Fundamentals of Electronics (DI01000051) - Summer 2025 Solution

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June 12, 2025

Question 1(a) [3 marks]

Draw Bi-stable multivibrator using 555 timer IC.

Solution

A Bi-stable multivibrator has two stable states (HIGH and LOW). It stays in one state until triggered to switch to the other.

Circuit Diagram:

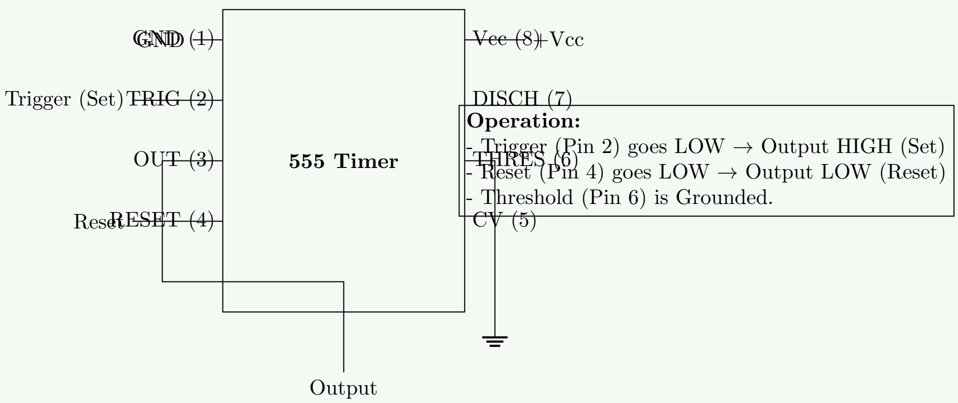


Figure 1. Bi-stable Multivibrator using 555 IC

- It functions as a basic Flip-Flop.
- **Set State:** When a negative pulse is applied to the Trigger pin (2), the output goes HIGH.
- **Reset State:** When a negative pulse is applied to the Reset pin (4), the output goes LOW.

Question 1(b) [4 marks]

Draw pin diagram of IC 555 timer and explain it.

Solution

The IC 555 is an 8-pin DIP (Dual Inline Package) integrated circuit.

Pin Diagram:

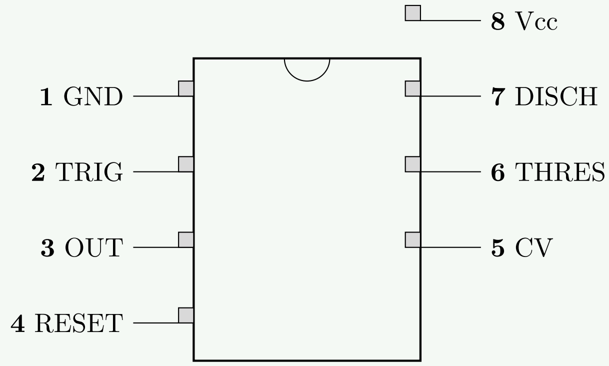


Figure 2. Pin Configuration of 555 Timer

Pin Explanations:

1. **GND (Ground):** Connected to the negative supply rail (0V).
2. **Trigger:** A negative pulse (voltage ¡ 1/3 Vcc) on this pin sets the internal Flip-Flop, making Output HIGH.
3. **Output:** The output pin can source or sink current (up to 200mA) to drive loads.
4. **Reset:** Active low pin. Connecting it to GND resets the timer (Output LOW). Normally connected to Vcc.
5. **Control Voltage (CV):** Allows access to the 2/3 Vcc internal divider point. Usually connected to GND via a 0.01μF capacitor for noise immunity.
6. **Threshold:** Checks voltage across the external capacitor. If voltage ¿ 2/3 Vcc, it resets the internal Flip-Flop (Output LOW).
7. **Discharge:** Connected to the open collector of the internal NPN transistor. Discharges the external capacitor when Output is LOW.
8. **Vcc:** Power supply pin (+5V to +15V).

Mnemonic

"Pins: G-T-O-R — C-T-D-V (Ground, Trigger, Out, Reset — Ctrl, Thres, Disch, Vcc)"

Question 1(c) [7 marks]

Draw and Explain block diagram of IC 555 timer.

Solution

The internal block diagram consists of resistors, comparators, an SR flip-flop, and an output stage.

