# Electronic Circuits Applications (4321103) - Summer 2024 Solution

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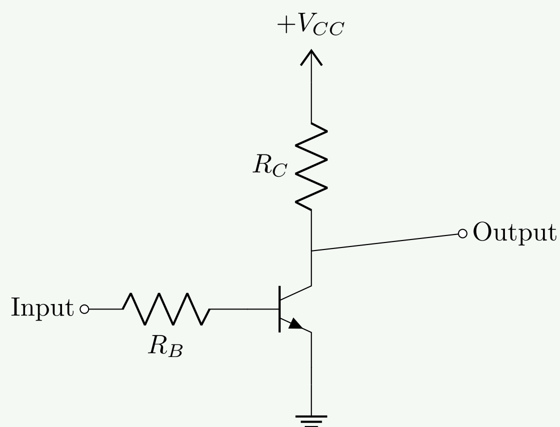
## Question 1 [a marks]

**3 Explain amplifier parameters Ai, Ri and Ro for CE configuration.**

**Solution**

In **Common Emitter (CE)** configuration, the key parameters are:




- **Current Gain ($A_i$)**: Ratio of output current to input current ($I_c/I_b$). Typically 50-200 in CE configuration.
- **Input Resistance ($R_i$)**: Opposition to input current at base terminal. Ranges from 1-2 kΩ in CE.
- **Output Resistance ($R_o$)**: Opposition at collector terminal. Typically 50 kΩ in CE.

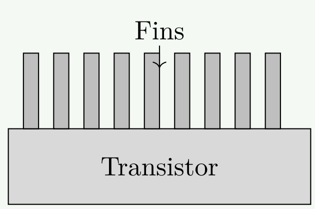
**Mnemonic**

"CIR parameters - **C**urrent gain, **I**nput resistance, and output **R**esistance determine amplifier performance"

## Question 1 [b marks]

**4 Write short-note on heat sink.**

**Solution**



- **Purpose**: Dissipates excess heat from electronic components (like power transistors) to prevent thermal damage.
- **Types**:
  - **Passive**: Aluminum or copper fins that rely on natural convection.
  - **Active**: Uses fans or liquid cooling for forced convection.
- **Thermal Resistance**: Lower thermal resistance ($\theta$, measured in °C/W) indicates better heat dissipation capability.
- **Materials**: Copper (best conductivity) or Aluminum (lightweight, cost-effective).

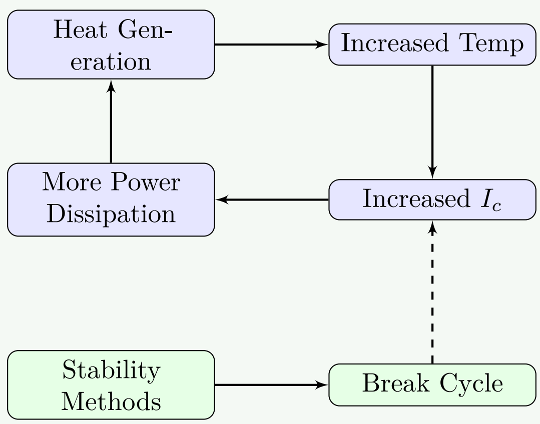
**Mnemonic**

"HARD sinks - **H**eat **A**way using **R**adiation and **D**issipation through metal sinks"

## Question 1 [c marks]

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

**Solution**




**Thermal Runaway:**

- **Definition**: A self-accelerating destructive process where the transistor heats up, causing more current to flow, which generates even more heat.
- **chain Reaction**: Increase in temperature → Increases leakage current ($I_{CO}$) → Increases collector current ($I_C = \beta I_B + (1+\beta)I_{CO}$) → Increases Power Dissipation ($P_D = V_{CE}I_C$) → Further Temperature Rise.
- **Result**: If unchecked, it leads to the physical destruction of the transistor.

**Thermal Stability:**

- **Definition**: The ability of a circuit to maintain a stable operating point ($Q$-point) despite variations in temperature.
- **Measure**: Quantified by the **Stability Factor (S)**. Lower values of S indicate better thermal stability.

**Overcoming Thermal Runaway:**

1. **Heat Sinks**: Increasing surface area to dissipate heat into the air.
2. **Emitter Resistor**: Using an unbypassed emitter resistor ($R_E$) provides negative feedback. If $I_C$ rises, voltage drop across $R_E$ increases, reducing $V_{BE}$, which reduces $I_B$ and thus opposes the rise in $I_C$.
3. **Biasing Methods**: Using circuits like **Voltage Divider Bias** which offer better stability than fixed bias.
4. **Compensation**: Using temperature-sensitive components (thermistors, diodes) in the bias circuit to counteract parameter changes.

