Fundamentals of Electronics (DI01000051) - Summer 2025 Solution

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June 12, 2025

Contents

1 Question 1

1.1 Question 1(a) [3 marks]

Draw Bi-stable multivibrator using 555 timer IC.

1.1.1 Solution

A **Bi-stable multivibrator** has two stable states (High and Low). It remains in one state until triggered to switch to the other.

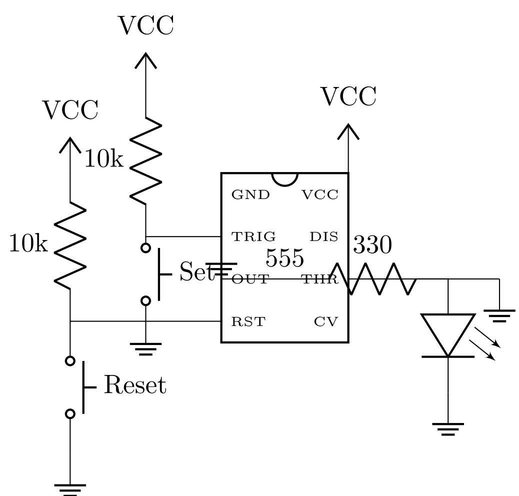


Figure 1: Bi-stable Multivibrator using 555 Timer

Circuit Diagram:

Working:

- When **Trigger (Pin 2)** is pressed (Low), Output goes **HIGH**.
- When **Reset (Pin 4)** is pressed (Low), Output goes **LOW**.
- Threshold (Pin 6) is grounded to preventing accidental switching.

Mnemonic: *Bi-Stable: Two Switches, Two States (Set & Reset).*

1.2 Question 1(b) [4 marks]

Draw pin diagram of IC 555 timer and explain it.

1.2.1 Solution

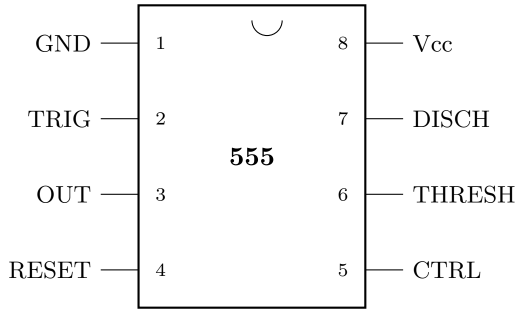


Figure 2: Pin Configuration of 555 Timer

Pin Diagram:

Pin Description:

Pin 1 (GND): Ground reference voltage (0V).

Pin 2 (Trigger): Turns output HIGH when voltage drops below 1/3 Vcc.

Pin 3 (Output): Output signal (sourcing/sinking max 200mA).

Pin 4 (Reset): Resets the timer when grounded (active low).

Pin 5 (Control Voltage): Access to internal voltage divider (2/3 Vcc).

Pin 6 (Threshold): Turns output LOW when voltage exceeds 2/3 Vcc.

Pin 7 (Discharge): Provides discharge path for external capacitor.

Pin 8 (Vcc): Supply voltage (+5V to +18V).

Mnemonic: *GTOR CV T D V: Ground, Trigger, Output, Reset — Control, Threshold, Discharge, Vcc.*

1.3 Question 1(c) [7 marks]

Draw and Explain block diagram of IC 555 timer.

