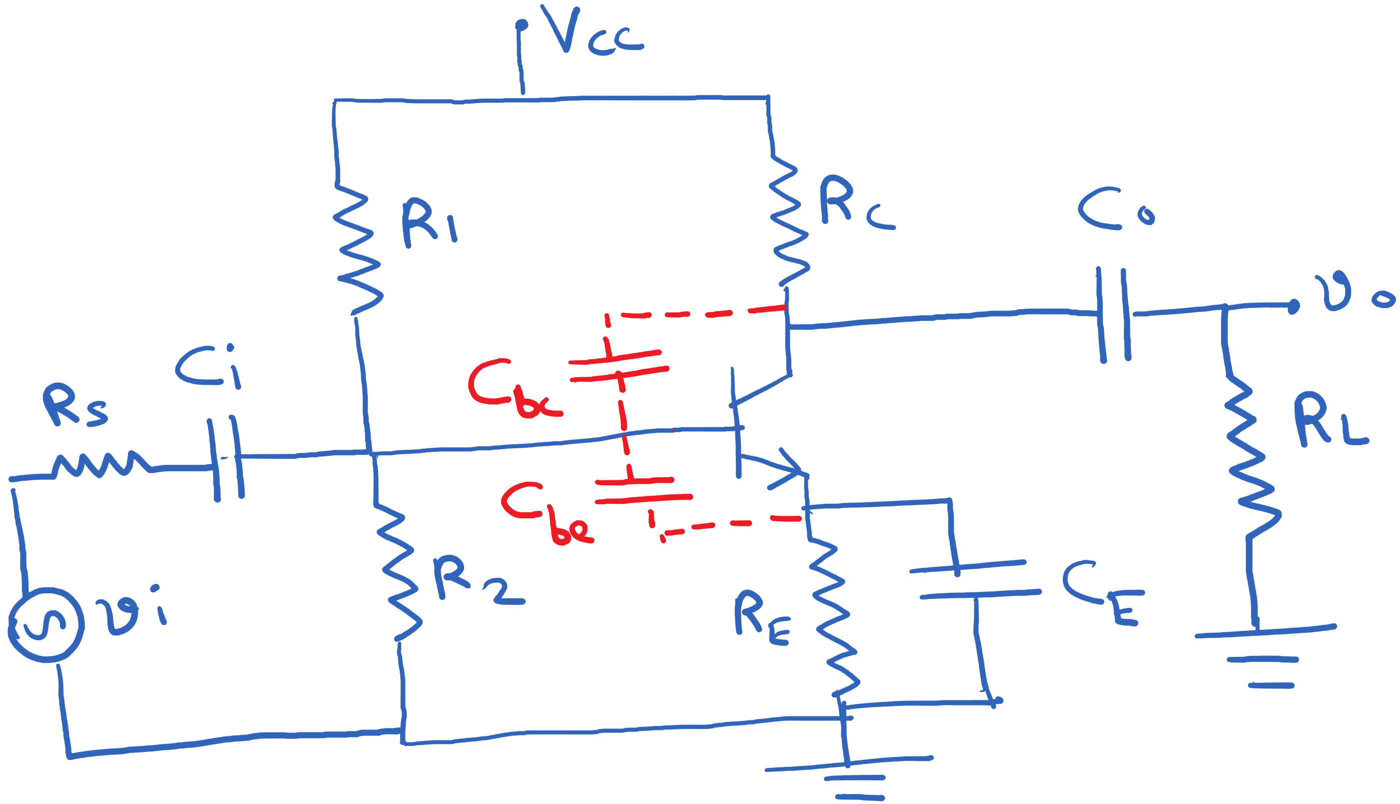
Class-24

Hybrid π- model



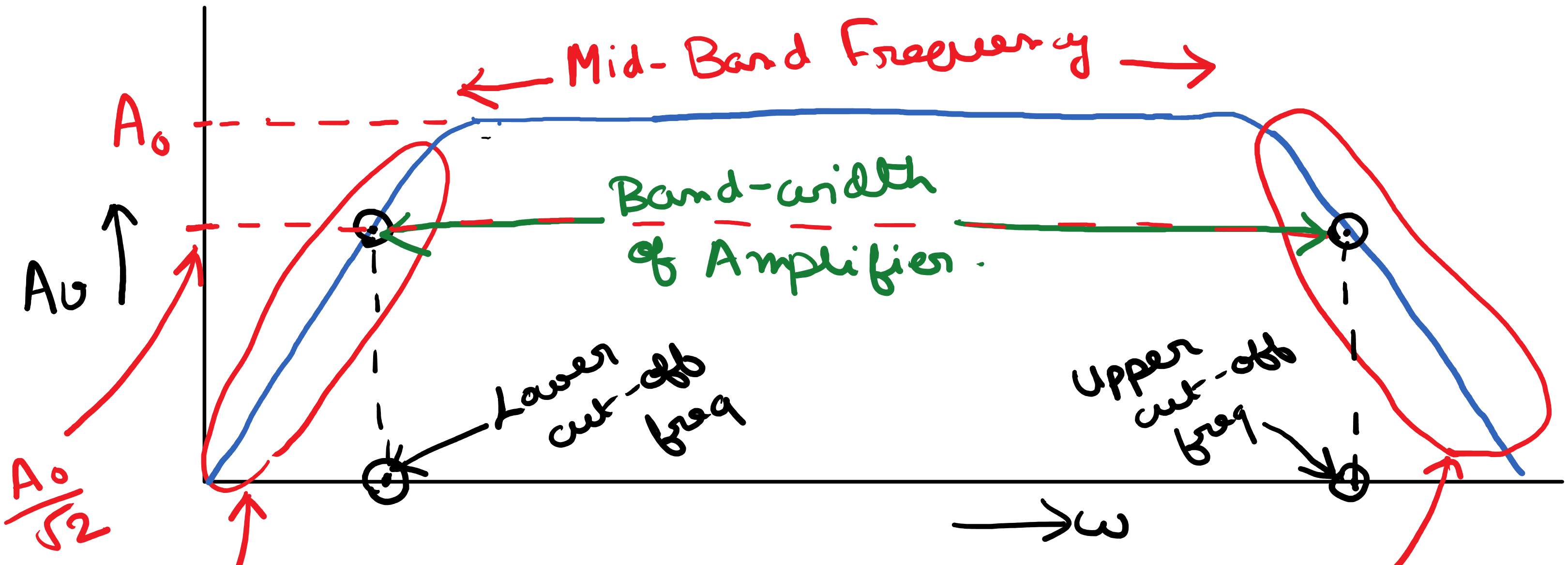
$C_i, C_o, C_E \rightarrow$ externally connected capacitors.

$C_{bc}, C_{be} \rightarrow$ internal junction capacitances of the transistor.

Frequency response defines how the gain of the transistor amplifier is behaving with change of frequency.

The gain that we calculate assuming C_i, C_E and C_o behave as short circuits and C_{be} and C_{bc} behave as open circuits is known as mid-band frequency gain or mid-band gain. This is often denoted by A_o or A_v^o

The range of frequency over which C_i, C_o and C_E can be considered to be short-circuits and C_{be} and C_{bc} can be considered to be open-circuits is known as the mid-band frequency range.

