1. What is the difference between bipolar junction transistor and field effect transistor (at least 3)? [3pt]
2. For the voltage-divider bias configuration of Fig. 1 given below, determine: [6pt]
   a. I_{BQ}
   b. I_{CQ}
   c. V_{CEQ}
   d. V_C
   e. V_E
   f. V_B

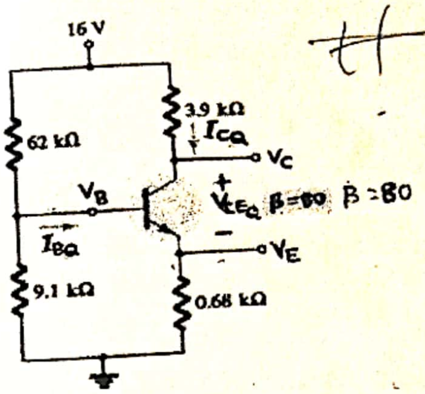


Fig. 1

3. For the network of Fig.2below by using re-equivalent circuit model: [9pt]
   a. Determine A_{VNL}, Zi, and Zo.
   b. Determine A_{VL} and A_{VS}.
   c. Calculate $A_i = \frac{I_o}{I_i}$.
   d. Change RL to 5.6 k and calculate A_{VS}

no Load

BJT

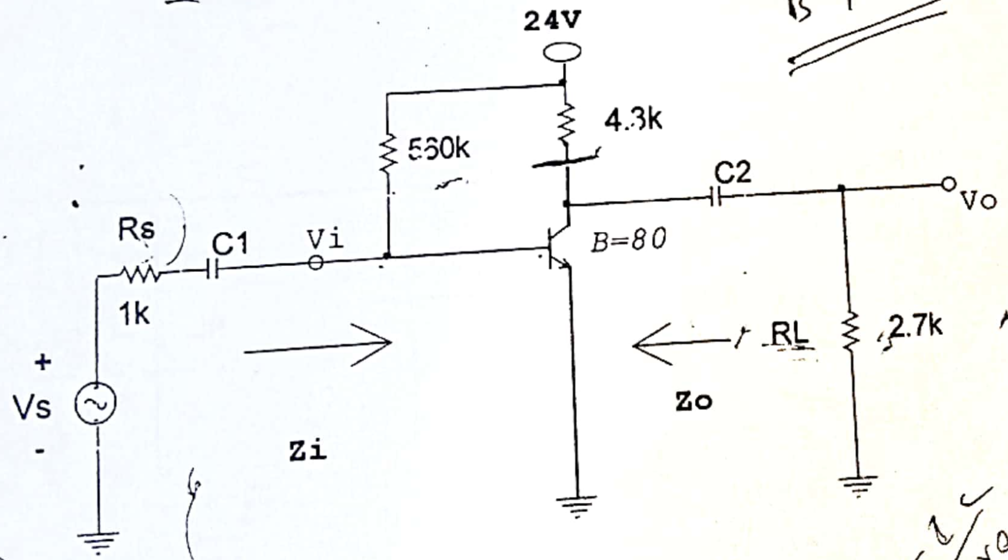


Fig.2

Vcc

Vcc − I_B

Vcc − V

Vcc − V

4. Given the measurement VS = 1.7 V for the network of Fig.3below , determine: **[5pt]**

   a. IDQ.
   b. VGSQ.
   c. IDSS.
   d. VD.
   e. VDS.

