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.

Solution

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]

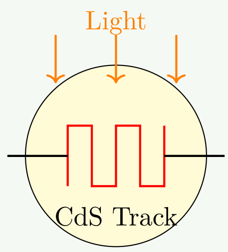
Explain construction and working of LDR.

Solution

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 (MΩ range). Few free carriers.
2. **Light**: Light energy breaks bonds, creating electron-hole pairs.
3. Conductivity increases → Resistance decreases (kΩ range).

Mnemonic

"Light Low Resistance"

Question 1(c) [7 marks]

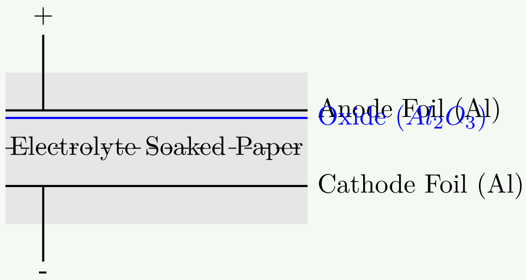
Define Capacitance and explain Aluminum Electrolytic wet type capacitor.

Solution

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 32Ω ±10% resistance.

Solution

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 Ω ± 10%:

- Value: $32 = 32 \times 10^0$ or better 32×1.
- Wait, standard bands usually form digit, digit, multiplier.
- $32\Omega = 3$ (Orange), 2 (Red) $\times$ 1 (Black)? No, 32×1.
- 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: ±10% → **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 32Ω, it should be Black (x1). Let's stick to standard calculation: $3, 2, x10^0$.

Mnemonic

"BBROYGBVGW" (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

Solution

1. **Rectifier**: An electronic circuit that converts alternating current (AC) into pulsating direct current (DC).
2. **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.
3. **Filter**: A circuit used to remove AC components (ripples) from the pulsating DC output of a rectifier to produce smooth DC.

Mnemonic

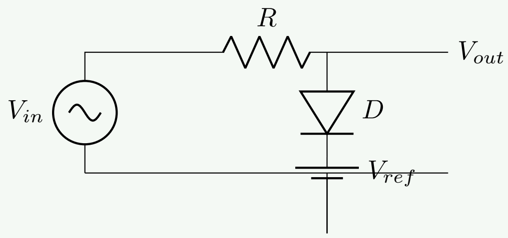
"Rectify Ripples, Filter Fixes"

Question 2(b) [4 marks]

Draw and explain positive clipper circuit with waveform.

Solution

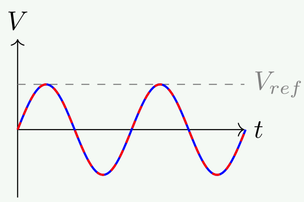
Circuit Diagram:



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:

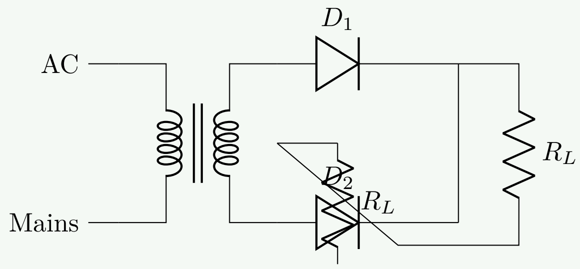


Question 2(c) [7 marks]

Explain working of full wave rectifier with two diodes.

Solution

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_1 conducts, D_2 off. Current flows through R_L.
- **Negative Half Cycle**: Bottom of secondary positive. D_2 conducts, D_1 off. Current flows through R_L 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.

Solution

Definition: Device converting AC to DC.

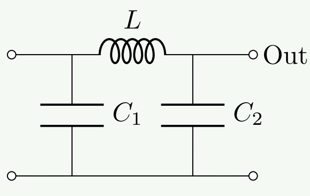
Applications:

- 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(π) type capacitor filter.

Solution



Working:

- C_1: Bypasses most AC ripples to ground (low reactance to AC).
- L: Blocks AC components (high reactance) while passing DC.
- C_2: 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.

