

# Electronic Circuits & Applications (4321103) - Summer 2023 Solution

Milav Dabgar

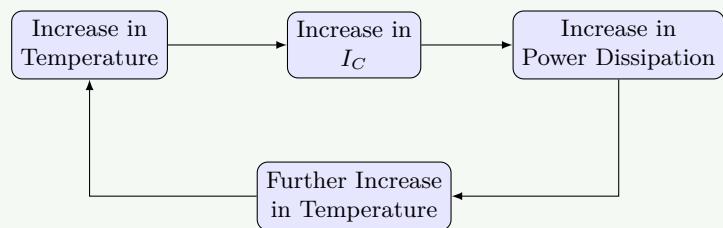
August 09, 2023

## Question 1 [a marks]

3 Explain thermal runaway in details.

### Solution

**Thermal Runaway:** Thermal runaway is a destructive mechanism in BJT transistors where increased temperature creates a self-reinforcing cycle leading to device failure.



1. **Heat Generation:** Temperature rises from normal operation.
2. **Leakage Current:** Collector current  $I_C$  increases with temperature.
3. **Power Dissipation:** More power = Temperature rises further.
4. **Destructive Cycle:** Continuous cycle until transistor destroys itself.

### Mnemonic

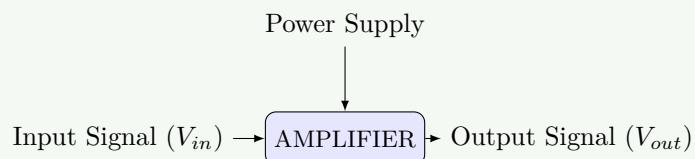
The Higher Temperature, The Higher Current

## Question 1 [b marks]

4 Define amplifier with simple block diagram write down amplifier parameters.

### Solution

**Amplifier:** An amplifier is an electronic device that increases the power, voltage or current of an input signal.



**Table 1.** Amplifier Parameters

Parameter	Description
Voltage Gain ( $A_v$ )	Ratio of output voltage to input voltage
Current Gain ( $A_i$ )	Ratio of output current to input current
Power Gain ( $A_p$ )	Product of voltage gain and current gain
Bandwidth	Range of frequencies amplifier can handle
Input Impedance	Resistance seen by the input source
Output Impedance	Internal resistance of amplifier

**Mnemonic**

VIPS-BIO (Voltage, Input impedance, Power, Supply, Bandwidth, Impedance Output)

## Question 1 [c marks]

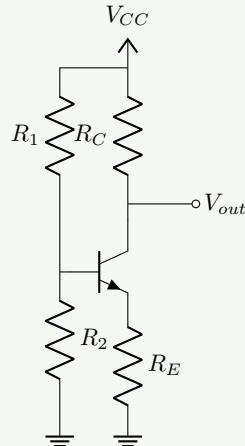
7 Define Biasing in transistor? Write down types of biasing methods. Explain the voltage divider biasing method in details.

**Solution**

**Biasing:** Biasing is the process of establishing a stable operating point (Q-point) for a transistor by applying DC voltages.

**Types of Biasing Methods:**

- Fixed Bias (Simple, poor stability)
- Collector Feedback Bias (Self-adjusting, better stability)
- Voltage Divider Bias (Best stability, widely used)
- Emitter Bias (Good stability, negative feedback)

**Voltage Divider Biasing:**

- $R_1$  &  $R_2$ : Form voltage divider to provide stable base voltage ( $V_B$ ).
- $R_E$ : Provides stabilization through negative feedback.
- $R_C$ : Determines collector current and voltage gain.
- **Stability:** Best stability against temperature variations. The base voltage is largely independent of  $\beta$ .

**Mnemonic**

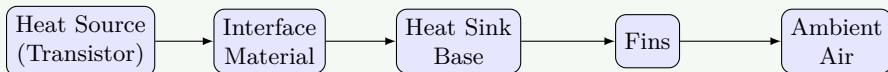
Divide Voltage Before Transistor Conducts

## Question 1 [c marks]

7 Explain Heat sink.

### Solution

**Heat Sink:** A heat sink is a passive heat exchanger that transfers heat from electronic devices to the surrounding air.