$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)$

$V_{GS} + 0.7 = 0$

$V_{GS} = -0.7$

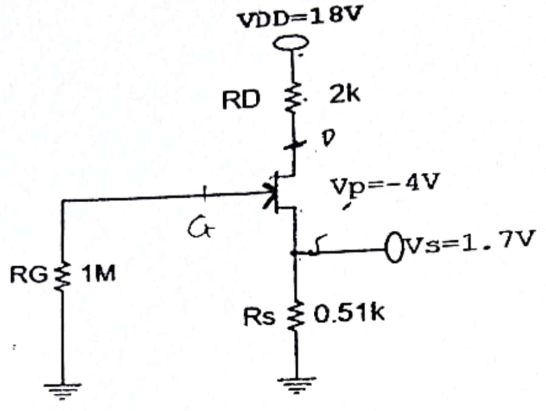
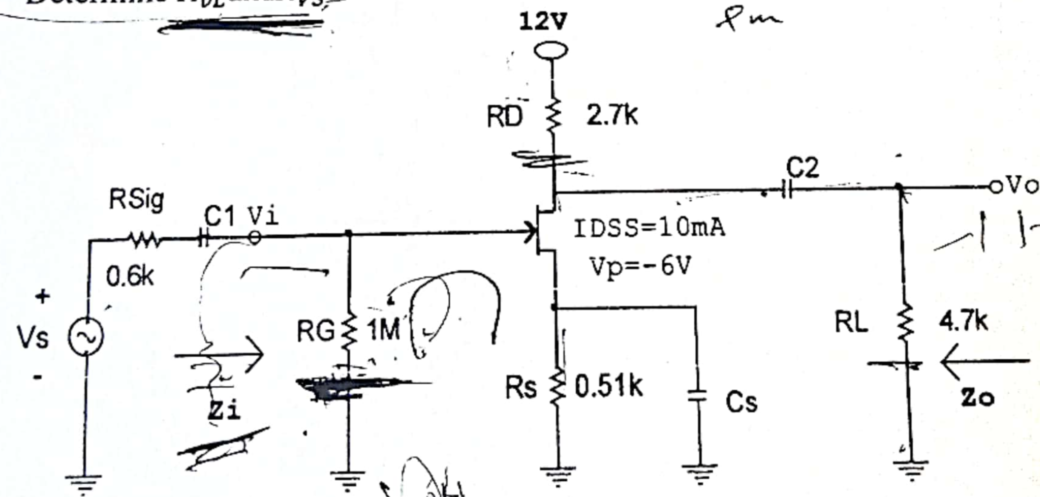


Fig.3

5. For the self-bias JFET network of Fig.4given below: **[8pt]**

   a. Determine Z_i, and Z_o.
   b. Determine A_{vL} and A_{VS}.



$Z_i = 1M$

Fig.4

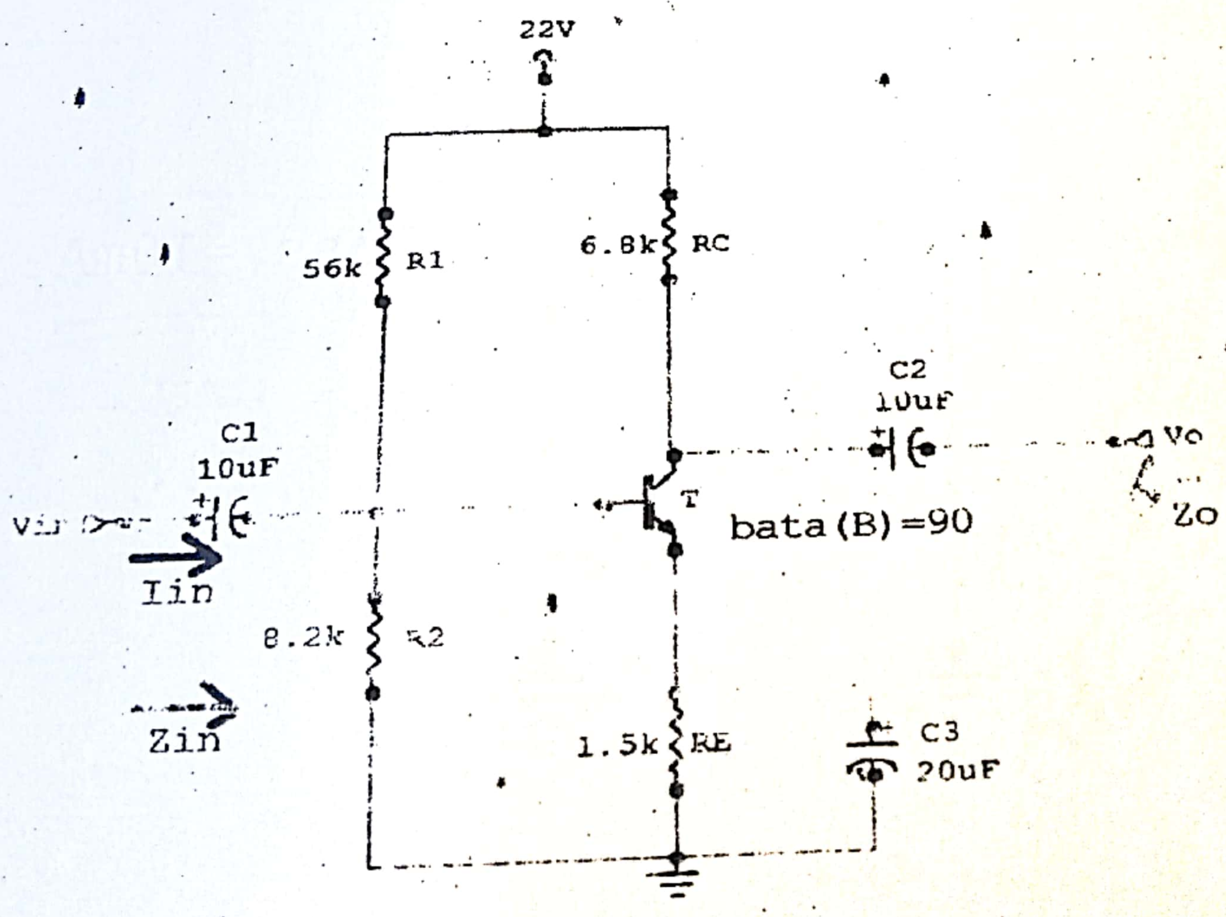
6. Design a Common Emitter Amplifier with Voltage Divider Bias for the following parameters: **VCC = 24V, IC = 5mA, VE = 0.1VCC, VC = 0.55VCC, β = 135 and R2=6.2kΩ.** **[4pt]**

