

# Fundamentals of Electronics (4311102) - Winter 2023 Solution

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## Question 1(a) [3 marks]

Define Forward and reverse bias of diode.

### Solution

Answer:

#### Forward Bias of Diode:

- **Connection Method:** P-type connected to positive terminal and N-type connected to negative terminal of battery
- **Barrier Width:** Barrier width decreases
- **Resistance:** Low resistance (typically 100-1000 $\Omega$ )
- **Current Flow:** Allows current to flow easily through the diode

#### Reverse Bias of Diode:

- **Connection Method:** P-type connected to negative terminal and N-type connected to positive terminal
- **Barrier Width:** Barrier width increases
- **Resistance:** Very high resistance (typically several M $\Omega$ )
- **Current Flow:** Blocks current flow (only small leakage current flows)

Diagram:

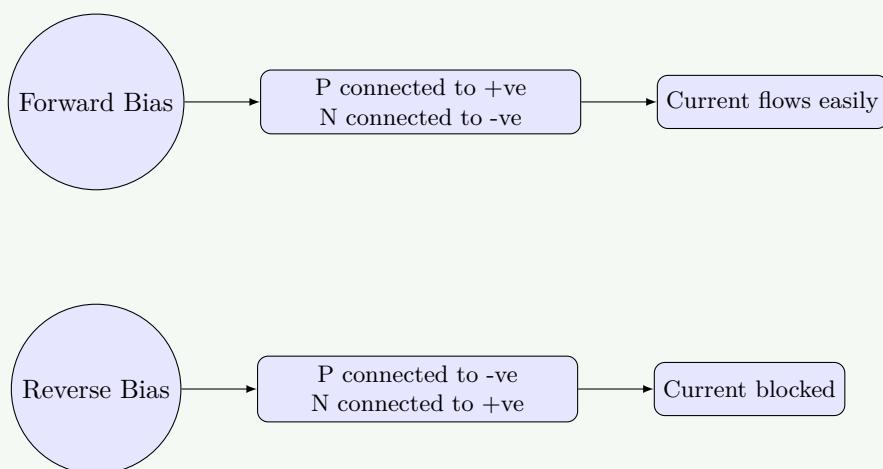


Figure 1. Forward and Reverse Bias Logic

### Mnemonic

"PFNR: "Positive to P Forward, Negative to P Reverse""

## Question 1(b) [4 marks]

Explain construction and working of LDR.

## Solution

**Answer:**

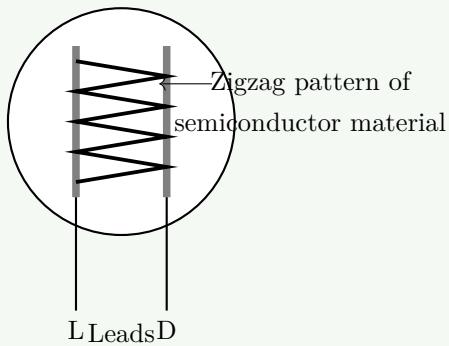
**Construction of LDR:**

- **Material:** Made of semiconductor material (Cadmium Sulfide)
- **Pattern:** Zigzag pattern of photosensitive material on ceramic base
- **Electrodes:** Metal electrodes at both ends
- **Package:** Encapsulated in transparent plastic or glass case

**Working Principle:**

- **Photoconductivity:** Based on photoconductivity principle
- **Dark Resistance:** High resistance ( $M\Omega$  range) in dark conditions
- **Light Exposure:** When exposed to light, photons release electrons
- **Resistance Drop:** Resistance decreases ( $k\Omega$  range) in bright light

**Diagram:**



**Figure 2.** LDR Construction

## Mnemonic

“MILD: “More Illumination, Less Dark-resistance””

## Question 1(c) [7 marks]

Explain the color band coding method of Resistor. Write color band of  $47k\Omega \pm 5\%$  resistance.

## Solution

**Answer:**

**Color Band Coding Method:**

**Table 1.** Resistor Color Code

Color	Value	Multiplier	Tolerance
Black	0	$10^0$	-
Brown	1	$10^1$	$\pm 1\%$
Red	2	$10^2$	$\pm 2\%$
Orange	3	$10^3$	-
Yellow	4	$10^4$	-
Green	5	$10^5$	$\pm 0.5\%$
Blue	6	$10^6$	$\pm 0.25\%$
Violet	7	$10^7$	$\pm 0.1\%$
Grey	8	$10^8$	$\pm 0.05\%$
White	9	$10^9$	-
Gold	-	$10^{-1}$	$\pm 5\%$
Silver	-	$10^{-2}$	$\pm 10\%$
Colorless	-	-	$\pm 20\%$

**4-Band Resistor Color Code:**

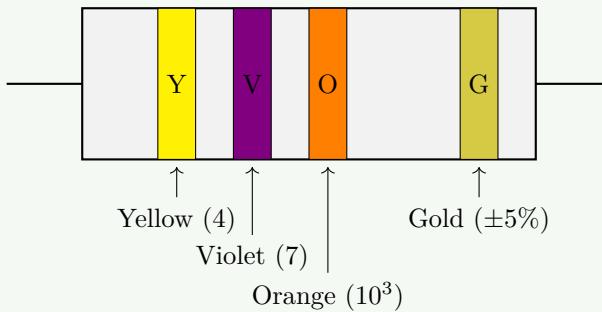
- **First Band:** First significant digit
- **Second Band:** Second significant digit
- **Third Band:** Multiplier
- **Fourth Band:** Tolerance

