

# Fundamentals of Electronics

DI01000051 – Winter 2024

Semester 1 Study Material

*Detailed Solutions and Explanations*

## Question 1(a) [3 marks]

Define Active and Passive Components with example.

### Answer

Table: Active vs Passive Components

Type	Definition	Examples
Active	Components that can amplify signals and control current flow. Can provide power gain.	Transistor, Diode, IC, SCR
Passive	Components that cannot amplify signals. Consumes, stores, or releases energy.	Resistor, Capacitor, Inductor

**Key Difference:** Active components require an external power source to operate; passive components do not.

### Mnemonic

“Active Amplifies, Passive Preserves”

## Question 1(b) [4 marks]

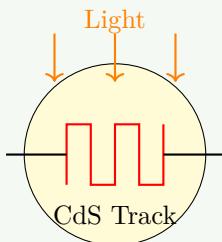
Explain construction and working of LDR.

### Answer

#### Construction:

- Made of high resistance semiconductor material like Cadmium Sulfide (CdS).
- Material is deposited as a zig-zag (serpentine) track on a ceramic substrate to maximize length and reduce area.
- Encased in plastic/resin with a clear window.

#### Diagram:



#### Working Principle (Photo-conductivity):

1. **Dark:** High Resistance ( $M\Omega$  range). Few free carriers.
2. **Light:** Light energy breaks bonds, creating electron-hole pairs.
3. Conductivity increases → Resistance decreases ( $k\Omega$  range).

### Mnemonic

“Light Low Resistance”

## Question 1(c) [7 marks]

Define Capacitance and explain Aluminum Electrolytic wet type capacitor.

### Answer

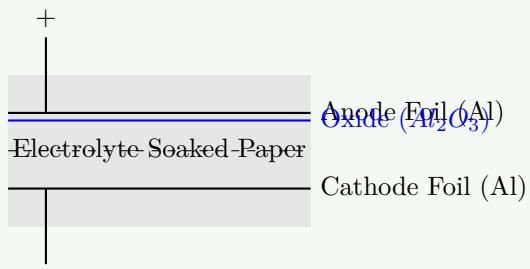
**Capacitance:** The ability of a system to store an electric charge.  $C = Q/V$  (Unit: Farad).

**Aluminum Electrolytic Capacitor:**

- **Construction:**

- **Anode (+):** Pure aluminum foil with a thin oxide layer ( $Al_2O_3$ ) acting as dielectric.
- **Cathode (-):** Second aluminum foil in contact with electrolyte.
- **Electrolyte:** Conductive liquid/gel soaked paper separator.

**Diagram:**



**Features:** High capacitance density, Polarized (must connect correctly), used in power supply filtering.

### Mnemonic

“Aluminum Always Amplifies (Capacitance)”

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

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

### Answer

**Color Code Table:**

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

**Calculation for  $32 \Omega \pm 10\%$ :**

- Value:  $32 = 32 \times 10^0$  or better  $32 \times 1$ .
- Wait, standard bands usually form digit, digit, multiplier.
- $32\Omega = 3$  (Orange), 2 (Red)  $\times 1$  (Black)? No,  $32 \times 1$ .
- Actually, for low values, gold/silver multipliers are used often. But 32 fits standard:
- 1st Digit: 3 → Orange
- 2nd Digit: 2 → Red
- Multiplier:  $10^0 = 1$  → Black
- Tolerance:  $\pm 10\% \rightarrow$  Silver
- Bands: Orange - Red - Black - Silver

Note: The provided MDX used Gold/Silver multiplier example (3, 2, 0.1).  $32 \times 0.1 = 3.2\Omega$ . For  $32\Omega$ , it should be Black (x1). Let's stick to standard calculation: 3, 2,  $x10^0$ .

### Mnemonic

“BBROYGBVGVW” (Black Brown Red Orange Yellow Green Blue Violet Gray White)

## Question 2(a) [3 marks]

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

### Answer

- Rectifier:** An electronic circuit that converts alternating current (AC) into pulsating direct current (DC).
- Ripple Factor:** The ratio of the RMS value of the AC component to the DC component in the rectifier output.  $\gamma = V_{ac,rms}/V_{dc}$ . Low is better.
- Filter:** A circuit used to remove AC components (ripples) from the pulsating DC output of a rectifier to produce smooth DC.

