

# 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 |
|---|--|------------------|
| <b>Current Gain (<math>A_i</math>)</b>      | Ratio of output current to input current | High (20-500)    |
| <b>Input Resistance (<math>R_i</math>)</b>  | Opposition to current flow at input      | Medium (1-2 kΩ)  |
| <b>Output Resistance (<math>R_o</math>)</b> | Opposition to current flow at output     | High (40-50 kΩ)  |

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 -- "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]

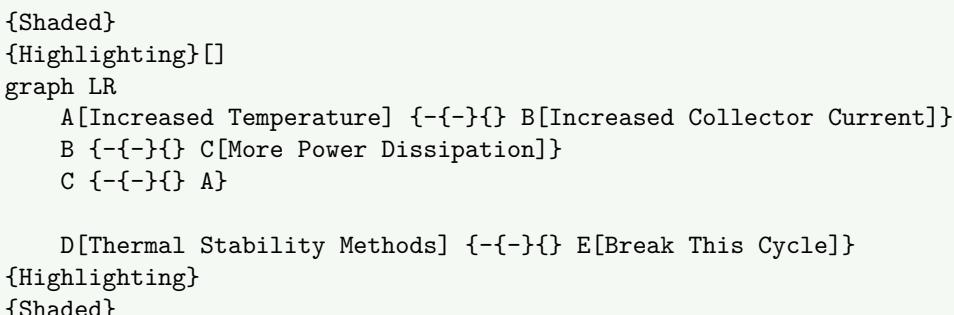
Describe Thermal Runaway and Thermal Stability. How can overcome thermal run away in transistor?

#### 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)



#### 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:

- $IC = ICBO(1 + \frac{V_{BE}}{V_T}) + IB$ : Shows collector current dependence
- **ICBO doubles:** For every  $10^{\circ}\text{C}$  increase in temperature, collector current doubles
- **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]

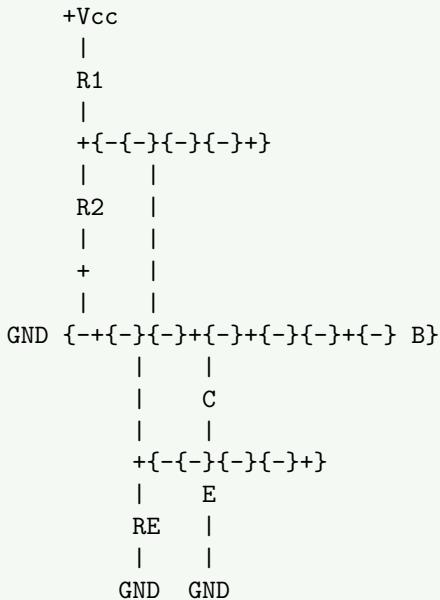
Write down types of biasing methods. Explain the voltage divider biasing method in details.

## 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 :** 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:**  $S = \Delta IC / \Delta IC_{BO}$  (Change in collector current / Change in reverse saturation current)

Table 2: Stability Factors for Different Bias Circuits

| Biassing Method   | Stability Factor                      | Stability Level |
|-------------------|---------------------------------------|-----------------|
| Fixed Bias        | $S = 1 + \frac{R_E}{R_E + R_C}$       | Poor            |
| Collector-to-Base | $S = \frac{1}{(1 + \frac{R_E}{R_C})}$ | 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