Block Diagram:

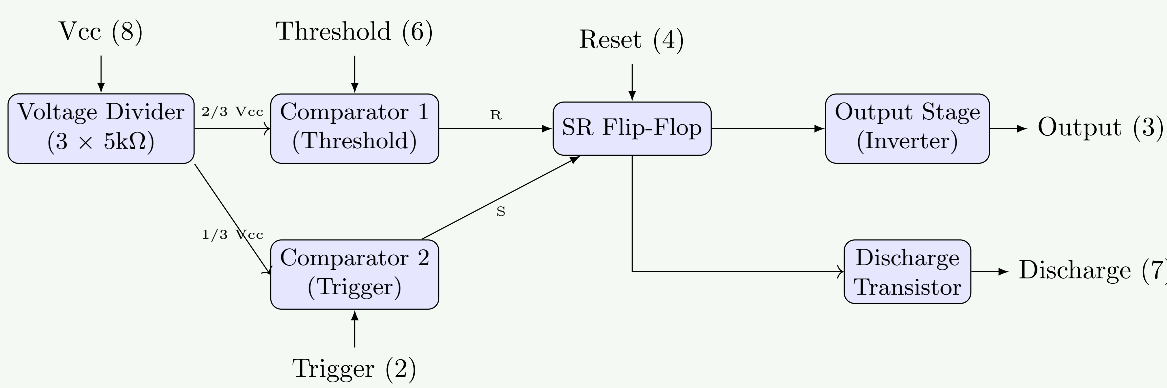


Figure 3. Functional Block Diagram of 555 Timer

Explanation of Blocks:

1. **Voltage Divider:** Three 5kΩ resistors divide Vcc into 2/3 Vcc and 1/3 Vcc references.
2. **Comparators:**
   - **Upper Comparator (Threshold):** Compares input at Pin 6 with 2/3 Vcc. If Pin 6 ¿ 2/3 Vcc, Output resets (LOW).
   - **Lower Comparator (Trigger):** Compares input at Pin 2 with 1/3 Vcc. If Pin 2 ¡ 1/3 Vcc, Output sets (HIGH).
3. **SR Flip-Flop:** Stores the state determined by the comparators. Reset pin (4) can force it to reset state.
4. **Output Stage:** A power amplifier/inverter buffer to drive external loads (Pin 3).
5. **Discharge Transistor:** An NPN transistor that switches ON when output is LOW, providing a discharge path for the external capacitor (Pin 7).

Question 1(c OR) [7 marks]

Draw and Explain A-stable and mono-stable multivibrator using 555 timer IC.

Solution

1. Astable Multivibrator (Free Running Oscillator)
- No stable state; oscillates between HIGH and LOW.
- **Circuit:** Pins 2 and 6 are tied together to a capacitor C. Two resistors R_1 and R_2 charge C, and R_2 discharges it.

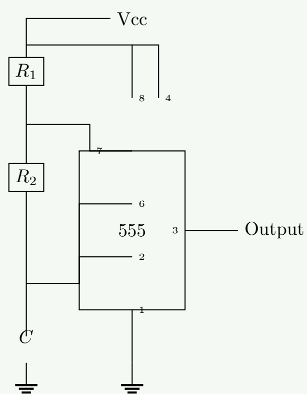


Figure 4. Astable Multivibrator

Operation: Capacitor charges via $R_1 + R_2$ (Output HIGH) and discharges via R_2 (Output LOW). Duty cycle depends on ratio of R_1 and R_2.

2. Monostable Multivibrator (One-Shot)
- One stable state (LOW). Trigger (Pin 2) creates a temporary HIGH pulse.
- **Circuit:** Trigger applied to Pin 2. Resistor R and Capacitor C determine pulse width $T = 1.1RC$.

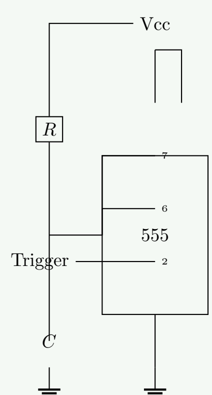


Figure 5. Monostable Multivibrator

Operation: Output is normally LOW. A negative trigger sets Output HIGH. Capacitor charges through R. When $V_C = 2/3Vcc$, Output resets to LOW and C discharges.

Question 2(a) [3 marks]

Write short note on Active components and passive components.

