

# Fundamentals of Electronics (DI01000051) - Winter 2024 Solution

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## Question 1(a) [3 marks]

Define Active and Passive Components with example.

### Solution

Answer:

Table 1. Active vs Passive Components

Component Type	Definition	Power	Examples
Active Components	Components that can amplify signals and control current flow	Can provide power gain	Transistor, Diode, IC
Passive Components	Components that cannot amplify signals	Cannot provide power gain	Resistor, Capacitor, Inductor

- **Active components:** Control and amplify electrical signals using external power
- **Passive components:** Store or dissipate energy without amplification

### Mnemonic

“Active Amplifies, Passive Preserves”

## Question 1(b) [4 marks]

Explain construction and working of LDR.

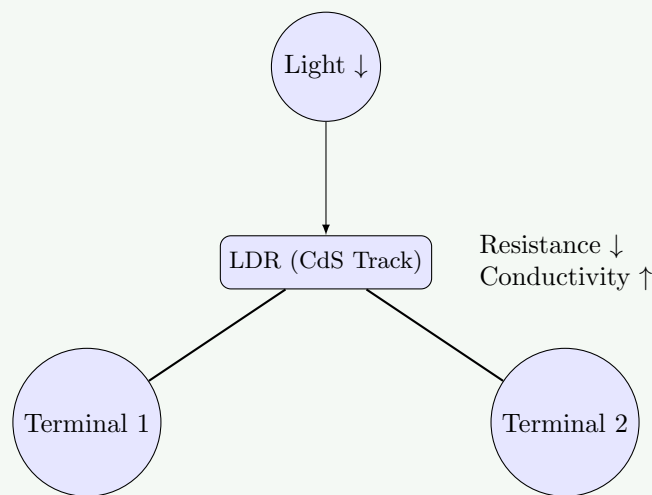
### Solution

Answer:

Construction:

- **Serpentine track** of cadmium sulfide on ceramic substrate
- **Metal electrodes** at both ends for connections
- **Protective coating** prevents moisture damage

Working Principle:



**Figure 1.** LDR Working

- **Light intensity ↑:** Resistance ↓ (conducts more)
- **Darkness:** Resistance ↑ (conducts less)
- **Applications:** Street lights, automatic cameras

#### Mnemonic

“Light Low Resistance”

## Question 1(c) [7 marks]

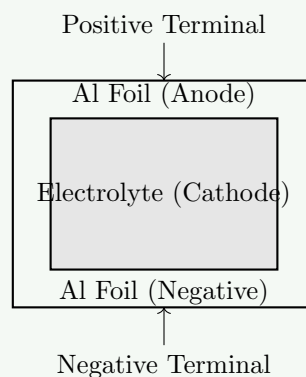
Define Capacitance and explain Aluminum Electrolytic wet type capacitor.

#### Solution

**Answer:**

**Capacitance Definition:** Ability to store electrical charge.  $C = Q/V$  (Farads)

**Aluminum Electrolytic Capacitor:**



**Figure 2.** Aluminum Electrolytic Capacitor

**Construction:**

- **Anode:** Aluminum foil with oxide layer
- **Dielectric:** Thin aluminum oxide film
- **Cathode:** Liquid electrolyte with aluminum foil
- **Polarity:** Must be connected correctly

**Features:**

- **High capacitance** values ( $1\mu\text{F}$  to  $10,000\mu\text{F}$ )
- **Polarized** - has positive and negative terminals
- **Applications:** Power supply filtering, coupling

### Mnemonic

“Aluminum Always Amplifies”

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

Explain the color band coding method of Resistor. Write color band of  $32\ \Omega \pm 10\%$  resistance.

### Solution

Answer:

Color Code Table:

Table 2. Resistor Color Code

Color	Digit	Multiplier	Tolerance
Black	0	1	-
Brown	1	10	$\pm 1\%$
Red	2	100	$\pm 2\%$
Orange	3	1K	-
Yellow	4	10K	-
Green	5	100K	$\pm 0.5\%$
Blue	6	1M	$\pm 0.25\%$
Violet	7	10M	$\pm 0.1\%$
Gray	8	100M	$\pm 0.05\%$
White	9	1G	-
Silver	-	0.01	$\pm 10\%$
Gold	-	0.1	$\pm 5\%$

For  $32\ \Omega \pm 10\%$ :