### Mnemonic

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

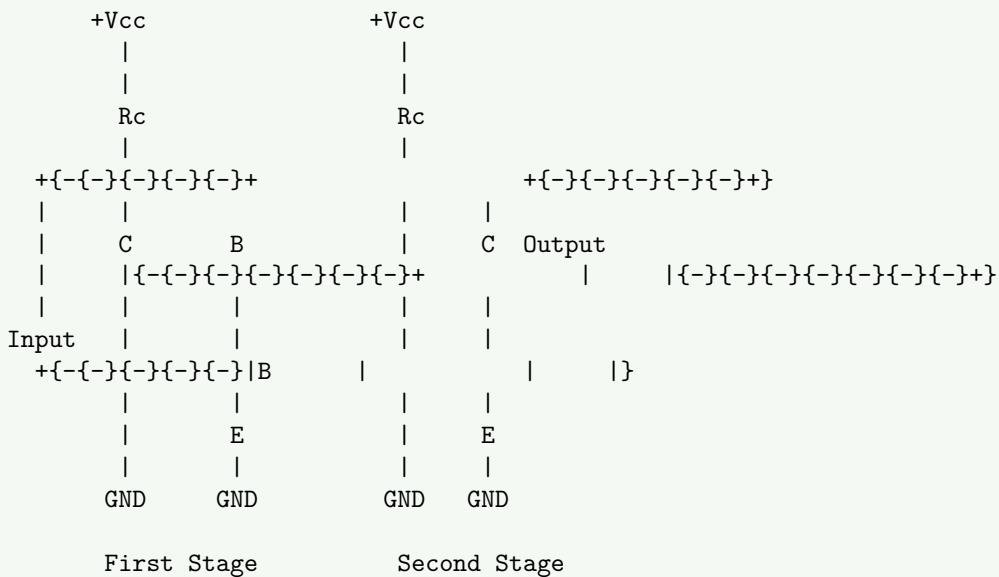
## Question 2(b) [4 marks]

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:

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

### 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
        L[Low Frequency] --- M[Mid Frequency]
        M --- H[High Frequency]
    end

    L -- "20Hz{-}500Hz{}br /{}Gain rises" --> M
    M -- "500Hz{-}20kHz{}br /{}Flat gain" --> H
    H -- "{}20kHz{}br /{}Gain falls" --> D[Drop{-}off]
{Highlighting}
{Shaded}

```

Table 3: Frequency Regions

| Region | Frequency Range | Characteristics           | Limiting Components    |
|--------|-----------------|---------------------------|------------------------|
| Low    | 20Hz-500Hz      | Gain rises with frequency | Coupling capacitors    |
| Mid    | 500Hz-20kHz     | Constant gain (maximum)   | None                   |
| High   | >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[f_{1:} Lower Cutoff] --- FM[Maximum Gain Region]
        FM --- FH[f_{2:} Upper Cutoff]
    end

    FL -- "0.707" --> G
    FH -- "0.707" --> G
{Highlighting}
{Shaded}

```

#### Key Formulas:

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

## 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.

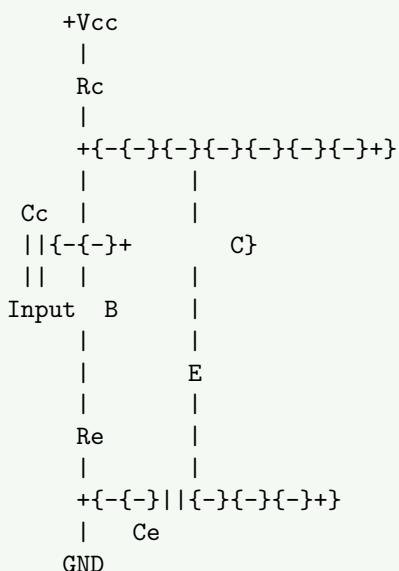
### Solution

#### Effects on Frequency Response:

Table 4: Capacitor Effects

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

#### Diagram:



#### Key Effects:

- **Without Ce:** Lower gain, better stability, better low-frequency response
- **Without Cc:** 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><br><b>Efficiency</b> | Transformer<br>High (90%) | Capacitor and Resistor<br>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                 |

