MID SEMESTER EXAM-2018 SOLUTIONS
5th SEMESTER
Analog Electronics

Ans. 1 (a)

Transconductance (g_m) → The transconductance of BJT is defined as the rate of change of collector current (i_c) with respect to input voltage i.e base to emitter voltage (v_{be}).

$$i_c = I_S \exp(v_{BE}/V_T) = I_S \exp((V_{BE} + v_{be})/V_T)$$

$$= I_S \exp(V_{BE}/V_T)\exp(v_{be}/V_T)$$

$$= I_C \exp(v_{be}/V_T)$$

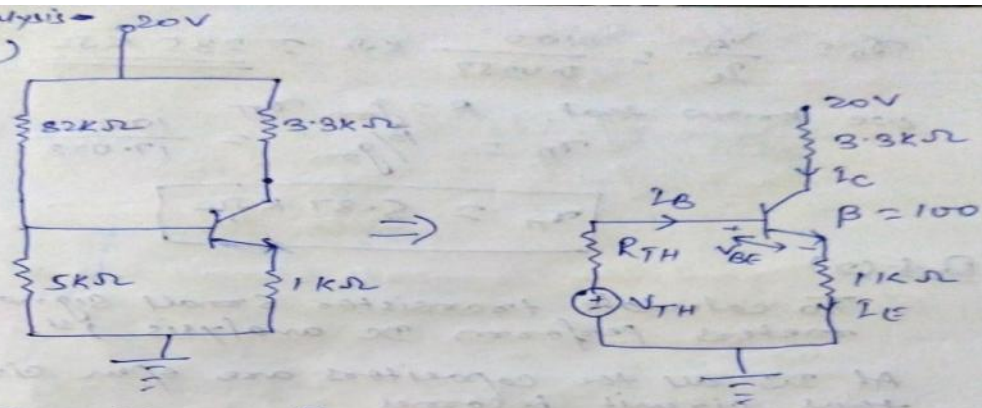
$$g_m = \frac{\partial i_c}{\partial v_{be}} = \frac{I_C}{V_T}$$

Output resistance (r_o) – The early effect, causes the collector current to depend not only on v_{BE} but also on v_{CE}. The output resistance r_o is given by,

$$r_o = \frac{V_A + V_{CE}}{I_C} \simeq \frac{V_A}{I_C}$$

DC analysis

Ans-(1)-(b)



where, $V_{TH} = \frac{5}{5+82} \times 20 = 1.15\text{V}$

$R_{TH} = 82 \| 5 = 4.71\text{ k}\Omega$

Apply KVL in base-emitter loop.

$V_{TH} - I_B R_{TH} - V_{BE} - I_E R_E = 0$

since, $I_E = (1+\beta) I_B$

$I_B(R_{TH} + (1+\beta)R_E) = V_{TH} - V_{BE}$

$$\therefore I_B = \frac{1.15 - 0.7}{4.71 + 101 \times 1} = \frac{0.45}{105.71} = 4.257\,\mu\text{A}$$

$I_C = \beta I_B = 4.257 \times 100 = 0.4257\text{ mA}$

$g_m = \frac{I_C}{V_T} = 17.028\text{ mS}$

$$r_o = \frac{V_A}{I_C} = \frac{100}{0.4257} K\Omega \simeq \underline{\underline{235\ K\Omega}}$$

we know that, $\beta = g_m r_\pi$

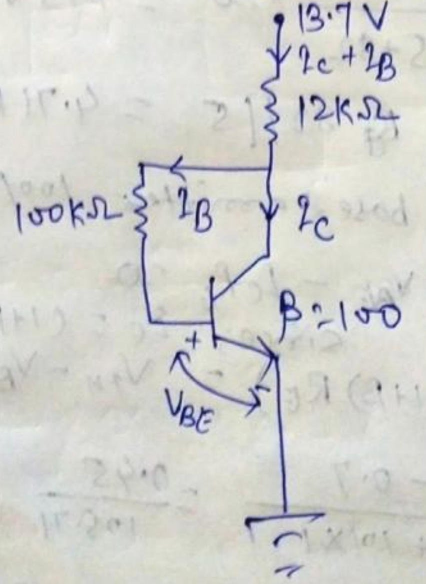
$$r_\pi = \beta / g_m = \frac{100}{17.028} K\Omega$$

$$\boxed{r_\pi = 5.87\ K\Omega}$$

Ans. (2)

To calculate transistor small signal parameters perform DC analysis 1st.

