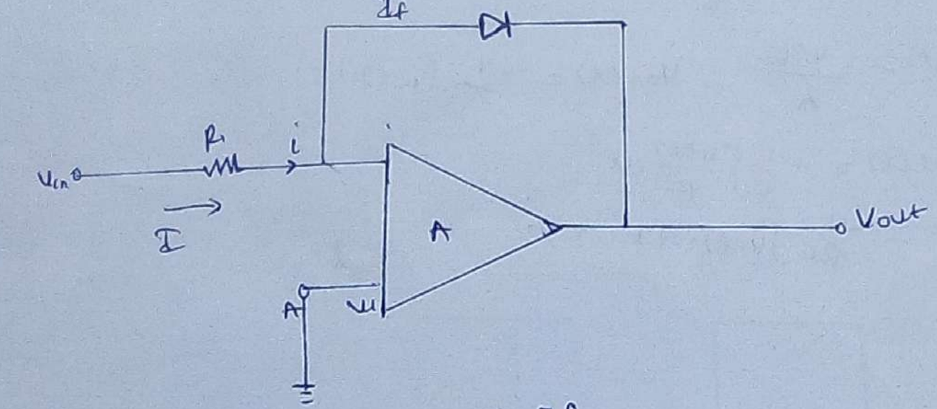
QUESTION 1

Draw the circuit diagram and derive the expression for the closed loop gain of Omp Amp configured as

(i) Logarithm Amplifier (ii) Antilog Amplifier (iii) Integrator

(iv) NON-INVERTING Amplifier (v) DIFFERENTIATOR

Logarithm Amplifier



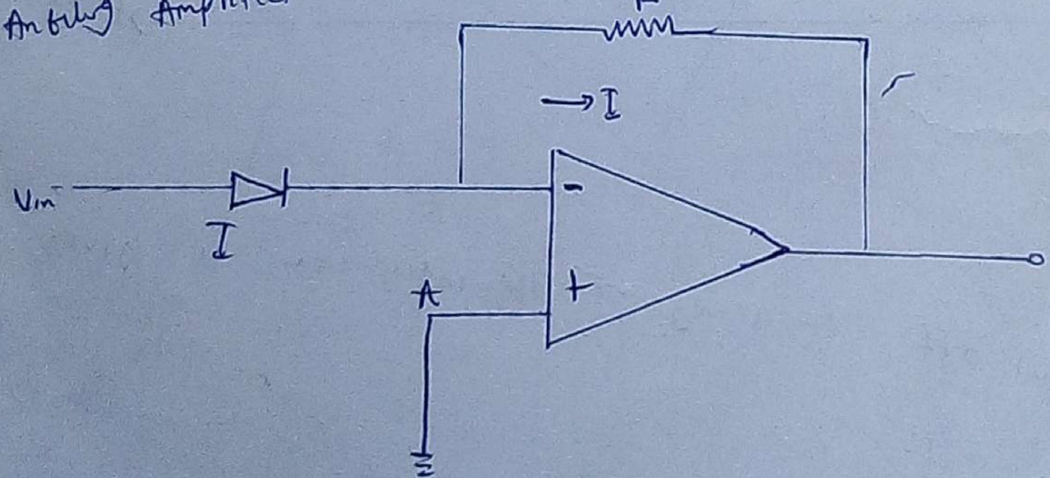
$V_{in} = IR$, $I = \frac{V_{in}}{R}$, $I = I_f$

$I_f = I_0\left[e^{V_D/\mu V_T} - 1\right] = I_0\left[e^{V_D/\mu V_T}\right]$ or $\frac{V_D}{\mu V_T} = \ln\left[\frac{I_f}{I_0}\right]$

$V_D = \mu V_T \ln\left[\frac{I_f}{I_0}\right]$. $V_o = -V_D$ and $I = I_f = V_{in}/R$

$V_{out} = \mu V_T \ln\left(\frac{V_{in}}{RI_0}\right)$

(ii) Antilog Amplifier

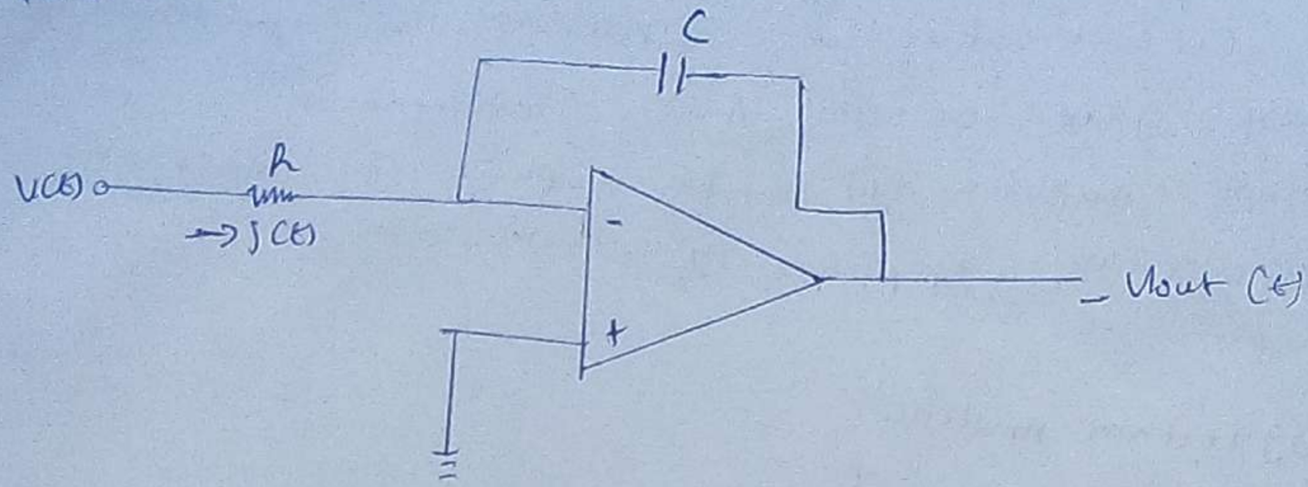


$I = I_0\left(e^{V_D/\mu V_T} - 1\right) = I_0 e^{\frac{V_D}{\mu V_T}}$ $V_D = V_{in}$

and $V_{out} = -I_f \times R$, $I_f = -V_o/R$, $V_{out} = -I_f R$

$V_{out} = -RI_0 e^{\left(\frac{V_{in}}{\mu V_T}\right)}$

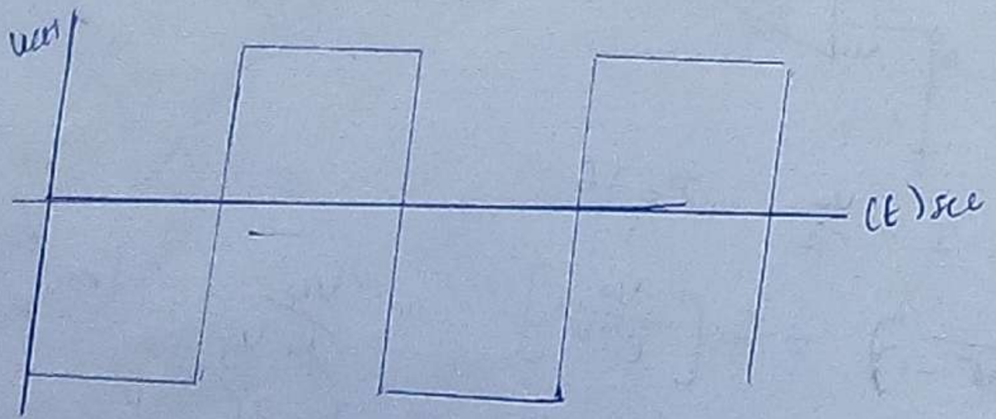
(iii) INTEGRATOR

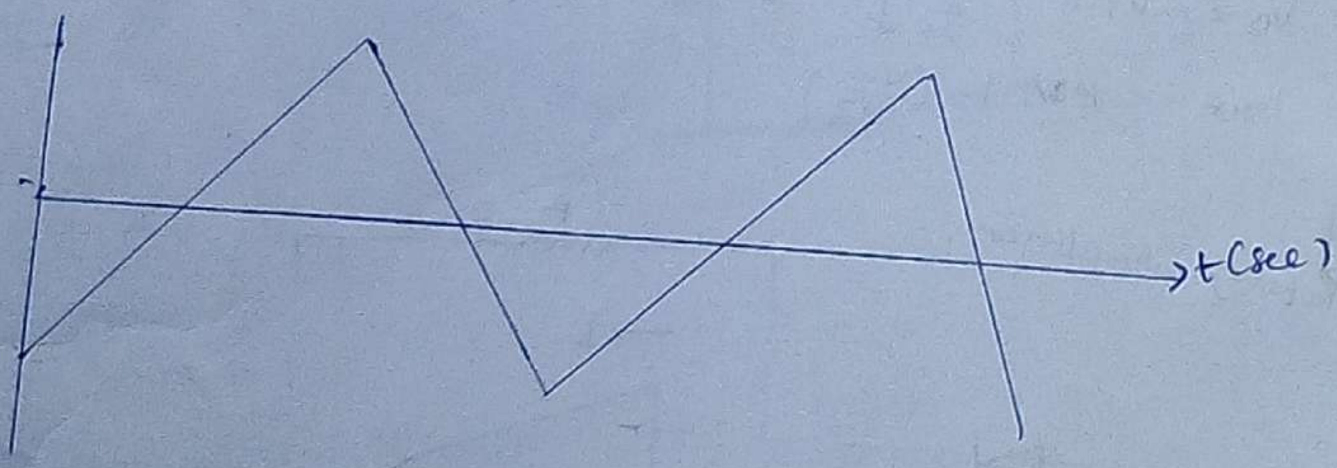


$$i(t) = \frac{v(t)}{R} \quad , \quad V_{out}(t) = \frac{-1}{C}\int i(t)\,dt$$

$$V_{out}(t) = -\frac{1}{C}\int \frac{v(t)}{R}\,dt$$

$$V_{out} = \frac{-1}{RC}\int v(t)\cdot dt + A$$

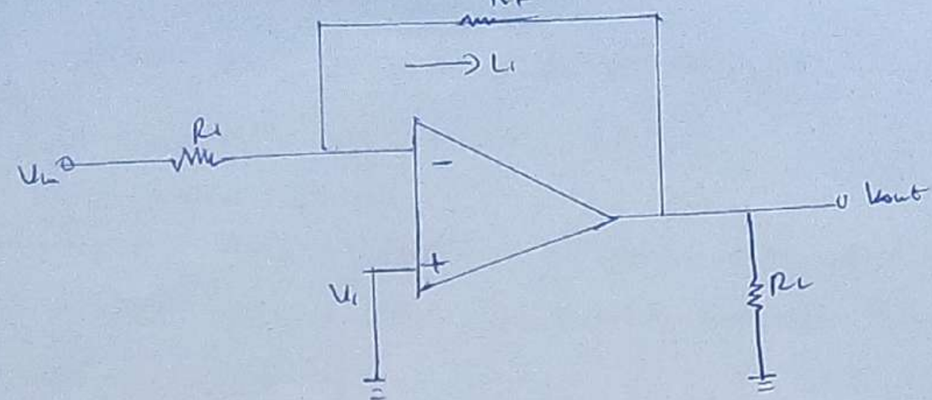




The cut off frequency of the integrator is given by

$$f = \frac{1}{2\pi RC}$$

INVERTING Amplifier



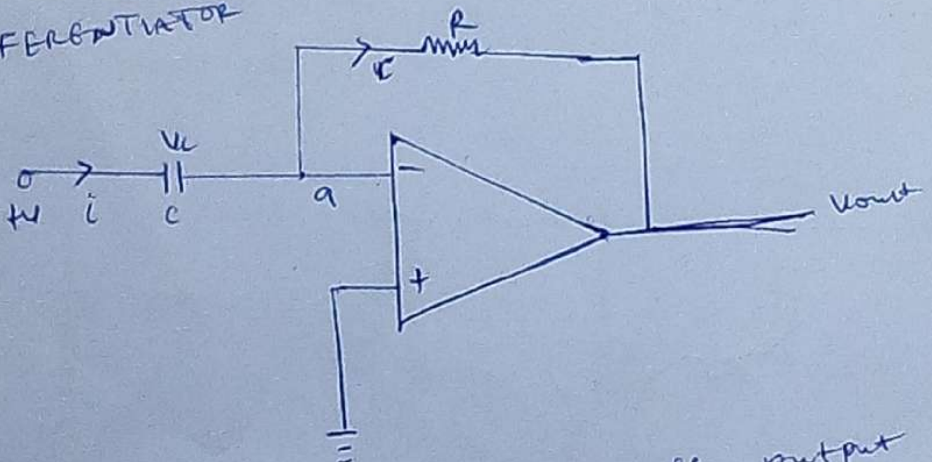
$$\frac{V_{in} - V_2}{R_1} = \frac{V_2 - V_{out}}{R_f}$$

$V_2 = 0$ because of virtual ground

$$\frac{V_{in}}{R_1} = \frac{-V_{out}}{R_f}, \quad \frac{V_{out}}{V_{in}} = A_f = \frac{-R_f}{R_1}$$

$$V_{out} = -\frac{R_f}{R_1}(V_{in})$$

DIFFERENTIATOR



The differentiator is a circuit whose output is proportional to the rate of change of its input signal.