### Mnemonic

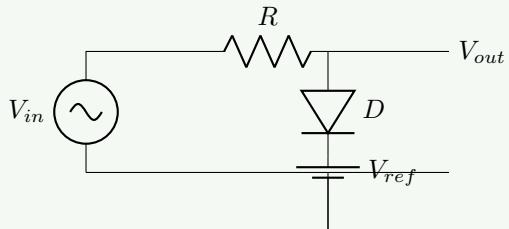
“Rectify Ripples, Filter Fixes”

## Question 2(b) [4 marks]

Draw and explain positive clipper circuit with waveform.

### Answer

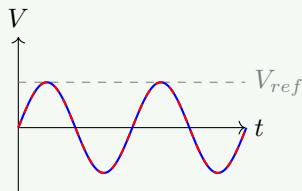
Circuit Diagram:



### Working:

- When  $V_{in} < V_{ref} + 0.7V$ , diode is reverse biased (OPEN).  $V_{out} = V_{in}$ .
- When  $V_{in} > V_{ref} + 0.7V$ , diode is forward biased (SHORT).  $V_{out}$  is clipped at  $V_{ref}$  (ignoring diode drop).

### Waveform:

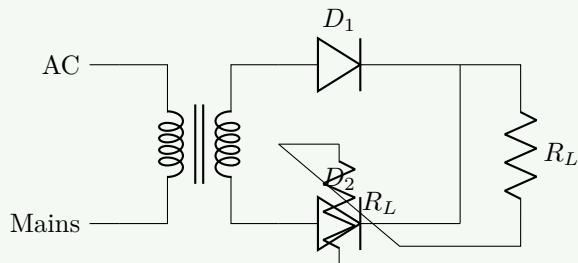


## Question 2(c) [7 marks]

Explain working of full wave rectifier with two diodes.

### Answer

Center-Tapped Full Wave Rectifier:



(Simplified drawing description for mental model: Center tap is ground reference. D1 and D2 feed RL).

Working:

- Positive Half Cycle: Top of secondary positive. D<sub>1</sub> conducts, D<sub>2</sub> off. Current flows through R<sub>L</sub>.
- Negative Half Cycle: Bottom of secondary positive. D<sub>2</sub> conducts, D<sub>1</sub> off. Current flows through R<sub>L</sub> in same direction.

Result: Output is unidirectional pulsating DC with frequency 2f. Efficiency  $\eta = 81.2\%$ .

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

Define rectifier and write its applications.

### Answer

**Definition:** Device converting AC to DC.

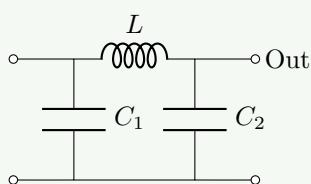
**Applications:**

- DC Power supplies for electronic devices (TV, Computers).
- Battery Charging circuits.
- DC Motor drives.
- Detection of radio signals (demodulation).

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

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

### Answer



Working:

- C<sub>1</sub>: Bypasses most AC ripples to ground (low reactance to AC).
- L: Blocks AC components (high reactance) while passing DC.
- C<sub>2</sub>: Bypasses any remaining AC ripples.
- Result: Very smooth DC output. Known as CLC filter.

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

Compare half wave and full wave bridge rectifier.

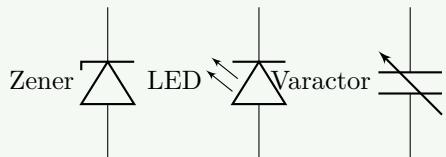
### Answer

Parameter	Half Wave	Bridge Rectifier
No. of Diodes	1	4
Transformer	Basic	Basic (No center tap needed)
Efficiency	40.6%	81.2%
Ripple Factor	1.21	0.48
PIV Rating	$V_m$	$V_m$
Fout	$f_{in}$	$2f_{in}$

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

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

### Answer



Note: Varactor symbol is a diode combined with a capacitor.

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

Explain construction and working of LED.

### Answer

**Construction:** PN junction made from compound semiconductors (GaAs, GaP) instead of Si/Ge. Transparent casing.

**Working:**

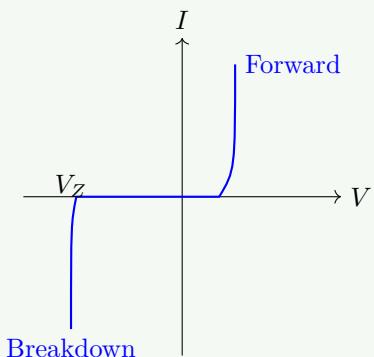
- Operates in **Forward Bias**.
- Electrons from N-side recombine with holes in P-side.
- Energy released during recombination is emitted as photons (Light).
- Color depends on band gap energy of material.