**Mnemonic**

"SHEER protection - **S**inks for **H**eat, **E**mitter resistors, **E**xternal cooling, and **R**obust biasing prevent thermal runaway"

# Question 1 [c marks]

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

## Solution

**Types of Biasing Methods:**

| Method | Stability | Complexity |
|---|---|---|
| Fixed Bias | Poor | Simple |
| Collector Feedback | Medium | Medium |
| Emitter Bias | Good | Medium |
| Voltage Divider | Excellent | Complex |

**Voltage Divider Biasing:**

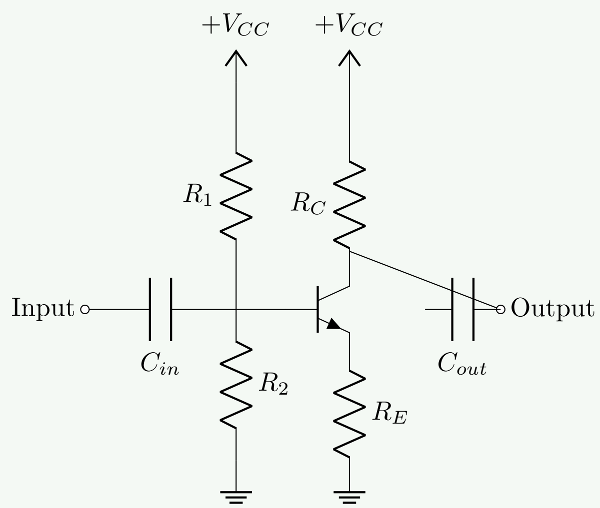



**Figure 1.** Voltage Divider Bias Circuit

- **Circuit Structure**: Uses two resistors $R_1$ and $R_2$ connected in series across the supply $V_{CC}$ to provide a fixed potential at the base.
- **Operating Principle**: The voltage across $R_2$ (base voltage $V_B$) forward biases the emitter junction.
- **Base Voltage**: $V_B = V_{CC} \times \frac{R_2}{R_1+R_2}$
- **Stability**: This is the most widely used method because the operating point is almost independent of the transistor's $\beta$.
  - If $I_C$ increases due to temperature, $I_E$ increases ($I_E \approx I_C$).
  - Voltage drop across $R_E$ ($V_E = I_E R_E$) increases.
  - Since $V_B$ is constant, $V_{BE} = V_B - V_E$ decreases.
  - Decreased $V_{BE}$ reduces $I_B$, which in turn reduces $I_C$, stabilizing the circuit.
- **Advantage**: High stability factor ($S \approx 1$).

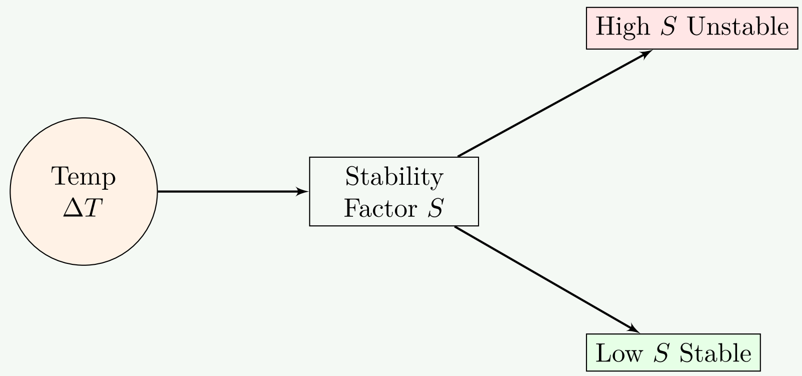
### Mnemonic

"DIVE for stability - **D**ivider **I**s **V**ery **E**ffective for temperature and $\beta$ variations"

# Question 2 [a marks]

**3 Explain Stability Factor with features.**

**Solution**




- **Definition**: Stability factor ($S$) indicates the degree of change in collector current ($I_C$) with respect to the reverse saturation current ($I_{CO}$), keeping $\beta$ and $V_{BE}$ constant.
- **Formula**: $S = \frac{dI_C}{dI_{CO}}$
- **Ideal Value**: Ideally $S = 1$. The lower the value of $S$, the better the thermal stability.
- **Significance**: It quantifies how sensitive the Q-point is to temperature variations. A circuit with $S = 10$ is less stable than one with $S = 2$.

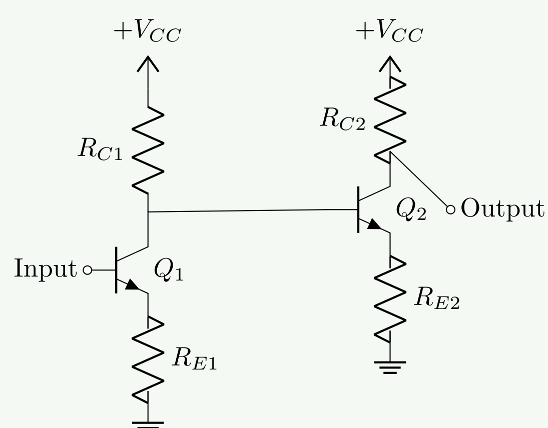
**Mnemonic**

"LESS is better - **L**ower values **E**nsure **S**table **S**ystem for temperature changes"

## Question 2 [b marks]

**4 Describe direct coupling technique of cascading.**

**Solution**




- **Definition**: In direct coupling, the output of the first stage is directly connected to the input of the next stage without any coupling capacitor or transformer.
- **Working**: The DC collector voltage of the first stage provides the DC base bias for the second stage.
- **Advantages**:
  - Can amplify extremely low frequencies (including DC).
  - Simple circuit, fewer components (no capacitors/transformers).
  - Easy to fabricate in Integrated Circuits (ICs).
- **Disadvantages**:
  - Thermal drift (shift in Q-point) is amplified stage by stage.
  - Requires careful design to match DC levels.