Solution

Electronic components are classified into two types based on their energy handling capability:

1. Active Components:

- Components that can **control** the flow of current or **amplify** a signal.
- They require an external power source to operate.
- **Examples:** Transistors (BJT, FET), Diodes (Zener, LED), ICs (Integrated Circuits), Op-Amps.

2. Passive Components:

- Components that can only **store** or **dissipate** energy. They cannot control current or amplify signals.
- They do not require an external power source to function.
- **Examples:** Resistors (Dissipate energy), Capacitors (Store electric energy), Inductors (Store magnetic energy).

Table 1. Comparison of Active and Passive Components

Parameter	**Active Components**	**Passive Components**
Function	Amplify/Switch signals	Store/Dissipate energy
Gain	Can provide power gain	No power gain (Gain ¡ 1)
Control	Control currrent flow	Cannot control current
Example	Transistor, Diode	Resistor, Capacitor

Question 2(b) [4 marks]

Write color band of following resistance. (1) 47 $\Omega \pm 5\%$

Solution

To find the color code for $47\Omega \pm 5\%$:

- **Value:** 47 Ω
- **Digit 1:** 4 corresponds to **Yellow**.
- **Digit 2:** 7 corresponds to **Violet**.
- **Multiplier:** To get 47, we need $47 \times 10^0 = 47$. So multiplier is 10^0, which corresponds to **Black**.
  - Alternatively, if interpreted as Band 3 being multiplier for ohms: $47 \times 1 = 47$. (Yellow, Violet, Black).
  - Note: Sometimes 47Ω might be represented as Yellow, Violet, Gold ($47 \times 0.1 = 4.7$ - Incorrect). Correct is 47×1.
- **Tolerance:** $\pm 5\%$ corresponds to **Gold**.

Answer:

Yellow - Violet - Black - Gold

Mnemonic

"BBROYGBVGW: Black Brown Red Orange Yellow Green Blue Violet Grey White"

Question 2(c) [7 marks]

Explain working of Full wave center tap rectifier with circuit diagram and wave form.

Solution

A Full Wave Center Tap Rectifier uses two diodes and a center-tapped transformer to convert the entire AC cycle into pulsating DC.
Circuit Diagram:

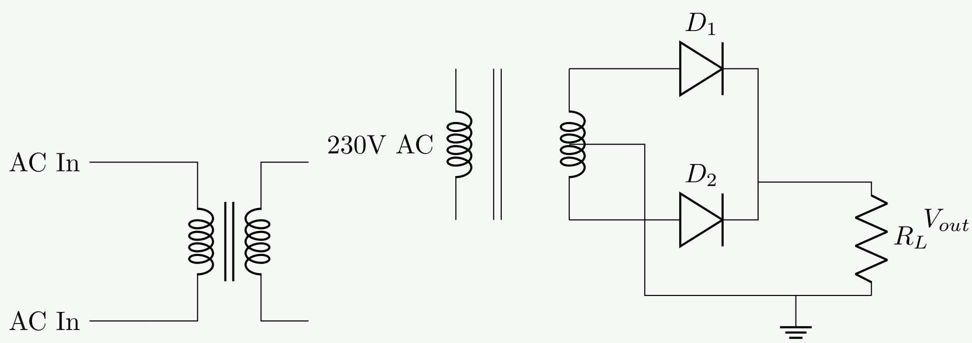


Figure 6. Full Wave Center Tap Rectifier

Operation:

- **Positive Half Cycle:** Point A (Top) is positive w.r.t CT. D_1 is Forward Biased (ON), D_2 is Reverse Biased (OFF). Current flows through D_1 and R_L.
- **Negative Half Cycle:** Point B (Bottom) is positive w.r.t CT. D_2 is Forward Biased (ON), D_1 is Reverse Biased (OFF). Current flows through D_2 and R_L.
- Current flows through R_L in the **same direction** during both half cycles.

Waveforms:

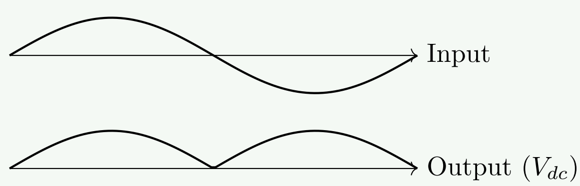


Figure 7. Input and Output Waveforms

Question 2(a OR) [3 marks]

Explain concept of capacitors.

