



CAPABILITY ENHANCEMENT - BASICS OF ELECTRONICS

K. RAMPRABHU & Team

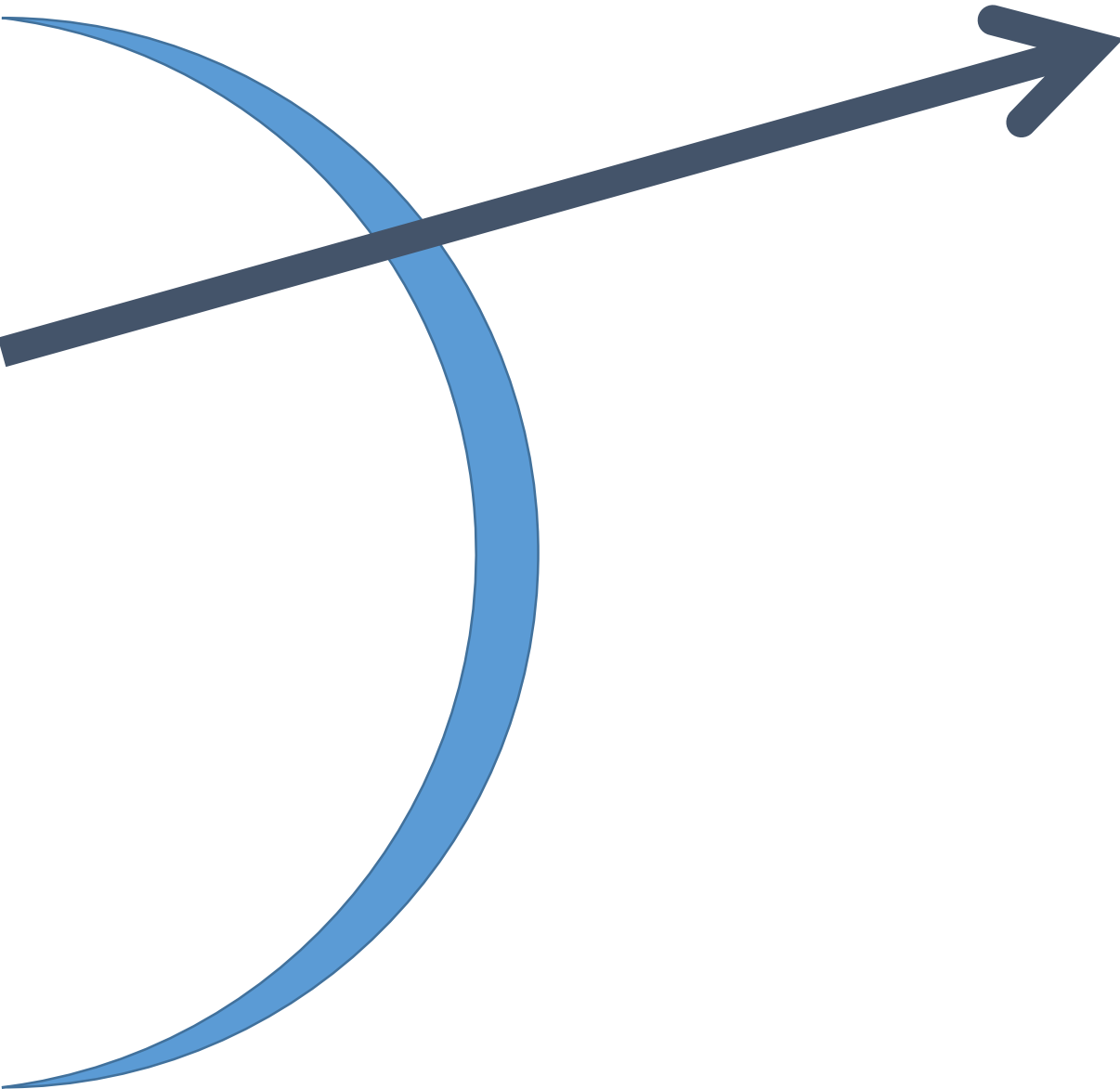
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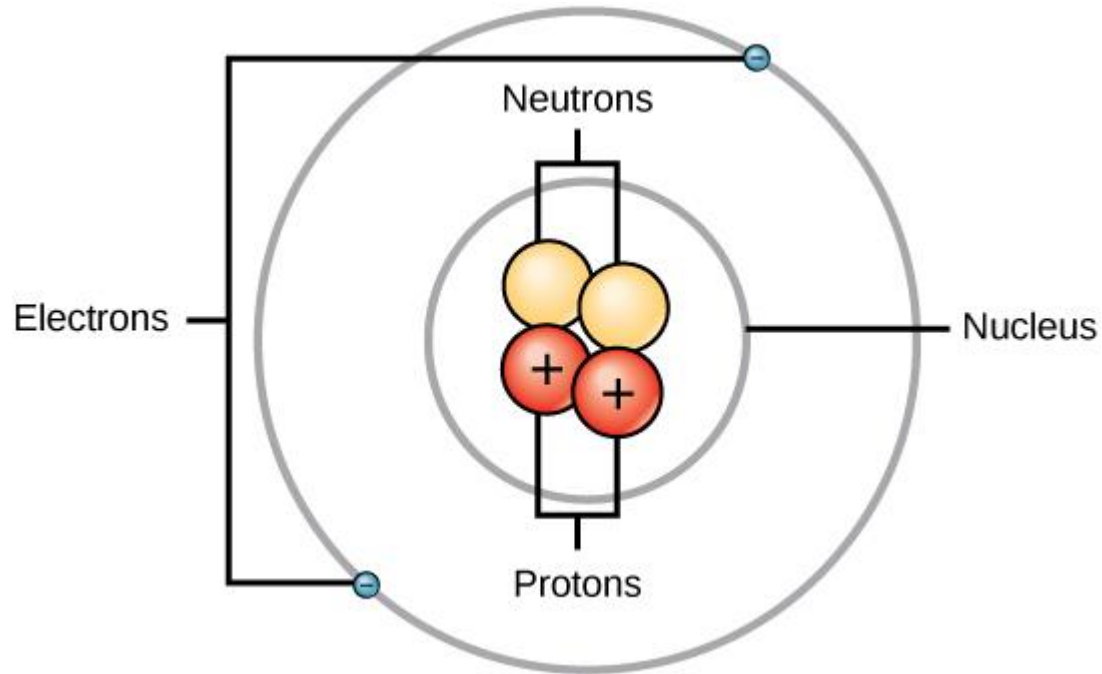


- 1. Electronics – Basic concept**
2. Passive & Active Electronic components – Basics & Application
3. Analog and digital signals
4. Logic Gates
5. Integrated circuits (IC) & PCB
6. Fuses, Relays and Circuit breakers – Basics & application
7. Module 2- Preface- Control unit /Sensor/Actuator/OBD
8. Q&A, Quiz & Feedback

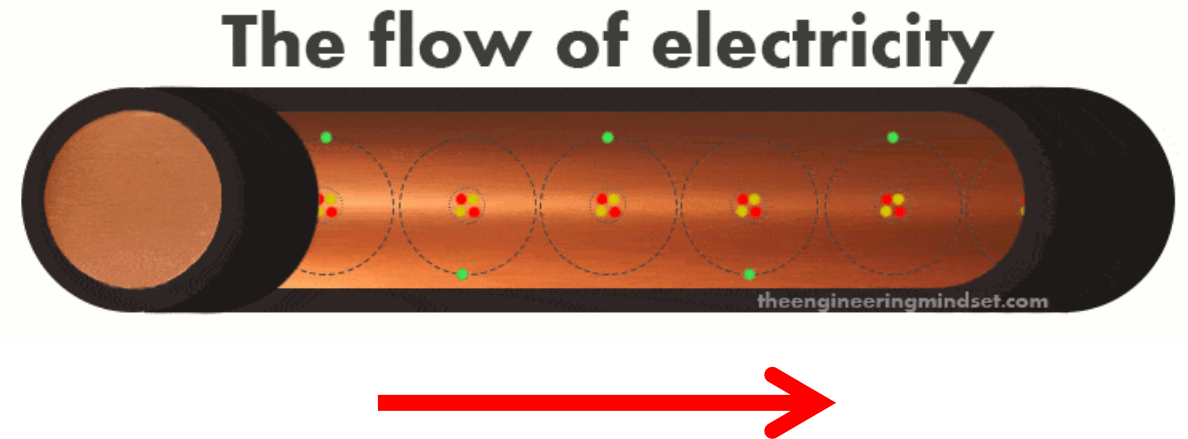


Electronics – Basic Concepts

Structure of Atom – Protons, Electrons and Neutrons



- Protons (Positively charged '+')
- Neutrons (No charge)
- Electrons (negatively charged '-') - Outermost regions of the atom are called electron shells

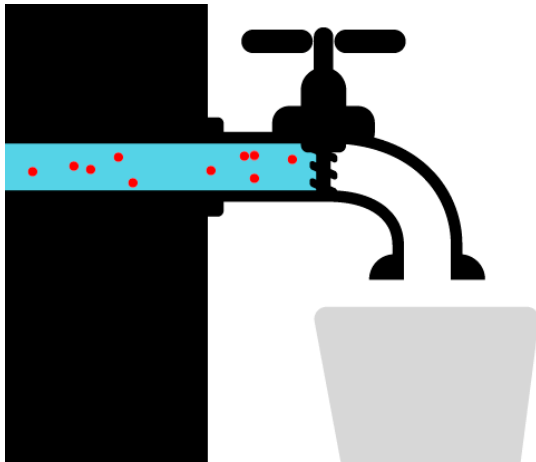


Flow of Electrons freely generates Electricity

DEFINE ELECTRONICS?

Electronics is the branch of science that deals with the study of **flow and control of Electrons** or Electricity - Study of their behavior and effects in vacuums, gases, and semiconductors, and with devices using such electrons.

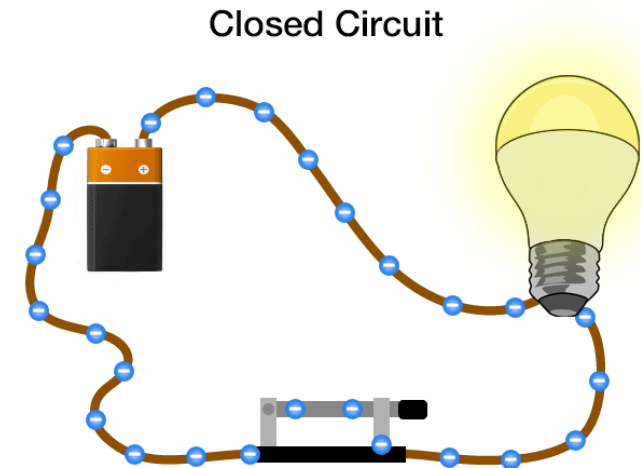
Water analogy - Mechanical
Illustration for Flow and
Control



DECISION MAKING CAPABILITY

Major Applications
Consumer products
Industry automation
Medical applications
Automotive Electronic Control Units

Simple Illustration for flow and control of
Electrons through a SWITCH
Open Circuit & Closed Circuit





Conductors, Insulators & Semi Conductors

Conductors are materials which allows the flow of charge freely (always allows the movement of electrons and ions easily).