1.3.1 Solution

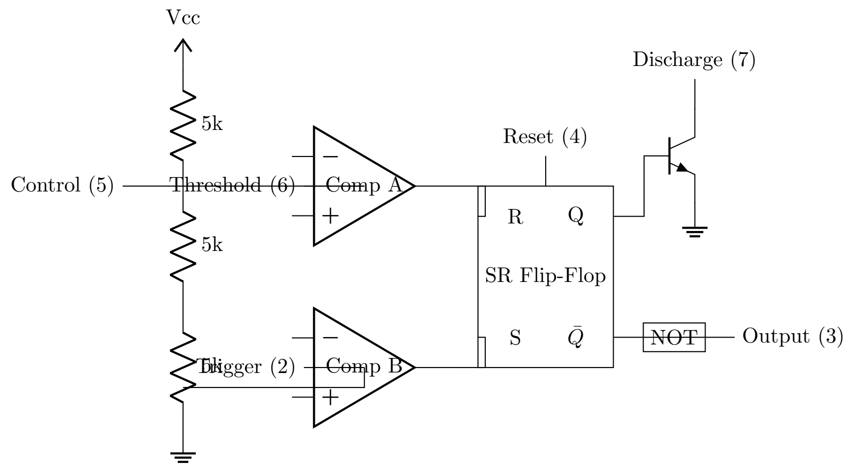


Figure 3: Internal Block Diagram of 555 Timer

Block Diagram:

Explanation: The 555 timer consists of:

1. **Voltage Divider:** Three 5kΩ resistors divide Vcc into 1/3 Vcc and 2/3 Vcc reference voltages.
2. **Comparators:**
   - **Comparator A (Upper):** Compares Threshold (Pin 6) with 2/3 Vcc. If Pin 6 ¿ 2/3 Vcc, Output is High (Resets FF).
   - **Comparator B (Lower):** Compares Trigger (Pin 2) with 1/3 Vcc. If Pin 2 ¡ 1/3 Vcc, Output is High (Sets FF).
3. **RS Flip-Flop:** Stores the state. Set by Trigger, Reset by Threshold.
4. **Output Driver:** Inverts $\bar{Q}$ output to drive the load (Pin 3).
5. **Discharge Transistor:** Discharges external capacitor when proper logic is met (Pin 7).

Mnemonic: *3-5-2-1: 3 Resistors, 5-5-5, 2 Comparators, 1 Flip-Flop.*

OR

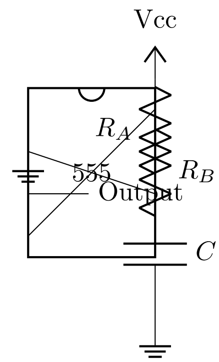
1.4 Question 1(c) [7 marks]

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

1.4.1 Solution

1. Astable Multivibrator (Free Running): Generates a continuous square wave without external triggering.

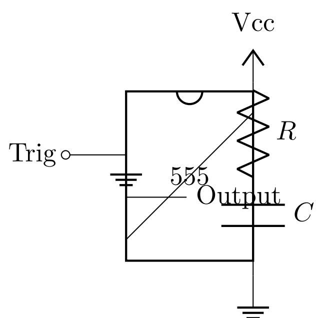
Circuit Diagram:



- **Operation:** Capacitor C charges through $R_A + R_B$ to 2/3 Vcc, then discharges through R_B to 1/3 Vcc.
- **Output:** Cycles between High and Low continuously.

2. Monostable Multivibrator (One Shot): Produces a single output pulse of fixed duration when triggered.

Circuit Diagram:



- **Operation:** When triggered, output goes High. C charges through R. When $V_c = 2/3Vcc$, output goes Low.
- **Pulse Width:** $T = 1.1RC$.

Mnemonic: *Astable = Infinite loops (Free running). Monostable = One pulse (One shot).*

2 Question 2

2.1 Question 2(a) [3 marks]

Write short note on Active components and passive components.

2.1.1 Solution

Comparison:

Active Components: Components that **can amplify** an electrical signal or produce power gain. They require an external source to operate.

- **Examples:** Transistors (BJT, FET), Diodes, Op-Amps, SCR.
- **Function:** Switching, Amplification, Regulation.

Passive Components: Components that **cannot amplify** a signal. They dissipate or store energy.

- **Examples:** Resistors, Capacitors, Inductors, Transformers.
- **Function:** Attenuation, Energy Storage, Filtering.