Solution

A capacitor is a passive component that stores electrical energy in an electric field.

- **Structure:** Consists of two conductive plates separated by an insulating material called a **dielectric** (Air, Paper, Mica, Ceramic).
- **Function:** It opposes any change in voltage. It blocks DC and passes AC.
- **Capacitance (C):** The ability to store charge. $C = Q/V$. Unit is Farad (F).
- **Charging/Discharging:** When voltage is applied, it charges up to the source voltage. When the path is closed, it discharges.

Question 2(b OR) [4 marks]

Calculate value of resistor and tolerance for following color bands on resistor: (1) Brown,

Green, yellow, gold (2) Grey, blue, brown

Solution

1. Brown, Green, Yellow, Gold
- **Brown (1st Band):** 1
- **Green (2nd Band):** 5
- **Yellow (Multiplier):** $\times 10^4$ (10,000)
- **Gold (Tolerance):** $\pm 5\%$
- **Calculation:** $15 \times 10,000 = 150,000\Omega$
- **Answer: 150 kΩ** $\pm 5\%$

2. Grey, Blue, Brown
- **Grey (1st Band):** 8
- **Blue (2nd Band):** 6
- **Brown (Multiplier):** $\times 10^1$ (10)
- **Tolerance:** No 4th band implies $\pm 20\%$ (Standard convention for 3-band).
- **Calculation:** $86 \times 10 = 860\Omega$
- **Answer: 860** Ω $\pm 20\%$

Question 2(c OR) [7 marks]

Explain working of Full wave bridge rectifier with circuit diagram and wave form.

Solution

A Full Wave Bridge Rectifier uses four diodes (D_1, D_2, D_3, D_4) in a bridge configuration. It does not require a center-tapped transformer.

Circuit Diagram:

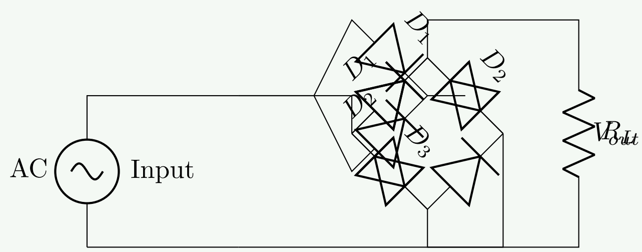


Figure 8. Bridge Rectifier Circuit

Operation:
- **Positive Half Cycle:** Current flows via $D_1 \rightarrow R_L \rightarrow D_3$ (assuming standard label). Two diodes conduct. Path is closed.
- **Negative Half Cycle:** Current flows via $D_2 \rightarrow R_L \rightarrow D_4$ (assuming standard label). Other two diodes conduct.
- Result is pulsating DC at the output.

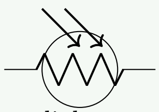
Advantages:
- No center-tap transformer needed.
- Higher PIV (Peak Inverse Voltage) rating efficiency compared to center-tap ($PIV = V_m$ vs $2V_m$).

Question 3(a) [3 marks]

Explain Light dependent resistor (LDR).

Solution

LDR (Light Dependent Resistor) is a passive component whose resistance changes with the intensity of light falling on it.

- **Principle:** Photoconductivity. When light falls on the material (Cadmium Sulfide - CdS), electron-hole pairs are generated, increasing conductivity (decreasing resistance).
- **Dark Resistance:** Very high (MΩ range) in darkness.
- **Light Resistance:** Low (kΩ or Ω range) in bright light.
- **Symbol:** 
- **Uses:** Street light control, burglar alarms, camera exposure control.

Question 3(b) [4 marks]

Explain half wave rectifier circuit with wave form.

Solution

A Half Wave Rectifier converts only one half of the AC cycle into DC.
Circuit Diagram:

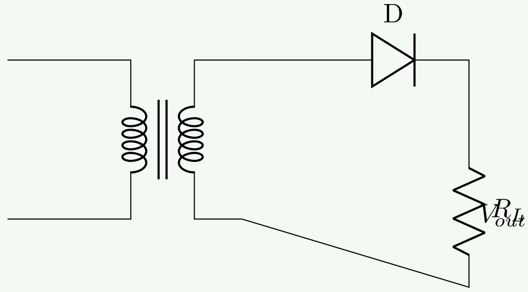


Figure 9. Half Wave Rectifier

Operation:

- During Positive half cycle: Diode is Forward Biased (ON). Current flows through R_L.
- During Negative half cycle: Diode is Reverse Biased (OFF). No current flows.

