Electronics Devices & Circuits

DI01009011

Previous Year Question Papers Solutions

Complete Bilingual Solutions (English & Gujarati)

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Contents

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Q.1 (a) List various types of filter circuits used with rectifier.

A rectifier circuit converts an alternating current (AC) into a direct current (DC). However, the output of a rectifier is not pure DC but contains pulsating AC components known as ripples. To smooth out these ripples and obtain a steady DC voltage, filter circuits are employed at the output of the rectifier.

The various types of filter circuits commonly used with rectifiers are listed below:

- **Capacitor Filter (C Filter):** Uses a capacitor connected in parallel with the load resistor to bypass AC ripples to the ground.
- **Inductor Filter (L Filter):** Uses an inductor connected in series with the load to block AC ripples while allowing DC to pass.
- **Choke Input Filter (LC Filter):** A combination of a series inductor (choke) and a parallel capacitor, offering better filtering than a single component.
- **Capacitor Input Filter (π Filter):** Consists of a capacitor in parallel, followed by a series inductor, and another parallel capacitor. It provides excellent ripple reduction and high DC output voltage.

Q.1 (b) Write various applications of P-N Junction Diode.

A P-N junction diode is a fundamental semiconductor device that allows current to flow in only one direction. Due to its unidirectional conduction property, it is widely utilized in various electronic circuits.

- **Rectifiers:** Diodes are extensively used in half-wave, full-wave, and bridge rectifiers to convert alternating current (AC) into direct current (DC) for power supplies.
- **Clipping Circuits:** Used to clip off or remove a specific portion (positive or negative half) of an input signal without distorting the remaining waveform.
- **Clamping Circuits:** Employed to shift the entire AC waveform to a different DC level (either positive or negative) without changing the shape of the signal.
- **Voltage Multipliers:** Diodes are used in cascade with capacitors to step up the input AC voltage by a factor of two (doubler), three (tripler), or more.
- **Logic Gates:** P-N junction diodes can be configured to construct basic digital logic gates like AND and OR gates (Diode Logic).
- **Protection Circuits:** They are used as freewheeling diodes to protect sensitive components from high voltage spikes produced by inductive loads, and for reverse polarity protection.

Q.1 (c) Explain the working of NPN Transistor.

An NPN transistor consists of a very thin and lightly doped P-type semiconductor layer sandwiched between two heavily doped N-type semiconductor layers. The three terminals are the Emitter, Base, and Collector.

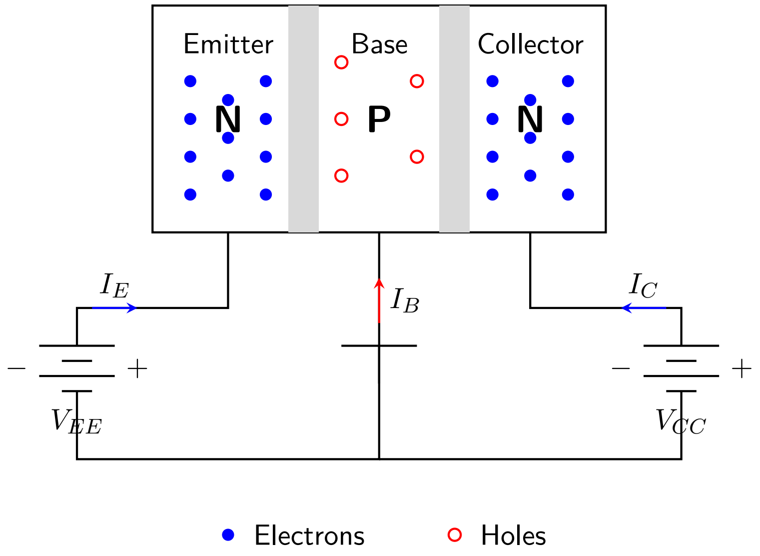


Figure 1: Working Mechanism of NPN Transistor

For normal operation in the active region, the Emitter-Base (EB) junction is forward-biased, and the Collector-Base (CB) junction is reverse-biased. The forward bias at the EB junction is provided by the voltage source V_{EE}, and the reverse bias at the CB junction is maintained by V_{CC}.

Working Mechanism:

1. **Emitter Injection:** Due to the forward bias at the EB junction, the majority charge carriers in the emitter (electrons) are repelled by the negative terminal of V_{EE} and pushed towards the base region. This movement of electrons constitutes the **Emitter Current** (I_E).

2. **Base Recombination:** The base is a P-type material containing holes as majority carriers. Because the base is very thin and lightly doped, only a small fraction (about 5%) of the injected electrons recombine with the holes in the base. This small recombination current leaves the base terminal, forming the **Base Current** (I_B).

3. **Collector Collection:** The remaining 95% of the electrons diffuse across the base and reach the depletion region of the CB junction. Since the CB junction is reverse-biased, its built-in electric field sweeps these electrons into the collector region, where they are attracted by the positive terminal of V_{CC}. This flow of electrons constitutes the **Collector Current** (I_C).

Applying Kirchhoff's Current Law (KCL) to the transistor, the total emitter current is the sum of the base current and the collector current:

$$I_E = I_B + I_C$$

Q.1 (c) OR Explain the working of PNP Transistor.

A PNP transistor consists of a very thin and lightly doped N-type semiconductor layer sandwiched between two heavily doped P-type semiconductor layers. The three terminals are the Emitter, Base, and Collector.

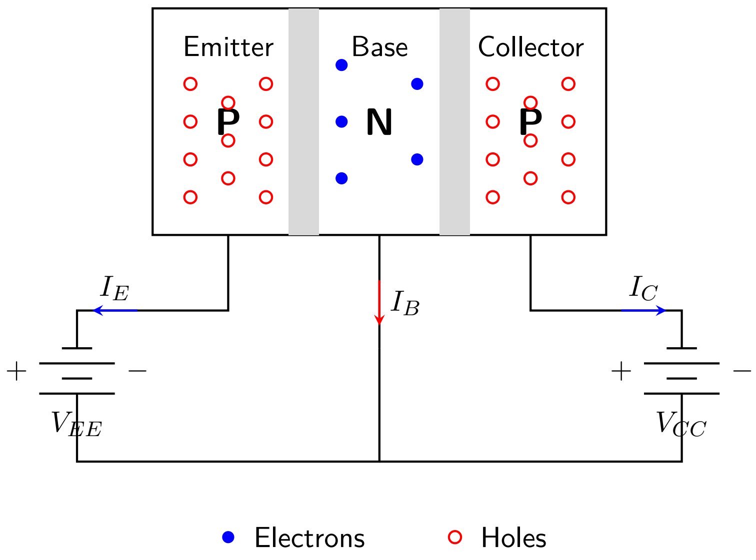


Figure 2: Working Mechanism of PNP Transistor

For operation in the active region, the Emitter-Base (EB) junction is forward-biased, while the Collector-Base (CB) junction is reverse-biased. The voltage source V_{EE} provides the forward bias at the EB junction, and V_{CC} maintains the reverse bias at the CB junction.