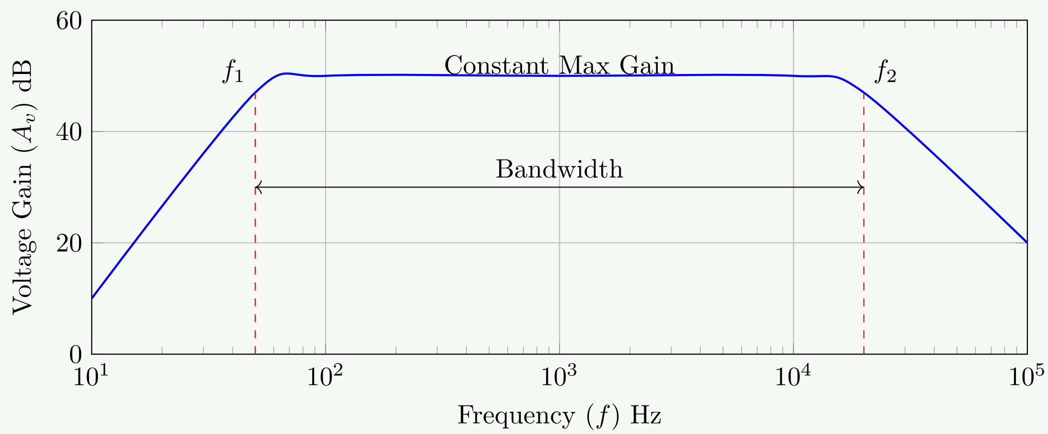
**Mnemonic**

"DIAL for DC - **D**irect **I**nterconnection **A**mplifies **L**ow frequencies without capacitors"

## Question 2 [c marks]

**7 Explain frequency response of two stages RC coupled amplifier.**

**Solution**




**Frequency Response Analysis:**

1. **Low Frequency Region ($f < f_1$)**:
   - The reactance of coupling capacitors ($C_C = 1/2\pi fC$) is high.
   - A significant voltage drop occurs across $C_C$, reducing the signal reaching the next stage.
   - The emitter bypass capacitor ($C_E$) also has high reactance, reducing the gain due to negative feedback.
2. **Mid Frequency Region ($f_1 < f < f_2$)**:
   - Capacitors act as short circuits.
   - Gain remains constant and maximum.
3. **High Frequency Region ($f > f_2$)**:
   - Reactance of internal transistor capacitances (inter-electrode capacitance) becomes low.
   - These shunt the signal to ground, reducing the gain.
   - Wiring capacitance also contributes to gain reduction.
4. **Bandwidth**: The range of frequencies between the lower cut-off ($f_1$) and upper cut-off ($f_2$) where gain is at least 70.7% (-3dB) of the maximum is the bandwidth.

**Mnemonic**

"LMH frequency regions - **L**ow has rising gain, **M**iddle has flat gain, **H**igh has falling gain"

## Question 2 [a marks]

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

**Solution**

**Bandwidth (BW):**

- It is the range of frequencies over which the amplifier provides satisfactory gain (usually defined as gain being $\geq$ 70.7% of maximum).

- Formula: $BW = f_2 - f_1$, where $f_2$ is upper cut-off and $f_1$ is lower cut-off frequency.

**Gain-Bandwidth Product (GBW):**

- For a given amplifier, the product of voltage gain ($A_v$) and bandwidth ($BW$) is a constant.
- $GBW = A_v \times BW =$ Constant.
- **Significance**: If we increase gain (e.g., by cascading), the bandwidth decreases, and vice versa. It represents the figure of merit for an amplifier.

**Mnemonic**

"BIG value - **B**andwidth and gain **I**nverse relationship is a **G**iven constant"

## Question 2 [b marks]

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

**Solution**

| **Capacitor** | **Low Freq** | **Mid Freq** | **High Freq** |
|---|---|---|---|
| Emitter Bypass ($C_E$) | High reactance, reduces gain (feedback active) | Short circuit, max gain (feedback bypassed) | Short circuit, no effect |
| Coupling ($C_C$) | High reactance, blocks/attenuates signal | Short circuit, allows full signal | Short circuit, no effect |

- **Coupling Capacitor** ($C_C$):
  - Blocks DC to prevent bias interaction between stages.
  - At low frequencies, its high reactance ($X_C$) causes signal loss, defining the lower cut-off frequency $f_1$.
- **Emitter Bypass Capacitor** ($C_E$):
  - Connected in parallel with $R_E$ to bypass AC signals to ground.
  - Prevents degeneration (negative feedback) at signal frequencies, thus increasing voltage gain.
  - At low frequencies, if $X_C$ is high, feedback occurs, reducing gain.