Waveform: output voltage appears only for 0 to π, zero for π to 2π.

Question 3(c) [7 marks]

List different types of clipper circuits and draw any two types of clipper circuits with its wave forms.

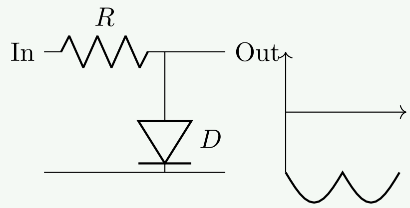
Solution

Types of Clipper Circuits:

1. Series Clipper (Positive/Negative)
2. Shunt (Parallel) Clipper (Positive/Negative)
3. Biased Clipper (Positive/Negative)
4. Combination (Dual) Clipper

1. Positive Shunt Clipper:

- Removes the positive half cycle.



For Positive Input: D is ON (Short), $V_{out} = 0$. For Negative Input: D is OFF (Open), $V_{out} = V_{in}$.

2. Positive Series Clipper:

- Diode in series, reverse direction.

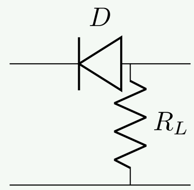


Figure 10. Positive Series Clipper

Question 3(a OR) [3 marks]

Explain self and mutual inductance in brief.

Solution

Self Inductance (L): The property of a coil to oppose any change in current flowing through **itself** by inducing an EMF. $e = -L\frac{di}{dt}$.
Mutual Inductance (M): The property of a coil to oppose current change in a **neighboring** coil by inducing an EMF in itself due to magnetic coupling. $e_2 = -M\frac{di_1}{dt}$.

Question 3(b OR) [4 marks]

Explain the following terms in brief. (1) Ripple factor (2) Ripple frequency

Solution

1. Ripple Factor (γ):

- It is the ratio of the RMS value of the AC component of the output to the DC component of the output.
- $\gamma = \frac{V_{ac(rms)}}{V_{dc}}$. It indicates the purity of the DC output (Lower is better).

2. Ripple Frequency (f_r):

- The frequency of the AC ripples present in the DC output.
- For Half Wave: $f_r = f_{in}$ (e.g., 50 Hz).
- For Full Wave: $f_r = 2f_{in}$ (e.g., 100 Hz).

Question 3(c OR) [7 marks]

List different types of clamper circuits and draw any two types of clamper circuits with its wave forms.

Solution

Clampers shift the DC level of a signal without changing its shape. **Types:** Positive Clamper, Negative Clamper, Biased Clamper.

1. Positive Clamper:
- Shifts the waveform up.

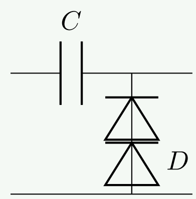


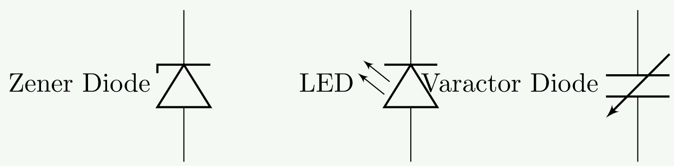
Figure 11. Positive Clamper

2. Negative Clamper:
- Shifts the waveform down.
- Diode direction reversed (Cathode at GND).

Question 4(a) [3 marks]

Draw Symbols of Zener diode, LED, and Varactor diode.

Solution



Question 4(b) [4 marks]

Explain Photodiode.

Solution

A Photodiode is a PN junction diode that converts light energy into electrical current.
- **Operation:** It is operated in **Reverse Bias**.
- **Working:** When light falls on the junction, energy breaks covalent bonds, creating electron-hole pairs. These carriers are swept by the electric field, creating a reverse current proportional to light intensity.
- **Dark Current:** Small leakage current that flows even when no light is present.
- **Applications:** Optical communication, remote controls, smoke detectors.

Question 4(c) [7 marks]

Explain construction, characteristics and working of Zener diode.

Solution

Zener Diode: A heavily doped PN junction diode designed to operate in the reverse breakdown region.
Construction:
- Heavily doped P and N regions to create a narrow depletion region.

- Encapsulated in glass or plastic.

