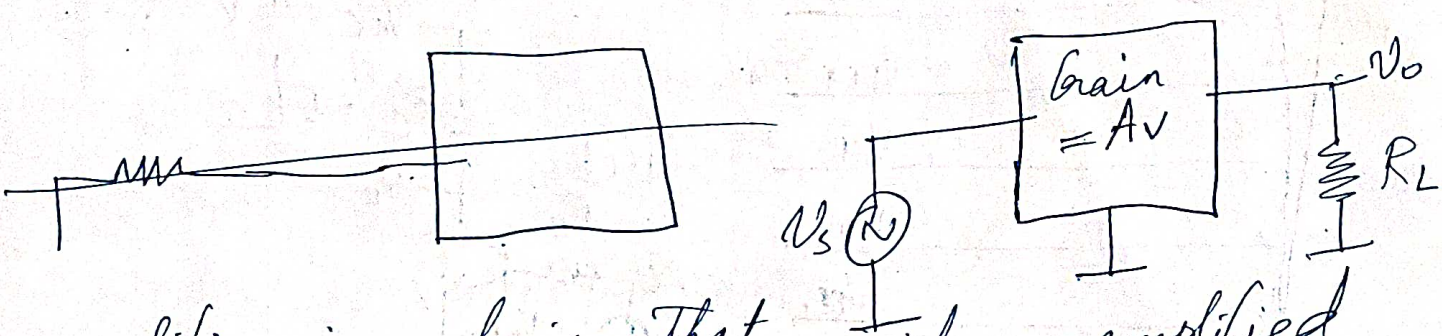
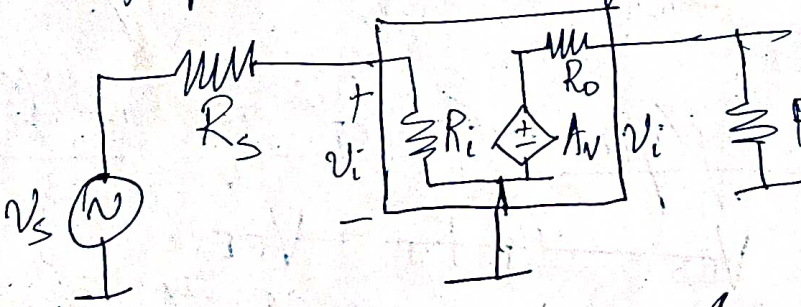
Expectations from transistor amplifier



The amplifier is a device that provides a amplified output for a input. Mathematically it does the following function $V_o = A_V V_i$.

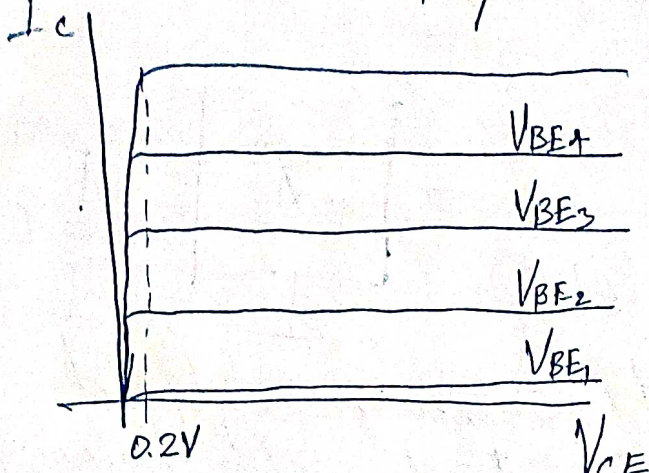
This means that the amplifier is a linear system. Besides practical sources come with a series resistance, and the amplifier by itself has output impedance; so general amplifier is of the form for practical signals.