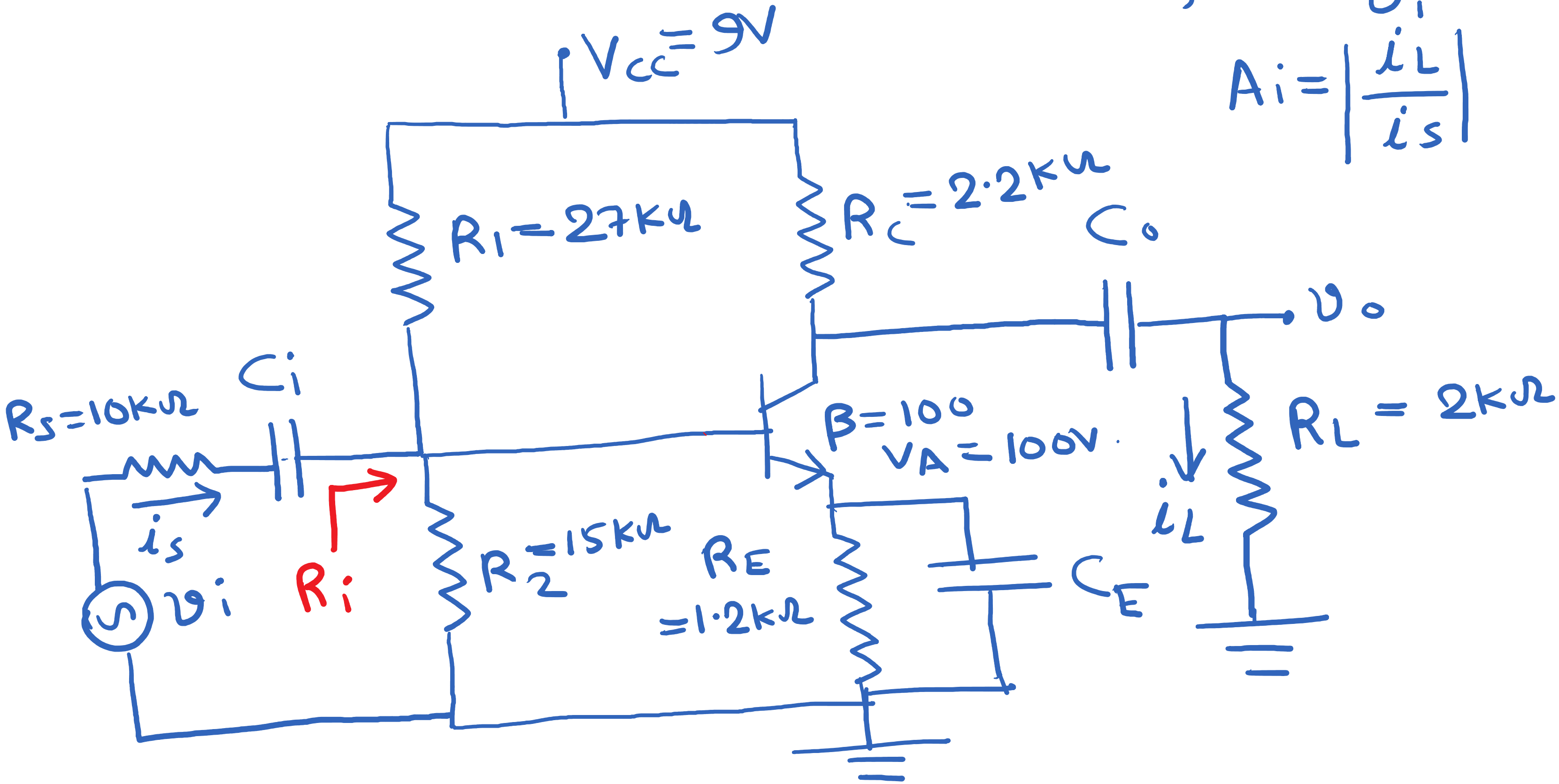


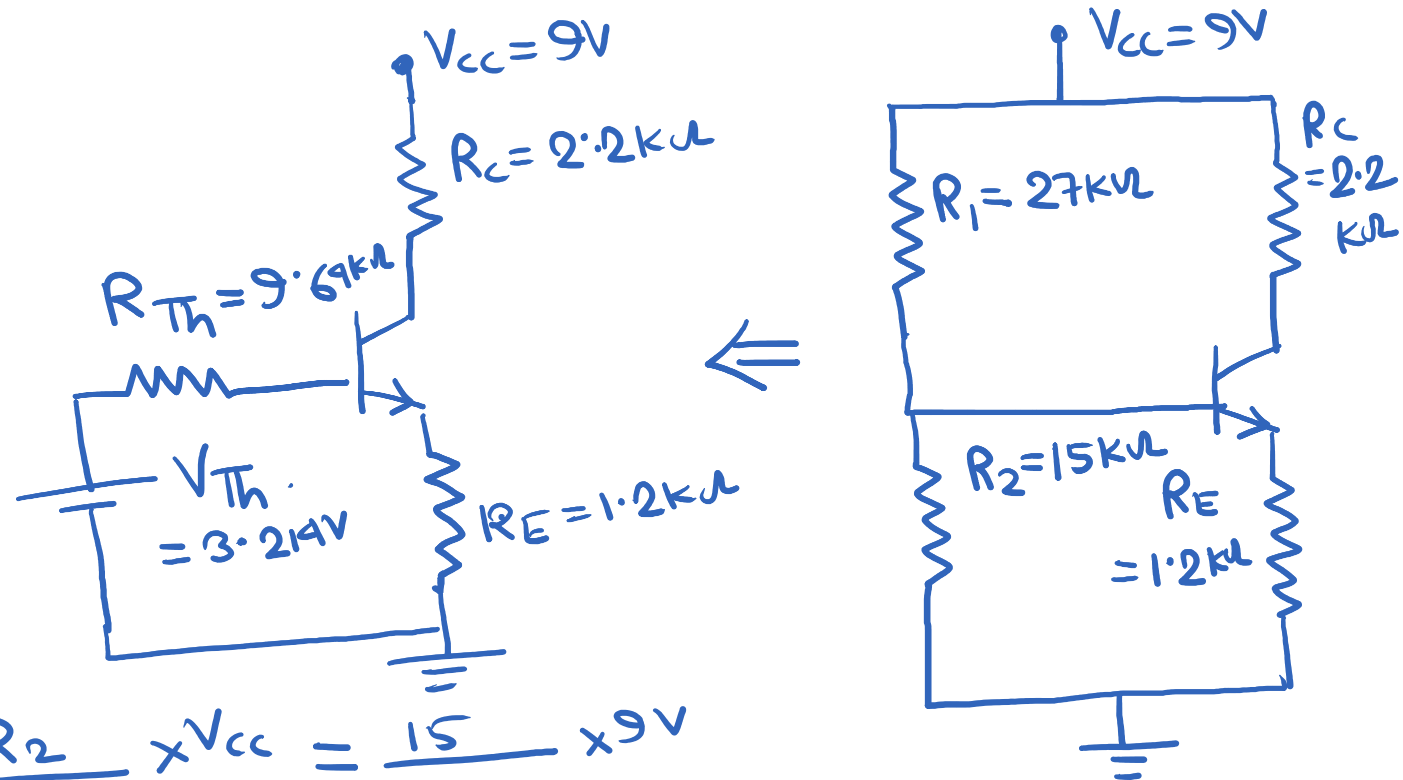
gain falls off in the low frequency regime due to C_o, C_E and C_i

gain falls of at very high frequencies due to the internal junction capacitance C_{be} and C_{bc}.

