Electronic Circuits & Applications (4321103) - Winter 2024 Solution

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Question 1 [a marks]

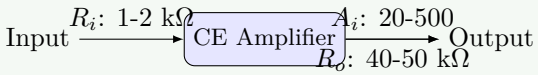
3 Explain amplifier parameters Ai, Ri and Ro for CE configuration.

Solution

CE Amplifier Parameters:

Table 1. CE Amplifier Parameters

Parameter	Definition	value
Current Gain (A_i)	Ratio of output current to input current	High (20-500)
Input Resistance (R_i)	Opposition to current flow at input	Medium (1-2 kΩ)
Output Resistance (R_o)	Opposition to current flow at output	High (40-50 kΩ)



Mnemonic

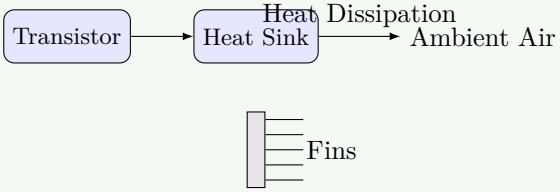
CAR - CE has Current gain high, Average input resistance, and Robust output resistance.

Question 1 [b marks]

4 Write short-note on heat sink.

Solution

Heat Sink: A device that absorbs and dissipates heat from electronic components to prevent overheating.



Types of Heat Sinks:
- **Passive**: Rely on natural convection (no fans).
- **Active**: Use fans for forced air convection.
- **Liquid-cooled**: Use liquid for better heat transfer.

Key Functions:
- **Thermal Conduction**: Draws heat away from the component.

- **Thermal Convection**: Transfers heat to the air.
- **Surface Area**: Fins increase area for maximum cooling.

Mnemonic

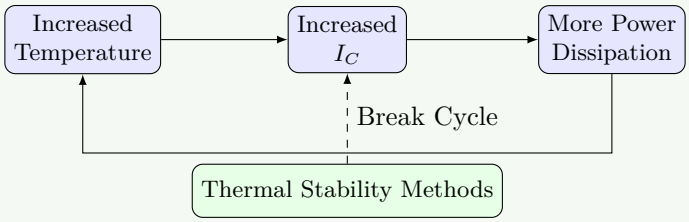
CRAFT - Cooling through Radiation And Fins for Transistors.

Question 1 [c marks]

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

Solution

Thermal Runaway: A self-reinforcing process where increased temperature causes more collector current, which generates more heat, further increasing temperature until the device fails.
Thermal Stability: The ability of a transistor circuit to maintain stable operation (constant Q-point) despite changes in temperature.



Methods to Overcome Thermal Runaway:
- **Heat Sink**: Physically dissipates excess heat.
- **Negative Feedback**: Using an emitter resistor (R_E) to stabilize current.
- **Bias Stabilization**: Using voltage divider biasing.
- **Temperature Compensation**: Using thermistors or diodes to counteract changes.

Key Points:
- $I_C = I_{CBO}(1 + \beta) + \beta I_B$.
- I_{CBO} doubles for every 10°C rise.
- **Stability Factor S**: Lower S means better stability (Ideal $S = 1$).

Mnemonic

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

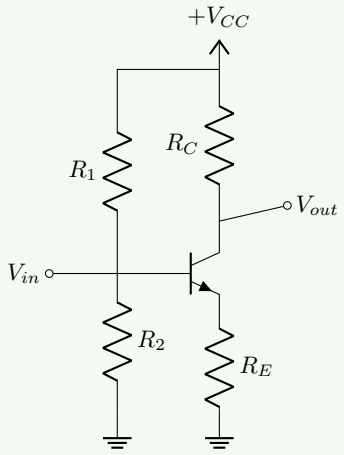
Question 1 [c marks]

7 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 a voltage divider to provide a fixed voltage at the base.
- **RE**: Provides negative feedback for stability. If I_C increases, voltage drop across R_E increases, reducing V_{BE}, which reduces I_B and brings I_C back down.
- **Stable Bias Point**: The Q-point is almost independent of β variations.

