Introduction to electronic devices and Digital electronics :-

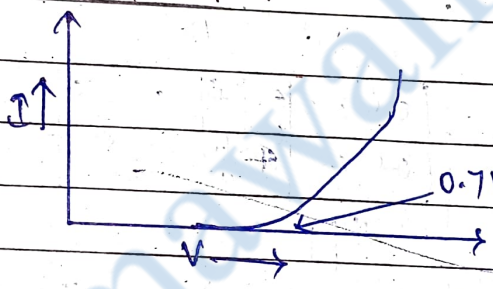
~~Series~~ :- P-N Junction :-

- **potential Barrier** :- The potential difference developed / created across the P-N junction due to diffusion of electrons and holes is called potential barrier.

Note :- potential barrier of Si = 0.7V
potential barrier of Ge = 0.3V

characteristics of P-N Junction diode :-

i) forward bias characteristic :-

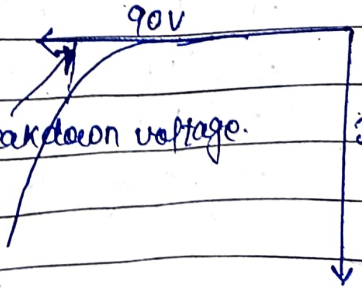


Note :- when the battery voltage is zero, diode not conduct. As the forward battery voltage(V) increases, the potential barrier starts decreasing and a small current start to flow.

- **knee voltage (threshold voltage)** :- The voltage at which the forward current start increasing rapidly is known as threshold voltage.

ii) **Reverse bias characteristics** :-

- when P-N ~~Junc~~ Junction is reverse biased. The majority carriers in a p and n region are repelled from the junction. There is small current due to minority carriers.

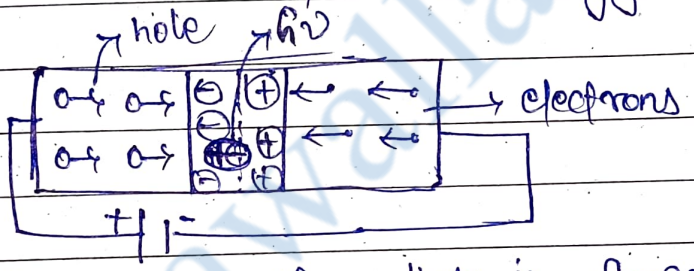


Types of diode:-

ii) **photodiode**:- photodiode is a semiconductor p-n junction diode which is operated under reverse bias.

uses:-
- it is used as photodector to detect optical signals.
- They are used as light operated switches.
- They are used in logic gates.

iii) **light emitting diode (LED)** :-
light emitting diode is a semiconductor p-n junction diode which is operated under forward bias.
it is used to convert electrical energy into light energy

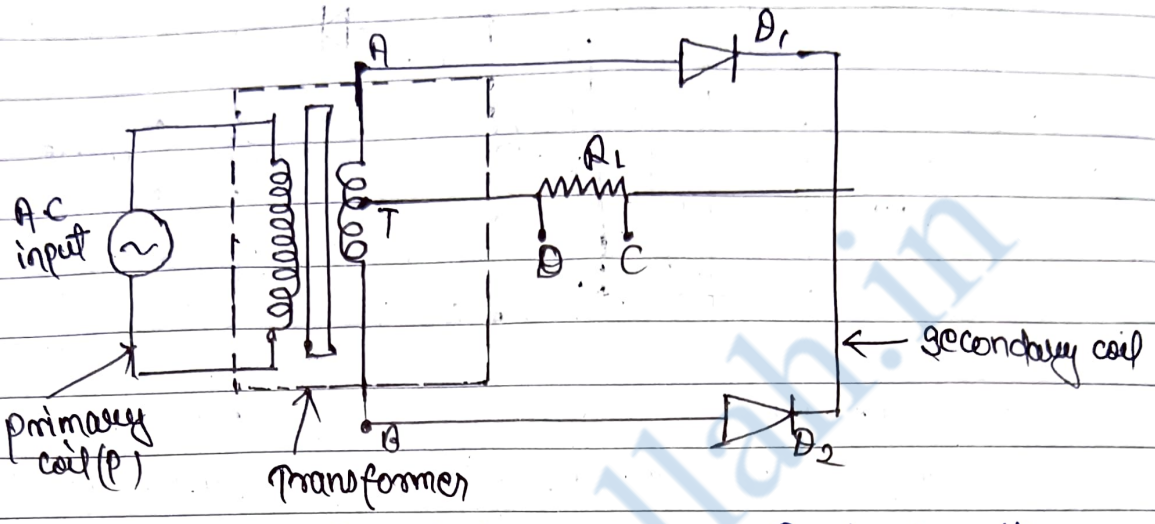


working principle :- when the diode is forward biased electron are sent from n → p and holes are sent from p → n.
Thus at the junction holes and electrons recombines, During recombination. the energy is released in the form of photons.

