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:

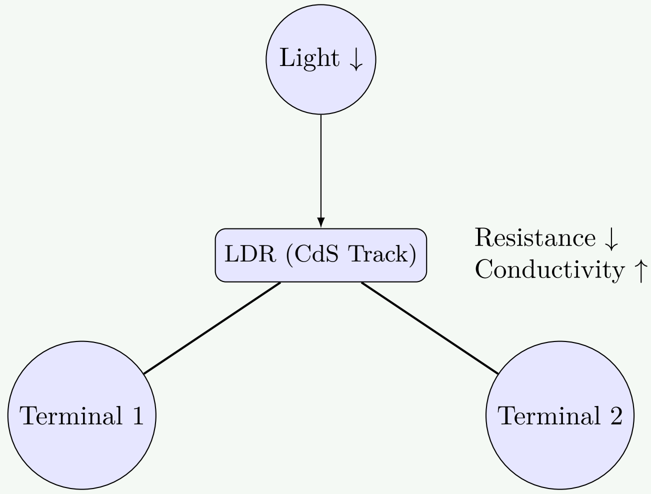


Figure 1. LDR Working

- **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:

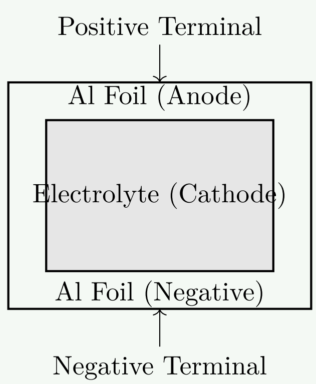


Figure 2. Aluminum Electrolytic Capacitor

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 (1μF to 10,000μF)
- **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 Ω ±10% resistance.

Solution

Answer:
Color Code Table:

Table 2. Resistor Color Code

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

For 32 Ω ±10%:

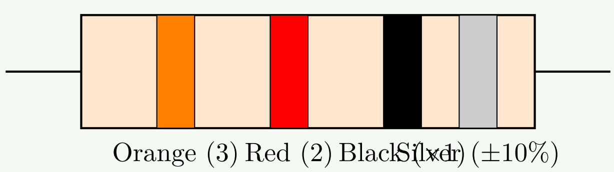


Figure 3. Resistor Color Code (32Ω)

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
Rectifier	Circuit that converts AC to pulsating DC
Ripple Factor	Ratio of AC component to DC component in output
Filter	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:

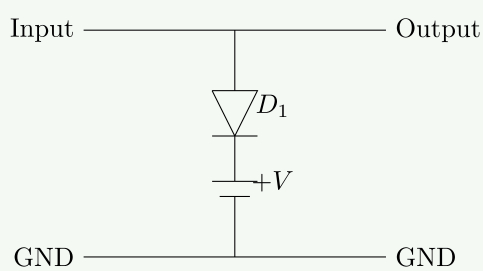


Figure 4. Positive Clipper Circuit

Working:
- **When Vin > +V**: Diode conducts, output = +V
- **When Vin < +V**: Diode off, output follows input
- **Result**: Clips positive peaks above +V level

Waveform:

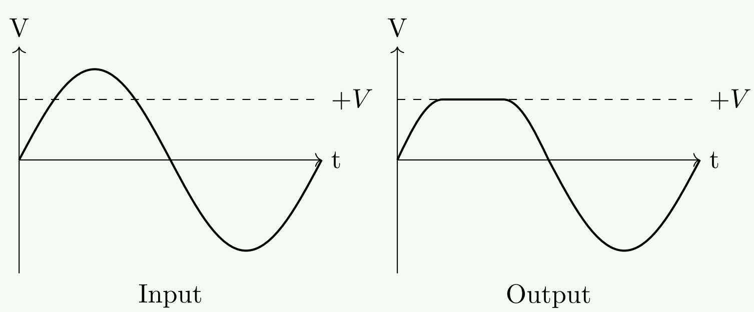


Figure 5. Clipper Waveforms

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:

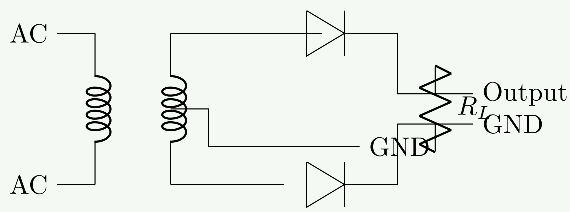


Figure 6. Full Wave Rectifier

Working:

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

Key Parameters:

Table 4. FWR Parameters

Parameter	Value
Peak Inverse Voltage	2Vm
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(π) type capacitor filter.