Let i be the rate of change of charge

i.e $i = dq/dt$

$$i = \frac{dq}{dt} = \frac{dCV_c}{dt} = C\frac{dV_c}{dt}$$

$$V_{out} = -IR = -\left[C\frac{dV_c}{dt}\right]R$$

$$V_{out} = -CR\frac{dV_c}{dt}$$

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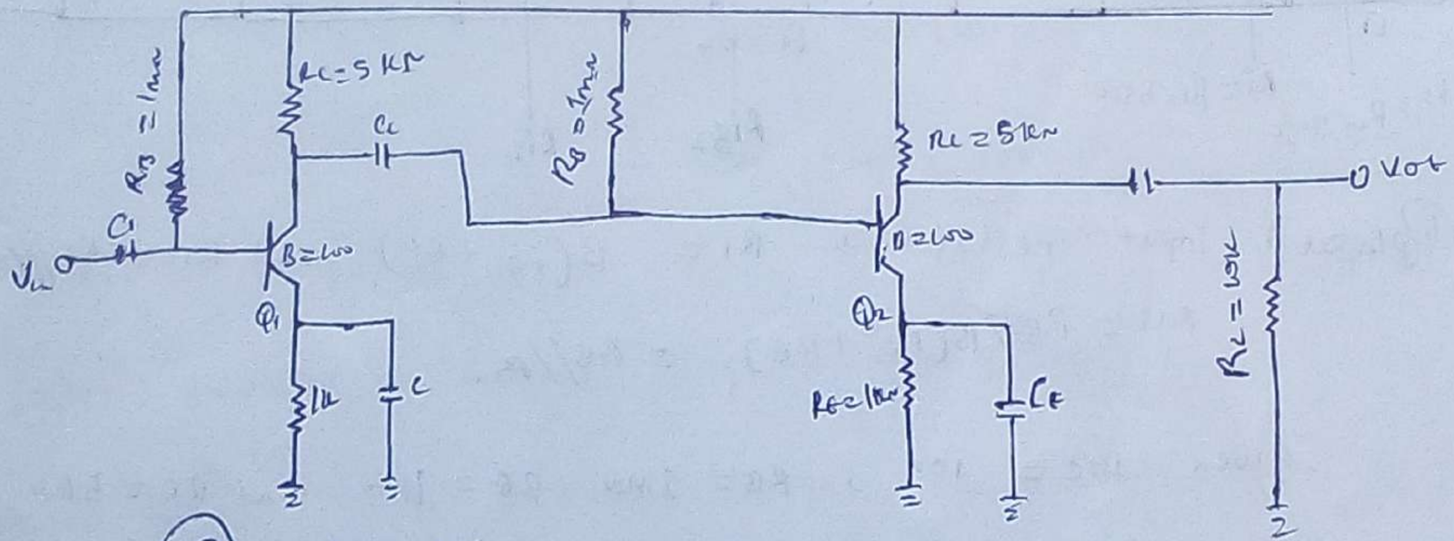
Question (2)

Fig below shows the circuit diagram of a two stage RC Couple amplifier.

(a) Draw the DC and AC equivalent Circuit

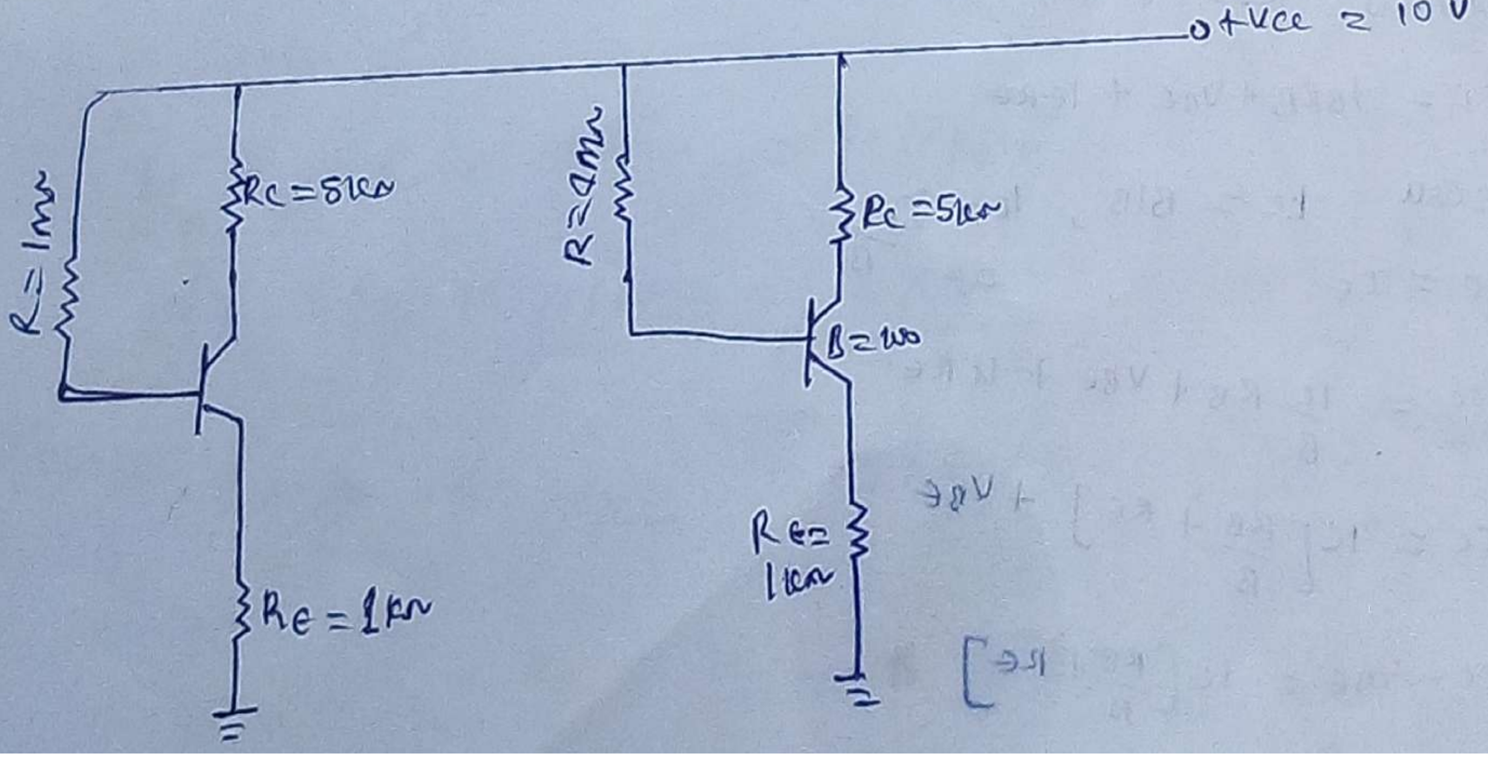
(b) Determine the value of the

(i) Input resistance (ii) Output resistance (iii) Current gain (iv) voltage gain for first stage and second stage (v) overall voltage gain (vi) overall dB voltage gain

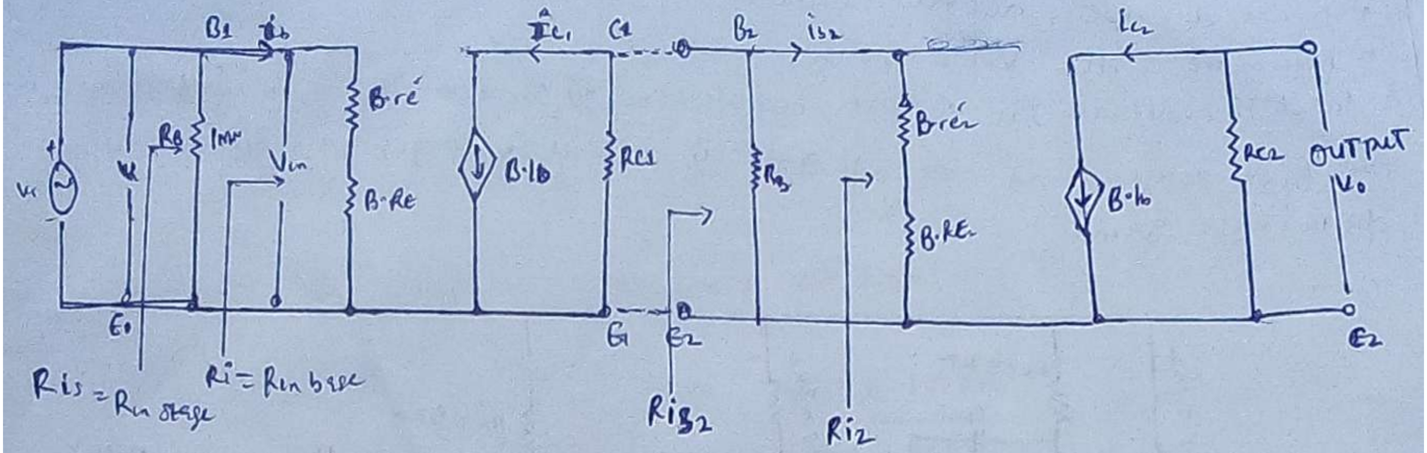


(a) ANSWER

DC equivalent Circuit



AC Circuit equivalent



(b) ~~Input~~ (i) Input resistance $Ri = B(r\acute{e} + RE)$ and ~~$Ris = RB // (B \cdot RE$~~

$$Ris = RB // B(r\acute{e} + RE) = RB // Ri$$

Given $Vcc = 10V$, $RB = 1M\Omega$, $RE = 1k\Omega$ and $RC = 5k\Omega$

$B = 100$

First stage input resistance

Applying KVL to the base side

$$Vcc = IB RB + VBE + IE RE$$

recall $Ic = B IB$, $IB = \frac{Ic}{B}$

$Ic \simeq IE$

$$Vcc = \frac{Ic}{B} RB + VBE + IC RE$$

$$Vcc = Ic\left[\frac{RB}{B} + RE\right] + VBE$$

$$Vcc - VBE = Ic\left[\frac{RB}{B} + RE\right]$$

$$Ic = \frac{Vcc - VBE}{\frac{RB}{B} + RE} \simeq IE$$

$$IE = \frac{10 - 0.7}{\frac{1 \times 10^6}{100} + 1 \times 10^3} = \frac{9.3}{11000} = 0.85mA$$

$r_e' = \frac{25mV}{I_E} = \frac{25\times10^{-3}V}{0.85\times10^{-3}A} = \frac{25}{0.85} = 29.411\Omega$

Input resistance $R_i = B(r_e' + R_E)$

$R_i = 100[29.411 + 1k] = 102941.17\Omega = 102.94k\Omega$

Since $R_E >> r_e'$ I can neglect r_e'

$R_i \simeq B[R_E] = 100[1k] = 100k\Omega$

$R_{is} = R_B // R_i = \frac{R_B \times R_i}{R_B + R_i} = \frac{1\times10^6 \times 100\times10^3}{1\times10^6 + 100\times10^3} = 90909.09\Omega$

$R_{is} = 90.907k\Omega$

Input resistance for the stage $= 90.901k\Omega$

for first and second stage $R_i \simeq 100k\Omega$ and $R_{is} = 90.901k\Omega$

(ii) Output resistance

Output resistance of the second stage is the load for the input resistance of the first stage

R_o for first stage $= R_C // R_{is2}$

$R_o = 5K // 90.901k\Omega = \frac{5\times90.90}{5+90.90} = 4.739k\Omega$

second stage $R_o = R_C // R_L = 5k\Omega // 10k\Omega = \frac{5\times10}{5+10} = 3.33k\Omega$

(iii) Current gain $A_i = \frac{I_C}{I_b} = B = 100$

(iv) voltage gain for First stage

$A_v = \frac{R_o}{r_{e1}'} = \frac{4.739k}{29.411} = 161.13$

Second stage, voltage gain $A_v = \frac{R_{o2}}{r_e'} = \frac{3.33k\Omega}{29.411} = 113.22$

(V) over-all voltage gain = $A_{v1} \times A_{v2}$ = 161.3×113.22

$= 18251.54$

(VI) over-all dB voltage gain

power gain $= 10 \log_{10} \frac{P_{out}}{P_{in}}$ dB

$P_1 = \frac{V_{in}^2}{R}$; $P_2 = \frac{V_{out}^2}{R}$

Voltage gain in dB $= 10 \log_{10} \frac{V_{out}^2/R}{V_{in}^2/R} = 20 \log_{10} \frac{V_{out}}{V_{in}}$

for multistage amplifier

Gain $= \frac{V_2}{V_1} \times \frac{V_3}{V_2}$

Gain in dB $= 20 \log_{10} \frac{V_2}{V_1} \times \frac{V_3}{V_2}$

$= 20 \log_{10} \frac{V_2}{V_1} + 20 \log_{10} \frac{V_3}{V_2}$

Voltage gain in dB $= 20 \log_{10} [161.3] + 20 \log_{10} [113.22] =$

$= 44.153 + 41.077 = 85.23$

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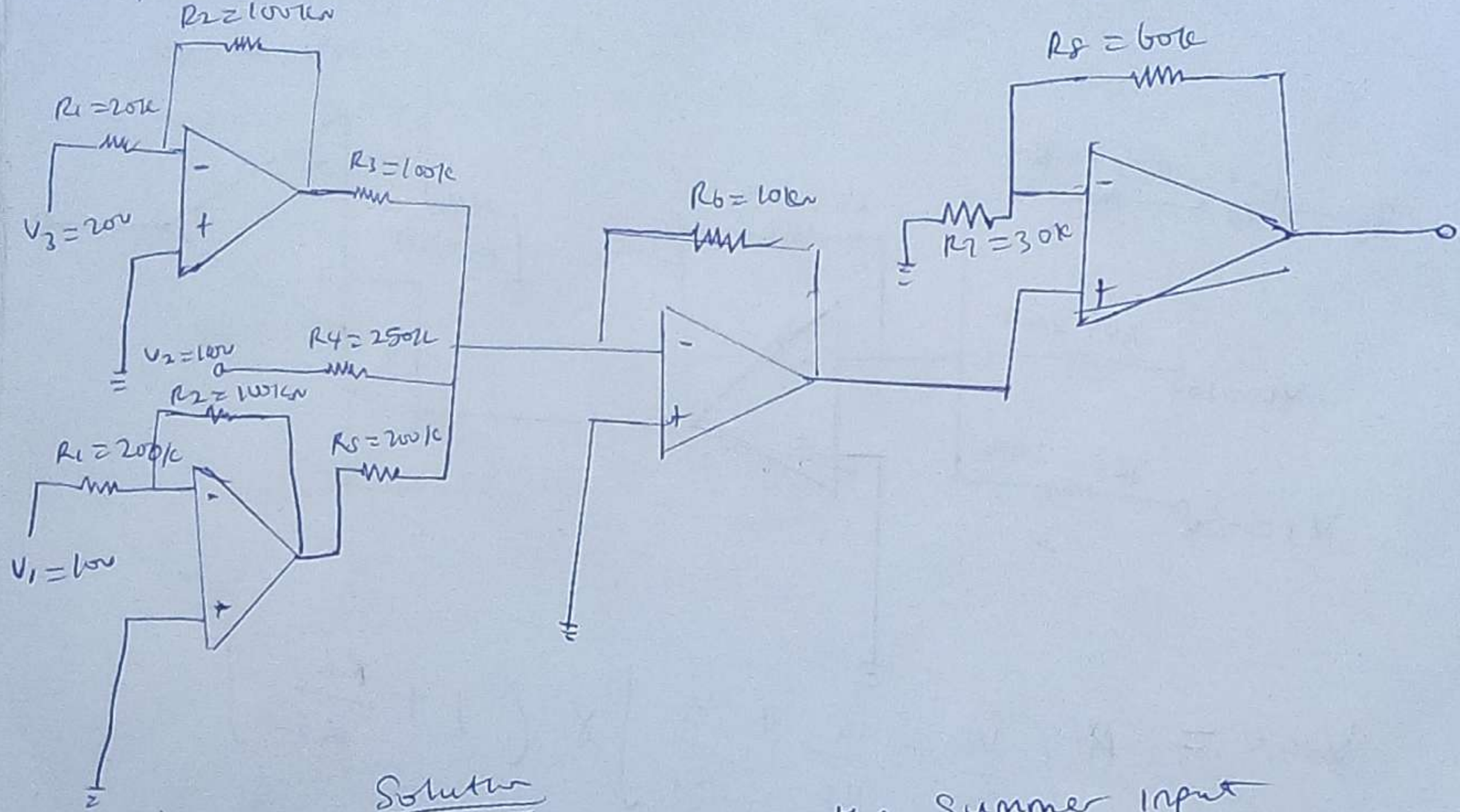
Question 3

