ElCoM

ELECTRICAL COMPUTER MECHATRONICS

تقدم لجنة ElCoM الاكاديمية

دفتر لمادة:

الكترونيات (2)

من شرح:

د.هادي العيثاوي

جزيل الشكر للطالب:

مؤمن القطامي

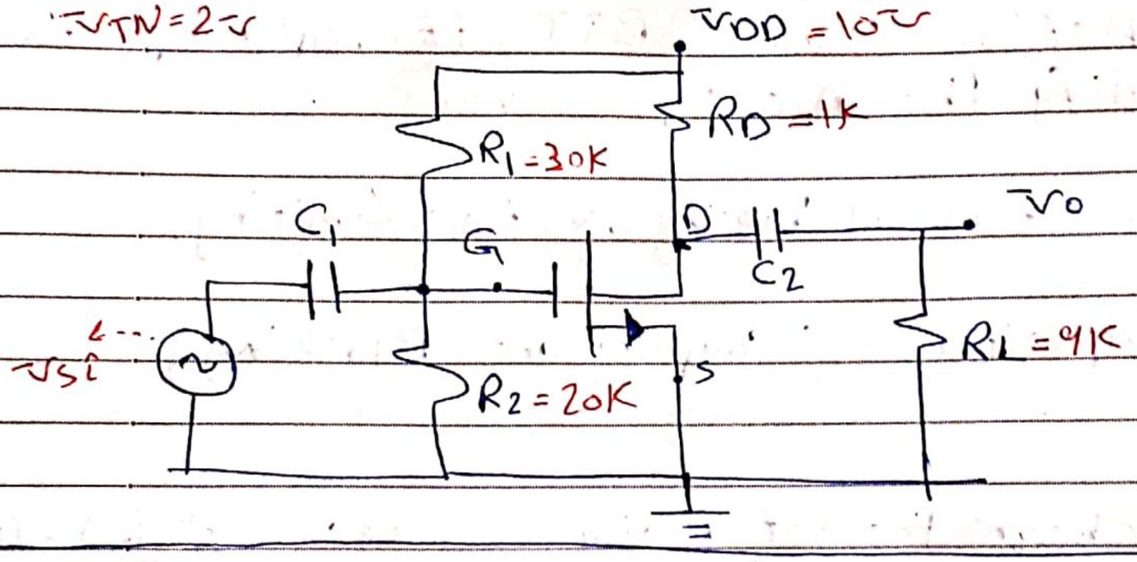
"Chapter 1" المحاضرة (1)

* Mosfet Amplifiers:

- The Mosfet must be biased in sat. Re to be Used as an amplifier.

$K_n = 1$

$V_{TN} = 2V$



* المصدر هنا "vsi" عشان نميز بينها وبين ال (vs تبع ال source)
وهي معناها ← signal voltage ← AC source voltage.

* (R_2 , R_1) ← Voltage de-vider ← biasing.

* RD ← voltage limiting Resister.

* وظيفة ال Capacitors: Coupling and bloking
O.S for DC and S.C for AC.
نفس الإشي بالنسبة للمواسع الثاني يمنع دخول تيار من مصدر ال D.C (شي غير مرغوب فيه) ويكون S.C بالنسبة لل A.C.

(VDD: وظيفتها تدخل ال Mos في ← D.C voltage
منطقة ال Sat.

Any Amplifier Contains:

① Dc sources to bias the device in proper mode (sat for Mosfet)
(F.A.M for BJT).

Diode or

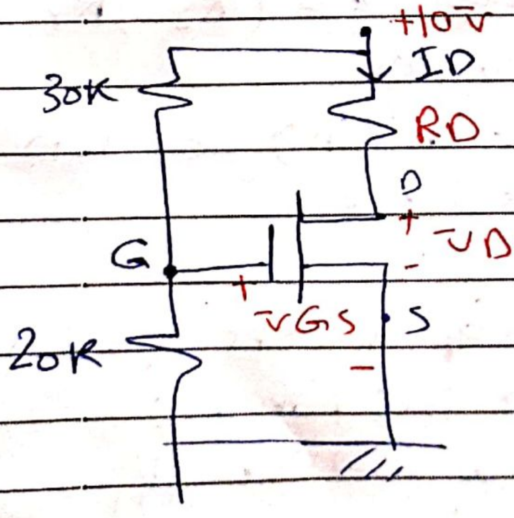
② Active device (BJT, FET, op-Amp) to Amplify the A.C i/p signal.

③ Resistors: (biasing, voltage Limiting)

④ Capacitors: (Coupling and Blocking)
A.C S.C — D.C O.C

- to cheak the sat. Region: ⊛ حل مثال السابق:
Dc Analysis must be Carried out:

① All Capacitors O.C:



$V_{GS} = V_G - V_S$

$V_G = \frac{10 \times 20}{50} = 4V$

$\boxed{V_{GS} = V_G = 4V}$

- Assume the Mosfet in sat :

$$\boxed{I_D = k_n (V_{GS} - V_{TN})^2} \quad (1)$$

- $I_D = 4mA$

to find V_{DS} :

$-10 + I_D R_D + V_{DS} = 0$

$$\boxed{V_{DS} = 6V}$$

$$\boxed{V_{DS(sat)} = V_{GS} - V_{TN}} \quad (2)$$

$$\boxed{V_{DS(sat)} = 2V}$$

- since $V_{DS} > V_{DS(sat)}$, Mosfet in sat Region

$P_D = I_D V_{DS} = \boxed{24m\,watt}$

- D.C.L.L and Q-point :

- KVL for Drain Source Loop:

$-10 + I_D R_D + V_{DS} = 0$

$$I_D = \frac{10 - V_{DS}}{R_D}$$

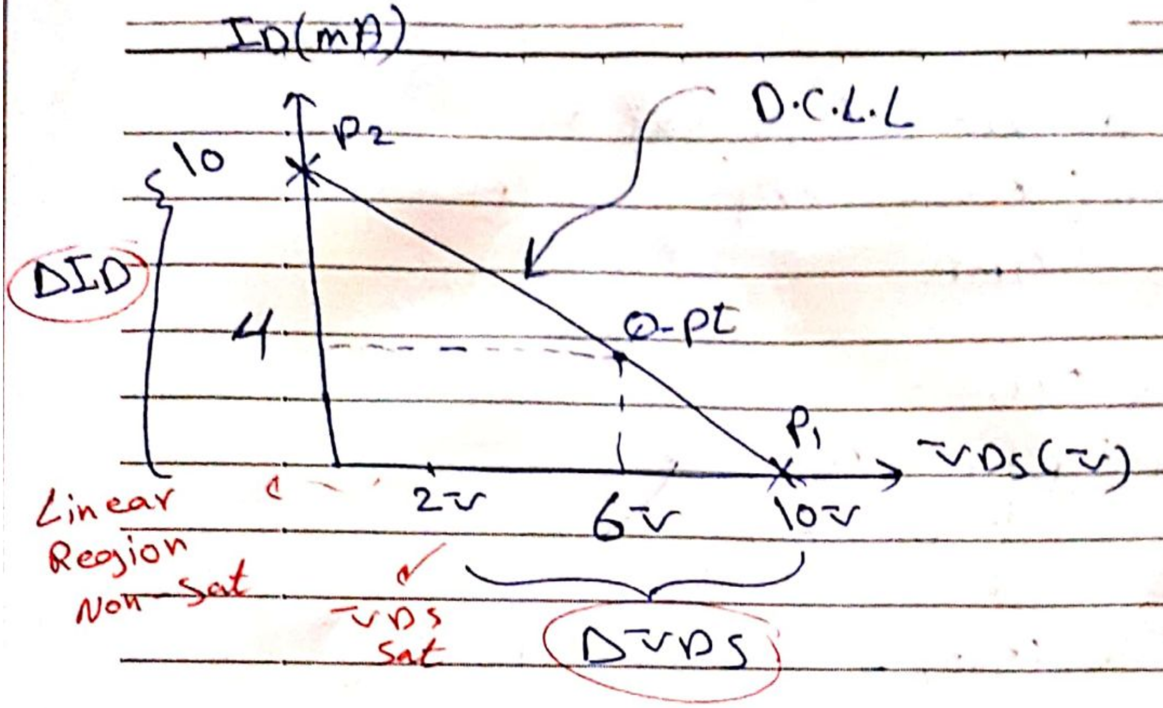
$$\boxed{I_D = \underbrace{\frac{-1}{R_D}}_{\text{slope}} \cdot V_{DS} + 10} \rightarrow \underline{y = mx + b}$$

m: slope.

- for equa (2) :

For $I_D = 0$, $V_{DS} = 10V$ $P_1 (10V, 0)$.

For $V_{DS} = 0$, $I_D = 10mA$ $P_2 (0, 10mA)$.



$$-\text{slope} = -\frac{\Delta I_D}{\Delta V_D} = -1\,mA/V \text{ or } -\frac{1}{R_D} = -1\,mA/V$$

$$Q\text{-}P\ (V_{DSQ}, I_{DQ}),\ (6V, 4mA)$$

---

* Repeat D.C Analysis,
(calculate I_D, V_{DS}), for $R_D = 2.5\,k\Omega$
$- V_{GS} = 4V$ (لا تتغير)

$$I_D = K_n (V_{GS} - V_{TN})^2 = 4mA$$

$$V_{DS} = 10 - I_D R_D = \text{Zero}$$

But $V_{DS}(sat) = V_{GS} - V_{TN} = 2V$

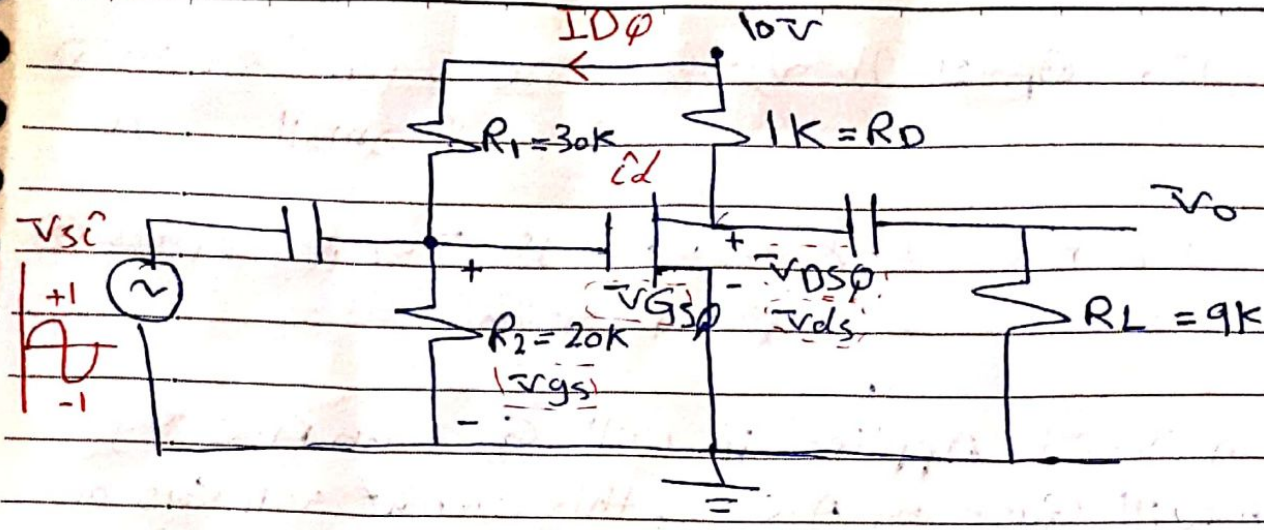
Since $V_{DS}(sat) > V_{DS}$, so Mosfet in Non-Sat. Region.

$$\boxed{I_D = K_n \left(2 (V_{GS} - V_{TN}) V_{DS} - V_{DS}^2 \right)} = (3)$$

$$\frac{10 - V_{DS}}{R_D} = (4 V_{DS} - V_{DS}^2) \rightarrow$$ obtain 2 values for V_{DS}, the correct value for V_{DS}, $V_{DS} < V_{DS}(sat)$.

(5)

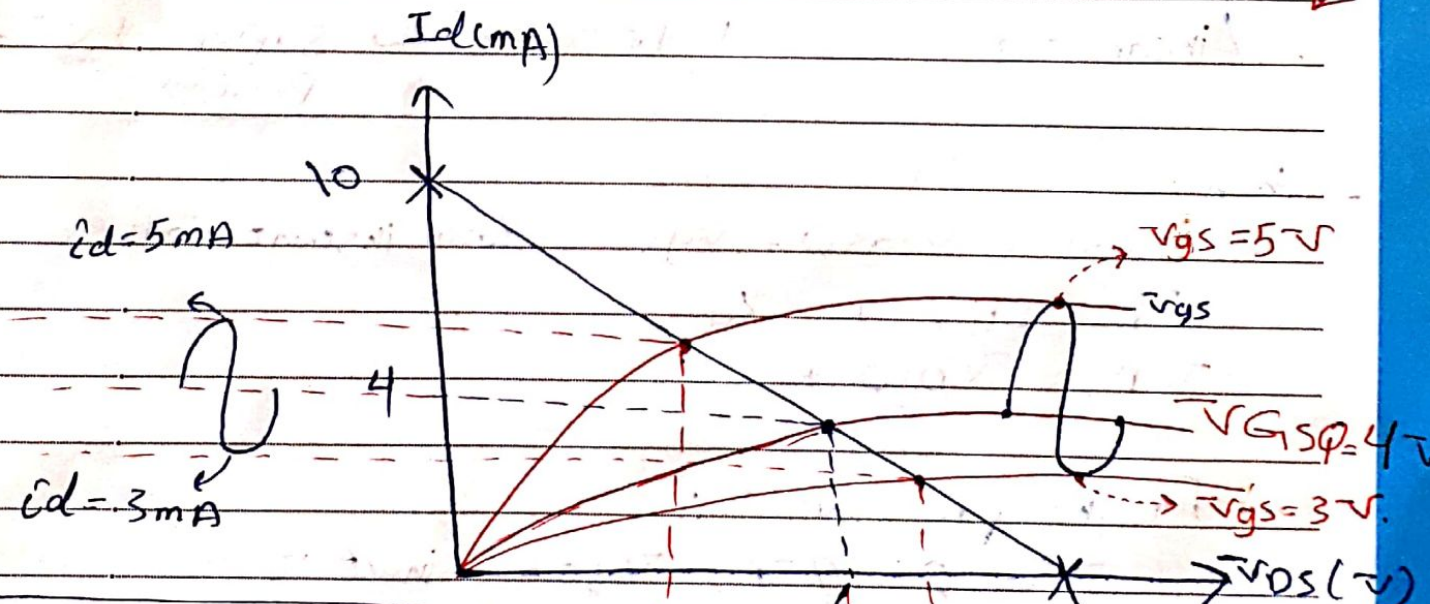
اطبا هزة اشارية

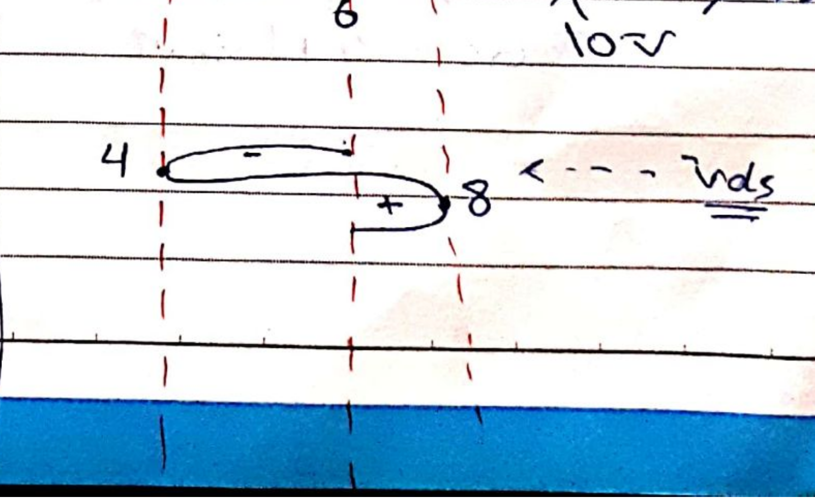


- From DC → $V_{GSQ} = 4V$, $I_{DQ} = 4mA$

$V_{DSQ} = 6V$, $V_{TN} = 2V$, $K_n = 1mA$

$i_D = K_n(V_{GS} - V_{TN})^2$, $\boxed{i_{D_T} = 4 + i_d}$





Voltage gain $= \frac{v_{ds}}{v_{si}}$

↳ A.C

DC

$\frac{v_{ds(p-p)}}{v_{si\,p}} = \frac{5-1}{1--1} = -2$

* ملاحظة كل تيارات DC ، راح نرمزله بال Capital ، وكل شي A.C بال small .