For  $47k\Omega \pm 5\%$ :

- First digit: 4 = Yellow
- Second digit: 7 = Violet
- Multiplier:  $10^3$  = Orange (for  $k\Omega$ )
- Tolerance:  $\pm 5\%$  = Gold

Color bands for  $47k\Omega \pm 5\%$ : Yellow-Violet-Orange-Gold

Diagram:

**Figure 3.** Resistor Color Bands: Yellow-Violet-Orange-Gold**Mnemonic**

“BAND: ”Beginning digits, Amplify with Multiplier, Note tolerance with last band, Decode carefully””

**Question 1(c OR) [7 marks]**

Explain Aluminum Electrolytic wet type capacitor.

## Solution

**Answer:**

**Aluminum Electrolytic Wet Type Capacitor:**

**Construction:**

- **Plates:** Two aluminum foils (anode and cathode)
- **Dielectric:** Aluminum oxide layer on anode foil
- **Electrolyte:** Liquid electrolyte (boric acid, sodium borate, etc.)
- **Separator:** Paper separator soaked in electrolyte
- **Enclosure:** Aluminum can with rubber seal

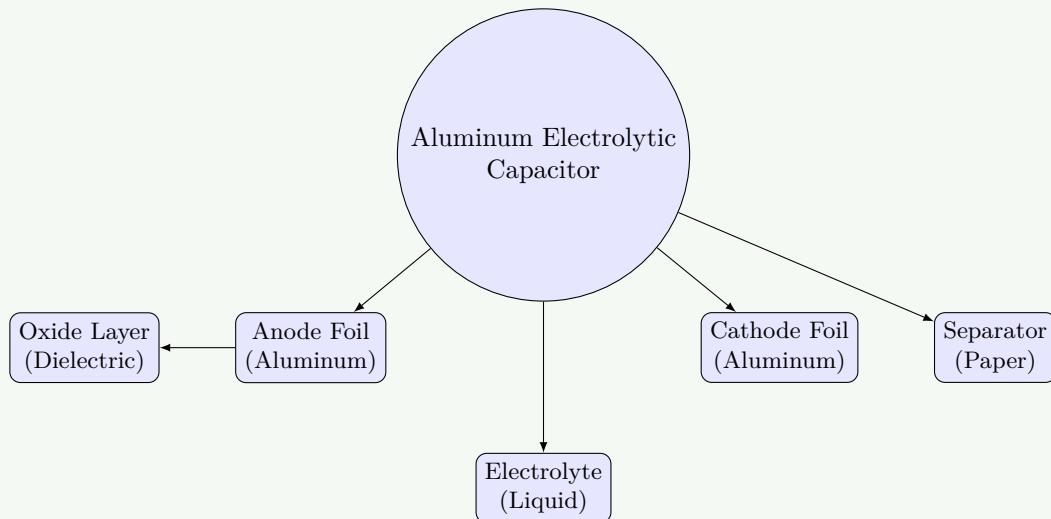
**Working Principle:**

- **Oxide Layer:** Thin aluminum oxide layer acts as dielectric
- **Electrolyte:** Acts as cathode connection to second plate
- **Polarization:** Has defined polarity (+ and -) terminals

**Characteristics:**

- **Capacitance Range:**  $1\mu\text{F}$  to  $47,000\mu\text{F}$
- **Voltage Rating:** 6.3V to 450V
- **Polarity:** Polarized (must connect correctly)
- **Leakage Current:** Higher than other capacitor types
- **ESR:** Higher equivalent series resistance

**Diagram:**



**Figure 4.** Aluminum Electrolytic Capacitor Components

## Mnemonic

“POLE: ”Polarized, Oxide layer, Liquid electrolyte, Enormous capacitance””

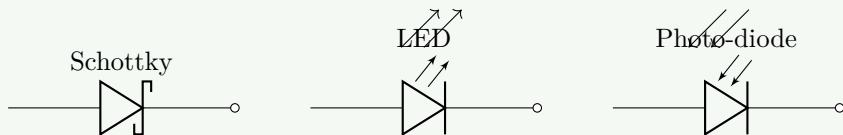
## Question 2(a) [3 marks]

Draw the symbol of Schottkey diode, LED and Photo-diode.