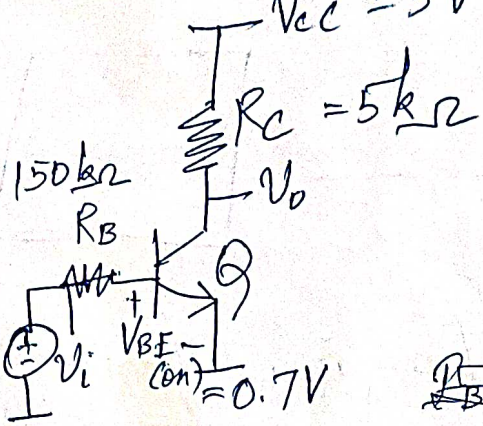


There is a voltage divider action at input,

$V_i = \frac{V_s R_i}{R_i + R_s}$, where V_i is the signal available at the amplifier input for amplification. To maximize input signal $R_i \gg R_s$. Likewise to maximize V_o, $R_L \, R_o \ll R_L$. Hence apart from providing a large gain the amplifier should meet these conditions for suitable amplification. Let us look how a specific non-linear device such as BJT or MOSFET can

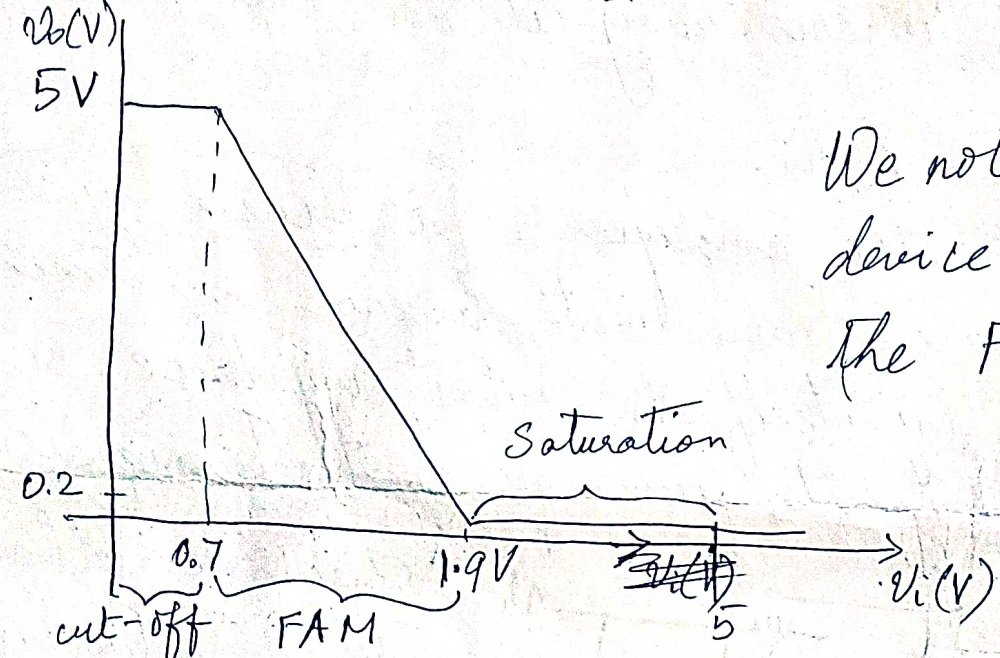
can become amplifiers. The fundamental amplifier circuit is





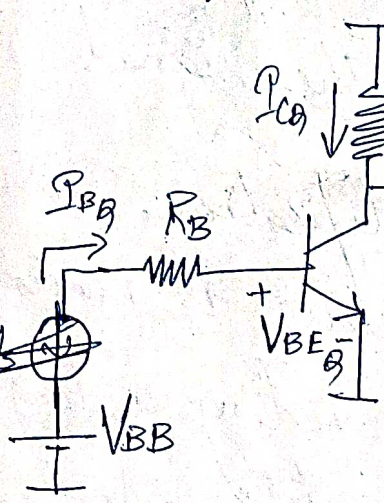
~~$I_B = I_S \exp\left(\frac{V_{BE}}{V_T}\right)$~~

$I_C = \beta I_B$



We notice that the device is linear in the Forward active region.

The Bipolar Linear Amplifier – Concept of Small Signals



~~$V_{BB} = I_B R_B + V_{BE}$~~

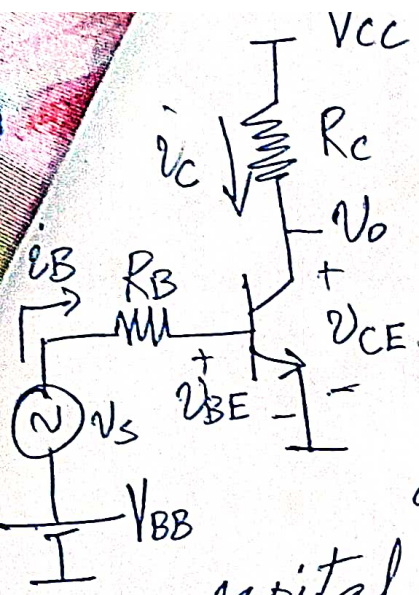
Let us assume that the device is operating in ~~For~~ Active region. Writing loop equation in the BE loop, we get

