

# Subject Name Solutions

4321103 – Winter 2024

Semester 1 Study Material

Detailed Solutions and Explanations

## Question 1(a) [3 marks]

Explain amplifier parameters  $A_i$ ,  $R_i$  and  $R_o$  for CE configuration.

Solution

Common Emitter (CE) amplifier parameters:

Table 1: CE Amplifier Parameters

Parameter	Definition	CE Configuration
Current Gain ( $A_i$ )	Ratio of output current to input current	High (20-500)
Input Resistance ( $R_i$ )	Opposition to current flow at input	Medium (1-2 k $\Omega$ )
Output Resistance ( $R_o$ )	Opposition to current flow at output	High (40-50 k $\Omega$ )

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    I[Input Signal] --> R[Ri: 1-2 kΩ]
    R --> A[CE Amplifier]
    A --> O[Output Signal]
    A --> RO[Ro: 40-50 kΩ]
    A -- "Ai: 20-500" --> O
{Highlighting}
{Shaded}
```

Mnemonic

“CAR” - CE has Current gain high, Average input resistance, and Robust output resistance.

## Question 1(b) [4 marks]

Write short-note on heat sink.

Solution

Heat Sink: Device that absorbs and dissipates heat from electronic components

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    T[Transistor] --> HS[Heat Sink]
    HS -- "Heat Dissipation" --> A[Ambient Air]

    subgraph Heat_Sink_Structure
        direction LR
        F[Fins] --> B[Base]
    end
```

```
end
{Highlighting}
{Shaded}
```

#### Types of Heat Sinks:

- **Passive Heat Sinks:** Rely on natural convection
- **Active Heat Sinks:** Use fans for forced air convection
- **Liquid-cooled Heat Sinks:** Use liquid for better heat transfer

#### Key Functions:

- **Thermal Conduction:** Draws heat away from components
- **Thermal Convection:** Transfers heat to surrounding air
- **Surface Area:** Fins increase surface area for better cooling

#### Mnemonic

“CRAFT” - Cooling through Radiation And Fins for Transistors.

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

Describe Thermal Runaway and Thermal Stability. How can overcome thermal run away in transistor?

#### Solution

**Thermal Runaway:** Self-reinforcing process where increased temperature causes more current flow, which further increases temperature

**Thermal Stability:** Ability of a transistor circuit to maintain stable operation despite temperature changes

**Diagram:**

#### Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Increased Temperature] --> B[Increased Collector Current]
    B --> C[More Power Dissipation]
    C --> A

    D[Thermal Stability Methods] --> E[Break This Cycle]
{Highlighting}
{Shaded}
```

#### Methods to Overcome Thermal Runaway:

- **Heat Sink:** Absorbs and dissipates excess heat
- **Negative Feedback:** Using emitter resistor for stabilization
- **Bias Stabilization:** Voltage divider biasing circuit
- **Temperature Compensation:** Using diodes or thermistors

#### Key Points:

- $I_C = I_{CBO}(1 + \beta) + I_B$ : Shows collector current dependence
- **ICBO doubles:** For every  $10^\circ\text{C}$  temperature rise
- **Stability Factor S:** Lower S means better stability

#### Mnemonic

“RENT” - Reduce heat with sinks, Emitter resistors stabilize, Negative feedback helps, Temperature compensation.

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

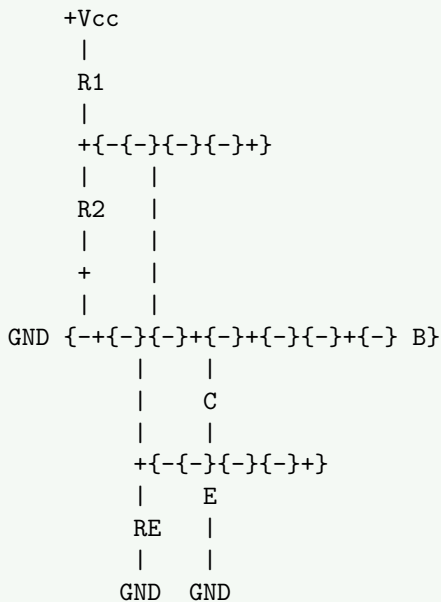
Write down types of biasing methods. Explain the voltage divider biasing method in details.

## Solution

### Types of Biasing Methods:

- Fixed Bias
- Collector-to-Base Bias
- Voltage Divider Bias
- Emitter Bias
- Collector Feedback Bias

### Voltage Divider Bias Circuit:



### Operation:

- **R1 and R2:** Form voltage divider providing base voltage
- **RE:** Provides stability and negative feedback
- **Stable Bias Point:** Less affected by temperature and variations

### Advantages:

- **Excellent Stability:** Less affected by temperature variations
- **Independent of  $\beta$ :** Bias point not greatly affected by transistor gain
- **Widely Used:** Most common biasing method for amplifiers

## Mnemonic

“DIVE” - Divider biasing Is Very Effective for stability.

## Question 2(a) [3 marks]

Explain Stability Factor with features.

## Solution

**Stability Factor (S):** Measure of how well a biasing circuit maintains stable operation with temperature changes

**Mathematical Definition:**  $S = \Delta I_C / \Delta I_{CBO}$  (Change in collector current / Change in reverse saturation current)

Table 2: Stability Factors for Different Bias Circuits

Biasing Method	Stability Factor	Stability Level
Fixed Bias	$S = 1 + \beta$	Poor
Collector-to-Base	$S = \beta / (1 + \beta)$	Better
Voltage Divider	$S \approx 1$	Excellent

**Key Features:**

- **Lower S Value:** Indicates better stability (ideal  $S=1$ )
- **Temperature Resistance:** Measures immunity to temperature changes
- **Circuit Design Tool:** Helps compare biasing methods

- Key Features:**

  - **Lower S Value:** Indicates better stability (ideal  $S=1$ )
  - **Temperature Resistance:** Measures immunity to temperature changes
  - **Circuit Design Tool:** Helps compare biasing methods

**Mnemonic**

“SOS” - Stability Of circuit Shows in its S-factor.

**Mnemonic**

“SOS” - Stability Of circuit Shows in its S-factor.

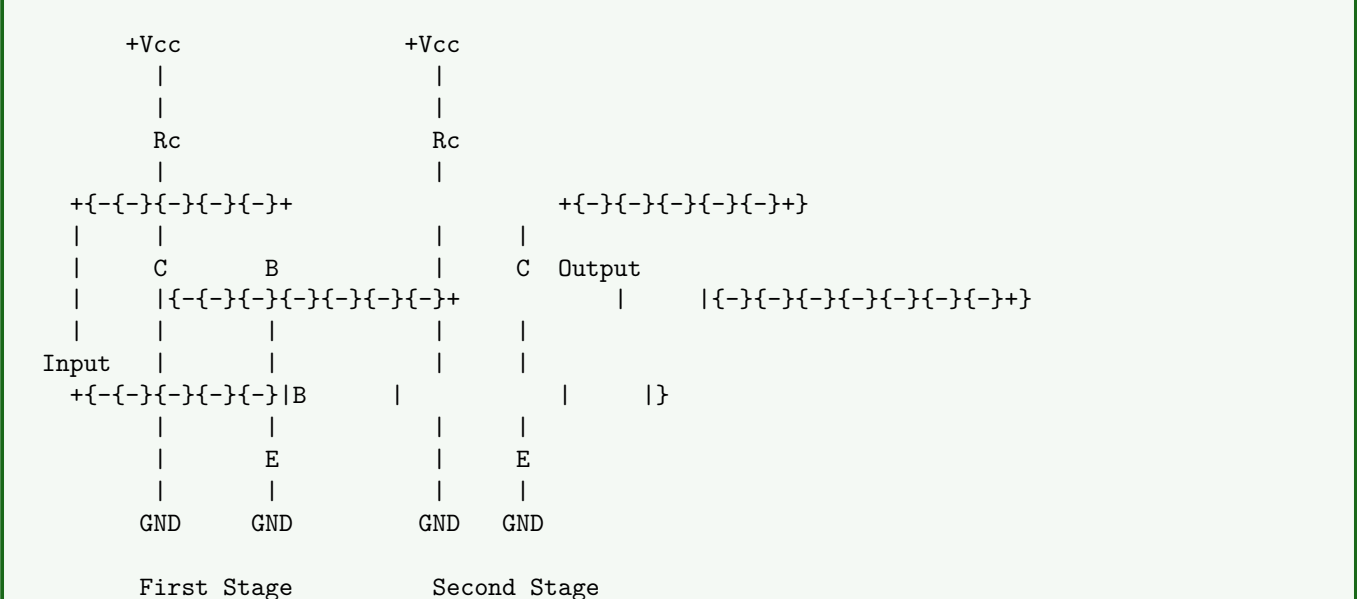
Question 2(b) [4 marks]

Describe direct coupling technique of cascading.

## Solution

**Direct Coupling:** Connecting stages without coupling capacitors, directly connecting collector of one stage to base of next

Diagram:



### Key Characteristics:

- **No Coupling Components:** Direct electrical connection
- **Full Frequency Response:** Good low-frequency performance
- **DC Level Shifting:** Required between stages

## Applications:

- Applications:**
- **Operational Amplifiers:** Internal stages
  - **DC Amplifiers:** Where low-frequency response is critical

**Mnemonic**

“DIRECT” - DC signals Immediately REach Connecting Transistors.

**Mnemonic**

“DIRECT” - DC signals Immediately REach Connecting Transistors.

Question 2(c) [7 marks]

**Explain frequency response of two stage RC coupled amplifier.**

#### Solution

RC Coupled Amplifier: Uses resistor-capacitor networks to couple between amplification stages

Frequency Response Diagram:

### Mermaid Diagram (Code)

{Shaded}