Find the output of the multistage Amplifier



Solution

let compute for Vin at the summer input

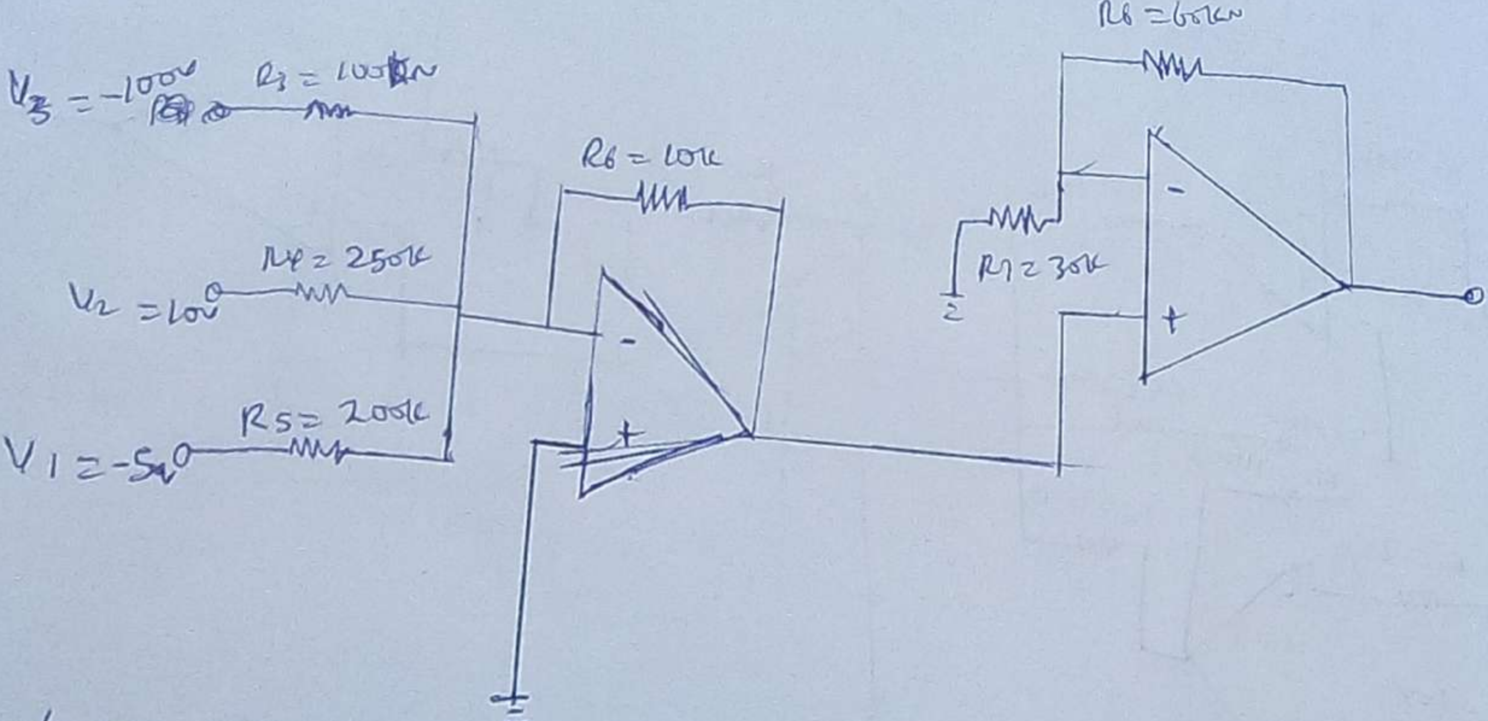
Vout for the first stage

$$V_{out} = -\frac{100}{200} \times 10 = -5V = V_1$$

~~Th~~ 2nd stage Vout

$$V_{out} = -\frac{100}{20} \times 20 = -100V = V_3$$

redraw the stages



$$V_{out} = Rf\left[\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right] \times \left(1 + \frac{R6}{R7}\right)$$

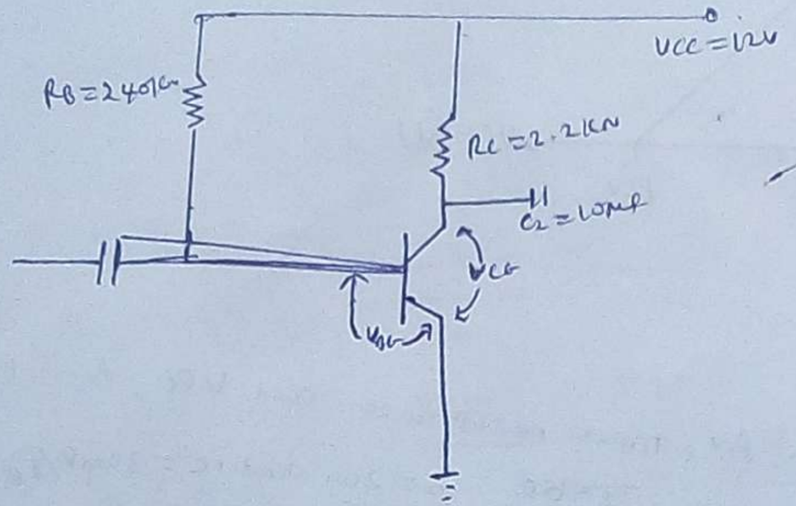
$$= 10\left[\frac{-5}{200} + \frac{10}{250} - \frac{100}{100}\right] \times \left[1 + \frac{60}{30}\right]$$

$$= 10\left[\frac{-1}{40} + \frac{1}{25} - 1\right] \times [3]$$

$$= 10\left[-\frac{197}{200}\right] \times 3 = -29.55V$$

QUESTION (4)

(a) Find I_C, V_{CE} and draw the load line on output character and indicate the Q-point for the circuit of fig below. Take $V_{BE} = 0.7V$ and $\beta = 50$



Solution

$V_{CC} = 12V$, $R_B = 240K$, $R_C = 2.2K\Omega$

DC load line, $V_{CE} = V_{CC} - I_C R_C$ when $I_C = 0$, $V_{CE} = V_{CC} = 12V$

when $V_{CE} = 0$, $V_{CC} = I_C R_C$, $I_C = \frac{V_{CC}}{R_C} = \frac{12}{2.2K} = 5.45mA$

The operating point Q, $V_{BE} = 0.7$

Applying KVL to base side

$I_B R_B + V_{BE} = V_{CC}$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{12 - 0.7}{240K} = 0.471\mu A$$

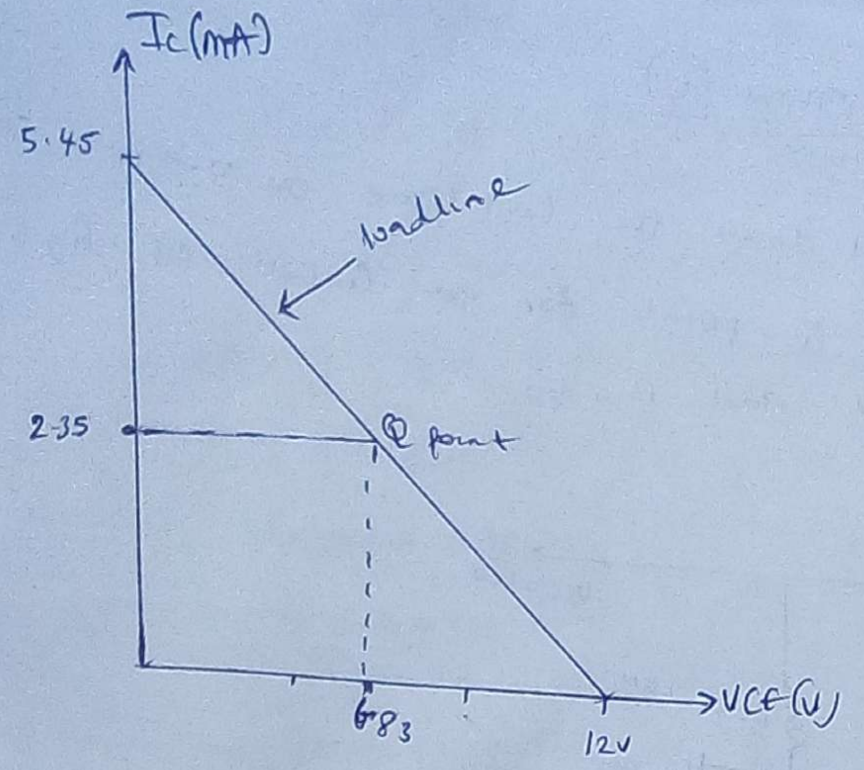
Collector current $I_C = \beta I_B = 50 \times 0.47\mu A = 2.354mA$

$I_C = 2.354mA$

$V_{CE} = V_{CC} - I_C R_C$

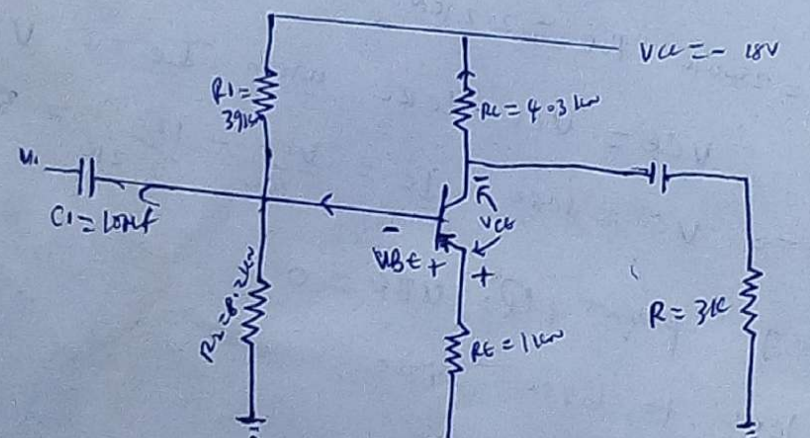
$= 12 - (2.354 \times 10^{-3} \times 2.2 \times 10^{3})$

$= 12 - 5.17 = 6.83V$



(4b)

Find the voltage gain Av, input resistance and VCE for the amplifier of fig below. Take $\beta = 200$ and $r_e = 30mV/I_E$



Solution:

$B = 200$

$RE = 1k\Omega$

$Vce = -18V$

The negative indicates that collector is connect in reverse bias (PNP) let compute for I_E

Voltage across R_2, $V_2 = \frac{V_{CC}}{R_1 + R_2} \times R_2 = \frac{18}{39k\Omega + 8.2k\Omega} \times 8.2k$

$V_2 = 3.127V$

Applying KVL to the base side

$-V_2 + V_{BE} + I_E R_E = 0$

$V_2 - V_{BE} = I_E R_E$

$I_E = \frac{V_2 - V_{BE}}{R_E}$

$I_E = \frac{V_2 - V_{BE}}{R_E}$

$= \frac{3.127 - 0.7}{1k} = 2.427mA$

$r_e' = \frac{30mV}{I_E} = \frac{30mV}{2.427mA} = 12.36\Omega$

Input resistance $= \beta(r_e' + R_E)$

Since $R_E >> r_e'$

$R_i = \beta R_E = 200 \times 1k = 200k$

Input resistance $R_i = 200k$

Voltage gain $= \frac{R_{ac}}{r_e'}$

$R_{AC} = R_C // R_L = 3k // 4.3k = \frac{\cancel{3 \times 4.3}}{\cancel{4 + 3.4}} =$

$= \frac{3 \times 4.3}{3 + 4.3} = 1.77k\Omega$

Voltage gain $A_v = \frac{R_{AC}}{r_e'} = \frac{1.77k}{12.36} = 142.97$

QUESTION (5)

VCE

Applying KVL at collector side

$$V_{CE} = -V_{CC} + I_E (R_C + R_E)$$
$$= -V_{CC} + [2.427mA [4.3k + 1k]]$$
$$= -V_{CC} + [2.427 (5.3)]$$
$$V_{CE} = -V_{CC} + [12.8631]$$
$$= -18 + 12.863$$
$$V_{CE} = -5.1369V$$

negative sign shows that collector emitter voltage is connected in ~~reverse~~ reverse bias.