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

Explain working characteristics of Zener diode.

### Answer

**V-I Characteristics:**



**Regions:**

- **Forward:** Acts like normal diode.
- **Reverse:** Blocks current until breakdown voltage  $V_Z$ .
- **Breakdown:** Current increases sharply while voltage remains constant at  $V_Z$ . This property is used for voltage regulation.

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

Enlist the applications of varactor diode.

**Answer**

- FM Radio transmitters (Modulation).
- TV Receivers (Electronic Tuning).
- Voltage Controlled Oscillators (VCOs).
- Adjustable Bandpass Filters.

**Principle:** Acts as a voltage-variable capacitor in reverse bias.

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

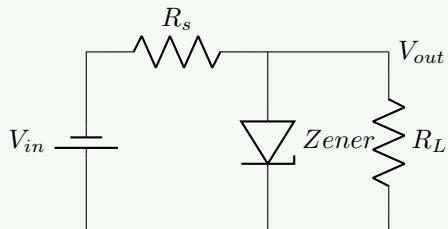
Explain working of photo diode.

**Answer****Working:**

- Operates in **Reverse Bias**.
- When light falls on junction, energy breaks bonds creating electron-hole pairs.
- These carriers are swept by electric field, creating a **Reverse Current**.
- Current is proportional to Light Intensity.

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

Explain Zener diode as a voltage regulator.

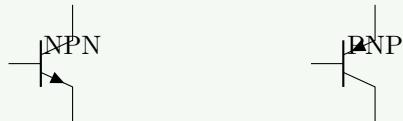
**Answer****Circuit:****Operation:**

- Zener connected in parallel with load, in reverse breakdown mode.
- If  $V_{in}$  increases, Zener current  $I_z$  increases, increasing drop across  $R_s$ , keeping  $V_{out}$  ( $= V_z$ ) constant.
- If  $I_L$  changes,  $I_z$  adjusts to keep total current and drop across  $R_s$  such that  $V_{out}$  remains stable.

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

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

### Answer



### Construction:

- **NPN:** P-type base sandwiched between N-type collector/emitter.
- **PNP:** N-type base sandwiched between P-type collector/emitter.

## Question 4(b) [4 marks]

Draw and Explain characteristics of CE amplifier.

### Answer

#### Characteristics:

1. **Input:**  $I_B$  vs  $V_{BE}$  (constant  $V_{CE}$ ). Looks like Forward Diode curve.
2. **Output:**  $I_C$  vs  $V_{CE}$  (constant  $I_B$ ). Similar to FET curves but controlled by  $I_B$ .
  - **Active:**  $I_C$  constant for given  $I_B$ .
  - **Saturation:**  $V_{CE}$  very low,  $I_C$  rises fast.
  - **Cutoff:**  $I_B = 0, I_C = 0$ .

## Question 4(c) [7 marks]

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

### Answer

Defs:  $\alpha = I_C/I_E$ ,  $\beta = I_C/I_B$ ,  $\gamma = I_E/I_B$ . We know  $I_E = I_B + I_C$ .

1.  **$\beta$  vs  $\alpha$ :** Divide by  $I_C$ :  $I_E/I_C = I_B/I_C + 1$   $1/\alpha = 1/\beta + 1 \Rightarrow 1/\alpha = (1 + \beta)/\beta$   $\alpha = \beta/(1 + \beta)$  OR  $\beta = \alpha/(1 - \alpha)$ .
2.  **$\gamma$  vs  $\alpha$ :**  $I_E = I_B + I_C \Rightarrow I_E = I_B + \alpha I_E$   $I_E(1 - \alpha) = I_B \Rightarrow I_E/I_B = 1/(1 - \alpha)$   $\gamma = 1/(1 - \alpha)$ .
3.  **$\gamma$  vs  $\beta$ :**  $\gamma = 1 + \beta$  (since  $\gamma = I_E/I_B = (I_C + I_B)/I_B = \beta + 1$ ).