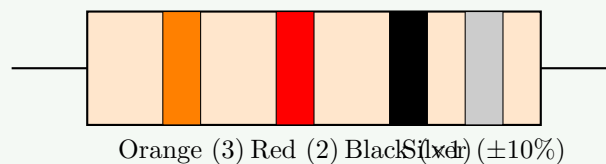


Figure 3. Resistor Color Code ( $32\ \Omega$ )

Calculation:  $3 \times 2 \times 1 = 32\ \Omega$

### Mnemonic

“Big Boys Race Our Young Girls But Violet Generally Wins”

## Question 2(a) [3 marks]

Define following terms: 1) Rectifier 2) Ripple factor 3) Filter

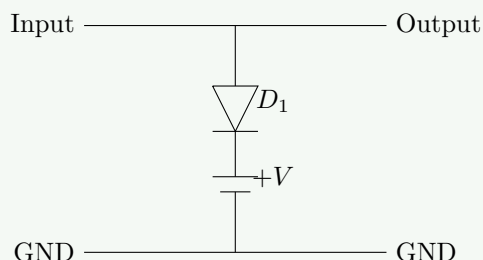
**Solution****Answer:****Table 3.** Rectifier Terms

Term	Definition
<b>Rectifier</b>	Circuit that converts AC to pulsating DC
<b>Ripple Factor</b>	Ratio of AC component to DC component in output
<b>Filter</b>	Circuit that smooths pulsating DC to pure DC

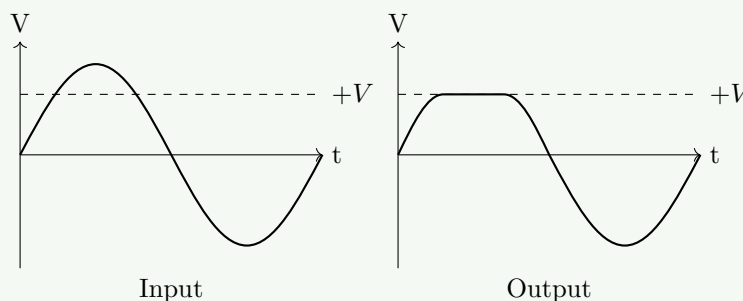
- **Rectifier:** Uses diodes to allow current in one direction
- **Ripple factor:** Lower value means better filtering
- **Filter:** Uses capacitors/inductors to reduce ripples

**Mnemonic**

“Rectify Ripples, Filter Fixes”

**Question 2(b) [4 marks]****Draw and explain positive clipper circuit with waveform.****Solution****Answer:****Circuit Diagram:****Figure 4.** Positive Clipper Circuit**Working:**

- When  $V_{in} > +V$ : Diode conducts, output =  $+V$
- When  $V_{in} < +V$ : Diode off, output follows input
- **Result:** Clips positive peaks above  $+V$  level

**Waveform:****Figure 5.** Clipper Waveforms**Applications:** Signal limiting, protection circuits

**Mnemonic**

“Positive Peaks Prevented”

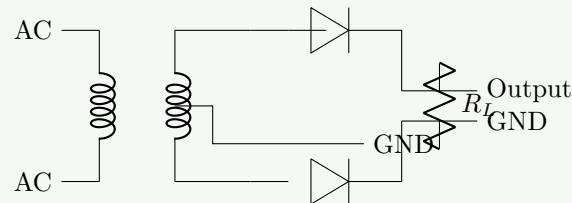
**Question 2(c) [7 marks]**

Explain working of full wave rectifier with two diodes.

**Solution**

**Answer:**

**Circuit Diagram:**



**Figure 6.** Full Wave Rectifier

**Working:**

- **Positive half-cycle:** D1 conducts, D2 off
- **Negative half-cycle:** D2 conducts, D1 off
- Both diodes work alternately
- **Output frequency** =  $2 \times$  input frequency

**Key Parameters:**

**Table 4.** FWR Parameters

Parameter	Value
Peak Inverse Voltage	$2V_m$
Efficiency	81.2%
Ripple Factor	0.48
Form Factor	1.11

**Advantages:**

- **Better efficiency** than half-wave
- **Lower ripple content**
- **Higher transformer utilization**

**Mnemonic**

“Two Diodes, Two Halves”

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

Define rectifier and write its applications.