## Solution

**Answer:**

**Symbols:**

**Figure 5.** Symbols: Schottky Diode, LED, Photo-diode**Key Features:**

- **Schottky Diode:** Standard diode symbol with curved bar (represents metal-semiconductor junction)
- **LED:** Standard diode symbol with two arrows pointing away (represents light emission)
- **Photo-diode:** Standard diode symbol with two arrows pointing toward diode (represents light detection)

**Mnemonic**

“SLP: ”Schottky has curve, LED emits, Photo-diode absorbs””

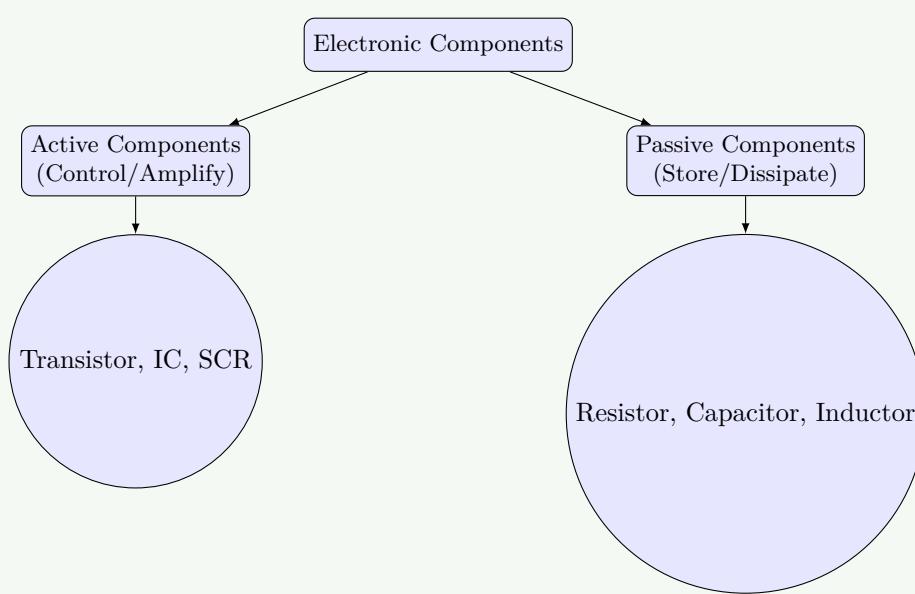
**Question 2(b) [4 marks]**

Define Active and Passive Components with example.

**Solution****Answer:****Passive Components:****Table 2.** Passive vs Active Components

Characteristic	Description	Examples
<b>Passive Components</b>		
Power	Cannot generate power	Resistors, Capacitors, Inductors
Signal	Cannot amplify signals	Transformers, Diodes
Control	No control over current flow	Connectors, Switches
Energy	Store or dissipate energy	Fuses, Filters
<b>Active Components</b>		
Power	Can generate power	Transistors, ICs
Signal	Can amplify signals	Op-amps, Amplifiers
Control	Control current flow	SCRs, MOSFETs
Dependency	Require external power	Voltage regulators, Microcontrollers

**Diagram:**

**Figure 6.** Classification of Electronic Components**Mnemonic**

"PASS-ACT: "Passive stores or dissipates, Active controls or amplifies""

**Question 2(c) [7 marks]**

**Explain working of full wave bridge rectifier.**

**Solution**

**Answer:**

**Full Wave Bridge Rectifier:**

**Circuit Construction:**

- **Diodes:** Four diodes arranged in bridge configuration
- **Input:** AC supply from transformer secondary
- **Output:** Pulsating DC across load resistor with filter capacitor

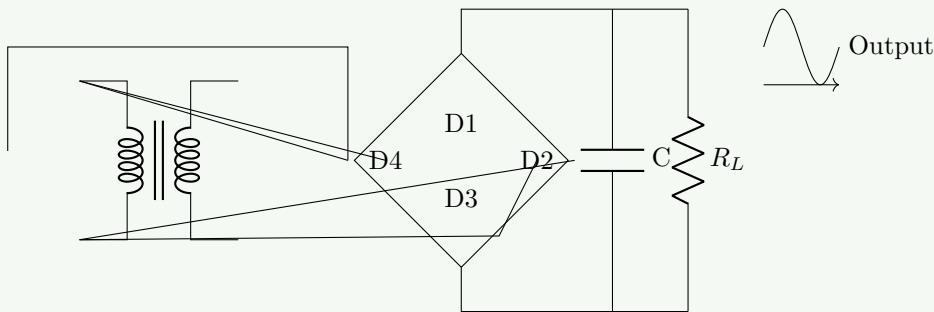
**Working Principle:**

- **Positive Half Cycle:** D1 and D3 conduct, D2 and D4 block
- **Negative Half Cycle:** D2 and D4 conduct, D1 and D3 block
- **Current Flow:** Always flows through load in same direction

**Performance Parameters:**

- **Ripple Frequency:**  $2 \times$  input frequency (100 Hz for 50 Hz input)
- **Efficiency:** 81.2%
- **PIV:**  $V_0(\max)$  per diode
- **TUF:** 0.812 (Transformer Utilization Factor)

**Diagram:**

**Figure 7.** Full Wave Bridge Rectifier Circuit**Mnemonic**

"BRIDGE: "Better Rectification with Improved Diode Geometry Efficiency""

**Question 2(a OR) [3 marks]**

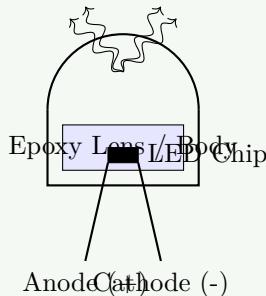
Explain construction and working of LED.