Working Mechanism:

1. **Emitter Injection:** Due to the forward bias at the EB junction, the majority charge carriers in the emitter (holes) are repelled by the positive terminal of V_{EE} and injected into the base region. This movement of holes constitutes the **Emitter Current (I_E)**.

2. **Base Recombination:** The base is an N-type material where electrons are the majority carriers. Since the base is very narrow and lightly doped, only a small percentage (around 5%) of the injected holes recombine with the electrons. This small flow of charge creates the **Base Current (I_B)**.

3. **Collector Collection:** The majority of the holes (about 95%) bypass the base and reach the depletion region of the CB junction. Because the CB junction is reverse-biased, the electric field sweeps these holes into the collector region, where they are attracted by the negative terminal of V_{CC}. This movement forms the **Collector Current (I_C)**.

By applying Kirchhoff's Current Law (KCL), the relationship between the currents in the transistor is given by:

$$I_E = I_B + I_C$$

In a PNP transistor, conduction is primarily due to holes, whereas in an NPN transistor, it is due to electrons.

Q.2 (a) Draw symbol with proper nomenclature 1) Diode 2) Transistor 3) Zener Diode.

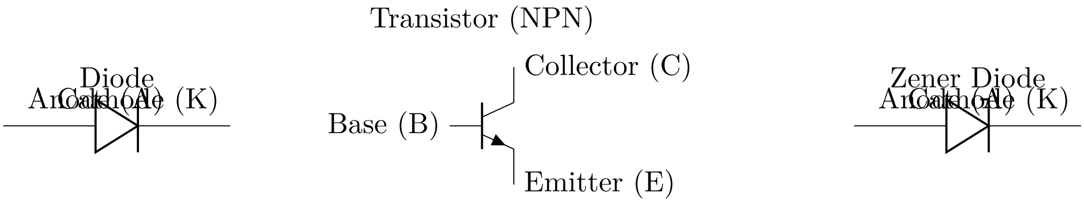
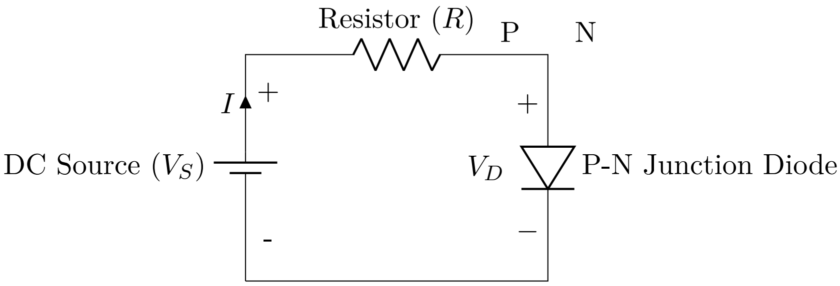


Figure 3: Symbols of Diode, Transistor, and Zener Diode

- **Diode**: A two-terminal device (Anode and Cathode) that allows current to flow primarily in one direction.
- **Transistor (NPN)**: A three-terminal device (Base, Collector, Emitter) used for amplification or switching.
- **Zener Diode**: A specialized diode designed to reliably allow current to flow backwards when a certain set reverse voltage is reached.

Q.2 (b) Draw a neat circuit of P-N Junction Diode in forward Biased conduction mode.

When the positive terminal of the battery is connected to the P-region and the negative terminal to the N-region, the P-N junction is said to be in forward bias.



Forward Biased Conduction Mode

Figure 4: P-N Junction Diode in Forward Biased Conduction Mode

- In forward bias, the applied voltage opposes the built-in potential barrier.
- The depletion region width decreases, making it easier for majority charge carriers to cross the junction.
- A significant amount of forward current flows through the diode once the applied voltage exceeds the cut-in voltage (0.7 V for Silicon).

Q.2 (c) Explain the working of Half Wave Rectifier with proper waveforms.

A Half Wave Rectifier is a circuit that converts alternating current (AC) into pulsating direct current (DC) by passing only one half of the input AC cycle and blocking the other.

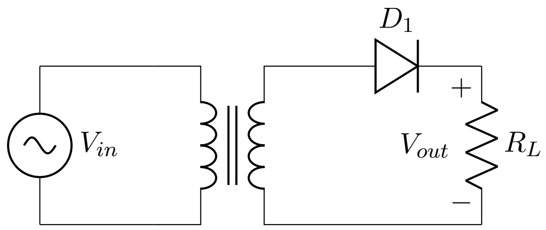


Figure 5: Circuit Diagram of Half Wave Rectifier

Working Principle:

- **Positive Half Cycle:** During the positive half cycle of the AC input, the anode of the diode D_1 becomes positive with respect to the cathode. The diode is forward-biased and conducts current through the load resistor R_L, producing an output voltage.
- **Negative Half Cycle:** During the negative half cycle, the anode becomes negative with respect to the cathode. The diode is reverse-biased and acts as an open switch. No current flows through R_L, and the output voltage is zero.

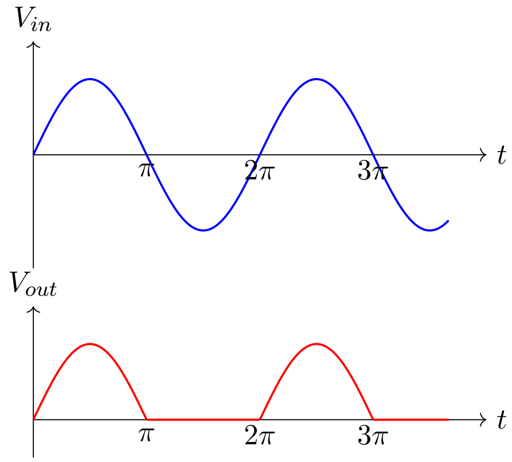


Figure 6: Input and Output Waveforms of Half Wave Rectifier

- **Efficiency:** The maximum rectification efficiency is 40.6%.
- **Ripple Factor:** It has a high ripple factor of 1.21, meaning the output contains a significant amount of AC components.

Q.2 (a) OR Explain intrinsic semi-conductors using at least 02 examples.

An **intrinsic semiconductor** is a pure semiconductor without any significant dopant species present.

- In an intrinsic semiconductor, the number of excited electrons in the conduction band (n) is exactly equal to the number of holes in the valence band (p).
- This is mathematically expressed as $n = p = n_i$, where n_i is the intrinsic carrier concentration.

- At absolute zero temperature (0 K), an intrinsic semiconductor behaves as a perfect insulator. As temperature increases, thermal energy excites some electrons across the bandgap, creating electron-hole pairs and allowing weak conduction.

Examples:

1. **Silicon (Si):** The most widely used semiconductor material due to its abundance and stable thermal properties. It has a bandgap of approximately 1.1 eV at room temperature.
2. **Germanium (Ge):** Widely used in early electronics, Germanium has a smaller bandgap of about 0.67 eV, making it more highly conductive at room temperature compared to Silicon, but also more sensitive to temperature variations.

Q.2 (b) OR Draw a neat circuit of P-N Junction Diode in Reverse Biased mode.

