Electronic Circuits & Applications (4321103) - Summer 2023 Solution

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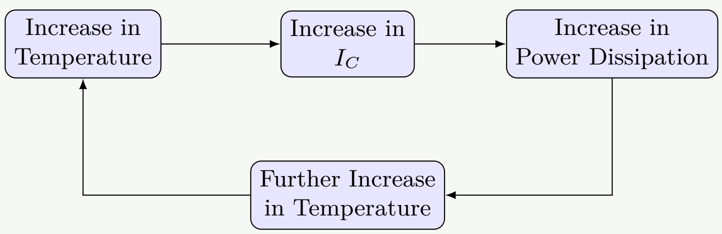
Question 1 [a marks]

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.

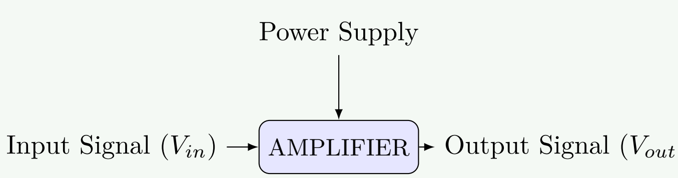


Table 1. Amplifier Parameters

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.

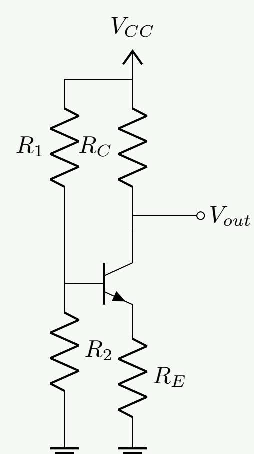
Solution

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 β.

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.

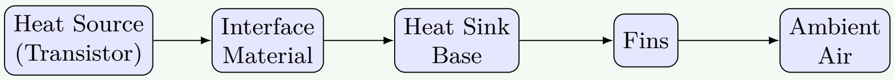


Table 2. Heat Sink Components

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

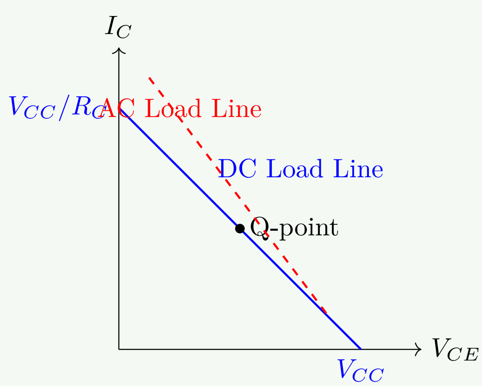
Heat Sinks Keep Transistors Running

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.

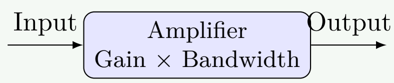


Table 3. Frequency Parameters

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

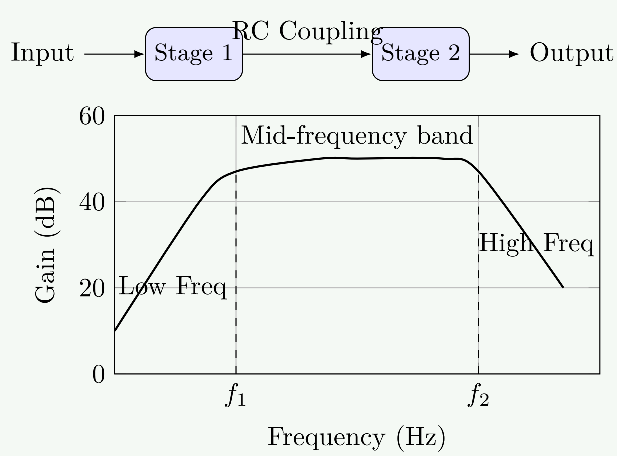
Better Bandwidth Gets Perfect Transmission

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

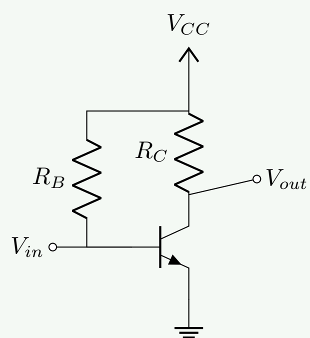
Low Couples Weakly, High Capacitance Blocks

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 β 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:

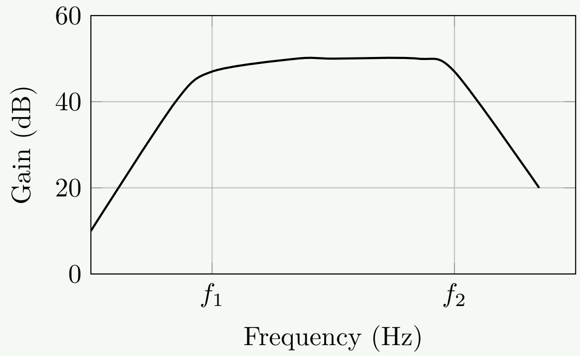


Table 4. Regions

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, ∞ 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

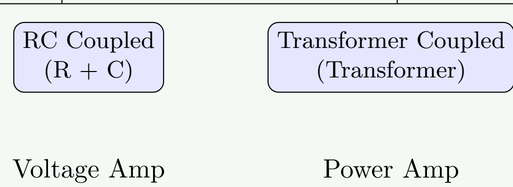
Question 2 [c marks]

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



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]

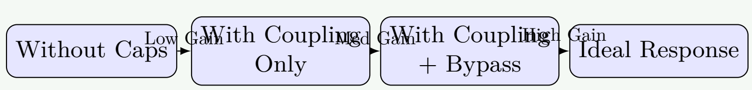
4 Explain effects of emitter bypass capacitor and coupling capacitor on frequency response of an amplifier.

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

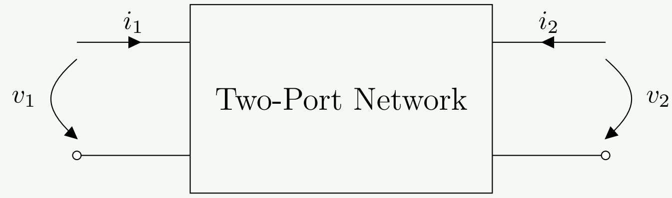
Coupling Controls Lows, Bypass Boosts All

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

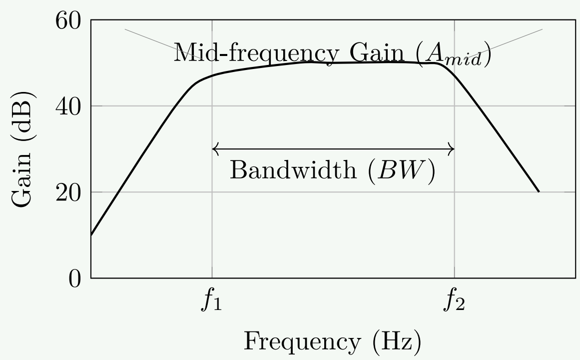
IRFO: Input, Reverse, Forward, Output

Question 3 [a marks]

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

Solution

Frequency Response Indicators:



Mnemonic

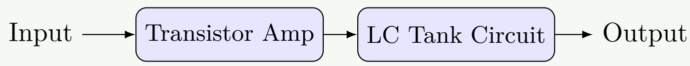
Lower Bandwidth Upper Makes Amplifier Response

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

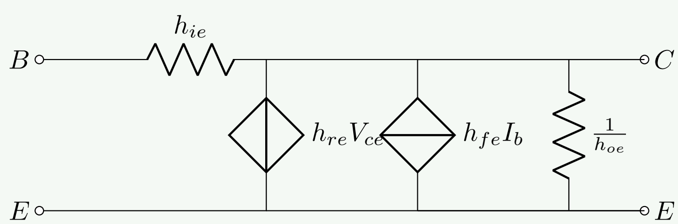
Tuning LC Selects Signals Precisely

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

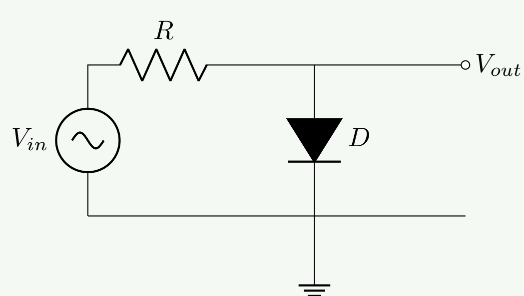
Input Resistance, Feedback Ratio, Forward Gain, Output Conductance

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.

Light ↑ → LDR → Resistance ↓

- **Material**: Cadmium Sulfide (CdS).
- **Function**: Dark = High Resistance (MΩ), Bright = Low Resistance (kΩ).
- **Use**: Street lights, camera meters.