* هنا بال Total كله ، رح يكون مجموع ال A.C مع ال DC .

"super position"

- When v_{si} is Applied it will Cause an A.C v_{gs} which will Cause an A.C i_d, this current will Cause an A.C v_{ds}.

- But, the Amplifier contains A.C and D.C, the total response will be AC + DC, According to super position theorem, because Amplifier is linear cct.

- كل ال super position بتطبق فقط على ال Linear cct .

- then:

$$v_{GS} = V_{GSQ} + v_{gs} \quad \text{(D.C, A.C)} \rightarrow \text{total instantanious}$$
$$i_D = I_{DQ} + i_d$$
$$v_{DS} = V_{DSQ} + v_{ds}$$

- For the previous cct:

$V_{GSQ} = 4v$, $v_{gs} = 1\sin\omega t$ v

$v_{GS} = 4 + 1\sin\omega t$

* Ac Analysis using Mosfet Model (equivalent cct)

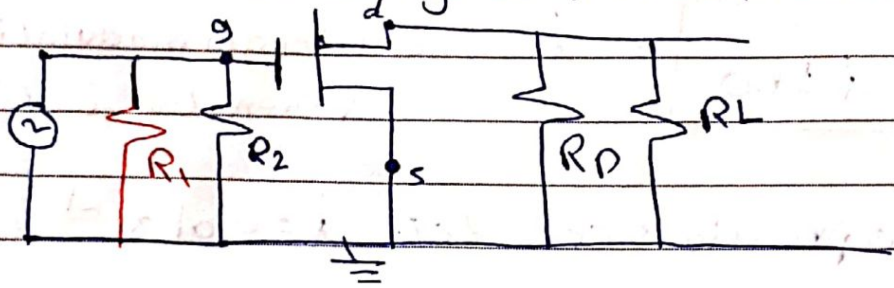
- For Ac analysis all Capacitors and DC → short cct.

1. $X_C = \frac{1}{2\pi f c} \Rightarrow$ For D.C → $f=0 \Rightarrow X_C=\infty \Rightarrow$ O.C

   $\Rightarrow$ For A.C → $f=\uparrow \Rightarrow X_C = \text{zero} \Rightarrow$ S.C

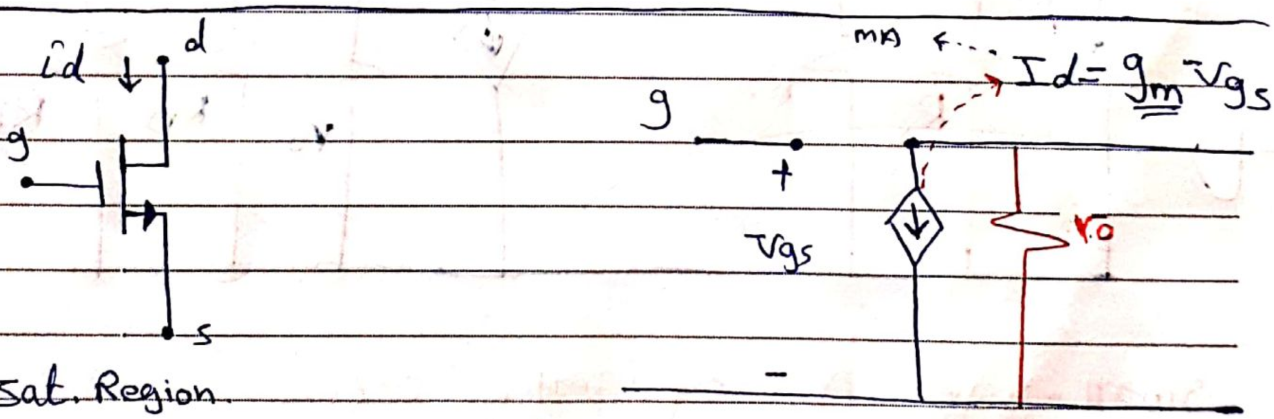
   $\Rightarrow$ (obtain Ac cct)

2. Replace Mosfet by it's model.



ليش قلنا ال DC في دارة ال A.C ؟ S.C ؟

لأنه قيمة ال D.C لا تتغير بتغير قيمة ال A.C وبعتبر ثابته.



Sat. Region

gm : trans Conductance

(A/V , mA/V , μA/V) ...

$$g_m = \frac{\partial I_D}{\partial V_{GS}} = \frac{\partial (K_n (V_{GS} - V_{TN})^2)}{\partial V_{GS}} \Rightarrow$$

$$\boxed{g_m = 2K_n (V_{GS} - V_{TN}) \text{ OR } g_m = 2\sqrt{K_n I_D}}$$

(8)

⊛ لاحظ كيف إن الـ gm تعتمد كل قيمها على D.C ، لا بد من الـ D.C analysis .

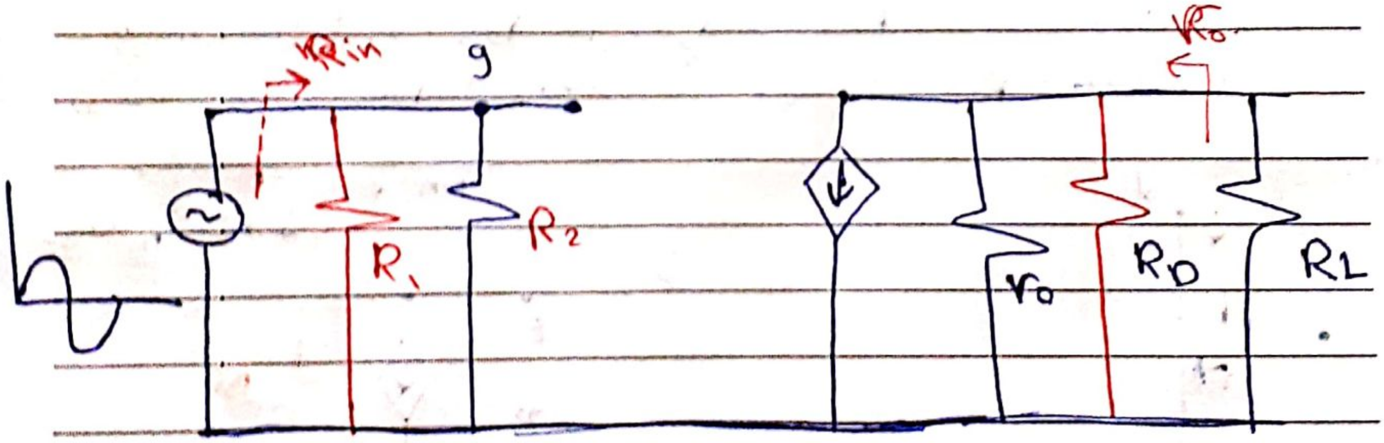
⊛ المقاومة r_o : هي المقاومة اللي ممكن أن تتواجد بين الـ drain و الـ source تسمى "output resistance"

- If the Mosfet has an o/p resistance r_o, then it must be included in model.

$$\boxed{r_o = \frac{1}{\lambda I_{DQ}}}$$

و λ: Channel Length modulation parameter (v^{-1})

- In the previous cct let $\lambda = 0.01\ v^{-1}$



"Small-signal A.C equivalent cct"

ليش بنسميها هيك ↑ ؟

لأنه عنصر الـ (Transister) بيشتغل بالـ sat. region

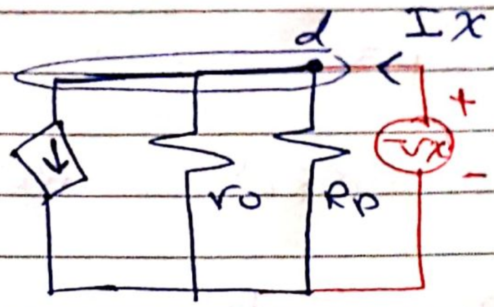
لهيك بنحكي هاد الاسم ، هي فعليًا "Linear cct"

(9)

- Input Resistance:

$R_{in} = R_1 // R_2 = 20 // 30 = 12\,k\Omega$.

- out put Resistanse: $R_o = \left.\frac{v_x}{I_x}\right|_{v_{si}=0}$



- KCL at Node (d):

$I_x = \frac{v_x}{R_D} + \frac{v_x}{r_o} + g_m v_{gs}$

- but when $v_{si} = 0$, $v_{gs} = 0$

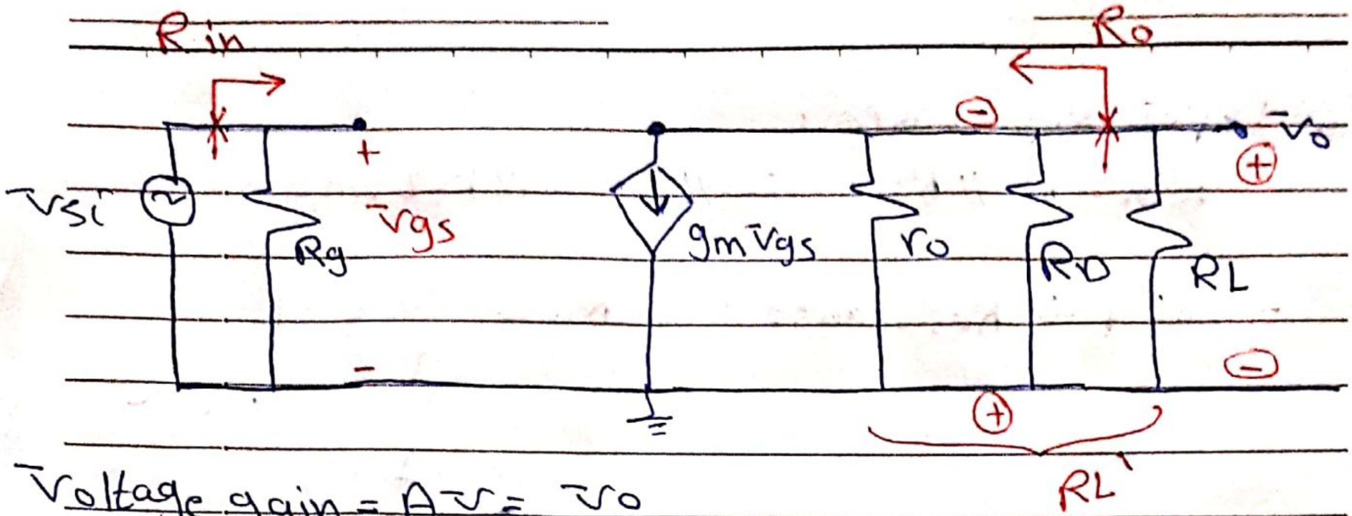
then $g_m v_{gs} = 0$

$$I_x = v_x\left(\frac{1}{r_o} + \frac{1}{R_D}\right)$$

$$\frac{I_x}{v_x} = \frac{1}{R_o} = \frac{1}{r_o} + \frac{1}{R_D} \Rightarrow \boxed{R_o = r_o // R_D}$$

١٠

الماحي مزة رقم 3



$$\text{Voltage gain} = A_v = \frac{v_o}{v_{si}}$$

$$v_o = -g_m v_{gs} R_L' \quad ; \quad R_L' = r_o \parallel R_D \parallel R_L .$$

$$v_{gs} = v_{si} \quad \therefore A_v = \frac{v_o}{v_{si}} = \frac{-g_m \cancel{v_{gs}} R_L'}{\cancel{v_{si}}} =$$

$$A_v = - g_m R_L'$$

↳ phase shift of 180° between v_o and v_{si}.

$$g_m = 2\sqrt{K_n I_D} \Rightarrow g_m = 4 mA/V$$

$$r_o = \frac{1}{\lambda I_D} = \frac{1}{0.01 * 4 * 10^{-3}} = 25 K\Omega .$$

$$A_v = -4 (25 \parallel 1 \parallel 9) \simeq -4 * 0.85 = \boxed{-3.4}$$

$$A_v = \frac{v_o}{v_{si}} \Rightarrow v_o = A_v . v_{si} = -3.4 \, v_{si}$$

لم تفخيم

- تذكر : R_o ←-- excluded RL

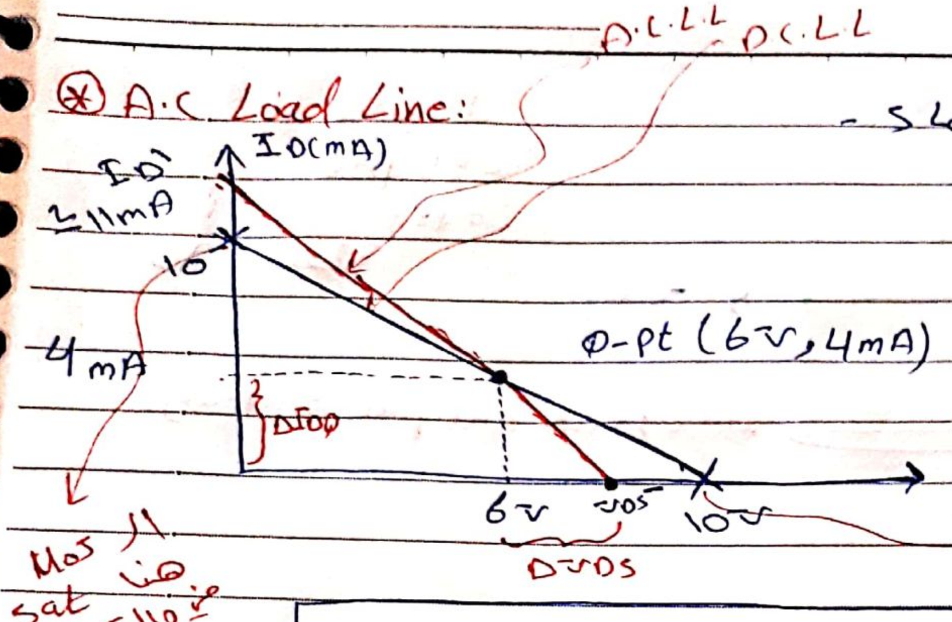
بحيث أن تغير الـ RL ، لا يؤثر على قيمة الـ R_o .

- بينما RL كلاقة قوية بالـ A_v ، كلما زادت الـ RL قلّ الـ A_v

- تذكر الـ r_o : هي مقاومة داخل للـ Mosfet ليس لها وجود

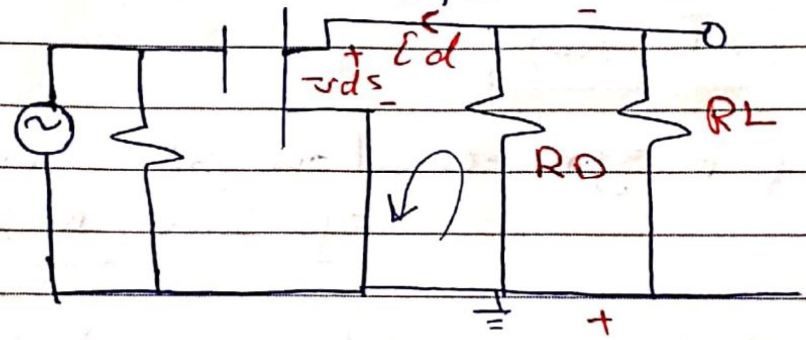
⊛ A.C Load Line:

$-\text{slope} = \frac{-1}{1K\Omega} = \frac{-1}{R_D} = \frac{-1}{1K}$



$\Delta V_{DS} = V_{DS}' - V_{DSQ}$

- write KVL for A.C cct.