When the negative terminal of the battery is connected to the P-region and the positive terminal to the N-region, the P-N junction is said to be in reverse bias.

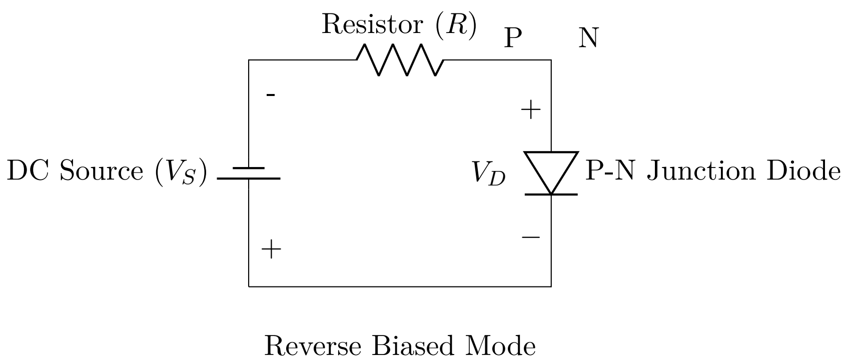


Figure 7: P-N Junction Diode in Reverse Biased Mode

- In reverse bias, the applied voltage adds to the built-in potential barrier, making it much harder for majority carriers to cross the junction.
- The depletion region widens as electrons and holes are pulled away from the junction by the battery terminals.
- Only a very small leakage current (due to minority carriers) flows through the diode until the breakdown voltage is reached.

Q.2 (c) OR Explain the working of Full Wave Bridge Rectifier with proper waveforms.

A Full Wave Bridge Rectifier uses four diodes arranged in a bridge configuration to convert both halves of an AC input cycle into pulsating DC, eliminating the need for a bulky center-tapped transformer.

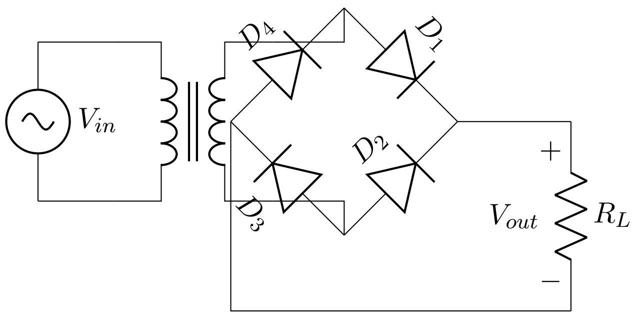


Figure 8: Circuit Diagram of Full Wave Bridge Rectifier

Working Principle:

- **Positive Half Cycle:** The top terminal of the secondary winding is positive, and the bottom is negative. Diodes D_1 and D_3 are forward-biased and conduct, while D_2 and D_4 are reverse-biased. Current flows from the top terminal, through D_1, down through the load resistor R_L, through D_3, and back to the bottom terminal.
- **Negative Half Cycle:** The bottom terminal is positive, and the top is negative. Diodes D_2 and D_4 are forward-biased, while D_1 and D_3 are reverse-biased. Current flows from the bottom terminal, through D_2, down through R_L (in the same direction as before), through D_4, and back to the top terminal.

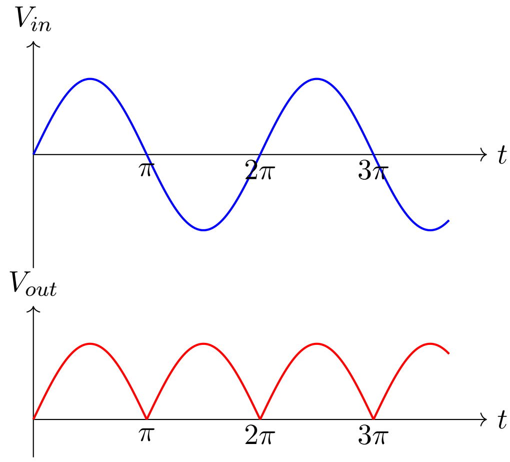


Figure 9: Input and Output Waveforms of Full Wave Bridge Rectifier

- **Efficiency:** The maximum rectification efficiency is 81.2%, which is double that of a half-wave rectifier.
- **Ripple Factor:** It has a much lower ripple factor of 0.48, providing a smoother DC output.

Q.3 (a) Explain extrinsic semi-conductors along with its types.

Extrinsic Semiconductor

An extrinsic semiconductor is a pure (intrinsic) semiconductor that has been intentionally doped with a small amount of specific impurities to enhance its electrical conductivity.

- The process of adding impurities to a pure semiconductor is called **doping**.

- It significantly increases the number of charge carriers (electrons or holes) at room temperature.
- There are two main types of extrinsic semiconductors based on the impurity added:
  1. **N-Type Semiconductor**: Formed by doping a pure semiconductor (like Silicon or Germanium) with a **pentavalent impurity** (having 5 valence electrons, e.g., Phosphorus, Arsenic, Antimony). Here, **electrons** are the majority charge carriers, and holes are the minority charge carriers.
  2. **P-Type Semiconductor**: Formed by doping a pure semiconductor with a **trivalent impurity** (having 3 valence electrons, e.g., Boron, Gallium, Indium). Here, **holes** are the majority charge carriers, and electrons are the minority charge carriers.

Q.3 (b) List various operating modes of transistor along with their configuration.

A Bipolar Junction Transistor (BJT) consists of two PN junctions: the Emitter-Base (EB) junction and the Collector-Base (CB) junction. Depending on the biasing (forward or reverse) of these two junctions, a transistor operates in four distinct modes.

Operating Modes of Transistor:

- **Active Mode**: The EB junction is forward-biased, and the CB junction is reverse-biased. This is the primary mode used for amplification purposes.
- **Saturation Mode**: Both the EB and CB junctions are forward-biased. The transistor acts like a closed switch (fully ON), allowing maximum current to flow.
- **Cut-off Mode**: Both the EB and CB junctions are reverse-biased. The transistor acts like an open switch (fully OFF), preventing current flow.
- **Reverse Active (Inverted) Mode**: The EB junction is reverse-biased, and the CB junction is forward-biased. It provides very poor amplification and is rarely used in practice.

Table 1: Summary of Operating Modes and Biasing Configurations

Operating Mode	**Emitter-Base Junction**	**Collector-Base Junction**	**Application**
Active	Forward Biased	Reverse Biased	Amplifier
Saturation	Forward Biased	Forward Biased	Closed Switch (ON)
Cut-off	Reverse Biased	Reverse Biased	Open Switch (OFF)
Reverse Active	Reverse Biased	Forward Biased	Attenuator

Note: Transistors are also configured in three basic ways based on the common terminal: Common Base (CB), Common Emitter (CE), and Common Collector (CC).

Q.3 (c) Explain the working of Center tap Full Wave Rectifier with proper waveforms.

A center-tap full-wave rectifier uses a center-tapped transformer and two diodes to convert the complete AC input cycle (both positive and negative half-cycles) into pulsating DC output.