**Solution**

**Answer:**

**Definition:** Electronic circuit that converts alternating current (AC) into direct current (DC) using diodes.

**Applications:**

Table 5. Rectifier Applications

Application	Use
Power Supplies	DC voltage for electronic circuits
Battery Chargers	Converting AC mains to DC
DC Motors	Providing DC for motor drives
Electronic Devices	Laptops, phones, LED drivers

- **Primary function:** AC to DC conversion
- **Essential component:** In all electronic devices

## Mnemonic

“Rectify AC, Deliver DC”

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

Explain working of Pi( $\pi$ ) type capacitor filter.

## Solution

Answer:

Circuit Diagram:

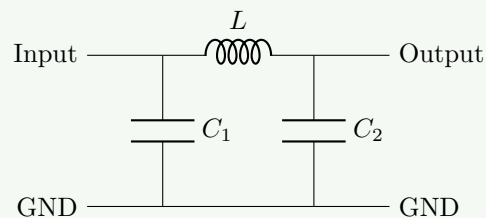


Figure 7. Pi Filter

Working:

- **C1:** Filters initial ripples from rectifier
- **Inductor L:** Opposes current changes, smooths further
- **C2:** Final filtering for smooth DC output
- **Combined effect:** Excellent ripple reduction

Characteristics:

Table 6. Pi Filter Characteristics

Parameter	Value
Ripple Factor	Very low ( $< 0.01$ )
Regulation	Good
Cost	Higher due to inductor
Applications	High-quality power supplies

Advantages:

- **Excellent filtering** performance
- **Low ripple** content
- **Good voltage regulation**

**Mnemonic**

“Pi Provides Perfect”

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

Compare half wave and full wave bridge rectifier.

**Solution**

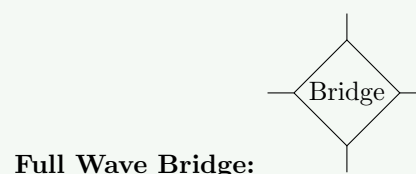
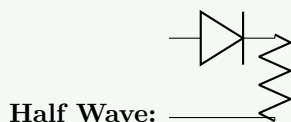
Answer:

Comparison Table:

Table 7. HWR vs FWR Bridge

Parameter	Half Wave	Full Wave Bridge
Diodes Required	1	4
Transformer	Simple	No center-tap needed
Efficiency	40.6%	81.2%
Ripple Factor	1.21	0.48
PIV	$V_m$	$V_m$
Output Frequency	$f$	$2f$
Transformer Utilization	28.7%	81.2%
Cost	Low	Moderate

Circuit Diagrams:

**Mnemonic**

“Half Wastes, Full Works”

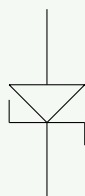
**Question 3(a) [3 marks]**

Draw the symbols of following: 1) Zener diode 2) LED 3) Varactor diode

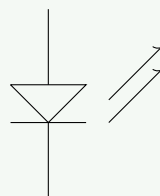
**Solution**

Answer:

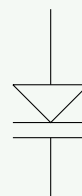
Zener Diode



LED



Varactor



**Figure 8.** Diode Symbols**Symbol Details:**

- **Zener Diode:** Normal diode with Z-shaped cathode
- **LED:** Diode with arrows showing light emission
- **Varactor Diode:** Diode with parallel lines (variable capacitor)

**Mnemonic**

“Zener Zigs, LED Lights, Varactor Varies”

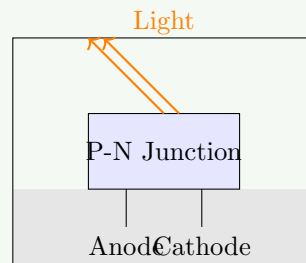
**Question 3(b) [4 marks]**

Explain construction and working of LED.

**Solution**

**Answer:**

**Construction:**

**Figure 9.** LED Construction**Materials:**

- **P-type:** Boron-doped semiconductor
- **N-type:** Phosphorus-doped semiconductor
- **Common materials:** GaAs, GaP, GaN

**Working Principle:**

- **Forward bias:** Electrons recombine with holes
- **Energy release:** In form of photons (light)
- **Color:** Depends on semiconductor material and bandgap
- **Efficiency:** High light output with low power

**Applications:**

- **Indicators:** Status lights, displays
- **Lighting:** LED bulbs, strips
- **Electronics:** Seven-segment displays

