ANALYSIS OF A TRANSISTOR AMPLIFIER USING H-PARAMETERS

To form a transistor amplifier it is only necessary to connect an external load and signal source as indicated in fig. 1 and to bias the transistor properly.

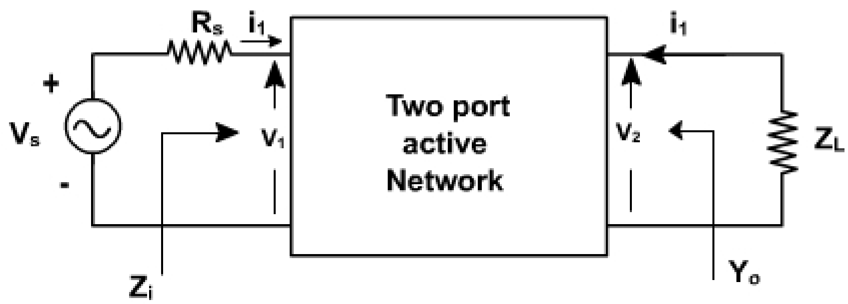

Fig. 1

Consider the two-port network of CE amplifier. RS is the source resistance and ZL is the load impedence h-parameters are assumed to be constant over the operating range. The ac equivalent circuit is shown in fig. 2. (Phasor notations are used assuming sinusoidal voltage input). The quantities of interest are the current gain, input impedance, voltage gain, and output impedance.

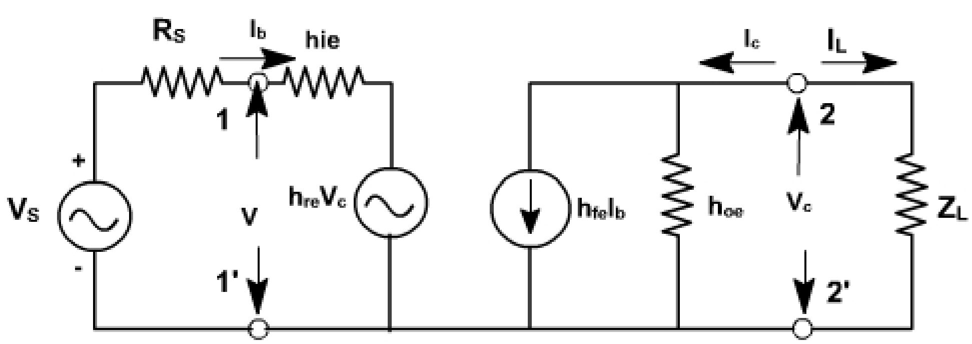

Fig. 2

Current gain:

For the transistor amplifier stage, Ai is defined as the ratio of output to input currents.

$$A_i = \frac{I_L}{I_b} = \frac{-I_C}{I_b} \qquad (I_L + I_c = 0. \quad \therefore I_L = -I_c)$$

$$I_C = h_{fe} I_b + h_{oe} V_c$$

$$V_c = I_L Z_L = -I_c Z_L$$

$$\therefore I_c = h_{fe} I_b + h_{oe} (-I_c Z_L)$$

$$\text{or } \frac{I_c}{I_b} = \frac{h_{fe}}{1 + h_{oe} Z_L}$$

$$\therefore A_i = -\frac{h_{fe}}{1 + h_{oe} Z_L}$$

Input Impedence:

The impedence looking into the amplifier input terminals (1,1') is the input impedence Zi

$$Z_i = \frac{V_b}{I_b}$$

$$V_b = h_{ie} I_b + h_{re} V_c$$

$$\frac{V_b}{I_b} = h_{ie} + h_{re} \frac{V_c}{I_b}$$

$$= h_{ie} - \frac{h_{re} I_c Z_L}{I_b}$$

$$\therefore Z_i = h_{ie} + h_{re} A_I Z_L$$

$$= h_{ie} - \frac{h_{re} h_{fe} Z_L}{1 + h_{oe} Z_L}$$

$$\therefore Z_i = h_{ie} - \frac{h_{re} h_{fe}}{Y_L + h_{oe}} \qquad (\text{since } Y_L = \frac{1}{Z_L})$$

Voltage gain:

The ratio of output voltage to input voltage gives the gain of the transistors.

$$A_v = \frac{V_C}{V_b} = -\frac{I_C Z_L}{V_b}$$

$$\therefore A_v = \frac{I_B A_i Z_L}{V_b} = \frac{A_i Z_L}{Z_i}$$

Output Admittance:

It is defined as

$$Y_0 = \left.\frac{I_c}{V_c}\right|_{V_s} = 0$$

$$I_c = h_{fe} I_b + h_{oe} V_c$$

$$\frac{I_c}{V_c} = h_{fe}\frac{I_b}{V_c} + h_{oe}$$

when $V_s = 0$, $\quad R_s . I_b + h_{ie} . I_b + h_{re} V_c = 0.$

$$\frac{I_b}{V_c} = -\frac{h_{re}}{R_s + h_{ie}}$$

$$\therefore Y_0 = h_{oe} - \frac{h_{re}\ h_{fe}}{R_s + h_{ie}}$$

Voltage amplification taking into account source impedance (R_S) is given by

$$A_{VS} = \frac{V_c}{V_s} = \frac{V_c}{V_b} * \frac{V_b}{V_s} \qquad \left(V_b = \frac{V_s}{R_s + Z_i} * Z_i\right)$$

$$= A_V . \frac{Z_i}{Z_i + R_s}$$

$$= \frac{A_i\ Z_L}{Z_i + R_s}$$

Av is the voltage gain for an ideal voltage source (Rv = 0).

Consider input source to be a current source IS in parallel with a resistance RS as shown in fig. 3.

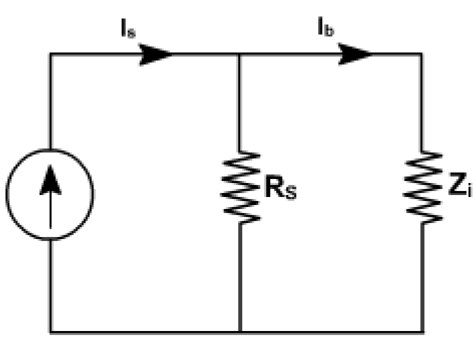

Fig. 3

In this case, overall current gain AIS is defined as

$$A_{I_s} = \frac{I_L}{I_s}$$

$$= -\frac{I_c}{I_s}$$

$$= -\frac{I_c}{I_b} * \frac{I_b}{I_s} \qquad \left(I_b = \frac{I_s * R_s}{R_s + Z_i} \right)$$

$$= A_I * \frac{R_s}{R_s + Z_i}$$

$$\text{If } R_s \to \infty, \quad A_{I_s} \to A_I$$