**Solution****Answer:****Construction of LED:**

- **Material:** Semiconductor (GaAs, GaP, AlGaInP, etc.)
- **Junction:** P-N junction with heavily doped semiconductors
- **Package:** Encased in transparent or colored epoxy lens
- **Cathode:** Identified by flat side on package or shorter lead

**Working Principle:**

- **Forward Bias:** Applied to P-N junction
- **Recombination:** Electrons and holes recombine at junction
- **Energy Release:** Energy released as photons (light)
- **Wavelength:** Determined by band gap of semiconductor material

**Diagram:****Figure 8.** LED Construction**Mnemonic**

"LEDS: "Light Emits During electron-hole recombination in Semiconductor""

**Question 2(b OR) [4 marks]**

Explain composition type resistors.

## Solution

**Answer:**

**Composition Resistors:**

**Construction:**

- **Core Material:** Carbon particles mixed with insulating material (clay/ceramic)
- **Binding:** Resin binder forms solid cylindrical shape
- **Terminals:** Metal caps with leads attached to ends
- **Protection:** Coated with insulating paint or plastic

**Characteristics:**

- **Resistance Range:**  $1\Omega$  to  $22M\Omega$
- **Power Rating:**  $1/8W$  to  $2W$
- **Tolerance:**  $\pm 5\%$  to  $\pm 20\%$
- **Temperature Coefficient:**  $-500$  to  $+500 \text{ ppm}/^\circ\text{C}$

**Advantages & Limitations:**

- **Cost:** Low cost
- **Noise:** Higher noise level
- **Stability:** Less stable with temperature
- **Applications:** General purpose, non-critical applications

**Diagram:**



**Figure 9.** Carbon Composition Resistor Structure

## Mnemonic

“CCRI: ”Carbon Composition Resistors are Inexpensive””

## Question 2(c OR) [7 marks]

Explain working of full wave rectifier with two diodes.

## Solution

**Answer:**

**Full Wave Rectifier with Two Diodes (Center-tap):**

**Circuit Construction:**

- **Transformer:** Center-tapped transformer secondary
- **Diodes:** Two diodes connected to opposite ends of secondary
- **Output:** Taken between center tap and diode junction

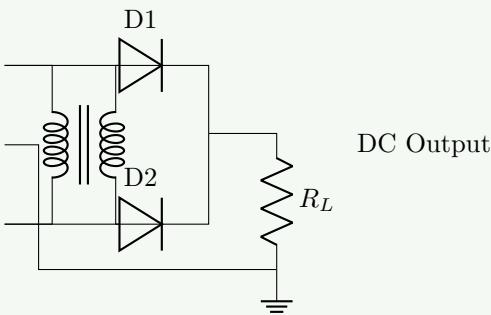
**Working Principle:**

- **Positive Half Cycle:** Upper half of secondary positive, D1 conducts, D2 blocks
- **Negative Half Cycle:** Lower half of secondary positive, D2 conducts, D1 blocks
- **Current Flow:** Always flows through load in same direction

**Performance Parameters:**

- **Ripple Frequency:**  $2 \times$  input frequency (100 Hz for 50 Hz input)
- **Efficiency:** 81.2%
- **PIV:**  $2V_0(\text{max})$  per diode (twice the center-tap rectifier)
- **TUF:** 0.693 (Transformer Utilization Factor)

**Diagram:**

**Figure 10.** Center-Tap Full Wave Rectifier**Mnemonic**

“CTFWR: ”Center Tap Facilitates Whole-cycle Rectification””

**Question 3(a) [3 marks]**

Explain working of schhotkey diode.

**Solution**

**Answer:**

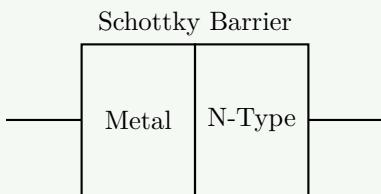
**Working of Schottky Diode:**

- **Junction Type:** Metal-Semiconductor (M-S) junction instead of P-N
- **Charge Carriers:** Majority carrier device (electrons in N-type)
- **Barrier:** Schottky barrier formed at metal-semiconductor interface
- **Forward Voltage:** Lower forward voltage drop (0.2-0.4V vs 0.7V for Si diode)

**Key Characteristics:**

- **Switching Speed:** Very fast switching (no minority carrier storage)
- **Applications:** High-frequency circuits, power supplies
- **Recovery Time:** Negligible reverse recovery time

**Diagram:**

**Figure 11.** Schottky Structure**Mnemonic**

“SFAM: ”Schottky’s Fast And Metal-based””

**Question 3(b) [4 marks]**

Explain N type semiconductor.