```

{Highlighting}[]
graph LR
    subgraph Frequency_Response [Frequency Response]
        L[Low Frequency] --- M[Mid Frequency] --- H[High Frequency]
    end

    L --- L_label["20Hz-500Hz  
Gain rises"] --- M
    M --- M_label["500Hz-20kHz  
Flat gain"] --- H
    H --- H_label[">20kHz  
Gain falls"] --- D[Drop-off]

{Highlighting}
{Shaded}

```

Table 3: Frequency Regions

Region	Frequency Range	Characteristics	Limiting Components
<b>Low</b>	20Hz-500Hz	Gain rises with frequency	Coupling capacitors
<b>Mid</b>	500Hz-20kHz	Constant gain (maximum)	None
<b>High</b>	>20kHz	Gain falls with frequency	Transistor capacitance

#### Two-Stage Effect:

- **Bandwidth:** Narrower than single stage
- **Gain:** Approximately square of single stage ( $A_1 \times A_2$ )
- **Phase Shift:** Doubled at low and high frequencies

#### Mnemonic

“LMH” - Low frequencies by coupling caps, Mid frequencies flat, High frequencies by transistor caps.

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

Briefly explain bandwidth and gain-bandwidth product of an amplifier.

#### Solution

**Bandwidth (BW):** Range of frequencies where amplifier gain is at least 70.7% of maximum gain  
**Gain-Bandwidth Product (GBP):** Product of voltage gain and bandwidth, constant for a given amplifier

**Diagram:**

#### Mermaid Diagram (Code)

```

{Shaded}
{Highlighting}[]
graph LR
    F[Frequency] --- G[Gain]

    subgraph Bandwidth
        FL[f1: Lower Cutoff] --- FM[Maximum Gain Region] --- FH[f2: Upper Cutoff]
    end