Circuit Construction:

- It consists of an AC source, a center-tapped step-down transformer, two diodes (D_1 and D_2), and a load resistor (R_L).
- The secondary winding of the transformer is divided into two equal halves by a center tap, which acts as the common return path (ground).

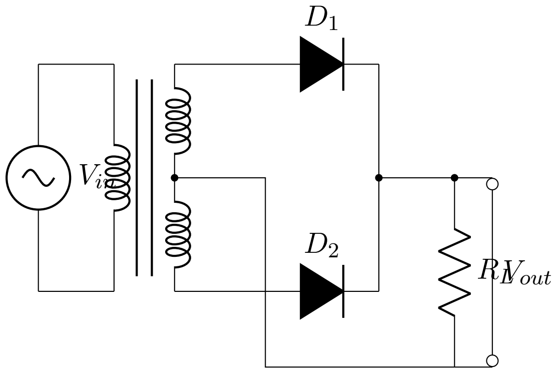


Figure 10: Circuit Diagram of Center Tap Full Wave Rectifier

Working Principle:

- **During Positive Half-Cycle**: The upper terminal of the secondary winding becomes positive, and the lower terminal becomes negative with respect to the center tap. Diode D_1 is forward-biased (conducts), and D_2 is reverse-biased (does not conduct). Current flows through D_1, R_L, and back to the center tap.
- **During Negative Half-Cycle**: The lower terminal becomes positive, and the upper terminal becomes negative. Diode D_2 is forward-biased, and D_1 is reverse-biased. Current flows through D_2, R_L, and back to the center tap.
- In both half-cycles, the current flows through the load resistor R_L in the same direction, producing a unidirectional (DC) output voltage.

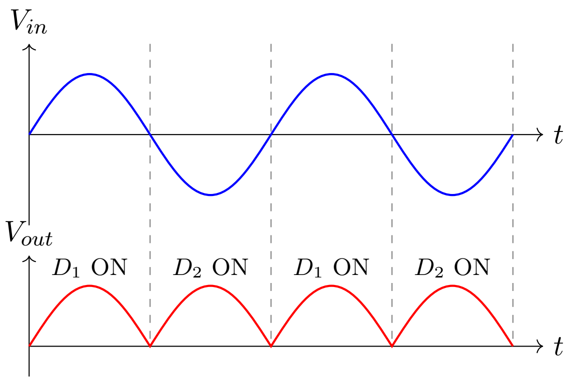


Figure 11: Input and Output Waveforms

Q.3 (a) OR Explain P Type semi-conductors using at least 03 examples.

P-Type Semiconductor

A P-type semiconductor is an extrinsic semiconductor created by doping a pure (intrinsic) semiconductor crystal with atoms of a trivalent impurity.

- **Mechanism**: A trivalent impurity atom has 3 valence electrons. When it replaces a Silicon (or Germanium) atom in the crystal lattice, it forms three covalent bonds with neighboring atoms. The fourth bond is left incomplete, creating a vacancy called a **hole**.
- **Charge Carriers**: In a P-type semiconductor, **holes** are the majority charge carriers, while **electrons** (generated thermally) are the minority charge carriers.
- **Acceptor Impurities**: Trivalent impurities are known as "acceptor impurities" because the holes they create can accept electrons from neighboring atoms.
- **Examples of Trivalent Impurities**:
  1. **Boron (B)**: Widely used for doping Silicon.
  2. **Gallium (Ga)**: Used in specialized high-frequency semiconductor devices.
  3. **Indium (In)**: Often used in manufacturing specific types of diodes and transistors.

Q.3 (b) OR Explain the working of Optical Fibre cable.

An optical fiber cable transmits data in the form of light pulses. It works on the principle of **Total Internal Reflection (TIR)**.

Basic Construction:

- **Core**: The central thin glass or plastic medium through which light travels.
- **Cladding**: The outer optical material surrounding the core. It has a **lower refractive index** than the core.
- **Coating/Jacket**: The outermost plastic layer that protects the fiber from physical damage and moisture.

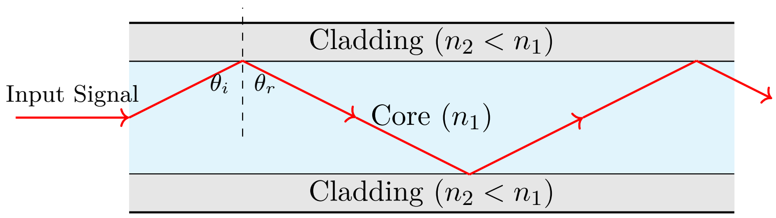


Figure 12: Total Internal Reflection in Optical Fiber

Working Principle:

- When a light ray enters the core at an angle greater than the **critical angle**, it strikes the core-cladding boundary.
- Because the refractive index of the core (n_1) is greater than the refractive index of the cladding (n_2), the light ray is completely reflected back into the core instead of refracting out.

- This continuous bouncing (Total Internal Reflection) allows the light signal to travel over long distances along the fiber with minimal energy loss.
- The optical signals are generated by light sources (LEDs or Lasers) at the transmitter and converted back to electrical signals by photodiodes at the receiver.

Q.3 (c) OR Explain V-I Characteristics of P-N junction diode.

The Voltage-Current (V-I) characteristics of a P-N junction diode represent the relationship between the applied voltage across the diode and the current flowing through it.

1. **Forward Bias Characteristics:**

- When the positive terminal of the battery is connected to the P-region and the negative terminal to the N-region, the diode is forward-biased.
- Initially, for low voltages, the forward current is almost zero because the applied voltage is less than the barrier potential.
- **Knee Voltage**: Once the applied forward voltage exceeds the barrier potential (approx. 0.7 V for Silicon and 0.3 V for Germanium), the depletion layer collapses.
- Beyond the knee voltage, the forward current increases exponentially with a small increase in voltage.

2. **Reverse Bias Characteristics:**

- When the positive terminal of the battery is connected to the N-region and the negative terminal to the P-region, the diode is reverse-biased.
- The depletion layer widens, and ideally, no current should flow. However, a very small **Reverse Saturation Current** (in microamperes) flows due to minority charge carriers.
- **Breakdown Voltage**: If the reverse voltage is increased excessively, it reaches a point called the breakdown voltage (V_{BR}). At this point, covalent bonds break, causing a sharp increase in reverse current, which can permanently damage the diode.