→ It is used in traffic light, digital watches, switch board and torches. etc.
→ LED works at low voltage.
→ LED has longer life
→ LED has low power consumption.
→ They can be switched on and off very fast.

iii) Full Wave Rectifier :-

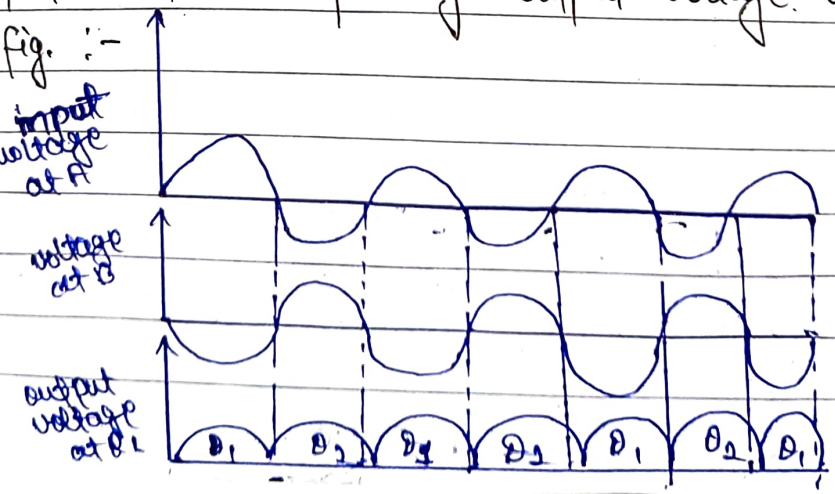
The primary coil transformer is connected to AC input signal. The secondary coil transformer is connected to p-side of two diode D_1 and D_2.



Working :- During ⊕ve half cycle of the input voltage, the terminal A is ⊕ve and B is ⊖ve with respect to tap T. Thus diode D_1 is forward biased and ~~so current due to diode D_2 is reverse biased and D_2 is forward biased~~ so, current due to diode D_1 flows through R_L from C to D.

During the ⊖ve half cycle, the terminal A is ⊖ve and B is ⊕ve with respect to T. Thus diode D_1 is reverse biased and D_2 is forward biased, so current due to diode D_2 flow through R_L from C to D.

The input and corresponding output voltage are shown in fig. :-



Sensors :-

The sensors can be defined as a device which can be used to sense/detect the physical quantity like force, pressure, temperature, strain, light, sound, motion, Humidity, voltage etc. then convert it into desired output like the electrical signal to measure the applied physical quantity.

Types of sensors and their rating :-

1) Temperature sensor :-

- working :- Measures temperature by sensing the voltage diff. betn two different metals.
- Rating :- Typically rated by temperature range -200°C to +1200°C, accuracy of : ±1°C.
- Applications :- HVAC system, weather stations, industrial process.

2. Pressure sensor :-

- working :- converts pressure into an electrical signal by utilizing the piezoelectric effect.
- Rating :- Rated by pressure range 0-100 bar accuracy: ±0.5%.
- Applications :- Automotive system, medical devices, industrial automation, working :-

3. proximity sensor :- Detects the presence or absence of an object by emitting an electromagnetic field or beam of electromagnetic radition.

- Rating :- Rated by sensing distance 0-10 cm, accuracy : ±mm
- Application :- Robotics, conveyor system, door automation.

4 Humidity sensor :-

- working :- Measures relative humidity by detecting changes in capacitance due to water absorption.
- Rating :- Rated by humidity range 0-100 % RH and accuracy : ±2%.
- Applications :- HVAC systems, agricultural monitoring, environmental chambers.