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

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

### Answer

#### Operating Regions:

Region	Base-Emitter	Base-Collector	State
<b>Active</b>	Forward	Reverse	Amplification
<b>Saturation</b>	Forward	Forward	Switch ON
<b>Cut-off</b>	Reverse	Reverse	Switch OFF

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

Explain working of Transistor as an amplifier.

### Answer

#### Working Principle:

1. Transistor biased in **Active Region**.

2. Small AC signal applied to Base-Emitter (Low resistance).
3. Small change in Base connection causes Large change in Collector current ( $I_C = \beta I_B$ ).
4. Output taken across high load resistance at Collector.
5. **Result:** Large amplified voltage/power at output.

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

Compare CB, CC, and CE amplifier configuration.

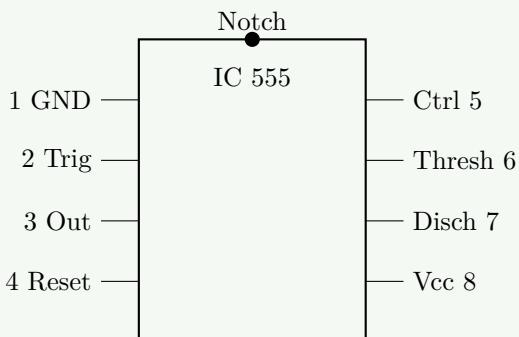
**Answer**

Parameter	Common Base	Common Emitter	Common Collector
<b>In/Out</b>	Emitter/Collector	Base/Collector	Base/Emitter
<b>Input <math>R_{in}</math></b>	Very Low	Medium	Very High
<b>Output <math>R_{out}</math></b>	Very High	Medium	Very Low
<b>Current Gain</b>	$< 1 (\alpha)$	High ( $\beta$ )	High ( $\gamma$ )
<b>Voltage Gain</b>	High	High	$\approx 1$
<b>Phase Shift</b>	$0^\circ$	$180^\circ$	$0^\circ$
<b>Application</b>	RF, HF Apps	Audio/Voltage Amp	Buffer/Matching

## Question 5(a) [3 marks]

Draw the pin diagram of IC 555.

**Answer**



## Question 5(b) [4 marks]

List out Features of 555 Timer IC.

**Answer**

- **Supply Voltage:** 5V to 18V DC.
- **Current Capability:** Can sink or source up to 200 mA.
- **Timing:** Microseconds to Hours.
- **Modes:** Monostable (One-shot) and Astable (Oscillator).
- **Stability:** High temperature stability ( $\approx 0.005\%/\text{ }^\circ\text{C}$ ).
- **Compatibility:** TTL and CMOS compatible.

## Question 5(c) [7 marks]

Explain Mono stable multivibrator using 555 timer IC.

### Answer

**Circuit:** Resistor  $R$  and Capacitor  $C$  connected. Pin 6 & 7 shorted and connected to RC junction. Trigger at Pin 2.

#### Working:

- Stable state: Output Low.
- Trigger (neg pulse) at pin 2 sets Flip-Flop. Output High. Discharge transistor OFF.
- Capacitor  $C$  charges via  $R$ .
- When  $V_c$  reaches  $2/3V_{cc}$ , threshold comparator resets Flip-Flop.
- Output Low. Capacitor discharges.
- **Pulse Width:**  $T = 1.1RC$ .

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

List out applications of IC 555.

### Answer

1. **Timers:** Delay circuits, precision timing.
2. **Pulse Generation:** Square wave generation, PWM.
3. **Oscillators:** Tone generators, clocks.
4. **Others:** Missing pulse detector, Frequency divider, Traffic light controller.

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

Draw and explain the internal block diagram of IC 555.

### Answer

#### Blocks:

- Voltage Divider (5k-5k-5k): Sets 1/3 and 2/3 Vcc.
- Comparators (2): Check Trigger and Threshold.
- SR Flip-Flop: Stores state.
- Discharge Transistor: Discharges timing cap.
- Output Driver: High current output.

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

Explain astable multivibrator using 555 timer IC.

### Answer

**Circuit:** Pins 2 & 6 shorted. Resistors  $R_A$ ,  $R_B$  and Capacitor  $C$ . **Working:**

- Charge: Through  $R_A + R_B$ . Time  $t_{high} = 0.693(R_A + R_B)C$ .
- Discharge: Through  $R_B$ . Time  $t_{low} = 0.693R_B C$ .
- Output oscillates between High and Low (Square wave).
- **Frequency:**  $f = 1.44 / ((R_A + 2R_B)C)$ .