    FL --- FL_label["0.707"] --- G
    FH --- FH_label["0.707"] --- G

{Highlighting}
{Shaded}

```

#### Key Formulas:

- **Bandwidth:**  $BW = f_2 - f_1$
- **Gain-Bandwidth Product:**  $GBP = A_0 \times BW(\text{constant})$

### Mnemonic

“BAND” - Bandwidth And gain Never Drop together (one increases when other decreases).

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

Explain effects of emitter bypass capacitor and coupling capacitor on frequency response of an amplifier.

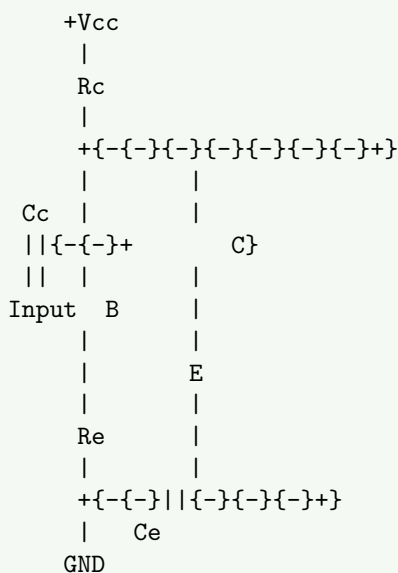
#### Solution

##### Effects on Frequency Response:

Table 4: Capacitor Effects

Capacitor	Function	Effect on Frequency Response
<b>Coupling Capacitor (Cc)</b>	Blocks DC, passes AC	Limits low-frequency response
<b>Bypass Capacitor (Ce)</b>	Bypasses emitter resistor	Increases gain at mid and high frequencies

##### Diagram:



##### Key Effects:

- **Without  $C_e$ :** Lower gain, better stability, better low-frequency response
- **Without  $C_c$ :** DC coupling, excellent low-frequency response
- **Capacitor Values:** Determine cutoff frequencies ( $f_1, f_2$ )

### Mnemonic

“CELL” - Coupling affects Extremely Low frequencies, bypass affects Low to high.

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

Compare transformer coupled amplifier and RC coupled amplifier

#### Solution

Table: Comparison of Transformer Coupled vs RC Coupled Amplifier

Feature	Transformer Coupled	RC Coupled
<b>Coupling Element</b>	Transformer	Capacitor and Resistor
<b>Efficiency</b>	High (90%)	Moderate (20-30%)

<b>Size and Weight</b>	Bulky and Heavy	Compact and Light
<b>Cost</b>	Expensive	Inexpensive
<b>Frequency Response</b>	Poor (limited bandwidth)	Good (wide bandwidth)
<b>Impedance Matching</b>	Excellent	Poor
<b>DC Isolation</b>	Complete	Only AC signals
<b>Distortion</b>	Higher	Lower

```
graph TB
    subgraph "RC Coupled"
        RC[Resistor{-Capacitor}] --{-} RCF[Flat Responsebr /Wide Bandwidth]}
    end

    subgraph "Transformer Coupled"
        TC[Transformer] --{-} TCF[Peaked Responsebr /Narrow Bandwidth]}
    end
```

- **RC Coupled:** Audio amplifiers, general-purpose amplifiers
- **Transformer Coupled:** Power amplifiers, radio transmitters

“TRIP” - Transformers are Robust for Impedance matching, Problematic for bandwidth.

**Describe the transistor used as a tuned amplifier.**

**Tuned Amplifier:** Amplifier that selectively amplifies signals within a narrow frequency band  
**Diagram:**

- **LC Tank Circuit:** Determines resonant frequency
- **Transistor:** Provides amplification
- **Resonant Frequency:**  $f_0 = 1/(2\pi\sqrt{LC})$

**Applications:**

- **Radio Receivers:** Selects desired frequency
- **TV Tuners:** Channel selection
- **RF Amplifiers:** Communication systems

**Mnemonic**

“TUNE” - Transistors Using Narrowband Elements for frequency selection.

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

Explain in brief Direct coupled amplifier.

**Solution**

**Direct Coupled Amplifier:** Multiple stage amplifier where stages are connected directly without coupling capacitors or transformers

**Diagram:**

**Mermaid Diagram (Code)**

```
{Shaded}
{Highlighting}[]
graph LR
    I[Input] --{} T1[Transistor 1] --{} T2[Transistor 2] --{} O[Output]
    T1 --{} "Direct Connection{}br /{}No Coupling Components" --{} T2
{Highlighting}
{Shaded}
```

**Key Characteristics:**

- **DC Amplification:** Can amplify from DC to high frequencies
- **No Coupling Elements:** Collector directly connected to next base
- **Level Shifting:** Required between stages
- **Thermal Drift:** Challenge due to direct DC coupling

**Applications:**

- **Operational Amplifiers:** Internal stages
- **DC Amplifiers:** Laboratory instruments
- **Sensing Circuits:** Temperature and pressure sensors

**Mnemonic**

“DCAP” - Direct Coupled Amplifier Passes all frequencies including DC.

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

Describe the importance of h parameters in two port networks. Draw h-parameters circuit for CE amplifier.

**Solution**

**h-parameters (hybrid parameters):** Set of four parameters that define behavior of two-port network

**Importance:**

- **Complete Characterization:** Fully describes amplifier behavior
- **Easy Measurement:** Can be measured under simple conditions
- **Analysis Tool:** Simplifies circuit analysis
- **Standardized Approach:** Universal method for comparing transistors

**h-parameter Equations:**

- $V_1 = h_{11}I_1 + h_{12}V_2$
- $I_2 = h_{21}I_1 + h_{22}V_2$

**h-parameter Circuit for CE Amplifier:**

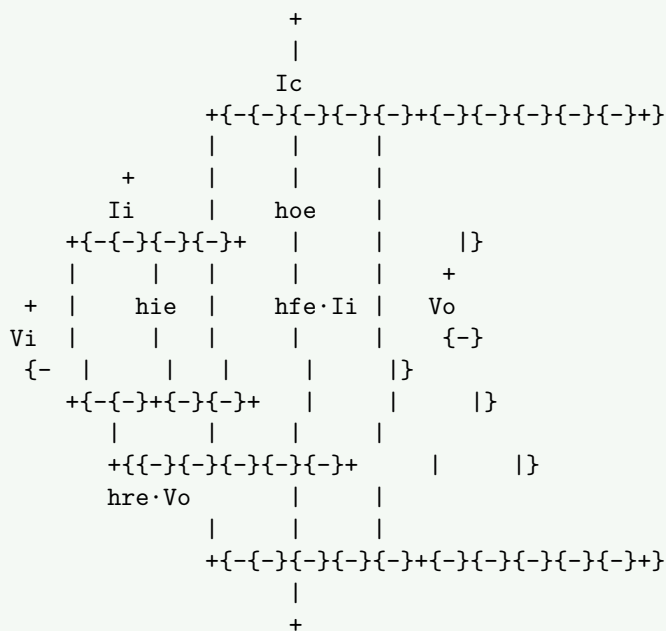


Table 5: h-parameters for CE Configuration

Parameter	Symbol	Typical Value	Physical Meaning
<b>Input impedance</b>	$h_{11}(hie)$	1-2 k $\Omega$	Input resistance with output shorted
<b>Reverse voltage transfer</b>	$h_{12}(hre)$	$1-4 \times 10^{-4}$	Reverse feedback ratio
<b>Forward current transfer</b>	$h_{21}(hfe)$	20-500	Current gain ( )
<b>Output admittance</b>	$h_{22}(hoe)$	20-50 S	Output conductance

#### Mnemonic

“HIRE” - h-parameters Include Resistance and current gain Effectively.

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

Compare transformer coupled amplifier and direct coupled amplifier.

#### Solution

Table: Comparison between Transformer and Direct Coupled Amplifiers

Feature	Transformer Coupled	Direct Coupled
<b>Coupling Element</b>	Transformer	None (direct connection)
<b>Frequency Response</b>	Limited at low frequencies	Excellent (DC to high freq)
<b>DC Isolation</b>	Complete	None
<b>Size</b>	Bulky	Compact
<b>Cost</b>	Higher	Lower
<b>DC Shift Problem</b>	No	Yes

Diagram:

### Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    subgraph "Transformer Coupled"
        T1[Transistor 1] --{}-- TR[Transformer] --{}-- T2[Transistor 2]
    end

    subgraph "Direct Coupled"
        D1[Transistor 1] --{}-- "Direct Connection" --{}-- D2[Transistor 2]
    end
{Highlighting}
{Shaded}
```