Example: Iron, Steel , Gold , Copper, Silver

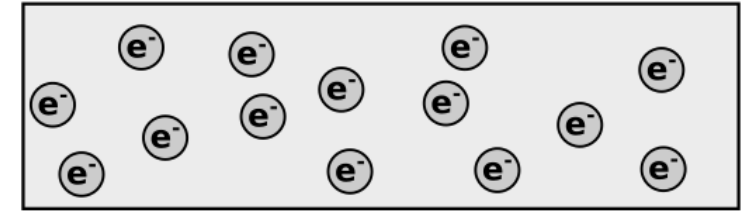
Insulators are material which **inhibits the flow** of charge (No Flow).

Example: Air, Rubber, Glass, Diamond, Plastic

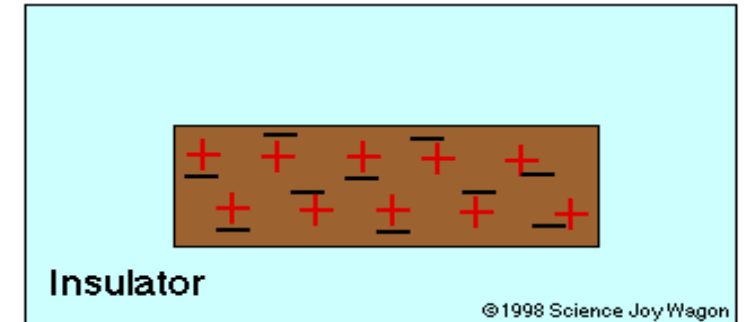
Semiconductors are materials **which have a conductivity properties** between conductors and insulators

Example: Silicon, Germanium, Gallium arsenide

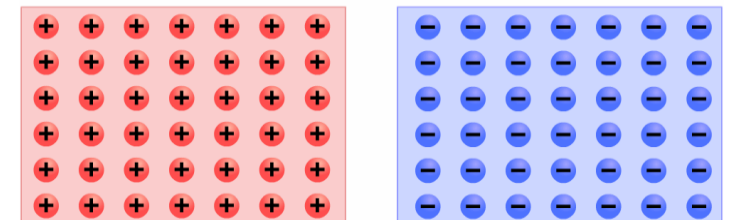
Conductivity: High



Conductivity: No



Conductivity: Medium

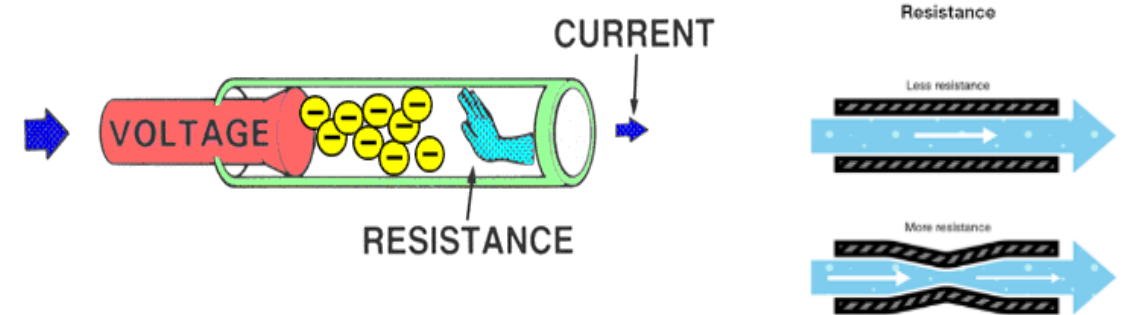




Resistance, Voltage & Current

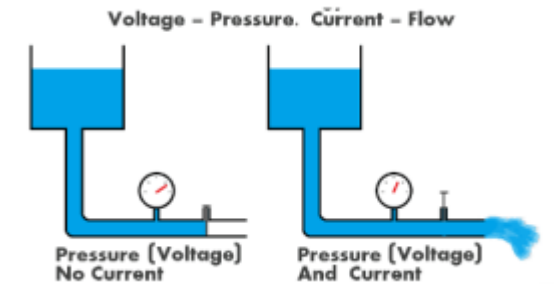
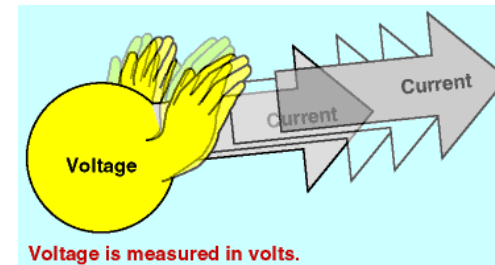
What is Resistance?

- **Resistance** is a measure of the opposition to current flow in an electrical circuit.
- Unit of measurement is **OHMS** (Symbol: Ω , Denoted as 'R').



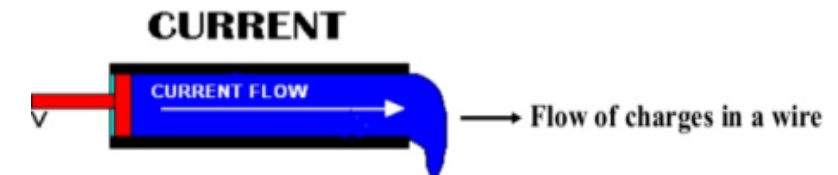
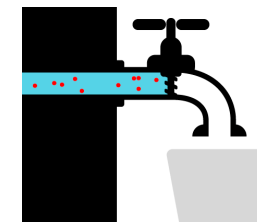
What is Voltage?

- **Voltage** is the pressure from an electrical circuit's power source that pushes charged electrons (current) through a conducting loop
- Unit of measurement is **Volts** (Symbol: V, Denoted as 'V')



What is Current?

- An Electric Current is a rate of flow of Electric Charge
- Unit of measurement is **Amperes** (Symbol: A, Denoted as 'I')

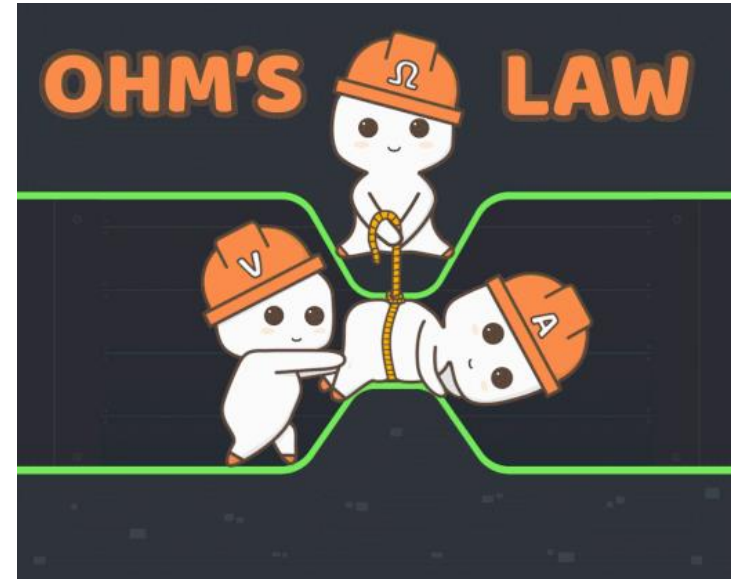




Ohm's Law & Power Law

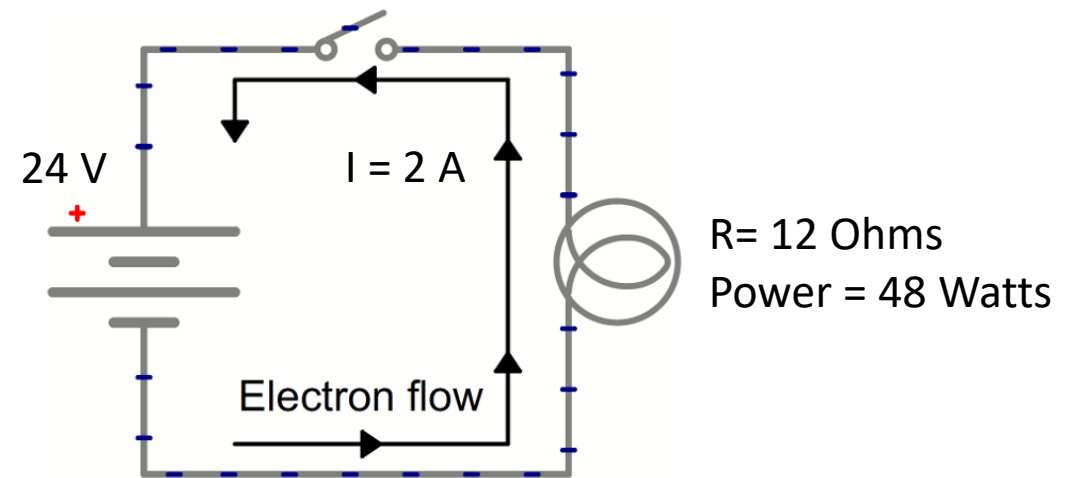
Ohm's Law

- **Ohm's Law** is used to calculate the relationship between voltage, current and resistance in an electrical circuit
- Ohm's law states that the current through a conductor between two points is directly proportional to the voltage across the two points. This law is applicable only to Ohmic Conductors such as Copper / Iron....
- Ohm's law states that: $V = I * R$



Power Law

- Electric power is the rate, per unit time, at which electrical energy is transferred by an electric circuit
- The unit of power is the Watt (W).
- Power Law States that $P = \text{Voltage (V)} * \text{Current (I)}$
- **Energy = Power (P) * Time (T)**





Types of Current Flow

Direct Current (DC) & Alternating Current (AC):

AC and **DC** describe types of **current** flow in a circuit.

In **direct current (DC)**, the electric charge (**current**) only flows in one direction.