$v_{ds} + i_d(R_D // R_L) = 0 \Rightarrow v_d = -i_d(R_D // R_L)$

$\rightarrow$ A.C.L.L equation

$i_d = -\frac{1}{R_D // R_L} * v_{ds} \Rightarrow \text{slope} = \frac{-1}{R_D // R_L} = \frac{-1}{1//9}$

$v_{DS} = V_{DSQ} + v_{ds}$

$i_D = I_{DQ} + i_d$

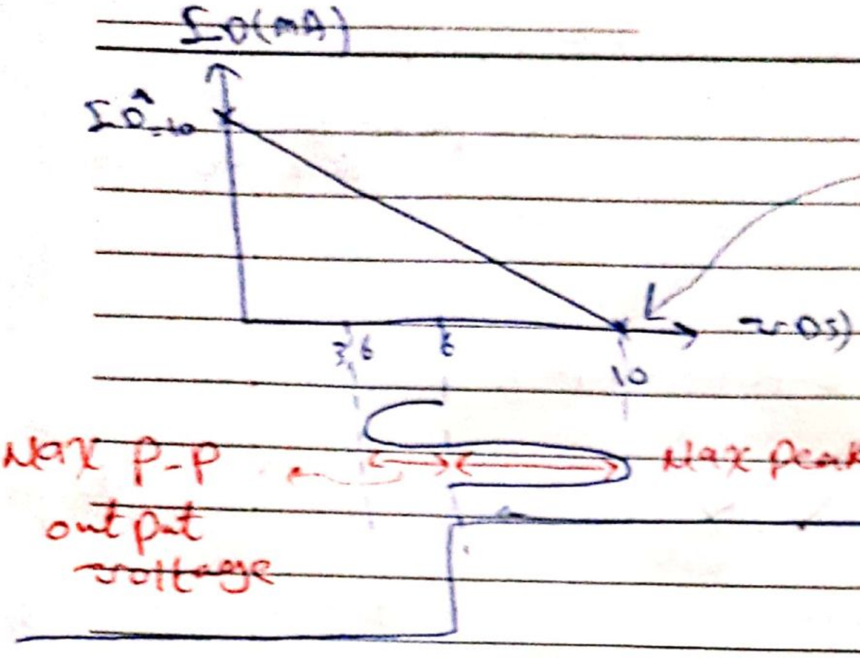
$\Rightarrow$

$V_{DS}' = V_{DSQ} + \Delta V_{DS}$

$\text{Slope} \Rightarrow \frac{\Delta I_D}{\Delta V_{DS}} \Rightarrow \Delta V_{DS} = \text{Slope} * \Delta I_D = -R_L // R_D * \Delta I_D$

$|\Delta V_{DS}| = I_{DQ}(R_L // R_D) = 3.6\,V$

$\boxed{I_{DQ} = \Delta I_D \quad V_{DS}' = 9.6\,V}$

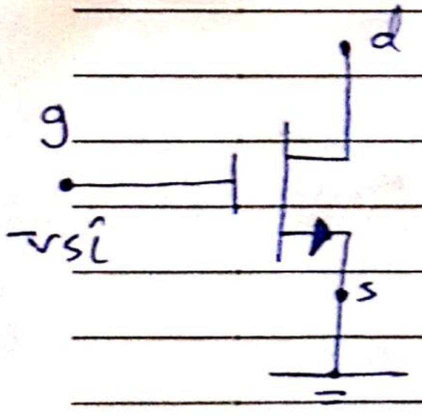


لا يمكن لل out put ان تكون اكبر من ٥ لأن النقطة

- Max peak symmetrical out put voltage = ΔV_D = $\boxed{I_{DQ}(R_D \parallel R_L)}$

- Max p-p symmetrical out put voltage = $2 * \Delta V_{DS}$ = $\boxed{2 I_{DQ}(R_L \parallel R_D)}$

(*) ملاحظة : دائماً $\text{slope}_{D.C} < \text{slope}_{A.C}$



- Amp. configuration (Connection)

C.S

1 Common Source Amp

S → Common Terminal.
- Input to gate //.
- output to drain //.

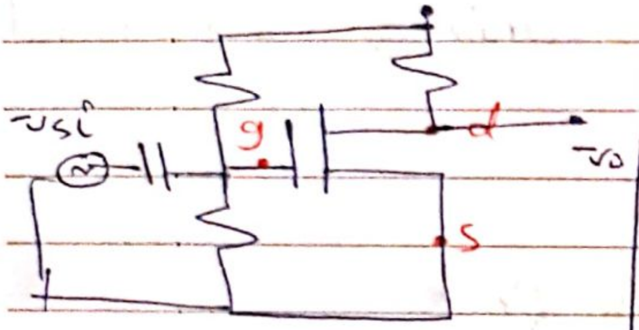
(i) Basic Common source Amp.
(S → directly connected to ground).

محاضرة(٦) ٤ ١١

② Mosfet Amp configration:

① C.s Amp :- (input to gate), (out put from drain)

source → Common terminal



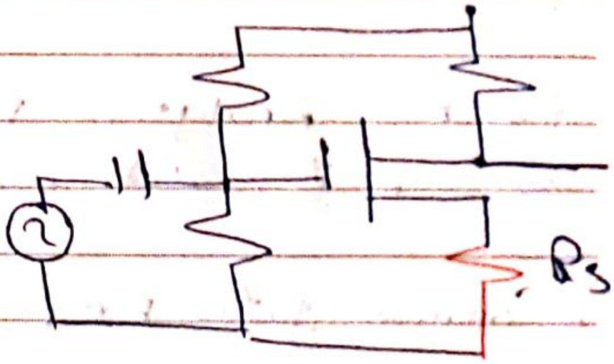
$\boxed{\phi = 180^\circ}$

فرق ال In بين ال out

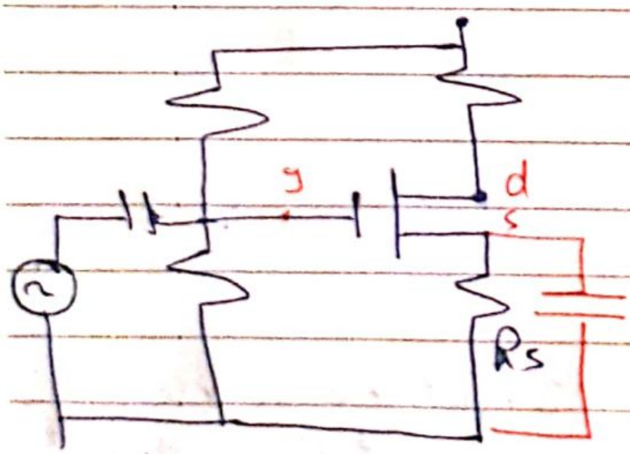
② C.s with Rs

"source - follower"

$\underline{A_v \simeq 1}$

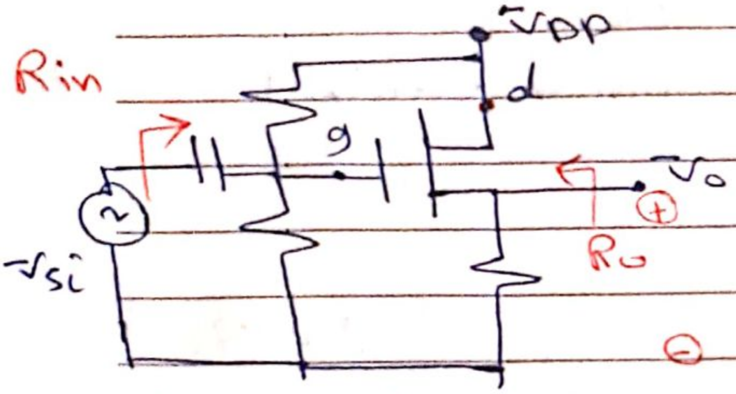


③ C.s with by pass Capacitor



14

[2] Common drain Amp:



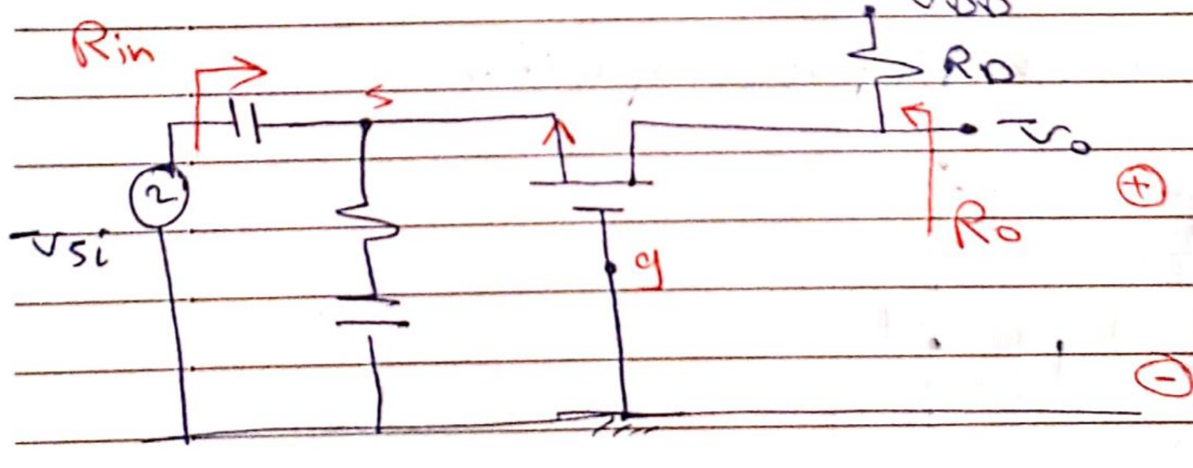
"Input to gate out from Source"

drain → Common terminal

- $\phi = 0 \Rightarrow V_o, V_{si} \Rightarrow$ in phase.

- For A.C Analysis Ds S.C → بروح للأرض
لوصل باذا تحطها او اي كاباستر لإنه بيروح

[3] Common gate Amp ⇒ G.G. Amp.

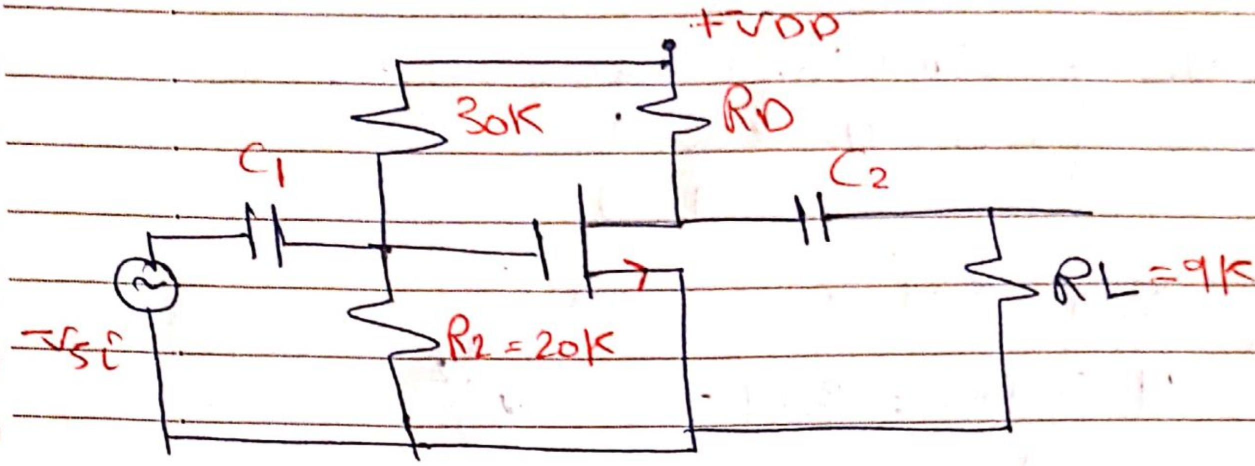


$\Phi = 0$

"Input to source out put from drain"

Common terminal: gate.

- C.S. Amp: C.S with source resistance:



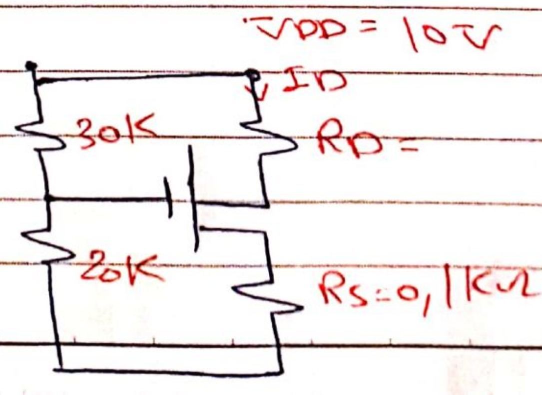
$K_n = 1\,mA/V^2$, $V_{TN} = 2V$, $\lambda = 0{,}01\,V^{-1}$

Sol: from D.C analysis ⇒
$V_{GS} = 4V$, $I_D = 4mA$, $V_{DS} = 6V$, $V_{DS(sat)} = 2V$.

- لو غيرنا ال Kn وخليناه Kn=2,5 ⇐ $I_D = 10mA$
$V_{DS} = 0 < V_{D(sat)}$

- لاحظ كيف تعديل قيمة صغيرة كال Kn أهم وانه بتاخذ
ال Mos مش في حالة ال sat ، لهيك
واحنا نحط مقاومة كال source ← (واشي ما 0,1 KΩ)

For. DC Analysis ⇒



16

Assume the Mos in sat Region.

- $I = \frac{10}{50K} = 0{,}2mA$

$\Rightarrow$ KVL: $-0{,}2m \times 20K + V_{GS} + I_D \cdot R_S = 0$

$$\boxed{I_D = \frac{4 - V_{GS}}{0{,}1}}$$

$\Rightarrow$ $I_D = K_n (V_{GS} - V_{TN})^2$

$$\frac{4 - V_{GS}}{0{,}1} = 2{,}5 (V_{GS} - 2)^2$$

$$4 - V_{GS} = 2{,}5 \times 0{,}1 (V_{GS}^2 - 4V_{GS} + 4)$$

$$\frac{3}{0{,}25} = V_{GS}^2 \Rightarrow \boxed{V_{GS} = \sqrt{12} \text{ volt}}$$

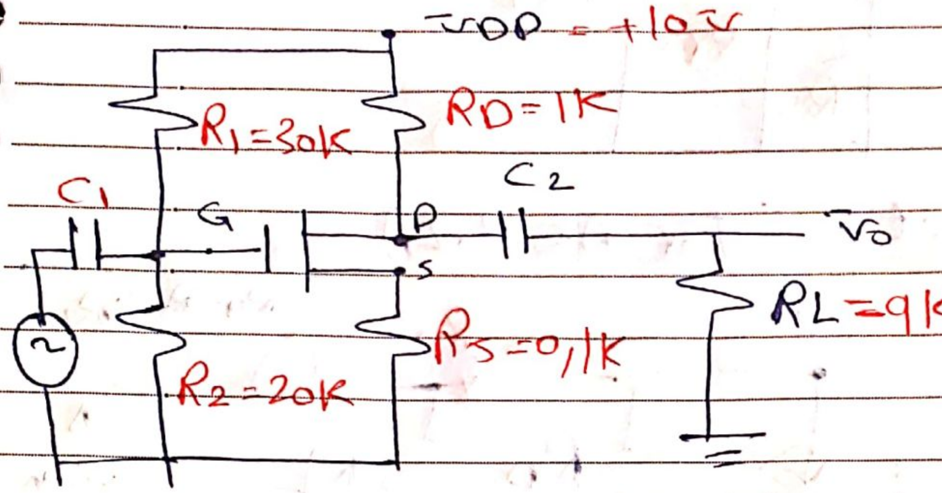
sat ✓

(V_{DS}) نعوض بـ

V_D

"الاطهارة رقم 5"

(*) C.S with Rs:



$K_n = 2{,}5\,mA/V^2$

$V_{TN} = 2V$

$\lambda = 0.$

(*) Calculate: ① V_{GSQ}, I_{DQ}, V_{DSQ}, V_S, V_D, P_D

② Draw S.S.A.C equivelant cct, Determine A_v, R_{in}, R_o.

③ Write D.C and A.C L.L and find their slope.

