Unit → 5

Amplifiers

Topics

** Single stage
1. Common Emitter Transistor Amplifier - Working, Voltage gain, phase reversal.
** Two stage
2. RC coupled transistor amplifier - frequency response.
**3. Power amplifiers - classification, principle & performance criteria of power amplifiers.

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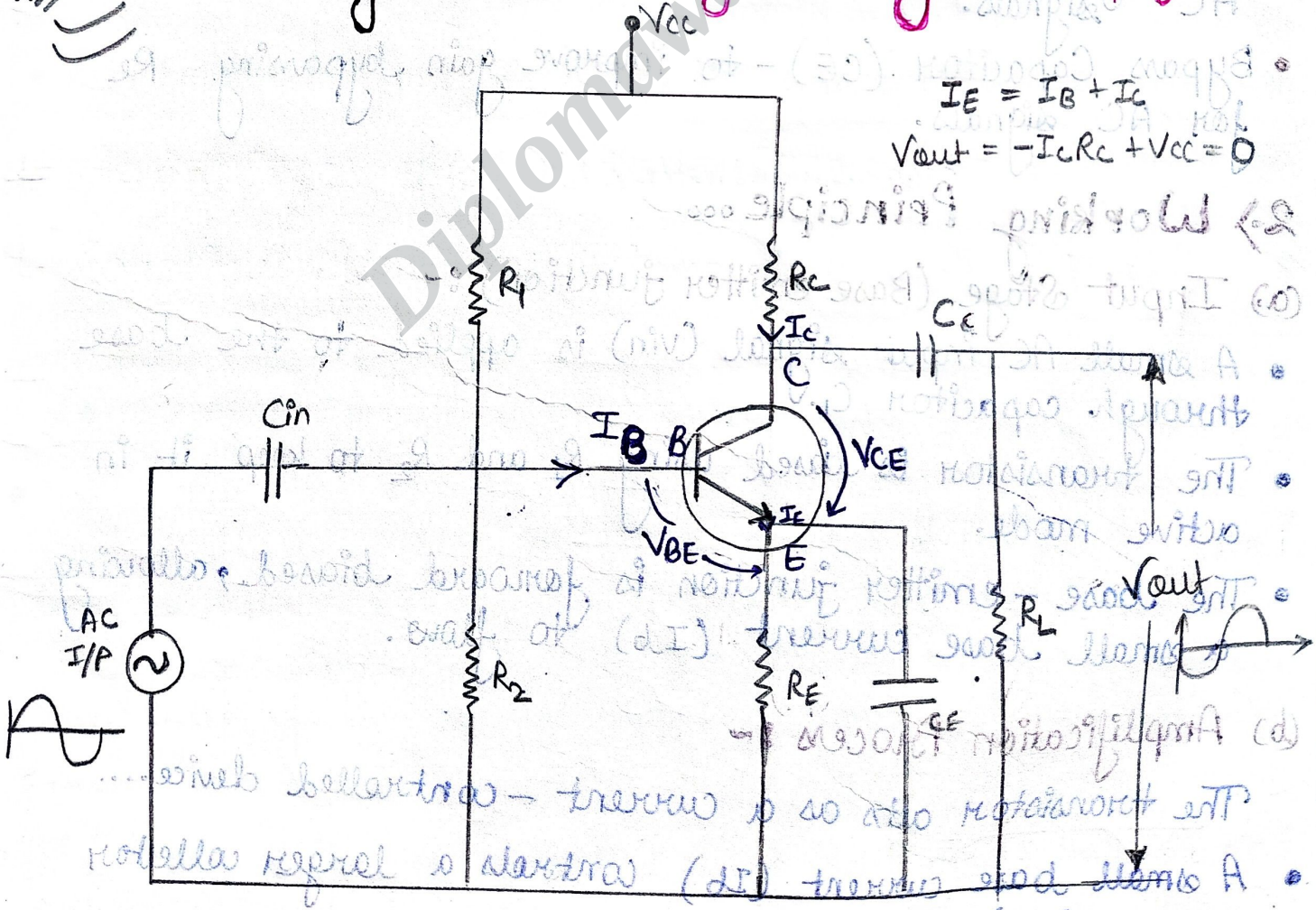
1.) Coommon Emitter Transistor Amplifier....

Single Stage Amplifier

Circuit Diagram....



$I_E = I_B + I_C$

$V_{out} = -I_C R_C + V_{CC} = 0$

Working :-

A common Emitter (CE) amplifier is one of the most widely used transistor amplifier configurations. It provides high voltage gain, moderate current gain and phase inversion between input and output.