Circuit
Applied Electronics-I Final-exam (solved)

Quastion paper

1. Draw the input and output characteristics curve of common emmiter and show the region of operation of BJT. (5 points)
2. Draw the electrical equivalent circuit of bipolar junction transistor (BJT) using **re** and **hybrid** equivalent model. (5 points)
3. Consider the two stage amplifier where the transistor specification and biasing conditions are the same but the voltage gain of the second stage is higher than the first. Why? Reason out (2 points)
4. Compiar and contrast BJT with FET (2 points)
5. For the network below determine: (10 points)
   a. re
   b. Zi
   c. Zo
   d. Av
   e. Ai
   f. Ap

   (note: assume ro is infinity)



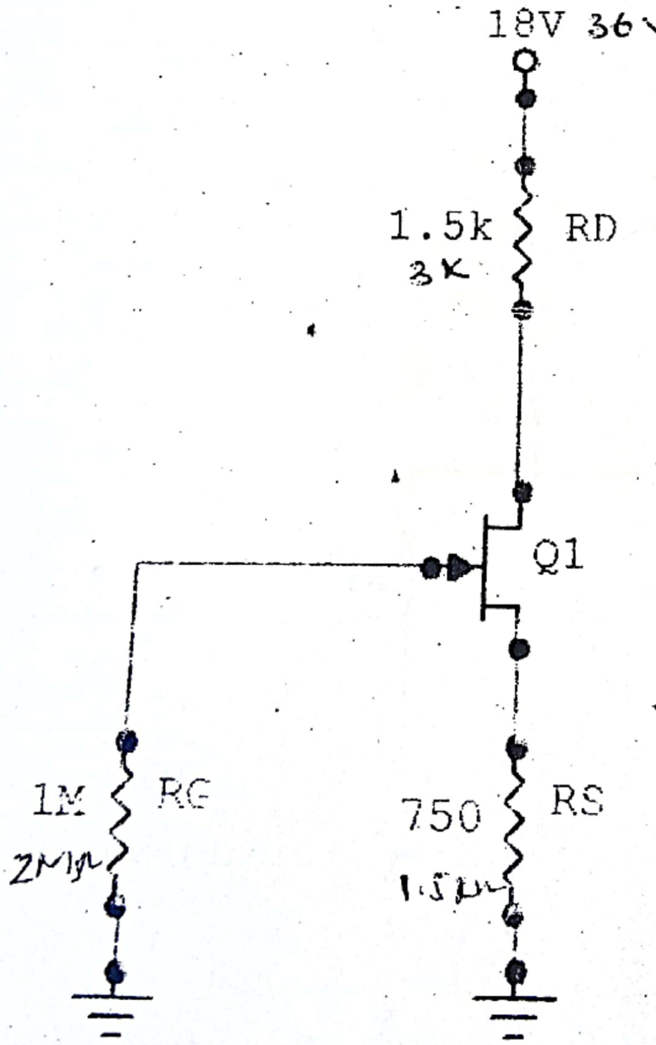
6. Given that a common emiter amplifier has the following h- parameters: (6 points)