Mnemonic: *Active Acts (Controls/Amplifies), Passive Passes (Consumes/Stores).*

2.2 Question 2(b) [4 marks]

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

2.2.1 Solution

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

Calculation:

- **1st Digit (4):** Yellow
- **2nd Digit (7):** Violet
- **Multiplier ($10^0 = 1$):** Black ($47 \times 1 = 47$)
- **Tolerance ($\pm 5\%$):** Gold

Result: **Yellow - Violet - Black - Gold**

Mnemonic: *BBROYGBVGW -¿ Black(0) Brown(1) Red(2) Orange(3) Yellow(4) Green(5) Blue(6) Violet(7) Grey(8) White(9).*

2.3 Question 2(c) [7 marks]

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

2.3.1 Solution

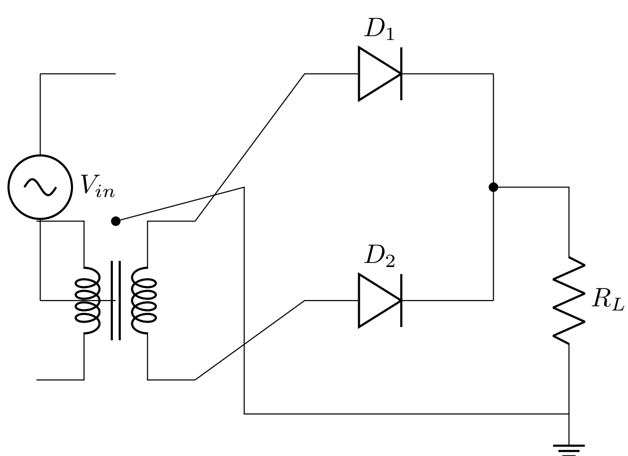


Figure 4: Full Wave Center Tap Rectifier

Circuit Diagram:

Working:

- A center-tap transformer with two diodes (D_1, D_2) is used.
- **Positive Half Cycle:** D_1 is forward biased (Conducts), D_2 is reverse biased. Current flows through D_1 and Load.
- **Negative Half Cycle:** D_2 is forward biased (Conducts), D_1 is reverse biased. Current flows through D_2 and Load.
- Current direction in R_L remains same for both cycles.

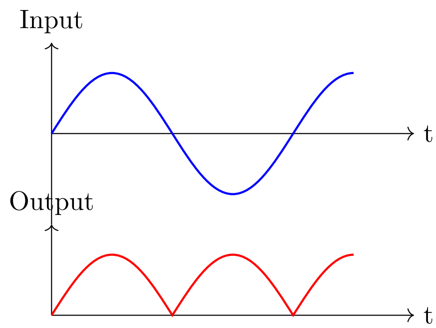


Figure 5: Input AC and Output Pulsating DC

Waveforms:

Mnemonic: *Center Tap = 2 Diodes, Both Halves Conduct.*

OR

2.4 Question 2(a) [3 marks]

Explain concept of capacitors.

2.4.1 Solution

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

Key Points:

- **Construction:** Two conductive plates separated by an insulator (dielectric).
- **Formula:** $C = \frac{Q}{V}$ where C is capacitance (Farads), Q is charge, V is voltage.
- **Function:** Blocks DC, passes AC characteristics. Used filtering, coupling, and timing circuits.
- **Energy Stored:** $E = \frac{1}{2}CV^2$.

Mnemonic: *Capacitor = Storage Tank for Charge.*

2.5 Question 2(b) [4 marks]

Calculate value of resistor and tolerance for following color bands on resistor:

1. Brown, Green, yellow, gold
2. Grey, blue, brown

2.5.1 Solution

1. Brown, Green, Yellow, Gold:

- Brown (1), Green (5) $\rightarrow$ 15
- Yellow (Multiple 10^4)
- Gold (Tolerance $\pm 5\%$)
- **Value:** $15 \times 10^4 \,\Omega = 150,000 \,\Omega = 150 \,k\Omega \pm 5\%$