Solution

Answer:
Circuit Diagram:

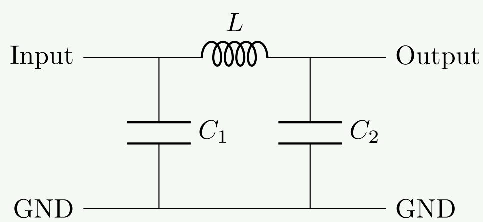


Figure 7. Pi Filter

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

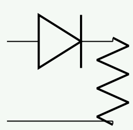
Answer:
Comparison Table:

Table 7. HWR vs FWR Bridge

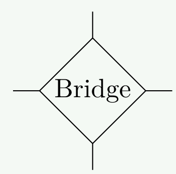
Parameter	Half Wave	Full Wave Bridge
Diodes Required	1	4
Transformer	Simple	No center-tap needed
Efficiency	40.6%	81.2%
Ripple Factor	1.21	0.48
PIV	Vm	Vm
Output Frequency	f	2f
Transformer Utilization	28.7%	81.2%
Cost	Low	Moderate

Circuit Diagrams:

Half Wave:



Full Wave Bridge:



Mnemonic

“”Half Wastes, Full Works””

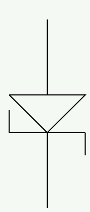
Question 3(a) [3 marks]

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

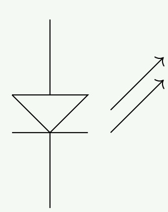
Solution

Answer:

Zener Diode



LED



Varactor

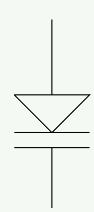


Figure 8. Diode Symbols

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:

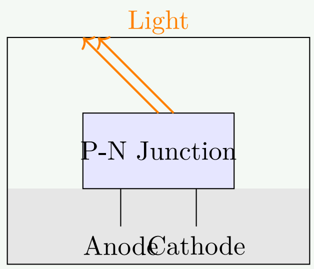


Figure 9. LED Construction

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:

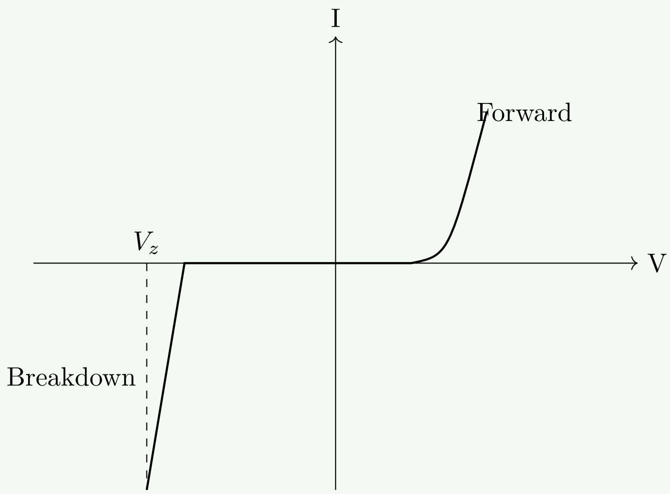


Figure 10. Zener V-I Characteristics

Key Regions:

Table 8. Zener Regions

Region	Characteristics
Forward Bias	Normal diode operation (0.7V)
Reverse Bias	Small leakage current
Zener Region	Constant voltage (Vz)
Breakdown	Sharp voltage breakdown

Important Parameters:
- **Zener Voltage (Vz)**: Breakdown voltage
- **Zener Current (Iz)**: Current in breakdown region
- **Maximum Power**: Vz × Iz(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
Voltage Controlled Oscillators	Frequency tuning with voltage
Automatic Frequency Control	Maintains oscillator frequency
Electronic Tuning	Radio/TV channel selection
Phase Locked Loops	Frequency synchronization
Frequency Multipliers	Harmonic generation
Parametric Amplifiers	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:

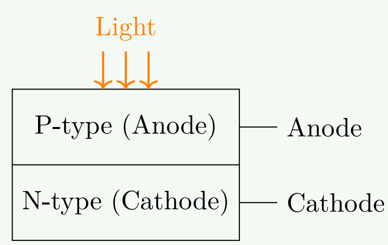


Figure 11. Photo Diode

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
Dark Current	Current without light
Photocurrent	Current proportional to light
Responsivity	Current per unit light power
Response Time	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:

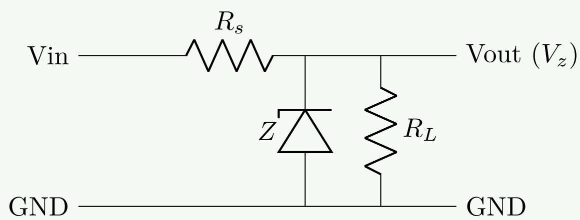


Figure 12. Zener Regulator

Working Principle:
- **Zener operates** in breakdown region
- **Output voltage** remains constant at Vz
- **Series resistor Rs** 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:

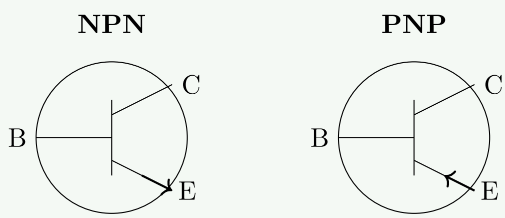


Figure 13. Transistor Symbols

Construction Diagrams:

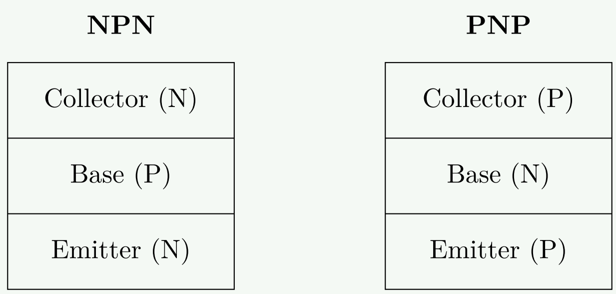


Figure 14. Transistor Construction

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:

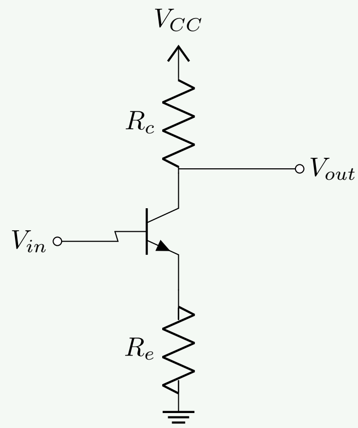


Figure 15. CE Circuit

Input Characteristics (I_B vs V_{BE}):

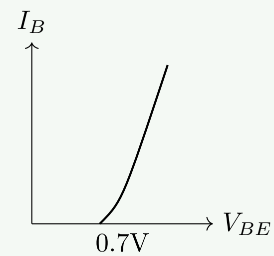


Figure 16. Input Char.

Output Characteristics (I_C vs V_{CE}):

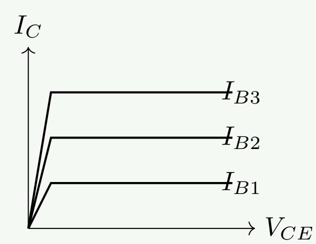


Figure 17. Output Char.

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^o

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 α, β and γ.

Solution

Answer:
Current Gain Definitions:

Table 13. Gain Definitions

Gain	Configuration	Formula
α **(Alpha)**	Common Base	$\alpha = I_C/I_E$
β **(Beta)**	Common Emitter	$\beta = I_C/I_B$
γ **(Gamma)**	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 $I_E = I_B + \alpha I_E$
$I_E - \alpha I_E = I_B$
$I_E(1 - \alpha) = I_B$
$I_E = I_B/(1 - \alpha)$ ... (2)
Step 4: Find β $\beta = I_C/I_B$
From (1): $I_C = \alpha I_E$
From (2): $I_E = I_B/(1 - \alpha)$
Therefore: $I_C = \alpha I_B/(1 - \alpha)$
Step 5: Final relation for β $\beta = I_C/I_B = \alpha/(1 - \alpha)$ ... (3)
Step 6: Express α in terms of β From equation (3):
$\beta(1 - \alpha) = \alpha$
$\beta - \beta\alpha = \alpha$
$\beta = \alpha + \beta\alpha = \alpha(1 + \beta)$
Therefore: $\alpha = \beta/(1 + \beta)$ ... (4)
Step 7: Find γ $\gamma = I_E/I_B$
From (2): $\gamma = 1/(1 - \alpha)$
Substituting α from (4):
$\gamma = 1/(1 - \beta/(1 + \beta))$
$\gamma = (1 + \beta)/(1 + \beta - \beta)$
$\gamma = 1 + \beta$ ... (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
Active	Forward Biased	Reverse Biased	Amplification region
Saturation	Forward Biased	Forward Biased	Switch ON state
Cut-off	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:

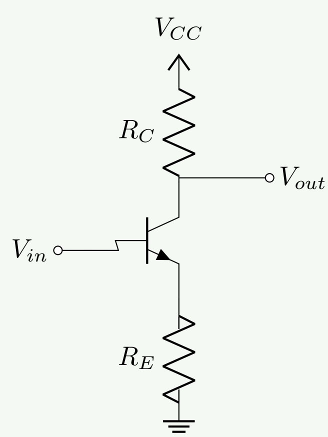


Figure 18. CE Amplifier

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**: β (50-200)
- **Voltage gain**: High
- **Power gain**: Product of current and voltage gains
- **Phase inversion**: 180^o

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
Input Terminal	Emitter	Base	Base
Output Terminal	Collector	Collector	Emitter
Common Terminal	Base	Emitter	Collector
Current Gain	$\alpha < 1$	$\beta \gg 1$	$\gamma = (1 + \beta)$
Voltage Gain	High	High	< 1 (≈ 1)
Power Gain	Medium	Very High	Medium
Input Resistance	Low (20-50Ω)	Medium (1-5kΩ)	High (100kΩ)
Output Resistance	High (1MΩ)	High (50kΩ)	Low (25Ω)
Phase Shift	0^o	180^o	0^o

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:

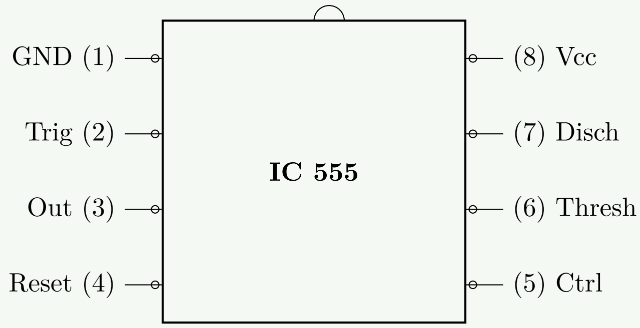


Figure 19. IC 555 Pinout

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
Supply Voltage	5V to 18V
Output Current	200mA source/sink
Temperature Range	0^oC to 70^oC
Timing Range	μs to hours
Accuracy	$\pm 1\%$ typical
Modes	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:

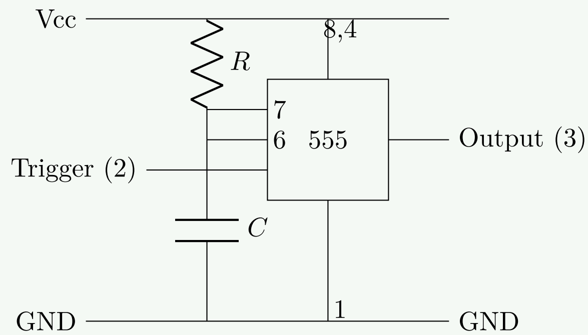


Figure 20. Monostable Circuit

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:

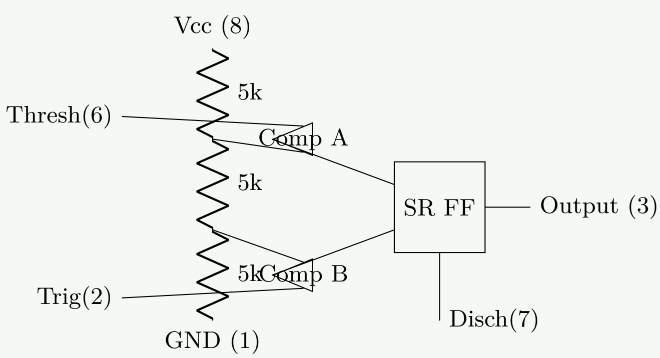


Figure 21. Internal Block Diagram

Block Functions:
- **Voltage Divider**: Sets 2/3 Vcc and 1/3 Vcc
- **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:

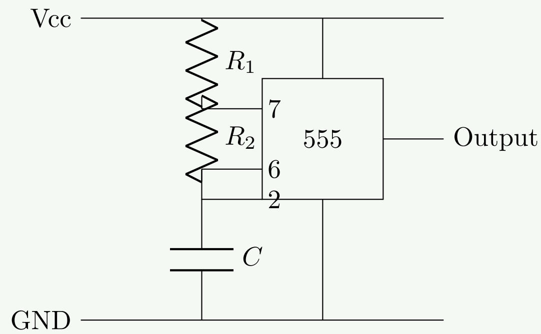


Figure 22. Astable Circuit

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 Vcc and 2/3 Vcc

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””