Fundamentals of Electronics (DI01000051) - Summer 2025 Solution

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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:

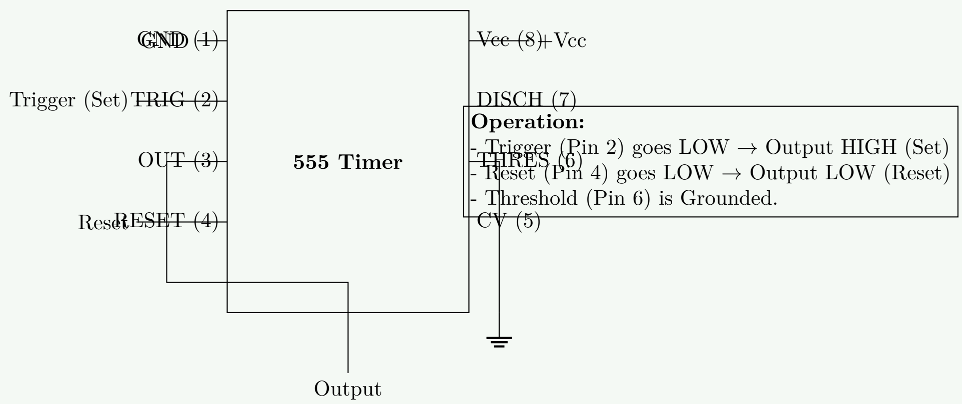


Figure 1. Bi-stable Multivibrator using 555 IC

- 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:

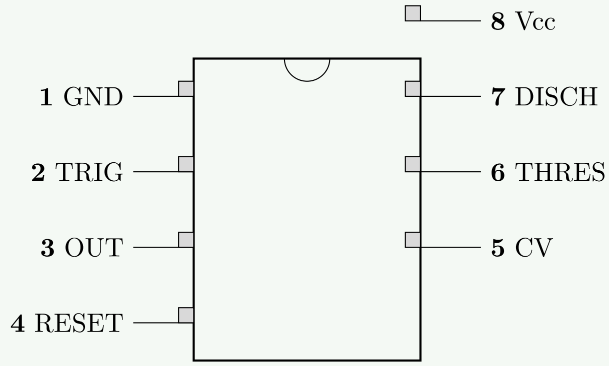


Figure 2. Pin Configuration of 555 Timer

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:

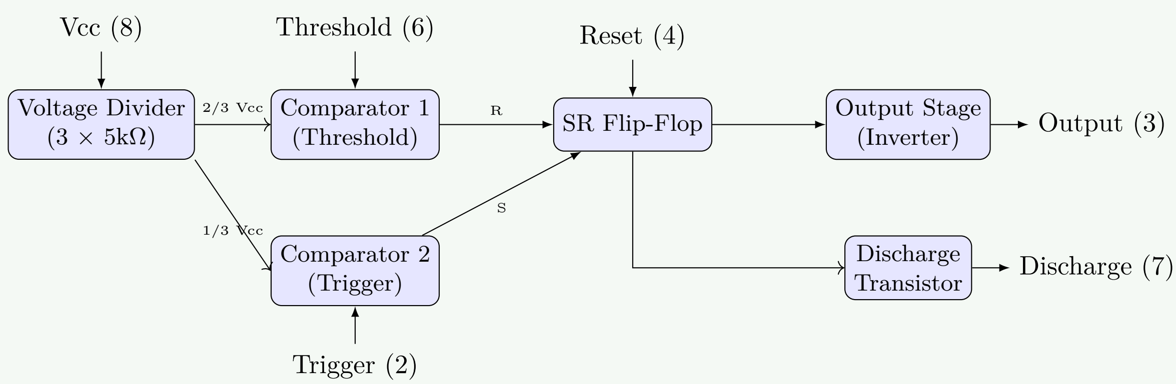


Figure 3. Functional Block Diagram of 555 Timer

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.

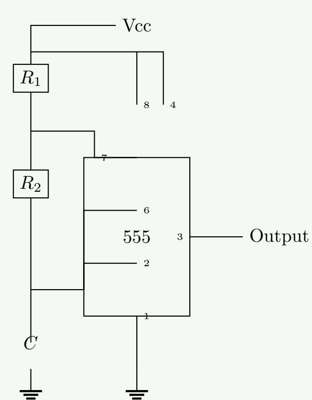


Figure 4. Astable Multivibrator

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 $T = 1.1RC$.