At DC all the capacitors are open circuited thus, circuit becomes



Apply KVL from 13.7 V to ground through base-emitter loop.

$13.7 - 12(I_C + I_B) - 100 I_B - V_{BE} = 0$

Since $I_C = \beta I_b = 100 I_b$

$$\therefore I_B = \frac{13.7 - 0.7}{100 + 12 \times 101} = \frac{13}{1312} \text{ mA}$$

$$\simeq 10 \mu A$$

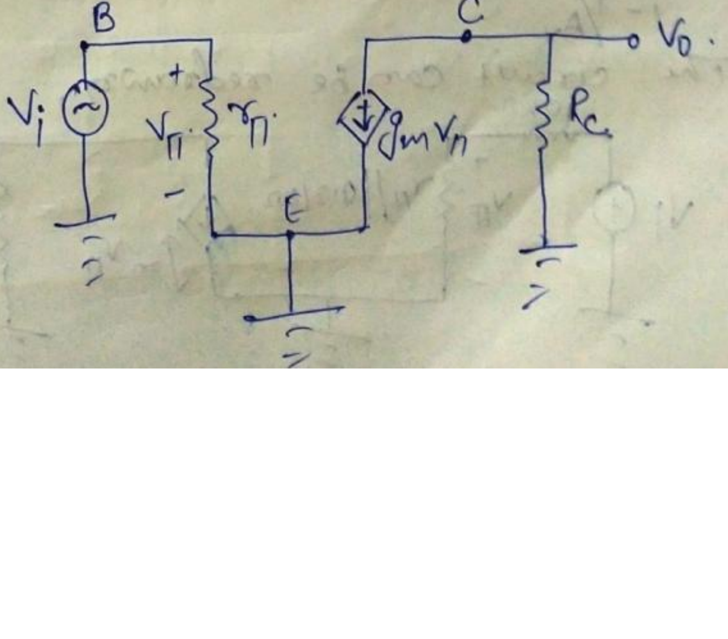
$$I_C = \beta I_b = 1 \text{ mA}$$

$$g_m = \frac{I_C}{V_T} = \frac{1 \text{ mA}}{25 \text{ mV}} = 1/25 \text{ A/V}$$

$$r_\pi = \beta / g_m = \frac{100}{1/25} = 2.5 K\Omega$$

~~Now, Draw the small signal model for of BJT for voltage gain.~~

Since a feedback resister is connected between collector and base, so this circuit can be solved by using miller theorem. for that 1st we ~~have~~ would have to calculate transistor Internal gain.