Advantages:
- **Excellent Stability**: Very low stability factor ($S \approx 1$).
- **Beta Independent**: Variations in transistor β do not affect the operating point significantly.
- **Widely Used**: Most common method for linear amplifiers.

Mnemonic

DIVE - Divider biasing Is Very Effective for stability.

Question 2 [a marks]

3 Explain Stability Factor with features.

Solution

Stability Factor (S): A measure of the sensitivity of the collector current (I_C) to changes in reverse saturation current (I_{CO}) or temperature. Equation: $S = \frac{\Delta I_C}{\Delta I_{CO}}$

Table 2. Stability Factors Comparison

Biasing Method	Stability Factor	Stability Level
Fixed Bias	$S = 1 + \beta$	Poor (Very High S)
Collector-to-Base	$S = \frac{\beta}{1+\beta}$	Better
Voltage Divider	$S \approx 1$	Excellent (Lowest S)

Features:
- **Lower is Better**: An ideal stability factor is 1.
- **Temperature Resistance**: Indicates how well the circuit resists thermal drift.
- **Design Tool**: Used to select appropriate biasing components.

Mnemonic

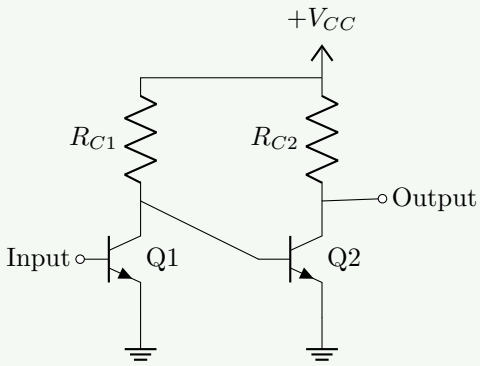
SOS - Stability Of circuit Shows in its S-factor.

Question 2 [b marks]

4 Describe direct coupling technique of cascading.

Solution

Direct Coupling: The output of one stage is connected directly to the input of the next stage without any coupling capacitors or transformers.



Key Characteristics:
- **No Coupling Components**: Simple circuit.
- **Frequency Response**: Excellent low-frequency response (amplifies DC).
- **Level Shifting**: DC potentials increase stage by stage, requiring level shifting techniques.

Applications: Operational Amplifiers, Regulators.

Mnemonic

DIRECT - DC signals Immediately REach Connecting Transistors.

Question 2 [c marks]

7 Explain frequency response of two stage RC coupled amplifier.

Solution

RC Coupled Amplifier Frequency Response:

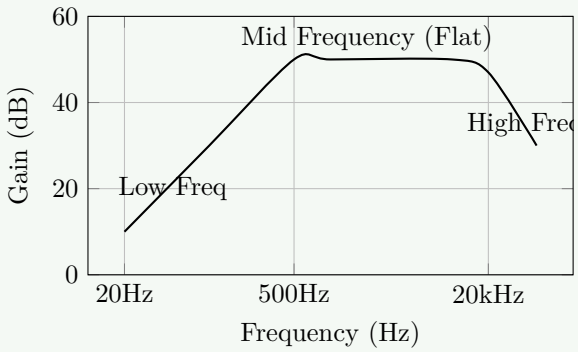


Table 3. Frequency Regions

Region	Frequency	Cause of Fall
Low	20Hz - 500Hz	Coupling Capacitors (C_C) high reactance
Mid	500Hz - 20kHz	Constant Gain (Ideal operation)
High	$>$ 20kHz	Transistor parasitic capacitances

Two-Stage Effect:
- **Bandwidth**: Reduces compared to single stage ($BW_n = BW_1 \times \sqrt{2^{1/n} - 1}$).
- **Gain**: Product of individual stage gains ($A_{total} = A_1 \times A_2$).

