# Amplifier
# Lecture 10

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**Common Collector Amplifier:**

The common collector amplifier is also known as emitter follower. The name is justified when a voltage equation is written around the input loop.

$$V_i - V_{be} - V_0 = 0 \rightarrow (i)$$

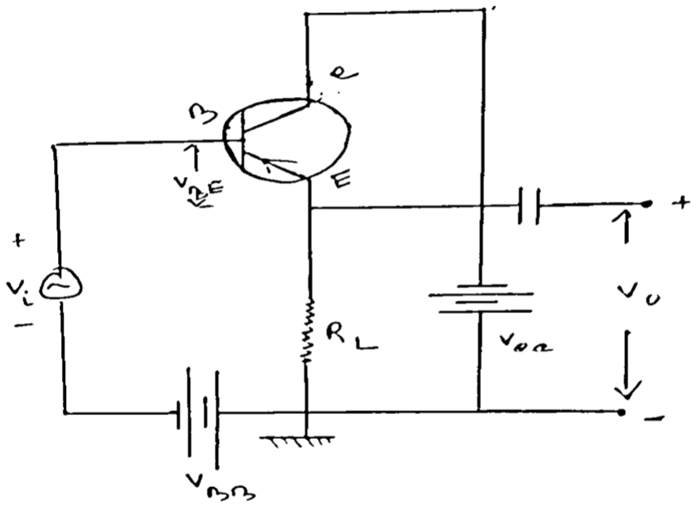

Fig 1

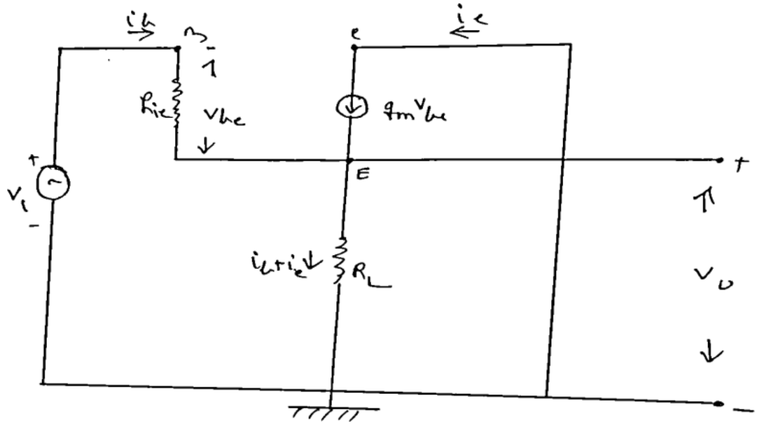

Fig 2

Making the input signal $V_{be}$ small or the gain large we have

$$V_i \approx V_0 \rightarrow (ii)$$

And the output voltage can be nearly equal to or follow the input voltage. The voltage gain $\frac{V_0}{V_i}$ is less than but nearly unity in magnitude. Between $B, C\ and\ E$ terminal, we may insert $g_m$ model as shown in $figure$ 2. From load in emitter current

$$V_0 = R_L(I_b + I_e) = (1 + h_{fe})R_L I_b \rightarrow (iii)$$

At input we have $V_{be} = h_{fe} I_b$ and when these relation are substituted in equation $(ii)$ gives

$$V_i = [h_{ie} + \left(1 + h_{fe}\right)R_L]I_b \rightarrow (iv)$$

The input resistance of the amplifier is

$$R_{ie} \approx \frac{V_i}{I_b} \approx h_{ie}(1 + g_m R_L) \approx h_{ie} + h_{fe}R_L \rightarrow (v)$$

Here $h_{fe} \gg 1$. Resistance $R_{ie}$ is much larger than $h_{ie}$ of the transistor alone. The current gain can be obtained from load current

$$I_e = -(I_b + I_c) = -(1 + h_{fe})I_b \rightarrow (vi)$$

Therefore

$$A_{ie} = \frac{I_e}{I_b} = -\left(1 + h_{fe}\right) \cong -h_{fe} \rightarrow (vii)$$

The voltage gain is

$$A_{ve} = -A_i \frac{R_L}{R_i} = \frac{h_{fe} R_L}{h_{ie}(1 + g_m R_L)} = \frac{g_m R_L}{1 + g_m R_L} \rightarrow (viii)$$

The power gain is

$$Power\ Gain = |A_{ve}||A_{ie}| = \frac{h_{fe} g_m R_L}{1 + g_m R_L} \rightarrow (ix)$$

The output resistance at $(2,2)$ port is found by using making the independent source $V_i = 0$ and thus opening the $g_m$ current source

$$R_{oe} = \frac{h_{ie} R_L}{h_{ie} + R_L} \rightarrow (x)$$

Which is less than $h_{ie}$ of transistor.