**Table 2.** Heat Sink Components

Component	Function
Base	Conducts heat from device
Fins	Increases surface area for heat dissipation
Thermal Interface Material	Improves contact between device and sink
Types	Extruded, Bonded, Folded, Die-cast

- **Thermal Resistance:** Lower is better for heat dissipation.
- **Material:** Usually aluminum or copper for good conductivity.
- **Surface Area:** More fins means better cooling.
- **Air Flow:** Critical for efficient heat removal.

### Mnemonic

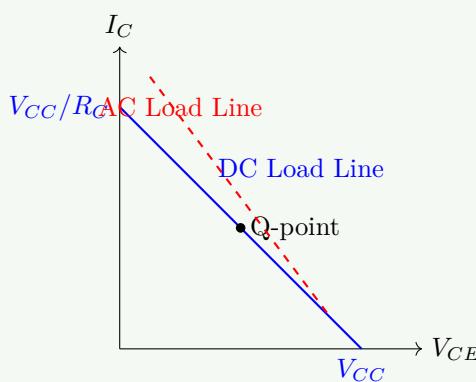
Heat Sinks Keep Transistors Running

## Question 2 [a marks]

3 Describe the D.C. and A.C. Load Lines.

### Solution

**Load Lines:** Load lines graphically represent possible operating points of a transistor on its characteristic curves.



- **DC Load Line:** Shows all possible operating points under DC conditions.
  - Equation:  $I_C = (V_{CC} - V_{CE})/R_C$
  - Endpoints:  $(0, V_{CC}/R_C)$  and  $(V_{CC}, 0)$
- **AC Load Line:** Shows operating points during AC signal handling.
  - Steeper Slope: Due to AC resistance being less than DC resistance.
  - Centered at Q-point: The operating point established by biasing.

**Mnemonic**

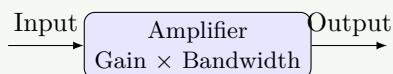
DC Draws Completely, AC Alters Course

**Question 2 [b marks]**

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

**Solution**

**Bandwidth and Gain-Bandwidth Product:** Key specifications for amplifier frequency performance.



**Table 3.** Frequency Parameters

Parameter	Description
Bandwidth	Frequency range where gain drops by less than 3dB
Lower Cutoff ( $f_1$ )	Frequency where gain drops by 3dB at low end
Upper Cutoff ( $f_2$ )	Frequency where gain drops by 3dB at high end
Gain-Bandwidth Product	Product of gain and bandwidth, remains constant

- **Bandwidth Formula:**  $BW = f_2 - f_1$
- **Gain-Bandwidth:** Remains constant when gain changes ( $A_v \times BW = C$ ).
- **Trade-off:** Higher gain means lower bandwidth.

**Mnemonic**

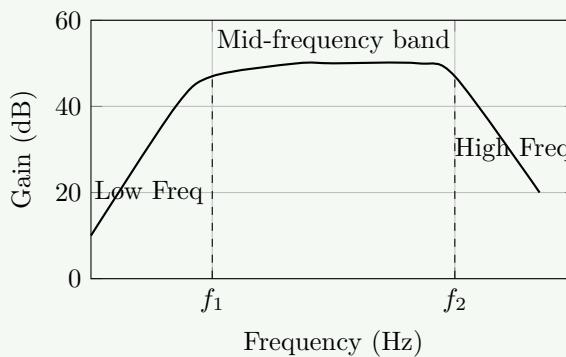
Better Bandwidth Gets Perfect Transmission

**Question 2 [c marks]**

7 Explain frequency response of two stage RC coupled amplifier.

**Solution**

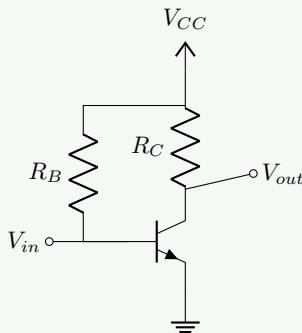
**Frequency Response of Two-Stage RC Coupled Amplifier:**



- **Low Frequency Response:** Limited by coupling capacitors ( $C_C, C_E$ ). Gain drops.
  - Roll-off Rate: -20 dB/decade per stage.
- **Mid Frequency Response:** Capacitors act as short circuits (coupling) or open (transistor internal). Gain is maximum and flat.
  - Total Gain: Product of individual stage gains ( $A_{total} = A_1 \times A_2$ ).
- **High Frequency Response:** Limited by transistor inter-electrode capacitances. Gain drops.

