostly power gain is expressed in deciBel or dB.
- For example, if an amplifier takes in an AC voltage signal measuring 2 volts RMS and outputs an AC voltage of 30 volts RMS, it has an AC voltage gain of 30 divided by 2, or 15

(https://www.allaboutcircuits.com/textbook/semiconductors/chpt-1/amplifier-gain/)

3.3 Voltage and power gains

- Electrical amplifier gains may be expressed in terms of voltage, current, and/or power in both AC and DC.
- A summary of gain definitions is as follows: The triangle-shaped "delta" symbol (Δ) represents change in mathematics, so "ΔVoutput / ΔVinput" means "change in output voltage divided by change in input voltage," or more simply, "AC output voltage divided by AC input voltage".
- The gain from the previous example is calculated as follows. (please check the source on the previous slide)

$$A_V = \frac{V_{output}}{V_{input}}$$

$$A_V = \frac{30V}{2V}$$

$$A_V = 15$$

3.3 Voltage and power gains

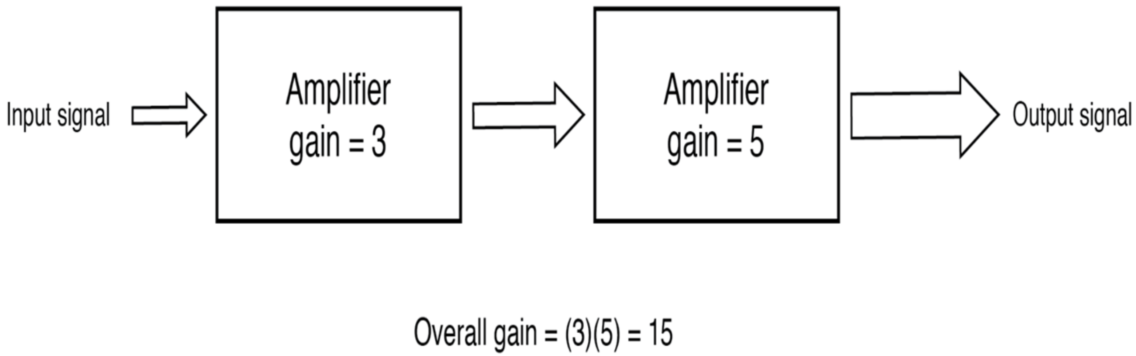
	DC gains	AC gains
Voltage	$A_V = \frac{V_{output}}{V_{input}}$	$A_V = \frac{\Delta V_{output}}{\Delta V_{input}}$
Current	$A_I = \frac{I_{output}}{I_{input}}$	$A_I = \frac{\Delta I_{output}}{\Delta I_{input}}$
Power	$A_P = \frac{P_{output}}{P_{input}}$	$A_P = \frac{(\Delta V_{output})(\Delta I_{output})}{(\Delta V_{input})(\Delta I_{input})}$
	$A_P = (A_V)(A_I)$	

Δ = "change in..."

$dB = 10\log_{10}[P_2/P_1]$

3.3 Voltage and power gains

- If multiple amplifiers are staged, their respective gains form an overall gain equal to the product (multiplication) of the individual gains. In the figure below, if a 1 V signal were applied to the input of the gain of 3 amplifier, a 3 V signal out of the first amplifier would be further amplified by a gain of 5 at the second stage yielding 15 V at the final output.



Thank you for your good attention

Q&A

References

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- Introduction to Resistors, Adnan Aqeel, The Engineering Projects, 2018.
- Passive Electronic Component Handbook, Charles A. Harper, McGraw Hill Professional, 1997, pp. 205-220.
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