### Diagram:

```

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

```

### Applications:

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

### Mnemonic

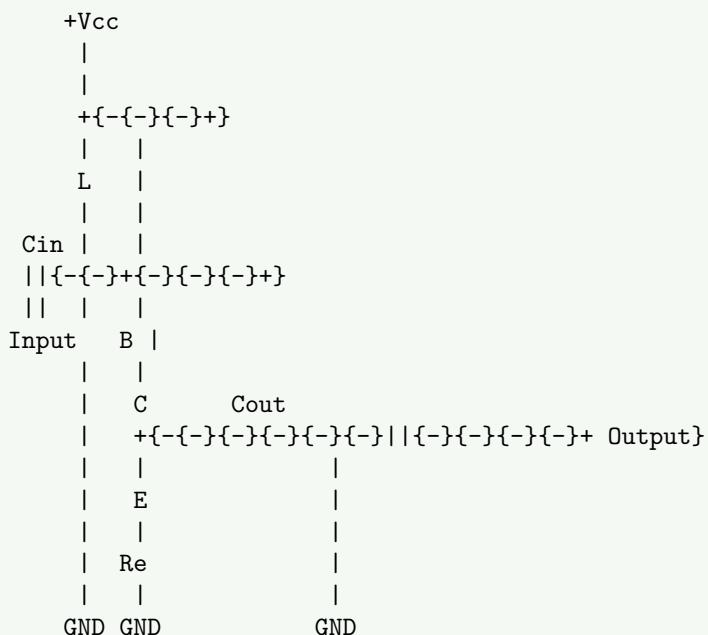
“TRIP” - Transformers are Robust for Impedance matching, Problematic for bandwidth.

## Question 3(a) [3 marks]

Describe the transistor used as a tuned amplifier.

### Solution

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



### Key Components:

- **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]
    T1 --> T2[Transistor 2]
    T2 --> O[Output]
    T1 --- T2
    T1 --- "Direct Connection"
    T2 --- "No Coupling Components"
{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:**

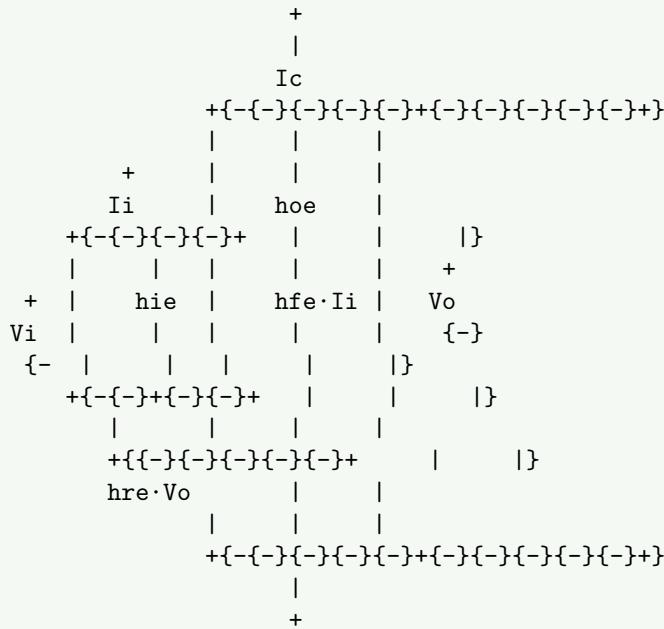


Table 5: h-parameters for CE Configuration

| 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]
        TR --- T2[Transistor 2]
    end

    subgraph "Direct Coupled"
        D1[Transistor 1] --- D2[Transistor 2]
        style D1 fill:#fff,stroke:#000
        style D2 fill:#fff,stroke:#000
        style TR fill:#000,stroke:#fff
    end