1.) Circuit Diagram and Components ...

A typical CE amplifier circuit consist of :-

- Transistor (NPN or PNP)
- Power Supply (V_{CC})
- Biasing resistors (R_1 & R_2) - to set the operating point.
- Emitter Resistor (R_E) :- for stability.
- Collector Resistor (R_C) :- for voltage gain.
- Coupling Capacitors (C_1, C_2) - to block DC and allow AC signals.
- Bypass Capacitor (C_E) - to improve gain bypassing R_E for AC signals.

2.) Working Principle ...

(a) Input Stage (Base emitter junction) :-

- A small AC input signal (V_{in}) is applied to the base through capacitor C_1.
- The transistor is biased using R_1 and R_2 to keep it in active mode.
- The base - emitter junction is forward biased, allowing a small base current (I_b) to flow.

(b) Amplification Process :-

The transistor acts as a current - controlled device....

A small base current (I_b) controls a larger collector current (I_C).

- The relationship follows $I_C = \beta + I_B$ (where β is the current gain).
- This amplified current flows through the collector resistor (R_C), generating a large voltage drop across it.

(c) Output stage (collector – Emitter Junction):-

- The output voltage (V_{out}) is taken from the collector via capacitor C_2.
- Since the transistor inverts the signal, the output is 180° out of phase with the input.

Voltage Gain of CE Amplifier ....

The voltage gain (A_V) is given by:

$$A_V = -\frac{R_C}{R_E}$$

- R_E (Emitter Resistor) stabilizes the gain and reduces distortion.

Operation... of common emitter transistor

- When the signal voltage increases in the +ve half cycle the phase current also increases the result is the collector current $I_C = \beta I_B$ and voltage drop $I_C R_C$ increases as V_{CC} is constant. Therefore the output voltage V_{out} is decreases.
- As the signal voltage is increasing is the positive half cycle the output voltage is increasing in the negative. i.e; output is 180° out of phase with the input. It follows that in a common emitter amplifier the +ve half cycle of the signal appears amplified in the output and vice-versa.
- The phase difference of 180° between the signal voltage and output voltage in a common emitter amplifier is known as phase reversal.

- The phase current fluctuates as the O signal base current. When the base current is maximum in the positive direction output becomes maximum in the negative direction.
- When the base current is maximum in the positive direction output is maximum in the negative direction. The input and output voltages are in phase opposition, the transistor is said to be produce a 180° phase reverser of output voltage with respect to signal voltage.

★ Current Gain (A_I) - $\frac{\text{Output}}{\text{Input}}$

The ratio of collector current and Base current is called as β factor.

$$\beta = \frac{I_c}{I_B} \longrightarrow \text{Current gain factor}$$

★ Voltage Gain (A_v)

The voltage gain of the amplifier is the ratio of AC output voltage to the AC input voltage.