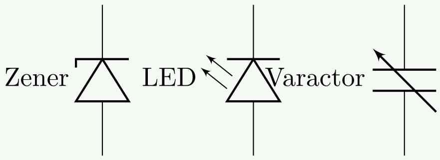
Solution

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

Solution



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

Question 3(b) [4 marks]

Explain construction and working of LED.

Solution

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

Working:

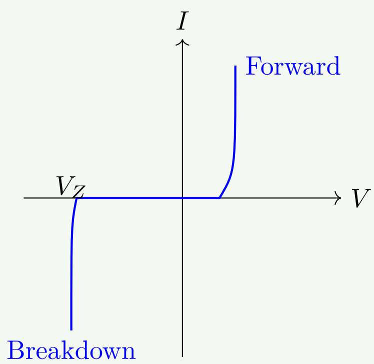
- Operates in **Forward Bias**.
- Electrons from N-side recombine with holes in P-side.
- Energy released during recombination is emitted as photons (Light).
- Color depends on band gap energy of material.

Question 3(c) [7 marks]

Explain working characteristics of Zener diode.

Solution

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.

Solution

- 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.

Solution

Working:

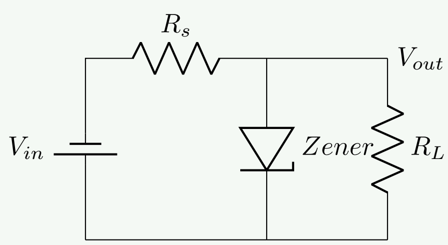
- Operates in **Reverse Bias**.
- When light falls on junction, energy breaks bonds creating electron-hole pairs.
- These carriers are swept by electric field, creating a **Reverse Current**.
- Current is proportional to Light Intensity.

Question 3(c OR) [7 marks]

Explain Zener diode as a voltage regulator.

Solution

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.

Solution

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.

Solution

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 α, β and γ.

Solution

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. β **vs** α: 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. γ **vs** α: $I_E = I_B + I_C \Rightarrow I_E = I_B + \alpha I_E$ $I_E(1-\alpha) = I_B \Rightarrow I_E/I_B = 1/(1-\alpha)$ $\gamma = 1/(1-\alpha)$.
3. γ **vs** β: $\gamma = 1 + \beta$ (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.

Solution

Operating Regions:

Region	**Base-Emitter**	**Base-Collector**	**State**
Active	Forward	Reverse	Amplification
Saturation	Forward	Forward	Switch ON
Cut-off	Reverse	Reverse	Switch OFF

Question 4(b OR) [4 marks]

Explain working of Transistor as an amplifier.

Solution

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.

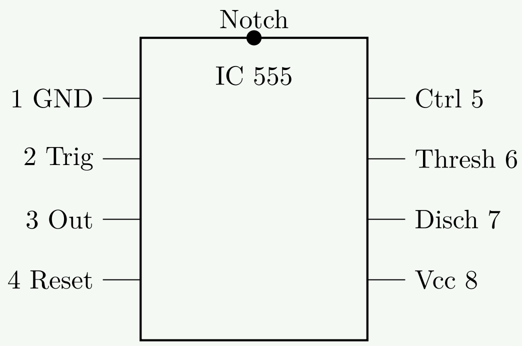
Solution

Parameter	Common Base	Common Emitter	Common Collector
In/Out	Emitter/Collector	Base/Collector	Base/Emitter
Input R_{in}	Very Low	Medium	Very High
Output R_{out}	Very High	Medium	Very Low
Current Gain	< 1 (α)	High (β)	High (γ)
Voltage Gain	High	High	≈ 1
Phase Shift	0°	180°	0°
Application	RF, HF Apps	Audio/Voltage Amp	Buffer/Matching

Question 5(a) [3 marks]

Draw the pin diagram of IC 555.

Solution



Question 5(b) [4 marks]

List out Features of 555 Timer IC.

Solution

- **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 ($\approx 0.005\%/°C$).
- **Compatibility**: TTL and CMOS compatible.

Question 5(c) [7 marks]

Explain Mono stable multivibrator using 555 timer IC.

Solution

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.

Solution

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.

Solution

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.

Solution

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