**Mnemonic**

Low Couples Weakly, High Capacitance Blocks

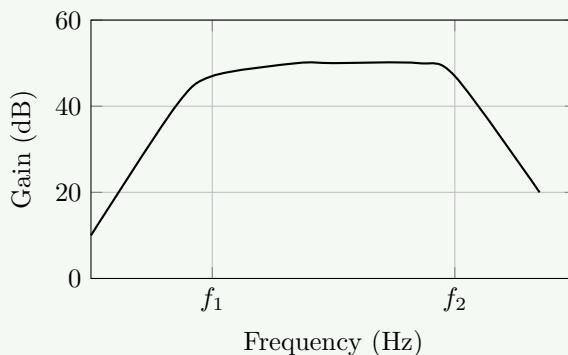
**Question 2 [a marks]****3 Explain fixed bias circuit for transistor biasing.****Solution****Fixed Bias Circuit:** Fixed bias uses a single resistor connected to the base.

- **Analysis:**
  - Base Current:  $I_B = (V_{CC} - V_{BE})/R_B$
  - Collector Current:  $I_C = \beta \times I_B$
- **Drawbacks:** Poor stability.  $I_C$  varies directly with  $\beta$  and temperature.

**Mnemonic**

Fix Bias, Face Burden (of instability)

**Question 2 [b marks]****4 Explain frequency response of single stage amplifier.****Solution****Frequency Response of Single Stage Amplifier:**

**Table 4.** Regions

Region	Characteristics
Low Frequency	Gain drops due to coupling/bypass capacitors ( $X_C$ is high)
Mid Frequency	Maximum and constant gain ( $X_C \approx 0$ for ext caps, $\infty$ for int)
High Frequency	Gain decreases due to internal transistor capacitances

- **Cutoff Frequencies:** Points where gain drops by 3dB from max.
- **Bandwidth:**  $BW = f_2 - f_1$ .

**Mnemonic**

Low Middle High - Capacitors Matter Here

**Question 2 [c marks]**

7 Compare transformer coupled amplifier and RC coupled amplifier

**Solution****Table 5.** Comparison

Parameter	RC Coupled	Transformer Coupled
Coupling Element	Resistor and Capacitor	Transformer
Frequency Response	Wide bandwidth	Limited bandwidth, poor low/high freq
Efficiency	Low (20-25%)	Higher (50-60%)
Size & Weight	Small, lightweight	Bulky, heavy
Cost	Inexpensive	Expensive
Impedance Matching	Poor	Excellent
Application	Voltage amplification	Power amplification

RC Coupled  
(R + C)

Transformer Coupled  
(Transformer)

Voltage Amp

Power Amp

**Mnemonic**

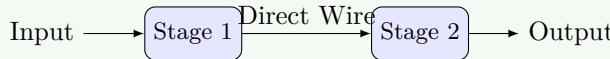
RC Takes Breadth, Transformer Takes Power

## Question 3 [a marks]

3 Explain in brief Direct coupled amplifier.

### Solution

**Direct Coupled Amplifier:** Connects stages without coupling capacitors/transformers.



- **DC Signal Handling:** Can amplify very low frequencies (down to 0 Hz / DC).
- **No Coupling Elements:** Simple and cheap.
- **Drawbacks:** Thermal drift (shift in Q-point with temp) is passed to next stage.

### Mnemonic

Directly Connected, Down to Complete zero frequency

## Question 3 [b marks]

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

### Solution

**Effects of Capacitors:**

**Table 6.** Capacitor Effects

Component	Function	Effect on Response
Emitter Bypass Cap ( $C_E$ )	Bypasses $R_E$ for AC	Increases gain at mid/high frequencies (prevents negative feedback). If removed, gain drops.
Coupling Cap ( $C_C$ )	Blocks DC, passes AC	Determines lower cutoff frequency. If too small, low freq gain drops.