Sol: From D.C analysis:

$V_{GSQ} = 3{,}45V$, $I_D = 5{,}5mA$,

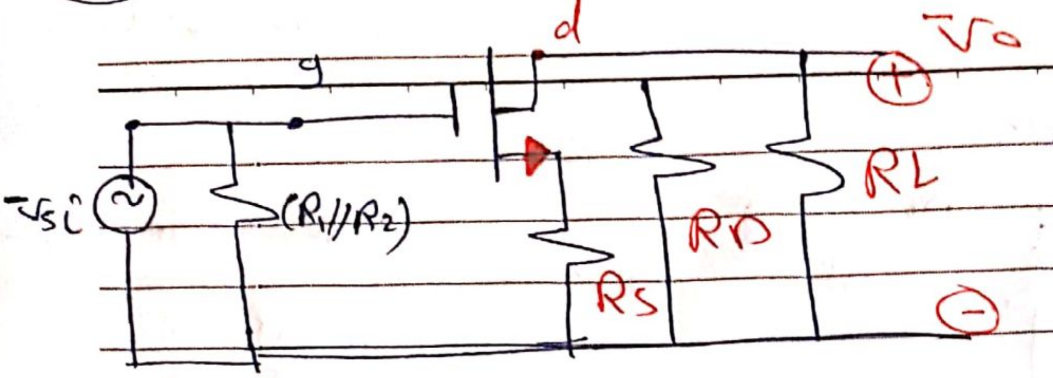
$V_{DS} = 3{,}95V$, $V_{D(sat)} = 1{,}45$ volt.

$V_S = I_D . R_S = 0{,}55V$

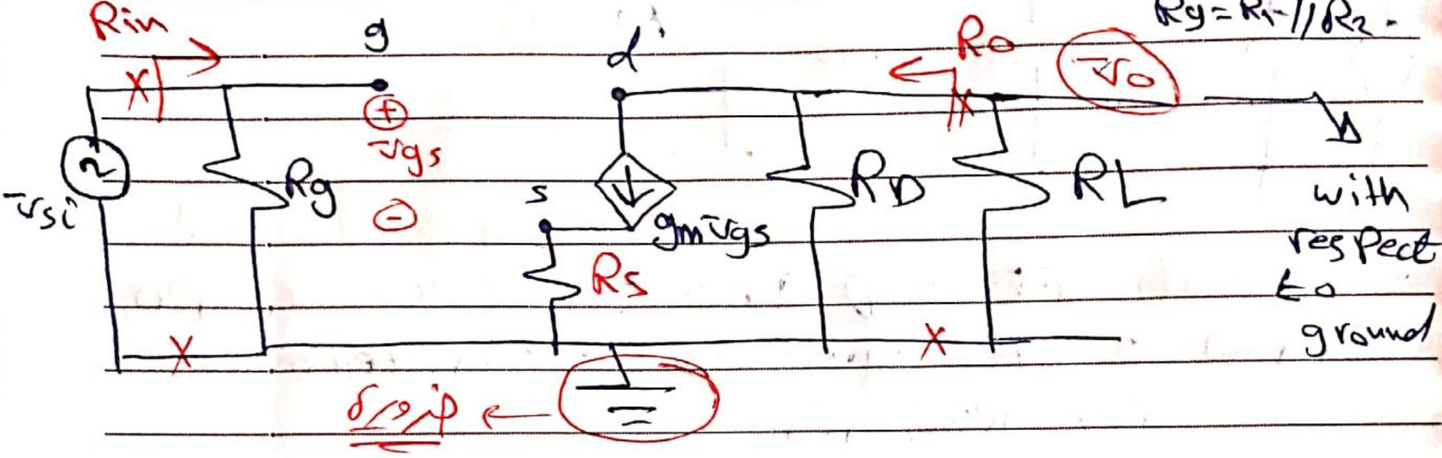
$V_{DS} = V_D - V_S \Rightarrow V_D = 3{,}95 + 0{,}55 = 4{,}5V$

P_D = power dissapeted in the Mos $= I_D V_{DS}$

$= 5{,}5mA * 3{,}95 = \text{---}$ mwatt.



A.C cct. (for A.C L.L)



"Small signal equivilent cct"

$$A_v = \frac{v_o}{v_{si}} \Rightarrow v_o = -g_m v_{gs} (R_D // R_L)$$

$$v_{si} = v_{gs} + g_m v_{gs} R_s$$

$$\boxed{\frac{v_{si}}{1 + g_m R_s} = v_{gs}}$$

$$v_o = -g_m \left(\frac{v_{si}}{1 + g_m R_s} \right) (R_D // R_L)$$

$$\boxed{\frac{v_o}{v_{si}} = A_v = \frac{-g_m}{1 + g_m R_s} (R_D // R_L)}$$

phase between v_{si} and v_o.

$\boxed{A_v = -2.3} \Rightarrow \phi = 180°, \quad A_v > 1$

Note that R_S reduces A_v.

- R_S, stabilize Q-pt against K_n parameter variation (بالتالي $A_v \downarrow$.)

$\Rightarrow R_{in} = R_g = R_1 \parallel R_2 = 12\,k\Omega.$

$\Rightarrow R_o = \left.\dfrac{v_x}{I_x}\right|_{v_{si}=0}$ $\Rightarrow$ Dependent source is open cct,

$R_o = R_D = 1\,k\Omega.$

- D.C.L.L $\Rightarrow -V_{DD} + I_D R_D + V_{DS} + I_D R_S = 0$

$V_{DS} = V_{DD} - I_D(R_D + R_S)$

- slope $\Rightarrow \dfrac{-1}{R_D + R_S}$

- A.C.L.L $\Rightarrow$

$v_{DS} + I_D R_S + I_D(R_D \parallel R_L) = 0$

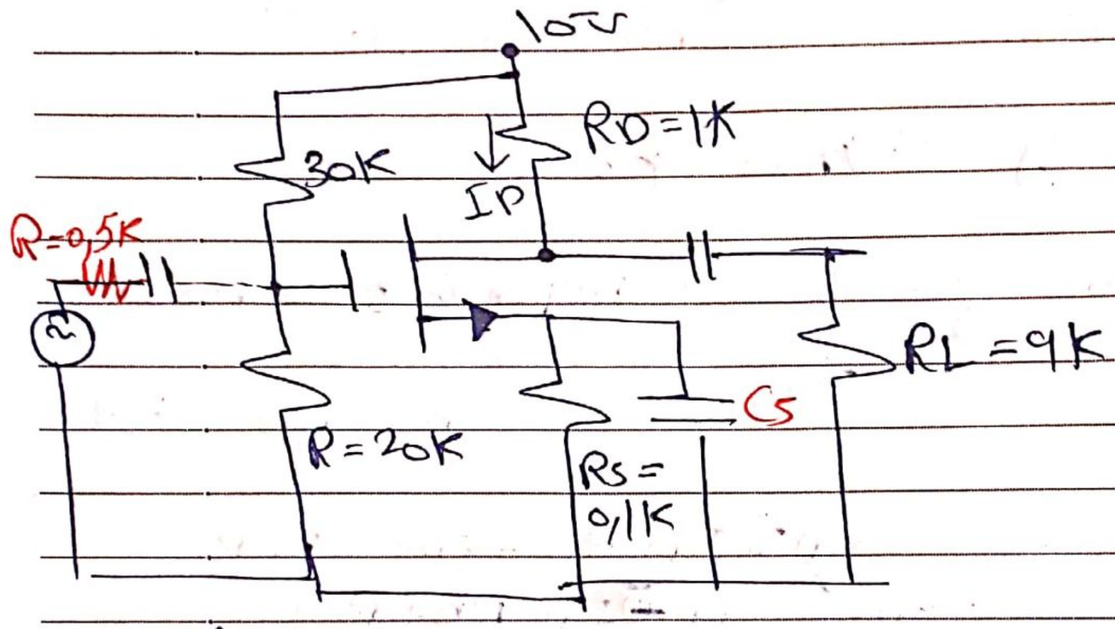
$v_{ds} = -I_D(R_S + R_D \parallel R_L)$

$\text{slope} = \dfrac{-1}{(R_S + R_D \parallel R_L)}$

⊛ C.S with by-pass Capacitor:

- هاهم الإشي بيفرق بكصفورين لاكبر واهر، ومعنا حظ الـ ثبات الـ Q-pt ومنه ما بيطلع الـ Av ← يقل.

بيتفق مع open cct الـ D.C و S.C مع الـ A.C.



[1] Find V_{GSQ}, I_{DQ}, V_{DSQ}, V_D, V_S.

[2] Draw S.S. A.C eq cct and find A_V, R_{in}, R_o

[3] Write D.C, A.C.L.L equs and find their slopes

[4] Calculate Max (P-P) Symmetrical o/p Voltage.

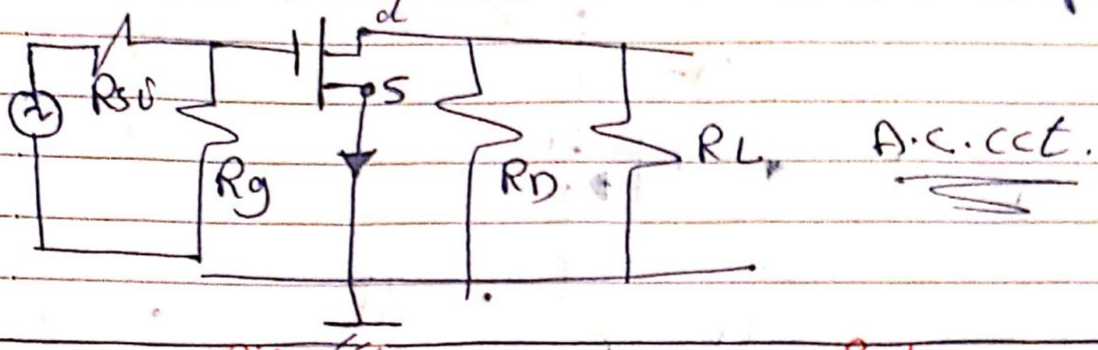
Sol: For D.C Analysis

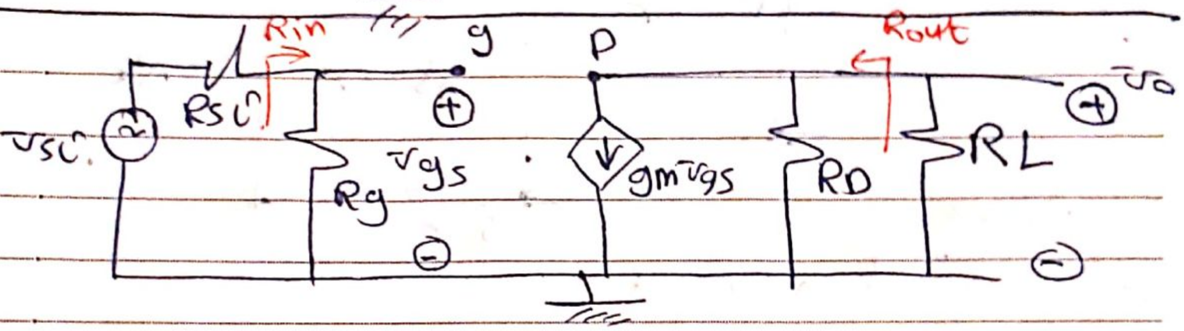
- all Caps → o.c

the cct is analysied as Common Source with

R_S $V_{GSQ} = 3,45\ v$, $I_{DQ} = 5,5\ mA$, $V_{DSQ} = 3,95\ v$

- For A.C all caps and D.C sources are s.c and the cct behaives as basic C.S. Amp.





- $R_{in} = R_g$, $R_o \Rightarrow \left.\frac{v_x}{I_x}\right|_{v_{gsi}=0} = R_D$

$A_v = \frac{v_o}{v_{si}} \Rightarrow v_o = -g_m v_{gs}(R_D // R_L)$

$\rightarrow$ $v_{gs} = \frac{v_{si} * R_g}{(R_{si} + R_g)}$

$v_o = -g_m \left(\frac{v_{si} * R_g}{(R_{si} + R_g)}\right) * (R_D // R_L)$

Av

$\frac{v_o}{v_{si}} = A_v = -g_m \left(\frac{R_g}{(R_{si} + R_g)}\right) * (R_D // R_L) = -6.2$

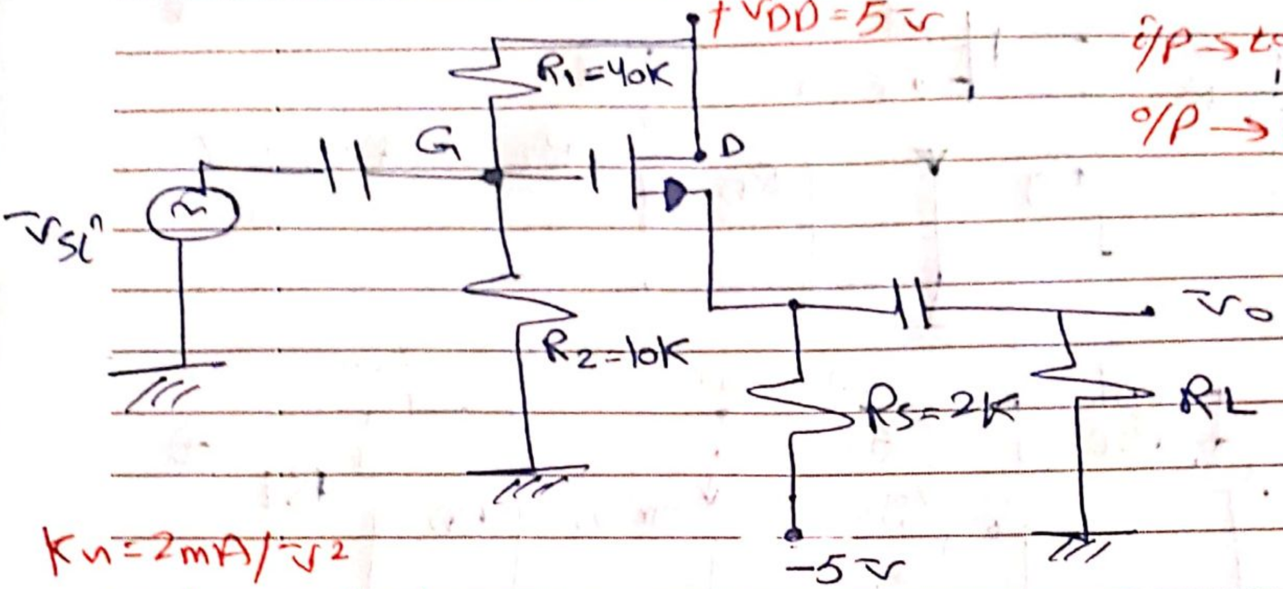
- Max(P-P) $\rightarrow$ symmetrical out put voltage

$\therefore v_{o\,max}(P\text{-}P) = \boxed{2 * I_{DQ}(R_L // R_D)} = \boxed{9.9\,v}$

محاضرة رقم (6)

[2] Common Drain Amp.

For D.C.
D is at ground
i/p → to gate
o/p → from s



$K_n = 2mA/V^2$
$V_{TN} = 1V$, $\lambda = 0.02 V^{-1}$.

① Calculate, V_{GSQ}, I_{DQ}, V_{DSQ}
② Draw S.S.A.C equ cct, find A_V, R_{in}, R_o.
③ write D.C and A.C.L.L and find slopes.