$$\text{Voltage gain } (A_v) = \frac{V_{out}}{V_{in}}$$

$$A_v = \frac{V_{out}}{V_{in}}$$

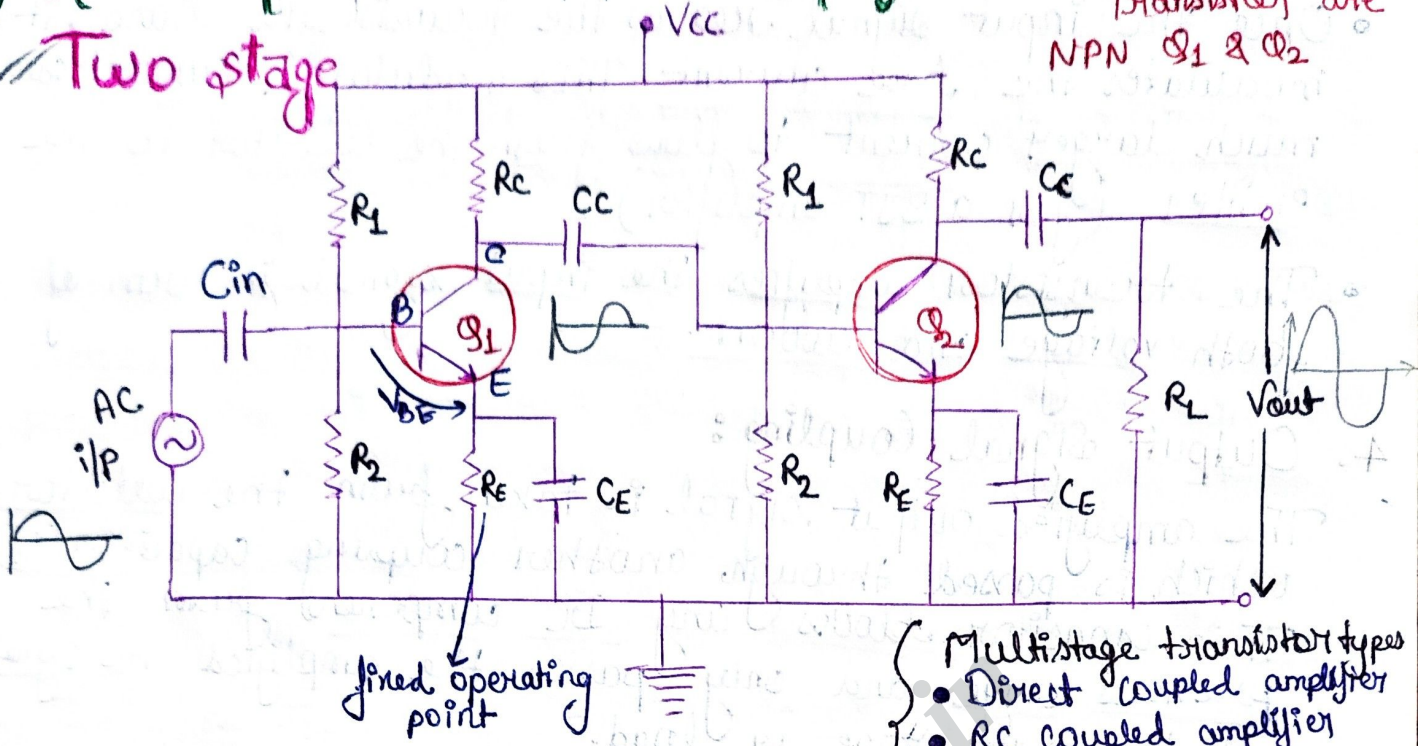
$$A_v = \frac{V_{out}}{V_{in}} = \frac{i_c R_{out}}{i_b R_{in}} \quad \{\because V = iR\}$$

$$A_v = \beta \frac{R_{out}}{R_{in}} \quad \because \{\beta = \frac{i_c}{i_b}\}$$

2) RC Coupled transistor amplifier...

Transistors are NPN Q_1 & Q_2

Two stage



Multistage transistor types
- Direct coupled amplifier
- RC coupled amplifier
- Transformer amplifier

→ An RC coupled transistor amplifier is a type of amplifier that uses a resistor, capacitor network to couple the stages of the amplifier. The basic idea is that the capacitor blocks DC components and allow AC signal to pass through between stage, while the resistors sets the biasing condition of the transistor.

Operation...

1. Biasing the transistor:
   A proper biasing network is set up to operate the transistor in the active region (for BJTs, this means the base-emitter junction is forward biased).
   The transistor needs a correct base voltage to ensure it amplifies the input signal.

2. Input signal coupling:
   The input AC signal is fed into the amplifier through the input capacitor (C1). This capacitor blocks any DC component in the signal and passes only AC portion to the transistor's base.

3. Amplification :

- Once the input signal reaches the transistor's base, it modulates the base current. This modulated current causes much larger current to flow from the collector to the emitter (for a BJT amplifier).
- The transistor amplifies the input signal in term of both voltage and current.

4. Output Signal Coupling :

The amplified output signal is taken from the collector, which is passed through another coupling capacitor (C_2). This capacitor blocks any DC component from the previous stage and only passes the amplified AC signal to the next stage or load.

Frequency Responce ...

★ Low frequency response :-
At lower frequency the gain drop due to the capacitive reactance of the coupling capacitor. Below a certain frequency (called the lower cut-off frequency).

★ Mid Frequency response :-
Within a specific frequency range the gain remain relatively constant this is the optional operating region of amplifier.

★ High frequency response :-
At higher frequencies the gain again drops due to parastic capacitances and the reactance of the coupling capacitor the frequency at which the decline starts is called the upper cut-off frequency.

3.) Power amplifier.... (Cont'd in dj)

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Large signal amplifier also known as power amplifier are capable providing large amount of power through the load. They are used as last stage electronics system.

A power amplifier takes the DC power supply to the output circuit and converts it into AC signal AC signal power. Output power is controlled by input signal.

* Important features of power Amplifier....

- Some of the features of power amplifiers are impedence matching with the load is necessary for delivering maximum power to the load.
- Power transistors are needed (to withstand large voltages and large currents).
- Power amplifiers are bulk.
- Due to the non-linear characteristics of transistors, harmonic distortions are available at the output.