5. Light sensor :- (photodiode)
- working :- converts light energy into an electrical signal, typically by generating a current proportional to the light intensity.
- Rating :- 0-1000 lux, accuracy : ± 5%.
- Applications :- photovoltaic system, smartphones, optical communication

6. Motion sensor :-
- working :- Measures acc'n changes by detecting changes in capacitance.
- Rating :- ±3 g, accuracy : ±0.1g
- Applications :- security system, lighting control, occupancy detection.

7. Gas sensor :-
- working :- Measures specific gases in the air through chemical reaction generating electric signals.
- Rating :- 0-1000 ppm, accuracy : ± 5%.
- Applications :- Air quality monitor, industrial safety, automotive emission control.

8. Sound sensor :-
- working :- Detect sound waves and convert them into electrical signal.
- Rating :- it is rated in mV/Pa. (-44 dBV/Pa)
- Applications :- Audio recording, noise monitoring, voice recognition system.

Actuators :-

- An Actuators is a device that converts electrical, hydraulic, or mechanical energy into physical movement. it is it is used to control or manipulate a mechanism or system by moving or adjusting a component.

Types of Actuators :-

1. Electric Actuators :-

working :- converts electrical energy into mechanical movement using motors such as DC motors, stepper motor.

Applications :- Robotics, automated manufacturing equipment, home automation (e.g. electric door locks.)

2. Hydraulic Actuators :-

- working :- uses pressurized hydraulic fluid to generate linear or rotary motion, often through a piston or cylinder arrangement.
- Applications :- Heavy machinery (e.g - excavators, bulldozers), industrial presses, aircraft flight control surfaces.

3. Mechanical Actuators :-

- working :- It Transforms rotational motion into linear motion or vice-versa through gear, cams, or lardscrews.
- Applications :- Mechanical lifts, adjustable seats in vehicles, throttle control in engines.

4. Pneumatic Actuators :-

- working :- converts compressed air pressure into mechanical force to move components like pistons or diaphragms.
- Applications :- control values in industrial automation, in manufacturing processes, robotic arms.

Application of Actuators :-

- Industrial Automation :- Actuators are used extensively in automated manufacturing processes to precisely control machinery and equipment.
- Robotics :- In robotic movement system, enabling robots to performs task with accuracy and speed.
- Aerospace and defense :- Actuators are critical in aircraft control surfaces and missile guidance systems.
- Medical devices :- Actuators are used in medical equipment such as surgical robots, prosthetic limbs, and automated drug delivery system.
- HVAC System :- Actuators regulate air flow and temperature in heating, ventilation and air conditioning system.
- Consumers electronics :- Actuators are found in devices like autofocus mechanism in cameras, vibration motors in mobile phones and in home appliances.

Relay as an actuator :-

A Relay is a type of actuator that acts as a switch to control the flow of electrical current or voltage to a circuit or device. it is an electrically operated switch that uses an electromagnet to move a mechanical switch, allowing it to control a high-power circuit with a low-power signal.

Types of Relay :-

i) Electromag electromechanical Relay :- uses a mechanical (EMR) switch and electromagnet.

(SSR)

ii) Solid-State Relay :- uses a semiconductor devices to switch the circuit.

iii) Hybrid Relay :- Combines EMR and SSR technologies.

Application of Relays in Actuators :-

1) power systems :- Relays are used ~~do~~ voltage regulation, circuit protection, and power distribution.

2) Industrial control system :- Relays are used to switch motors, lighting control and automation processes.

3) Communication systems :- Relays are used for switching signals and circuits in telecommunications equipment and network.

4) Automotive systems :- Relays are used in vehicles to control headlights, fan, wiper control and other high-power devices.

5) Home appliances :- Refrigerator, AC, and washing machine control, controlling lights.

Advantages / Relays are widely used as actuators due to their :-

- High current-handling capacity.
- Low power consumption.
- fast switching times
- High reliability
- low cost.
- Due to

- **Digital Systems :-**

A digital system is an electronic system that processes and represent information in a digital format rather than analog ones. Digital signals are discrete and represent data as binary numbers (0s and 1s) to store, process and transmit data.

e.g :- i) Digital computer (laptops, desktops, tablets and smartphones).

ii) Digital communications (networks, internet protocols, wireless communication)

iii) Digital watches

iv) Digital cameras.

v) Digital Audio players.

vi) Digital TV

- **Binary Numbers :-**

Binary no. are a base-2 number system that uses only two digits : 0 and 1. They are used to represent information in digital system.