{Highlighting}
{Shaded}
```

## Mnemonic

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

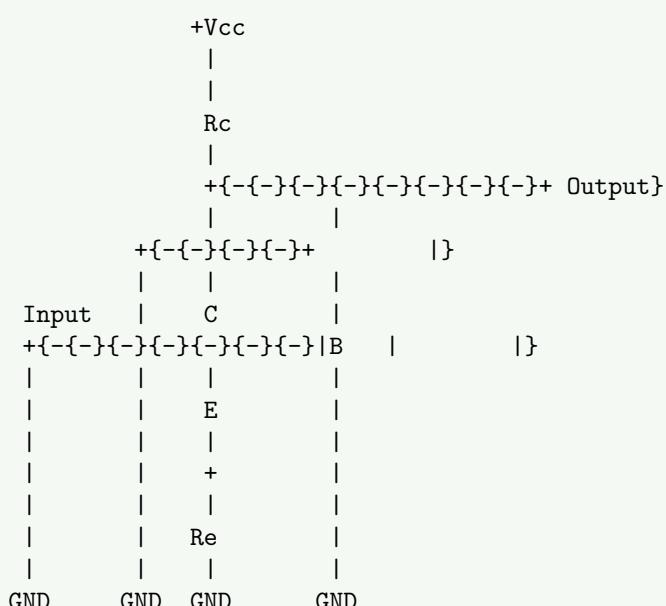
### Question 3(b) OR [4 marks]

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

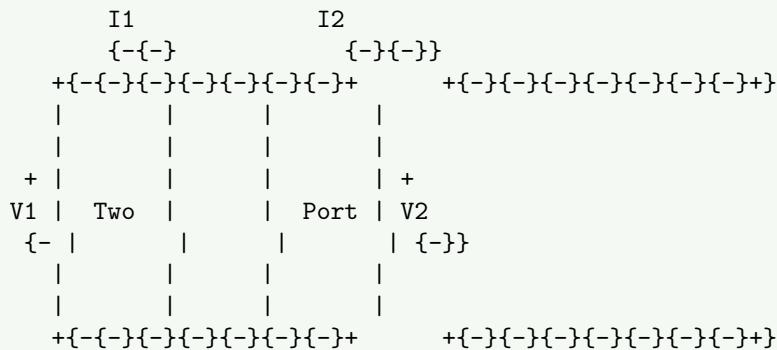
“CEA” - Common Emitter Amplifiers with signal inversion.

### 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               |
|---------------------------------|----------|--------------------|-------------------------------------|
| <b>Input impedance</b>          | $h_{11}$ | Ratio of $V_1/I_1$ | $V_2 = 0$ ( <i>Output shorted</i> ) |
| <b>Reverse voltage transfer</b> | $h_{12}$ | Ratio of $V_1/V_2$ | $I_1 = 0$ ( <i>Input open</i> )     |
| <b>Forward current transfer</b> | $h_{21}$ | Ratio of $I_2/I_1$ | $V_2 = 0$ ( <i>Output shorted</i> ) |