R_i, $A_v = \frac{v_o}{v_i}$

$A_i = \left| \frac{i_L}{i_s} \right|$





$$V_{Th} = \frac{R_2}{R_1+R_2} \times V_{cc} = \frac{15}{27+15} \times 9V$$

$$= 3.214V$$

$$R_{Th} = R_1 \| R_2 = \frac{15 \times 27}{15+27} k\Omega = 9.64 k\Omega$$

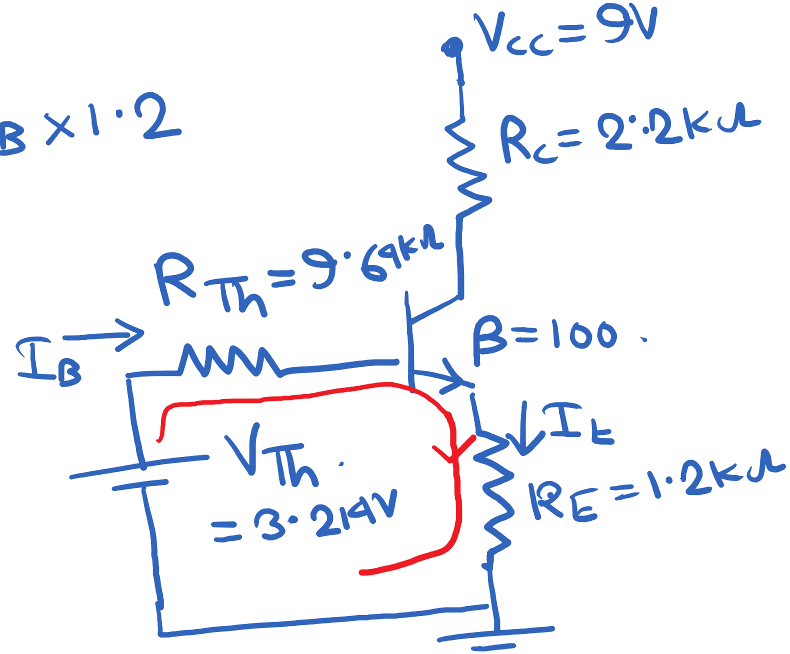
$$V_{Th} = I_B R_{Th} + V_{BE(ON)} + I_E R_E$$

$$= 9.64\, I_B + 0.7V + (\beta+1) I_B \times 1.2$$

$$\Rightarrow I_B = \frac{V_{Th} - 0.7}{9.64 + (\beta+1)\times 1.2} \text{ mA}$$

$$= \frac{3.214 - 0.7}{9.64 + 101 \times 1.2}$$

$$= 0.0192 \text{ mA}$$



$$I_C = \beta I_B = 100 \times 0.0192 \text{ mA}$$

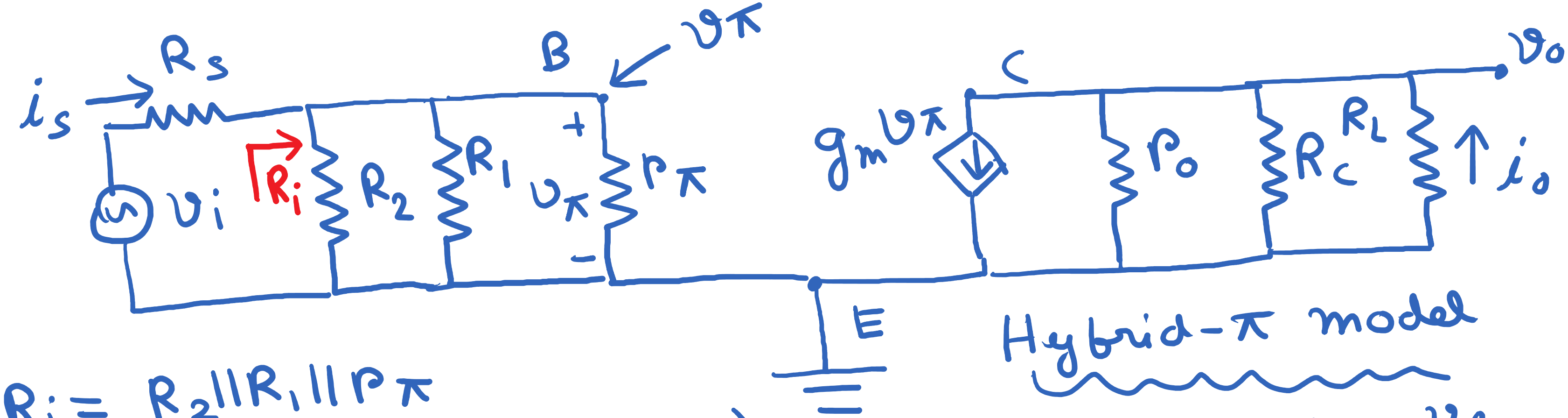
$$= 1.92 \text{mA}$$

AC small signal parameters

$$r_\pi = \frac{V_T}{I_B} = \frac{0.026V}{0.0192mA} = 1.354k\Omega$$

$$g_m = \frac{\beta}{r_\pi} = \frac{100}{1.354k\Omega} = 73.85 \text{ milli-mho}.$$