- For D.C, all Capacitors O.C:

$$-V_{DD} + I(50K) = 0 \Rightarrow I = \frac{5}{50K} = 0.1mA$$

$$\Rightarrow KVL: -1R_2 + V_{GS} + I_D R_S - 5 \Rightarrow I_D = \frac{6 - V_{GS}}{2}$$

$$I_D = K_n(V_{GS} - V_{TN})^2 \Rightarrow$$

$$\frac{6 - V_{GS}}{2} = 2(V_{GS}^2 - 2V_{GS} + 1)$$

$$6 - V_{GS} = 4V_{GS}^2 - 8V_{GS} + 4 \Rightarrow 4V_{GS}^2 - 7V_{GS} - 2$$

(23)

- $v_{GS} = -0.25\alpha$, $v_{GS_Q} = 2v \Rightarrow V_{TN}$ مقصودة لكن

$I_{DQ} = 2mA$, $v_{DSQ} =$

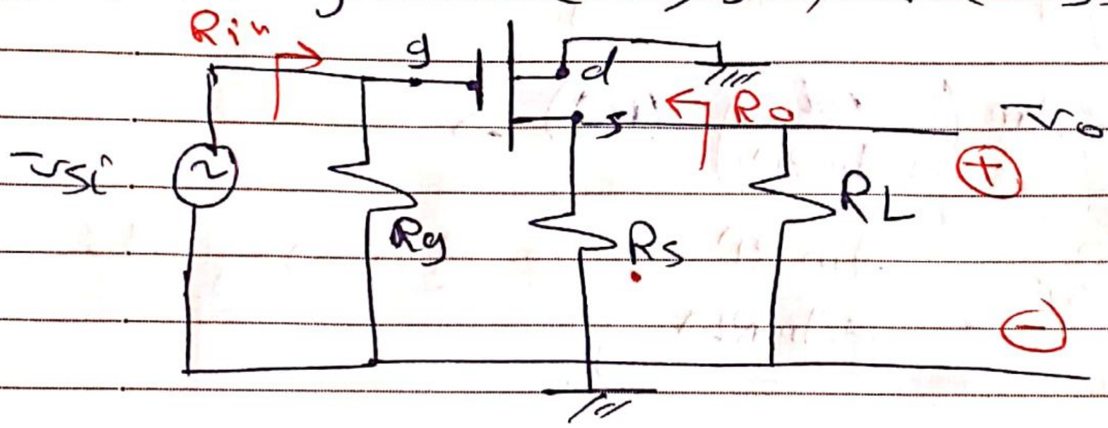
$\rightarrow -V_{DD} + V_{DS} + I_D R_S - 5 = 0 \Rightarrow V_{DS} = 6v.$

$V_{DS(sat)} = V_{GS} - V_{TN} = 2 - 1 = 1v.$

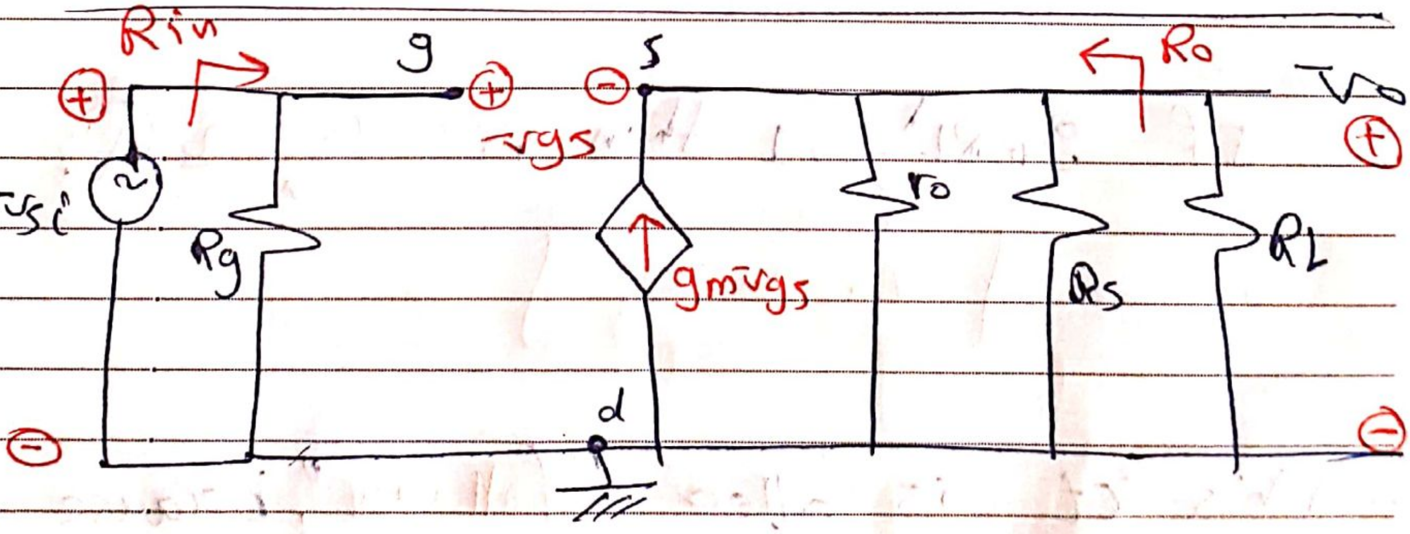
$v_S = -1v, \; v_D = 5v.$

نقول بال Sat ← نستطيع استخدامه ك Amplifier.

⊛ A.C analysis: $C \rightarrow S$, $D.C \rightarrow S$



A.C. cct S.S.



$R_{in} = R_g = R_1 // R_2 = 8K\Omega.$

$$v_o = g_m v_{gs}\underbrace{(r_o \parallel R_S \parallel R_L)}_{R_L'}$$

⇒ Loop → (ظ، ح) ⇒

$-v_{si} + v_{gs} + v_o = 0$ ⇒

$-v_{si} + v_{gs} + g_m v_{gs}(R_L') = 0$

$v_{si} = v_{gs}(1 + g_m R_L')$

$$\boxed{v_{gs} = \frac{v_{si}}{1 + g_m R_L'}}$$

* $v_o = g_m \left(\frac{v_{si}}{1 + g_m R_L'}\right)(R_L')$ ⇒

$$\boxed{A_v = \frac{v_o}{v_{si}} = \frac{g_m R_L'}{1 + g_m R_L'}}$$ → هاك قانون 1

$A_v < 1$, $\Phi = \text{zero}$ (v_o v_{in} بتأخذ)

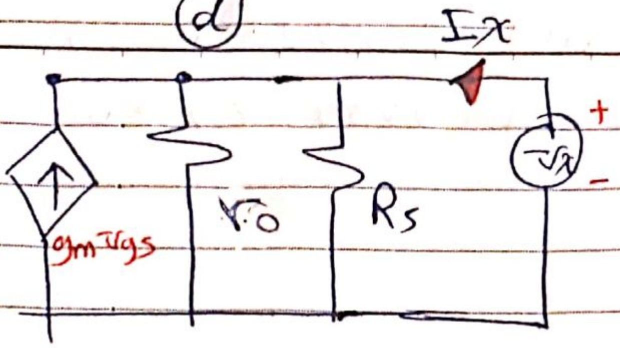
– If $g_m R_L' \gg 1$ then $A_v = \frac{v_o}{v_{in}} \simeq 1$

$$\boxed{v_o \simeq v_{si}}$$

– This cct is called "follower", because v_o is approximatly follows v_{si} in taken from Source.

هذول cct، لا نستعملها كـ Amp ← لأنها ما بتكبر.

(25)



$\left.\dfrac{v_x}{I_x}\right|_{v_{si}=0}$

- KCL at Node (d) :

$\Sigma I_{in} = \Sigma I_{out} \Rightarrow g_m v_{gs} + I_x = v_x\left(\dfrac{1}{r_o} + \dfrac{1}{R_s}\right)$

- Look, when $v_{si} = 0 \Rightarrow$ then $v_{gs} = -v_x$

$$I_x = \frac{v_x}{r_o} + \frac{v_x}{R_s} + v_x g_m$$

$$\frac{I_x}{v_x} = \frac{1}{R_o} = \frac{1}{r_o} + \frac{1}{R_s} + g_m \quad \text{then}$$

$$R_o = \left(r_o \,//\, R_s \,//\, \frac{1}{g_m}\right) \Rightarrow \text{Note: Low } R_o.$$

$$R_o = \frac{1}{\lambda I_D} \,//\, R_s \,//\, \frac{1}{2\sqrt{k_n I_D}} \Rightarrow 250\Omega \,//\, 25K \,//\, 2K$$

$$\simeq \boxed{220\,\Omega} \rightarrow$$ ∴ أقل من أقل وحدة

D.C.L.L $\Rightarrow -5 + v_{DS} + I_D R_s - 5 = 0$

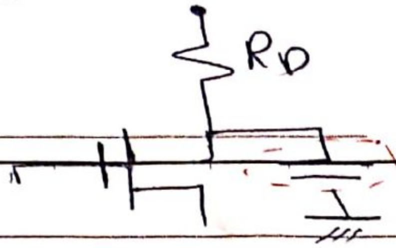
$$v_{DS} = 10 - I_D R_s$$

$$\text{Slope} \Rightarrow -\frac{1}{R_s} = -\frac{1}{2K}$$

(*) A.C.L.L $\Rightarrow$

$\underbrace{v_{DS} + I_D(R_s \,//\, R_L)}_{=0} \Rightarrow \text{Slope} \Rightarrow -\dfrac{1}{R_s \,//\, R_L}$

(26)



ع/ يفضل Common Drain

ال RD ع تشتغل بالـ DC

بس ما/ ع تشتغل بالـ A.C.

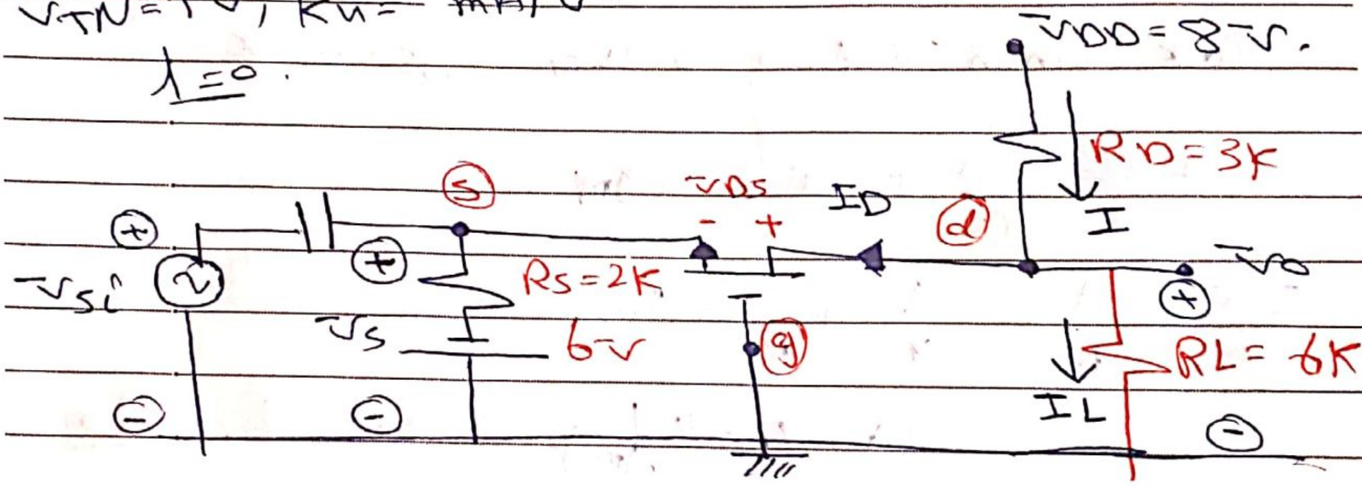
محاضرة رقم "7"

* Common-gate Amp:

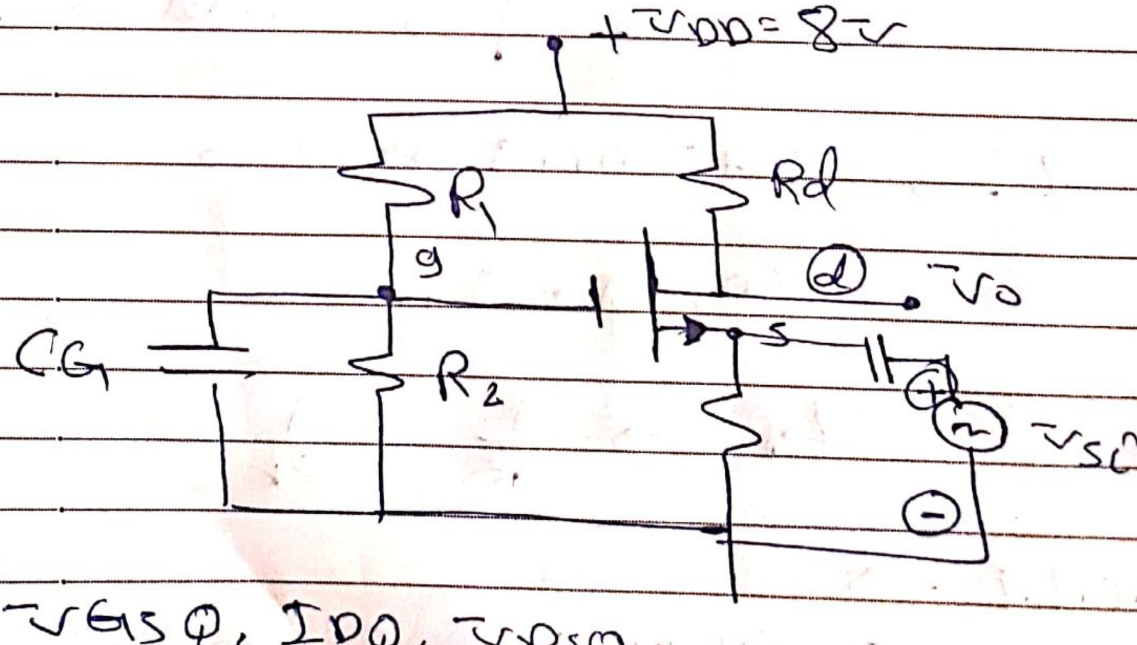
- i/p to source.
- o/p from Drain.
- gate: Common terminal.

$V_{TN} = 1V$, $K_n = 1\ mA/V^2$

$\lambda = 0$.



هاي الدارة بآخر :



Find: ① V_{GSQ}, I_{DQ}, V_{DSQ},

② Draw s.s eq cct and Find A_V, R_{in}, R_o.

A.C

(27)

in D.C. Analysis

- Assume the MOS in sat region: $\Rightarrow$ all C_{ap} O.C

$I_D = K_n(V_{GS} - V_{TN})^2$

$V_{GS} = V_G - V_S \Rightarrow \boxed{V_G = 0}$

$-V_S + I_D R_S - 6 = 0$

$\boxed{V_S = -6 + I_D R_S}$

$V_{GS} = 0 - 6 + I_D R_S \Rightarrow I_D = \dfrac{-V_{GS} + 6}{R_S}$

$\dfrac{6 - V_{GS}}{R_S} = \overset{1\,mA/V}{\cancel{K_n}}(V_{GS} - 1)^2$

$6 - V_{GS} = 2(V_{GS}^2 - 2V_{GS} - 1)$

$2V_{GS}^2 - 3V_{GS} - 4 = 0$

$\boxed{V_{GS} = 4\,V}$

- $I_{DQ} = \dfrac{6-4}{2K} = \boxed{1\,mA}$

- to find V_{DS}: $\Rightarrow$

$-V_{DD} + I R_D + V_{DS} + I_D R_S - 6 = 0$

- KCL on Node (d): $\sum I_{in} = \sum I_{out}$

$I = I_L + I_D \Rightarrow \dfrac{V_{dd} - V_d}{3K} = \dfrac{V_d}{6K} + 1\,mA$

$8 - V_d = 0{,}5\,V_d + 3$

$5 = 1{,}5\,V_d \Rightarrow \boxed{V_d = 3{,}33\ \text{volt}}$

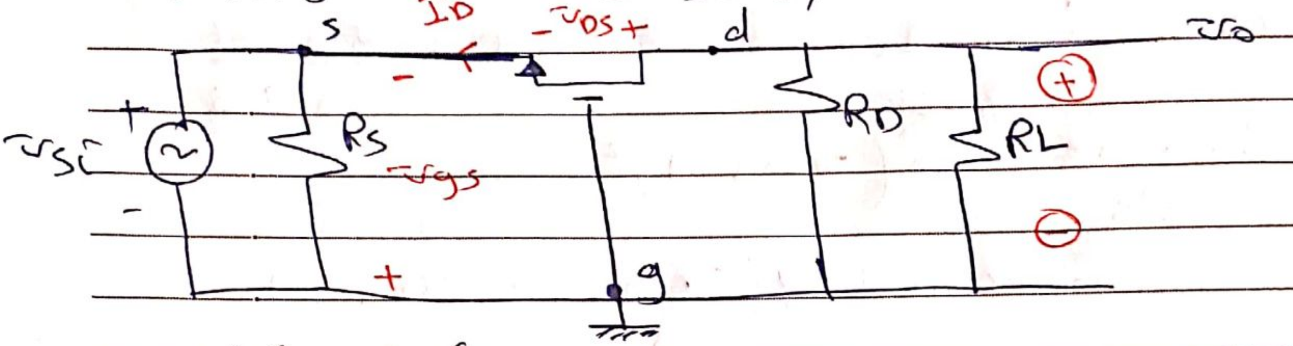
$\Rightarrow I = \dfrac{8 - 3{,}33}{3K} = \boxed{1{,}55\,mA}$