**Mnemonic**

"CABLE effect - **C**apacitors **A**ct as **B**arriers at **L**ow frequencies, improving at higher frequencies"

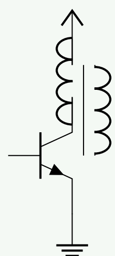
## Question 2 [c marks]

**7 Compare transformer coupled amplifier and RC coupled amplifier.**

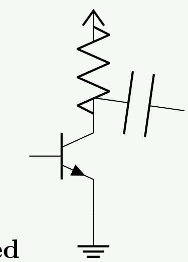
**Solution**

| Parameter | Transformer Coupled | RC Coupled |
|---|---|---|
| Coupling Device | Transformer | Capacitor & Resistor |
| Impedance Matching | Excellent (adjustable via turns ratio) | Poor |
| Frequency Response | Poor (limited due to transformer inductance) | Excellent (wide and flat over audio range) |
| Efficiency | High (no power loss in collector resistor) | Low (power wasted in collector resistor) |
| Size & Weight | Bulky and Heavy | Compact and Light |
| Cost | Expensive | Inexpensive |
| Application | Power Amplifiers (Impedance matching) | Voltage Amplifiers (Audio/Pre-amps) |

**Transformer Coupled**



**RC Coupled**



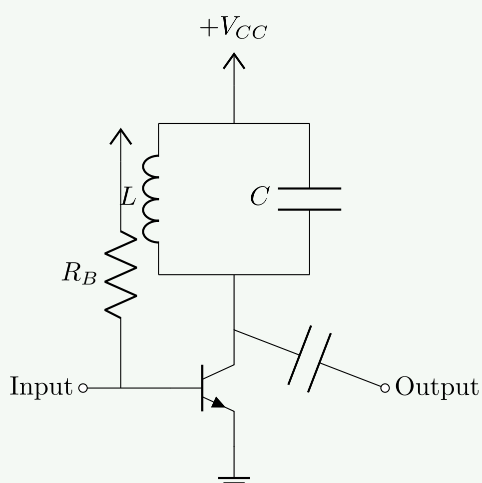
**Mnemonic**

"TREE factors - **TR**ansformers provide **E**fficiency and **E**xcellent impedance matching, RC provides Cost savings"

## Question 3 [a marks]

**3 Describe the transistorized tuned amplifier.**

**Solution**




- **Definition**: An amplifier that uses a parallel LC circuit (tank circuit) as the collector load to amplify a specific narrow band of frequencies.
- **Resonance**: The LC circuit resonates at frequency $f_r = \frac{1}{2\pi\sqrt{LC}}$.
- **Gain**: At resonance, the impedance of the tank circuit is maximum (resistive), resulting in maximum voltage

gain.
- **Applications**: Used in the Radio Frequency (RF) and Intermediate Frequency (IF) stages of receivers.

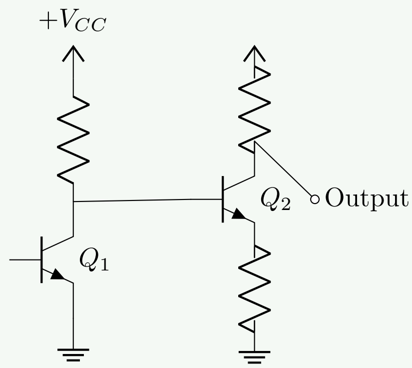
**Mnemonic**

"TRIP to resonance - **T**uned **R**esonant circuits **I**mprove **P**erformance at specific frequencies"

## Question 3 [b marks]

**4 Explain in brief Direct coupled amplifier.**

**Solution**




- **Definition**: A multi-stage amplifier where the output of one stage is connected directly to the input of the next stage without any reactive components.
- **Characteristics**:
  - **Low Frequency Response**: Excellent, can amplify down to DC (0 Hz).
  - **Simplicity**: Requires fewer components (no bulky capacitors).
  - **Issues**: Suffers from **DC drift** (thermal instability shifting the operating point).
- **Application**: Linear ICs, Operational Amplifiers, low-frequency instrumentation.

**Mnemonic**

"COLD advantages - **C**ompact design, **O**utstanding low-frequency response, **L**ess components, **D**irect connection"

## Question 3 [c marks]

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

**Solution**

**Transistor h-parameter Model (CE Configuration):**

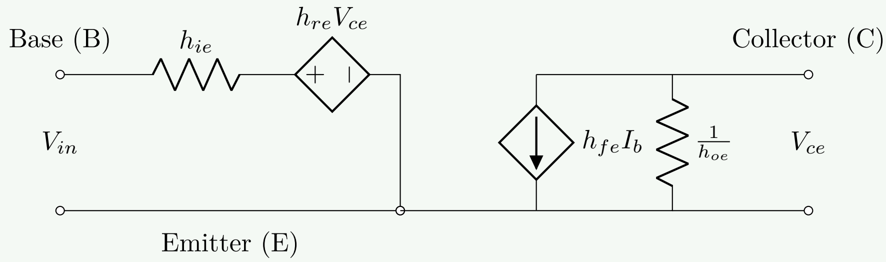



**Figure 2.** h-parameter Equivalent Circuit for CE

**Importance of h-parameters:**

- **Hybrid Nature**: They use a mix of units (Ω, Siemens, dimensionless), hence "hybrid".
- **Ease of Measurement**: They are defined based on open-circuit and short-circuit conditions which are easy to implement practically.
- **Accuracy**: They provide accurate results for small-signal analysis at low frequencies.
- **Standardization**: Manufacturers specify transistor characteristics using these parameters ($h_{fe}$, $h_{ie}$, etc.).