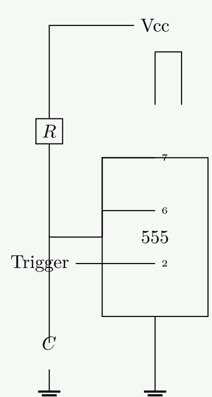


Figure 5. Monostable Multivibrator

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:

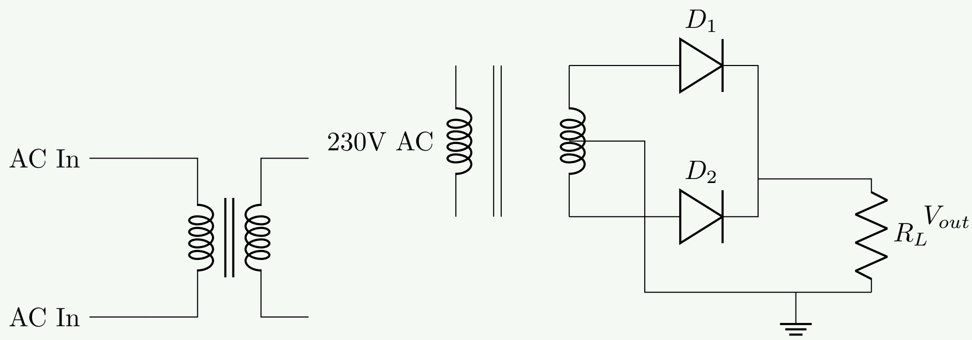


Figure 6. Full Wave Center Tap Rectifier

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:

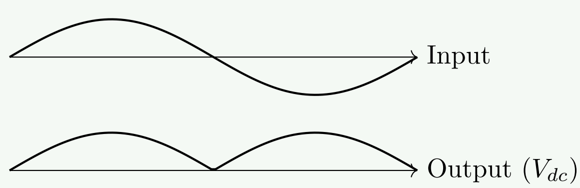


Figure 7. Input and Output Waveforms

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 k**Ω $\pm 5\%$

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:

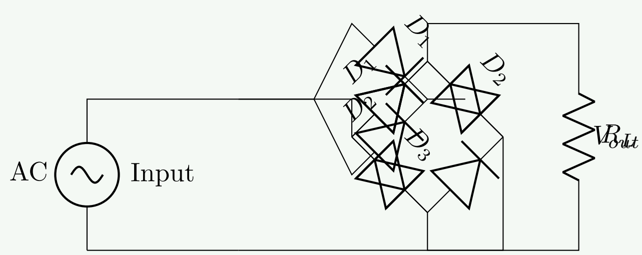


Figure 8. Bridge Rectifier Circuit

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.

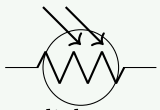
Advantages:
- No center-tap transformer needed.
- Higher PIV (Peak Inverse Voltage) rating efficiency compared to center-tap ($PIV = V_m$ vs $2V_m$).

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:

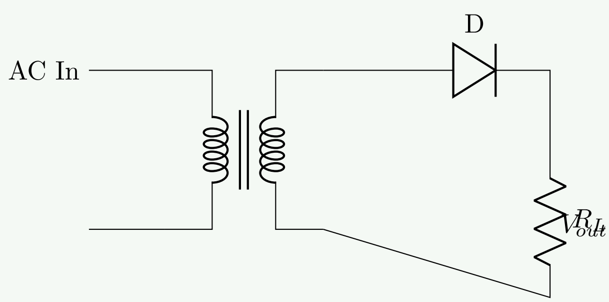


Figure 9. Half Wave Rectifier

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.

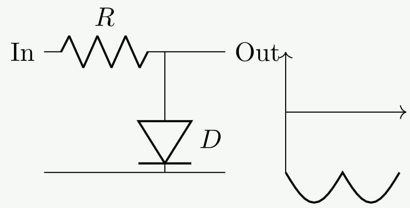
Solution

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.

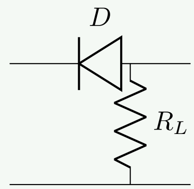


Figure 10. Positive Series Clipper

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.