$h_{ie} = 1.1\ K\ \Omega$, $h_{re} = 0.25 \times 10^{-3}$, $h_{fe} = 50$, $h_{oe} = 25\mu$ mho

If the load resistance is 1 kΩ, and source resistance is also 1kΩ, calculate,

a) Current gain
b) voltage gain
c) input impednce
d) output impednce

7. Determine I_{DSQ} for the network below using mathematical method (10 points)



IDSS =10mA = 20mA

Vp= -4V
-8V

1) $\frac{1}{Z_o} = h_o - \frac{h_f h_r}{R_s + h_i}$

$= 25 - \frac{50 \times 0.25 \times 10^3}{1k\Omega + 1.1k\Omega}$

$= 25 - \frac{12.5}{2.1k\Omega}$

$= 25 - 5.95$

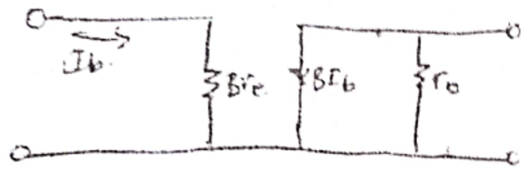
$\frac{1}{Z_o} = 19.04 \text{ k}\Omega$

$Z_o = \frac{1}{19.04}$

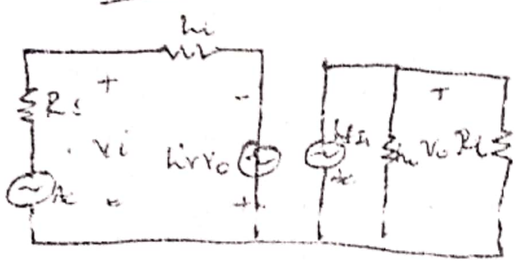
$= 0.0525 \text{ M}\Omega$

$= 52.5 \text{ k}\Omega$

2) Draw the electrical equivalent circuit of BJT using re & hybrid equivalent model

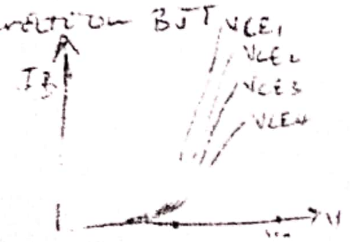


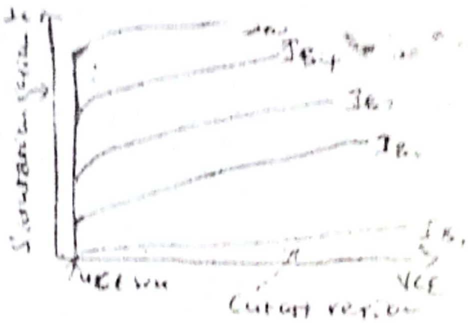
> the re equivalent circuit ac analysis



=> hybrid equivalent model

3) Draw the input & out put characteristics curve of common emitter & show the region of operation BJT





Out put Characteristics

4) ~~Draw~~ compare & contrast BJT with FET

* BJT - operation involves both electron & holes, Charge flow in such transistor is due to bidirectional diffusion of charge carrier across a junction b/w two region of diff charge concentration
* FET - is only one carrier type is involved in charge flow due to drift. This charge carrier is either electrons or holes as majority charge carriers only

5) Given that common emiter amplifier

$h_{ie} = 1.1k\Omega$
$h_{re} = 0.25\times10^{-3}$, $R_L = 1k\Omega$
$h_{f} = 50$ $R_s = 1k\Omega$
$h_o = 25\mu mho$

* the current Gain

$A_i = \frac{I_o}{I_i}$

$A_i = \frac{h_f}{1+h_oR_L}$ -- see the proof on the hard copy in the last paper (BJT)

$A_i = \frac{50}{1+25*1k\Omega}$

$= \frac{50}{26} = 1.92$

* Voltage gain

$A_V = \frac{V_o}{V_i}$

$A_V = \frac{-h_fR_L}{h_i+R_L(h_ih_o-h_fh_r)}$ --> on the hard copy

$= \frac{-50*1k\Omega}{1.1+(27.5-12.5)}$

$= -3.33$

* Input impedance --> on the hard copy (BJT)

$Z_i = \frac{V_i}{I_i}$

$Z_i = h_i - h_r A_i R_L$

$= 1.1 - 0.25\times10^{-3}*1.92*1k$

$= 0.62k\Omega$

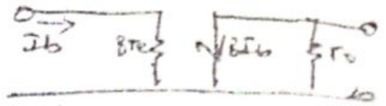
* Out put impedance --> on the hard copy (BJT)