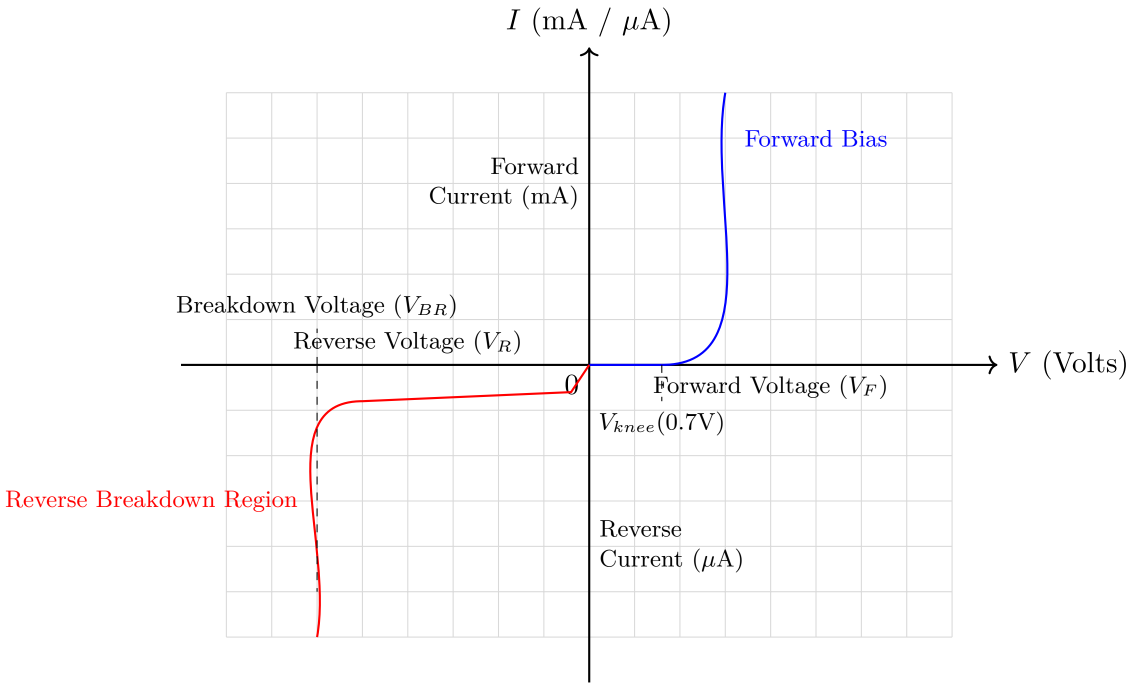


Figure 13: V-I Characteristics of P-N Junction Diode

Q.4 (a) Explain N-Type semi-conductors using at least 03 examples.

N-Type Semiconductor

An N-type semiconductor is created by adding pentavalent impurities (doping) to a pure (intrinsic) semiconductor like Silicon (Si) or Germanium (Ge).

- **Doping Process:** Pentavalent atoms have five valence electrons. When added, four electrons form covalent bonds with the neighboring semiconductor atoms, while the fifth electron remains loosely bound and becomes a free electron.
- **Charge Carriers:** Because of the extra free electrons, the majority charge carriers are electrons, and the minority charge carriers are holes.
- **Nomenclature:** The term 'N-type' stands for 'Negative' type due to the abundance of negatively charged free electrons.

Examples of Pentavalent Impurities:

1. Phosphorus (P)
2. Arsenic (As)
3. Antimony (Sb)
4. Bismuth (Bi)

Q.4 (b) Compare CB, CE and CC configurations of transistor (At least 6 points).

Table: Comparison of CB, CE, and CC Transistor Configurations

Sr. No.	Parameter	Common Base (CB)	Common Emitter (CE)	Common Collector (CC)
1	**Input Terminal**	Emitter	Base	Base
2	**Output Terminal**	Collector	Collector	Emitter
3	**Common Terminal**	Base	Emitter	Collector
4	**Current Gain**	Less than unity ($\alpha < 1$)	High (β)	Very High (γ)
5	**Voltage Gain**	High	High	Less than unity (≈ 1)
6	**Input Resistance**	Very Low ($\approx 100\,\Omega$)	Low/Moderate ($\approx 1\,\mathrm{k}\Omega$)	Very High ($\approx 100\,\mathrm{k}\Omega$)
7	**Output Resistance**	Very High ($\approx 1\,\mathrm{M}\Omega$)	High/Moderate ($\approx 40\,\mathrm{k}\Omega$)	Very Low ($\approx 50\,\Omega$)
8	**Phase Shift**	0° (In-phase)	180° (Out-of-phase)	0° (In-phase)
9	**Applications**	High-frequency circuits	Audio/General purpose amplifiers	Impedance matching

Q.4 (c) Draw CB(Common Base) & CE(Common Emitter) configuration of transistor with proper nomenclature.