Example:

Automotive Battery, HVDC (High Voltage DC Transmission)

Electric charge in **alternating current (AC)**, on the other hand, changes direction periodically (by alternating the polarity of voltage at the generator or other voltage source)

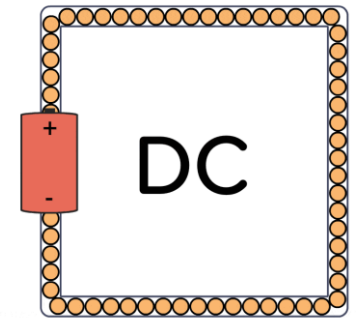
Example:

Domestic appliances, HVAC (High Voltage AC transmission)

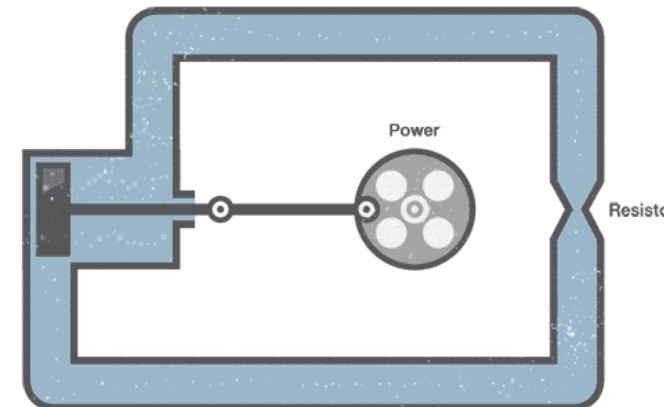
Direct Current: The Water Analogy



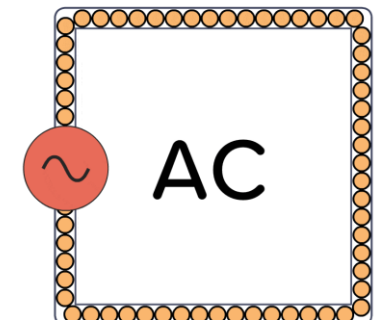
Direct Current

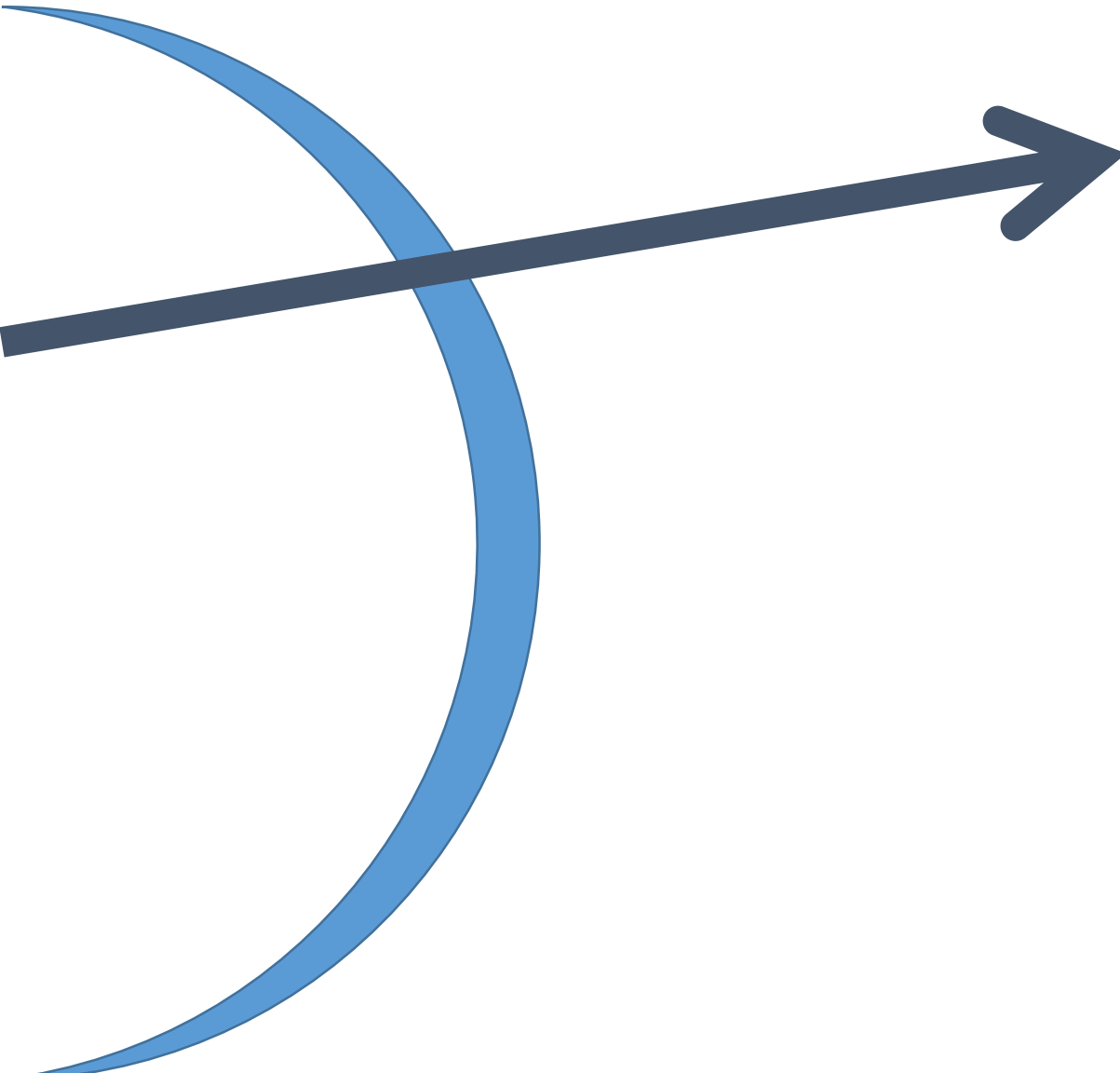


Alternating Current: The Water Analogy



Alternating Current



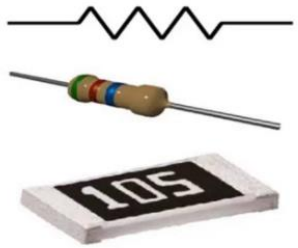


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Passive & Active Electronic components

Passive electronic components consumes energy. It does not produce energy, is incapable of power gain and requires no **electrical** power to operate. They simply absorb energy.



RESISTOR



CAPACITOR



INDUCTOR

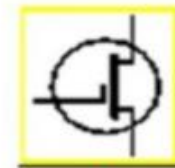


Diode

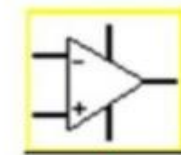
Active electronic components are parts of a circuit that rely on an external power source to control or modify **electrical** signals. It amplify an electric signal and produce power



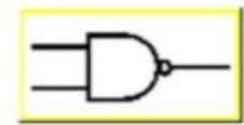
Transistor



MOSFET



Amplifier



Logic Gates



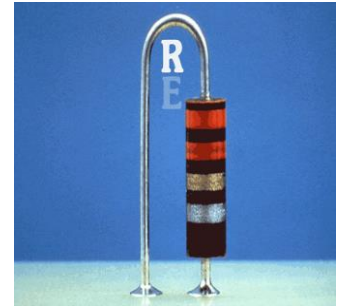
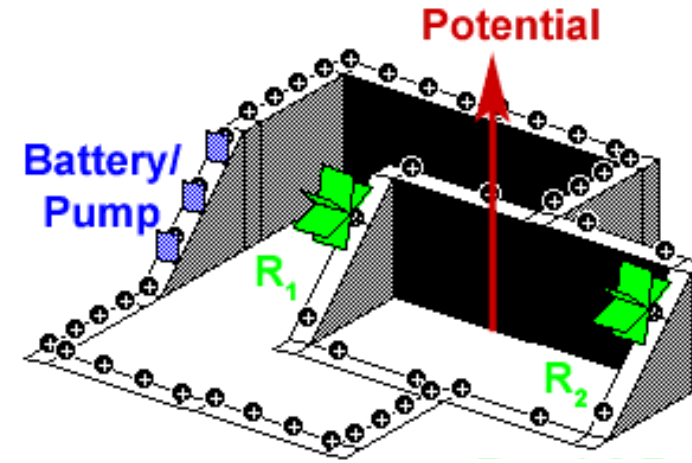
SCR



Passive Electronic components

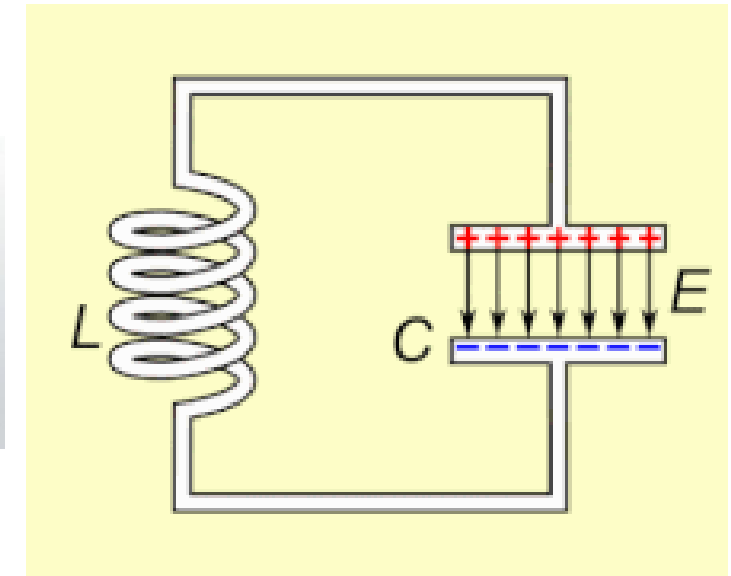
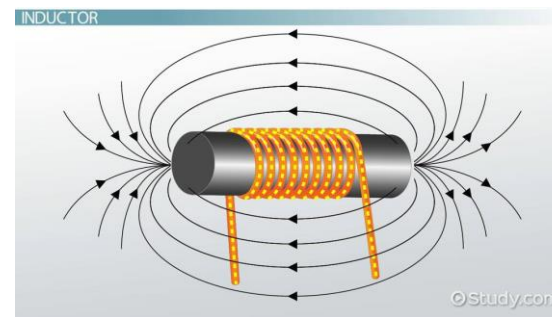
RESISTOR (Unit: Ohms (Ω))

- Resistors are an electrical component that reduces the electric current.
- The resistor's ability to reduce the current is called resistance and is measured in units of ohms (symbol: Ω).
- If we make an analogy to water flow through pipes, the resistor is a thin pipe that reduces the water flow.
- **Application:** Used in Circuits to limit the current flow



INDUCTOR (Unit: Henry (L))

- An inductor, also called a **coil, choke, or reactor**, is a passive two-terminal electrical component that stores energy in a magnetic field when electric current flows through it.
- An inductor typically consists of an insulated wire wound into a Coil
- **Application:** Starter Motor & Alternator (Coil Winding), Induction Motor