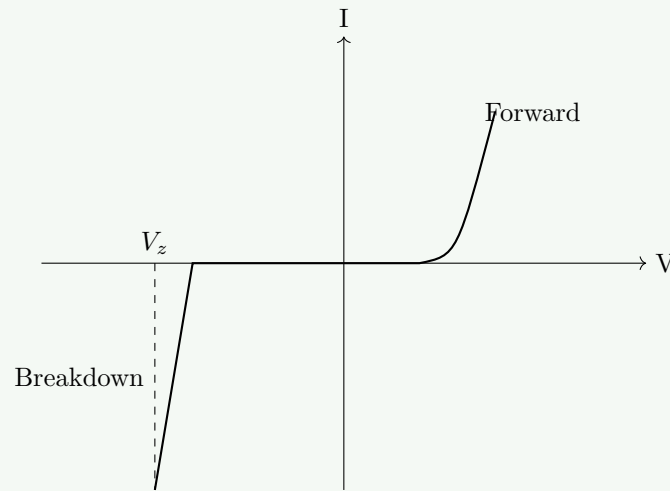
**Mnemonic**

“Light Emitting, Energy Efficient”

**Question 3(c) [7 marks]**

Explain working characteristics of Zener diode.



**Solution****Answer:****V-I Characteristics:****Figure 10.** Zener V-I Characteristics**Key Regions:****Table 8.** Zener Regions

Region	Characteristics
<b>Forward Bias</b>	Normal diode operation (0.7V)
<b>Reverse Bias</b>	Small leakage current
<b>Zener Region</b>	Constant voltage ( $V_z$ )
<b>Breakdown</b>	Sharp voltage breakdown

**Important Parameters:**

- **Zener Voltage ( $V_z$ ):** Breakdown voltage
- **Zener Current ( $I_z$ ):** Current in breakdown region
- **Maximum Power:**  $V_z \times I_{z(max)}$
- **Temperature coefficient:** Voltage variation with temperature

**Applications:**

- **Voltage regulation:** Maintains constant output
- **Reference voltage:** Precise voltage source
- **Overvoltage protection:** Protects circuits

**Mnemonic**

“Zener Zones Zero variation”

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

Enlist the applications of varactor diode.

**Solution****Answer:****Applications Table:**

**Table 9.** Varactor Applications

Application	Function
<b>Voltage Controlled Oscillators</b>	Frequency tuning with voltage
<b>Automatic Frequency Control</b>	Maintains oscillator frequency
<b>Electronic Tuning</b>	Radio/TV channel selection
<b>Phase Locked Loops</b>	Frequency synchronization
<b>Frequency Multipliers</b>	Harmonic generation
<b>Parametric Amplifiers</b>	Low-noise amplification

**Key Features:**

- **Voltage variable:** Capacitance changes with reverse voltage
- **No mechanical parts:** Electronic tuning only
- **Fast response:** Quick frequency changes

**Mnemonic**

“Voltage Varies Capacitance”

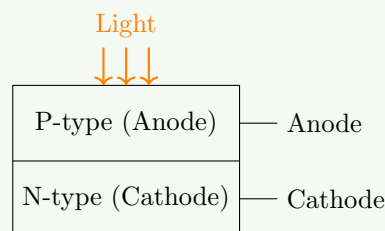
**Question 3(b OR) [4 marks]**

Explain working of photo diode.

**Solution**

**Answer:**

**Construction & Symbol:**

**Figure 11.** Photo Diode**Working Principle:**

- **Light absorption:** Creates electron-hole pairs
- **Reverse bias:** Widens depletion region
- **Photocurrent:** Proportional to light intensity
- **Fast response:** Quick detection capability

**Characteristics:****Table 10.** Photo Diode Params

Parameter	Description
<b>Dark Current</b>	Current without light
<b>Photocurrent</b>	Current proportional to light
<b>Responsivity</b>	Current per unit light power
<b>Response Time</b>	Speed of detection

**Applications:**

- **Light sensors:** Automatic lighting systems

- **Optical communication:** Fiber optic receivers
- **Safety systems:** Smoke detectors
- **Solar panels:** Light to electrical energy

### Mnemonic

“Photo Produces Proportional current”

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

Explain Zener diode as a voltage regulator.