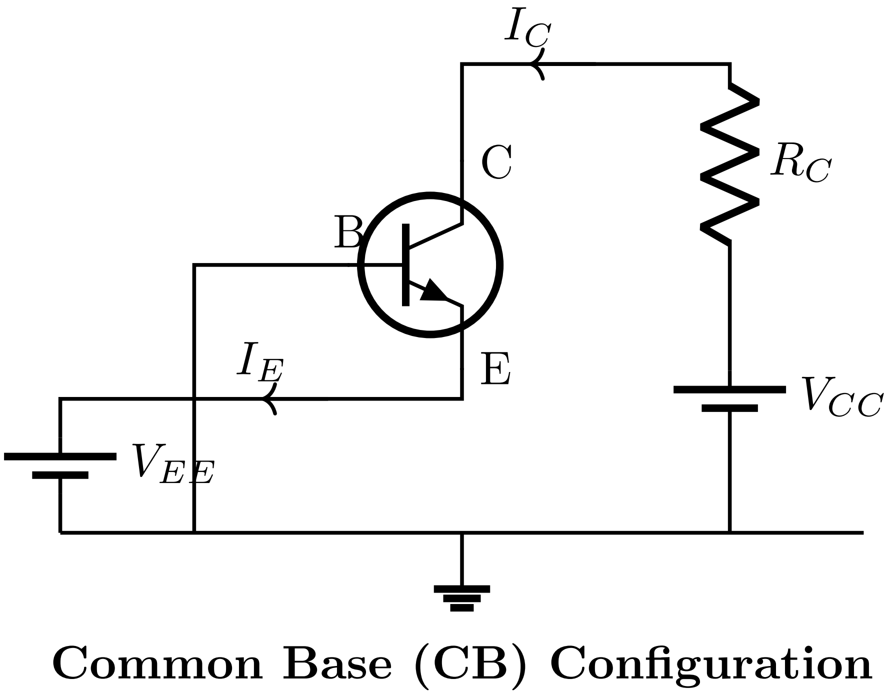


Figure 14: Common Base (CB) Configuration

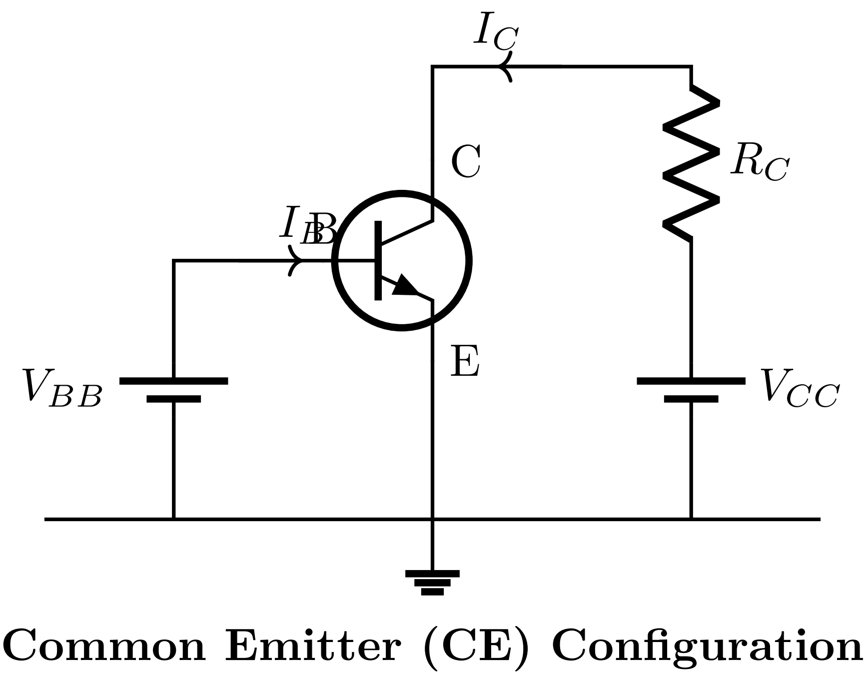


Figure 15: Common Emitter (CE) Configuration

- **Common Base (CB):** The base terminal is common to both the input and output circuits. The input is applied at the emitter, and the output is taken from the collector.

- **Common Emitter (CE):** The emitter terminal is common to both the input and output circuits. The input is applied at the base, and the output is taken from the collector.

— OR —

Q.4 (a) OR Draw symbol with proper nomenclature 1) UJT 2) SCR 3) LDR

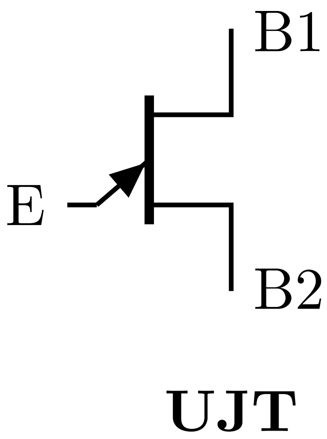


Figure 16: UJT Symbol

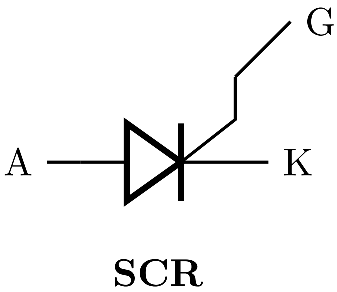


Figure 17: SCR Symbol

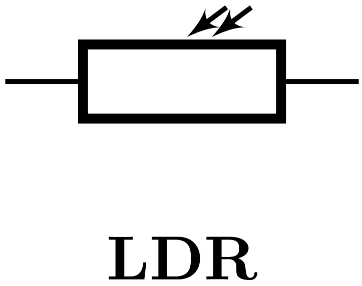


Figure 18: LDR Symbol

Q.4 (b) OR Explain working of Zener Diode as Voltage Regulator.

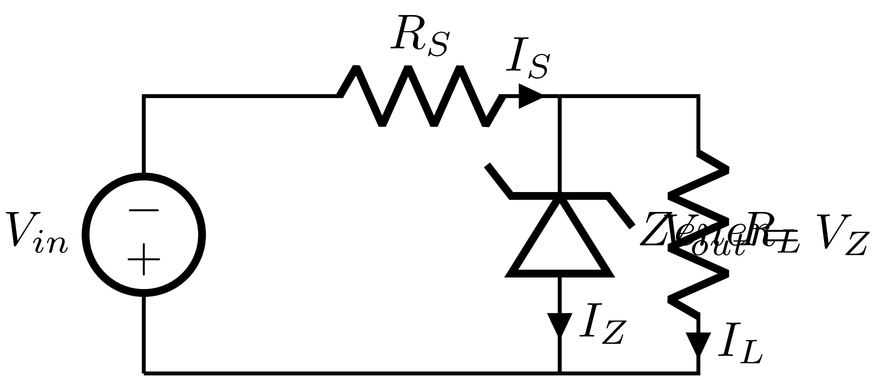


Figure 19: Zener Diode as a Voltage Regulator

- A Zener diode operates in the reverse breakdown region to regulate voltage.
- When the reverse-biased voltage across the diode exceeds the Zener breakdown voltage (V_Z), the voltage across it remains constant, even if the current through it changes significantly.

- As shown in the circuit, the Zener diode is connected in parallel with the load resistor (R_L), and a series resistor (R_S) is used to limit the current.
- **Varying Input Voltage:** If the input voltage (V_{in}) increases, the total current increases. The Zener diode absorbs the extra current, keeping the voltage across the load ($V_L = V_Z$) constant. The extra voltage drop occurs across R_S.
- **Varying Load Current:** If the load resistance decreases, load current (I_L) increases. The Zener diode compensates by drawing less current (I_Z), keeping the total current (I_S) and the output voltage constant.

Q.4 (c) OR Derive relation $\beta = \alpha/(1-\alpha)$ for transistors.

- For a Bipolar Junction Transistor (BJT), the total emitter current (I_E) is the sum of the base current (I_B) and the collector current (I_C):
$$I_E = I_B + I_C$$
- The **Common Base current gain** (α) is defined as the ratio of collector current to emitter current:
$$\alpha = \frac{I_C}{I_E} \quad \Rightarrow \quad I_E = \frac{I_C}{\alpha}$$
- The **Common Emitter current gain** (β) is defined as the ratio of collector current to base current:
$$\beta = \frac{I_C}{I_B} \quad \Rightarrow \quad I_B = \frac{I_C}{\beta}$$
- Substituting the values of I_E and I_B into the fundamental current equation:
$$\frac{I_C}{\alpha} = \frac{I_C}{\beta} + I_C$$
- Dividing the entire equation by I_C:
$$\frac{1}{\alpha} = \frac{1}{\beta} + 1$$
- Rearranging to solve for β:
$$\frac{1}{\beta} = \frac{1}{\alpha} - 1$$
$$\frac{1}{\beta} = \frac{1-\alpha}{\alpha}$$
- Inverting both sides yields the final relationship:
$$\beta = \frac{\alpha}{1-\alpha}$$

Q.5 (a) List various biasing methods used for transistors.

Transistor Biasing

Transistor biasing is the process of setting a transistor's DC operating voltage or current conditions to the correct level so that any AC input signal can be amplified properly by the transistor.

The various biasing methods used for BJT (Bipolar Junction Transistor) are as follows:

1. **Base Resistor Bias (Fixed Bias):**
   - In this method, a single resistor is connected from the base to the supply voltage.
   - It is the simplest method but suffers from poor thermal stability.
2. **Collector-to-Base Bias (Collector Feedback Bias):**
   - A resistor is connected between the collector and the base.
   - It provides negative feedback, which improves thermal stability compared to fixed bias.
3. **Voltage Divider Bias (Self Bias):**
   - Two resistors form a voltage divider across the supply voltage to set the base voltage.
   - This is the most widely used biasing method because it provides excellent stabilization of the operating point, independent of β.
4. **Emitter Bias:**
   - Uses both a positive and a negative supply voltage.
   - It provides very good stability but requires a dual-polarity power supply.