## Solution

**Answer:**

**N-type Semiconductor:**

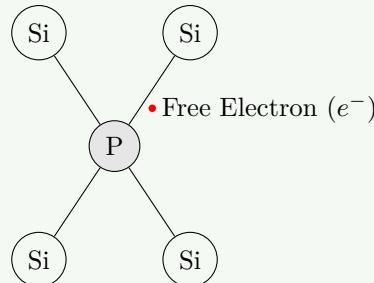
**Formation:**

- **Base Material:** Intrinsic semiconductor (Silicon or Germanium)
- **Doping Element:** Pentavalent impurity (P, As, Sb)
- **Doping Process:** Thermal diffusion or ion implantation
- **Concentration:** Typically 1 part impurity to  $10^8$  parts silicon

**Characteristics:**

- **Majority Carriers:** Electrons (negative charge carriers)
- **Minority Carriers:** Holes
- **Conductivity:** Higher than intrinsic semiconductor
- **Fermi Level:** Closer to conduction band

**Diagram:**



Crystal Lattice with Pentavalent Impurity

**Figure 12.** N-Type Doping

## Mnemonic

“PENT: ”Pentavalent Element makes N-Type with free electrons””

## Question 3(c) [7 marks]

Explain construction and working of PN Junction Diode.

## Solution

**Answer:**

**Construction of PN Junction Diode:**

- **Materials:** P-type and N-type semiconductor regions
- **Junction:** Formed by diffusion or epitaxial growth
- **Depletion Region:** Forms at junction interface
- **Contacts:** Metal contacts attached to both regions
- **Packaging:** Sealed in glass, plastic, or metal case

**Working Principle:**

- **Depletion Region:** Forms due to diffusion of carriers
- **Barrier Potential:** Created across junction (0.7V for Si, 0.3V for Ge)
- **Forward Bias:** Current flows when forward voltage > barrier potential
- **Reverse Bias:** Only small leakage current flows until breakdown

**Diagram:**

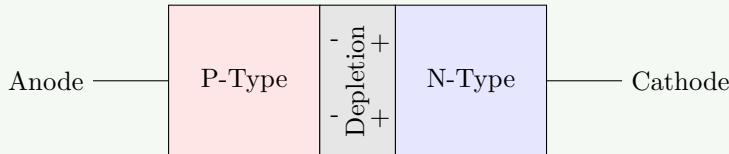


Figure 13. PN Junction Structure

**Mnemonic**

"BIRD: "Barrier forms at Interface, Rectifies Direct current""

**Question 3(a OR) [3 marks]**

**Explain working of photo diode.**

**Solution**

**Answer:**

**Working of Photo Diode:**

- **Operation:** Always operated in reverse bias
- **Dark Current:** Small leakage current flows when no light incident (due to thermal generation)
- **Light Incidence:** When light falls on junction, energy breaks covalent bonds
- **Carrier Generation:** Electron-hole pairs generated in depletion region
- **Photocurrent:** Electric field sweeps carriers across junction, increasing reverse current
- **Proportionality:** Current increases linearly with light intensity

**Diagram:**

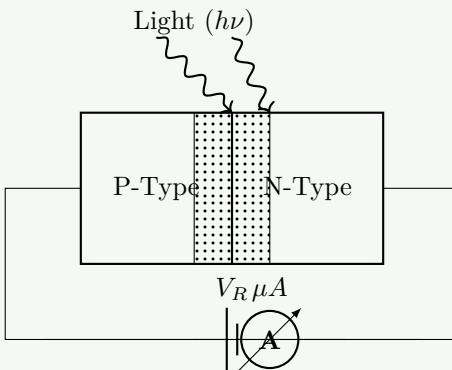


Figure 14. Photo Diode Operation

**Mnemonic**

"DARK: "Dark current exists, Absorbs photons, Reverse bias, K-current increases""

**Question 3(b OR) [4 marks]**

**Explain P type semiconductor.**

## Solution

**Answer:**

**P-type Semiconductor:**

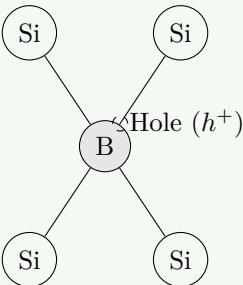
**Formation:**

- **Base Material:** Intrinsic semiconductor (Si or Ge)
- **Doping Element:** Trivalent impurity (Boron, Aluminum, Indium, Gallium)
- **Process:** Adding trivalent atoms creates vacancies (holes)

**Characteristics:**

- **Majority Carriers:** Holes (positive charge carriers)
- **Minority Carriers:** Electrons
- **Fermi Level:** Closer to valence band
- **Acceptor Ions:** Negative ions created when holes accept electrons

**Diagram:**



Crystal Lattice with Trivalent Impurity

**Figure 15.** P-Type Doping

## Mnemonic

“TRIP: ”Trivalent Impurity produces Positive holes””

## Question 3(c OR) [7 marks]

Compare half wave and full wave rectifier.

## Solution

**Answer:**

**Comparison of Rectifiers:**

**Table 3.** Rectifier Comparison

Parameter	Half Wave	Full Wave (Center Tap)	Bridge Rectifier
No. of Diodes	1	2	4
Max Efficiency	40.6%	81.2%	81.2%
Ripple Factor	1.21	0.48	0.48
Ripple Freq	$f_{in}$	$2f_{in}$	$2f_{in}$
PIV Rating	$V_m$	$2V_m$	$V_m$
TUF	0.287	0.693	0.812
Output Voltage	$V_{dc} = V_m/\pi$	$V_{dc} = 2V_m/\pi$	$V_{dc} = 2V_m/\pi$
Transformer	Simple	Center Tapped Required	Simple
Cost	Lowest	Medium	Highest (due to 4 diodes)

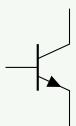
## Question 4(a) [3 marks]

Draw the symbol and construction of PNP and NPN transistor with proper labelling.