### Solution

Answer:

Voltage Regulator Circuit:

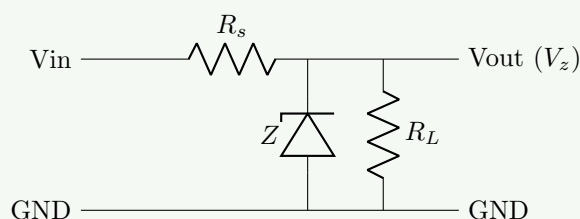


Figure 12. Zener Regulator

Working Principle:

- Zener operates in breakdown region
- Output voltage remains constant at  $V_z$
- Series resistor  $R_s$  limits current
- Load changes don't affect output voltage

Design Equations:

Table 11. Design Equations

Parameter	Formula
Series Resistance	$R_s = (V_{in} - V_z)/I_z$
Load Current	$I_L = V_z/R_L$
Zener Current	$I_z = I_s - I_L$
Power Dissipation	$P_z = V_z \times I_z$

Regulation Characteristics:

- **Line regulation:** Output change with input variation
- **Load regulation:** Output change with load variation
- **Efficiency:** Generally low due to Zener power loss

Advantages:

- **Simple circuit:** Few components required
- **Good regulation:** Stable output voltage
- **Fast response:** Quick voltage correction

Limitations:

- **Poor efficiency:** Power wasted in Zener
- **Limited current:** Cannot supply high currents
- **Temperature sensitivity:** Voltage varies with temperature

Applications:

- **Reference voltage:** Precise voltage source

- **Simple regulators:** Low current applications
- **Protection circuits:** Overvoltage protection

### Mnemonic

“Zener Zones provide Zero variation”

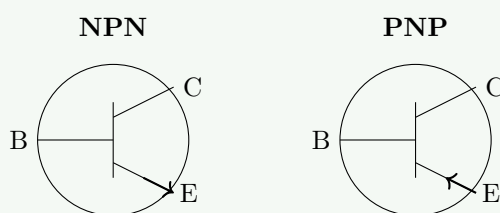
## Question 4(a) [3 marks]

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

### Solution

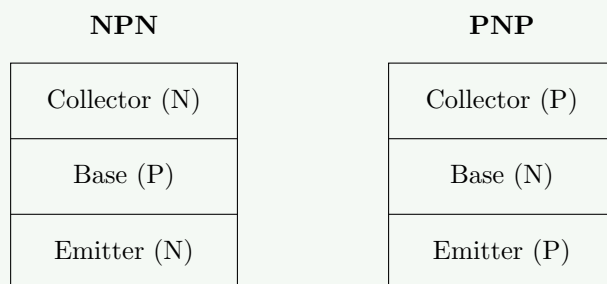
**Answer:**

**Transistor Symbols:**



**Figure 13.** Transistor Symbols

**Construction Diagrams:**



**Figure 14.** Transistor Construction

**Terminal Identification:**

- **Emitter:** Heavily doped, arrow shows current direction
- **Base:** Thin, lightly doped middle region
- **Collector:** Moderately doped, collects charge carriers

**Current Direction:**

- **NPN:** Arrow points outward (emitter to base – wait, base to emitter current, but arrow on emitter points OUT)
- **PNP:** Arrow points inward (emitter to base)

### Mnemonic

“NPN: Not Pointing iN, PNP: Pointing iN Please”

## Question 4(b) [4 marks]

Draw and Explain characteristics of CE amplifier.

## Solution

Answer:

CE Amplifier Circuit:

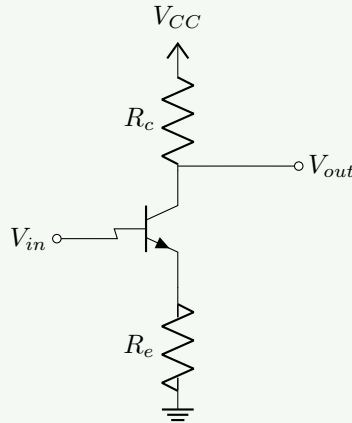


Figure 15. CE Circuit

Input Characteristics ( $I_B$  vs  $V_{BE}$ ):

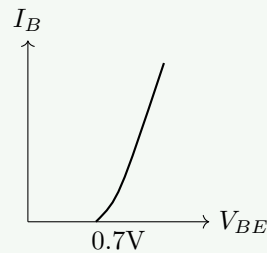


Figure 16. Input Char.

Output Characteristics ( $I_C$  vs  $V_{CE}$ ):

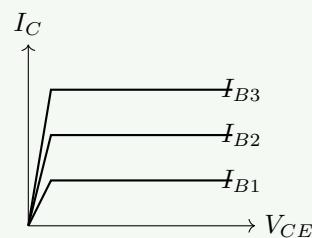


Figure 17. Output Char.