$V_0 = -g_m V_\pi R_C$

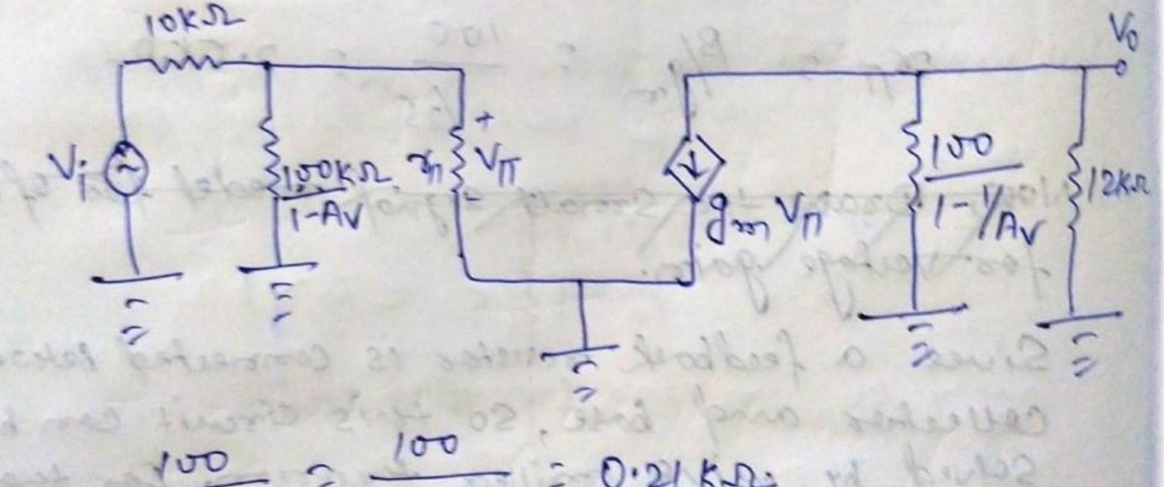
and $V_\pi = V_i$

$\therefore V_0 = -g_m R_C V_i$

$A_V = -g_m R_C = -\frac{1}{\cancel{25}} \times 12 \times \cancel{1000}^{40}$

$= -480$

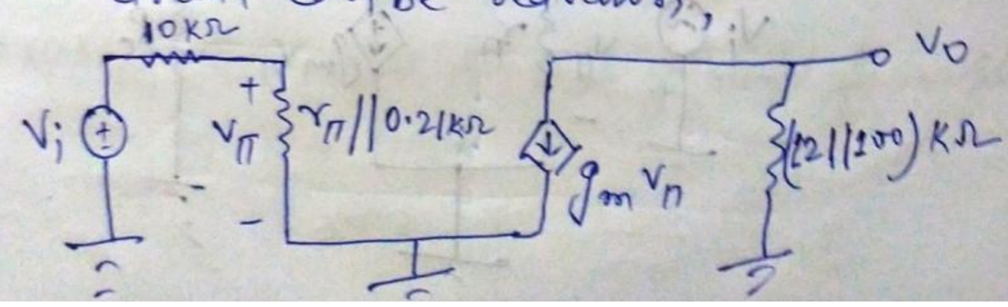
Now Draw the complete Small signal model of transistor.



$\frac{100}{1-A_V} = \frac{100}{1+480} = 0.21\,K\Omega$

$\frac{100}{1-1/A_V} \simeq 100\,K\Omega$

The circuit can be redrawn,



$\therefore V_0 = -g_m V_\pi (12 || 100)$

$V_0 = -g_m V_\pi (10.71 k\Omega)$ —— (i)

Now, $r_\pi || 0.21 k\Omega = \frac{2.5 \times 0.21}{2.5 + 0.21} = 0.194 k\Omega$

Let $R_i = r_\pi || 0.21 k\Omega = 0.194 k\Omega$

$\therefore V_\pi = \frac{0.194}{10 + 0.194} V_i = 0.019 V_i$

put V_π in eq^n (i)

$V_0 = -g_m (10.71 k\Omega) \times (0.019) V_i$

$\therefore A_v' = -\frac{1}{25} \times 10.71 \times 1000 \times 0.019$

$\boxed{A_v' = -8.14}$

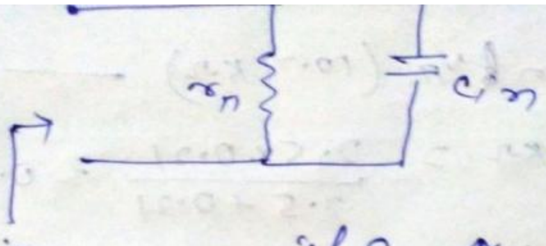
Ans: (3) (a)

(i) Due to increase in input capacitance, ~~the~~ Bandwidth of CE configuration decreases.

$B.W. \simeq f_H \simeq \frac{1}{2\pi C_{in} (R_s || R_i)}$

Therefore, CE configuration is not suitable in wideband Amplifier.

(ii) Input impedance of CE configuration decreases at high frequencies.

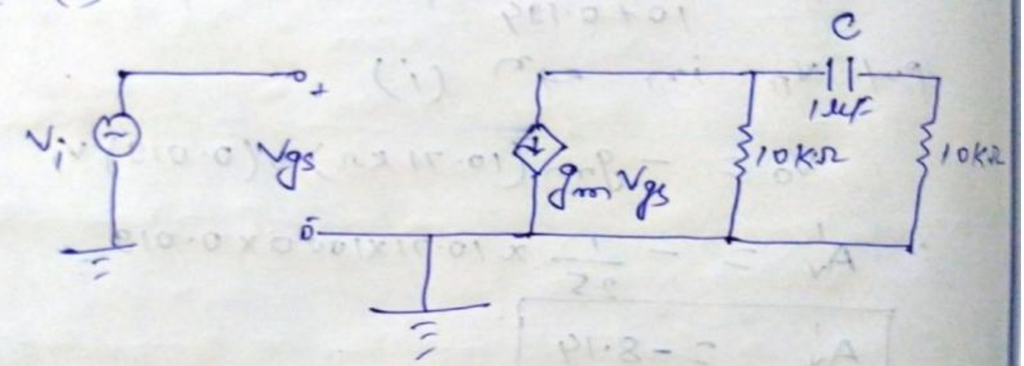


$Z_{in} = r_\pi \,||\, x_{in}$

$x_{in} = \dfrac{1}{\omega C_{in}}$

If $C_{in} \uparrow \rightarrow x_{in} \downarrow \rightarrow Z_i \downarrow$

Ans: (3)(b)