### Mnemonic

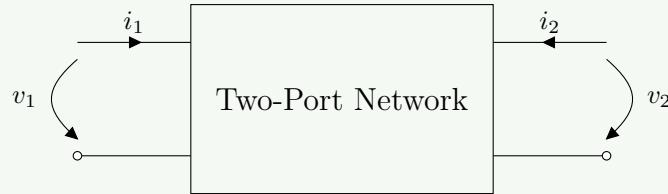
Coupling Controls Lows, Bypass Boosts All

## 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 Model:**

**H-Parameters (Hybrid Parameters):**

1.  $h_{11}$  ( $h_i$ ): Input Impedance (Output Shorted) -  $\frac{v_1}{i_1}|_{v_2=0}$
2.  $h_{12}$  ( $h_r$ ): Reverse Voltage Ratio (Input Open) -  $\frac{v_1}{v_2}|_{i_1=0}$
3.  $h_{21}$  ( $h_f$ ): Forward Current Gain (Output Shorted) -  $\frac{i_2}{i_1}|_{v_2=0}$
4.  $h_{22}$  ( $h_o$ ): Output Admittance (Input Open) -  $\frac{i_2}{v_2}|_{i_1=0}$

**Advantages:**

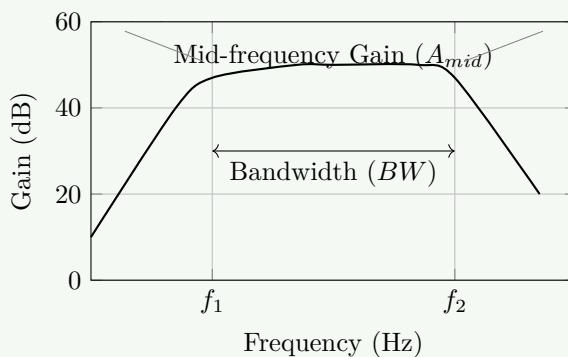
- Easiliy Measured:  $h_i, h_f$  at short circuit,  $h_r, h_o$  at open circuit.
- Accurate Model: Good for small-signal analysis.
- Dimensions: Mixed (Ohm, Unitless, Mho).

**Mnemonic**

IRFO: Input, Reverse, Forward, Output

**Question 3 [a marks]**

3 Draw frequency response ... and indicate ...

**Solution****Frequency Response Indicators:****Mnemonic**

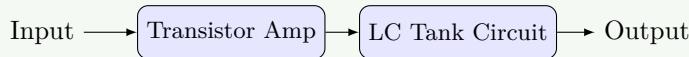
Lower Bandwidth Upper Makes Amplifier Response

**Question 3 [b marks]**

4 Describe the transistor used as a tuned amplifier.

### Solution

**Tuned Amplifier:** Uses LC resonant circuits to selectively amplify specific frequencies (e.g., radio receivers).



- **Resonance ( $f_r$ ):**  $f_r = \frac{1}{2\pi\sqrt{LC}}$
- **Quality Factor (Q):** Determines selectivity (Narrow BW = High Q).
- **Application:** Communication systems (Radio/TV).

#### Mnemonic

Tuning LC Selects Signals Precisely

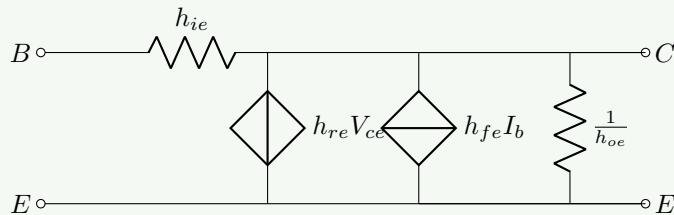
## Question 3 [c marks]

7 Importance of h parameters ... Draw h-parameters circuit for CE amplifier.

### Solution

**Importance:** Standardized, accurate, easily measured parameters for transistor analysis.

**CE Amplifier h-parameter Model:**



#### Mnemonic

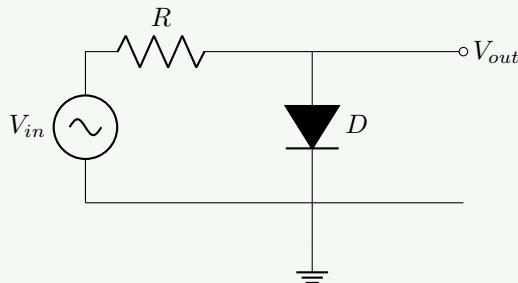
Input Resistance, Feedback Ratio, Forward Gain, Output Conductance

## Question 4 [a marks]

3 Describe the diode clipper circuit with necessary diagram.

### Solution

**Diode Clipper:** Limits/clips input signal above or below a reference level.



(Diagram: Positive Clipper - clips positive half cycle)

**Mnemonic**

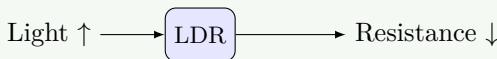
Clip Portions Passing Preset Points

**Question 4 [b marks]**

**4 Explain Short note on LDR.**

**Solution**

**LDR (Light Dependent Resistor):** Resistance decreases as light intensity increases.



- **Material:** Cadmium Sulfide (CdS).
- **Function:** Dark = High Resistance ( $M\Omega$ ), Bright = Low Resistance ( $k\Omega$ ).
- **Use:** Street lights, camera meters.