$Z_o = 1$

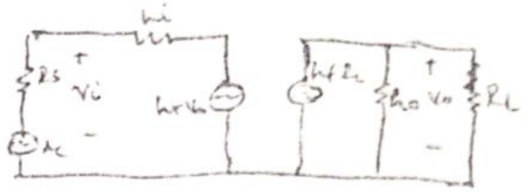
$\frac{1}{Z_o} = h_o - \frac{h_fh_r}{R_s+h_i}$

$Z_o = 52.5k\Omega$

(2) Draw the electrical equivalent circuit of BJT using re & hybrid equivalent model

#1


the re equivalent circuit

#


the hybrid equivalent circuit

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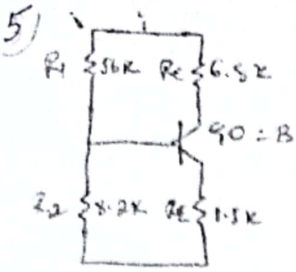
-11-

5)



$V_B = \dfrac{R_2 V_{CC}}{R_1 + R_2}$

$= \dfrac{8.2 * 22}{8.2+56}$

$= \underline{2.81V}$

$V_{BE} = V_B - V_E$

$V_E = V_B - V_{BE}$

$= 2.81 - 0.7$

$= \underline{2.11V}$

$I_E = \dfrac{V_E}{R_E} = \dfrac{2.11V}{1.5} = \underline{1.45mA}$

$r_e = \dfrac{26mV}{1.45mA} = \underline{18.45\Omega}$

$R' = R_1 \| R_2 \Rightarrow \dfrac{1}{56} + \dfrac{1}{8.2} = \dfrac{8.2 * 56}{56+8.2} = \underline{7.15k\Omega}$

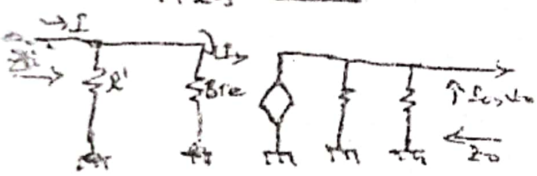
~~the~~ from input section

$V_{CC} - R' I_b - V_{BE} - I_E R_E$

$V_{CC} - R' I_b - V_{BE} - B I_b R_E$

$I_b = \dfrac{V_{CC} - V_{BE}}{R' + BR_E} = \dfrac{22 - 0.7}{7.15k\Omega + 90 \times 1.5k\Omega}$

$I_b = \dfrac{21.3}{142.5} = \underline{0.15mA}$



$Z_i = R' \| Br_e$

$= \dfrac{1}{7.15k\Omega} + \dfrac{1}{90 * 18.48\Omega}$

$= \dfrac{11.89}{8.81} = \underline{1.349k\Omega}$

$Z_o = R_C$

$= \underline{6.8k\Omega}$

$V_i = I_b B r_e$

$= 0.15mA * 90 * 18.45\Omega$

$= \underline{0.25V}$

$V_o = -R_C B I_b \quad , I_b = \dfrac{V_i}{Br_e}$

$= -\dfrac{R_C V_i \cdot B}{Br_e} = \dfrac{-R_C V_i}{r_e}$

$= \dfrac{-6.8k\Omega \times 0.25V}{18.48}$

$= \underline{-92V}$

$A_V = \dfrac{-V_o}{V_i} = \dfrac{92V}{0.25V}$

$= \underline{-367.96}$

$A_i = \dfrac{-I_o}{I_i}$, but $I_c = BI_b$, $I_i = I_b$

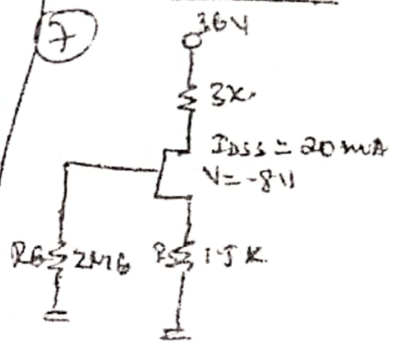
$= \dfrac{B I_b}{I_b} = \underline{B = 90}$