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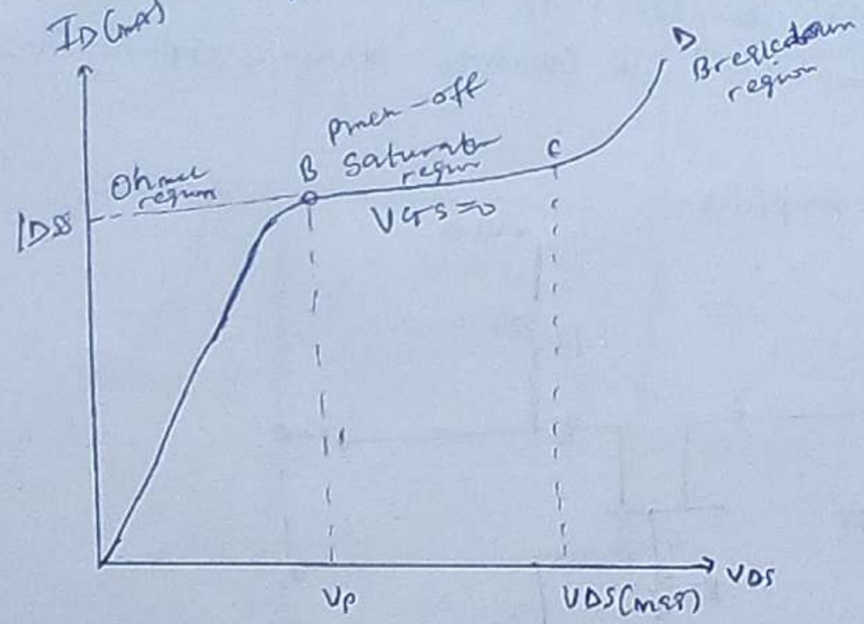
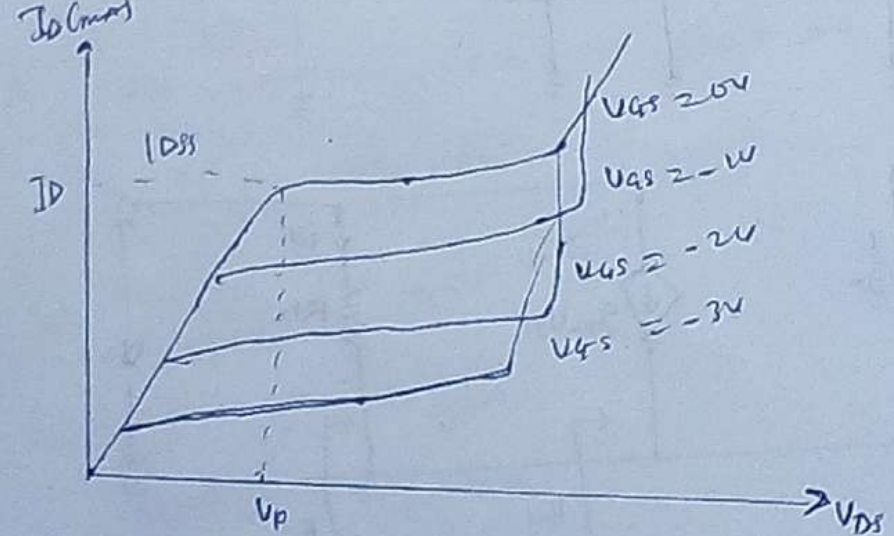
QUESTION (5)

a Draw the graph showing the drain characteristic of JFET with $V_{GS} = 0V$ and explain briefly the different region in the curve

ANSWER





(i) OHMIC REGION : The drain current increases linearly with the increase in drain to source voltage

(ii) Curve AB the Drain Current increase at the reverse Square law ~~rate~~ rate with increased in drain to source voltage.

(iii) Pinch off region : The drain current remain constant at its maxium value "IDSS, ~~the~~ drain current ~~[illegible]~~ The pinch off region depend upon the gate to source voltage and is given by :

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

Gate source

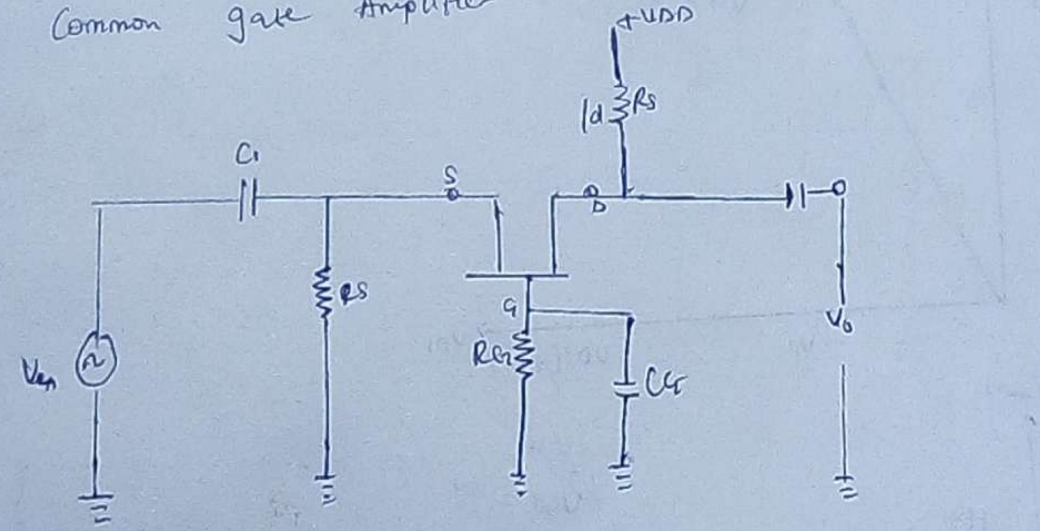
Pinch off

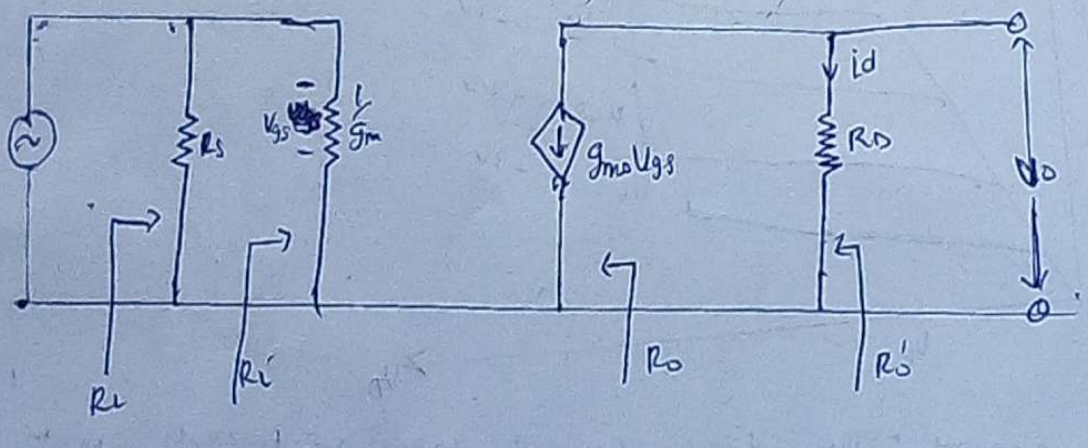
(iii) Breakdown region: The drain current increase rapidly as the drain to source voltage is also increased.

(5b)

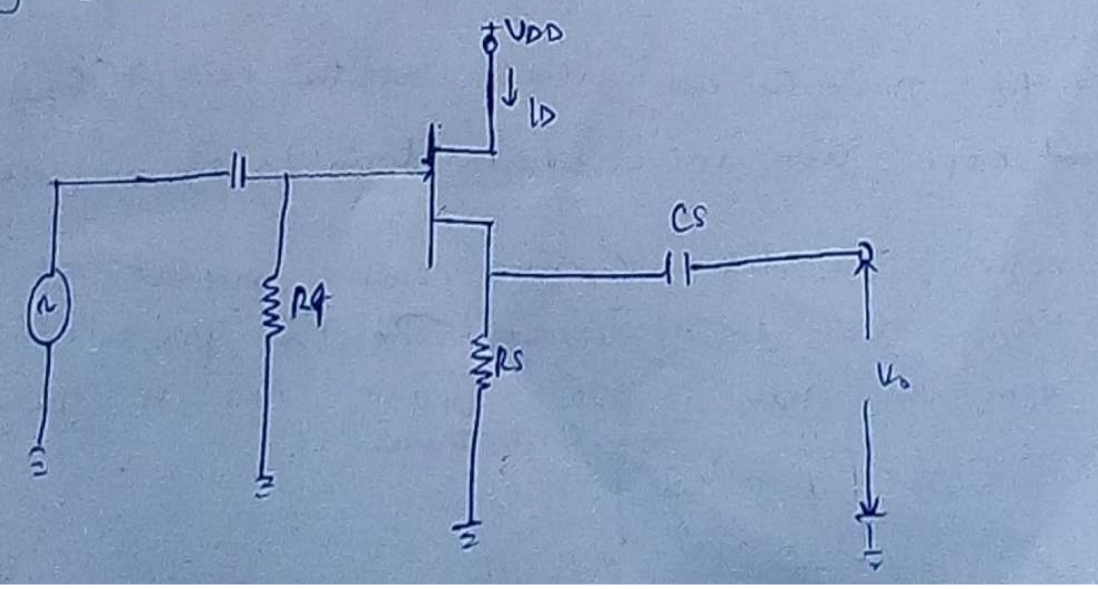
Draw the circuit diagram and the equivalent circuit of N channel JFET connected as (i) Common gate amplifier (ii) Common drain amplifier (iii) Common source

Common gate Amplifier



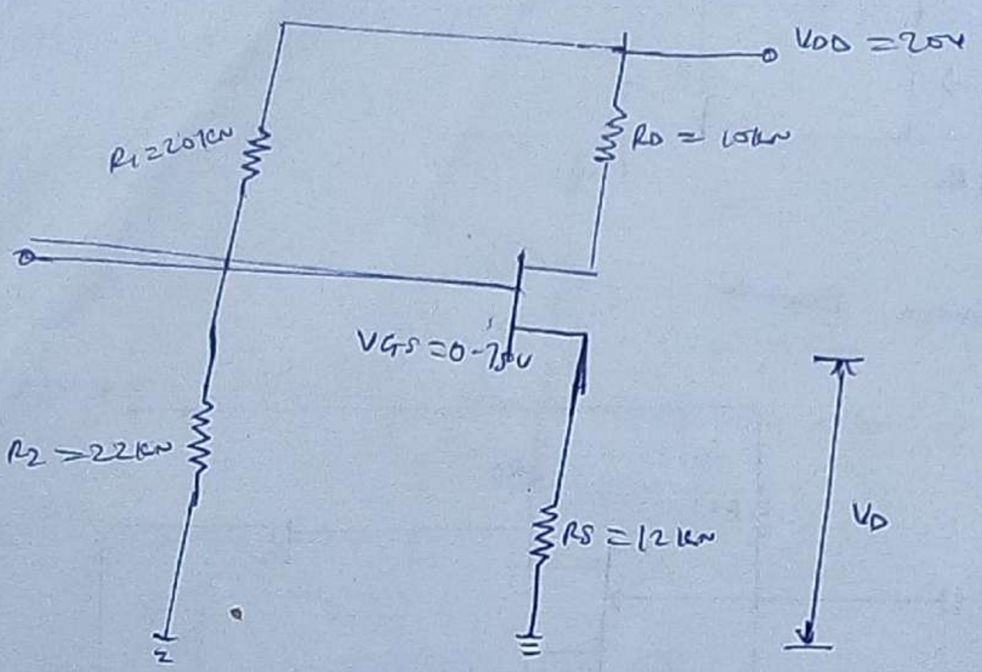


(ii) Common drain amplifier



QUESTION 6

(a) Calculate the drain current ID and drain voltage VD for the circuit below



Solution

$R_1 = 20k\Omega$ $R_2 = 22k\Omega$, $V_{GS} = 0.75V$ $V_{DD} = 20V$, $R_D = 10k\Omega$ and $R_S = 12k\Omega$

$$V_2 = V_G = \frac{V_{DD}}{R_1 + R_2} \times R_2$$

$$V_2 = \frac{20}{20+22} \times 22 = 10.48V$$

KVL at the gate

$$V_2 = V_{GS} + I_D R_S$$

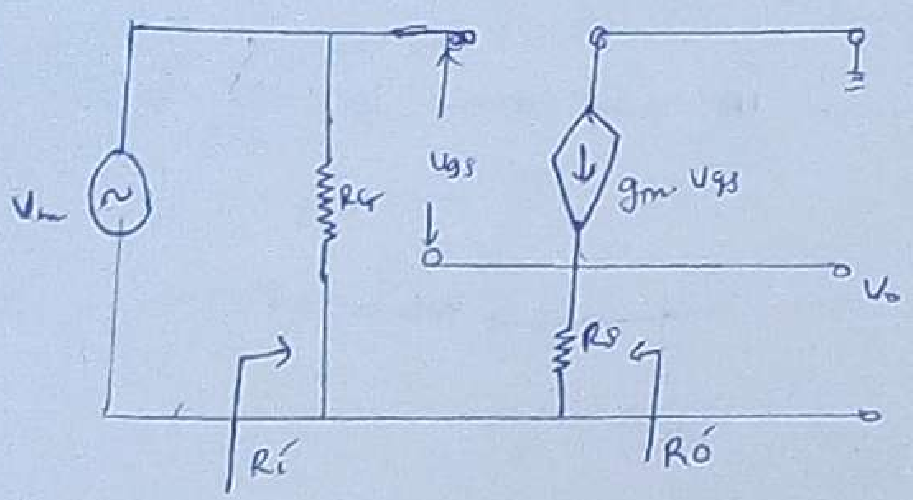
$$V_2 - V_{GS} = I_D R_S$$

$$I_D = \frac{V_2 - V_{GS}}{R_S}$$

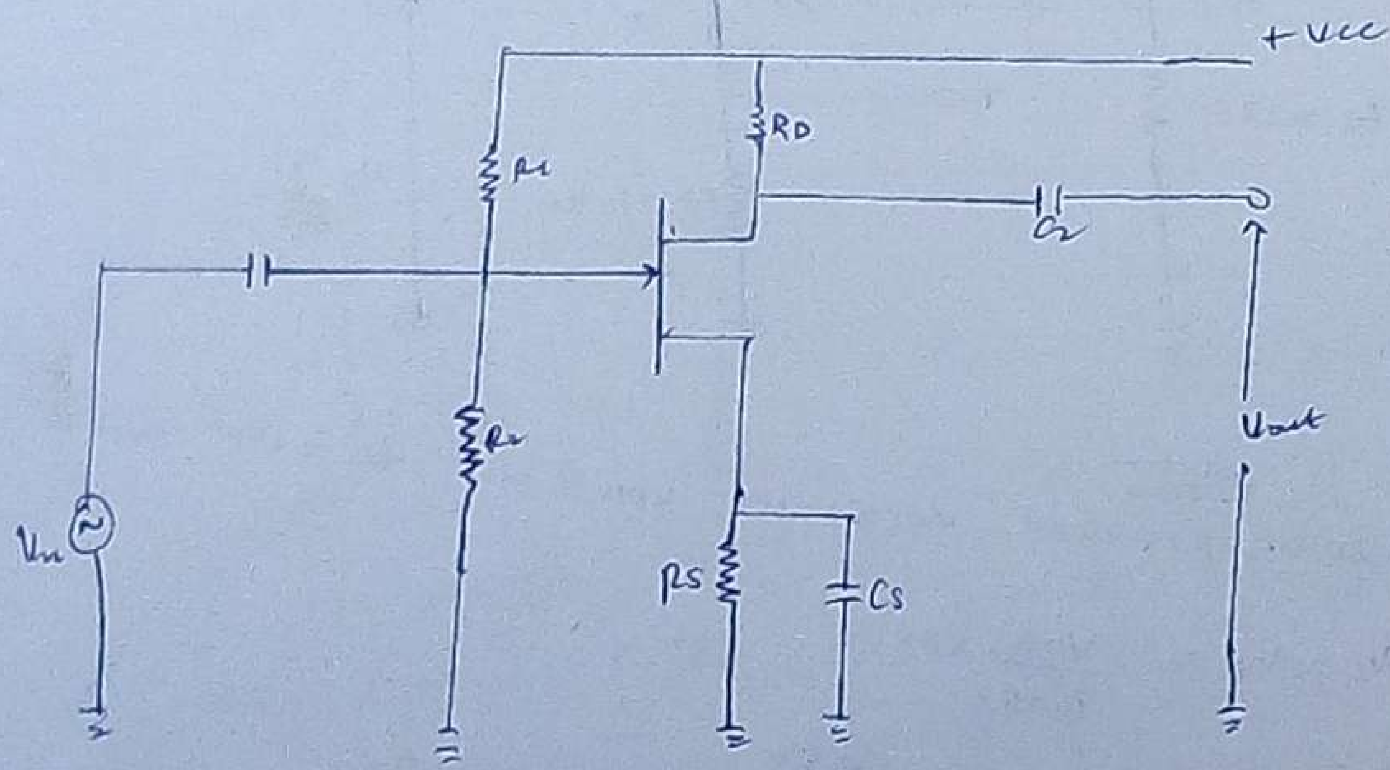
$$I_D = \frac{10.48 - 0.75}{12k\Omega} = 0.81mA$$