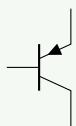
### Solution

**Answer:**

**Construction and Symbols:**



NPN Symbol



PNP Symbol

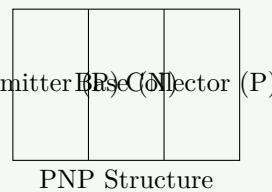
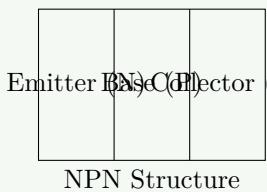


Figure 16. Transistor Symbols and Construction

### Mnemonic

"P-POINT: "PNP Points In, NPN Points Out""

## Question 4(b) [4 marks]

Explain working of transistor amplifier.

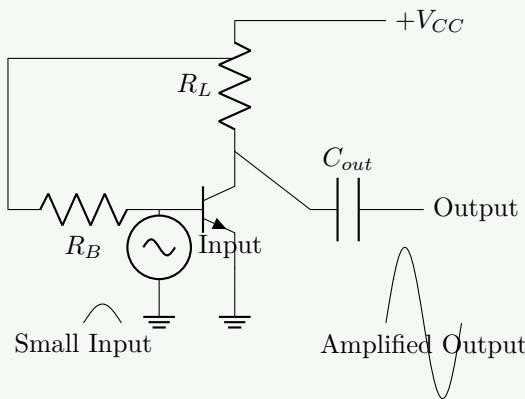
### Solution

**Answer:**

**Transistor Amplifier Working:**

- **Biassing:** Emitter-Base junction is forward biased, Collector-Base junction is reverse biased (Active Region)
- **Input:** Weak AC signal applied across Emitter-Base
- **Control:** Small variations in Base current ( $I_B$ ) cause large variations in Collector current ( $I_C$ )
- **Gain:** Current Gain  $\beta = \Delta I_C / \Delta I_B$  is typically large (50-300)
- **Output:** Amplified voltage developed across load resistor connected in collector circuit
- **Process:**  $I_E$  electrons injected into Base, most cross to Collector (due to reverse bias attraction), forming  $I_C$

Diagram:

**Figure 17.** Common Emitter Amplifier Concept**Question 4(c) [7 marks]**

Explain working of Zener diode.

**Solution**

**Answer:**

**Zener Diode:**

**Construction:**

- Heavily doped P-N junction diode
- Designed to operate in reverse breakdown region

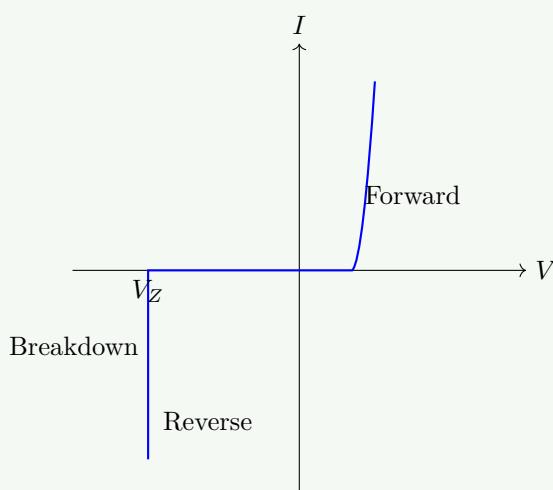
**Working Principle:**

- **Forward Bias:** Acts like normal diode
- **Reverse Bias:** Blocks current up to breakdown voltage ( $V_Z$ )
- **Breakdown:** At  $V_Z$ , sharp increase in current occurs due to Zener effect (quantum tunneling) or Avalanche effect
- **Voltage Regulation:** Voltage across diode remains constant ( $V_Z$ ) despite large changes in current

**Applications:**

- Voltage Regulator
- Reference voltage source
- Over-voltage protection

**Characteristics Diagram:**

**Figure 18.** Zener V-I Characteristics

**Mnemonic**

“ZAP: “Zener Always Provides constant voltage””

**Question 4(a OR) [3 marks]**

Explain transistor as a switch.

**Solution****Answer:**

**Transistor as Switch:** Operates in Cut-off and Saturation regions.

- **OFF State (Open Switch):**
  - Base current  $I_B = 0$
  - Operates in **Cut-off Region**
  - Collector current  $I_C \approx 0$
  - Output voltage  $V_{CE} = V_{CC}$
- **ON State (Closed Switch):**
  - Sufficient Base current supplied
  - Operates in **Saturation Region**
  - Maximum Collector current flows ( $I_{sat}$ )
  - Output voltage  $V_{CE} \approx 0.2V$  (Saturation voltage)

**Diagram:**

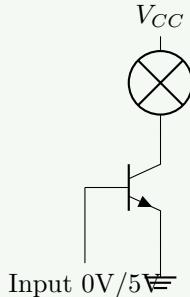


Figure 19. Transistor Switch Circuit

**Mnemonic**

“CO-SI: “Cut-off is Open, Saturation is Closed””

**Question 4(b OR) [4 marks]**

Draw and explain characteristics of CE amplifier.