Mnemonic

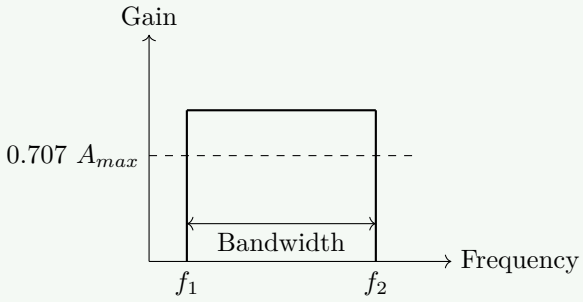
LMH - Low frequencies by coupling caps, Mid frequencies flat, High frequencies by transistor caps.

Question 2 [a marks]

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

Solution

Bandwidth (BW): The range of frequencies over which the amplifier gain is at least 70.7% (or -3dB) of its maximum value. $BW = f_2 - f_1$
Gain-Bandwidth Product (GBP): The product of the voltage gain and the bandwidth is constant for a given amplifier. $GBP = A_v \times BW = \text{Constant}$



Mnemonic

BAND - Bandwidth And gain Never Drop together.

Question 2 [b marks]

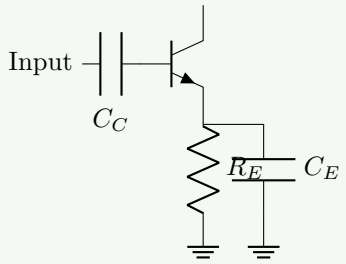
4 Explain effects of emitter bypass capacitor and coupling capacitor on frequency response of an amplifier.

Solution

Capacitor Effects:

Table 4. Capacitors

Capacitor	Function	Effect
Coupling (C_C)	Blocks DC, passes AC	Limits Low Frequency response (High reactance at low f)
Bypass (C_E)	Bypasses R_E	Increases Mid-band gain. If removed, gain drops due to negative feedback.



Mnemonic

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

Question 2 [c marks]

7 Compare transformer coupled amplifier and RC coupled amplifier

Solution

Comparison:

Table 5. Transformer vs RC Coupled

Feature	Transformer Coupled	RC Coupled
Coupling	Transformer	Resistor-Capacitor
Impedance Matching	Excellent	Poor
Frequency Response	Poor (Resonant peaks)	Good (Flat over wide range)
Efficiency	High	Low
Size/Weight	Bulky/Heavy	Small/Light
Cost	Expensive	Inexpensive
Application	Power Amplifiers	Voltage Amplifiers

Mnemonic

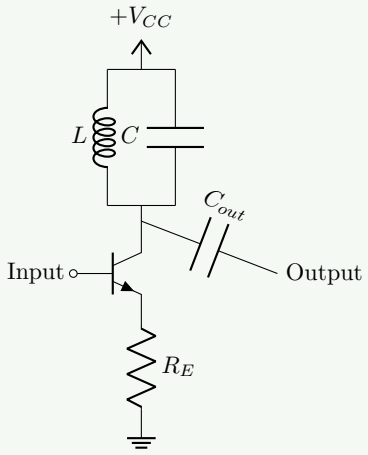
TRIP - Transformers are Robust for Impedance matching, Problematic for bandwidth.

Question 3 [a marks]

3 Describe the transistor used as a tuned amplifier.

Solution

Tuned Amplifier: An amplifier that uses a parallel LC tank circuit as the collector load to amplify a specific narrow band of frequencies.



Key Components:
- **LC Tank**: Determines resonant frequency $f_r = \frac{1}{2\pi\sqrt{LC}}$.
- **High Q**: Provides high selectivity.

Applications: Radio and TV receivers (IF amplifiers).

Mnemonic

TUNE - Transistors Using Narrowband Elements for frequency selection.

Question 3 [b marks]

4 Explain in brief Direct coupled amplifier.

Solution

Direct Coupled Amplifier: (See Q2(b) for diagram) A multi-stage amplifier where the output of one stage is directly connected to the input of the next.