Capacitor

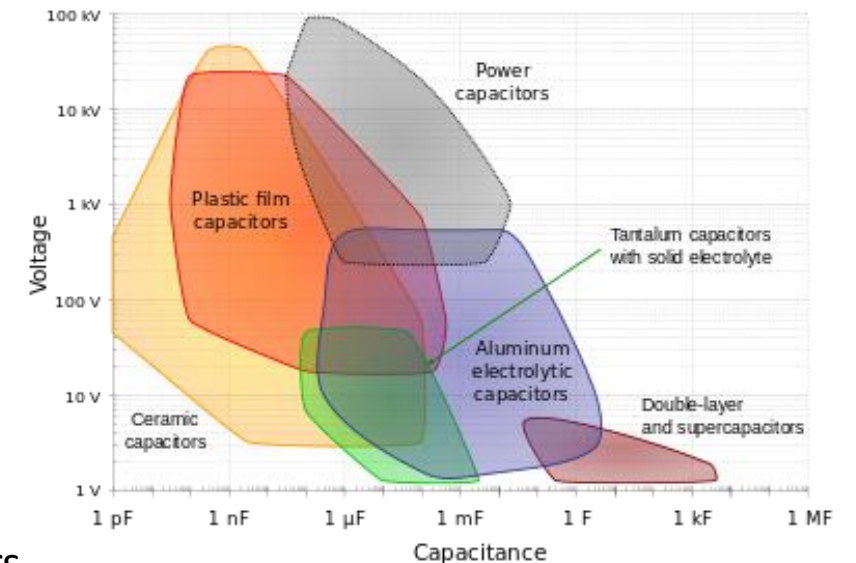
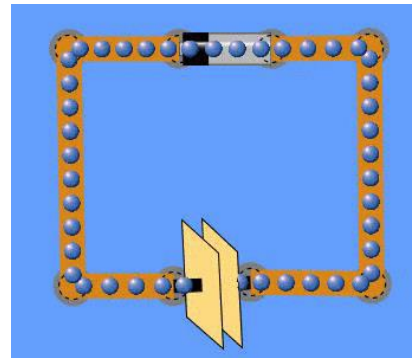
➤ A capacitor is a device that stores electrical energy in an electric field. It is a passive electronic component with two terminals.

➤ The effect of a capacitor is known as capacitance.

➤ **Unit of Capacitance is FARAD (F)**

➤ Major Types of Capacitor are:

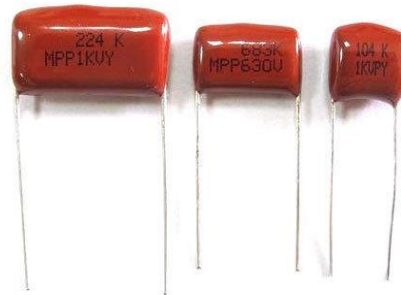
- Ceramic Capacitors
- Film Capacitors
- Electrolytic Capacitors
- Super Capacitors



Ceramic Capacitors



Film Capacitors



Electrolytic Capacitors



Super Capacitors

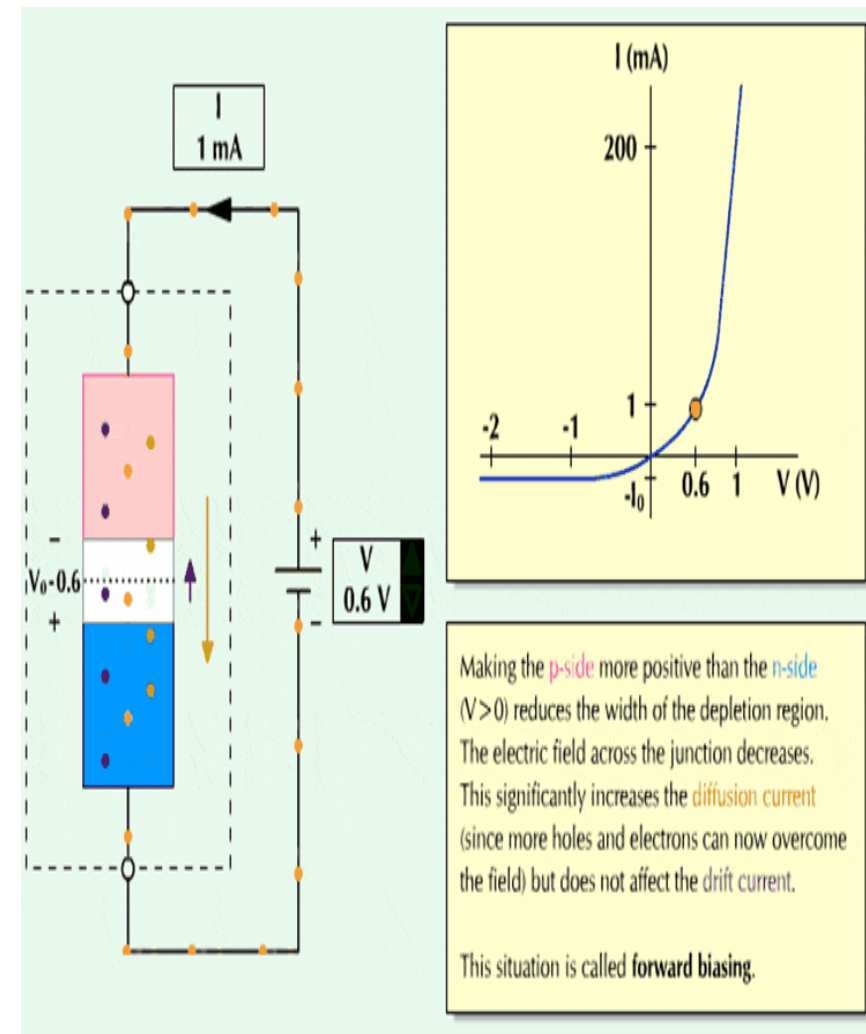
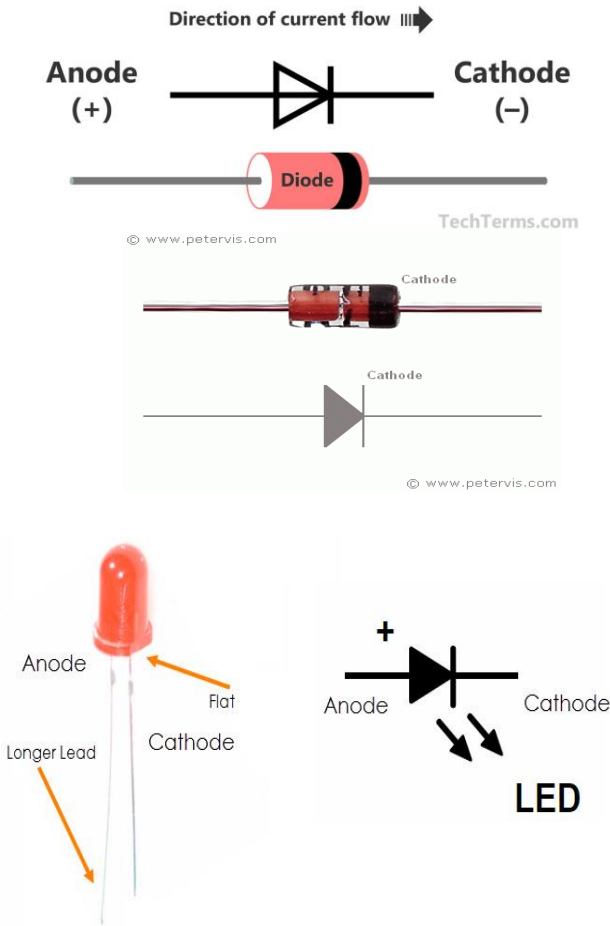


APPLICATION: Power conditioning circuits, Oscillators and Electronic Filters

Diode



- A **diode** is a semiconductor device that essentially acts as a one-way switch for current.
- It allows current to flow easily in one direction, but severely restricts current from flowing in the opposite direction



Major Types of Diode:

1. Light Emitting Diode (LED)

Applications: Headlights / Dashboard Lamps / Domestic use – Lamps / Bulbs

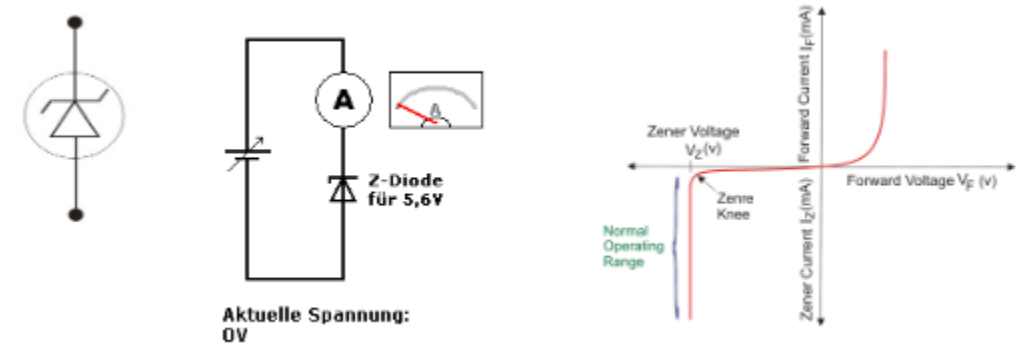
Diode



2. Zener Diode:

It is a semiconductor device that allows current to flow either in a forward or reverse direction

Application: **Voltage regulator / Overvoltage protection**



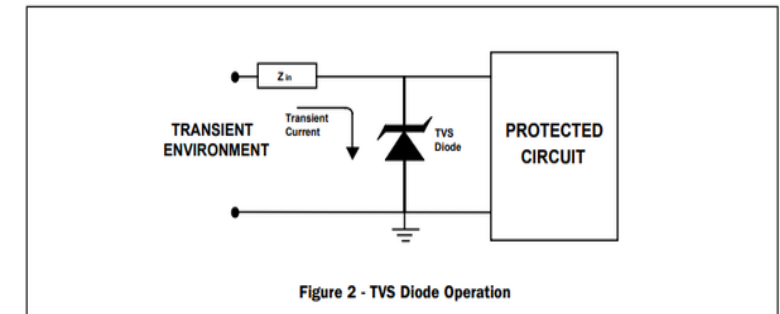
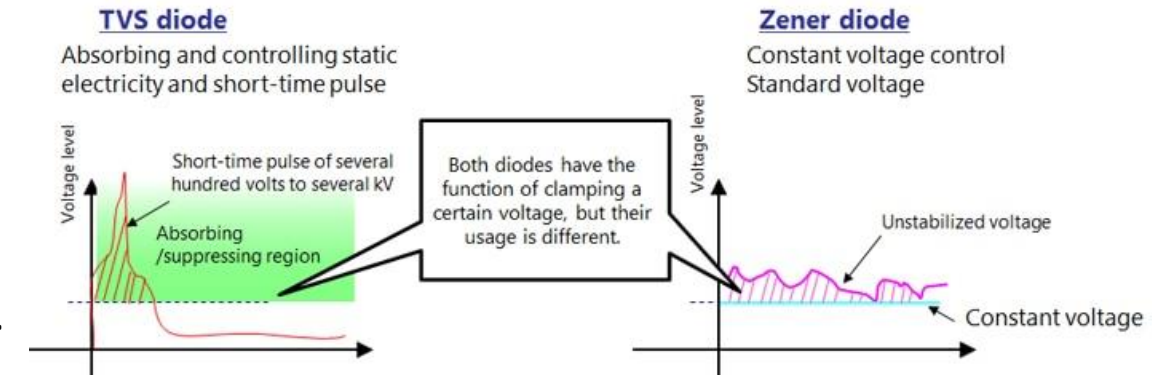
3. Transient Voltage Suppressors (TVS) diodes:

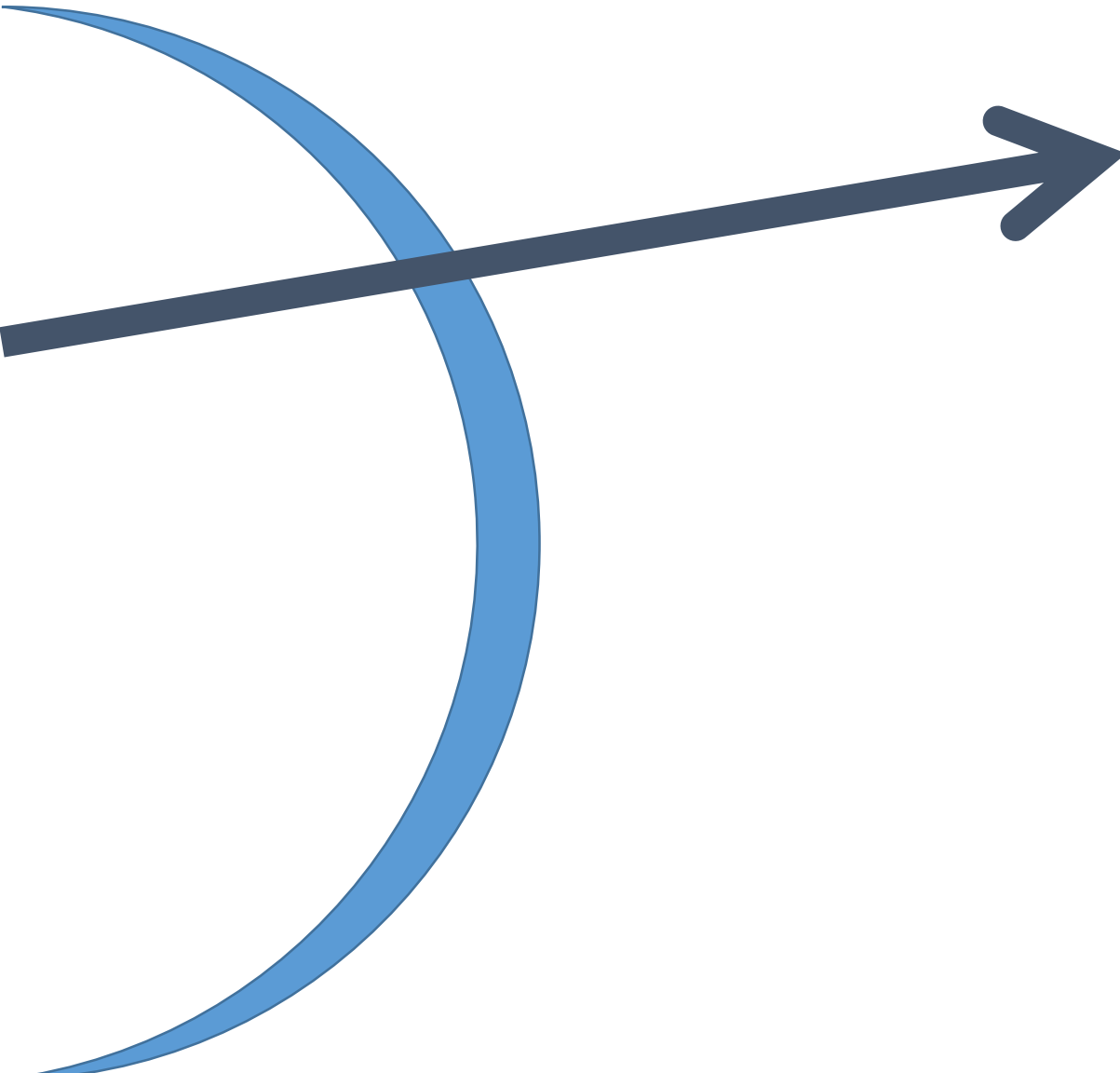
TVS diode is a protection diode designed to protect electronic circuits against transients and overvoltage threats (like load dump).

It is used to protect vulnerable circuits from electrical overstress such as that caused by electrostatic discharge, inductive load switching and induced lightning

ELECTRICAL OVERSTRESS - EOS

Application: **ECU / Sensors – Transient Voltage protection**



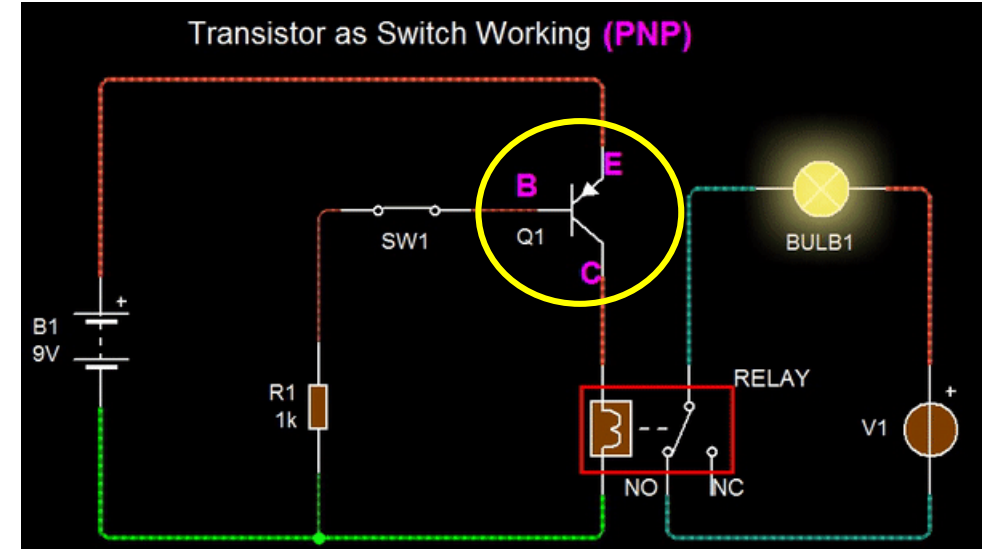
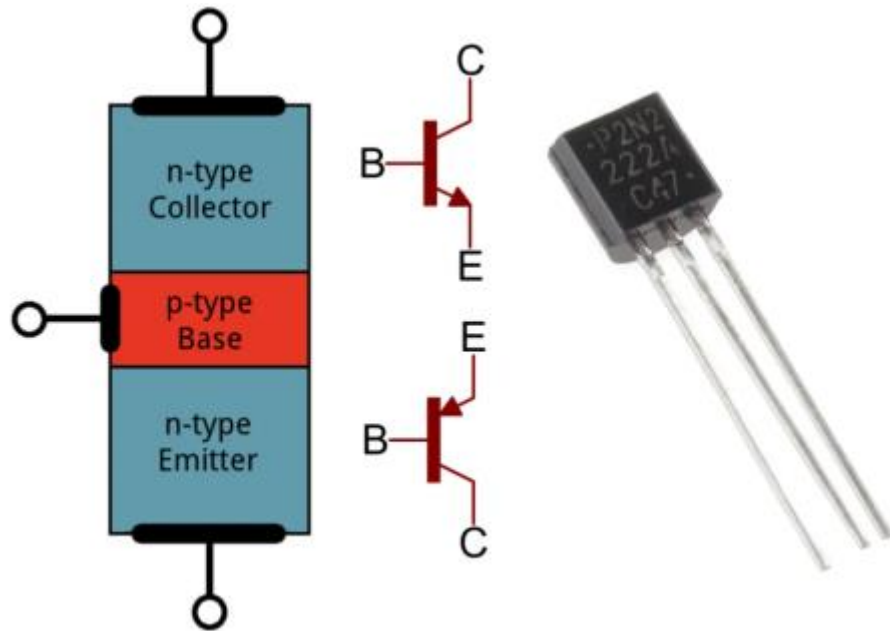


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Transistor

- A **Transistor** is a semiconductor device used to amplify or switch electronic signals and electrical power. **Transistors** are one of the basic building blocks of modern electronics.
- **Application:** Switching applications, Logic Gates
- Transistor is a three terminal device- Base(B), Emitter(E) and Collector(C).





Silicon controlled rectifier (SCR)

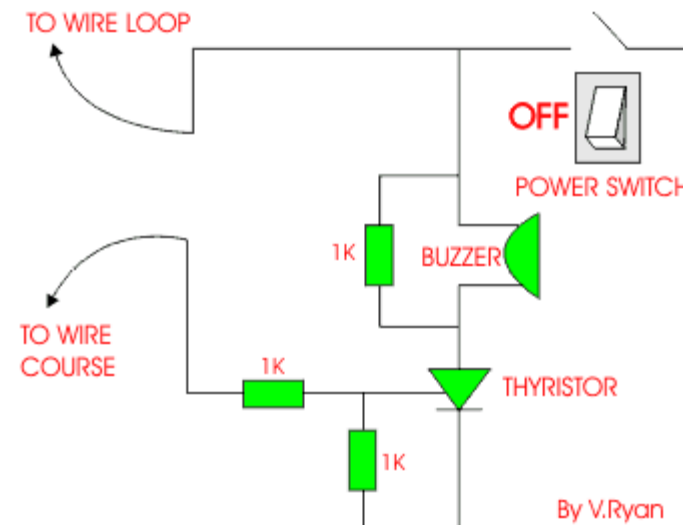
A **Silicon Controlled Rectifier** or semiconductor-**controlled rectifier** is a four-layer solid-state current-controlling device. It is also known as **Thyristor**.

The **SCR** is a unidirectional device that allows the current to flow in one direction and opposes it in another direction.

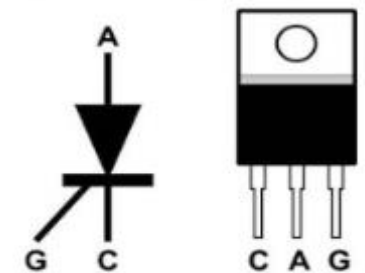
SCR has three terminals namely Anode (A), Cathode (K) and gate (G), it can be turned ON or OFF by controlling the biasing conditions or the gate input

SCRs are mainly used in electronic devices that require **control** of high voltage and power.