Key Features:

Table 12. CE Config

Parameter	CE Configuration
Current Gain	$\beta = I_C/I_B$ (high)
Voltage Gain	High
Power Gain	Very high
Input Impedance	Medium
Output Impedance	High
Phase Shift	$180^\circ$

Regions of Operation:

- **Cut-off:** Both junctions reverse biased
- **Active:** BE forward, BC reverse biased
- **Saturation:** Both junctions forward biased

### Mnemonic

“Common Emitter, Current Enlarged”

## Question 4(c) [7 marks]

Derive relation between current gains  $\alpha$ ,  $\beta$  and  $\gamma$ .

### Solution

**Answer:**

**Current Gain Definitions:**

**Table 13.** Gain Definitions

Gain	Configuration	Formula
$\alpha$ ( <b>Alpha</b> )	Common Base	$\alpha = I_C/I_E$
$\beta$ ( <b>Beta</b> )	Common Emitter	$\beta = I_C/I_B$
$\gamma$ ( <b>Gamma</b> )	Common Collector	$\gamma = I_E/I_B$

**Derivation:**

**Step 1: Basic Current Relation**  $I_E = I_B + I_C$  ... (Kirchhoff's Current Law)

**Step 2: Express  $I_C$  in terms of  $I_E$**   $\alpha = I_C/I_E$  Therefore:  $I_C = \alpha I_E$  ... (1)

**Step 3: Substitute in current equation**  $I_E = I_B + \alpha I_E$

$$I_E - \alpha I_E = I_B$$

$$I_E(1 - \alpha) = I_B$$

$$I_E = I_B/(1 - \alpha) \dots (2)$$

**Step 4: Find  $\beta$**   $\beta = I_C/I_B$

$$\text{From (1): } I_C = \alpha I_E$$

$$\text{From (2): } I_E = I_B/(1 - \alpha)$$

$$\text{Therefore: } I_C = \alpha I_B/(1 - \alpha)$$

**Step 5: Final relation for  $\beta$**   $\beta = I_C/I_B = \alpha/(1 - \alpha) \dots (3)$

**Step 6: Express  $\alpha$  in terms of  $\beta$**  From equation (3):

$$\beta(1 - \alpha) = \alpha$$

$$\beta - \beta\alpha = \alpha$$

$$\beta = \alpha + \beta\alpha = \alpha(1 + \beta)$$

$$\text{Therefore: } \alpha = \beta/(1 + \beta) \dots (4)$$

**Step 7: Find  $\gamma$**   $\gamma = I_E/I_B$

$$\text{From (2): } \gamma = 1/(1 - \alpha)$$

Substituting  $\alpha$  from (4):

$$\gamma = 1/(1 - \beta/(1 + \beta))$$

$$\gamma = (1 + \beta)/(1 + \beta - \beta)$$

$$\gamma = 1 + \beta \dots (5)$$

**Final Relations:**

- $\beta = \alpha/(1 - \alpha)$
- $\alpha = \beta/(1 + \beta)$
- $\gamma = 1 + \beta$

**Typical Values:**

- $\alpha \approx 0.98$  to  $0.995$
- $\beta \approx 50$  to  $200$
- $\gamma \approx 51$  to  $201$

**Mnemonic**

“Alpha Beta Gamma, Always Better Gains”

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

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

**Solution**

**Answer:**

**Operating Regions:**

**Table 14.** Operating Regions

Region	Base-Emitter	Base-Collector	Characteristics
<b>Active</b>	Forward Biased	Reverse Biased	Amplification region
<b>Saturation</b>	Forward Biased	Forward Biased	Switch ON state
<b>Cut-off</b>	Reverse Biased	Reverse Biased	Switch OFF state

**Detailed Description:**

- **Active:**  $I_C = \beta I_B$ , Linear operation
- **Saturation:** Max current,  $V_{CE} \approx 0.2V$ , Switch ON
- **Cut-off:**  $I_B = 0, I_C = 0$ , Open switch

**Mnemonic**

“Active Amplifies, Saturated Switches, Cut-off Cuts”

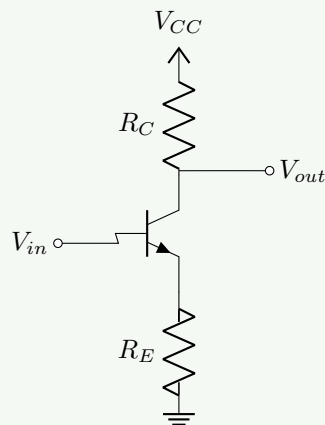
**Question 4(b OR) [4 marks]**

Explain working of Transistor as an amplifier.