| <b>Output admittance</b>        | $h_{22}$ | Ratio of $I_2/V_2$ | $I_1 = 0$ ( <i>Input open</i> )     |

### 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]

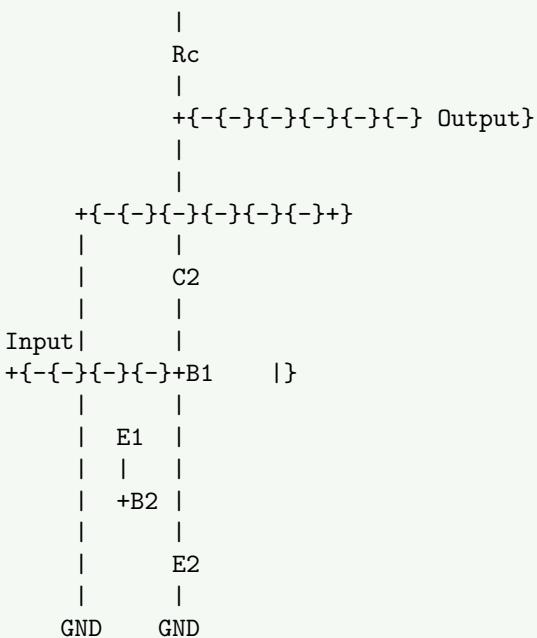
Explain Darlington pair and its applications.

## 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.

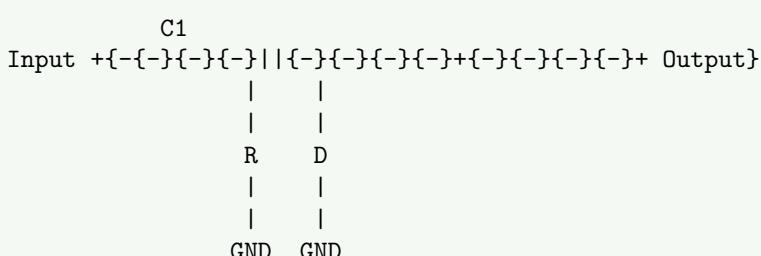
#### Question 4(b) [4 marks]

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
        direction LR
        C[Cathode<br />Metal Layer] --- E[Emissive Layer<br />Organic Material]
        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

**LDR (Light Dependent Resistor):** Photoresistor whose resistance decreases with increasing light intensity

**Symbol and Structure:**

/ { }

Symbol

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.

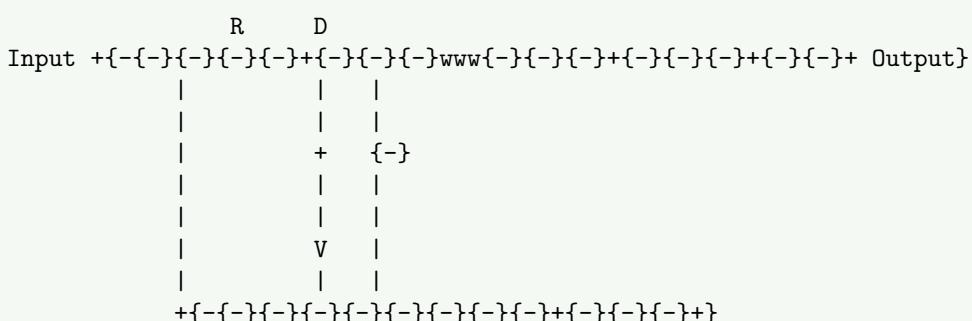