Diode is Uncontrolled rectifier and SCR is Controlled turn-on



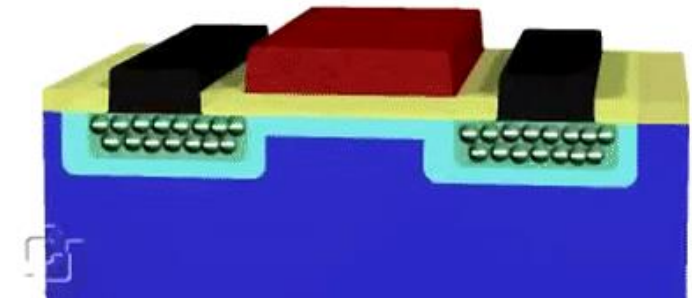
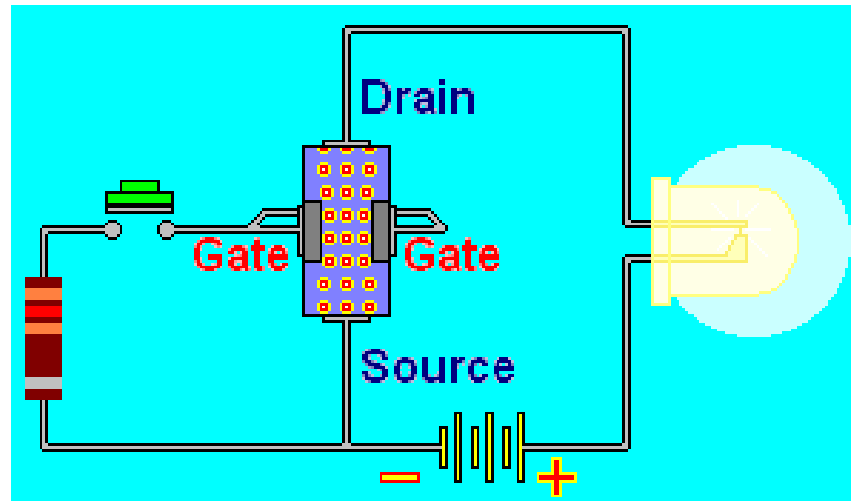
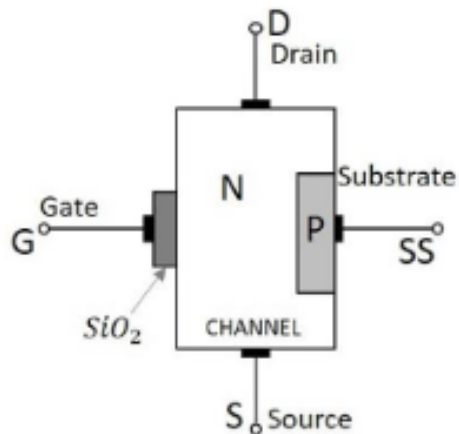
Silicon Control Rectifier

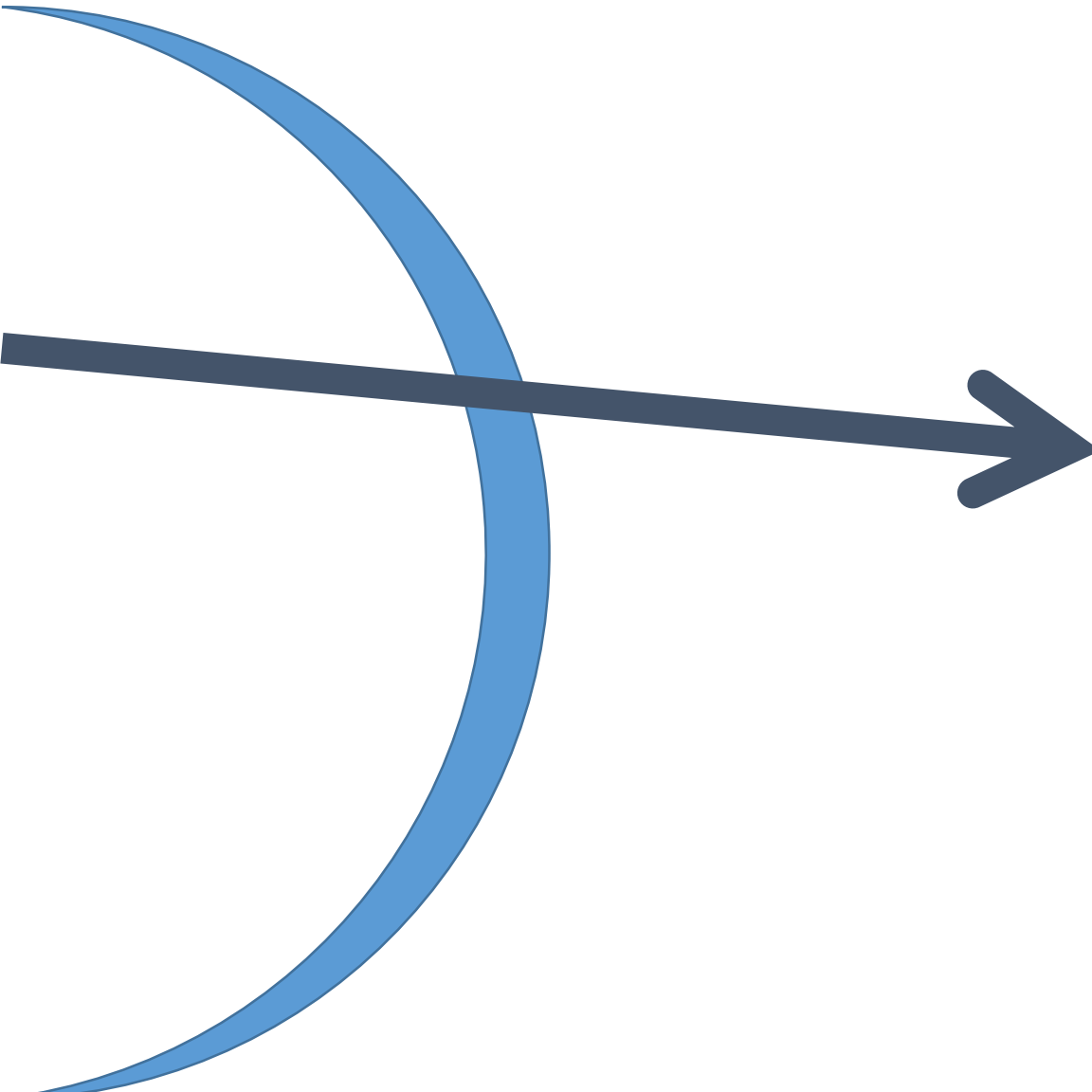


Gate
Cathode
Anode

MOSFET

- The **Metal Oxide Semiconductor Field Effect Transistor (MOSFET)**, is a type of insulated-gate [field-effect transistor](#) that is fabricated by the [controlled oxidation](#) of a [semiconductor](#), typically [silicon](#).
- The MOSFET is a three terminal device such as Source (S), Gate (G) and Drain (D)
- In general, the **MOSFET works** as a switch, the **MOSFET** controls the voltage and current flow between the source and drain
- **Application:** Power electronics / High power switching





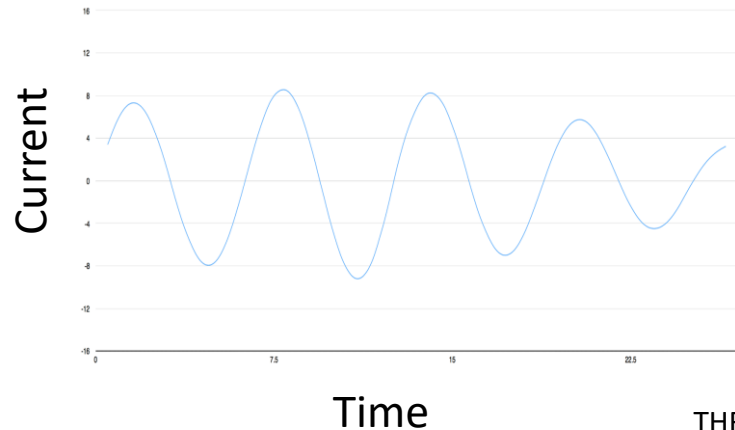
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Analog & Digital Signals



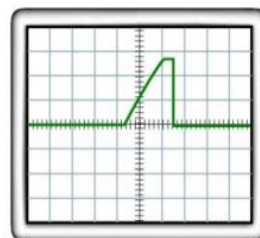
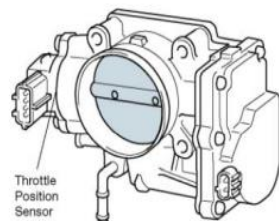
An **analog signal** is any continuous signal for which the time-varying feature of the signal is a representation of some other time-varying quantity

Example: Throttle Position sensor / Pressure Sensor / Temperature Sensor / Fan regulator



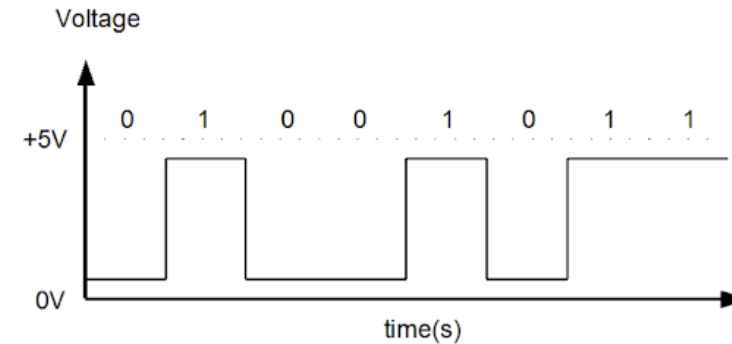
Analog Signal

THROTTLE POSITION SENSOR



A **digital signal** is a signal that is being used to represent data as a sequence of discrete values.

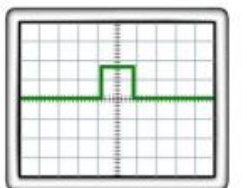
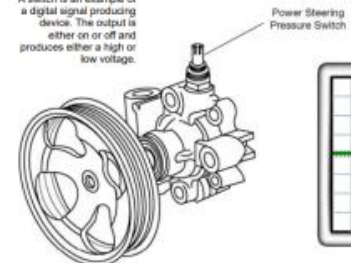
Example: Switches, Pressure or temperature switch, Logic Gates, Digital Electronics.



Digital signal

Digital Signal - Power Steering Pressure Switch
A switch is an example of a digital signal producing device. The output is either on or off and produces either a high or low voltage.