### Mnemonic

“TDC” - Transformers provide DC isolation, Direct provides Complete frequency range.

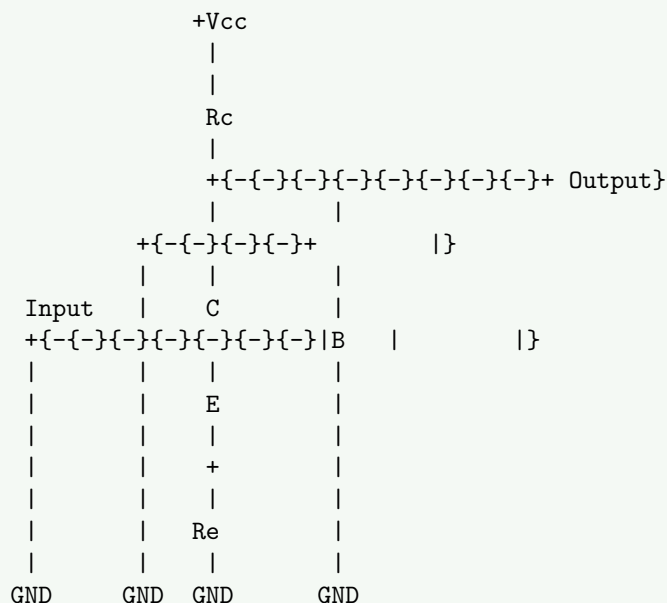
**Question 3(b) OR [4 marks]**

Draw and Explain circuit diagram of common emitter amplifier.

## Solution

**Common Emitter Amplifier:** Configuration where emitter is common to both input and output circuits

### Circuit Diagram:



**Operation:**

- **Input:** Applied between base and emitter
- **Output:** Taken from collector and emitter
- **Phase Shift:**  $180^\circ$  *between input and output*
- **Gain:** High voltage and current gain

### Key Features:

- **High Gain:** Typical voltage gain 300-1000
- **Medium Input Impedance:** 1-2 k $\Omega$
- **High Output Impedance:** 40-50 k $\Omega$
- **Signal Inversion:** Output is inverted

### Mnemonic

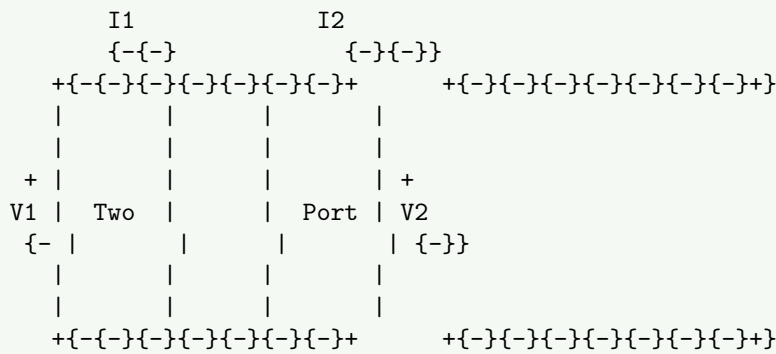
“CEA” - Common Emitter Amplifies with signal inversion.

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

Draw Transistor Two Port Network and describe h-parameters for it. Write down advantages of hybrid parameters.

### Solution

Transistor Two-Port Network:



**h-parameter Equations:**

- $V_1 = h_{11}I_1 + h_{12}V_2$
- $I_2 = h_{21}I_1 + h_{22}V_2$

Table 6: h-parameters Description

Parameter	Symbol	Description	Measurement Condition
Input impedance	$h_{11}$	Ratio of $V_1/I_1$	$V_2 = 0$ (Output shorted)
Reverse voltage transfer	$h_{12}$	Ratio of $V_1/V_2$	$I_1 = 0$ (Input open)
Forward current transfer	$h_{21}$	Ratio of $I_2/I_1$	$V_2 = 0$ (Output shorted)
Output admittance	$h_{22}$	Ratio of $I_2/V_2$	$I_1 = 0$ (Input open)

**Advantages of Hybrid Parameters:**

- **Easy Measurement:** Simple conditions for each parameter
- **Universality:** Works for all transistor configurations
- **Complete Characterization:** Fully describes behavior
- **Mathematical Simplicity:** Linear equations
- **Standardized:** Industry standard for specification

### Mnemonic

“HAEM” - Hybrid parameters Are Easily Measured and mathematically simple.