$A_P = A_V * A_i$

$= -367.96 * -90$

$= \underline{33116.4}$

(7)



from the input section

$V_G = -I_{DS} R_S$

$I_{DS} = I_{DSS}\left(1 - \dfrac{V_G}{V_P}\right)^2$

$= 0.02\left(1 - \dfrac{(-I_{DS}R_S)}{-V_P}\right)^2$

$= 0.02\left(1 - \dfrac{I_{DS}(1500)}{8}\right)^2$

$= 0.02(1 - 187.5 I_{DS})^2$

$I_D = 703.125 I_D^2 - 7.5 I_D + 0.02$

$0 = 703.125 I_D^2 - 8.5 I_D + 0.02$

by using quadratic formula

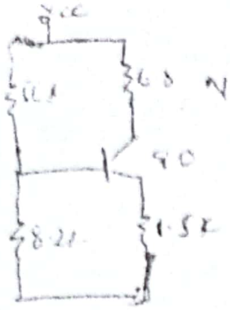
$I_D = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$I_{DS} = 7.7mA \quad , I_{DS} = 2.8mA$

but $I_{DS} < I_{DSS}$

both are the posible answer

-5-



(3)

$V_B = \frac{R_2 V_{CC}}{R_1+R_2}$

$= \frac{8.2 * 22}{8.2+56}$

$= 2.81V$

$V_{BE} = V_B - V_E$

$V_E = V_B - V_{BE}$

$= 2.81 - 0.7$

$V_E = 2.11V$

$I_E = \frac{V_E}{R_E} = \frac{2.11V}{1.5} = 1.406mA$

$r_e = \frac{26mV}{1.406mA} = 18.48\Omega$

$R' = R_1 || R_2$

$= \frac{1}{56} + \frac{1}{8.2} = \frac{8.2 * 56}{56+8.2}$

$= 7.15k\Omega$

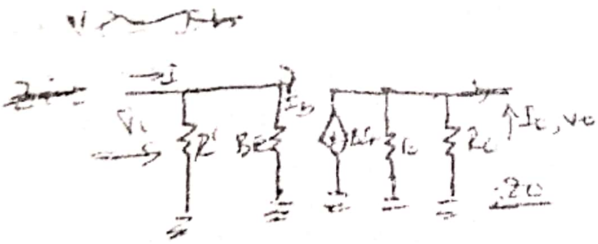
$V_{CC} - R'I_b - V_{BE} - I_E R_E$

$V_{CC} - R'I_b - V_{BE} - \beta I_b R_E$

$I_b = \frac{V_{CC} - V_{BE}}{R' + \beta R_E}$

$= \frac{22 - 0.7}{7.15k\Omega + 90 * 1.5}$

$I_b = \frac{21.3}{142.5} = 0.15mA$



$Z_i = R' || \beta r_e$

$= \frac{1}{7.15k} + \frac{1}{90 * 18.48\Omega}$

$= \frac{7.15 * 1.6632}{7.15 + 1.6632}$

$= \frac{11.89}{8.81} = 1.349k\Omega$

$Z_o = R_C$

$= 6.8k\Omega$

$V_i = I_b \beta r_e$

$= 0.15mA * 90 * 18.48\Omega$

$= 0.25V$

$V_o = R_C \beta I_b$, $I_b = \frac{V_i}{\beta r_e}$

$= R_C \beta \left(\frac{V_i}{\beta r_e}\right)$

$= \frac{R_C V_i}{r_e}$

$= 6.8k * \frac{0.25V}{18.48}$

$= 0.0919k = 92V$

~~$A_V = \frac{V_o}{V_i} = \frac{V_o}{V_i} = \frac{0.0919V}{0.25V}$~~

$A_V = -\frac{V_o}{V_i} = \frac{92V}{0.25V}$

$= -367.96$

$A_i = \frac{I_o}{I_i}$

but: $I_o = \beta I_b$, $I_i = I_b$

$A_i = \frac{\beta I_b}{I_b} = \beta = 90$ or

$A_i = \frac{I_o}{I_i}$, $I_o = V_o/R_C$

$I_i = V_i/Z_i$

$A_i = \frac{V_o}{R_C} \cdot \frac{Z_i}{V_i} = -A_V \cdot \frac{\beta r_e}{R_C}$

$= \frac{367.96 * 90 * 18.}{6.8k\Omega}$

$= \frac{611,991.072}{6.8k}$

$A_p = A_V * A_i$

22136.4 — 6 — = −90

(6)