Advantages:
- Low cost (no capacitors/transformers).
- Amplifies DC signals (0 Hz to high frequency).

Disadvantages:
- Thermal drift issues (DC shift).
- Requires stable power supplies.

Mnemonic

DCAP - Direct Coupled Amplifier Passes all frequencies including DC.

Question 3 [c marks]

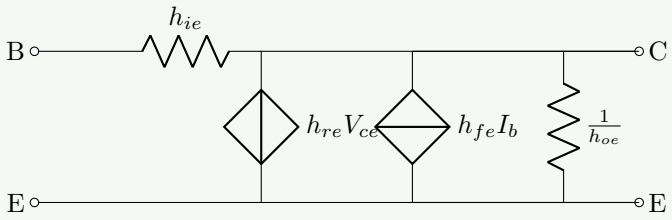
7 Describe the importance of h parameters in two port networks. Draw h-parameters circuit for CE amplifier.

Solution

Importance of h-parameters:
- **Hybrid Nature**: Mix of impedance and admittance parameters.
- **Easy to Measure**: h_{11}, h_{21} measured with output shorted; h_{12}, h_{22} measured with input open.

- **Standard**: Manufacturers provide transistor specs in h-parameters.

h-parameter Circuit for CE Amplifier:



Parameters:

1. h_{ie}: Input Impedance.
2. h_{re}: Reverse Voltage Ratio.
3. h_{fe}: Forward Current Gain (β).
4. h_{oe}: Output Admittance.

Mnemonic

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

Question 3 [a marks]

3 Compare transformer coupled amplifier and direct coupled amplifier.

Solution

Comparison:

Table 6. Comparison

Feature	Transformer Coupled	Direct Coupled
Frequency Response	Bandpass (Poor Low/High)	DC to High Frequency
Cost	High	Low
Size	Bulky	Compact
Impedance Matching	Excellent	Poor
DC Isolation	Yes	No

Mnemonic

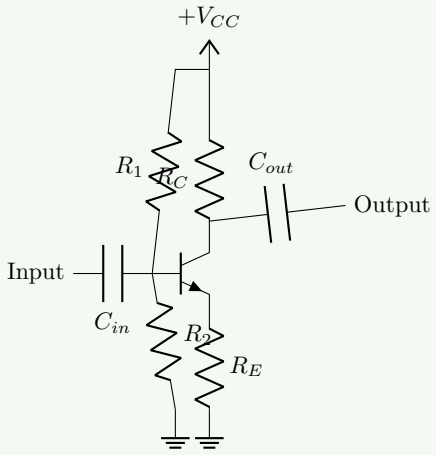
TDC - Transformers provide DC isolation, Direct provides Complete frequency range.

Question 3 [b marks]

4 Draw and Explain circuit diagram of common emitter amplifier.

Solution

Common Emitter (CE) Amplifier:



Explanation:
- **Input**: Applied to Base-Emitter.
- **Output**: Taken from Collector-Emitter.
- **Phase Shift**: 180° (Output is inverted).
- **Gain**: High voltage and current gain.

Mnemonic

CEA - Common Emitter Amplifies with signal inversion.

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: (See Q3(c) above for h-parameter model explanation).

Equations: $V_1 = h_{11}I_1 + h_{12}V_2$
$I_2 = h_{21}I_1 + h_{22}V_2$
Advantages:
- Real numbers at audio frequencies.
- Easily measured.
- Suitable for circuit analysis.

Mnemonic

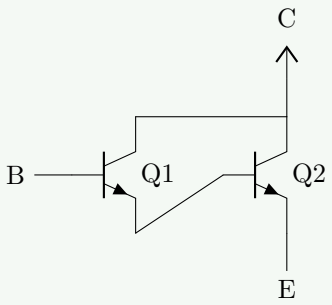
HAEM - Hybrid parameters Are Easily Measured.