**Mnemonic**

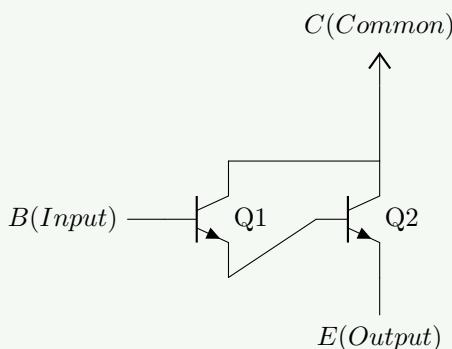
Light Decreases Resistance

**Question 4 [c marks]**

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

**Solution**

**Darlington Pair:** Two transistors connected in cascade (Super-Beta arrangement) for very high current gain.



**Characteristics:**

- **High Current Gain:**  $\beta \approx \beta_1 \times \beta_2$ .
- **High Input Impedance:** Good for buffering.

**Applications:** Power amplifiers, Relay drivers, Touch switches.

**Mnemonic**

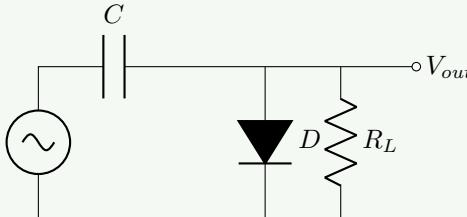
Double Transistors Amplify Really Greatly

## Question 4 [a marks]

3 Describe the diode clamper circuit with necessary diagram.

### Solution

**Diode Clamper:** Shifts the DC level of a signal (adds DC offset) without changing its shape.



Capacitor charges and acts as a battery, shifting the signal.

### Mnemonic

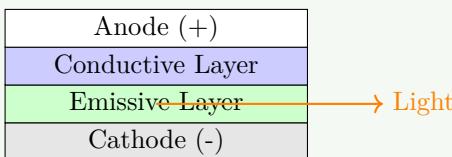
Clamps Peaks Down Consistently

## Question 4 [b marks]

4 Explain the working and applications of OLED.

### Solution

**OLED (Organic LED):** Display technology using organic films that emit light when current flows.



- **Structure:** Anode, Conductive, Emissive (Organic), Cathode.
- **Pros:** Self-emissive (no backlight), deeper blacks, flexible.
- **Uses:** Phones, TVs, Wearables.

### Mnemonic

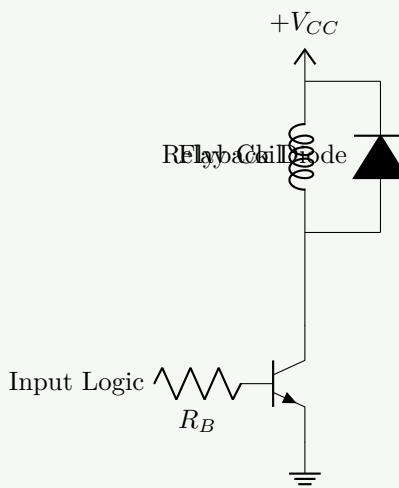
Organic Layers Emit Diode-light

## Question 4 [c marks]

7 Describe the transistor used as a relay driver.

### Solution

**Relay Driver:** Transistor acts as a switch to drive a high-current relay coil from a low-current logic signal.



- **Transistor:** Saturates (ON) to energize relay, Cutoff (OFF) to de-energize.
- **Flyback Diode:** Protects transistor from high voltage spike (Back EMF) when relay turns off.