$V_{DS} = 14 - 1.55mA \times 3K - 1mA \times 2K$

$\boxed{V_{DS} \simeq 7 \text{ volt}}$

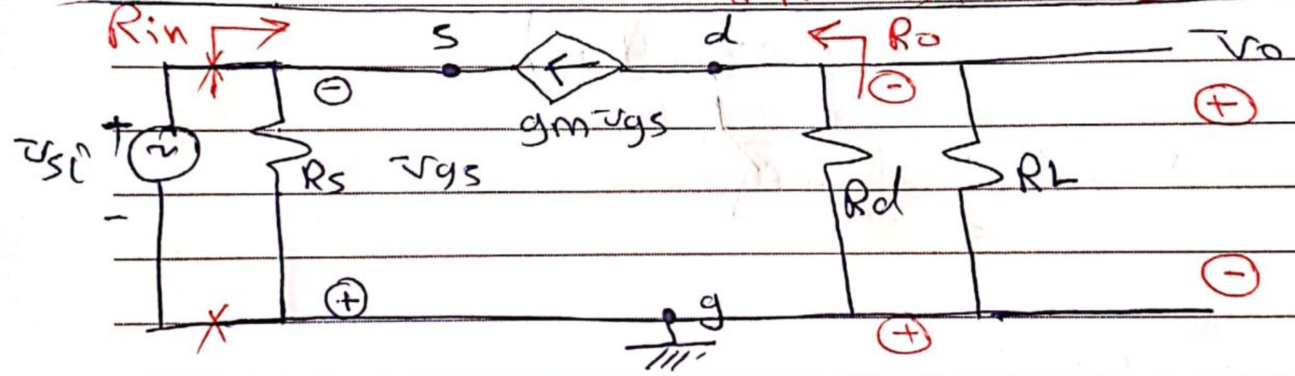
$V_{DS(sat)} = V_{GS} - V_{TN} = 4 - 1 = \boxed{3 \text{ volt}}$

- A.C analysis: C → S.C , D.C → S.C



~~S.S.A.C~~ A.C cct

كمل معادلة ، (A.C.L.L) f.



" S.S A.C equ cct "

$$A_V = \frac{V_o}{V_{si}} \Rightarrow \frac{-g_m \cancel{V_{gs}}(R_d \| R_L)}{-\cancel{V_{gs}}}$$

$$A_V = g_m (R_d \| R_L)$$

1) $A_V > 1$, $\phi = 0°$

Assume $K_n = 2mA/V$

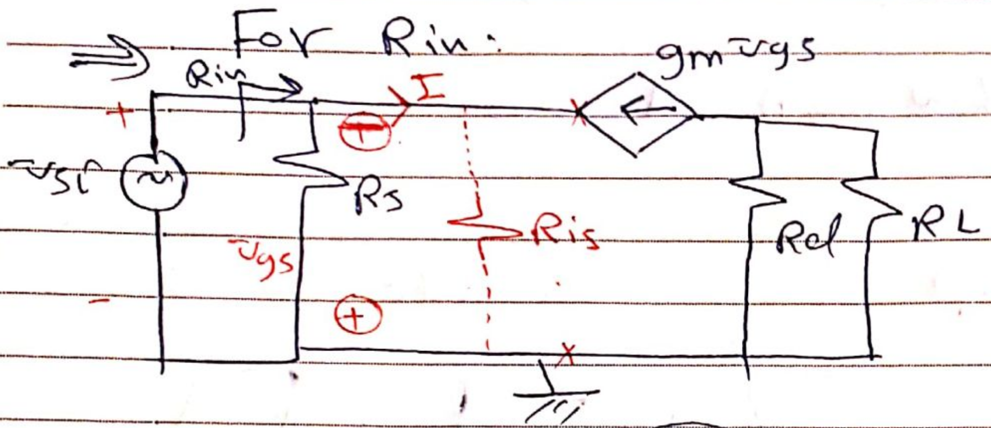
$g_m = 2\sqrt{K_n I_D} = 2\sqrt{2} = 2.828 mA/V$

$\Rightarrow \boxed{A_V = 5.6}$

- $R_o = \left.\dfrac{v_x}{I_x}\right|_{v_{si}=0}$ $\Rightarrow$ when $v_{si}=0$, then $v_{gs}=0$ i.e. $g_m v_{gs}=0 \Rightarrow$ dep source o.c $\Rightarrow$

$$\boxed{R_o = R_D = 3K\Omega.}$$

$\Rightarrow$ For Rin:



$$R_{is} = \frac{-v_{gs}}{-g_m v_{gs}} = \frac{1}{g_m} \quad // R_s$$

$$R_{in} = 2K \,//\, \frac{1000}{2,828} = 2K \,//\, 350\Omega \Rightarrow \boxed{\simeq 320\Omega.}$$

- Comparison of sigle-stage:

Amp	Av	ϕ	Rin	Ro
C.S	>1	180°	Moderate	Moderate
C.D	<1	0	Moderate	Low
C.G	>1	0	low	Moderate

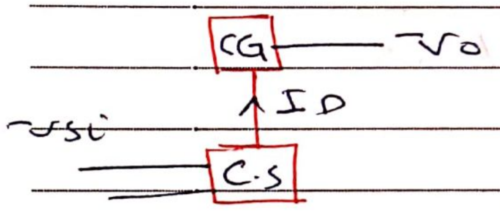
⊛ Multistage Amps:

- Amps contain more than single-Mosfet (at least two Mos), used to achieve certain combined specifications which can't be achieved using single-stage such as:

i) Low R_{in}, Low R_o, $A_v > 1$

ii) high A_v

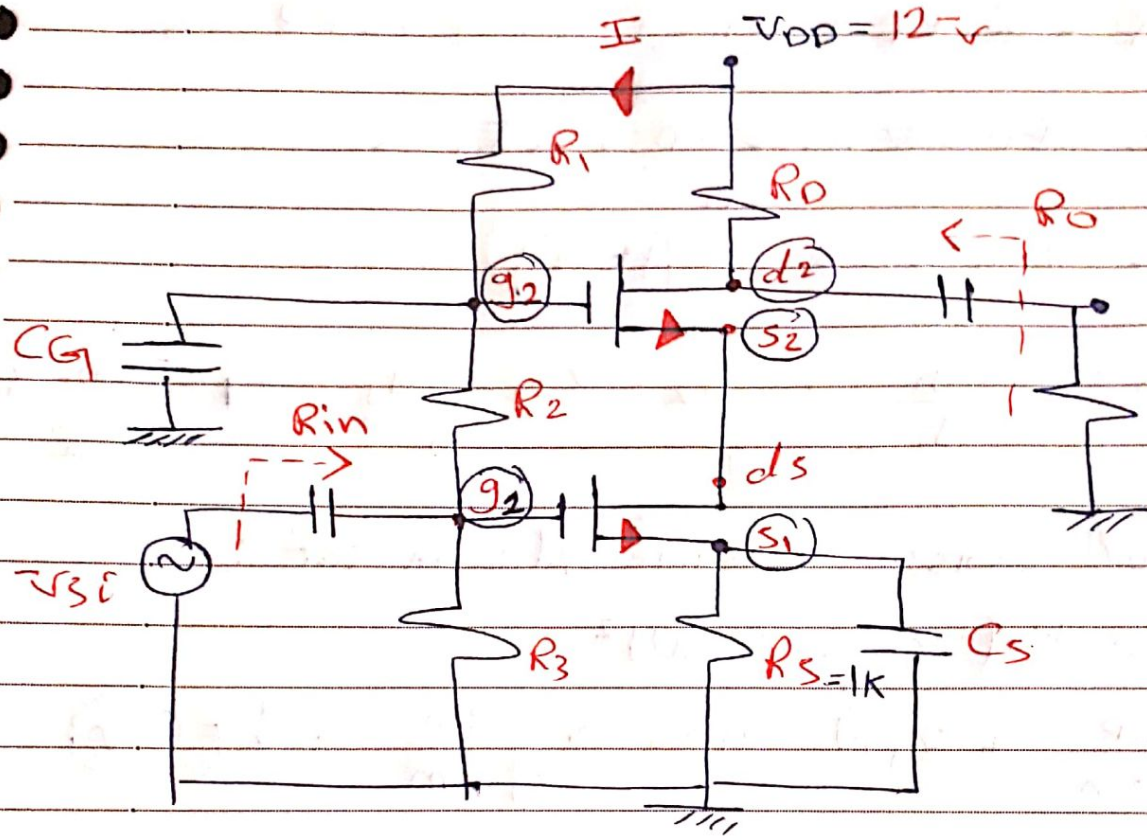
- Cascode Amp



Cascade

محاضرة رقم "8"

[1] Cas Code Multistage:



- Design the cct shown such that $I_{DQ} = 2mA$, $V_{DS_1} = V_{DS_2} = 4V$

Given M_1 and M_2 are identical with

$K_n = 2mA/V^2$, $V_{TN} = 1V$, $\lambda = 0$

Use $I = 10\% \, I_D \Rightarrow \boxed{I = 0.2mA}$

- (1) Find R_D, R_1, R_2, R_3.

(2) Draw s.s.A.C equ cct and find A_v, Rin, R_o

32

⇒ D.C Analysis: all capacitors O.C:

① $-V_{DD} + I_D R_D + V_{DS_2} + V_{DS_1} + I_D R_S = 0$

$$R_D = \frac{V_{DD} - V_{DS_1} - V_{DS_2} - I_D R_S}{I_D}$$

$$R_D = \frac{12 - 8 - 2}{2m} = \boxed{1K\Omega}$$

② $R_3 = \frac{V_{g_1}}{I}$, $R_2 = \frac{V_{g_2} - V_{g_1}}{I}$, $R_1 = \frac{V_{DD} - V_{g_2}}{I}$

⇒ Find V_{GS}: Assume MOS in sat:

$$I_D = K_n (V_{GS} - V_{TN})^2$$

$$\sqrt{\frac{I_D}{K_n}} + V_{TN} = V_{GS} \Rightarrow \sqrt{\frac{2m}{2m}} + 1 = 2V$$

⇒ $-V_{g_1} + V_{gs_1} + I_D R_S = 0$

$$V_{g_1} = 2 + 2m \times 1k = \boxed{4V}$$

$$R_3 = \frac{4}{0.2} = \boxed{20K}\Omega$$

→ $-V_{g_2} + V_{gs_2} + V_{DS} + I_D R_S = 0$

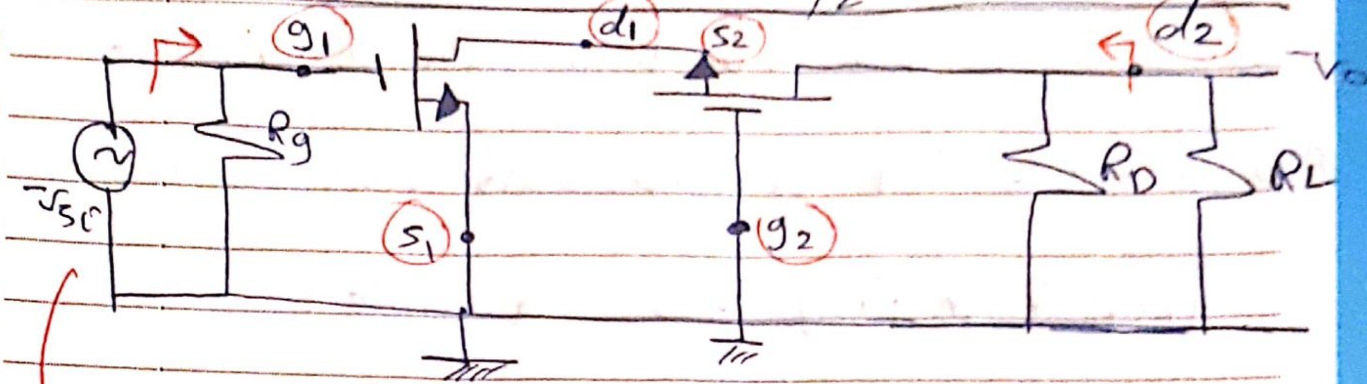
$$V_{g_2} = 2 + 4 + 2m \times 1k = \boxed{8V}$$

$$R_2 = \frac{8 - 4}{0.2} = \boxed{20K}\Omega$$

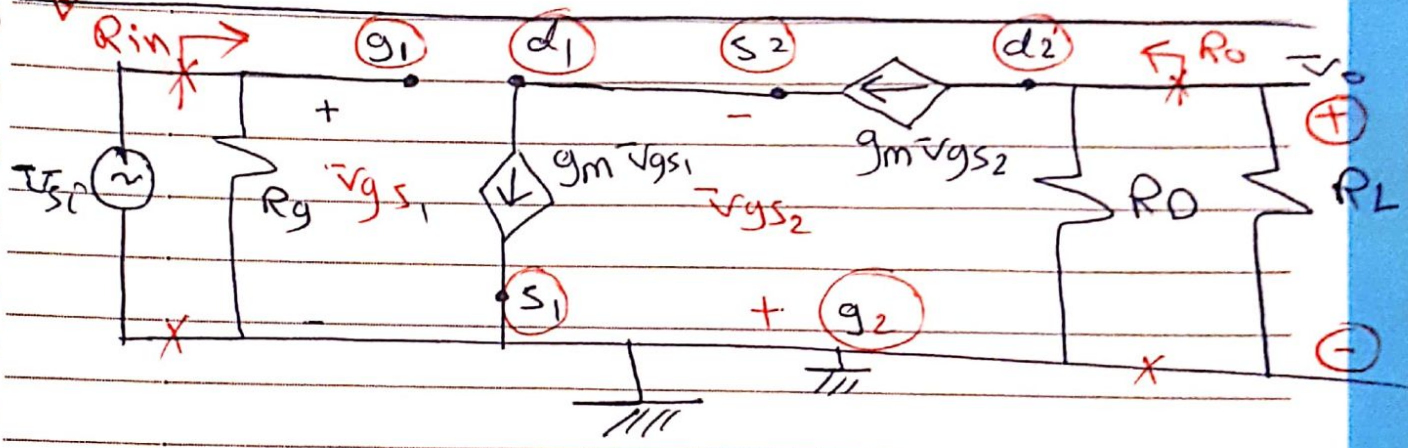
Scanned by CamScanner

33

$$\Rightarrow R_1 = \frac{V_{DD} - V_{g2}}{I} = \frac{12-8}{0.2} = 20K\Omega$$



A.C cct $\Rightarrow$ $R_g = R_1 // R_2$



S.S. A.C equ cct:

- $R_{in} = R_2 // R_3 \Rightarrow 20//20 = \boxed{10K\Omega}$

$$A_v = \frac{V_o}{V_{si}} = \frac{-g_m \cancel{V_{gs1}} \cdot (R_D // R_L)}{\cancel{V_{gs1}}} = -g_m (R_D // R_L)$$

$g_m = 2\sqrt{I_D K_n} = 4mA/V \Rightarrow A_v = -2{,}5$

$$R_o = \left.\frac{V_x}{I_x}\right|_{V_{si}=0} \Rightarrow R_o = R_D = 2K$$

* لاحظ أن دائرة ال Common gate لم تكبر التيار بال

Cascode دا اعطى ال gain تاعه نفس تاع ال C.S.

ليش؟ لأن ال ... ما فاتت عليه ال C.G فات التيار وهو ما كبر التيار

- $\boxed{\text{For high freq} \Rightarrow \text{Cascode.}}$

(34)

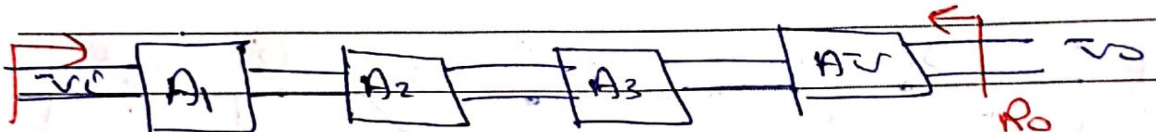
* لاحظ أن ده زي ال Common gate لم تكبر التيار بال Cascode دا جاب ال gain تقريباً نفس قيمة ال C.S.