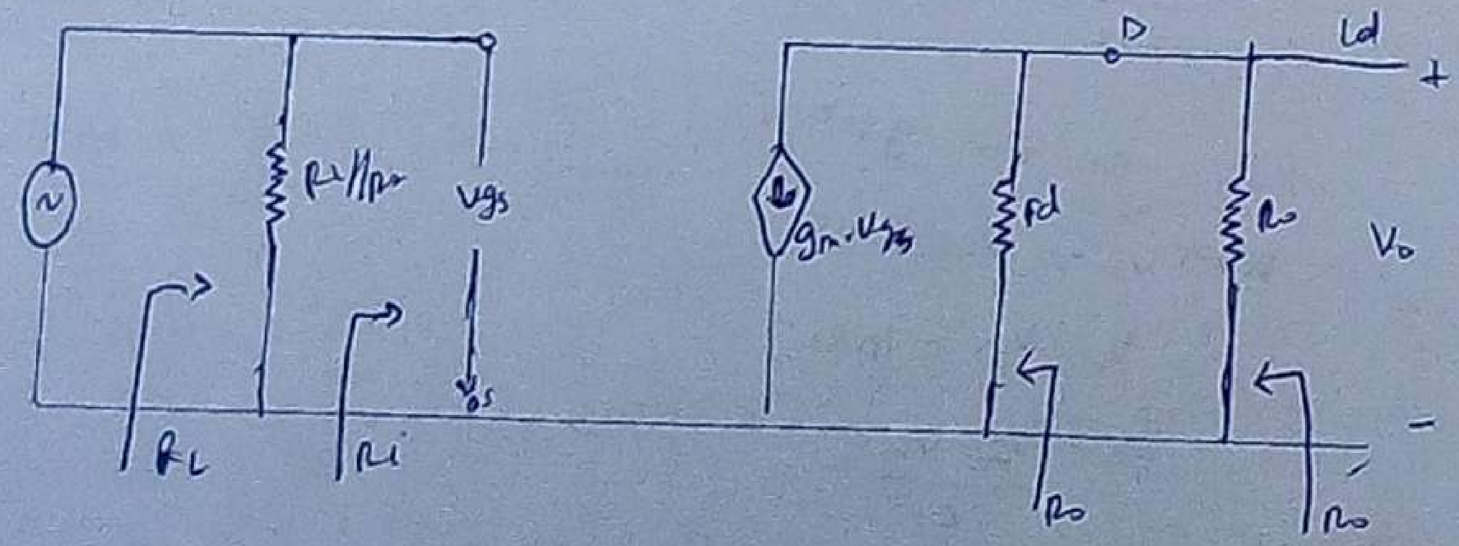
$$V_D = I_D R_D = 0.81mA \times 10k = 8.1V$$

$$V_D = 8V$$

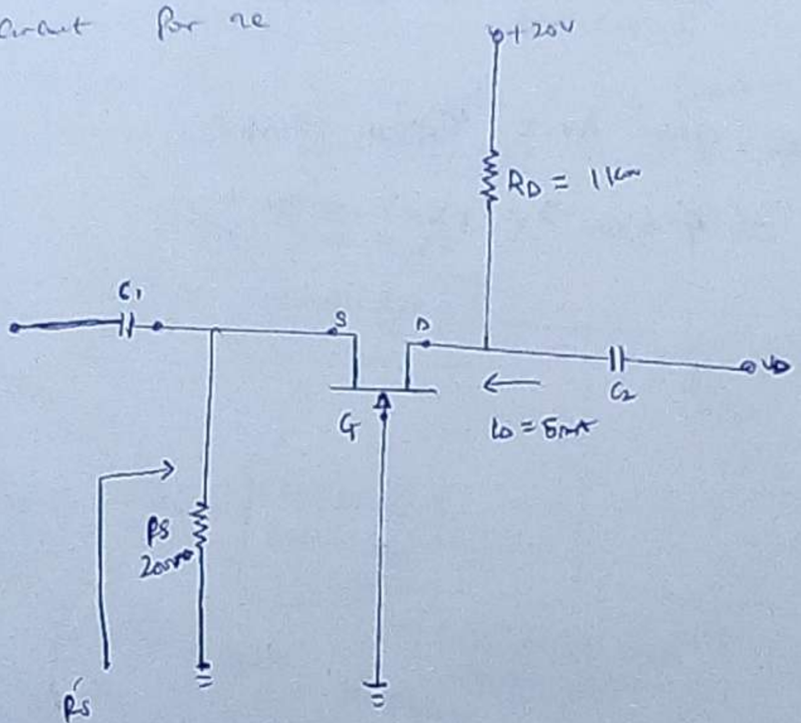


(4) Common Source





For the JFET of fig Q5 the Transconductance at zero gate to source voltage $g_{mo} = 5mS$. Determine the amplifier input resistance (R_i) and a.c voltage gain (V_o/V_{in}). Assume the capacitors to be short circuit for ac



Solution

$V_{DD} = 20V$, $I_D = 5mA$, $R_D = 1k\Omega$ $R_S = 200\Omega$ $g_{mo} = 5mS$

a.c drain resistance $r_d = \frac{1}{g_m} \frac{V_{ds}}{i_d}$

$$g_m = g_{mo}\left[1 - \frac{V_{GS}}{V_{GS(off)}}\right]$$

$$V_{GS} = -I_D R_S = -(5mA \times 200) = -1V$$

$$V_{DS} = V_{DD} - I_D(R_D + R_S) = 20 - 5m(1000 + 200)$$
$$= 20 - 6 = 14V$$

$V_P = V_{DS} = 14V$

$V_{GS(off)} = -14V$

$$g_m = g_{mo}\left[1 - \frac{V_{GS}}{V_{GS(off)}}\right] = 5\times10^{-3}\left[1 - \frac{-1}{-14}\right]$$

$g_m = 5\times10^{-3}\left[1 - \frac{1}{14}\right]$, $g_m = 5\times10^{-3}[0.9286] = 4.6mS$

Input resistance $= R_S // \frac{1}{g_m} = 200 // \frac{1}{4.6ms}$

$= 200 // 215.39$

$$R_i = \frac{200 \times 215.39}{200 + 215.39} = 103.7\Omega$$

voltage gain $A_V = g_m R_D$

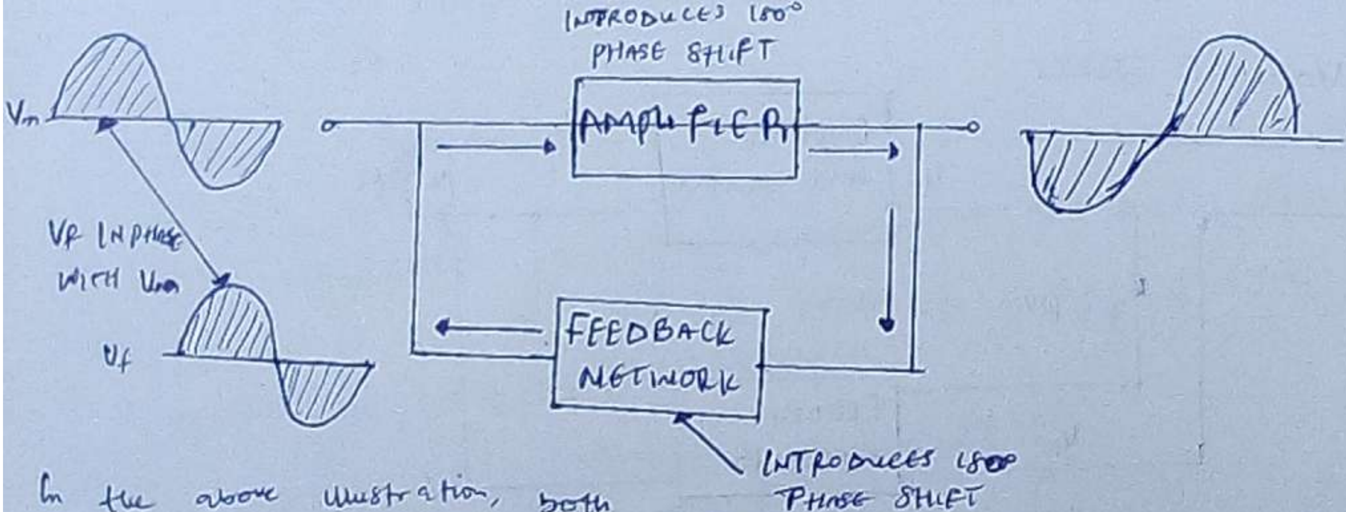
$$A_V = 4.6 \times 10^{-3} \times 1 \times 10^3 = 4.6$$

Question 7

(a) Distinguish between positive and negative feedback amplifier.

Answer

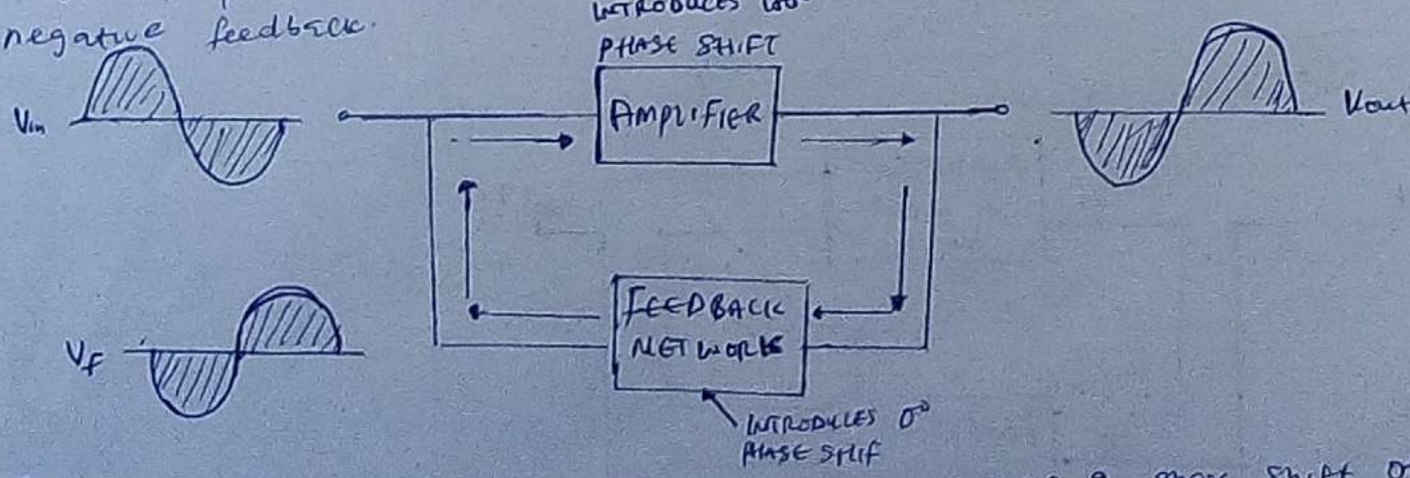
POSITIVE FEEDBACK: When the feedback energy (voltage or current) is in phase with the input signal and thus aids it, it is called positive feedback



In the above illustration, both amplifier and feedback network introduce a phase shift of 180°. The result is 360° phase shift around the loop, causing the feedback voltage V_f to be in phase with the input signal V_{in}.

The positive feedback increases the gain of the amplifier. However it has the disadvantages of increased distortion and instability. One important use of positive feedback is in oscillators.

NEGATIVE FEEDBACK: When the feedback energy (voltage or current) is out of phase with the input signal and thus oppose it, it is called negative feedback.



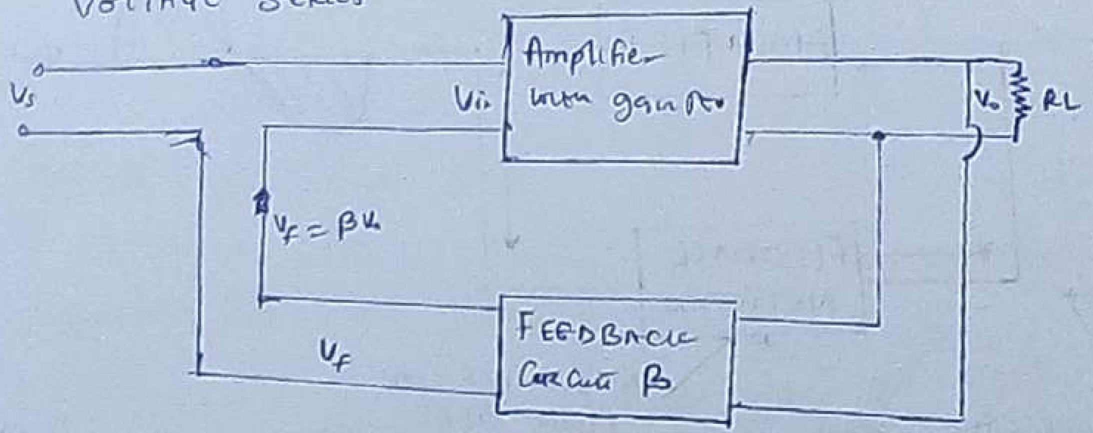
From the illustration above, the amplifier introduces a phase shift of 180° into the circuit while the feedback network is so designed that it introduces no phase shift (i.e 0° phase shift). The result is that the feedback voltage V_f is 180° out of phase with the input signal.