The emitter follower serves as a unity gain impedance transformer providing a high input resistance that can be power matched to low resistance load. This action is the inverse of that of the $CB$ circuit.

**Comparation of CE, CB and CC Amplifier:**

The common emitter circuit is widely used because it has high current gain approximating $h_{fe}$ , the highest available power gain and input-output resistance near enough to the same order that cascading without impedance matching transformers does not give severe gain loss.

In $CB$ circuit the input current is to the emitter and current gain is less than unity. The input source must supply this current to the low input resistance considerably lower than that of $CE$ circuit.

The output resistance is higher than that of $CE$ circuit by the factor $h_{fe}$ . The voltage gain is equal to the that of $CE$ stage.

The $CC$ circuit has a voltage gain which is less than unity since the output voltage across the emitter load can never exceed the input voltage to the base at the emitter base junction would become back biased. The current gain is high at $h_{fe}$.

The use of the base for input implies a high input resistance which includes the amplified effect of the emitter load as $h_{ie}(1 + g_m R_L)$. With its output limited in voltage but capable of supplying a large current, the $CC$ stage has a low output resistance.

The circuit is suitable to service as a buffer or isolating amplifier or to couple to a load with large current demands.

**Class A, B and C Amplifier:**

An amplifier is an active device which transform power from the $DC$ power supply into signal power at output, the signal amplitude at the output being proportional to that at input. Amplifiers are classified in different ways in accordance with the desired performance; the frequency range; the method of operation ; type of load e.t.c.

Voltage Amplifier is required to amplify signal voltage, where power consumed by load impedance. Such amplifier gives at its output an amplified voltage as input to the next stage.

Power Amplifier seeks the power supply to a load such as loudspeaker or antenna. Power amplifier constitute the last stage of radio receiver feeding the loudspeaker or the last stage of a transistor.

Current Amplifier as like voltage amplifier except that they primarily amplify current waveform rather than voltage waveform.

Am ideal voltage amplifier is one for which the proportionality factor between input and output is independent of signal amplitude and frequency which have no noise and distortion have infinite input impedance and zero output impedance.

An ideal current amplifier is defined as an amplifier for which the proportion factor between the input and output is independent, have no noise and zero input impedance and infinite output impedance.

An amplifier in between range of $20\ Hz\ to\ 20\ KHz$ an $AF\ amplifier$ and in between range of $20\ KHz\ to\ 20\ MHz$ known as $RF\ amplifier$.

In terms of method of operation amplifiers are divided into $Class\ A, Class\ B\ and\ Class\ AB\ or\ Class\ C\ amplifier$. The position $Q - point$ and portion of characteristic that is used to determine the method of operation.

A $Class\ A\ amplifier$ is one in which $Q - point$ and amplitude of input signal are such that output current flows during the entire cycle of input signal.

If $Q - point$ is at an extreme point of load line such that quiescent power is zero and output current flows for just one half of the input signal cycle, the amplifier is said to be $Class\ B\ amplifier$.

If the $Q - point$ and amplitude signal of input signal voltage are such that the output current flows for more than one half but less than one complete cycle of the input signal, the amplifier is known as $Class\ AB\ amplifier$. It is termed and operate in between two extreme of $Class\ A$ and $Class\ B$.

## Class A Power Amplifier:

In this amplifier $CE$ mode is used for its largest power gain. As shown in $Figure\ 3$, the amplifier is directly coupled to load resistance $R_L$. As the operation is $Class\ A$ , collector current flow over entire cycle of input signal. The blocking capacitor $C_1$ prevents interaction between the $DC$ voltage of the base current and $AC$ signal voltage.