**Solution****Answer:**

**Common Emitter Characteristics:**

1. **Input Characteristics** ( $I_B$  vs  $V_{BE}$  at constant  $V_{CE}$ ):  
  - Resembles forward biased diode characteristic
  - Beyond knee voltage (0.7V for Si),  $I_B$  increases rapidly with small increase in  $V_{BE}$
  - Increasing  $V_{CE}$  shifts curve slightly to right (Early effect - ignoring for basic explanation)
2. **Output Characteristics** ( $I_C$  vs  $V_{CE}$  at constant  $I_B$ ):  
  - **Cut-off Region:**  $I_B = 0$ ,  $I_C \approx 0$ . Transistor OFF.

- Active Region:**  $I_C$  is constant for given  $I_B$ , almost independent of  $V_{CE}$ . Used for amplification. Linear region.
- Saturation Region:**  $V_{CE}$  is very low ( $< 0.2V$ ).  $I_C$  increases rapidly with  $V_{CE}$ . Transistor ON.

Diagram:

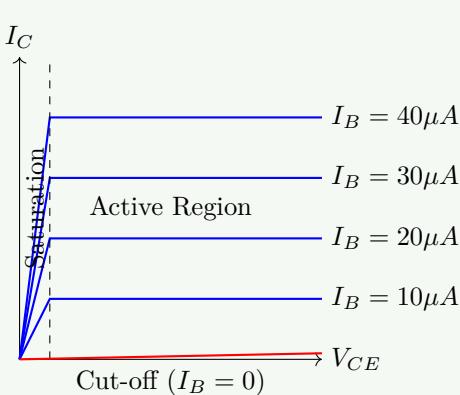


Figure 20. CE Output Characteristics

## Question 4(c OR) [7 marks]

Explain working of varactor diode.

### Solution

Answer:

#### Working of Varactor Diode:

- Function:** Acts as a voltage-controlled variable capacitor
- Operation:** Always operated in reverse bias
- Principle:**
  - Reverse bias voltage increases width of depletion region
  - Depletion region acts as dielectric between P and N regions (acting as plates)
  - Capacitance  $C = \epsilon A/d$  (where  $d$  is depletion width)
  - As Reverse Voltage ( $V_R$ ) increases  $\rightarrow$  Width ( $d$ ) increases  $\rightarrow$  Capacitance ( $C$ ) decreases
- Relationship:**  $C_T \propto \frac{1}{\sqrt{V_R}}$
- Application:** Tuning circuits (Radio/TV tuners), VCOs (Voltage Controlled Oscillators)

Diagram:

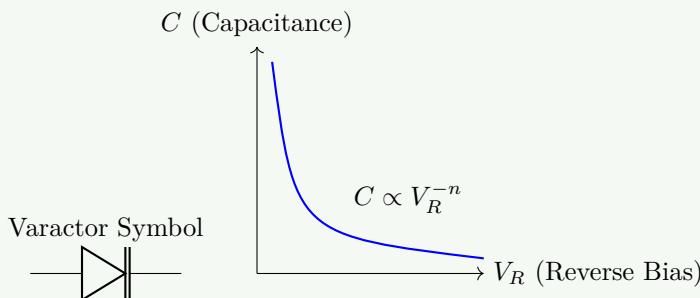


Figure 21. Varactor Diode Characteristics

### Mnemonic

“VARY: “Voltage Adjusts Reverse-bias Yielding capacitance””

## Question 5(a) [3 marks]

Define Active, Saturation and Cut-Off region for transistor amplifier.

### Solution

**Answer:**

- **Active Region:**
  - Emitter-Base junction: Forward Biased
  - Collector-Base junction: Reverse Biased
  - Use: Amplification
- **Saturation Region:**
  - Emitter-Base junction: Forward Biased
  - Collector-Base junction: Forward Biased
  - Use: ON Switch (Closed)
- **Cut-Off Region:**
  - Emitter-Base junction: Reverse Biased
  - Collector-Base junction: Reverse Biased
  - Use: OFF Switch (Open)

## Question 5(b) [4 marks]

Check current gain  $\alpha$  and  $\beta$  if  $I_c = 10mA$  and  $I_b = 100\mu A$ .

### Solution

**Answer:**

**Given:**

- $I_C = 10mA$
- $I_B = 100\mu A = 0.1mA$

**Calculations:**

1. Calculate  $\beta$ :

$$\beta = \frac{I_C}{I_B} = \frac{10mA}{0.1mA} = 100$$

2. Calculate Emitter Current  $I_E$ :

$$I_E = I_C + I_B = 10mA + 0.1mA = 10.1mA$$

3. Calculate  $\alpha$ :

$$\alpha = \frac{I_C}{I_E} = \frac{10mA}{10.1mA} \approx 0.9901$$

Alternatively using relation:

$$\alpha = \frac{\beta}{1 + \beta} = \frac{100}{101} \approx 0.9901$$

**Result:**

- $\beta = 100$
- $\alpha = 0.99$

## Question 5(c) [7 marks]

Discuss strategies for Electronic Waste management in small electronic industries.