Negative feedback reduces the gain of the amplifier. However, the advantages of negative feedback are; reduction in distortion, stability in gain, increased bandwidth and improved input and output impedance.

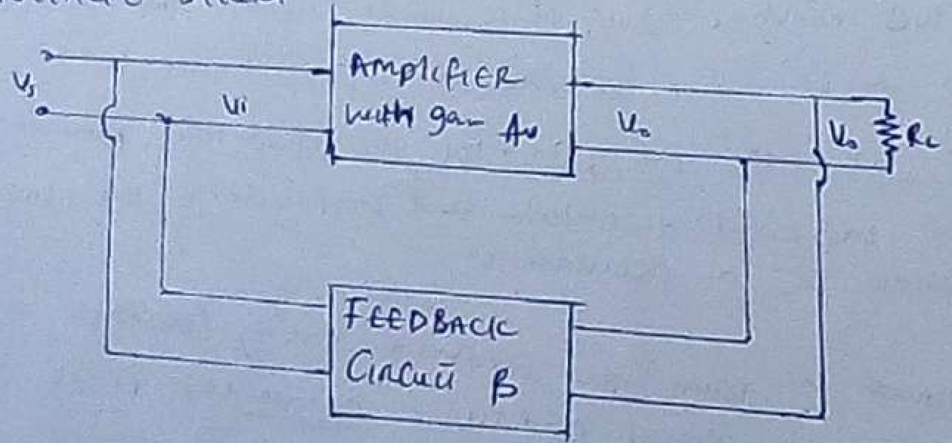
7b

Draw the block diagram of the following feedback networks.
(i) Voltage series (ii) Voltage shunt (iii) Current series and (iv) Current shunt

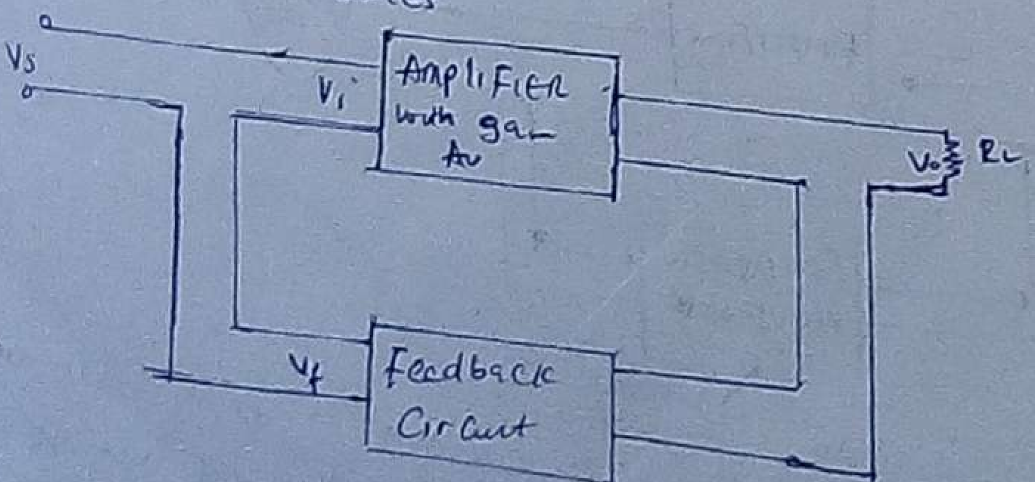
VOLTAGE SERIES



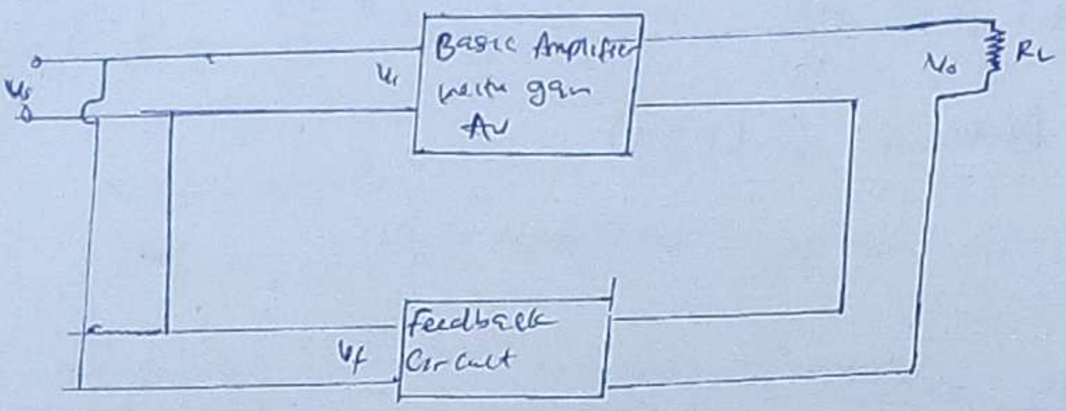
VOLTAGE SHUNT



CURRENT SERIES

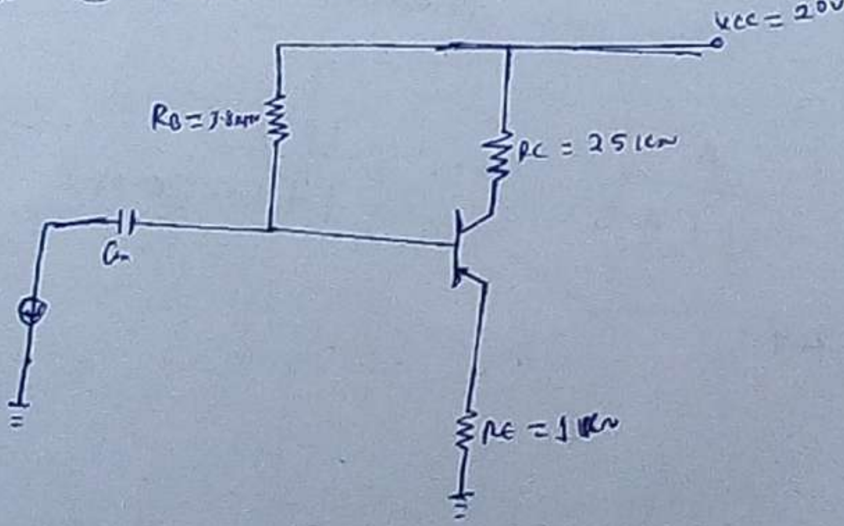


CURRENT - SHUNT FEEDBACK



(7C)

For the feedback amplifier circuit of fig below find (i) feedback ratio (ii) feedback factor (iii) voltage gain without feedback (iv) voltage gain with feedback



Solution

Vcc = 20V , RB = 3.8MΩ , RC = 25kΩ , RE = 1kΩ , β = 200

Applying KVL at collector side

$$I_E = \frac{V_{CC}}{\frac{R_B}{\beta} + R_E} = \frac{20}{\left(\frac{3.8\times10^6}{200}\right) + (1\times10^3)} = \frac{20}{19000 + 1000}$$

$$I_E = \frac{20}{20000} = 1mA$$

$$r_e' = \frac{25mV}{I_E} = \frac{25mV}{1mA} = 25\Omega$$

(i) feedback ratio $B = \frac{Rf}{Rc} = \frac{1k\Omega}{25k} = \frac{1}{25} = 0.04$

(ii) The feedback factor = $(1 + BA)$

where A is voltage with feed back

$A_v = \frac{Rc}{r_e} = \frac{25k\Omega}{25} = 1000$

feedback factor $= (1 + BA) = 1 + 0.04(1000) = 41$

(iii) voltage gain without feedback

$A_v = \frac{RC}{r_e} = \frac{25k\Omega}{25} = 1000$

(iv) voltage gain with feedback

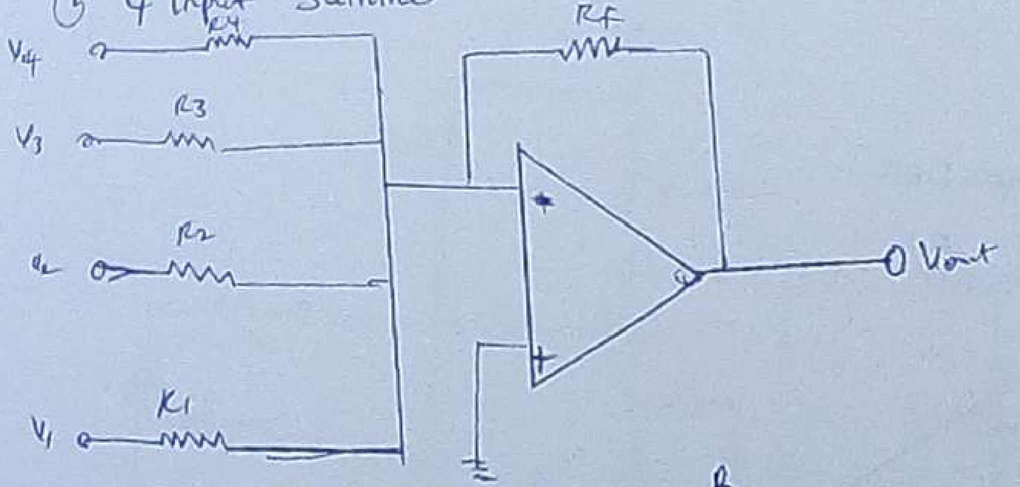
$A_{vf} = \frac{A_v}{1 + A_v B} = \frac{1000}{1 + 1000(0.04)} = \frac{1000}{41} = 24.39$

$A_{vf} = 24$

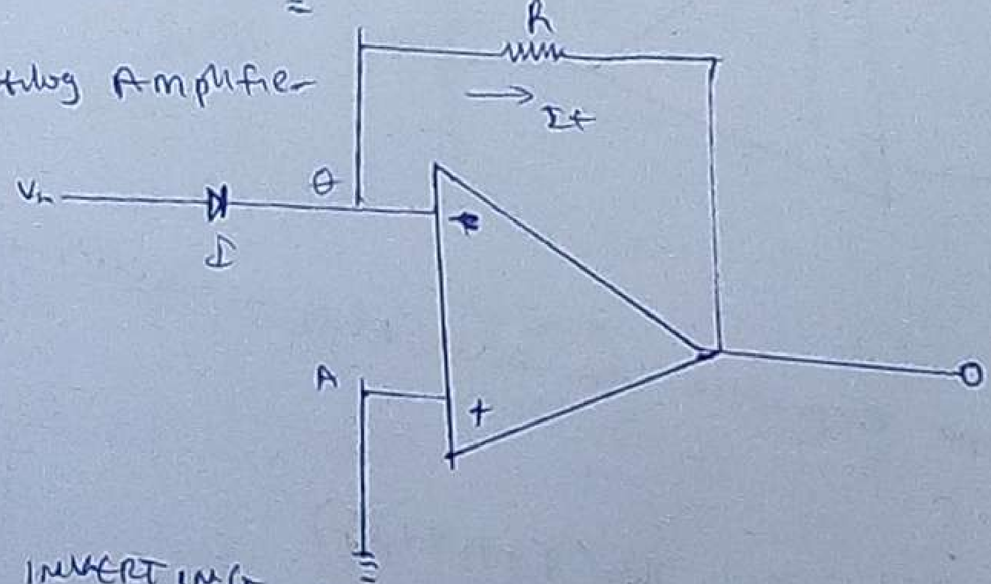
Question 8

(A) Draw the circuit diagram of how an operational Amplifier can be configured as (i) 4 input summer (ii) Antilog Amplifier (iii) NON INVERTING Amplifier (iv) COMPARATOR (v) DIFFERENTIAL AMPLIFIER