Question 4 [a marks]

3 Explain Darlington pair and its applications.

Solution

Darlington Pair: Two transistors connected in cascade ($CC - CC$) to behave like a single "super" transistor.



Features:
- High Current Gain: $\beta \approx \beta_1\beta_2$.
- High Input Impedance.

Applications: Power amplifiers, relay drivers, touch switches.

Mnemonic

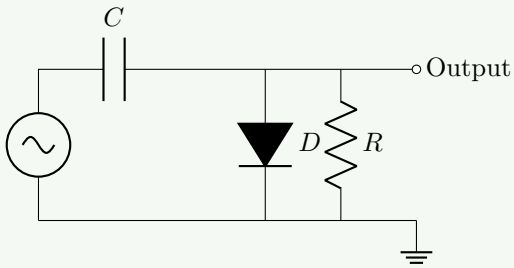
DISH - Darlington Integrates Stages for High current gain.

Question 4 [b marks]

4 Describe the diode clamper circuit with necessary diagram.

Solution

Diode Clamper: A circuit that shifts the DC level of a waveform.



Operation: Capacitor charges to peak voltage, acting as a battery in series with the input signal, shifting it up or down. **Application**: TV Receivers (DC restoration).

Mnemonic

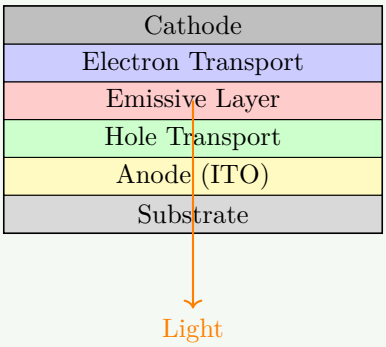
CLAMP - Circuit Levels Are Modified Precisely.

Question 4 [c marks]

7 Explain the construction, working and applications of OLED.

Solution

OLED (Organic Light Emitting Diode):



Working:
- Charge carriers (holes and electrons) are injected from anode and cathode.
- They recombine in the emissive layer.
- Energy is released as light (Electroluminescence).

Applications: Curved screens, Flexible displays, High-end smartphones.

Mnemonic

OLED - Organic Layers Emit Directly.

Question 4 [a marks]

3 Explain Short note on LDR.

Solution

LDR (Light Dependent Resistor): A photoresistor made of Cadmium Sulfide (CdS) whose resistance decreases when light shines on it.

Logic: Light Energy creates electron-hole pairs → Conductivity increases → Resistance decreases. **Use**: Street lights, alarms.

Mnemonic

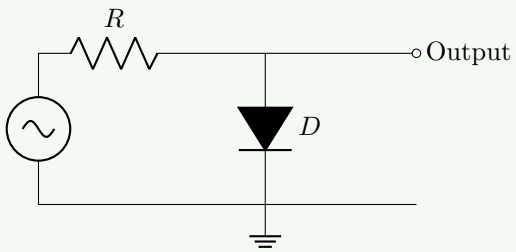
LORD - Light Oppositely Reduces the Device's resistance.

Question 4 [b marks]

4 Describe the diode clipper circuit with necessary diagram.

Solution

Diode Clipper: Removes parts of a signal.



Positive Clipper: Diode points down (removes positive). **Negative Clipper**: Diode points up (removes negative).

Mnemonic

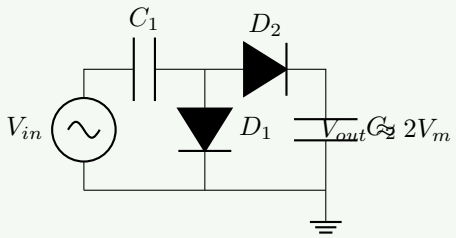
CLIP - Circuit Limits Input Peaks.