Working:

- **Forward Bias:** Acts like a normal diode.
- **Reverse Bias:**
- At low voltage, negligible current flows.
- At Breakdown Voltage (V_z), current increases sharply (Avalanche/Zener breakdown). The voltage across it remains constant (V_z) despite large changes in current.

V-I Characteristics:

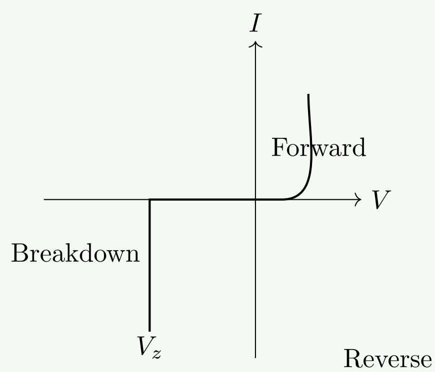


Figure 12. V-I Characteristics of Zener Diode

Question 4(a OR) [3 marks]

List applications of LED and Varactor diode.

Solution

LED (Light Emitting Diode):

- Indicators and Displays (7-segment).
- Lighting (Bulbs, Torch).
- Optical Communication (Fiber optics).
- Remote Controls (IR LED).

Varactor Diode (Varicap):

- Tuning circuits (FM/TV receivers).
- Voltage Controlled Oscillators (VCO).
- Frequency Multipliers.
- Adjustable Bandpass Filters.

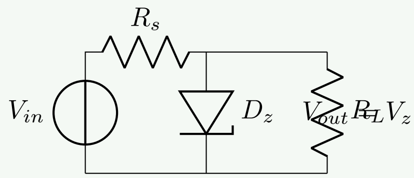
Question 4(b OR) [4 marks]

Explain Zener diode as a voltage regulator.

Solution

Zener diode maintains a constant output voltage (V_z) irrespective of changes in input voltage (V_{in}) or load current (I_L).

Circuit:



Working:

- If V_{in} increases, Current rises. Zener absorbs extra current. Voltage drop across Series Resistor (R_s) increases. V_{out} remains V_z.
- If Load current (I_L) changes, Zener current (I_z) adjusts such that $I_s = I_z + I_L$ keeps voltage constant.

Question 4(c OR) [7 marks]

Explain construction, characteristics and working of Varactor diode.

Solution

Varactor Diode: A variable capacitance diode. It acts as a voltage-dependent capacitor.
Working Principle:

- Operates in **Reverse Bias**.
- The depletion region acts as a dielectric. P and N regions act as plates.
- **Capacitance Formula:** $C_T = \frac{\epsilon A}{W}$.
- Increasing Reverse Voltage (V_R) $\rightarrow$ Width of Depletion Region (W) Increases $\rightarrow$ Capacitance (C_T) Decreases.
- $C \propto \frac{1}{\sqrt{V_R}}$.

Characteristics:

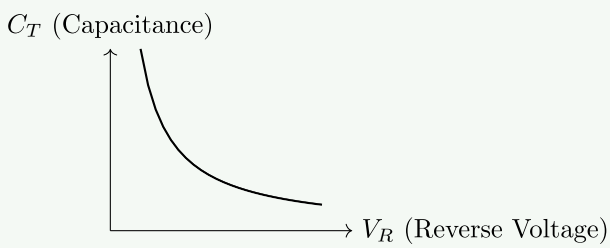


Figure 13. C-V Characteristics of Varactor Diode

Question 5(a) [3 marks]

Explain transistor as a switch.

Solution

A transistor operates as a switch by shifting between **Cut-off** and **Saturation** regions.

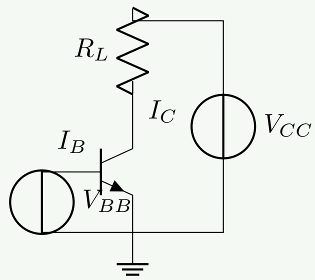
- **OFF State (Open Switch):** Operates in Cut-off region. $I_B = 0 \Rightarrow I_C = 0$. $V_{CE} = V_{CC}$.
- **ON State (Closed Switch):** Operates in Saturation region. I_B is high enough such that I_C is maximum (V_{CC}/R_C). $V_{CE} \approx 0$ (Saturation voltage).