**CE Parameters:**

- $h_{ie}$ ($h_{11}$): Input Impedance.
- $h_{re}$ ($h_{12}$): Reverse Voltage Ratio.
- $h_{fe}$ ($h_{21}$): Forward Current Gain.
- $h_{oe}$ ($h_{22}$): Output Admittance.

**Mnemonic**

"FINE parameters - **F**our **I**nterconnected **N**etwork **E**lements define transistor completely"

## Question 3 [a marks]

**3 Compare transformer coupled amplifier and direct coupled amplifier.**

**Solution**

| **Parameter** | **Transformer Coupled** | **Direct Coupled** |
|---|---|---|
| DC Isolation | Complete | None |
| Freq Response | Poor (limited band) | Excellent (down to DC) |
| Size/Weight | Bulky/Heavy | Compact/Light |
| Impedance Matching | Excellent | Poor |
| Cost | High | Low |
| Drift | No drift problem | Severe drift problem |

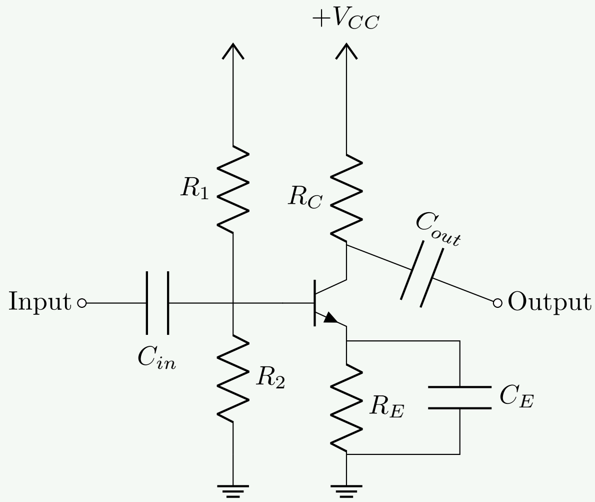
**Mnemonic**

"TIP for selection - **T**ransformer for **I**mpedance matching and **P**ower transfer, Direct for low frequencies"

## Question 3 [b marks]

**4 Draw and Explain circuit diagram of common emitter amplifier.**

**Solution**




- **Circuit**: Uses Voltage Divider Bias ($R_1, R_2$) for stability. Capacitors $C_{in}$ and $C_{out}$ block DC. $C_E$ bypasses $R_E$ to prevent AC gain application.
- **Operation**: Small AC input at base varies base current, which is amplified by $\beta$ at the collector.
- **Phase Shift**: Output is **180° out of phase** with input.
- **Characteristics**: Moderate input/output impedance, high voltage and current gain.

**Mnemonic**

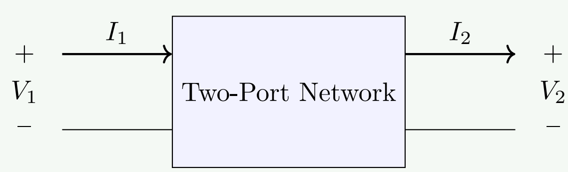
"GAIN characteristics - **G**ood **A**mplification with **I**nverted output and **N**otable efficiency"

## Question 3 [c marks]

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

**Solution**

**Two-Port Network:**




**h-Parameter Equations:**

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

**Advantages:**

- **Realizable**: Parameters correspond to easy-to-measure physical quantities (impedance, gain, etc.).
- **Low Frequency Suitability**: Highly accurate for analyzing audio frequency circuits.
- **Universal**: Apply to any active device (BJT, FET) treated as a black box.
- **Dimensional Variety**: Since they mix ohms, siemens, and dimensionless ratios, they flexibly describe complex interactions.

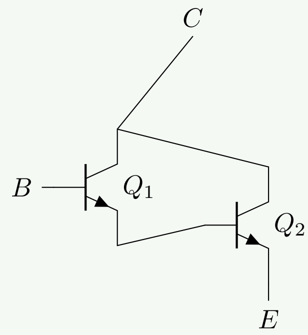
**Mnemonic**

"SMART parameters - **S**imple **M**easurement, **A**ccurate modeling, **R**eliable, **T**emperature-stable"

# Question 4 [a marks]

**3 Explain Darlington pair and its applications.**

**Solution**




- **Definition**: Two transistors connected such that the emitter current of the first becomes the base current of the second, often packaged as a single device.
- **Current Gain**: The total current gain is the product of individual gains ($\beta_{total} \approx \beta_1 \times \beta_2$). Extremely high.
- **Input Impedance**: Very high.
- **Applications**: High current drivers (relays, motors), input stages of high-impedance amplifiers.

**Mnemonic**

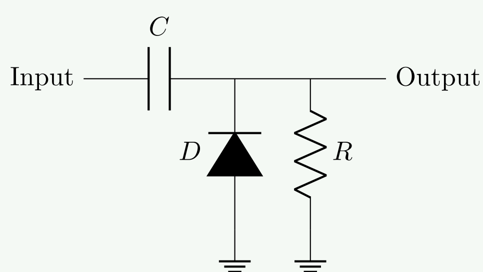
"HIGH gain - **H**ugely **I**ncreased **G**ain from **H**arnessing two transistors"

# Question 4 [b marks]

**4 Describe the diode clamper circuit with necessary diagram.**

**Solution**

**Positive Clamper:**




- **Function**: Adds a DC shift to the input signal without changing its shape (DC Restorer).
- **Positive Clamper**: Shifts the signal UP so negative peaks sit on zero (or reference) level.
- **Operation**:
  - During the negative half-cycle, Diode conducts, charging Capacitor to $V_p$ (polarity: + on right).
  - During the positive half-cycle, Diode is reverse biased.
  - Output voltage $V_o = V_{in} + V_C = V_{in} + V_p$.