- **Boolean identities :-**

Boolean identities are mathematical rules that describe the behavior of binary numbers and where the variables and operations are restricted to true and false, typically represented as 1 and 0.

Some laws are :-

- **Identity laws :-** $A + 0 = A$ and $A \cdot 1 = A$

- **Domination laws :-** $A + 1 = 1$ and $A \cdot 0 = 0$

- **Complement laws :-** $A + \bar{A} = 1$ and $A \cdot \bar{A} = 0$

OR Means + (Add)

- Double Negation law :- $\bar{\bar{A}} = A$
- De Morgan's law :- $\overline{A+B} = \bar{A}.\bar{B}$ and $\overline{A.B} = \bar{A}+\bar{B}$
- Associative laws :- $(A+B)+C = A+(B+C)$ $(A.B).C = A.(B.C)$
- Distributive laws :- $A.(B+C) = A.B + A.C$ $A+(B+C) = (A+B).(A+C)$

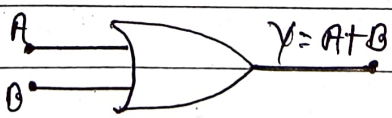
Logic gates :- A digital gate is a digital circuit that follows certain logic relationships betn input and output voltages.

Notes :- A logic gate has one or more inputs but it has only one output.

There are three types of basic logic gates :-
i) OR gate
ii) AND gate
iii) NOT gate

i) OR gate :- An OR gate has two or more inputs with one output. It gives high output (1) if either input A or B or both are high (1)

Symbol :-



The boolean expression for OR gate is given by $Y = A+B$

Truth Table:- A table which represents the operation of a logic gate is called Truth table. It contains all possible inputs and output.

Truth table of OR gate :-

A	B	output (Y)
0	0	0
0	1	1
1	0	1
1	1	1

ii) **AND gate:-** AND gate has two (or more) inputs with one output. It gives a high output (1) if both inputs A and B are high (1)

Symbol :-

The Boolean expression of AND gate is given by $Y = A \cdot B$

Truth table:-

A	B	output ($Y = A \cdot B$)
0	0	0
0	1	0
1	0	0
1	1	1

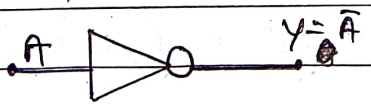
iii) **NOT gate :-** The NOT gate has only one input and one output.

Note:- NOT gate inverts the inputs, due to this reason, it is also called inverter.

Truth table

A (input)	output $Y = \bar{A}$
0	1
1	0

Symbol :-

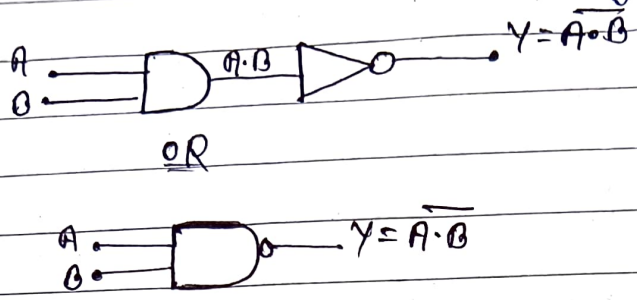


The Boolean expression for NOT gate is given by

$Y = \bar{A}$

iv) NAND gate:- The logic gate in which the output of the AND gate is given to the input of NOT gate is called NAND gate.

Symbol :-



The Boolean expression for NAND gate is given by:-

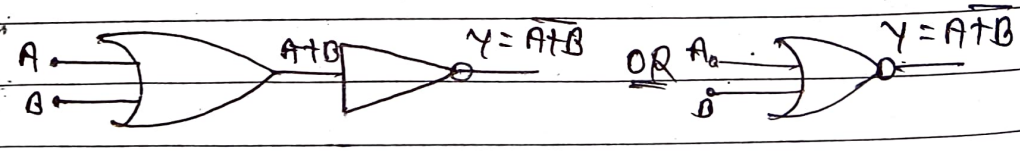
$$Y = \overline{A \cdot B}$$

Truth Table for NAND gate:-

Input		Output
A	B	$Y = \overline{A \cdot B}$
0	0	1
0	1	1
1	0	1
1	1	0

v) NOR gate:- The logic gate in which the output of the OR gate is given to the input of NOT gate is called NOR gate.

Symbol :-



The Boolean expression for NOR gate is given by:-

$$Y = \overline{A+B}$$