2. Grey, Blue, Brown:

- Grey (8), Blue (6) $\rightarrow$ 86
- Brown (Multiplier 10^1)
- No 4th band (Assume $\pm 20\%$)
- **Value:** $86 \times 10^1 \,\Omega = 860 \,\Omega \pm 20\%$

Mnemonic: *Band1-Digit, Band2-Digit, Band3-Multiplier, Band4-Tolerance.*

2.6 Question 2(c) [7 marks]

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

2.6.1 Solution

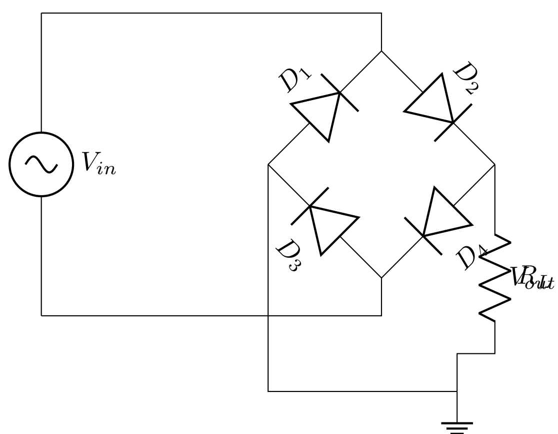


Figure 6: Full Wave Bridge Rectifier

Circuit Diagram:

Working:

- Uses 4 diodes ($D_1 - D_4$) in a bridge topology.
- **Positive Half:** D_2 and D_4 conduct (Forward), D_1 and D_3 OFF. Path: Source $\rightarrow D_2 \rightarrow Load \rightarrow D_4 \rightarrow$ Return.
- **Negative Half:** D_1 and D_3 conduct, D_2 and D_4 OFF. Path: Source $\rightarrow D_3 \rightarrow Load \rightarrow D_1 \rightarrow$ Return.
- Output is pulsating DC. Efficiency is 81.2

Waveforms: Same as Center Tap Rectifier (Full Wave).

Mnemonic: *Bridge = 4 Diodes, High Efficiency, No Center Tap.*

3 Question 3

3.1 Question 3(a) [3 marks]

Explain Light dependent resistor (LDR).

3.1.1 Solution

LDR (Light Dependent Resistor), also known as a photoresistor, is a component whose resistance varies with light intensity.

Key Points:

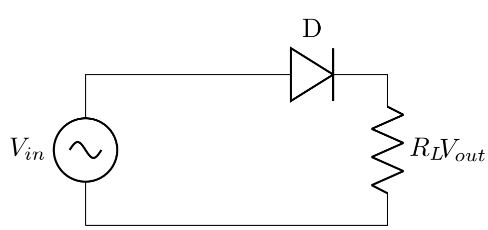
- **Principle:** Photoconductivity.
- **Operation:**
  - **Dark:** High resistance ($M\Omega$ range).
  - **Light:** Low resistance (few hundred Ω).
- **Material:** Cadmium Sulfide (CdS).
- **Application:** Street lights, Camera shutter control.

Mnemonic: *LDR: Light Up -¿ Resistance Down.*

3.2 Question 3(b) [4 marks]

Explain half wave rectifier circuit with wave form.

3.2.1 Solution



Circuit Diagram:

Explanation:

- **Positive Half:** Anode positive wrt Cathode → Diode ON → Current flows.
- **Negative Half:** Anode negative wrt Cathode → Diode OFF → No current.
- **Result:** Only positive half cycles appear at output.
- **Efficiency:** Max 40.6%.

Waveform: Output exists only for $0 - \pi$, $2\pi - 3\pi$, etc. Zero for $\pi - 2\pi$.

Mnemonic: *Half Wave = One Diode, 50% (approx) loss.*

3.3 Question 3(c) [7 marks]

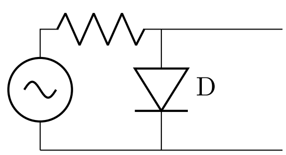
List different types of clipper circuits and draw any two types of clipper circuits with its wave forms.