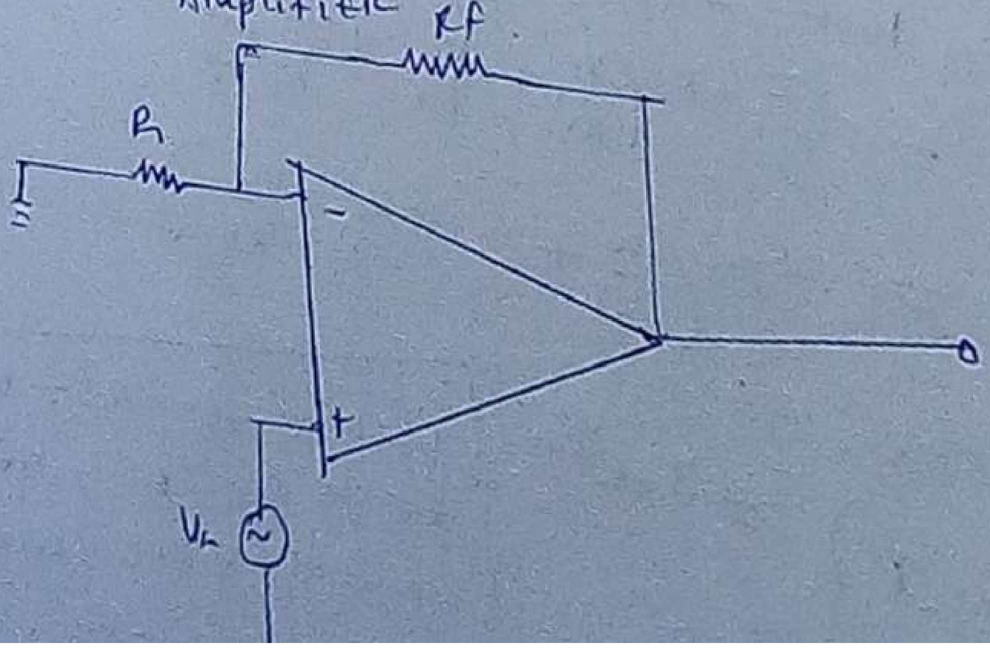
(i) 4 Input Summer



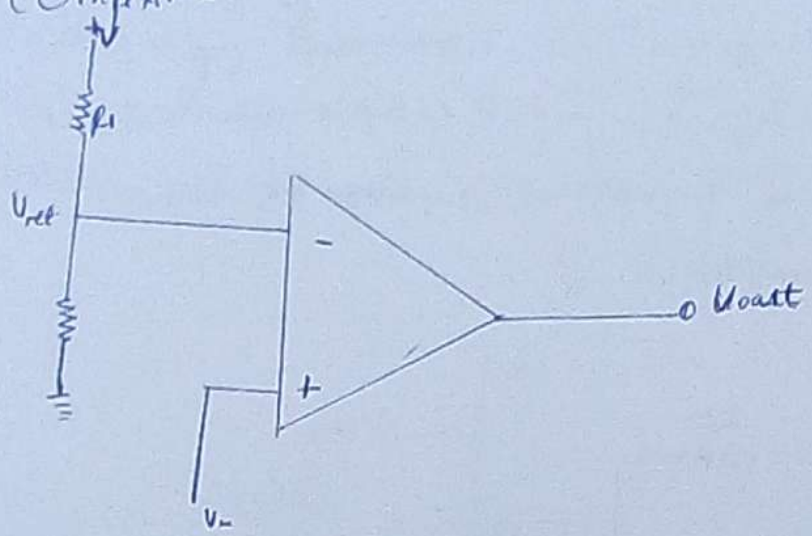
(ii) Antilog Amplifier



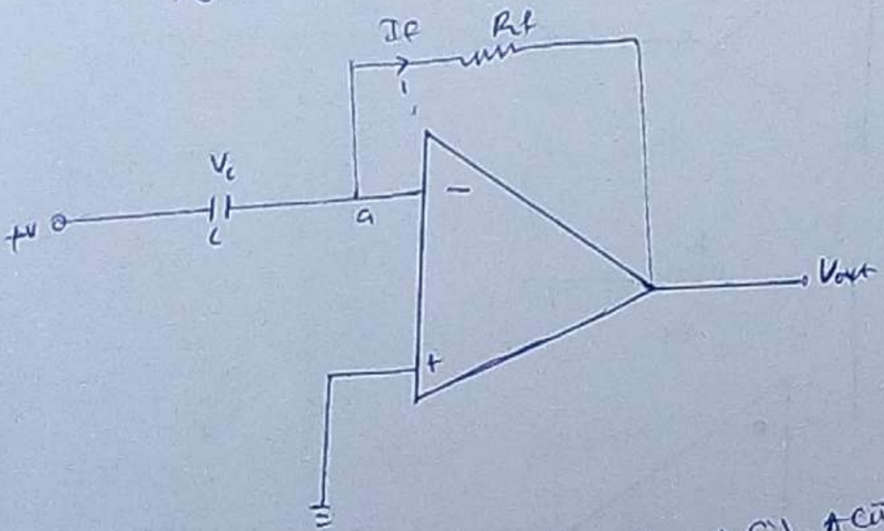
(iii) NON INVERTING AMPLIFIER



(iv) COMPARATOR



(v) DIFFERENTIAL AMPLIFIER



(B) Derive the output expression for A(i), A(ii) and A(iii) above

(i) 4 input summer

Output Voltage $V_{out} = -I_f R_f = R_f(I_1 + I_2 + I_3 + I_4)$

$$= -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \frac{V_4}{R_4}\right)$$

$$V_{out} = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \frac{V_4}{R_4}\right)$$

(ii) Antilog Amplifier

$$I = I_0\left(e^{\frac{V_D}{\eta V_T}} - 1\right) \simeq I_0 e^{\frac{V_D}{\eta V_T}}$$

$V_D = V_{in}$, $V_{out} = -I_f \cdot R_f$

$$V_{out} = -R I_0 e^{\left(\frac{V_{in}}{\eta V_T}\right)}$$

(iii) NON INVERTING:

Voltage across $R_1 = V_{in} - 0$

Voltage across $R_f = V_{out} - V_{in}$

Current through R_1 = Current through R_f

$$\frac{V_i - 0}{R_1} = \frac{V_{out} - V_{in}}{R_f}$$

$$V_{in} R_f = V_{out} R_1 - V_{in} R_1$$

$$V_{in}(R_f + R_1) = V_{out} R_1$$

$$\frac{V_{out}}{V_{in}} = \frac{R_f + R_1}{R_1} = 1 + \frac{R_f}{R_1}, \quad V_{out} = V_{in}\left(1 + \frac{R_f}{R_1}\right)$$

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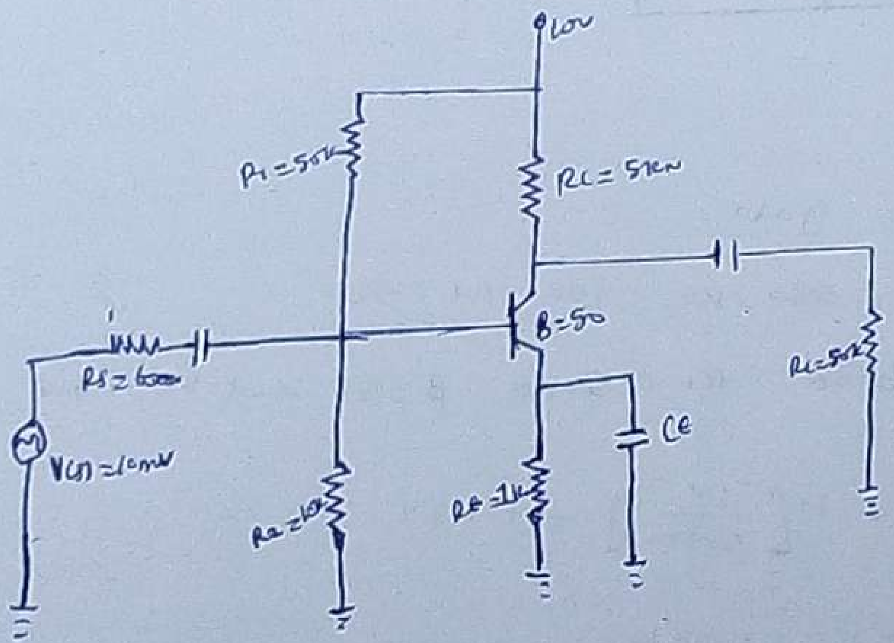
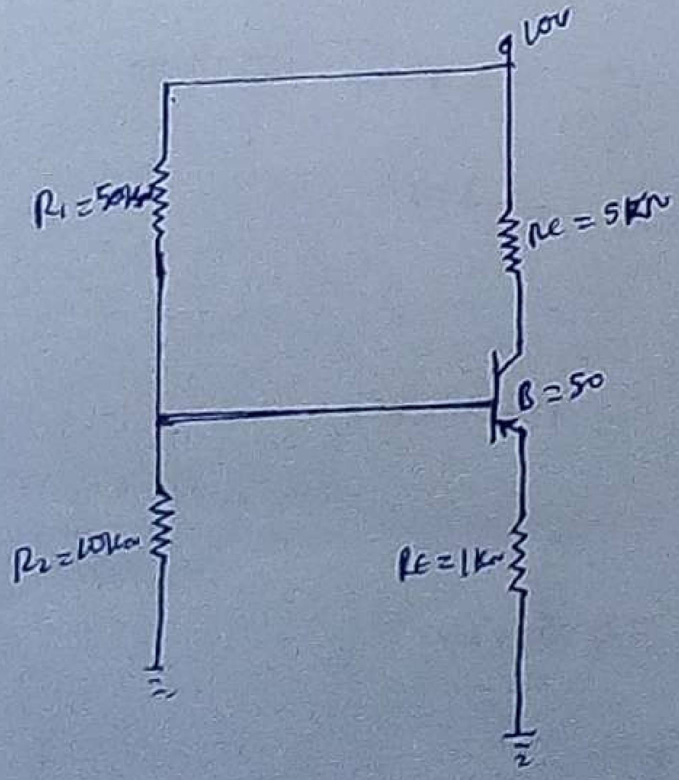
Question 9

(A) For the single stage amplifier shown in fig Q2, draw the DC and AC equivalent circuit.

(B) From the equivalent circuit of fig Q2, calculate the (i) Output voltage gain (ii) The overall voltage gain (Take $V_{BE} = 0.7V$)

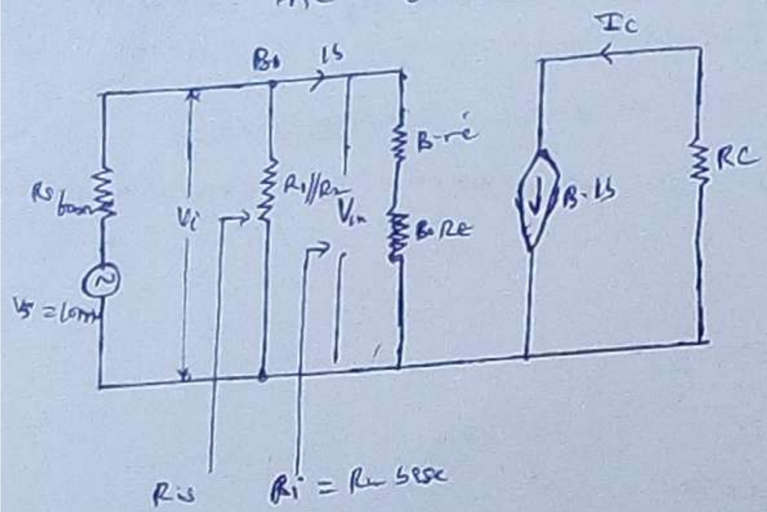


(A) DC equivalent circuit



Question 9

AC circuit equivalent



Output voltage gain

(B) (i) Given $V_{CC} = 10V$, $R_C = 5k\Omega$, $R_E = 1k\Omega$, $R_1 = 50k\Omega$, $R_2 = 10k\Omega$, $R_S = 600\Omega$, $R_L = 50k\Omega$, $\beta = 50$ and $V_S = 10mV$

Solution

$$V_{th} = V_{cc}\left[\frac{R_2}{R_1+R_2}\right] = 10\left[\frac{10}{50+10}\right] = 1.67V$$

$$R_{th} = R_1 // R_2 = \frac{(R_1 \times R_2)}{R_1+R_2} = \frac{50 \times 10}{50+10} = 8.3k\Omega$$

$$I_E = \frac{V_{th} - V_{BE}}{R_E + \frac{R_{th}}{\beta}} = \frac{1.67-0.7}{1000 + \frac{8.3\times10^3}{50}} = 0.83mA$$

AC emitter resistance $r_e' = \frac{25}{I_E} = \frac{25}{0.83} = 30.12\Omega \approx 30\Omega$

$R_{is} = (R_1//R_2) // (\beta \cdot r_e') = R_{th} // \beta \cdot r_e'$ ~~= 8.3~~

$\beta \cdot r_e' = 50 \times 30.12 = 1506\Omega = 1.51k\Omega$

~~$R_{is} = \frac{8 \times 1.51}{8+1.51}$~~ $R_{is} = \frac{8.3 \times 1.5}{8.3+1.5} = 1.270 k\Omega$

$$R_L = R_C // R_L = 5 // 50 = \frac{5 \times 50}{5+50} = 4.545 k\Omega$$

$$A_V = \frac{r_L}{r_e} = \frac{4.545}{30} \times 10^3 = 151.5$$

$$V_{in} = V_s\left[\frac{R_{is}}{R_{is}+R_s}\right] = 10\left[\frac{1270}{1270+600}\right] = 6.79mV$$

Question 9

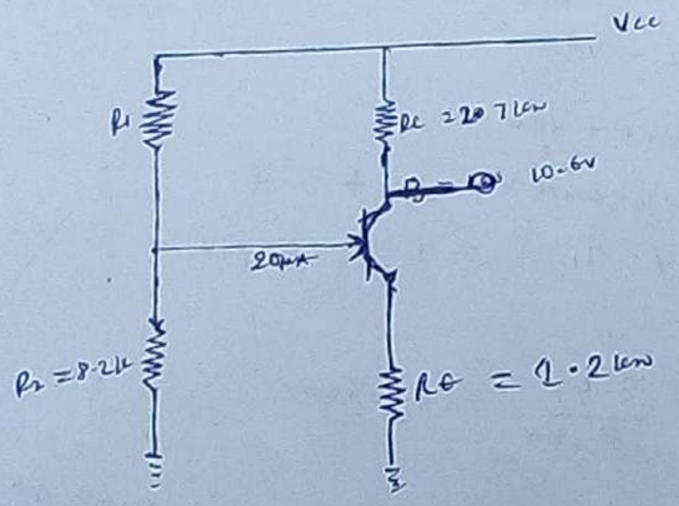
(6) $V_o = A_v \times V_{in} = 151.5 \times 6.79 = 1.029V$

(5) overall voltage gain

$A_{vs} = A_v \times \frac{V_{in}}{V_s} = 151.5 \times \frac{6.79}{10} = 102.9$

Question TO

(A) Calculate the following for the voltage divider configuration shown in fig below (i) I_C (ii) V_E (iii) V_{CC} (iv) V_{CE} (v) R_1.