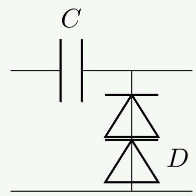


Figure 11. Positive Clamper

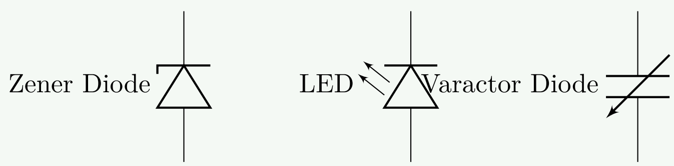
2. Negative Clamper:

- 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:

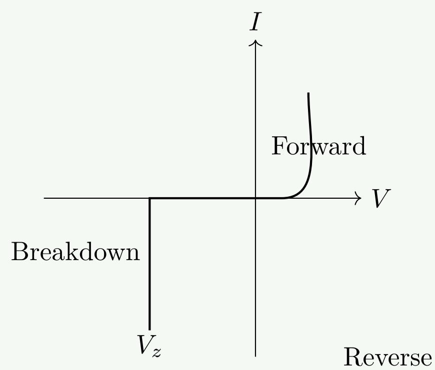


Figure 12. V-I Characteristics of Zener Diode

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.

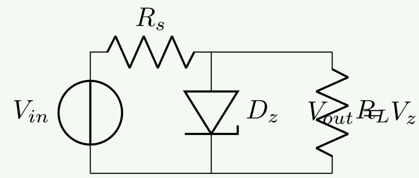
Question 4(b OR) [4 marks]

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:

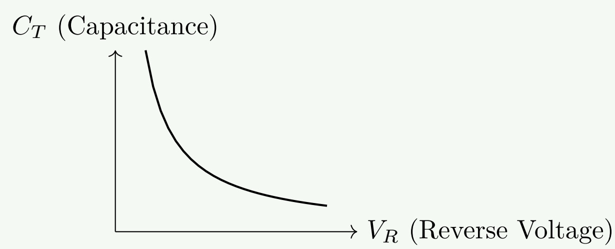


Figure 13. C-V Characteristics of Varactor Diode

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.

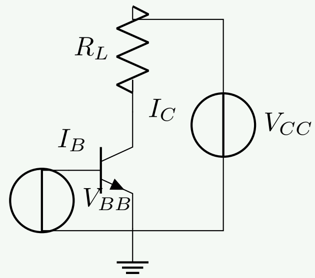
- **OFF State (Open Switch):** Operates in Cut-off region. $I_B = 0 \Rightarrow I_C = 0$. $V_{CE} = V_{CC}$.
- **ON State (Closed Switch):** Operates in Saturation region. I_B is high enough such that I_C is maximum (V_{CC}/R_C). $V_{CE} \approx 0$ (Saturation voltage).

Question 5(b) [4 marks]

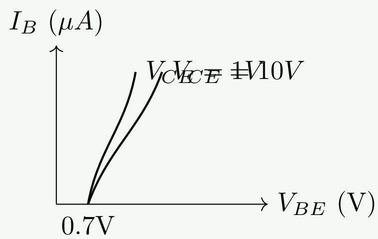
Draw Common Emitter (CE) configuration of NPN transistors and its input characteristics.

Solution

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



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

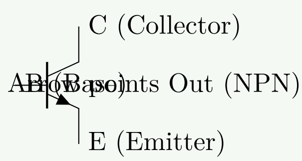


Question 5(c) [7 marks]

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:

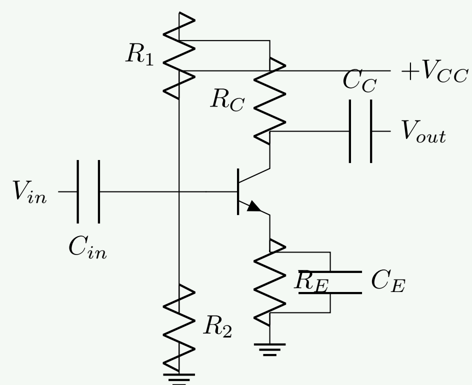


Figure 14. Single Stage CE Amplifier (Voltage Divider Bias)

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):

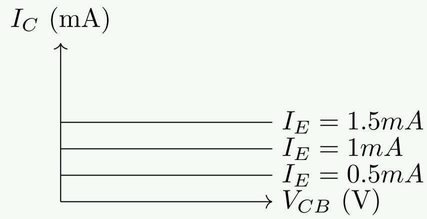


Figure 15. Output Characteristics of CB Config

- **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.