**Mnemonic**

"CAPS effect - **C**apacitor **A**nd diode **P**air **S**hifts signal by exact DC level"

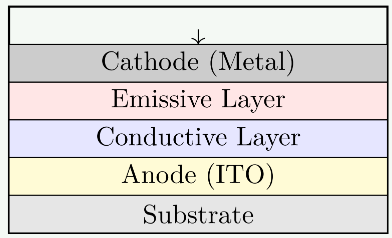
# Question 4 [c marks]

**7 Explain the construction, working and applications of OLED.**

## Solution

**OLED Construction:**

Structure of OLED




- **Construction**: Consists of organic semiconductor layers sandwiched between two electrodes (Anode and Cathode) deposited on a substrate.
- **Layers**:
  - **Emissive Layer**: Organic molecules that emit light.
  - **Conductive Layer**: Transports holes from anode.
- **Working**:
  - When voltage is applied, current flows from cathode to anode.
  - Cathode gives electrons to emissive layer; Anode removes electrons (adds holes) to conductive layer.
  - Electrons and holes recombine in the emissive layer, releasing energy as photons (Light).
- **Applications**: Premium smartphones, TVs, flexible displays, digital signage.

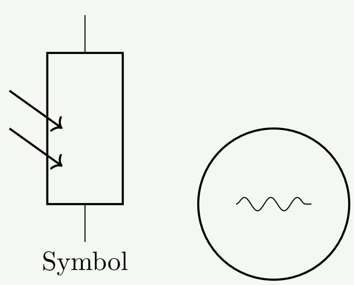
**Mnemonic**

"OLED benefits - **O**rganic materials, **L**ightweight design, **E**fficient operation, **D**irect emission"

# Question 4 [a marks]

**3 Explain Short note on LDR.**

## Solution




Structure (Top View)

- **Full Form**: Light Dependent Resistor.
- **Principle**: Photoconductivity. Resistance decreases when light intensity increases.
- **Material**: Made of Cadmium Sulfide (CdS).
- **Operation**: In dark, resistance is very high (MΩ). In light, electron-hole pairs are generated, resistance drops (to few 100 Ω).
- **Use**: Automatic street lights, camera exposure meters.

**Mnemonic**

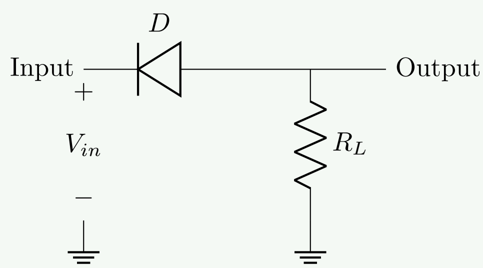
"DARK increases resistance - **D**ecreasing light **A**nd **R**ising darkness **K**eep resistance high"

## Question 4 [b marks]

**4 Describe the diode clipper circuit with necessary diagram.**

**Solution**

**Positive Clipper (Series):**




- **Definition**: A circuit that removes (clips) a portion of the input signal waveform.
- **Positive Clipper**: Removes the positive half cycle.
- **Working**:
  - During positive half cycle, Diode is reverse biased (Open). No current flows to load. Output = 0.
  - During negative half cycle, Diode is forward biased (Short). Current flows. Output = Input (approx).
- **Applications**: Waveform shaping, protection against voltage spikes.

**Mnemonic**

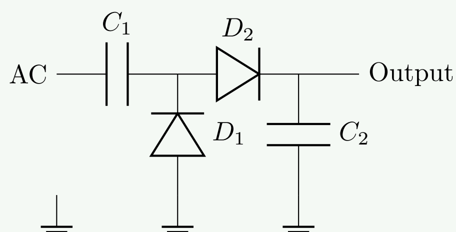
"CLIP waves - **C**ircuit **L**imits **I**nput **P**eaks by using diode conduction"

## Question 4 [c marks]

**7 Explain Half Wave and Full wave Voltage Doubler.**

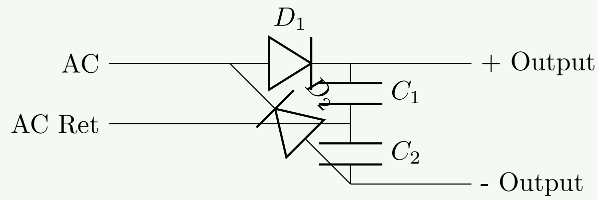
**Solution**

**Half-Wave Voltage Doubler:**




- **Operation**:
  - Negative Cycle: $D_1$ conducts, $C_1$ charges to $V_m$ (peak).
  - Positive Cycle: $D_2$ conducts. Input voltage ($V_m$) + $C_1$ voltage ($V_m$) charges $C_2$ to $2V_m$.
- **Output**: DC voltage $\approx 2V_m$.