**Solution**

**Answer:**

**Amplifier Circuit:**



**Figure 18.** CE Amplifier

**Working Principle:**

- **Small input signal** applied to base-emitter
- **Input resistance** is low
- **Small base current** controls large collector current
- **Output taken** from collector-emitter
- **Current amplification:**  $I_C = \beta I_B$

**Key Features:**

- **Current gain:**  $\beta$  (50-200)
- **Voltage gain:** High
- **Power gain:** Product of current and voltage gains
- **Phase inversion:**  $180^\circ$

**Mnemonic**

“Tiny signal Triggers Tremendous output”

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

Compare CB, CC, and CE amplifier configuration.

**Solution**

**Answer:**

**Comprehensive Comparison:**

**Table 15.** Amp Comparison

Parameter	Common Base	Common Emitter	Common Collector
<b>Input Terminal</b>	Emitter	Base	Base
<b>Output Terminal</b>	Collector	Collector	Emitter
<b>Common Terminal</b>	Base	Emitter	Collector
<b>Current Gain</b>	$\alpha < 1$	$\beta \gg 1$	$\gamma = (1 + \beta)$
<b>Voltage Gain</b>	High	High	$< 1$ ( $\approx 1$ )
<b>Power Gain</b>	Medium	Very High	Medium
<b>Input Resistance</b>	Low (20-50 $\Omega$ )	Medium (1-5k $\Omega$ )	High (100k $\Omega$ )
<b>Output Resistance</b>	High (1M $\Omega$ )	High (50k $\Omega$ )	Low (25 $\Omega$ )
<b>Phase Shift</b>	$0^\circ$	$180^\circ$	$0^\circ$

**Selection Criteria:**

- **High Frequency:** CB (Excellent freq response)
- **General Amplification:** CE (Max power gain)
- **Buffer/Isolation:** CC (High input, low output impedance)

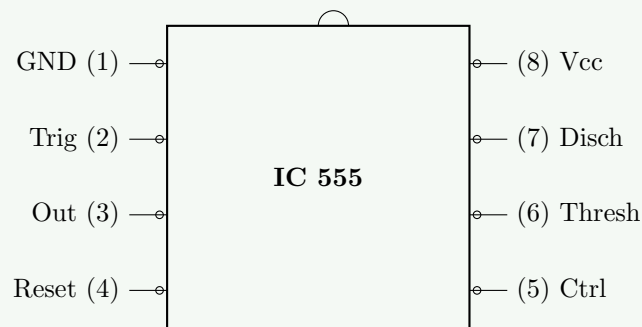
**Mnemonic**

“CB for Communication, CE for Common use, CC for Coupling”

**Question 5(a) [3 marks]**

Draw the pin diagram of IC 555.



**Solution****Answer:****IC 555 Pin Diagram:****Figure 19. IC 555 Pinout****Pin Functions:**

- **1 GND:** 0V reference
- **2 Trigger:** Start timing
- **3 Output:** Signal out
- **4 Reset:** Active low reset
- **5 Control:** Voltage reference
- **6 Threshold:** End timing
- **7 Discharge:** Capacitor discharge
- **8 Vcc:** Supply (5-18V)

**Mnemonic**

“Great Timer, Great Pins”

**Question 5(b) [4 marks]****List out Features of 555 Timer IC.****Solution****Answer:****Key Features:****Table 16. 555 Features**

Feature	Specification
<b>Supply Voltage</b>	5V to 18V
<b>Output Current</b>	200mA source/sink
<b>Temperature Range</b>	0°C to 70°C
<b>Timing Range</b>	μs to hours
<b>Accuracy</b>	±1% typical
<b>Modes</b>	Monostable, Astable, Bistable

**Technical Features:**

- **CMOS/TTL compatible**
- **High current capability**
- **Temperature stable**

**Mnemonic**

“Fantastic Features, Flexible Functions”

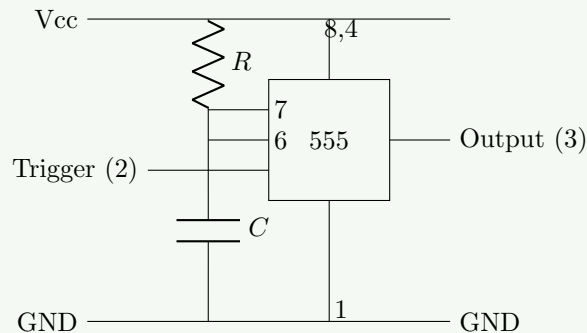
**Question 5(c) [7 marks]**

Explain Mono stable multivibrator using 555 timer IC.