3.3.1 Solution

List of Clipper Circuits:

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

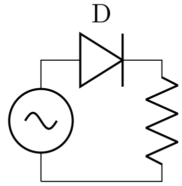
1. Positive Shunt Clipper: Removes positive half of the waveform.



Only Negative Half remains

Waveform: Output is zero during positive cycle (Diode Short), follows input during negative (Diode Open).

2. Negative Series Clipper: Removes negative half.



Waveform: Output exists only for positive cycle.

Mnemonic: *Clipper: Scissors applied to Waveform (Clips off parts).*

OR

3.4 Question 3(a) [3 marks]

Explain self and mutual inductance in brief.

3.4.1 Solution

Definitions:

Self Inductance (L): The property of a coil to oppose any change in current flowing through **itself** by inducing an EMF ($V = -L\frac{di}{dt}$).

Mutual Inductance (M): The property where a changing current in one coil induces an EMF in a **neighboring** coil.

Mnemonic: *Self = Me (My current opposes me). Mutual = Us (Your current affects me).*

3.5 Question 3(b) [4 marks]

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

3.5.1 Solution

Definitions:

Ripple Factor (γ): The ratio of RMS value of AC component to the DC component in the output working.

$$\gamma = \frac{V_{ac(rms)}}{V_{dc}}$$

Indicates how smooth the DC output is. Lower is better.

Ripple Frequency (f_r): The frequency of the AC component (ripple) present in the DC output.

- Half Wave: $f_r = f_{in}$ (50Hz)
- Full Wave: $f_r = 2f_{in}$ (100Hz)

Mnemonic: *Factor = Ratio (AC/DC). Frequency = Rate of pulses.*

3.6 Question 3(c) [7 marks]

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

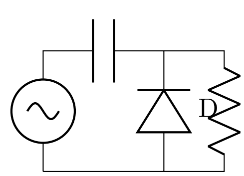
3.6.1 Solution

Circuit that shifts the DC level of a signal without changing its shape.

Types:

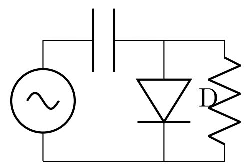
1. Positive Clamper
2. Negative Clamper
3. Biased Clamper

1. Positive Clamper: Shifts waveform UP (Negative peak connects to zero/bias).



Waveform: Input (ex: -5V to +5V) becomes Output (0V to +10V).

2. Negative Clamper: Shifts waveform DOWN.



Waveform: Input (-5V to +5V) becomes Output (-10V to 0V).

Mnemonic: *Clamper: Elevator (Lifts signal Up or Down).*

4 Question 4

4.1 Question 4(a) [3 marks]

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

4.1.1 Solution

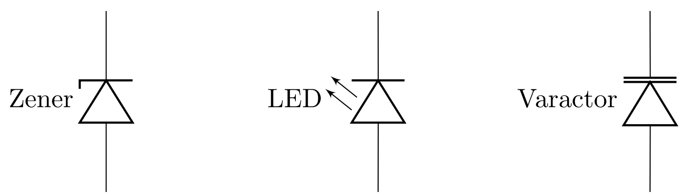


Figure 7: Diode Symbols

Symbols:

Mnemonic: *Zener: Z shape. LED: Arrows Out (Light Emitting). Varactor: Capacitor symbol + Diode.*

4.2 Question 4(b) [4 marks]

Explain Photodiode.

4.2.1 Solution

A **Photodiode** is a PN junction diode designed to operate in **reverse bias**. It converts light energy into electrical current.

Working:

- When light falls on the junction, electron-hole pairs are generated.
- In reverse bias, these carriers are swept across the junction, creating a reverse current (I_λ) proportional to light intensity.
- Dark current flows when no light is present (very small).