$$V_{BB} = I_{B_Q} R_B + V_{BE_Q} \quad \text{——— (1)}$$

$$I_{B_Q} = I_S \exp\left(\frac{V_{BE_Q}}{V_T}\right)$$

$$V_o = V_{CE_Q}$$

$$V_{CC} = I_{C_Q} R_C + V_{CE_Q} \quad \text{——— (2)}$$



When a small signal (or incremental) signal is applied, the base and collector currents are expected to change by small amounts. The new quantities are indicated by small letters with capital subscripts.

$$i_B = I_{BQ} + i_b \; ; \; v_{BE} = V_{BEQ} + v_{be}$$

$$i_C = I_{CQ} + i_c$$

$$V_{BB} + v_s = i_B R_B + v_{BE}$$

$$= (I_{BQ} + i_b) R_B + V_{BEQ} + v_{be}$$

$$V_{BB} - I_{BQ} R_B - V_{BEQ} = i_b R_B + v_{be} - v_s$$

From (1) we know that LHS = 0

$$v_s = i_B R_B + v_{be}$$

$$i_B = I_S \exp\left(\frac{v_{BE}}{V_T}\right)$$

$$i_B = I_S \exp\left[\frac{V_{BEQ} + v_{be}}{V_T}\right]$$

$$= I_S \exp\left(\frac{V_{BEQ}}{V_T}\right) \exp\left(\frac{v_{be}}{V_T}\right)$$

$$= I_{BQ} \exp\left(\frac{v_{be}}{V_T}\right) = I_{BQ}\left[1 + \frac{v_{be}}{V_T}\right]$$

$$i_B = I_{BQ} + \left(\frac{I_{BQ}}{V_T}\right) v_{be}$$

$$= I_{BQ} + i_b$$

$$i_b = \left(\frac{I_{BQ}}{V_T}\right) v_{be}$$

(or)

$$\frac{v_{be}}{i_b} = \frac{V_T}{I_{BQ}} = r_\pi$$

$$V_{CC} = i_c R_c + V_{CE}$$

$$= (I_{CQ} + i_c) R_c + (V_{CEQ} + v_{ce})$$

$$V_{CC} - I_{CQ} R_c - V_{CEQ} = i_c R_c + v_{ce}$$

$$v_{ce} = -i_c R_c$$

$$i_c = \beta I_S \exp\left(\frac{V_{BE}}{V_T}\right)$$

$$= \beta I_S \exp\left[\frac{V_{BE} + v_{be}}{V_T}\right] = \beta I_S I_B \exp$$

$$I_C = \beta I_C \exp\left(\frac{v_{be}}{V_T}\right)$$

$$= I_C + \frac{v_{be}}{V_T} I_C$$

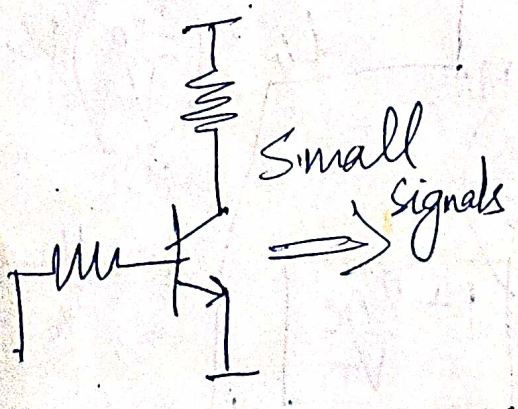
$$I_C + i_c = I_C + \frac{I_C}{V_T} v_{be}$$

At CE loop $\boxed{i_c = g_m v_x \; ; \; v_{ce} = -i_c R_c}$

At BE loop $v_s = v_{be} + i_b R_B \Rightarrow v_s = v_x + i_b R_B$

$$\boxed{v_x = r_x i_b}$$

$$\boxed{v_s = i_b (r_x + R_B)} = i_b (R_B + r_x)$$



Small signals $\Rightarrow$