Q.5 (b) Explain working of transistor as an Amplifier.

Transistor as an Amplifier

An amplifier is an electronic circuit that increases the amplitude of a weak input signal (voltage, current, or power) without changing its shape or frequency. A transistor can act as an amplifier when operated in its active region.

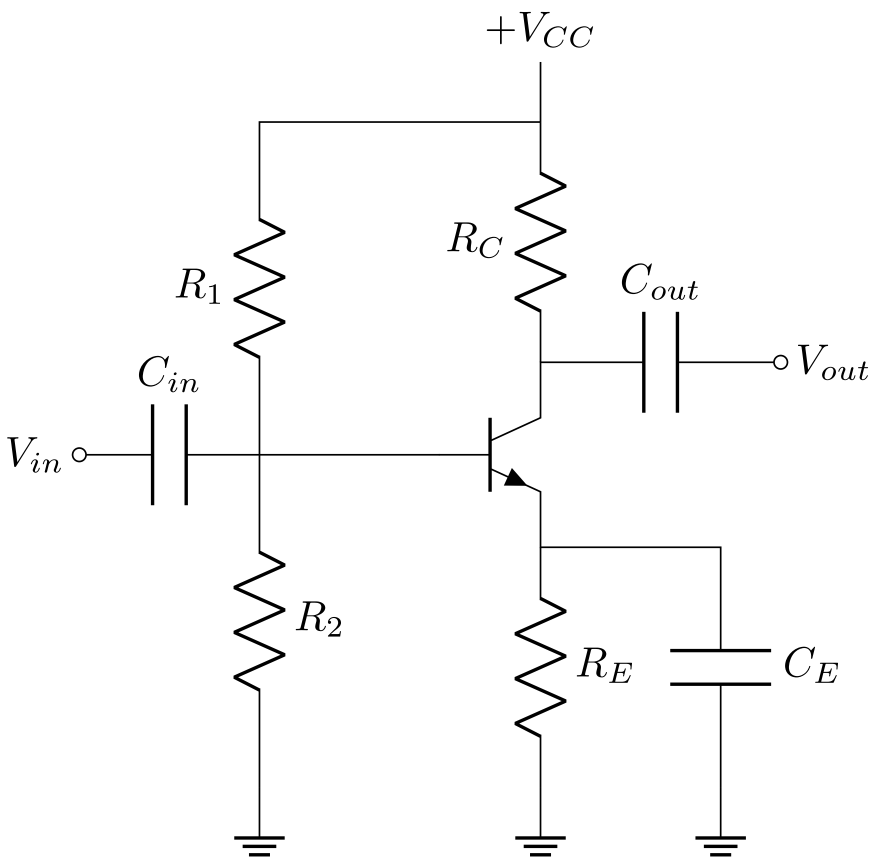


Figure 20: Transistor as a CE Amplifier

The working of a transistor as an amplifier in the Common Emitter (CE) configuration can be explained as follows:

- **Biasing Condition:** To function as an amplifier, the transistor's emitter-base junction is forward-biased, and the collector-base junction is reverse-biased (Active Region).
- **Input Signal:** A weak AC input signal V_{in} is applied across the base-emitter terminals using a coupling capacitor C_{in}.
- **Positive Half Cycle:**
  - During the positive half cycle of the input AC signal, the forward bias across the base-emitter junction increases.
  - This results in an increase in the base current I_B.
  - Since collector current $I_C = \beta I_B$, a small increase in I_B causes a large increase in I_C.
  - The increased I_C causes a larger voltage drop across the collector resistor R_C, which decreases the output voltage V_{out} (Phase reversal of 180°).
- **Negative Half Cycle:**
  - During the negative half cycle, the forward bias decreases, reducing I_B and consequently I_C.
  - The voltage drop across R_C decreases, causing the output voltage V_{out} to increase.
- **Overall Amplification:** A small change in input base current produces a proportionally large change in the collector current, leading to a magnified voltage signal at the output.

Q.5 (c) Draw a neat detailed sketch of construction of Optical Fibre Cable with proper nomenclature.

An optical fibre cable is a cylindrical dielectric waveguide that transmits light along its axis by the process of total internal reflection.

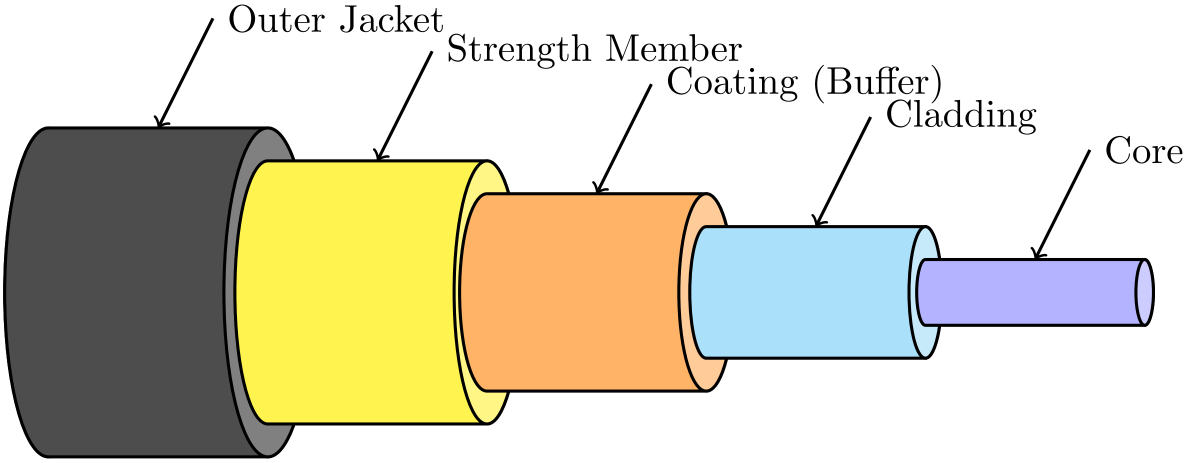


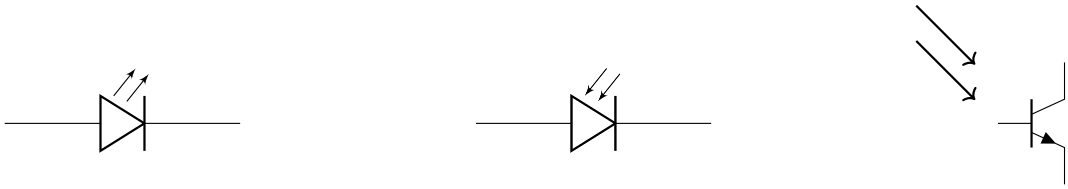
Figure 21: Construction of Optical Fibre Cable

The basic structural components of an optical fibre cable include:

1. **Core:**
   - The innermost part of the optical fibre where the light propagates.
   - Made of high-purity glass (silica) or plastic.
   - It has a higher refractive index (n_1) to allow total internal reflection.
2. **Cladding:**
   - The layer surrounding the core.
   - Also made of glass or plastic but with a slightly lower refractive index ($n_2 < n_1$).
   - It traps the light inside the core by reflecting it back towards the centre.
3. **Buffer Coating:**
   - A protective plastic layer applied over the cladding.
   - It shields the fibre from physical damage, moisture, and micro-bending losses.
4. **Strength Member:**
   - Materials like aramid yarn (Kevlar) or steel wire surrounding the buffer coating.
   - Provides high tensile strength to prevent the cable from breaking during installation and pulling.
5. **Outer Jacket:**
   - The outermost protective sheath typically made of PVC or polyurethane.
   - Protects the inner components from environmental factors such as moisture, abrasion, and chemical damage.