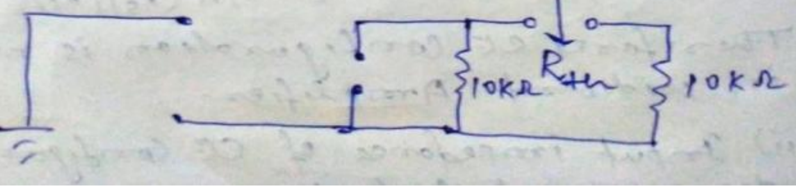


To calculate lower cut-off frequency make $V_i = 0$

Since, $V_i = 0$, so, $V_{gs} = V_i = 0$

Thus, $g_m V_{gs} = 0$

~~opera~~ so, circuit reduce to



$R_{th} = R_D + R_L = (10+10) = 20k\Omega$

$$f_L = \frac{1}{2\pi C R_{th}} = \frac{1}{2\pi \times 10^{-6} \times 20\times 10^{3}}$$

$$= \frac{25}{\pi} \text{ Hz}$$

$$\boxed{\therefore f_L = 7.957 \text{ Hz.}}$$

Ques. 4 (a)

a. $A_f = A/(1 + \beta A) =$ -100/(1 + (-0.1)(-100))

= -100/11 = **-9.09**

$Z_{if} = Zi\,(1 + \beta A)$ = 10 kΩ . (11) = **110 kΩ**

$Z_{of} = Zo\,/\,(1 + \beta A)$ = 20 * 10^3 / 11 = **1.82 kΩ**

b. $A_f = A/(1 + \beta A) =$ -100/(1 + (-0.5)(-100))

= -100/51 = **-1.96**

$Z_{if} = Zi\,(1 + \beta A)$ = 10 kΩ . (51) = **510 kΩ**

$Z_{of} = Zo\,/\,(1 + \beta A)$ = 20 * 10^3 / 51 = **392.16 Ω**

Ans. 4 (b)

Feedback Topologies ↓	Input impedance (Z_i)	Output Impedance (Z_o)
a) Voltage Series	Increases	Decreases
(b) Voltage Shunt	Decreases	,,
(c) Current Series	Increases	Increases
(d) Current Shunt	Decreases	,,

Ques. 5

a. For the emitter-follower configuration, the loaded gain is

$$V_{0_1} = \frac{Z_{i_2}}{Z_{i_2}+Z_{0_1}} A_{vNL} V_{i_1} = \frac{26}{26+12} \text{ x } 1 \text{ x } V_{i_1} = 0.684\ V_{i_1}$$

Therefore, $A_{v_1} = 0.684$

For the common base configuration,

$$V_{0_2} = \frac{R_L}{R_L+R_{0_2}} A_{vNL} V_{i_2} = \frac{8.2}{8.2+5.1} \text{ x } 240 \text{ x } V_{i_2} = 147.97\ V_{i_2}$$

$$A_{v_2} = 147.97$$

b. $A_{v_T} = A_{v_1}\,A_{v_2} = 101.20$

$$A_{V_s} = \frac{Z_{i_1}}{Z_{i_1} + R_s} A_{V_T} = \frac{(10k\Omega)(101.20)}{10k\Omega + 1k\Omega} = 92$$

c. $V_i = \frac{Z_{i_2}}{Z_{i_2} + R_s} V_s = \frac{26\Omega}{26\Omega + 1k\Omega} V_s = 0.025 V_S$

and $\frac{V_i}{V_S} = 0.025$ with $\frac{V_0}{V_i} = 147.97$ from above

and $A_{V_S} = \frac{V_0}{V_S} = \frac{V_i}{V_S} \cdot \frac{V_0}{V_i} = (0.025)(147.97) = 3.7$