## Question 4(b) OR [4 marks]

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.

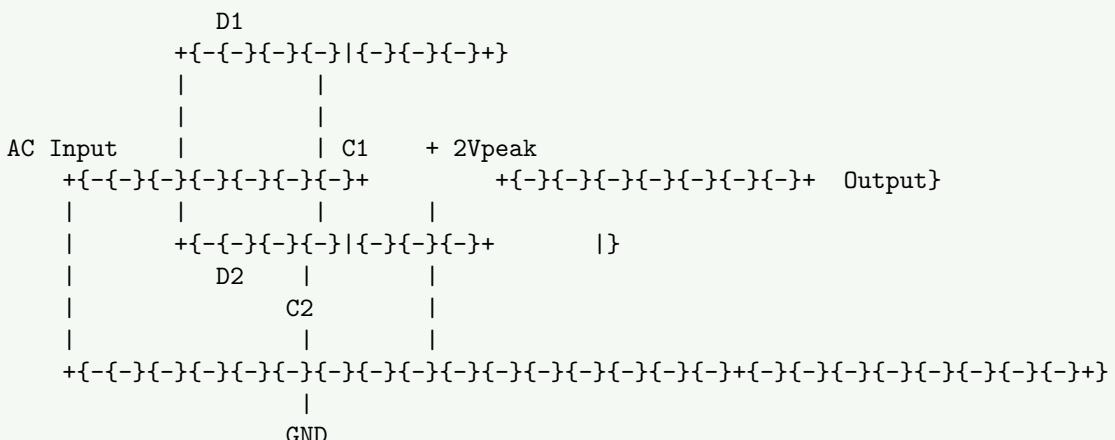
**Question 4(c) OR [7 marks]**

**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:**

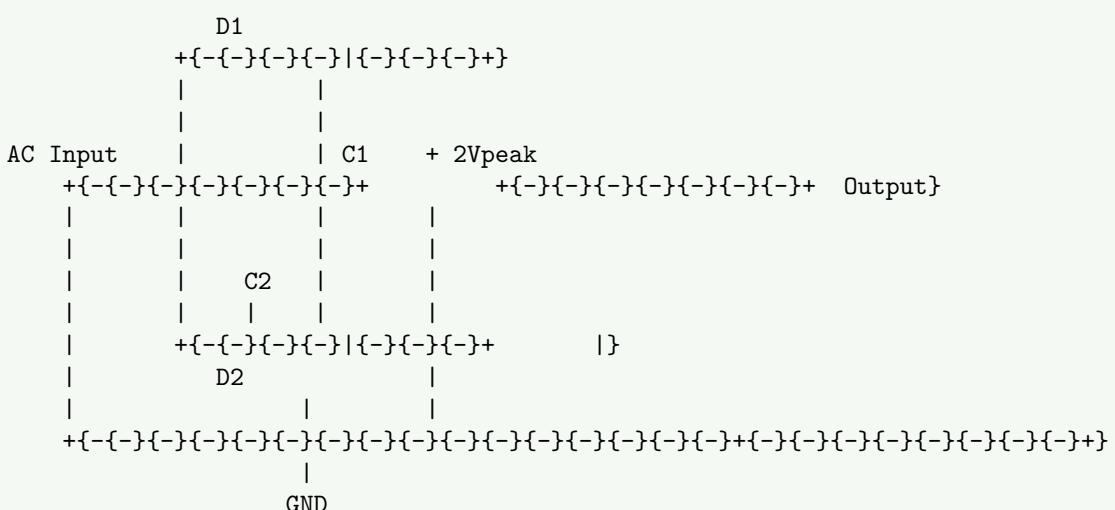


Table 8: Comparison

| 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

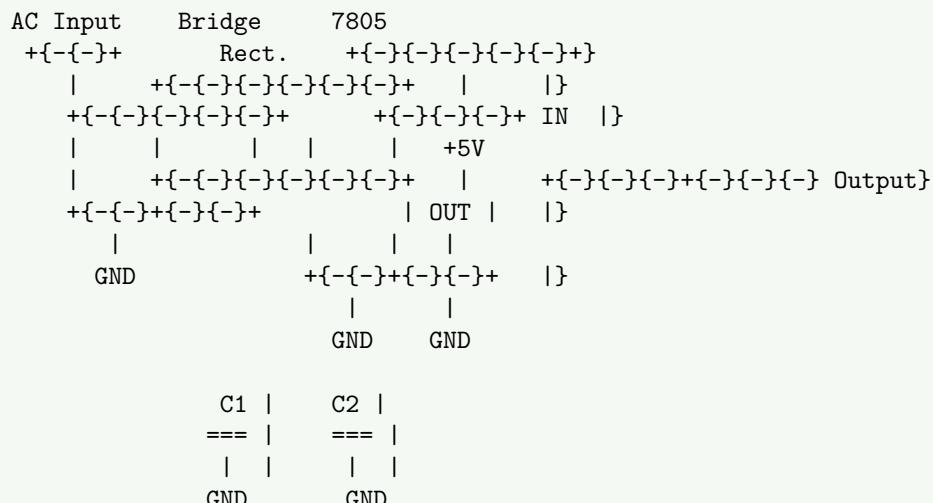
“DOUBLE” - Diodes Organize Unidirectional Boost, Lifting Electricity to twice input.

### 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  
/ Input Voltage Changes"]  
    A --> C["Load Regulation  
/ Output Current Changes"]  
    B --> D["Constant Output  
/ 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.

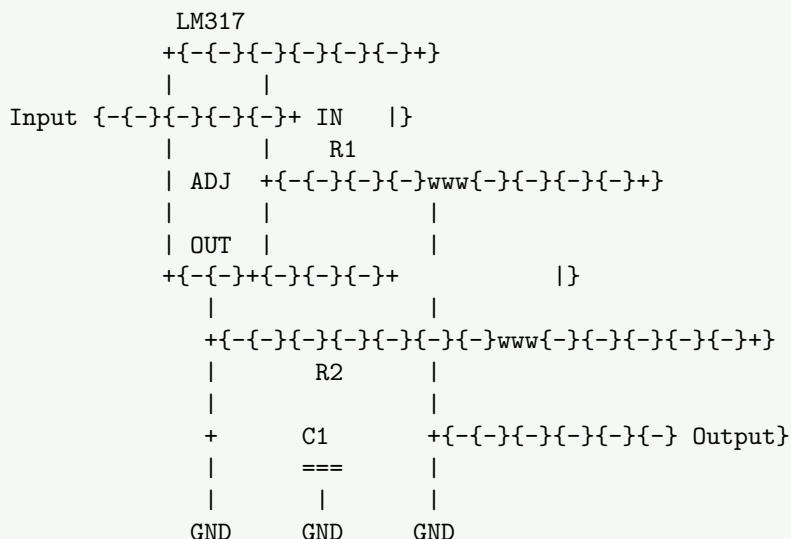
## Question 5(c) [7 marks]

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  $240\Omega$