Performance Parameters....

- Circuit Efficiency :- It is also known as conversion efficiency or overall efficiency.

$$\text{maximum efficiency } (\eta) = \frac{\text{maximum a.c. output power}}{\text{d.c input power}}$$

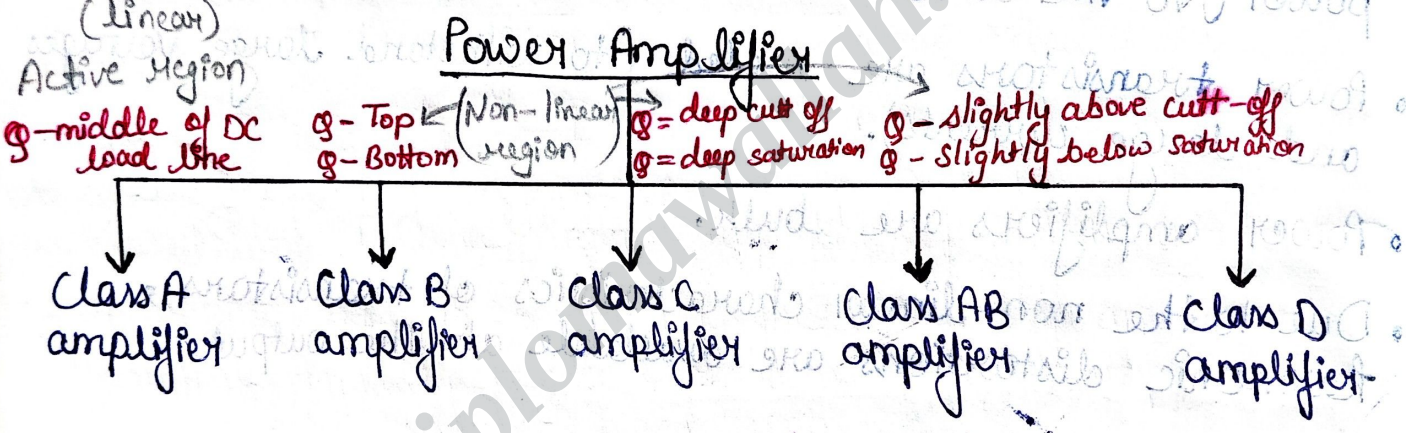
- Distortion :- The difference between the output and input of an amplifier is known as distortion. Even though the output is enlarge and faithful reproduction of input but in actual practice there may be differences in the waveform of frequencies.

a.) Amplitude distortion :- Due to non-linearity in transistor.

b.) Cross-over distortion :- When transistors are not operating in correct phase with each other.

- Power dissipation Capacity :- It is the ability to dissipate the hit by the power transistor also known as power rating. During amplification process large current passes through power transistor. hence, hit generated.

  By connecting a metal sheet power dissipation capability can be increased.



* Difference between voltage amplifier and power amplifier :-

Voltage amplifier	Power amplifier
(i) An amplifier which is designed the level of input signal is called a voltage amplifier. (level badhata he input signal ka)	(i) A power amplifier which is designed to boost the power level of the input signal is called a power amplifier. (power level ko boost karta he)
(ii) Voltage amplifier is also called small signal amplifier.	(ii) Power amplifier is called large signal amplifier.

(ii) The input voltage of a voltage amplifier is very low i.e. milivolt. and mv.	(iii) The input voltage of a power amplifier is high of the order of few volt.
(iv) Voltage amplifier has high voltage and low power output.	(iv) Power amplifier has high power and low voltage output.
(v) The RC coupling is used in the voltage amplifier.	(v) Power amplifier always uses transformer coupling.
(vi) The collector current of the voltage amplifier is low. Approximately equal to 1mA.	(vi) The collector current of the power amplifier is high, greater than 100 mA.
(vii) The transistor used in the voltage amplifier circuit is smaller in size.	(vii) The transistor used in the power amplifier is larger physical size.
(viii) In the voltage amplifier the load has high resistance value i.e., 4kΩ to 10kΩ	(viii) In the power amplifier the value of load resistance is low around 5Ω to 20Ω.
(ix) The AC power output of a voltage amplifier is low.	(ix) Comparatively high.
(x) Voltage amplifier has high output impedance aprox 12kΩ.	(x) The output impedence of power amplifier is low around 200Ω.
(xi) In voltage amplifier their is no need hit sink.	(xi) The hit sink is necessary required in the power amplifier.
(xii) The voltage amplifier is usually used at the first stage of amplification.	(xii) The power amplification is usuall used at the last stage of amplification.