Q.5 (a) OR Draw symbol with proper nomenclature 1) LED Diode 2) Photo Diode 3) Photo Transistor

The standard electronic symbols for the given optoelectronic devices are shown below:



(1) LED (2) Photo Diode (3) Photo Transistor

Figure 22: Symbols of LED, Photo Diode, and Photo Transistor

- **LED (Light Emitting Diode):** A PN junction diode that emits light when forward-biased. The arrows point outwards to indicate the emission of light.
- **Photo Diode:** A semiconductor diode that generates a current when exposed to light. It is operated in reverse bias. The arrows point inwards to indicate the reception of light.
- **Photo Transistor:** A bipolar junction transistor whose base region is exposed to light. The light controls the base current, which in turn controls the larger collector current. The arrows point towards the base region.

Q.5 (b) OR Explain working of transistor as an Switch.

Transistor as a Switch

A transistor can be used as a solid-state switch to turn a load ON or OFF. When used as a switch, the transistor operates entirely in the cut-off region (OFF state) or the saturation region (ON state), avoiding the active region.

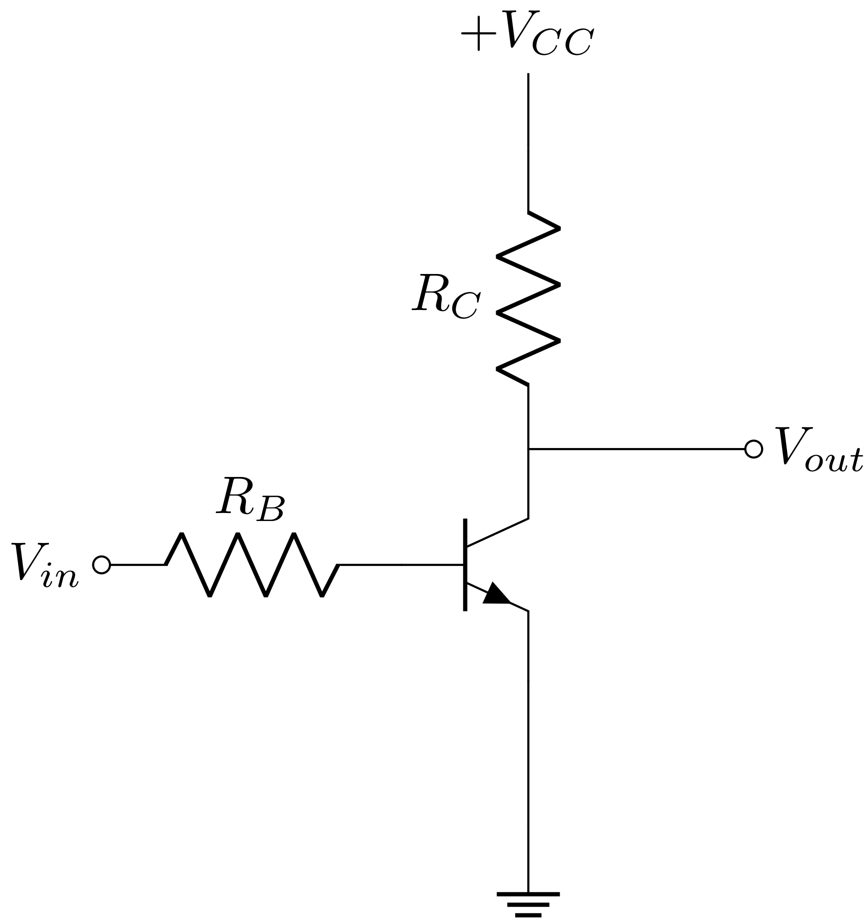


Figure 23: Transistor as a Switch

The operation of the transistor as a switch can be understood in two states:

1. **OFF State (Cut-off Region):**
   - When the input voltage V_{in} is zero or less than the cut-in voltage (e.g., 0.7 V for Silicon), the base-emitter junction is not forward-biased.
   - The base current $I_B = 0$, which results in zero collector current ($I_C = 0$).
   - Since there is no current flowing through the collector resistor R_C, there is no voltage drop across it.
   - Therefore, the output voltage $V_{out} \approx V_{CC}$. The transistor behaves like an open switch.
2. **ON State (Saturation Region):**
   - When a sufficient positive input voltage V_{in} is applied, a large base current I_B flows.
   - This forces the transistor to conduct heavily, driving it into the saturation region.
   - The collector current I_C reaches its maximum limit, limited only by R_C.
   - The voltage drop across the transistor ($V_{CE(sat)}$) becomes almost zero (typically 0.2 V).
   - As a result, the output voltage drops to nearly zero ($V_{out} \approx 0$ V). The transistor acts like a closed switch.

Q.5 (c) OR Derive relation $\alpha = \beta/1 + \beta$ for transistors.

The current gains for a transistor in different configurations are defined as α (Common Base) and β (Common Emitter).

Definitions of Current Gains

- **Alpha (α):** It is the ratio of collector current (I_C) to emitter current (I_E).

$$\alpha = \frac{I_C}{I_E}$$

- **Beta (β):** It is the ratio of collector current (I_C) to base current (I_B).

$$\beta = \frac{I_C}{I_B}$$

The fundamental current equation for any Bipolar Junction Transistor (BJT) is given by:

$$I_E = I_B + I_C \quad \text{— (Equation 1)}$$

Where:

- I_E = Emitter Current
- I_B = Base Current
- I_C = Collector Current

Dividing both sides of Equation 1 by the collector current I_C, we get:

$$\frac{I_E}{I_C} = \frac{I_B}{I_C} + \frac{I_C}{I_C}$$

$$\frac{I_E}{I_C} = \frac{I_B}{I_C} + 1$$

From the definitions of α and β, we know that:

$$\frac{I_E}{I_C} = \frac{1}{\alpha} \quad \text{and} \quad \frac{I_B}{I_C} = \frac{1}{\beta}$$

Substituting these values into the above equation:

$$\frac{1}{\alpha} = \frac{1}{\beta} + 1$$

Taking the least common multiple (LCM) on the right hand side:

$$\frac{1}{\alpha} = \frac{1 + \beta}{\beta}$$

Taking the reciprocal of both sides to solve for α:

$$\alpha = \frac{\beta}{1 + \beta}$$

This is the required relationship between the current amplification factors α and β.