PRESSURE SWITCH



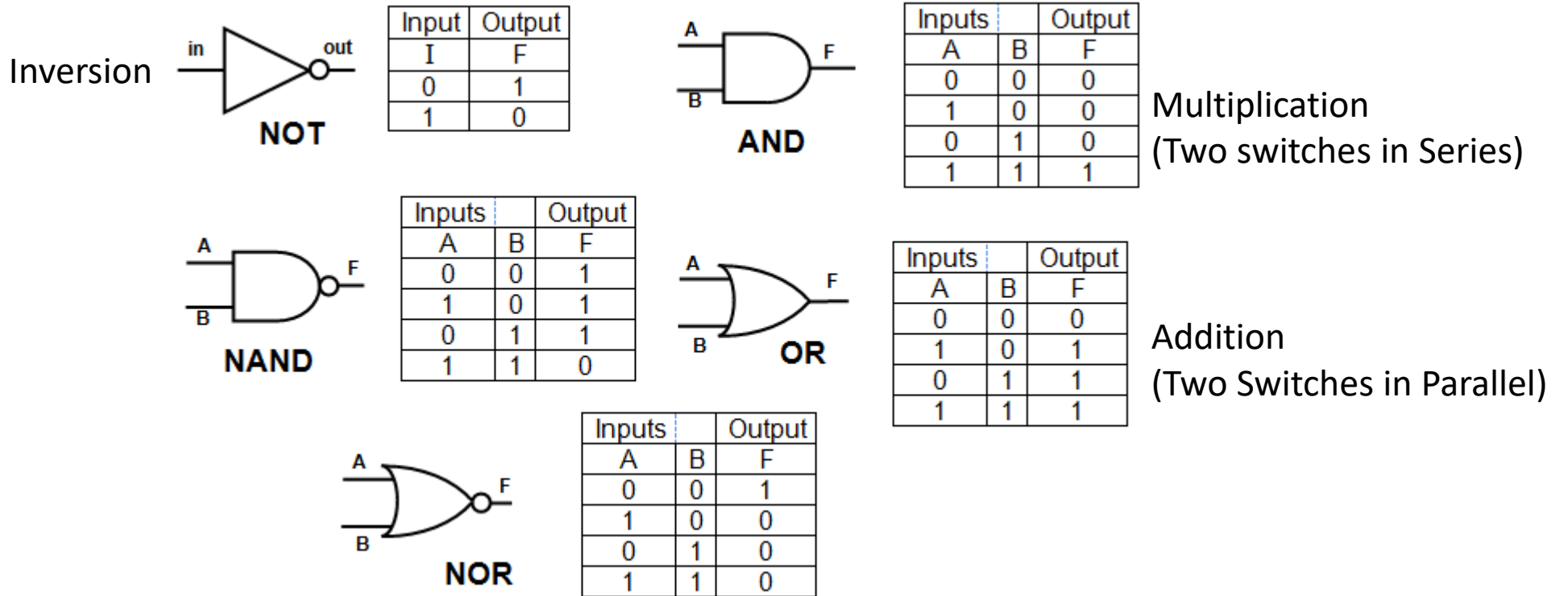
LOGIC Gates



Logic gates are the basic building blocks of any digital system.

It is an electronic **circuit** having one or more than one input and only one output.

The relationship between the input and the output is based on a certain **logic**.



NAND & NOR are called as Universal Gates (any logical Boolean expression)

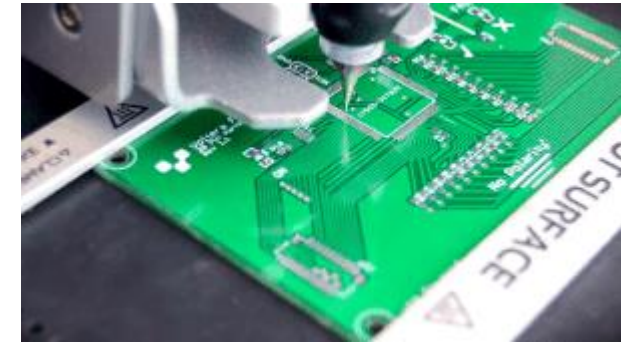
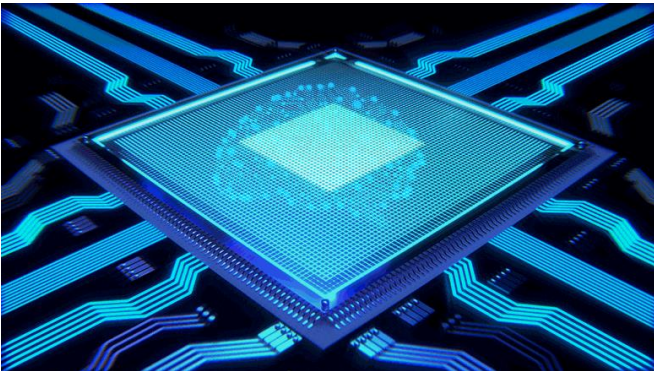
Logic gates are used in microcontrollers, microprocessors, and embedded system applications



Integrated Circuit (IC) & PCB

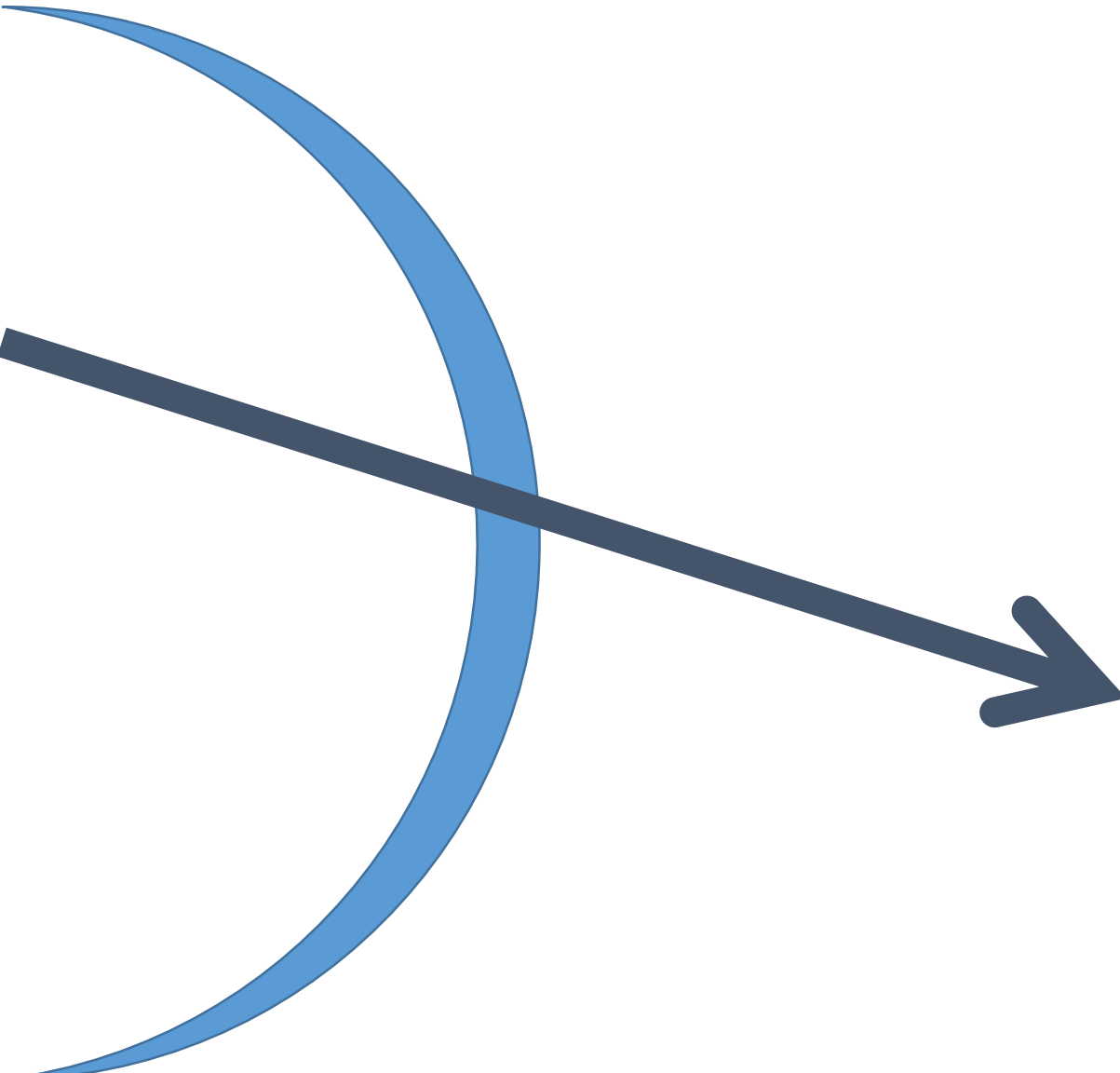
Integrated Circuit

- An **integrated circuit (IC)**, sometimes called a chip or microchip, is a semiconductor wafer on which thousands or millions of tiny resistors, capacitors, and transistors are fabricated
 - **Application Specific Integrated Circuits** or ASICs are integrated circuits that have been designed for a specific use or application
- Applications:** Digital circuits, Programmable circuits, Logic circuits



- **Printed circuit board (PCB)** mechanically supports and electrically connects electrical or electronic components using conductive tracks, pads and other features etched from one or more sheet layers of copper laminated onto a non-conductive substrate.
- Single-layer PCBs, Double-layer PCBs, Multi-layer PCBs, Rigid PCBs, Flexible PCBs, Rigid-Flex PCBs, High-frequency PCBs, Aluminum-backed PCBs.