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

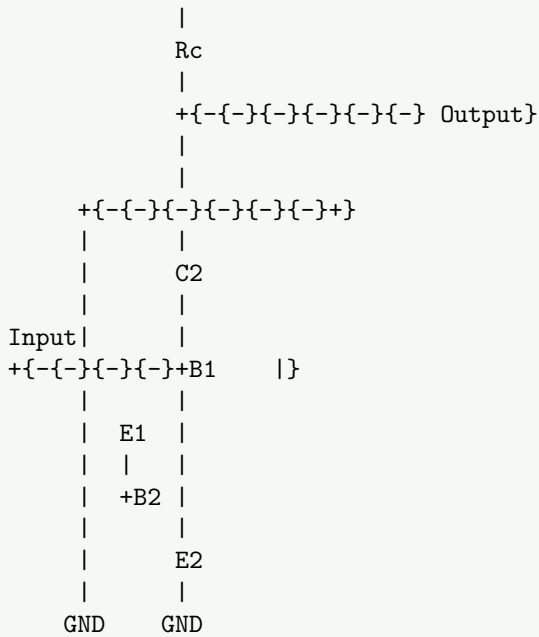
Explain Darlington pair and its applications.

### Solution

**Darlington Pair:** Configuration of two transistors where emitter of first is connected to base of second

**Diagram:**





#### Key Features:

- **Very High Current Gain:**  $\beta_1 \times \beta_2$  (typical 1000 – 30000)
- **High Input Impedance:**  $\beta_2 \times R_{in1}$
- **Low Output Impedance:** Similar to single transistor

#### Applications:

- **Power Amplifiers:** Audio equipment
- **Buffer Circuits:** High impedance to low impedance
- **Motor Drivers:** Control high-current loads
- **Touch Sensors:** High sensitivity applications

#### Mnemonic

“DISH” - Darlington Integrates Stages for High current gain.

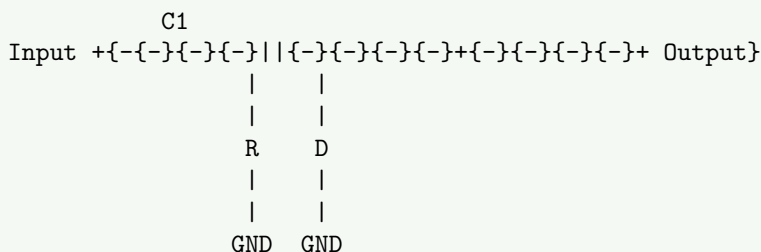
### Question 4(b) [4 marks]

Describe the diode clamper circuit with necessary diagram.

#### Solution

**Clamper Circuit:** Shifts the DC level of a waveform without changing its shape

**Diagram:**



#### Operation:

- **Positive Clamper:** Shifts waveform downward
- **Negative Clamper:** Shifts waveform upward
- **Capacitor:** Blocks DC, passes AC
- **Diode:** Conducts during one half-cycle
- **Resistor:** Discharge path for capacitor

#### Time Constants:

- **Charging:** Very small (diode forward resistance  $\times C$ )
- **Discharging:** Large ( $R \times C$ ) compared to signal period

**Applications:**

- **TV Signal Processing:** Restores DC component
- **Pulse Circuits:** Level shifting
- **Signal Processing:** DC restoration

**Mnemonic**

“CLAMP” - Circuit Levels Are Modified Precisely.

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

Explain the construction, working and applications of OLED.

**Solution**

**OLED (Organic Light Emitting Diode):** Light-emitting device using organic compounds

**Construction:**

**Mermaid Diagram (Code)**

```
{Shaded}
{Highlighting}[]
graph TD
    subgraph OLED_Structure [OLED Structure]
        direction LR
        C["Cathode{br /{}Metal Layer}"] --- E["Emissive Layer{br /{}Organic Material}"] --- H["Hole Transport Layer"]
    end
end
{Highlighting}
{Shaded}
```

**Working Principle:**

- **Electron Injection:** Cathode injects electrons
- **Hole Injection:** Anode injects holes
- **Recombination:** Electrons and holes combine in emissive layer
- **Light Emission:** Energy released as photons
- **Color Control:** Different organic materials emit different colors

Table 7: OLED Types

Type	Structure	Key Feature
<b>PMOLED</b>	Passive Matrix	Simpler design, lower cost
<b>AMOLED</b>	Active Matrix	Better refresh rates, higher resolution
<b>TOLED</b>	Transparent	See-through when off or on
<b>FOLED</b>	Flexible	Can be bent or rolled

**Applications:**

- **Displays:** Smartphones, TVs, smartwatches
- **Lighting:** Thin, efficient lighting panels
- **Signage:** High-contrast digital signs
- **Wearable Technology:** Flexible displays

**Mnemonic**

“OLED” - Organic Layers Emit Directly when electrically stimulated.

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

Explain Short note on LDR.

## Solution

**Symbol and Structure:**

Light  
↓↓↓

CdS

## Structure

### Key Characteristics:

- **Material:** Usually Cadmium Sulfide (CdS)
- **Dark Resistance:** High ( $M\Omega$  range)
- **Light Resistance:** Low ( $k\Omega$  range)
- **Response Time:** Milliseconds to seconds

**Applications:**

- **Light Sensors:** Automatic lighting control
- **Camera Exposure Control:** Light metering
- **Street Light Control:** Dawn-to-dusk activation
- **Alarm Systems:** Light beam detection

**Mnemonic**

“LORD” - Light Oppositely Reduces the Device’s resistance.