Mnemonic

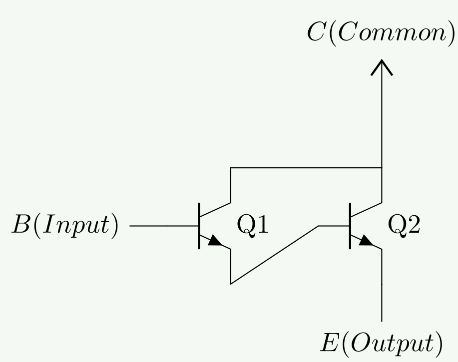
Light Decreases Resistance

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 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

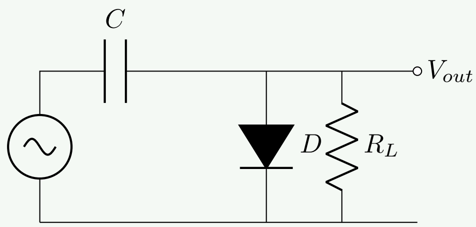
Double Transistors Amplify Really Greatly

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

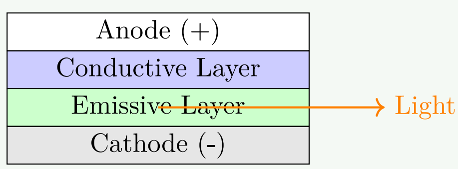
Clamps Peaks Down Consistently

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

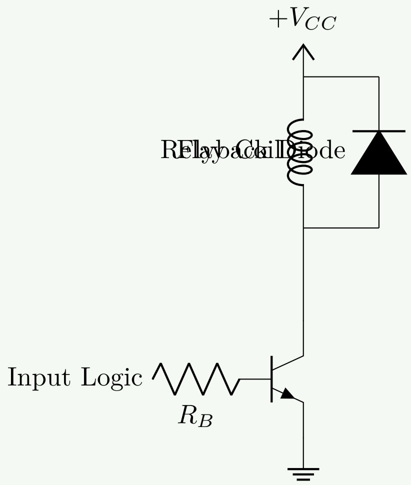
Organic Layers Emit Diode-light

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

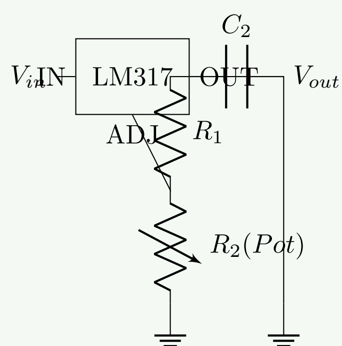
Tiny Regulates Driving Relays

Question 5 [a marks]

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

Solution

LM317 Variable Supply:



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

Mnemonic

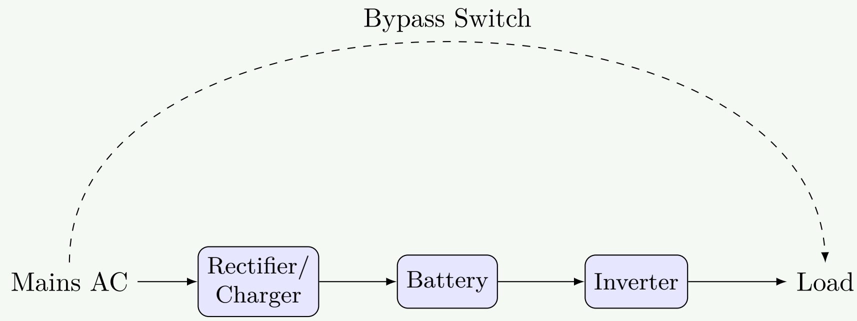
LM317 Makes Voltage Adjustable

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

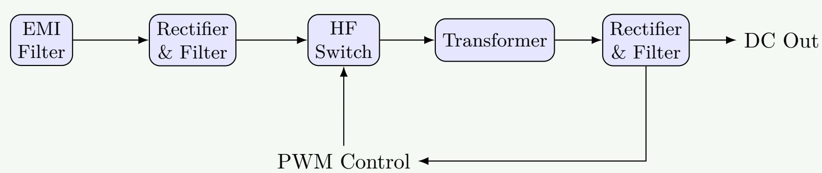
Uninterrupted Power Supplied During Blackouts

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

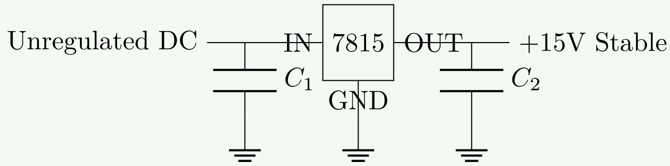
Switch Makes Power Stable

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

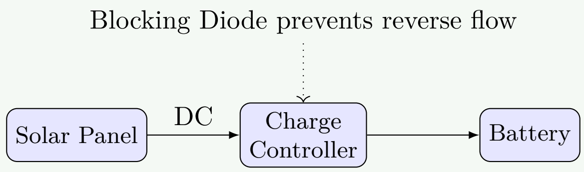
7815 Fixes Voltage To Fifteen

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