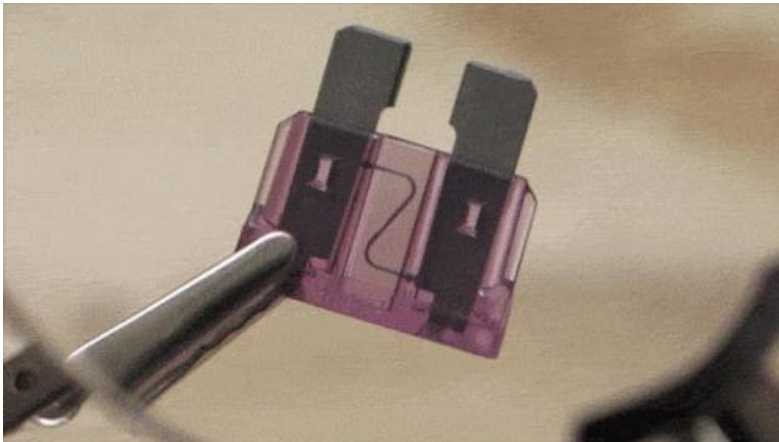


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Fuse



- Fuse is an electrical **safety device** that **operates to provide over current protection** of an electrical circuit.
- Its essential component is a metal wire or strip that melts when too much current flows through it, thereby stopping or interrupting the current. **Rating of a Fuse is expressed in AMPERES.**
- **Application:** Electrical Safety



While Short circuiting Positive (Red Wire) and Negative Wire (Black) – Fuse blows



Major Automotive Fuses

Mini-Fuses -

Range: 1 to 30 Amps

Maxi-Fuses -

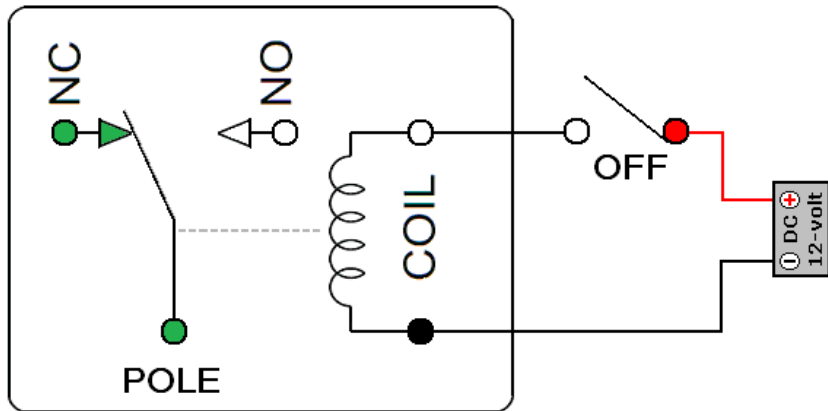
Range: 20 to 100 Amps



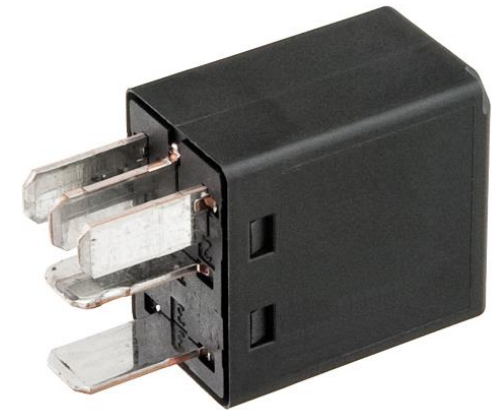
Relay

- Relay is an electrically operated switch. They commonly use an electromagnet (coil) to operate their internal mechanical switching mechanism (contacts) - To switch high current circuit using a low current circuit

Applications: Head lamp, Flasher, Ignition switch



Mini-Relay – Usually 40A class



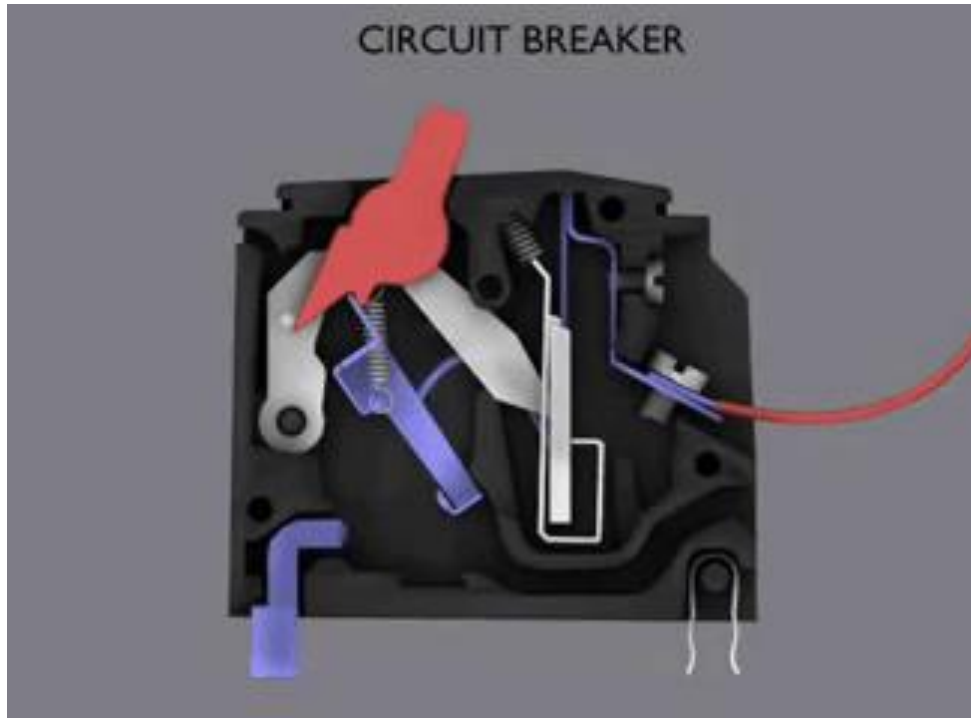
Micro-Relay – Usually 25 to 30A class

Power Mini Relay or Maxi Relay
Usually 70A Class



Circuit breakers

- A **Circuit Breaker** is an electrical switch designed to protect an electrical circuit from damage caused by overcurrent/overload or short circuit. Its basic function is to interrupt current flow after protective relays detect a fault.



CIRCUIT BREAKER OPERATION



Miniature Circuit Breaker



Automotive Resettable Fuses

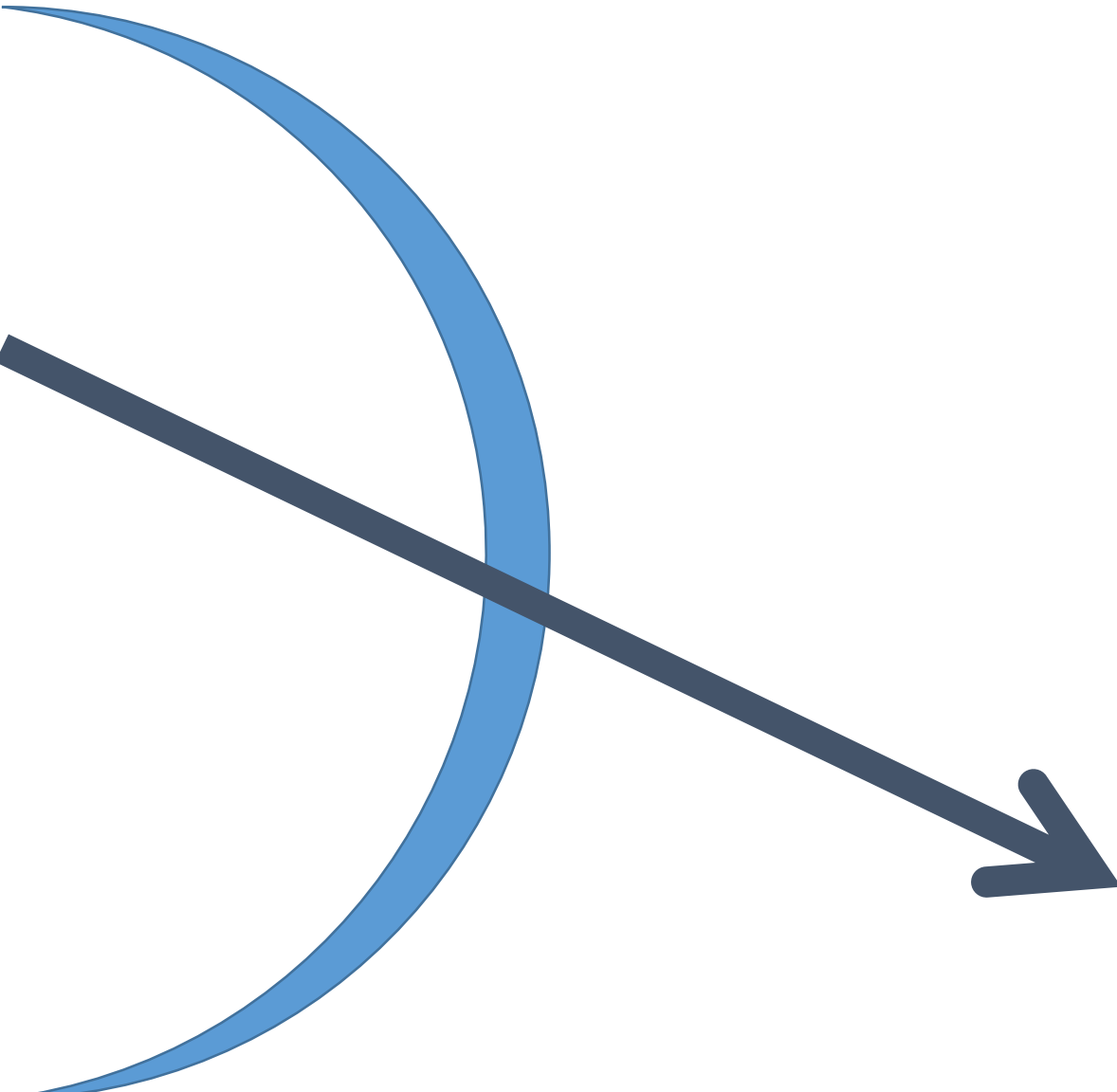


QUIZ TIME



References & Practices

- ❖ Basic Electronics - by D P Kothari & I Nagrath, Chinmoy Saha, BL Theraja
- ❖ The Art of Electronics by Paul Horowitz / Winfield Hill (3rd Edition)
- ❖ Bosch Automotive Electrics and Electronics: Systems and components
- ❖ Bosch Automotive Handbook
- ❖ Modern Digital Electronics – RP Jain
- ❖ Python programming & Basics
- ❖ Arduino Boards (open-source electronics platform based on easy-to-use hardware and software)
- ❖ TM4C123G Launchpad Evaluation Board – Practice Coding – Youtube videos are available



1. Electronics – Basic concept
2. Passive & Active Electronic components – Basics & Application
3. Analog and digital signals
4. Logic Gates
5. Integrated circuits (IC) & PCB
6. Fuses, Relays and Circuit breakers – Basics & application
- 7. Module 2- Preface- Control unit /Sensor/Actuator/OBD**
8. Q&A, Quiz & Feedback



- I. ECU - Electronic Control Unit
 - a) Basic Functions
 - b) Block diagram & Internal module
 - c) Protection circuits
 - d) BSVI architecture
- II. ECU – Sensors, Switches and actuators
 - a) Speed Sensor
 - b) Temperature Sensor
 - c) Pressure Sensor
 - d) Other Sensors – APS, WIFS
 - e) Switches
 - f) Actuators – ITV, EGR
- III. OBD - Introduction
- IV. ISO 26262 – Introduction to automotive functional safety

- I. Basic architecture and Functions of Exhaust After Treatment System (EATS) – ACU (**A**ftertreatment **C**ontrol **U**nit)
 - a) Compact S type
 - b) Compact Linear type
 - c) Emission & OBD limit
 - d) DOC
 - e) DPF
 - f) SCR
- II. ACU – Sensors and actuators
 - a) Exhaust Gas temperature sensor
 - b) Nox Sensor
 - c) Delta pressure sensor
 - d) HC Dozer & function
 - e) DEF header unit & function
 - f) Ambient air temperature sensor
 - g) Urea Dosing System (UDS)
- III. OBD – Stage 1 & 2 - Introduction



Thank you!



Any Questions?