ليه بقى ؟ عشان ال Rin بتاعت ال C.G قليلة فأن التيار هو هو ماتكبرش.

- $\boxed{\text{For high freq} \Rightarrow \text{Cascode.}}$

"محاضرة / رقم ٩"

* Cascaded Multistage:

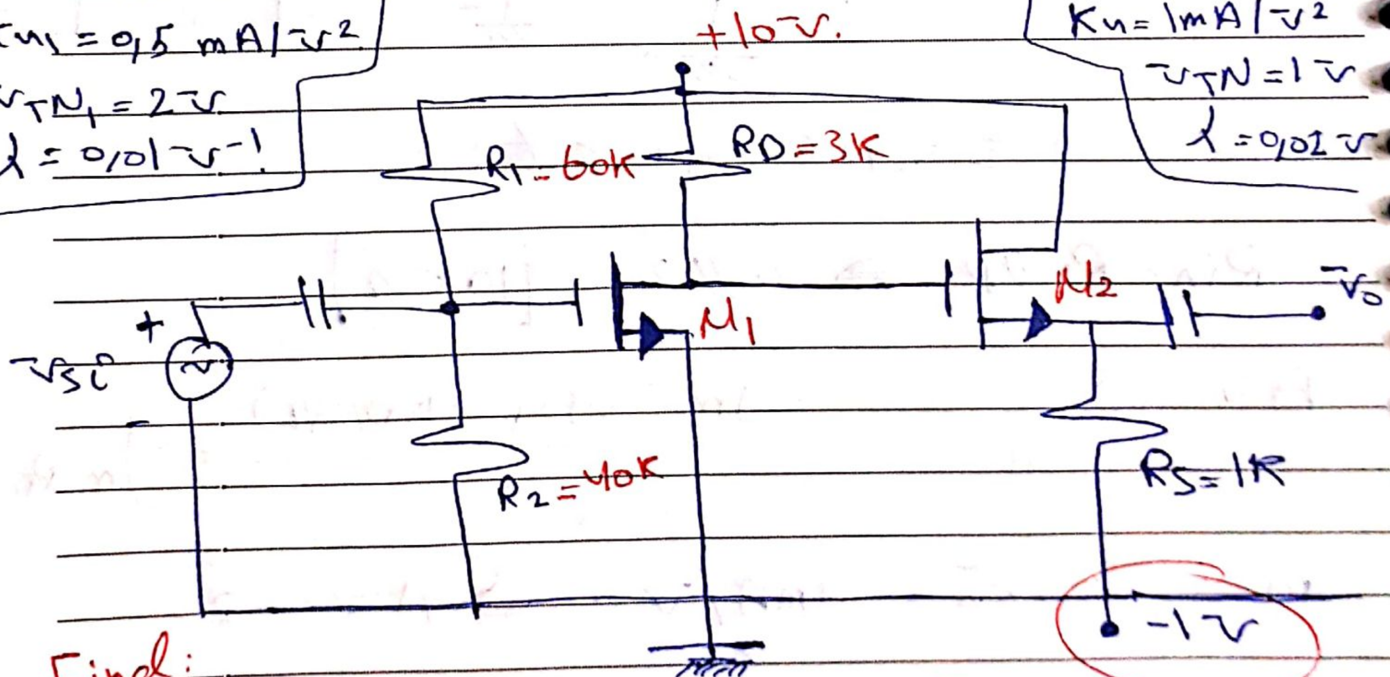


$R_{in} = R_{in_1}$.

$R_o = R_{on}$.

For M_1:
$K_{n1} = 0.5\ mA/V^2$
$V_{TN_1} = 2V$
$\lambda = 0.01\ V^{-1}$

For M_2:
$K_n = 1mA/V^2$
$V_{TN} = 1V$
$\lambda = 0.01\ V$



Find:

① $V_{GS_1}, I_{D_1}, V_{DS_1}, V_{GS_2}, I_{D_2}, V_{DS_2}$

② Draw S.S.A.C equ cct. and find:

$A_v = \frac{v_o}{v_{si}}$ / $A_{v_1} = \frac{v_{o_1}}{v_{si}}$ / $A_{v_2} = \frac{v_o}{v_{i_2}}$ /

- For D.C Analysis, all Capacitors O.C:
- Assum M_1 and M_2 in saturation region:

$$I_1 = \frac{\Sigma V}{\Sigma R} = \frac{10}{R_2 + R_1} = \frac{10}{40K + 60K} = 0{,}1mA$$

$\Rightarrow$ KVL: $-0{,}1m \times 40K + V_{GS_1} = 0$

$$\boxed{V_{GS_1} = 4V}$$

- $I_{D_1} = K_{n_1}(V_{GS_1} - V_{TN_1})^2 \Rightarrow I_{D_1} = 0{,}5(3)^2 = \underline{2mA}$

- $-10 + i_{d_1} R_d + V_{DS_1} = 0 \Rightarrow V_{DS_1} = 10 - 2m \times 3K$

$$\boxed{V_{DS_1} = 4V}$$

- $V_{DS(sat)} = V_{GS} - V_{TN} = 4 - 2 = \boxed{2V}$ sat

- For MOS 2 $\Rightarrow$ Assume in sat Region:

$-V_{DS_1} + V_{GS_2} + I_{D_2} R_S - 1 = 0$

$$I_{D_2} = \frac{V_{DS_1} + 1 - V_{GS_2}}{R_S} = \boxed{5 - V_{GS_2} = I_{D_2}}$$

$$I_{D_2} = K_{n_2}(V_{GS_2} - V_{TN_2})^2$$

$$5 - V_{GS_2} = (V_{GS_2}^2 - 2V_{GS_2} + 1)$$

$$0 = V_{GS_2}^2 - V_{GS} - 4$$

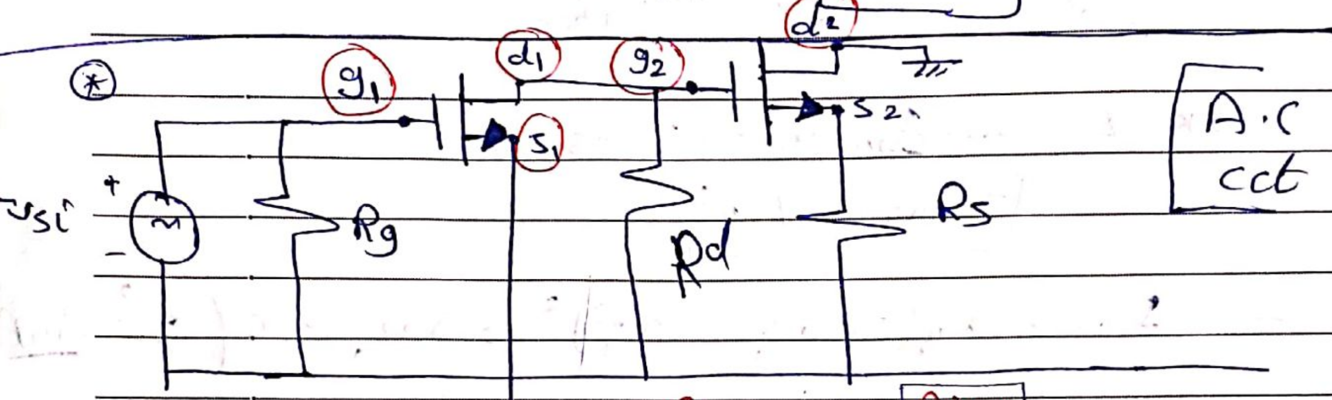
$$\boxed{V_{GS_2} \simeq 2{,}6V}$$

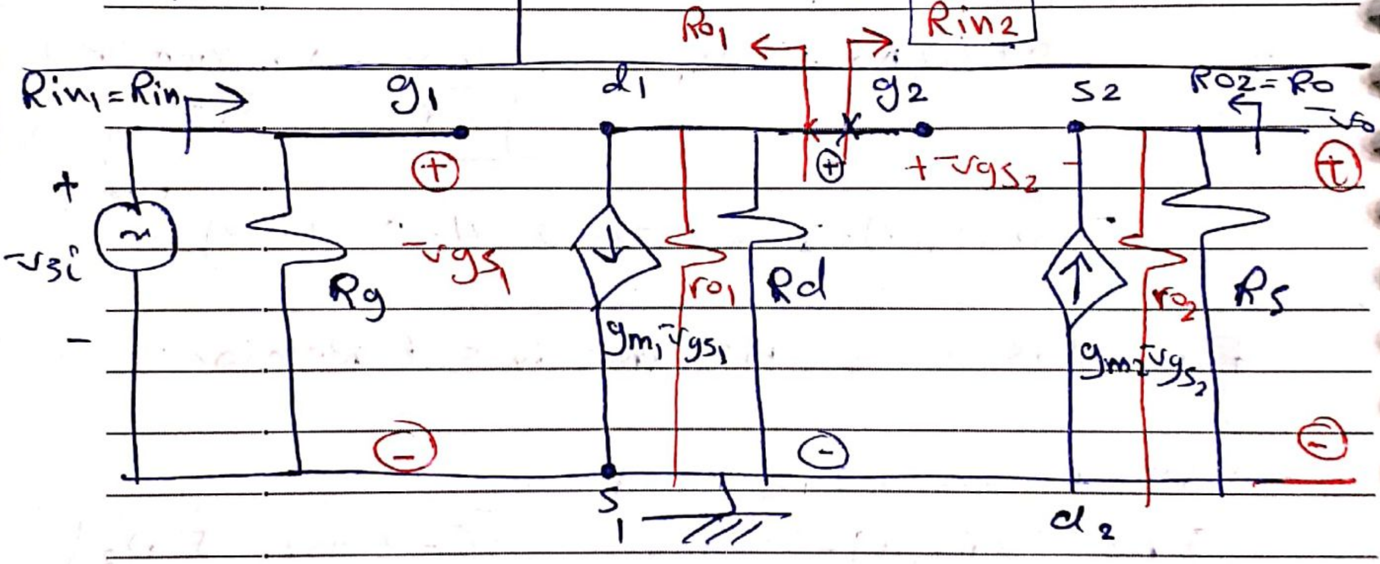
(36)

- $I_{D2} = 5 - 2.6 = \boxed{2.4\,mA}$

- $-10 + v_{DS2} + I_{D2} R_S - 1 = 0$

$v_{DS2} = 11 - 2.4 * 1 = \boxed{8.6\,v}$





$$A_v = \frac{v_o}{v_{si}} = \underbrace{\frac{v_o}{v_{si_2}}}_{A_{v2}} * \underbrace{\frac{v_{o1}}{v_{si}}}_{A_{v1}}$$

$$A_{v2} = \frac{v_o}{v_{si_2}} = \left[v_o = g_{m_2} v_{gs_2} (r_{o2} \| R_S) \right]$$

(37)

* $-v_{si_2} + v_{gs_2} + v_o = 0$

$$v_{si_2} = v_{gs_2} + g_{m_2} v_{gs_2} (r_o // R_s)$$

$$v_{si_2} = v_{gs_2}\left(1 + g_{m2}(r_o // R_s)\right)$$

- $$A_{v_2} = \frac{g_{m2} \cancel{v_{gs_2}} (r_{o2} // R_s)}{\cancel{v_{gs_2}} (1 + g_{m_2}(r_o // R_s))} = \boxed{\frac{g_{m2} (r_{o2} // R_s)}{(1 + g_{m2}(r_o // R_s))}}$$

$A_{v_2} < 1$

- $$A_{v_1} = \frac{v_{o_1}}{v_{si}} = \frac{-g_{m_1} (r_{o_1} // R_d) \cdot \cancel{v_{gs_1}}}{\cancel{v_{gs_1}}}$$

$$A_{v_1} > 1 = \boxed{-g_{m_1} (r_{o_1} // R_d)}$$

- $$A_v = A_{v_1} * A_{v_2} = \boxed{-g_{m_1} (r_{o_1} // R_d) * \frac{g_{m2} (R_s // r_{o2})}{1 + g_{m2}(r_o // R_s)}}$$

- $R_{in} = R_{in_1} = R_g = R_1 // R_2$

- $R_o = R_{o2} = \left(r_{o2} // R_s // \frac{1}{g_m}\right)$ "Low"

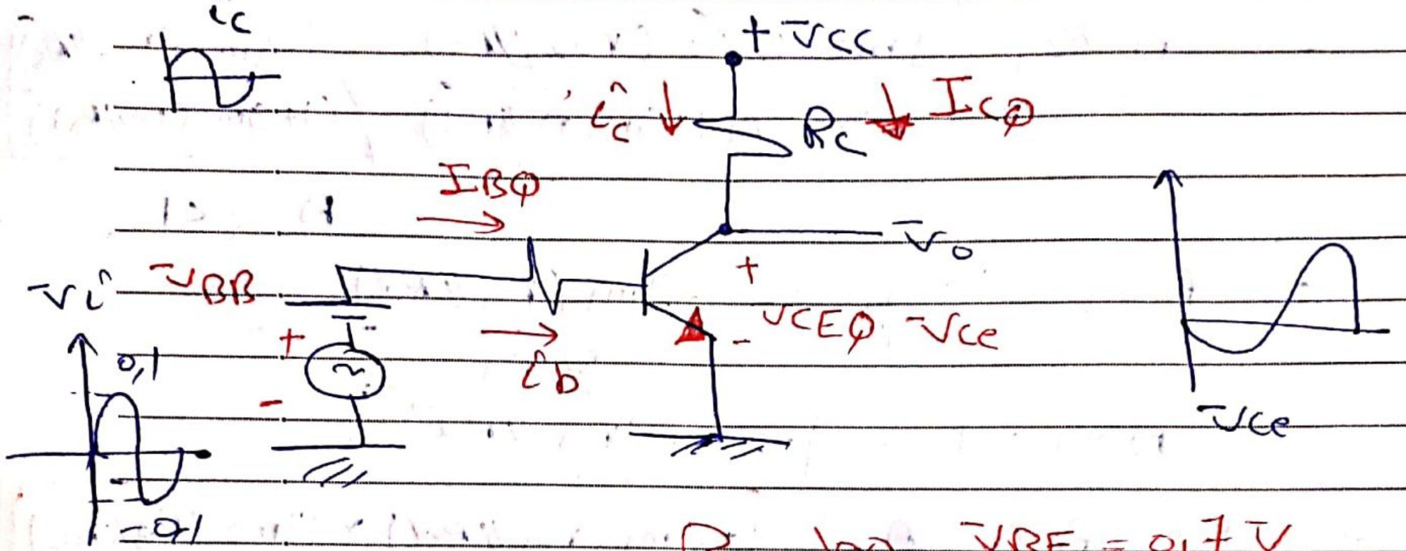
- $R_{in_2} = \infty$

- $R_{o_1} = r_{o_1} // R_d$

(محاضرة رقم "10")

* BJT Amplifiers:

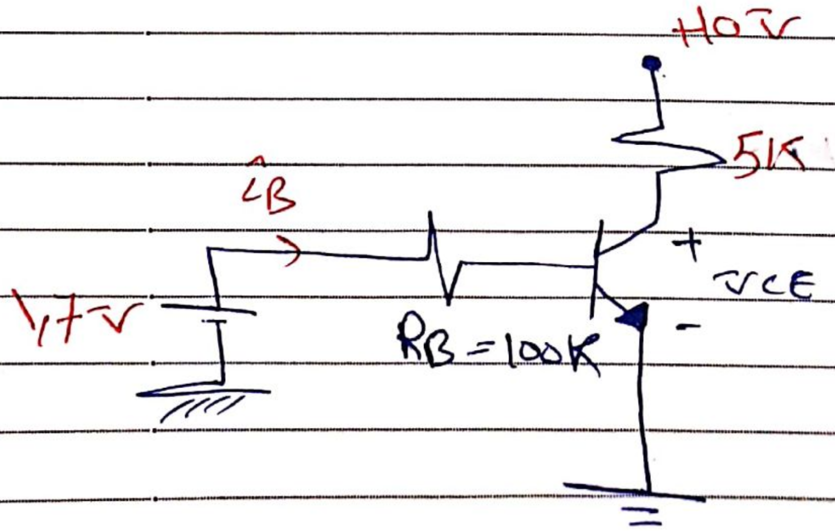
(BJT must be biased in F.A.N to be used as an Amp).