$$r_o = \frac{V_A}{I_C} = \frac{100V}{1.92mA} = 52.08k\Omega.$$

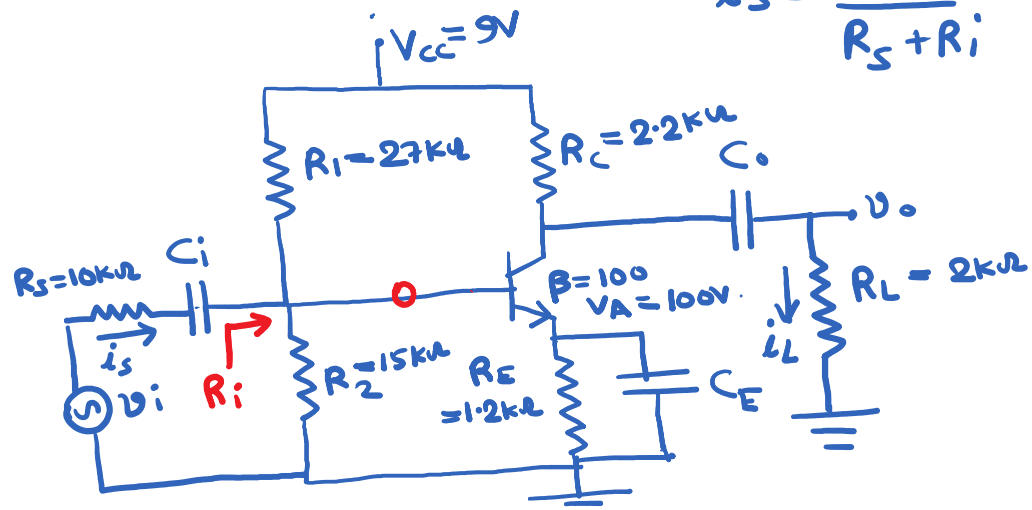


Hybrid-π model

$$R_i = R_2 \| R_1 \| r_\pi$$
$$= (15\,k\Omega \| 27\,k\Omega \| 1.354\,k\Omega)$$
$$= 1.187\,k\Omega$$

$$i_o = \frac{v_o}{R_L}$$
$$i_s = \frac{v_s}{R_s + R_i}$$

$$v_\pi = \frac{v_i}{R_s + R_i} \times R_i$$
$$= v_i \times \frac{1.187}{10 + 1.187}$$
$$= 0.106\,v_i$$



$R_i = 1.187\,k\Omega \quad , \quad v_\pi = 0.106 v_s$.

$$i_c = g_m v_\pi$$

$$v_o = -i_c \times (r_o \| R_c \| R_L)$$

$$= -g_m v_\pi (r_o \| R_c \| R_L)$$

$$= -v_\pi \times 73.85 \text{ milli-mho}$$

$$\times (52.08\,k\Omega \| 2.2\,k\Omega \| 2\,k\Omega)$$

$$= -v_\pi \times 73.85 \text{ milli-mho} \times 1.027\,k\Omega.$$

$$= -75.84\, v_\pi = -75.84 \times 0.106 v_s$$

$$= -8.039\, v_s$$

$$A_v = \frac{v_o}{v_s} = -8.039$$

$$A_i = \left|\frac{i_o}{i_s}\right|$$

$$i_o = \frac{v_o}{R_L} \quad , \quad i_s = \frac{v_s}{R_s + R_i}$$

$$\Rightarrow A_i = \left|\frac{i_o}{i_s}\right| = \left|\frac{v_o}{v_s}\right| \times \frac{R_s + R_i}{R_L}$$

$$= |A_v| \times \frac{10 + 1.187}{2}$$

$$= 8.039 \times \frac{11.187}{2}$$

$$= 44.96.$$

$R_i = 1.187\,k\Omega$, $A_v = -8.039$, $A_i = 44.96.$