**Full-Wave Voltage Doubler:**




- **Operation**: Charges one capacitor during the positive cycle and the other during the negative cycle. The output is the sum across both.
- **Advantage**: Higher ripple frequency (easier to filter).

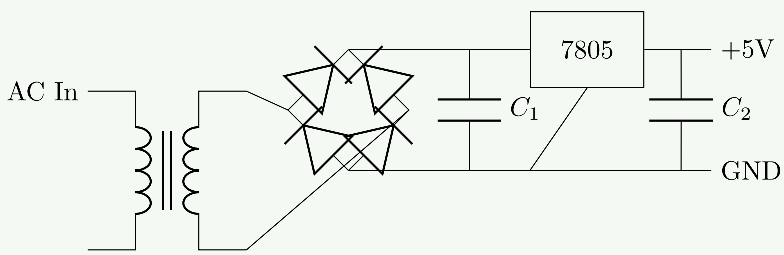
**Mnemonic**

"CHASE 2V - **C**apacitors **H**old **A**lternating **S**upply **E**nergy to produce 2× Voltage"

## Question 5 [a marks]

**3 Draw circuit diagram for +5v Power Supply using its IC and explain in brief.**

**Solution**




- **Components**:
  - **Transformer**: Steps down AC mains (230V to 9V).
  - **Rectifier**: Converts AC to pulsating DC.
  - **Filter** ($C_1$): Smooths pulsations to produce unregulated DC.
  - **IC 7805**: Voltage regulator that provides constant +5V output.
  - **Capacitor** ($C_2$): Removes high-frequency noise/transients.
- **Working**: The AC is rectified, filtered, and then regulated by the 7805 IC which dissipates excess voltage as heat to maintain 5V.

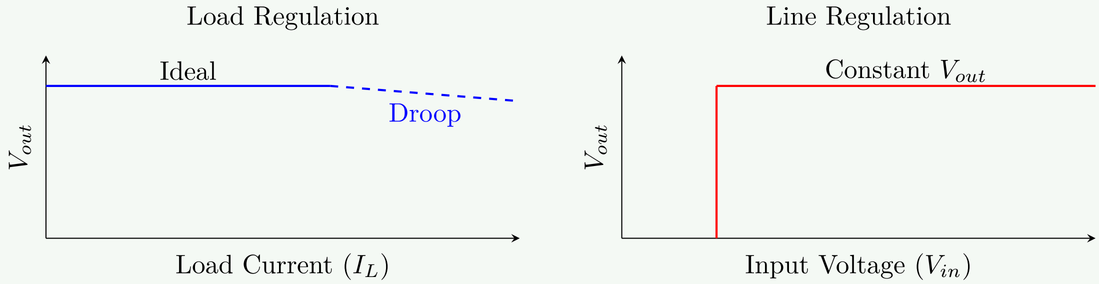
**Mnemonic**

"FIRM voltage - **F**iltered **I**nput, **R**egulated by 7805 **M**akes stable voltage"

## Question 5 [b marks]

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

**Solution**




- **Load Regulation**:
  - **Definition**: The ability of a power supply to maintain constant output voltage despite changes in load current.
  - **Formula**: $\%LR = \frac{V_{NoLow} - V_{FullLoad}}{V_{FullLoad}} \times 100$
  - **Ideal**: 0% (Perfectly stiff voltage source).
- **Line Regulation**:
  - **Definition**: The ability to maintain constant output voltage despite changes in AC input (mains) voltage.
  - **Formula**: $\%SR = \frac{\Delta V_{out}}{\Delta V_{in}} \times 100$
  - **Significance**: Ensures voltage stability during brownouts or surges.

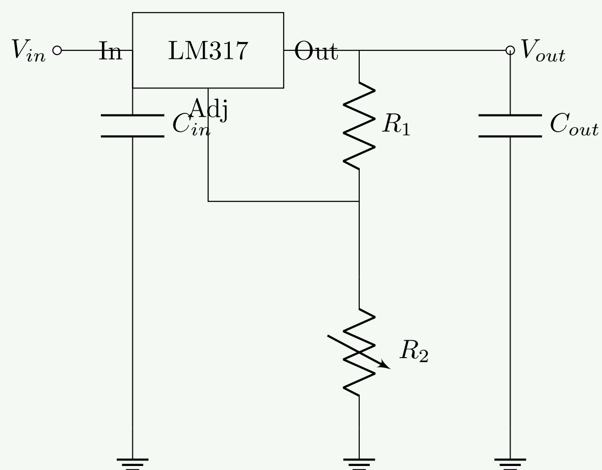
**Mnemonic**

"LIVER health - **LI**ne regulation for **V**ariations in Input, load regulation for **E**xternal **R**esistance changes"

## Question 5 [c marks]

**7 Explain adjustable voltage regulator using LM317 with circuit diagram.**

**Solution**




- **Description**: LM317 is a popular adjustable positive voltage regulator capable of supplying more than 1.5A over a 1.25V to 37V output range.
- **Working**:
  - It develops a nominal 1.25V reference voltage ($V_{ref}$) between the Output and Adjustment terminal.
  - This reference voltage is impressed across resistor $R_1$, causing a constant current $I_1$ to flow.
  - This current also flows through $R_2$ (ignoring small $I_{Adj}$).
- **formula**: $V_{out} = 1.25V \left(1 + \frac{R_2}{R_1}\right) + I_{Adj} R_2$
- **Applications**: Variable bench power supplies, battery chargers.