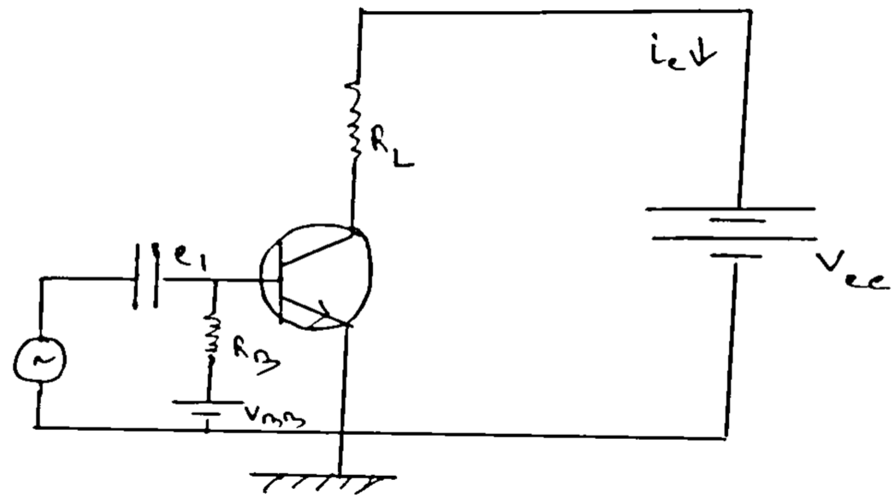


Fig 3

For a given desired temperature maximum power dissipation is given by

$$V_c' \; I_c' = Constant$$

Where $V_c'$ is collector voltage and $I_c'$ is collector current. The $Q - point$ is so chosen near the centre of load line between cut off and saturation. At cut off collector voltage has maximum value $V_{c_{min}}$ and collector current has maximum value of $I_{c_{max}}$ As operating swing equally either side of $Q - point$ the amplitude of collector current $I_m$ and collector voltage $V_m$ is given by

$$I_m = \frac{I_{c_{max}} - I_{c_{min}}}{2}$$

$$V_m = \frac{V_{c_{max}} - V_{c_{min}}}{2}$$

$$V_m = I_m R_L$$

The instanous collector current is

$$i_c(t) = I_{CQ} + I_m \sin \omega t$$

Where $\omega$ is angular frequency of $AC$ signal The instanous collector emitter voltage drop is

$$V_c(t) = V_{cc} - I_c R_L$$

$$V_c(t) = V_{cc} - (I_{CQ} + I_m \sin \omega t)R_L$$

The instanous power dissipated in load resistance is

$$P_L(t) = I_c^2 R_L$$

Average power in load is

$$P_L = \frac{1}{2\pi}\int_0^{2\pi} i_c^2 R_L d(\omega t)$$

$$P_L = I_{CQ}^2 R_L + \frac{1}{2} I_m^2 R_L$$

In absence of signal

$$P_L = I_{CQ}^2 R_L$$

It is the DC power dissipation across $R_L$. In presence of signal $P_L$ increase by $\frac{1}{2} I_m^2 R_L$ which represent AC power.

Therefore

$$P_{AC} = \frac{1}{2} I_m^2 R_L = \frac{1}{2} I_m V_m = I_{rms} V_{rms}$$

Output Power $(P_{AC}) = \frac{1}{2} I_m V_m = \frac{1}{8} (I_{c_{max}} - I_{c_{min}})(V_{c_{max}} - V_{c_{min}})$

Collector Efficiency $(\eta) = \frac{P_{AC}}{P_{DC}} = \frac{(I_{c_{max}} - I_{c_{min}})(V_{c_{max}} - V_{c_{min}})}{8 V_{CQ} I_{CQ}}$

For ideal collector characteristic

$$V_{c_{min}} = 0, I_{c_{max}} = 2I_{CQ}, V_{c_{max}} = V_{cc}, I_{c_{min}} = 0$$

Therefore

$$\eta = \frac{2I_{CQ}V_{CC}}{8I_{CQ}V_{CC}} = 0.25$$

Thus maximum efficiency for $Class\ A$ Power Amplifier directly coupled to load resistance 25%