Given that common emitter amplifier

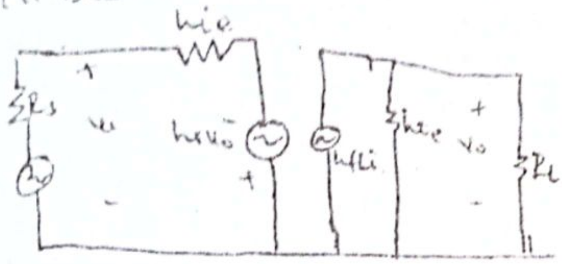
$h_{ie} = 1.1k\Omega$, $R_L = 1k\Omega$

$h_{re} = 0.25 \times 10^{-3}$, $R_s = 1k\Omega$

$h_{fe} = 50$

$h_{oe} = 25\mu mho$

The hybrid equivalent model as small signal amplifier circuit will be



The Current Gain

$A_i = \frac{I_o}{I_i}$, but $I_o = h_f I_i + V_o h_o$

$I_o = h_f I_i + h_o V_o$, $V_o = -I_o R_L$

$I_o = h_f I_i + h_o(-I_o R_L)$

$I_o = h_f I_i - h_o I_o R_L$

$I_o + h_o I_o R_L = h_f I_i$

$I_o(1 + h_o R_L) = h_f I_i$

$I_o = \frac{h_f I_i}{1 + h_o R_L}$

$\frac{I_o}{I_i} = \frac{h_f}{1 + h_o R_L}$

$A_i = \frac{h_f}{1 + h_o R_L}$

$= \frac{50}{1 + 25\mu mho \cdot 1k}$

$= \frac{50}{26} = 1.92$

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Voltage gain

$A_V = \frac{V_o}{V_i}$, $V_i = h_i I_i + h_r V_o$

but $V_o = -I_c R_L$

$A_V = \frac{-I_c R_L}{V_i}$, $I_c = A_i I_i$

$= \frac{-A_i I_i R_L}{V_i}$, but $\frac{I_i}{V_i} = \frac{1}{Z_i}$

$= \frac{A_i R_L}{Z_i}$ $\quad \frac{1}{Z_i} = \frac{I_i}{V_i}$

$= \frac{1.92 \times 1k\Omega}{Z_i}$ $\quad Z_i = \frac{V_i}{I_i}$

but Z_i is unknown therefore by other method.

$A_V = \frac{V_o}{V_i}$, $V_i = h_i I_i + h_r V_o$

$I_i = \frac{I_o}{h_f}(1 + h_o R_L)$

$I_o = \frac{-V_o}{R_L}$

$V_i = h_i I_i + h_r V_o$

$V_i = h_i\left(\frac{I_o}{h_f}(1 + h_o R_L)\right) + h_r V_o$

$V_i = -\frac{h_i V_o}{h_f R_L}(1 + h_o R_L) + h_r V_o$

$V_i = \left(-\frac{h_i}{h_f R_L}(1 + h_o R_L) + h_r\right) V_o$

$V_i = \left(\frac{-h_i(1 + h_o R_L) + h_f R_L h_r}{h_f R_L}\right)$

$\frac{V_i(h_f R_L)}{-h_i(1 + h_o R_L) + h_f R_L h_r} = V_o$

$\frac{-h_f R_L}{h_i(1 + h_o R_L) + h_f R_L h_r} = \frac{V_o}{V_i}$

$- h_f \; I_{\ldots}$

b)

$$A_V = \frac{-h_f R_L}{h_i(1+h_o R_L)+h_f R_L h_r}$$

$$= \frac{-h_f R_L}{h_i + h_i h_o R_L + h_f R_L h_r}$$

$$= \frac{-h_f R_L}{h_i + R_L(h_i h_o + h_f h_r)}$$

$$= \frac{-h_f R_L}{h_i + R_L(h_i h_o - h_f h_r)}$$

$$= \left(\frac{-50 * 1k\Omega}{1.1k\Omega + 1k(1.1 * 25 - 50 * .025m)}\right)$$

$$= \frac{-50}{1.1 + (27.5 - 12.5)}$$

$$= \frac{-50}{1.1 + 1(15)}$$

$$AV = \frac{-50}{16.1} = \underline{\underline{-3.35}}$$

c) Input impidence

$$Z_i = \frac{V_i}{I_i}, \quad V_i = h_i I_i + h_r V_o$$

$$, V_o = -I_o R_L$$

$$I_o = A_i I_i$$

$$V_i = h_i I_i + h_r V_o$$

$$V_i = h_i I_i + h_r(-I_o R_L)$$

$$V_i = h_i I_i - h_r I_o R_L$$

$$V_i = h_i I_i - h_r A_i I_i R_L$$

$$V_i = (h_i - h_r A_i R_L) I_i$$

$$\frac{V_i}{I_i} = h_i - h_r A_i R_L$$

$$Z_i = h_i - h_r A_i R_L$$

$$= 1.1 - 0.25 * 192.1 k\Omega$$

$$= 1.1 - 0.48$$

$$= \underline{\underline{0.62 k\Omega}}$$

Out put impidance.