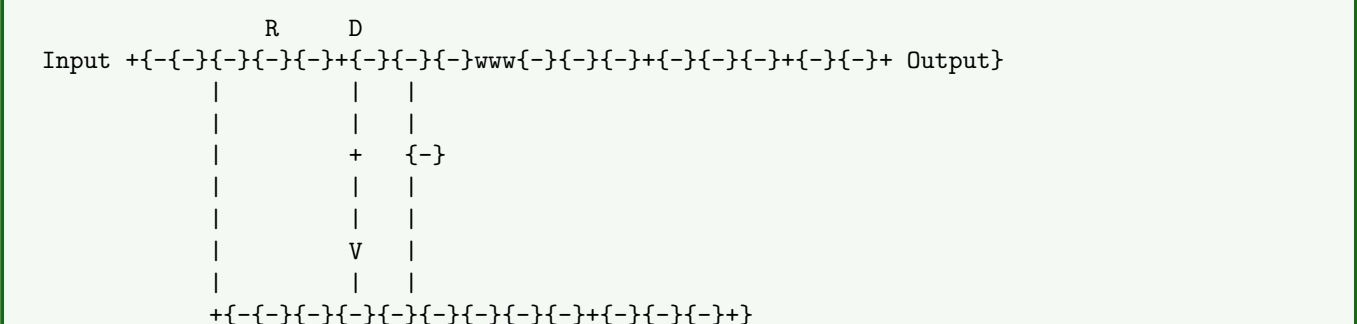
Question 4(b) OR [4 marks]

Describe the diode clipper circuit with necessary diagram.

#### Solution

**Clipper Circuit:** Removes (clips) portion of input signal that exceeds certain voltage level

Diagram (Positive Clipper):



### Types of Clippers:

- **Positive Clipper:** Removes positive peaks
- **Negative Clipper:** Removes negative peaks
- **Biased Clipper:** Clips at non-zero reference
- **Combination Clipper:** Clips both peaks

**Operation:**

- **Diode ON:** When signal exceeds reference voltage
- **Diode OFF:** When signal is below reference voltage
- **Clipping Level:** Determined by reference voltage

#### Applications:

- **Wave Shaping:** Creating square waves
- **Circuit Protection:** Voltage limiting
- **Noise Removal:** Limiting impulse noise

#### Mnemonic

“CLIP” - Circuit Limits Input Peaks using diodes.

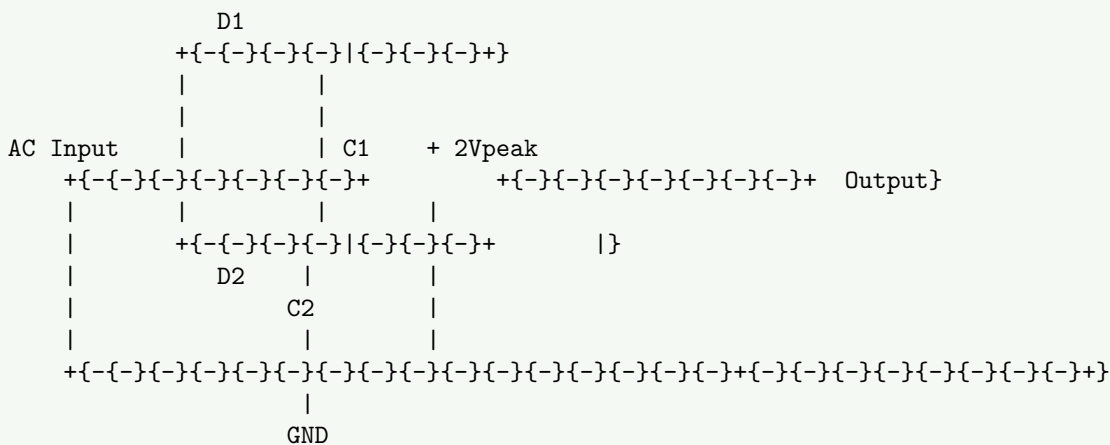
### Question 4(c) OR [7 marks]

Explain Half Wave and Full wave Voltage Doubler.

#### Solution

**Voltage Doubler:** Circuit that produces DC output voltage approximately twice the peak input voltage

**Half-Wave Voltage Doubler:**



**Full-Wave Voltage Doubler:**

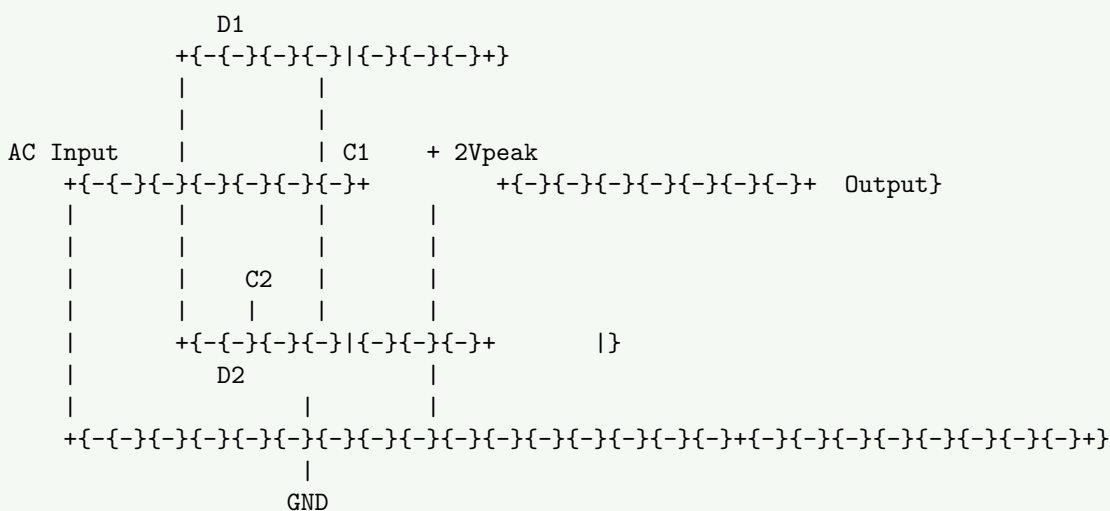


Table 8: Comparison

Feature	Half-Wave	Full-Wave
<b>Ripple</b>	Higher	Lower
<b>Efficiency</b>	Lower	Higher
<b>Response Time</b>	Slower	Faster

<b>Components</b>	2 diodes, 2 capacitors	2 diodes, 2 capacitors
<b>Regulation</b>	Poor	Better

#### Operation:

- **Half-Wave:** Charges each capacitor on alternate half-cycles
- **Full-Wave:** Charges both capacitors on every cycle
- **Output:** Sum of voltages across both capacitors

#### Applications:

- **Power Supplies:** Low-current high-voltage needs
- **Cascade Connection:** For voltage multiplication
- **Electronic Flash:** Camera equipment
- **CRT Displays:** High voltage generation