Question 4 [c marks]

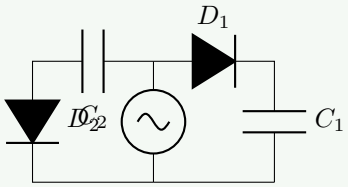
7 Explain Half Wave and Full wave Voltage Doubler.

Solution

Voltage Doubler: Produces DC voltage twice the peak AC input ($2V_m$).
Half-Wave Doubler:



Full-Wave Doubler:



Explanation: Capacitors charge in alternate cycles and their voltages sum up.

Mnemonic

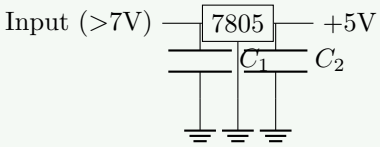
DOUBLE - Diodes Organize Unidirectional Boost.

Question 5 [a marks]

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

Solution

+5V Power Supply (7805):



Mnemonic

FIVE - Fixed IC Voltage Efficiently provided.

Question 5 [b marks]

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

Solution

Regulation: Keeping output voltage constant.

1. **Line Regulation**: Ability to maintain constant V_{out} when Input Voltage (V_{in}) changes.

$$\%\text{Reg} = \frac{\Delta V_{out}}{\Delta V_{in}} \times 100$$

2. **Load Regulation**: Ability to maintain constant V_{out} when Load Current (I_L) changes.

$$\%\text{Reg} = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$$

Mnemonic

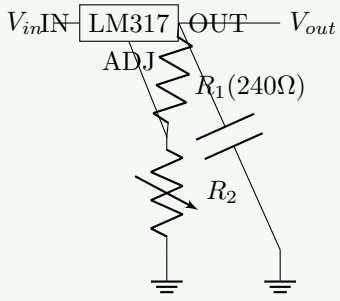
LINE LOAD - Line Is Normal-input Efficiency, LOAD is Output Adjustment Defense.

Question 5 [c marks]

7 Explain adjustable voltage regulator using LM317 with circuit diagram.

Solution

LM317 Adjustable Regulator:



Formula: $V_{out} = 1.25(1 + \frac{R_2}{R_1}) + I_{ADJ}R_2$. **Use**: Bench power supplies.

Mnemonic

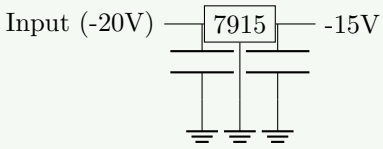
VARY - Voltage Adjustable Regulator Yields custom outputs.

Question 5 [a marks]

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

Solution

-15V Power Supply (7915):



Note: 79xx series is for negative voltage.

Mnemonic

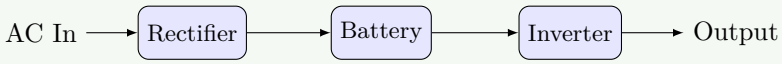
NINE - Negative IC Needs Efficient filtering.

Question 5 [b marks]

4 Explain working of UPS.

Solution

UPS (Uninterruptible Power Supply): Provides emergency power.



Operation: 1. Rectifier charges battery. 2. Inverter converts DC to AC for load. 3. If power fails, battery continues to supply inverter.

Mnemonic

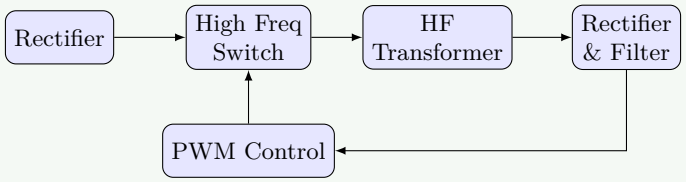
UPBEAT - Uninterruptible Power Backup.

Question 5 [c marks]

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

Solution

SMPS (Switch Mode Power Supply):



Advantages: High efficiency ($> 80\%$), Compact size, Light weight. **Disadvantages**: High noise (EMI), Complex circuit.

Mnemonic

SWITCH - Smaller Weight, Improved Thermal efficiency.