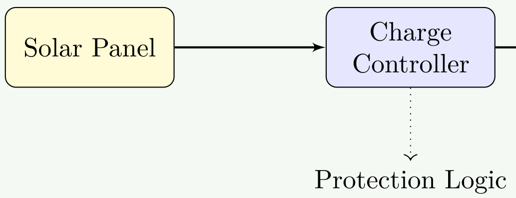
## Mnemonic

"VAIR control - **V**ariable **A**djustable **I**ntegrated **R**egulator controls voltage precisely"

# Question 5 [a marks]

**3 Explain working of solar battery charger circuits.**

## Solution




- **Function**: Converts solar energy into electrical energy to charge a rechargeable battery.
- **Charge Controller**:
  - Regulates voltage and current from solar panels.
  - Prevents **Overcharging** (which damages battery) and **Reverse Current** (battery discharging into panel at night).
- **Operation**: Panel generates DC → Controller adjusts levels → Battery stores energy → Load uses it.

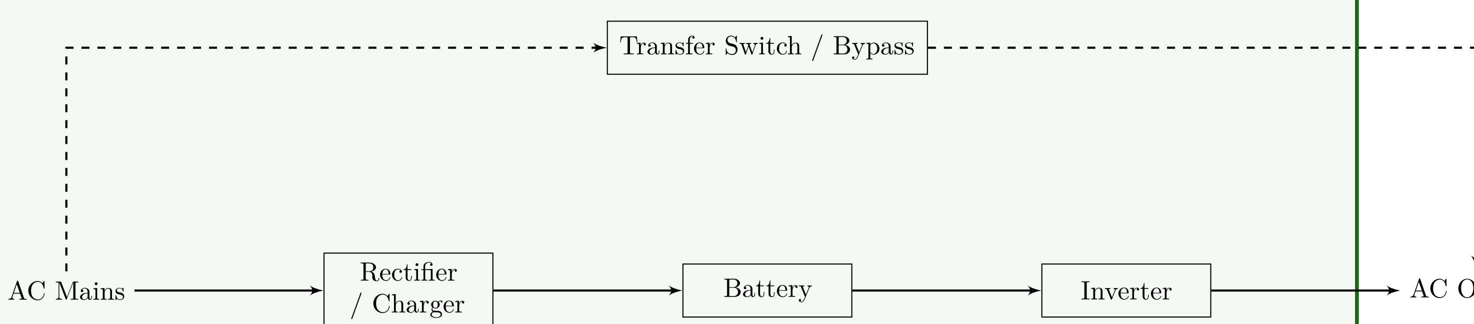
## Mnemonic

"SCBL system - **S**olar panel **C**onverts sunlight, **B**attery stores, **L**oad consumes"

# Question 5 [b marks]

**4 Explain working of UPS.**

## Solution




- **Full Form**: Uninterruptible Power Supply.
- **Normal Mode**: AC mains powers the load (directly or via rectification) and charges the battery.
- **Backup Mode**: When mains fail, the Inverter converts DC from the Battery back to AC to power the load.
- **Transfer Switch**: Seamlessly switches between Mains and Inverter output to assume zero downtime.

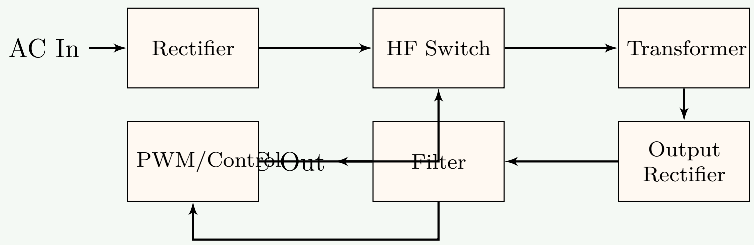
## Mnemonic

"PRIME power - **P**ower **R**emains **I**ntact during **M**ains **E**lectricity problems"

# Question 5 [c marks]

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

## Solution




**Working of SMPS (Switch Mode Power Supply):**

1. **Input Rectification**: AC mains is converted to high-voltage DC.
2. **Switching**: A high-speed transistor switches this DC on and off at high frequency (kHz to MHz).
3. **Transformation**: The high-frequency pulses are stepped down by a small, lightweight ferrite-core transformer.
4. **Output Rectification**: The secondary output is rectified and filtered to smooth DC.
5. **Regulation**: A feedback circuit adjusts the duty cycle (PWM) of the switch to maintain constant output voltage.

**Advantages:**

- **High Efficiency**: 70-90% (transistor operates as switch, low power loss).
- **Compact**: High frequency allows smaller transformers and capacitors.
- **Flexible**: Can step-up, step-down, or invert voltage.

**Disadvantages:**

- **Noise**: Switching generates EMI (Interference) and output ripple.
- **Complexity**: Complex circuit design compared to linear supplies.

### Mnemonic

"FISH factors - **F**requency switching, **I**solation, **S**mall size, **H**igh efficiency are SMPS benefits"