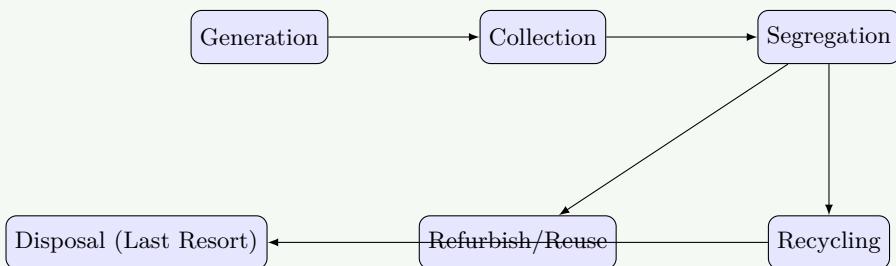
### Solution

**Answer:**

**E-Waste Management Strategies:**

1. **Inventory Management:** Keep track of all electronic equipment and lifespan to plan replacements efficiently.
2. **Reduce:** Minimize purchase of unnecessary equipment. Opt for upgradable modular devices instead of replacing entire units.
3. **Reuse:** refurbish old electronics for less demanding tasks (e.g., using older PCs for data entry or print servers).
4. **Recycle:** Partner with certified e-waste recyclers who safely extract valuable metals (Au, Ag, Cu) and dispose of hazardous materials (Pb, Hg).
5. **Segregation:** Set up separate bins for e-waste (batteries, cables, circuit boards) to prevent mixing with general waste.
6. **EPR Compliance:** Adhere to Extended Producer Responsibility (EPR) guidelines if involved in manufacturing.
7. **Employee Training:** Educate staff about proper disposal methods and data wiping before disposal.

**Diagram:**



**Figure 22.** E-Waste Flow

### Mnemonic

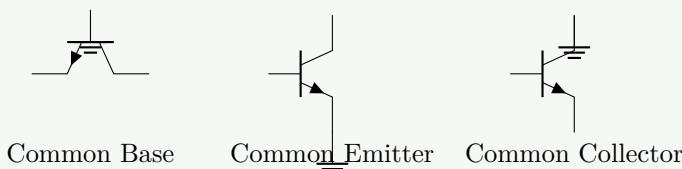
“3R: ”Reduce, Reuse, Recycle””

## Question 5(a OR) [3 marks]

Draw circuit configuration of CB, CE and CC transistor.

### Solution

**Answer:**



**Figure 23.** Transistor Configurations

## Question 5(b OR) [4 marks]

Derive the relation between current gain  $\alpha$  and  $\beta$ .

### Solution

**Answer:**

**Derivation:**

- We know transistor currents:

$$I_E = I_C + I_B$$

- Divide entire equation by  $I_C$ :

$$\begin{aligned} \frac{I_E}{I_C} &= \frac{I_C}{I_C} + \frac{I_B}{I_C} \\ \frac{1}{\alpha} &= 1 + \frac{1}{\beta} \end{aligned}$$

(Because  $\alpha = I_C/I_E$  and  $\beta = I_C/I_B$ )

- Solve for  $\alpha$ :

$$\begin{aligned} \frac{1}{\alpha} &= \frac{\beta + 1}{\beta} \\ \alpha &= \frac{\beta}{1 + \beta} \end{aligned}$$

- Solve for  $\beta$ :

$$\begin{aligned} \frac{1}{\beta} &= \frac{1}{\alpha} - 1 = \frac{1 - \alpha}{\alpha} \\ \beta &= \frac{\alpha}{1 - \alpha} \end{aligned}$$

**Conclusion:**

$$\alpha = \frac{\beta}{1 + \beta}, \quad \beta = \frac{\alpha}{1 - \alpha}$$

## Question 5(c OR) [7 marks]

Define E-waste and explain disposal of Electronic waste.

### Solution

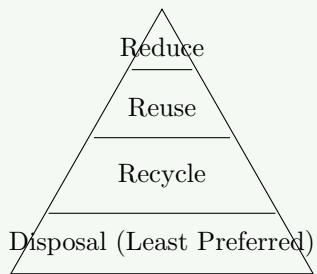
**Answer:**

**Definition:** E-Waste (Electronic Waste) refers to discarded electrical or electronic devices such as computers, phones, printers, and appliances that have reached the end of their useful life.

**Disposal Methods:**

- Landfilling:** Dumping waste in trenches. Least preferred method as toxic substances (Lead, Cadmium) leach into soil and groundwater.
- Incineration:** Controlled burning of waste. Reduces volume but can release toxic gases into atmosphere if not filtered properly.
- Acid Bath:** Soaking circuits in acid to extract gold. Highly hazardous to workers and environment.
- Mechanical Recycling (Preferred):**
  - Shredding: Breaking devices into small pieces.
  - Separation: Using magnets and eddy currents to separate metals from plastic.
  - Recovery: Smelting metals for reuse.
- Reuse/Refurbishing:** Extending life by repairing. Best for environment.

**Pyramid of E-Waste:**



**Figure 24.** Waste Management Hierarchy