Mnemonic: *Photo = Light, Reverse Bias, Light In -¿ Current Flow.*

4.3 Question 4(c) [7 marks]

Explain construction, characteristics and working of Zener diode.

4.3.1 Solution

Construction:

- Heavily doped P-N junction diode.
- Thin depletion layer.
- Designed to operate in breakdown region without damage.

Working:

- **Forward Bias:** Acts like a normal diode.
- **Reverse Bias:**
  - Until breakdown voltage (V_z), very little current flows.
  - At V_z, current increases sharply due to Zener Effect (tunneling) or Avalanche Effect.
  - Voltage remains constant across it despite change in current.

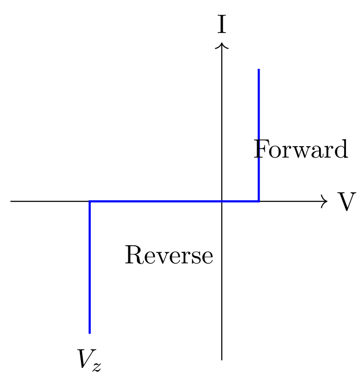


Figure 8: Zener Characteristics

Characteristics (V-I Curve):

Mnemonic: *Zener = Reverse Breakdown, Voltage Stabilizer.*

OR

4.4 Question 4(a) [3 marks]

List applications of LED and Varactor diode.

4.4.1 Solution

Applications:

LED (Light Emitting Diode):
- Indicators (Power on/off).
- Displays (7-segment, Screens).

- Lighting (Traffic lights, Homes).
- Optical Communication (Fiber optics).

Varactor Diode:
- Tuning circuits (Radio/TV tuners).
- Frequency multipliers.
- Voltage Controlled Oscillators (VCO).
- Filters (Tunable).

Mnemonic: *LED = Light/Display. Varactor = Tuning (Variable Reactor).*

4.5 Question 4(b) [4 marks]

Explain Zener diode as a voltage regulator.

4.5.1 Solution

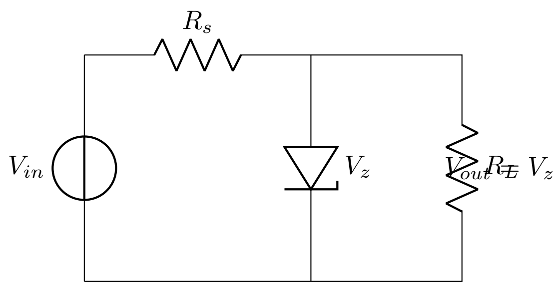


Figure 9: Zener Voltage Regulator

Circuit Diagram:

Operation:

- Zener is connected in **parallel** (shunt) with load, in **reverse bias**.
- If V_{in} increases, Zener current (I_z) increases, increasing drop across series resistor (R_s).
- V_{out} remains clamped at V_z.
- Effectively absorbs excess current to keep voltage constant.

Mnemonic: *Shunt Regulator: Zener eats the extra current to save voltage.*

4.6 Question 4(c) [7 marks]

Explain construction, characteristics and working of Varactor diode.

4.6.1 Solution

Construction:

- A P-N junction diode optimized for **variable capacitance**.
- Operates in **reverse bias**.
- Depletion layer acts as dielectric, P and N regions act as plates.

Working:

- Reverse voltage determines width of depletion layer (W).
- Capacitance $C = \frac{\epsilon A}{W}$.
- Higher Reverse Voltage $\rightarrow$ Wider Depletion Layer ($W \uparrow$) $\rightarrow$ Lower Capacitance ($C \downarrow$).
- Used as a voltage-controlled capacitor.

Characteristics: Graph of Capacitance (C) vs Reverse Voltage (V_R) shows inverse relationship. C decreases as V_R increases.

Mnemonic: *Varactor = Variable Capacitor. Voltage Up -¿ Cap Down.*

5 Question 5

5.1 Question 5(a) [3 marks]

Explain transistor as a switch.

5.1.1 Solution

A transistor (BJT) works as a switch by operating in Cut-off and Saturation regions.