Question 5(b) [4 marks]

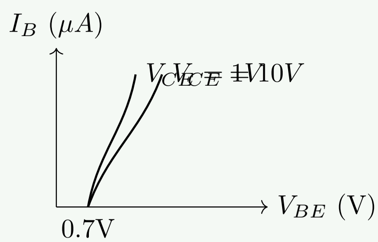
Draw Common Emitter (CE) configuration of NPN transistors and its input characteristics.

Solution

CE Configuration: Emitter is common to both input and output.



Input Characteristics: Graph of I_B vs V_{BE} at constant V_{CE}.

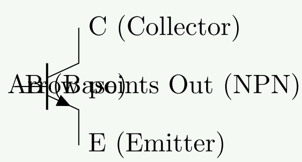


Question 5(c) [7 marks]

Draw symbol and construction of NPN Transistor and explain its working.

Solution

Symbol:



Construction:

- Consists of three layers: Two N-type regions separated by a P-type region.
- **Emitter:** Heavily doped (Supplies carriers).
- **Base:** Lightly doped and very thin (Controls carriers).
- **Collector:** Moderately doped and physically large (Collects carriers).

Working (Active Mode):

- **Biasing:** Emitter-Base junction is Forward Biased (V_{BE}). Collector-Base junction is Reverse Biased (V_{CB}).
- Majority carriers (Electrons) from Emitter crossover to Base.
- Since Base is thin and lightly doped, only a few ($\approx 5\%$) recombine with Holes. I_B is small.
- The rest ($\approx 95\%$) are attracted by the high positive potential of the Collector.
- $I_E = I_B + I_C$.

Question 5(a OR) [3 marks]

Compare CB, CE and CC configuration of transistor.

Solution

Table 2. Comparison of Transistor Configurations

Parameter	**Common Base (CB)**	**Common Emitter (CE)**	**Common Collector (CC)**
Input Res.	Low	Medium	High
Output Res.	High	Medium	Low
Current Gain	Low ($\alpha < 1$)	High (β)	High (γ)
Voltage Gain	High	Medium	Low (< 1)
Phase Shift	0°	180°	0°
Application	RF Amplifier	Audio Amplifier	Impedance Matching

Question 5(b OR) [4 marks]

Explain transistor as a single stage common emitter amplifier.

Solution

Circuit Diagram:

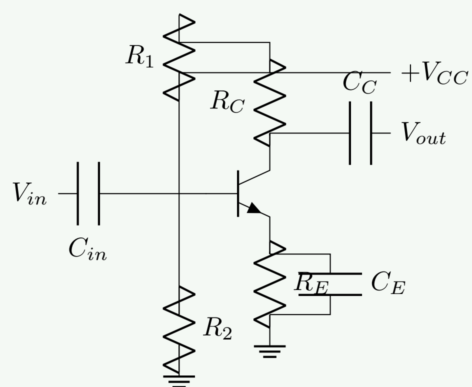


Figure 14. Single Stage CE Amplifier (Voltage Divider Bias)

Operation:
- R_1, R_2 form a voltage divider to bias the base.
- Input signal superimposes on the DC bias.
- During positive half of inputs, V_{BE} increases $\rightarrow I_B$ increases $\rightarrow I_C$ increases $\rightarrow$ Voltage drop across R_C increases $\rightarrow V_{CE}$ decreases.
- Result: Output is 180° phase shifted (Inverted) and amplified.

Question 5(c OR) [7 marks]

Explain common base (CB) configuration of NPN transistors with its input-output characteristics.

Solution

CB Configuration: Base is common (Grounded). Input at Emitter, Output at Collector.
Input Characteristics (V_{EB} vs I_E at constant V_{CB}):
- Similar to a forward-biased diode.
- As V_{EB} increases, I_E increases rapidly.

Output Characteristics (V_{CB} vs I_C at constant I_E):

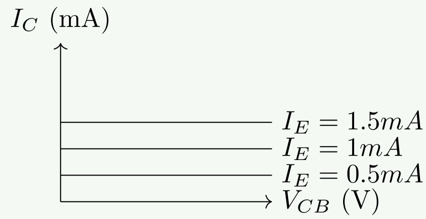


Figure 15. Output Characteristics of CB Config

- **Active Region:** I_C is almost independent of V_{CB} and depends only on I_E. ($I_C \approx I_E$).
- **Saturation Region:** $V_{CB} < 0$. I_C drops.