#### Mnemonic

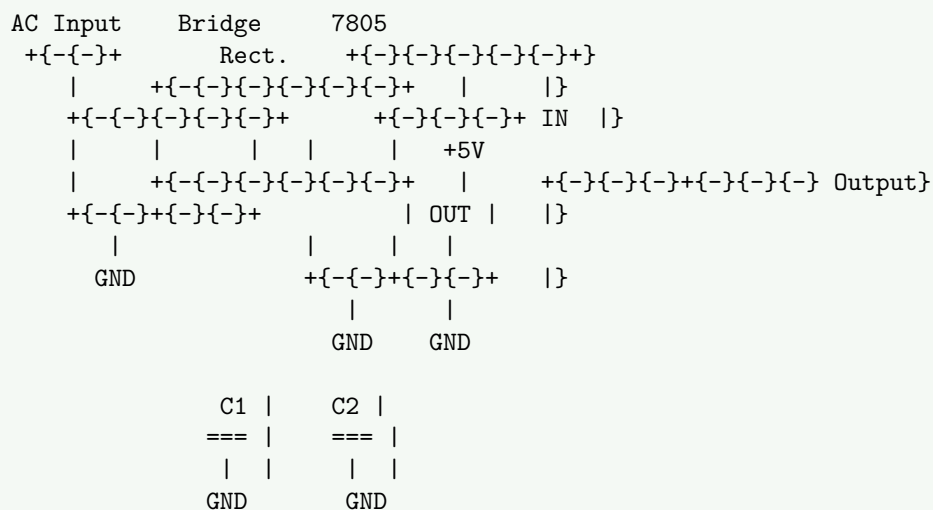
“DOUBLE” - Diodes Organize Unidirectional Boost, Lifting Electricity to twice input.

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

Draw circuit diagram for +5 v Power Supply using its IC

#### Solution

+5V Power Supply Using 7805 Voltage Regulator IC (continued):



#### Key Components:

- **7805 IC:** Three-terminal fixed voltage regulator
- **Input Capacitor (C1):** Filters input ripple
- **Output Capacitor (C2):** Improves transient response
- **Bridge Rectifier:** Converts AC to pulsating DC

#### Mnemonic

“FIVE” - Fixed IC Voltage Efficiently provided.

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

Discuss load regulation and line regulation in reference to power supply.

#### Solution

**Load Regulation:** Ability of power supply to maintain constant output voltage despite load current changes

## Diagram:

### Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Power Supply] --> B["Line Regulation<br/>/(Input Voltage Changes)"]
    A --> C["Load Regulation<br/>/(Output Current Changes)"]
    B --> D["Constant Output<br/>Voltage"]
    C --> D
{Highlighting}
{Shaded}
```

### Formulas:

- **Load Regulation:**  $(V_1 - V_2)/V_2 \times 100\%$ 
  - $V_1 = \text{No-load voltage}$
  - $V_2 = \text{Full-load voltage}$
- **Line Regulation:**  $(V_1 - V_2)/V_2 \times 100\%$ 
  - $V_1 = \text{Output voltage at maximum input}$
  - $V_2 = \text{Output voltage at minimum input}$

### Key Points:

- **Lower Percentage:** Better regulation
- **Feedback Circuit:** Improves regulation performance
- **IC Regulators:** Typically offer good regulation (0.01-0.1%)

## Mnemonic

“LINE LOAD” - Line Is Normal-input Efficiency, LOAD is Output Adjustment Defense.

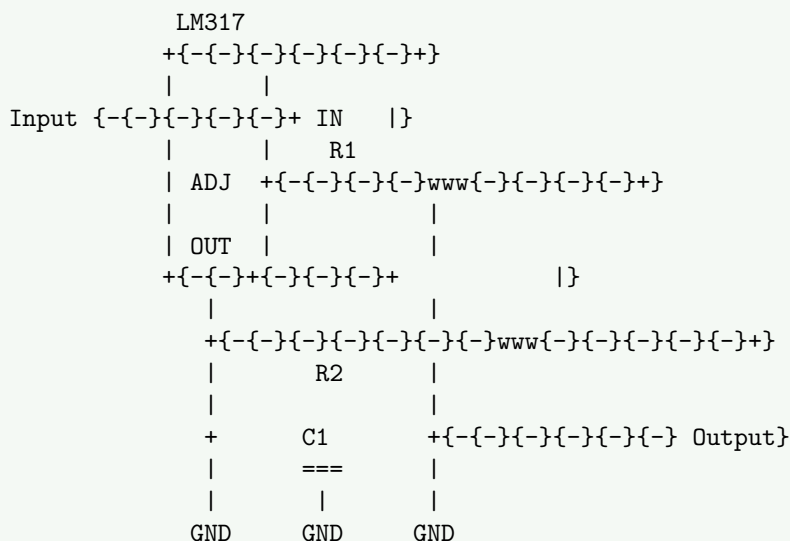
## Question 5(c) [7 marks]

Explain adjustable voltage regulator using LM317 with circuit diagram.

## Solution

**LM317 Adjustable Voltage Regulator:** Three-terminal device that provides variable regulated output voltage

**Circuit Diagram:**



### Operation:

- **Reference Voltage:** 1.25V between OUT and ADJ terminals
- **Output Voltage:**  $V_{OUT} = 1.25V \times (1 + R2/R1)$
- **Adjustment Range:** 1.25V to 37V

- **Maximum Current:** 1.5A (with proper heat sink)
- Component Selection:**
- **R1:** Typically 240Ω
  - **R2:** Variable resistor to adjust output
  - **C1:** Output capacitor for stability (1-10 F)
- Key Features:**
- **Current Limiting:** Built-in protection
  - **Thermal Shutdown:** Protection against overheating
  - **Safe Area Protection:** For output transistors
  - **Ripple Rejection:** 80dB typically

**Mnemonic**

“VARY” - Voltage Adjustable Regulator Yields custom outputs.

“VARY” - Voltage Adjustable Regulator Yields custom outputs.

Question 5(a) OR [3 marks]

Draw circuit diagram for -15 v Power Supply using its IC

## Solution