- **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

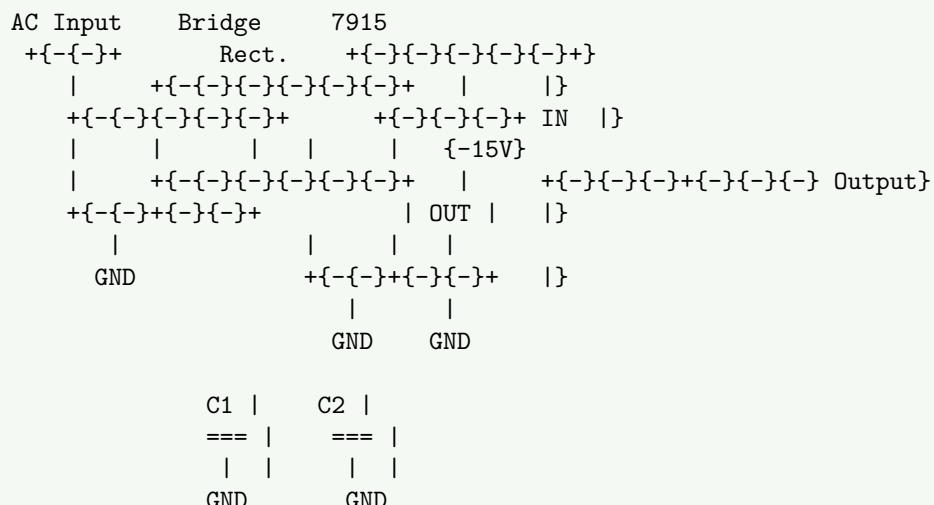
“VARY” - Voltage Adjustable Regulator Yields custom outputs.

### 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:



#### 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

#### Mnemonic

“NINE” - Negative IC Needs Efficient filtering.

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

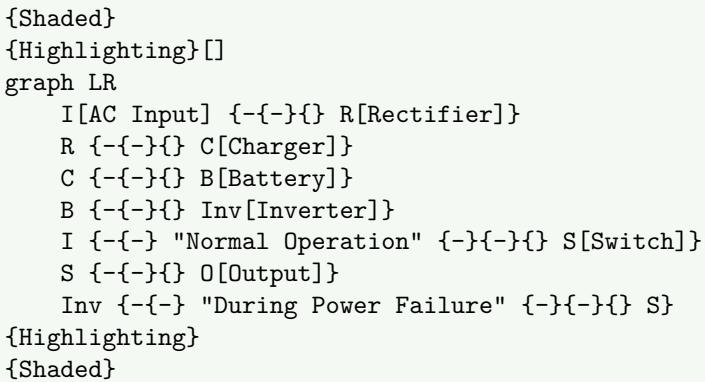
Explain working of UPS.

#### Solution

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

**Block Diagram:**

Mermaid Diagram (Code)



#### Types of UPS:

- **Offline/Standy 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.

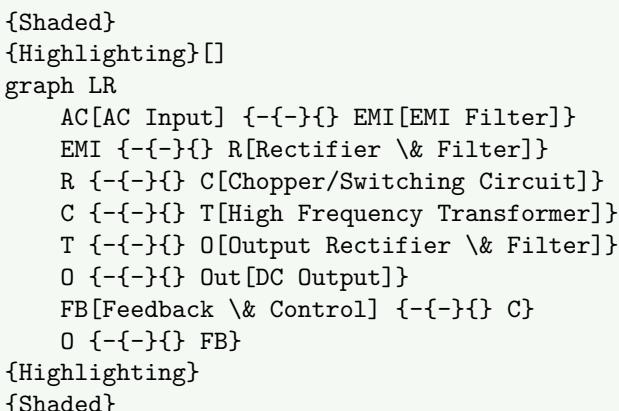
### Question 5(c) OR [7 marks]

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)



#### 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.