Solution

$V_{CC} = ?$ $V_C = 10.6V$ $R_C = 2.7k\Omega$, $R_B = 20\mu A$

(i) $V_C = I_C R_C$, $I_C = \frac{V_C}{R_C} = \frac{10.6}{2.7k} = 3.926mA$

$I_C \simeq I_E = 3.926mA$

(ii) $V_E = I_E R_E = \cancel{3} \; 3.926mA \times 1.2k\Omega = 4.71V$

(iii) V_{CC}

Applying K voltage law to collector side

$V_{CE} = V_{CC} - I_C(R_C + R_E)$

$V_{CE} = V_C - V_E = 10.6 - 4.71 = 5.29V$

$V_{CC} = V_{CE} + I_C(R_C + R_E)$

$= 5.29 + 3.926mA(2.7k\Omega + 1.2k\Omega)$

$= 5.29 + 7.826 = 13.116V \simeq 13V$

$V_{CC} = 13V$

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(iv) $V_{CE} = V_C - V_E = 10.6 - 4.71 = 5.29\,V$

(v) R_1

Emitter Current $I_E = \dfrac{V_2 - V_{BE}}{R_E}$

$$I_E R_E = V_2 - V_{BE}$$

$$V_2 = I_E R_E + V_{BE}$$

$$= (3.926\,mA \times 1.2k) + 0.7$$

$$= 4.71 + 0.7 = 5.41\,V$$

$$I_2 = \frac{V_2}{R_2} = \frac{5.41}{8.2\,k\Omega} = 0.66\,mA$$

$$I_1 = I_B + I_2 = 0.66\,mA + 20\,\mu A = 0.68\,mA$$

Since $I_2 >> I_B$, I_B can be neglected $I_1 = 0.66\,mA$

$$I_1 = \frac{V_{CC}}{R_1 + R_2} = \frac{13.12}{R_1 + 8.2k}$$

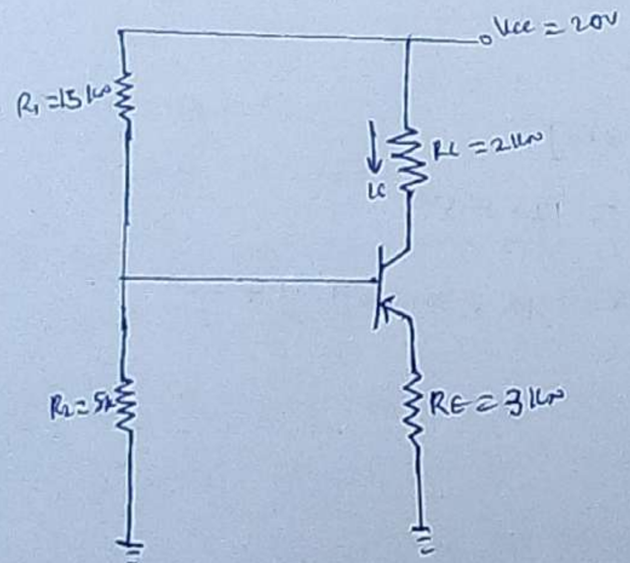
$$0.66\,mA\,(R_1 + 8.2\,k\Omega) = 13.12$$

$$R_1 = \frac{13.12 - 5.412}{0.66 \times 10^{-3}} = \frac{7.708}{0.66 \times 10^{-3}} = 11678.78\,\Omega$$

$$R_1 = 11.7\,k\Omega$$

(b) Question 10

For the circuit in fig below, draw dc load line and mark the Q point of the silicon transistor if $V_{BE} = 0.7V$ and I_C max 4mA



Solution

Given $V_{BE} = 0.7V$ $V_{CC} = 20V$, $R_C = 2k\Omega$ $R_E = 3k\Omega$

D.C load line

$V_{CE} = -V_{CC} + I_C(R_C + R_E)$

Negative sign of V_{CC} shown it is connected in reverse bias.

$V_{CE} = V_{CC} + I_C(R_C + R_E)$

$I_{C max} = 4mA$ when $V_{CE} = 0$

when $I_C = 0$

$V_{CE} = V_{CC} = -20V$

Q point

Voltage across R_2, $V_2 = \frac{V_{CC}}{R_1 + R_2} \times R_2$

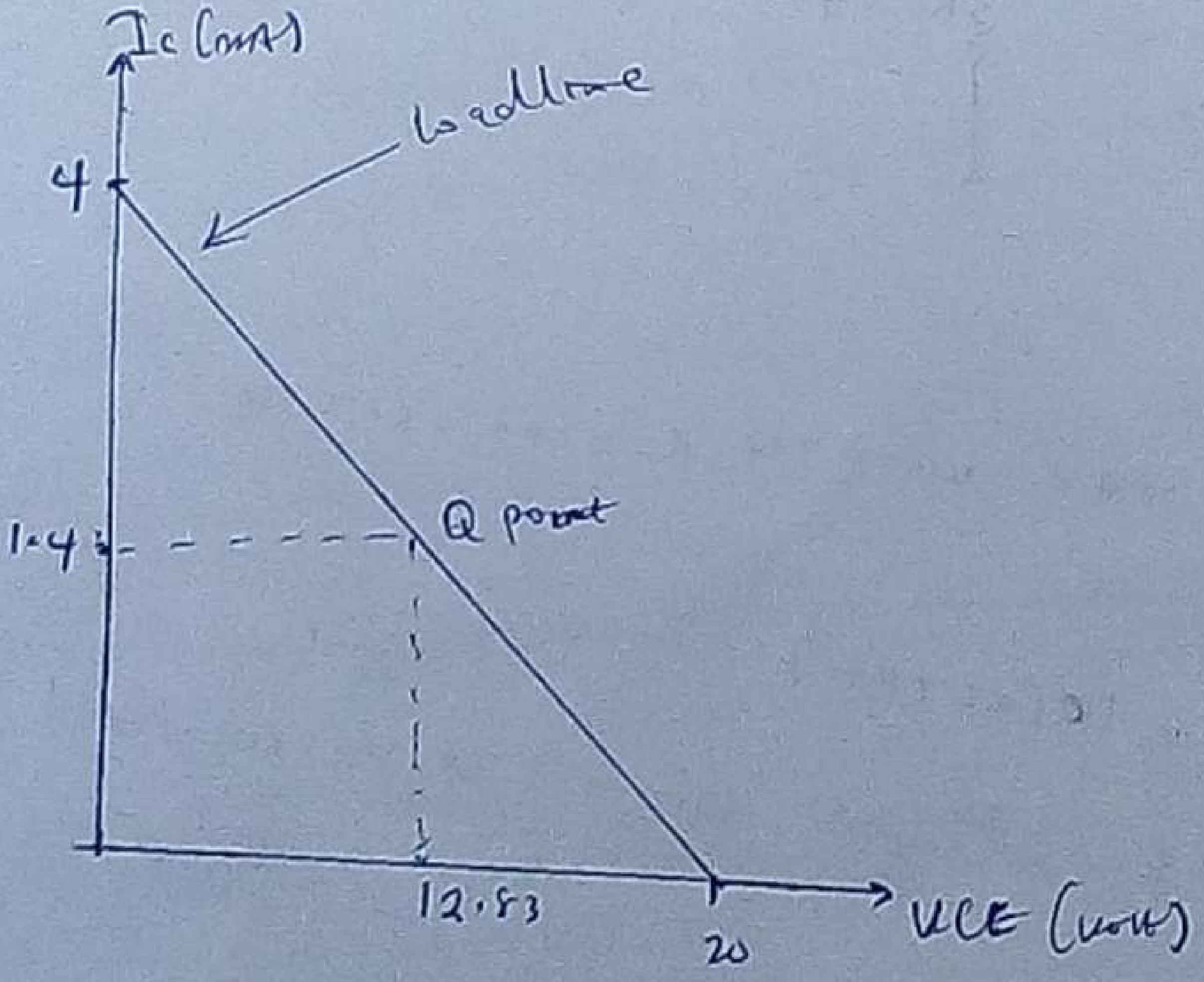
$$V_2 = \frac{20}{15+5} \times 5 = 5V$$

$$I_E = \frac{V_2 - V_{BE}}{R_E} = \frac{5 - 0.7}{3k\Omega} = 1.43mA$$

$$I_E \simeq I_C = 1.43mA$$

$$V_{CE} = V_{CC} - I_C(R_C + R_E)$$
$$= 20 - 1.4mA\,[2k\Omega + 3k\Omega]$$
$$= 20 - 1.4mA\,[5k\Omega] = 12.83V$$

Operating point Q are 12.83V and 1.43mA



(13)

(A) List four Characteristic of an ideal Op-Amp

CHARACTERISTIC OF AN IDEAL OP-AMP

(i) The internal stages of an Op-Amp are direct-coupled i.e no Coupling Capacitors are used. This coupling allows the Op-Amp to amplify d.c as well as a.c signals.

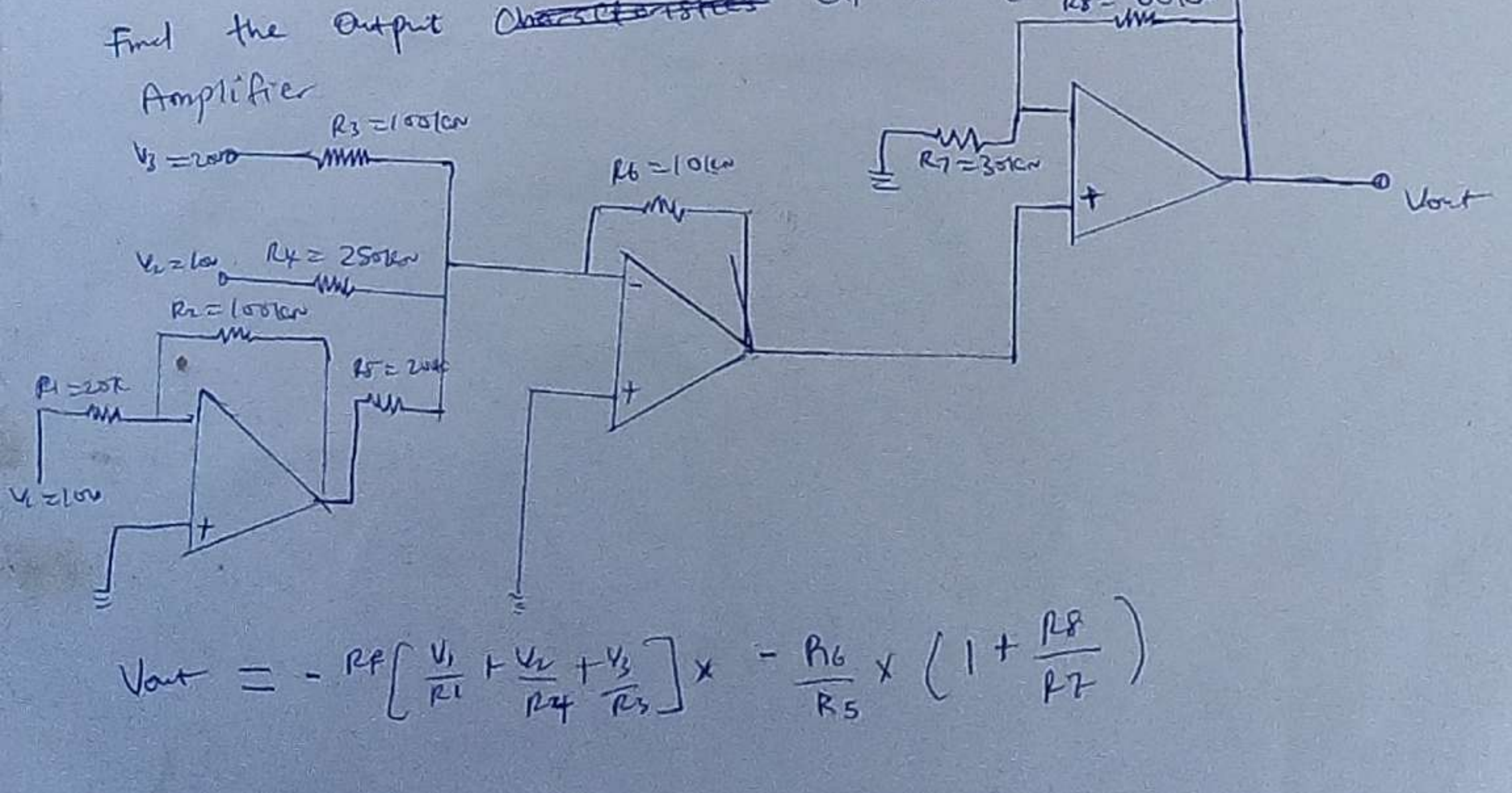
(ii) An Op-Amp has very high input impedance (ideally infinite) and very low Output Impedance (ideally zero).

(iii) An Op-Amp has very high open-loop voltage gain (~~ideally info~~ (ideally infinite); typically more than 200,000

(iv) Input stage of an Op-Amp is a differential amplifier (DA) and the Output stage is typically a Class B push-pull emitter follower.

(B)

Find the Output ~~Characteristics~~ Of ~~an ideal Op Amp~~ the multistage Amplifier



$$V_{out} = -R_f\left[\frac{V_1}{R_1} + \frac{V_2}{R_4} + \frac{V_3}{R_3}\right] \times -\frac{R_6}{R_5} \times \left(1 + \frac{R_8}{R_7}\right)$$

$$V_{out} = -R_f\left[\frac{V_1}{R_1} + \frac{V_2}{R_4} + \frac{V_3}{R_3}\right] \times -\frac{R_6}{R_5} \times \left(1 + \frac{R_8}{R_7}\right)$$

$$V_{out} = -R_2\left[\frac{V_1}{R_1} + \frac{V_2}{R_4} + \frac{V_3}{R_3}\right] \times -\frac{R_6}{R_5} \times \left(1 + \frac{R_8}{R_7}\right)$$

~~Vout = -100~~

Since all resistances are in ~~tedo~~ kΩ

$$= -100\left[\frac{10}{20} + \frac{10}{250} + \frac{20}{100}\right] \times -\frac{10}{200} \times \left(1 + \frac{60}{30}\right]$$

$$= -100\left[\frac{37}{50}\right] \times \left(-\frac{10}{200}\right) \times \left[3\right]$$

$$V_{out} = 11.1V$$

14C

Given that the gain of an amplifier in a feedback arrangement is 10, the feedback factor B is 2, the input and output resistance is $R_i = 25\Omega$ and $R_o = 140$ respectively, calculate the feedback amplifier input resistance R_i and output resistance R_o for the four networks of question 7(b) above

Solution

Given $A_v = 10$, $B = 2$, $R_i = 25\Omega$, $R_o = 140\Omega$.

(i) For voltage series

$$R_i' = (1 + B \cdot A_v) R_i$$

$$R_i' = (1 + 2(10)) \times 25 = 21 \times 25 = 525\Omega$$

$$R_o' = \frac{R_o}{1 + B \cdot A_v} = \frac{140}{1 + 2(10)} = \frac{140}{21} = 6.7\Omega$$

(ii) For voltage shunt

$$R_i' = \frac{R_i}{1 + B \cdot A_v} = \frac{25}{1 + 2(10)} = \frac{25}{21} = 1.19\Omega$$

$$R_o' = \frac{R_o}{1 + B \cdot A_v} = \frac{140}{21} = 6.7\Omega$$

(iii) For current shunt

$$R_i' = \frac{R_i}{1 + B \cdot A_v} = \frac{25}{21} = 1.9\Omega$$

$$R_o' = (1 + B A_v) R_o = (21) \times 140 = 2.94k\Omega$$

(iv) For current series

$$R_i' = (1 + B \cdot A_v) R_i = (1 + 20) 25 = 20 \times 25 = 525\Omega$$

$$R_o' = (1 + B \cdot A_v) R_o = 25 \times 140 = 2.94k\Omega$$