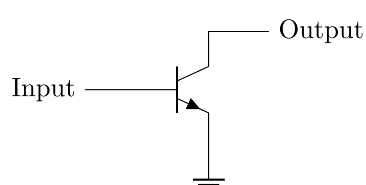
- **OFF State (Open Switch):** Works in **Cut-off** region. Base current $I_B = 0$, so $I_C = 0$. $V_{CE} = V_{CC}$.
- **ON State (Closed Switch):** Works in **Saturation** region. Base current is high. $V_{CE} \approx 0$ (Saturation voltage). Max current flows.

Mnemonic: *Cutoff = OPEN. Saturation = CLOSED.*

5.2 Question 5(b) [4 marks]

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

5.2.1 Solution



Input Characteristics: Graph of Base Current (I_B) vs Base-Emitter Voltage (V_{BE}) at constant V_{CE}. Similar to a forward-biased diode curve. Current rises effectively after $V_{BE} > 0.7V$ (Si).

Mnemonic: *Input Char = Diode Curve (Ib vs Vbe).*

5.3 Question 5(c) [7 marks]

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

5.3.1 Solution

Structure:

- **NPN:** P-type layer sandwiched between two N-type layers.
- **Terminals:** Emitter (Heavily doped), Base (Lightly doped, thin), Collector (Moderately doped, large area).

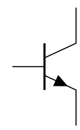


Figure 10: NPN Symbol (Arrow Out)

Symbol:

Working (Active Mode):

- Emitter-Base junction is **Forward Biased**. Collector-Base is **Reverse Biased**.
- Electrons injected from Emitter to Base.
- Since Base is thin, most electrons ($> 95\%$) cross Base and are swept into Collector by high potential.
- $I_E = I_B + I_C$. Small I_B controls large I_C.

Mnemonic: *NPN: Not Pointing In (Arrow points out). Emitter Emits, Base Controls, Collector Collects.*

OR

5.4 Question 5(a) [3 marks]

Compare CB, CE and CC configuration of transistor.

5.4.1 Solution

Parameter	Common Base (CB)	Common Emitter (CE)	Common Collector (CC)
Input Res	Low	Medium	High
Output Res	High	Medium	Low
Current Gain	Low (< 1)	High (β)	High (γ)
Voltage Gain	High	High	Low (< 1)
Phase Shift	0	180 degrees	0
Used as	HF Apps	Audio Amp	Impedance Matching

Mnemonic: *CE is Best for Power/Audio (Universal). CC is Buffer. CB is HF.*

5.5 Question 5(b) [4 marks]

Explain transistor as a single stage common emitter amplifier.

5.5.1 Solution

Circuit: Uses an NPN transistor in CE mode with voltage divider biasing.

- **Biasing:** R_1, R_2 provide stable bias to Base.
- **Coupling Caps:** C_{in}, C_{out} block DC.
- **Bypass Cap:** C_E across R_E to prevent AC gain reduction.

Working:

- Small AC signal at Base fluctuates base current I_B.
- This causes large fluctuation in I_C (β times larger).
- Varying I_C flows through R_C to produce amplified voltage swing at output.
- Output is 180° phase shifted.

Mnemonic: *CE Amp: Small Signal In -¿ Large Inverted Signal Out.*

5.6 Question 5(c) [7 marks]

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

5.6.1 Solution

Circuit: Base is common to both input and output.

- Input applied between Emitter and Base.
- Output taken between Collector and Base.

Characteristics:

Input (I_E vs V_{EB}): Similar to diode. I_E increases rapidly for small V_{EB}.

Output (I_C vs V_{CB}): Almost horizontal lines. I_C depends mostly on I_E, independent of V_{CB} (Active region).

Current Gain (α): Ratio I_C/I_E. Always slight less than 1 (0.95 to 0.99).

Mnemonic: *CB: Current Gain ¡ 1, Voltage Gain High.*