#### Mnemonic

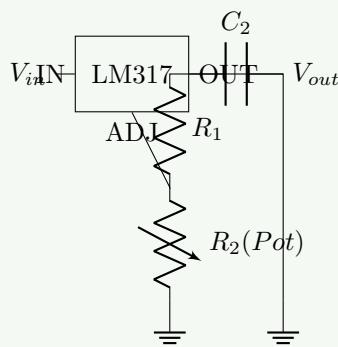
Tiny Regulates Driving Relays

## Question 5 [a marks]

3 Draw circuit diagram of a variable power supply using LM317 IC.

#### Solution

**LM317 Variable Supply:**



$$\text{Formula: } V_{out} = 1.25 \left(1 + \frac{R_2}{R_1}\right).$$

#### Mnemonic

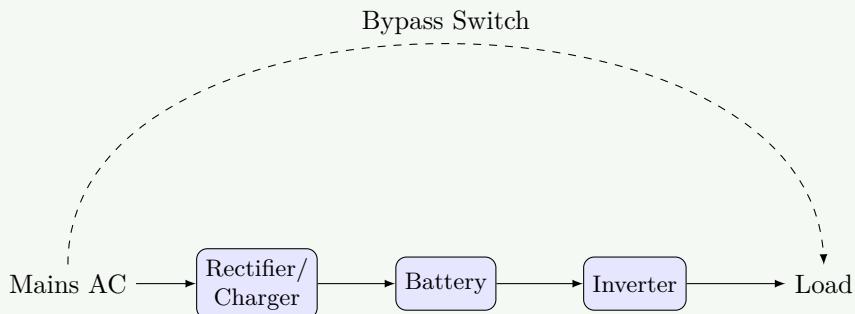
LM317 Makes Voltage Adjustable

## Question 5 [b marks]

4 Explain working of UPS.

### Solution

**UPS (Uninterruptible Power Supply):** Provides backup power during mains failure.



- **Normal:** Mains powers load + charges battery.
- **Backup:** Battery powers inverter -> load.

### Mnemonic

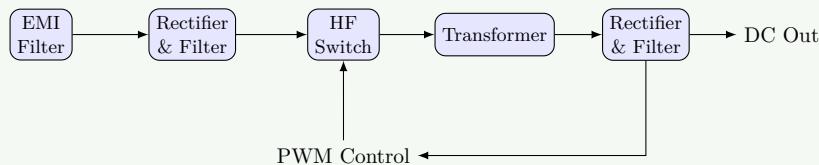
Uninterrupted Power Supplied During Blackouts

## Question 5 [c marks]

7 Draw and explain SMPS block diagram.

### Solution

**SMPS (Switch Mode Power Supply):** Efficient power conversion using high-frequency switching.



- **High Efficiency:** 70-90% (transistor acts as switch, low power loss).
- **Compact:** High frequency allows smaller transformer.

### Mnemonic

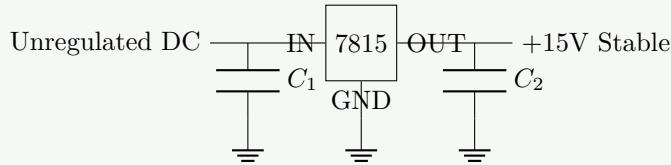
Switch Makes Power Stable

## Question 5 [a marks]

3 Draw circuit diagram for +15 v Power Supply using its IC and explain in brief

### Solution

**+15V Supply (7815 IC):**



Uses 7815 linear regulator to output fixed +15V.  $C_1, C_2$  filter noise.

#### Mnemonic

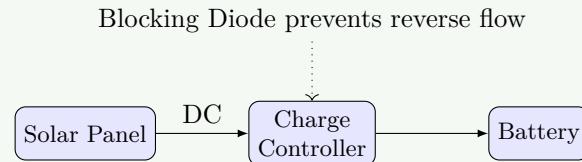
7815 Fixes Voltage To Fifteen

## Question 5 [b marks]

4 Explain working of solar battery charger circuits.

#### Solution

##### Solar Charger:



Regulates solar voltage to safely charge battery. Prevents overcharge.

#### Mnemonic

Sun Charges Batteries Safely

## Question 5 [c marks]

7 Discuss comparison of linear regulated power supply with switch mode power supply.

#### Solution

##### Comparison:

**Table 7.** Linear vs SMPS

Parameter	Linear PS	SMPS
Efficiency	Low (30-40%)	High (70-90%)
Size/Weight	Bulky/Heavy (50Hz Tx)	Compact/Light (HF Tx)
Noise	Low	High (Switching noise)
Complexity	Simple	Complex
App	Audio, Lab	PC, Adapters

Linear: Drop Excess Voltage as Heat    SMPS: Chop Power Efficiently

**Mnemonic**

Linear Loves Low noise, Switching Saves Size