$$Z_o = \frac{V_o}{I_o} = Z_o = \frac{1}{Y_o}$$

$$\Leftrightarrow Y_o = \frac{I_o}{V_o}$$

$$I_o = h_f I_i + h_o V_o$$

$$\frac{I_o}{V_o} = \frac{h_f I_o}{V_o} + h_o$$

$$Y_o = \frac{h_f I_o}{V_o} + h_o, \quad \cancel{I_o = A_i I_i}$$

$$V_o = -I_o R_L$$

$$= \frac{h_f \cancel{I_o}}{-\cancel{I_o} R_L} + h_o$$

$$= \underline{\underline{-\frac{h_f}{R_L} + h_o}}$$

Or by other method

$Z_o = \frac{V_o}{I_o}$, with signal V_s set $\underline{\underline{0}}$

then from the input section

$$I_i(R_s + h_i) = -h_r V_o$$

$$I_i = \frac{-h_r V_o}{R_s + h_i}$$

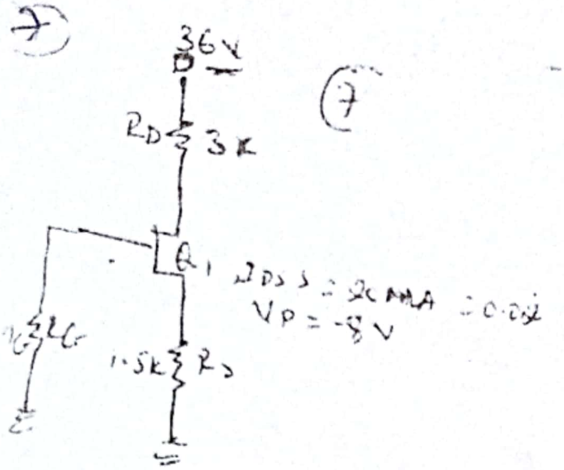
$$I_o = h_f I_i + h_o V_o$$

$$I_o = -\frac{h_f h_r V_o}{R_s + h_i} + h_o V_o$$

$$I_o = \left(\frac{-h_f h_r}{R_s + h_i} + h_o\right) V_o$$

$$\frac{I_o}{V_o} = h_o - \frac{h_f h_r}{R_s + h_i}$$

7)



from the input section

$V_G = -I_{DS} R_S$

$I_{DS} = I_{DSS}\left(1 - \frac{V_G}{V_P}\right)^2$

$= 0.02\left(1 - \frac{(-I_{DS} R_S)}{-V_P}\right)^2$

$= 0.02\left(1 - \frac{1500 I_D}{8}\right)^2$

$= 0.02(1 - 187.5 I_D)^2$

$= 0.02(35156.25 I_D^2 - 375 I_D + 1)$

$I_D = 703.125 I_D^2 - 7.5 I_D + 0.02$

$I_D - I_D = 703.125 I_D^2 - 7.5 I_D - I_D + 0.02$

$= 703.125 I_D^2 - 8.5 I_D + 0.02$

then using by quadratic formula

$I_D = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$= \frac{-(-8.5) \pm \sqrt{(-8.5)^2 - 4 * 703.125 * 0.02}}{2 * 703.125}$

$= \frac{8.5 \pm \sqrt{72.25 - 56.25}}{1406.25}$

$= \frac{8.5 \pm \sqrt{16}}{1406.25}$

$= \frac{\ \ }{1606.25}$

$I_D = \frac{8.5 + 4}{1606.25}$ & $\frac{8.5 - 4}{1606.25}$

$= \frac{12.5}{1606.25}$; $= \frac{4.5}{1606.25}$

$= 0.0077$; $= 0.0028$

$I_{DS} = 7.7mA$; $= 2.8mA$

~~then get~~ $I_{DS} < I_{DSS}$

therefor I_{DS} is two possible answers thos are 7.7mA & 2.8mA