**Solution**

**Answer:**

**Monostable Circuit:**



**Figure 20.** Monostable Circuit

**Working Principle:**

- **Stable State:** Output LOW, Capacitor discharged
- **Triggered:** Pulse on pin 2 -> Output HIGH, C charges through R
- **Timing:**  $T = 1.1RC$
- **Return:** When  $V_c \geq 2/3V_{cc}$ , Output LOW, C discharges

**Applications:**

- Pulse generation, Time delays, Missing pulse detection

**Mnemonic**

“Mono means One pulse Only”

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

List out applications of IC 555.

**Solution**

**Answer:**

**Timer Applications:**

**Table 17.** 555 Applications

Category	Applications
Timing Circuits	Delay timers, Pulse generators
Oscillators	Clock generators, Frequency dividers
Control Circuits	PWM controllers, Motor speed control
Detection	Missing pulse detectors, Alarms
Automotive	Indicators, Wipers

Common Projects:

- Electronic dice, Traffic lights, Digital clocks

#### Mnemonic

“Timer for Tremendous Tasks”

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

Draw and explain the internal block diagram of IC 555.

#### Solution

Answer:

Internal Block Diagram:

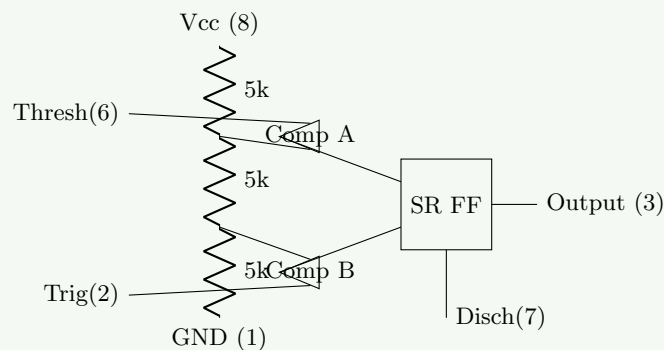


Figure 21. Internal Block Diagram

Block Functions:

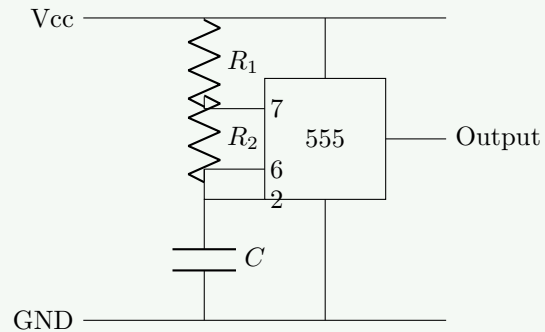
- **Voltage Divider:** Sets  $2/3 V_{cc}$  and  $1/3 V_{cc}$
- **Comparators:** Compare inputs with references
- **Flip-Flop:** Controlled by comparators
- **Output Buffer:** Drive load
- **Discharge Transistor:** Discharges external C

#### Mnemonic

“Internal Intelligence, Integrated Implementation”

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

Explain astable multivibrator using 555 timer IC.

**Solution****Answer:****Astable Circuit:****Figure 22.** Astable Circuit**Working Principle:**

- **Charging:** C charges via  $R_1 + R_2$  (Output HIGH)
- **Discharging:** C discharges via  $R_2$  (Output LOW)
- **Oscillation:** Cycles between  $1/3 V_{cc}$  and  $2/3 V_{cc}$

**Frequency Calculations:**

- $T_1 = 0.693(R_1 + R_2)C$  (High)
- $T_2 = 0.693R_2C$  (Low)
- $f = 1.44 / ((R_1 + 2R_2)C)$
- **Duty Cycle**  $> 50\%$

**Applications:** LED flashers, Clock generators, Tone generators**Mnemonic**

“Astable Always Alternates Automatically”