```

-15V Power Supply Using 7915 Voltage Regulator IC:

AC Input      Bridge      7915
+{-{-}+      Rect.      +{-}{-}{-}{-}{-}{-}+
|            +{-{-}{-}{-}{-}{-}{-}+ | |}
+{-{-}{-}{-}{-}{-}{-}+ +{-}{-}{-}{-}+ IN |}
|            |            | {-15V}
|            +{-{-}{-}{-}{-}{-}{-}+ | +{-}{-}{-}{-}+{-}{-}{-} Output}
+{-{-}+{-}{-}+ | OUT | |}
|              |            |
GND            +{-{-}+{-}{-}+ |}
              |            |
              GND          GND

C1 | C2 |
=== | === |
| | | |
GND GND

Key Components:
• 7915 IC: Three-terminal negative voltage regulator
• Input Capacitor (C1): Filters input ripple
• Output Capacitor (C2): Improves transient response
• Bridge Rectifier: Converts AC to pulsating DC

```

```

-15V Power Supply Using 7915 Voltage Regulator IC:

AC Input      Bridge      7915
+{-{-}+      Rect.      +{-}{-}{-}{-}{-}{-}+
|            +{-{-}{-}{-}{-}{-}{-}+ | |}
+{-{-}{-}{-}{-}{-}{-}+ +{-}{-}{-}{-}+ IN |}
|            |            | {-15V}
|            +{-{-}{-}{-}{-}{-}{-}+ | +{-}{-}{-}{-}+{-}{-}{-} Output}
+{-{-}+{-}{-}+ | OUT | |}
|              |            |
GND            +{-{-}+{-}{-}+ |}
              |            |
              GND          GND

C1 | C2 |
=== | === |
| | | |
GND GND

Key Components:
• 7915 IC: Three-terminal negative voltage regulator
• Input Capacitor (C1): Filters input ripple
• Output Capacitor (C2): Improves transient response
• Bridge Rectifier: Converts AC to pulsating DC

```

- **7915 IC:** Three-terminal negative voltage regulator
- **Input Capacitor (C1):** Filters input ripple
- **Output Capacitor (C2):** Improves transient response
- **Bridge Rectifier:** Converts AC to pulsating DC

- **7915 IC:** Three-terminal negative voltage regulator
- **Input Capacitor (C1):** Filters input ripple
- **Output Capacitor (C2):** Improves transient response
- **Bridge Rectifier:** Converts AC to pulsating DC

**Mnemonic**

“NINE” - Negative IC Needs Efficient filtering.

**Mnemonic**

“NINE” - Negative IC Needs Efficient filtering.

Question 5(b) OR [4 marks]

Explain working of UPS.

### Solution

**UPS (Uninterruptible Power Supply):** Device providing emergency power when main power fails

**Block Diagram:**

Mermaid Diagram (Code)

**UPS (Uninterruptible Power Supply):** Device providing emergency power when main power fails

**Block Diagram:**

Mermaid Diagram (Code)

**UPS (Uninterruptible Power Supply):** Device providing emergency power when main power fails

**Block Diagram:**

Mermaid Diagram (Code)

```

{Shaded}
{Highlighting}[]
graph LR
    I[AC Input] --> R[Rectifier]
    R --> C[Charger]
    C --> B[Battery]
    B --> Inv[Inverter]
    I --> S[Switch]
    S --> O[Output]
    Inv --> S
    Inv --> S2[During Power Failure]
    S2 --> S
{Highlighting}
{Shaded}

```

#### Types of UPS:

- **Offline/Standby UPS:** Switches to battery when power fails
- **Line-Interactive UPS:** Has voltage regulation
- **Online/Double-Conversion UPS:** Always uses battery power

#### Key Components:

- **Rectifier:** Converts AC to DC
- **Battery:** Stores energy
- **Inverter:** Converts DC back to AC
- **Control Circuit:** Monitors power and switches source

#### Applications:

- **Computers:** Prevents data loss
- **Medical Equipment:** Critical operations
- **Industrial Controls:** Prevents costly interruptions
- **Telecommunications:** Maintains connections

#### Mnemonic

“UPBEAT” - Uninterruptible Power Backup Ensures Available Technology.

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

Draw and explain SMPS block diagram with its advantages and disadvantages.

#### Solution

**SMPS (Switch Mode Power Supply):** Power supply that uses switching regulation for efficiency  
**Block Diagram:**

#### Mermaid Diagram (Code)

```

{Shaded}
{Highlighting}[]
graph LR
    AC[AC Input] --> EMI[EMI Filter]
    EMI --> R[Rectifier & Filter]
    R --> C[Chopper/Switching Circuit]
    C --> T[High Frequency Transformer]
    T --> O[Output Rectifier & Filter]
    O --> Out[DC Output]
    Out --> FB[Feedback & Control]
    FB --> C
    Out --> FB2[Feedback]
    FB2 --> FB
{Highlighting}
{Shaded}

```

#### Operation:

- **EMI Filter:** Reduces electromagnetic interference
- **Rectifier:** Converts AC to unregulated DC
- **Switching Circuit:** Chops DC at high frequency (20-100 kHz)
- **Transformer:** Provides isolation and voltage conversion

- **Output Stage:** Rectifies and filters to clean DC
- **Feedback Loop:** Controls switching for regulation

**Advantages:**

- **High Efficiency:** 70-90% (vs. 30-60% for linear)
- **Small Size:** Higher operating frequency means smaller components
- **Light Weight:** Smaller transformer and heat sinks
- **Wide Input Range:** Can operate on various input voltages
- **Low Heat Generation:** Less power wasted as heat

**Disadvantages:**

- **Complex Design:** More sophisticated circuitry
- **EMI Generation:** Switching creates interference
- **Higher Cost:** For low-power applications
- **Noise:** Higher output noise than linear supplies
- **Slower Response:** To sudden load changes

**Applications:**

- **Computers:** Desktop and laptop power supplies
- **TVs and Monitors:** Compact power source
- **Mobile Chargers:** Small, efficient adapters
- **Industrial Power:** High-efficiency needs

**Mnemonic**

“SWITCH” - Smaller Weight, Improved Thermal efficiency, Complex Hardware.