$\beta = 100$, $V_{BE} = 0{,}7\,V$.

(i) D.C Analysis (C → O.C), A.C → S.C

* super position: (1) D.C source → A.C → S.C.
(2) A.C // → D.C → S.C.



KVL: $-1.7 + i_B R_B + V_{BE} = 0 \Rightarrow$

$$i_B = \frac{1.7 - V_{BE}}{R_B} = \frac{1.7 - 0.7}{100K} = \boxed{0.01\,mA}$$

$$I_C = \beta I_{BQ} = \boxed{1\,mA}$$

KVL: $-10 + I_{CQ} * 5K + V_{CE} = 0$

$$V_{CE} = 10 - 1m * 5K = \boxed{5\ \text{volt}}$$

- Since $I_B > 0$, then B-E Jun → F.W
and $V_{CE} > V_{BE}$, B-C Jun → Re.V

then BJT is in F.A.M.

(*) D.C.L.L and Q-pt:

$-10 + I_C R_C + V_{CE} = 0 \Rightarrow V_{CE} = 10 - I_C R_C$

$$\boxed{\text{Slope} = \frac{-1}{R_C}}$$

i) for $i_C = 0 \Rightarrow V_{CE} = 10\,V \Rightarrow P_1 (10, 0)$
ii) For $V_{CE} = 0$, $I_C = 2mA$, $P_2 (0, 2mA)$

Q-pt $\Rightarrow (V_{CEQ}, I_{CQ})$.
$(5V, 1mA)$

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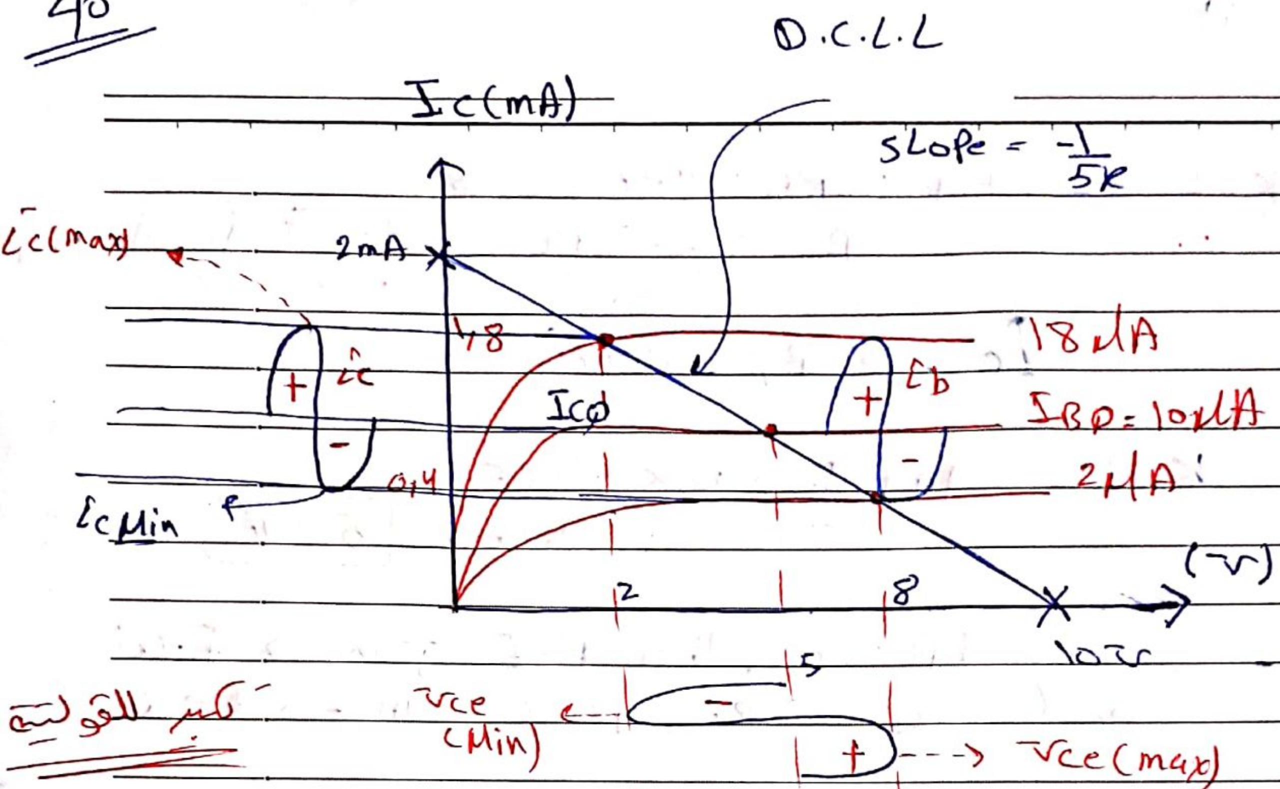


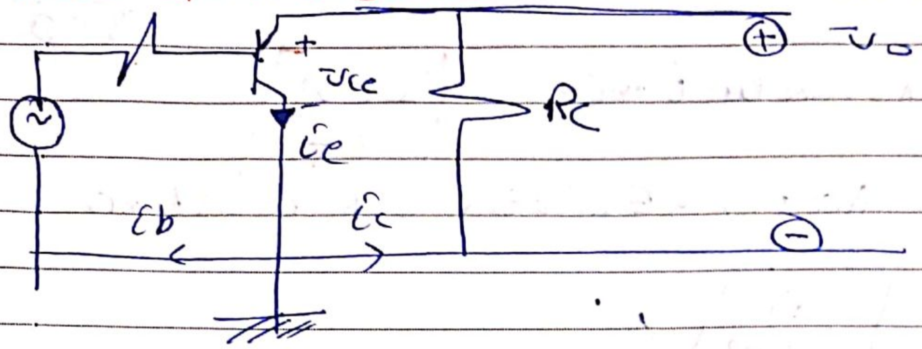
$$A_v = \left|\frac{v_{ce}}{v_i}\right| = \frac{v_{cep}}{v_{ip}} = \frac{v_{ce\,p\text{-}p}}{v_{i\,p\text{-}p}} = \frac{3}{0.1} = 30$$

← ال تكبير للفولتية، القدرة، التيار بال BJT يكون أعلى من ال Mosfet.

* ال Mosfet فقط تكبير فولتية ولا يكبر تيار، أما ال BJT في تكبير للتيار والفولتية.

"Current Controlled current source" ⇐ BJT

* effect of A.C source : D.C → S.C

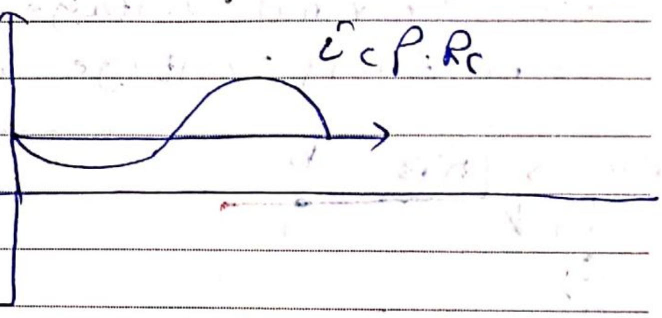


A.C.L.L ⇒ $v_{ce} + i_c R_C = 0 \Rightarrow v_{ce} = -i_c R_C$

$\hat{i}_B = I_{BQ} + \hat{i}_b$

$\hat{i}_C = I_{CQ} + \hat{i}_c$

$v_{CE} = v_{CEQ} + v_{ce}$

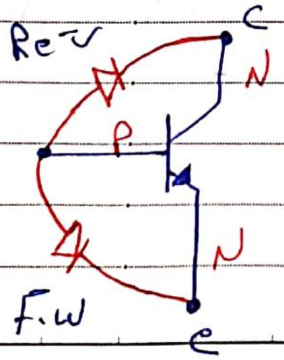


* Assume (v_i) drives a peak base current

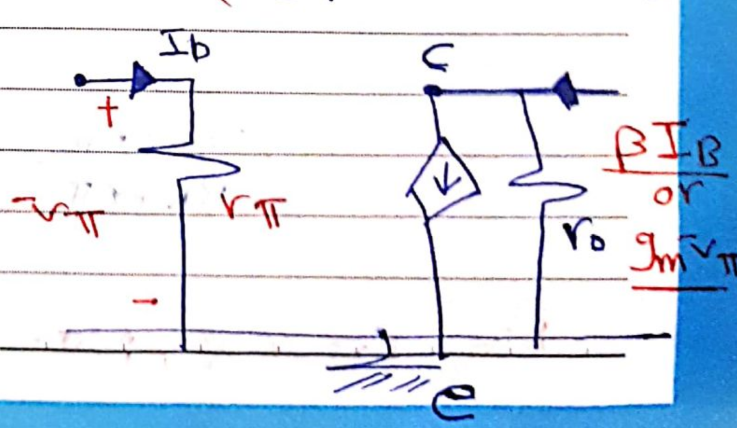
($\hat{i}_b = 8\,\mu A \Rightarrow i_b = 8\sin\omega t\ (\mu A) \Rightarrow$

$i_B = (I_{BQ} + 8\sin\omega t)\,\mu A.$

* To perform A.C analysis the BJT in A.C cct is replaced by it's model (hyprid -π model)



⇒



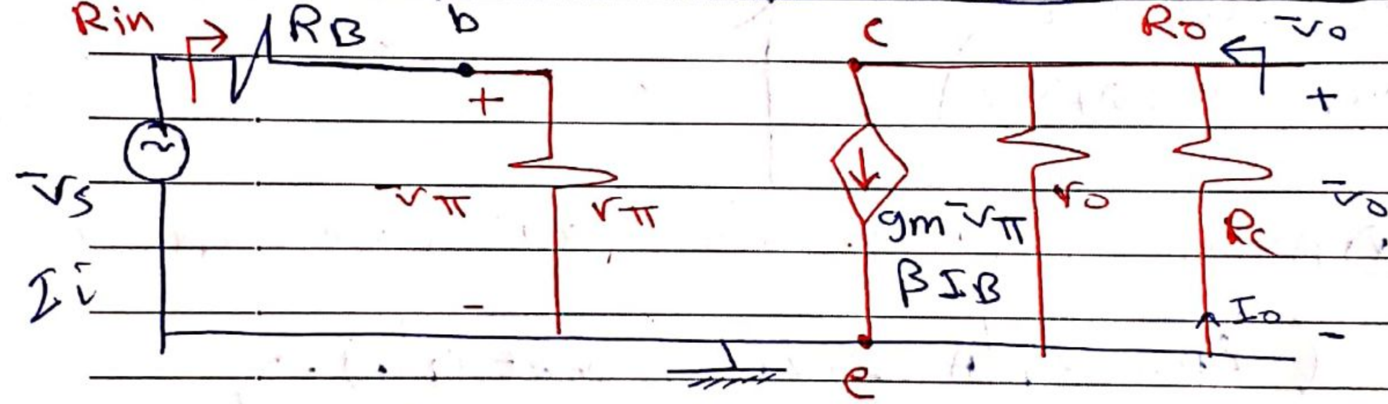
r_π : F.W base - emitter resistance = $\boxed{\dfrac{\beta v_T}{I_{CQ}}}$

g_m : Transconductance = $\boxed{\dfrac{I_{CQ}}{v_T}}$

$r_o \Rightarrow$ Collecter - Emitter o/p resistance

$r_o = \boxed{\dfrac{v_A}{I_{CQ}}}$,

v_T : Thermal voltage = 26 mV.
v_A : Early voltage 50 < v_A < 30 V. (given)



S.S.A.C eq. cct.

$$A_v = \frac{v_o}{v_s} = \frac{-g_m \cancel{v_\pi}(r_o // R_C)}{\frac{\cancel{v_\pi}(R_B+r_\pi)}{r_\pi}} = \boxed{r_\pi * \frac{-g_m(r_o // R_C)}{(R_B+r_\pi)}}$$

$$\boxed{\frac{v_s * r_\pi}{R_B+r_\pi} = v_\pi}$$

$R_{in} = R_B + r_\pi$, $R_o = r_o // R_C$

AS: Current gain $= \dfrac{I_o}{I_i}$

$$I_o = \frac{-g_m v_\pi * r_o}{r_o + R_c} \quad \text{oR} \quad \boxed{\frac{\beta I_b * r_o}{r_o + R_c}}$$

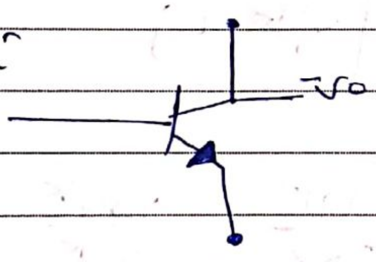
$$\boxed{I_b = I_i} \Rightarrow \boxed{I_o = -\beta I_i \cdot r_o / r_o + R_c}$$

$$A_I = \frac{I_o}{I_i} = \frac{-\beta r_o}{r_o + R_c}$$

"11 [illegible]"

(*) Single stage BJT Amplifiers:

[I]. Common Emitter Amp:



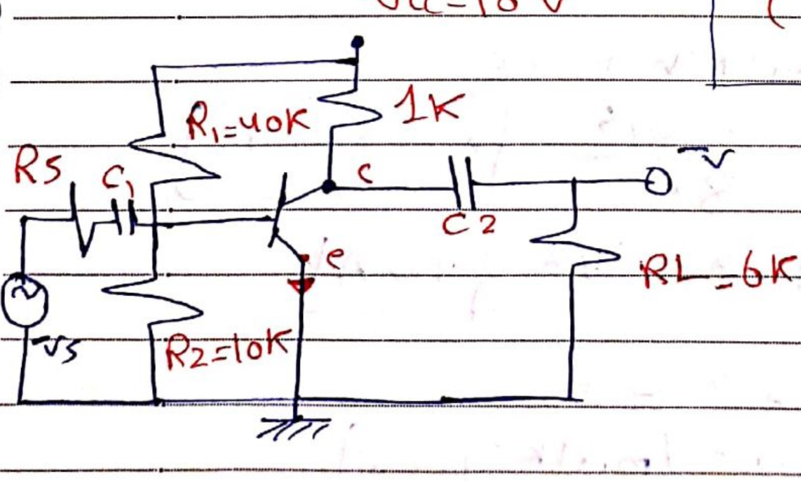
$v_i \rightarrow$ to base

$v_o \rightarrow$ from Collect[illegible]

$E \rightarrow$ Common - ter[illegible]

(1) Basic Common Emi[illegible]

(E → directly Connected to ground)



$\beta = 40$

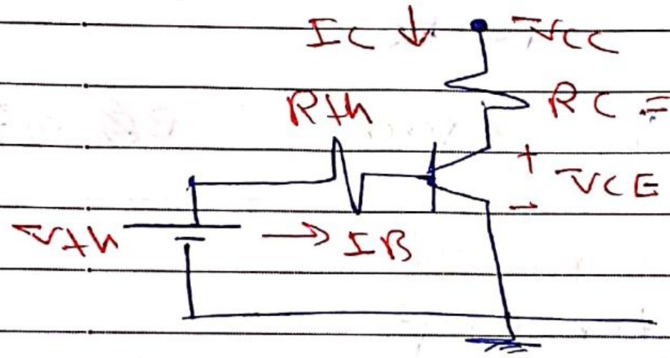
$V_{BE} = 0.6$

$V_A = 100V$

[1] find: I_B, I_C, V_{CE}.
[2] Draw S.S.A.C eq cct and determine A_V, A_I, R_{in}, R_o.

[3] write Dc and Ac L.L equations and find their slops

* D.C Analysis: All Cps $\longrightarrow$ O.C



D.C.cct

$R_{th} = R_1 // R_2 = \frac{400k^2}{50k} = \boxed{8k\Omega}$

$V_{th} = 10 * \frac{R_2}{R_1 + R_2} = \frac{10 * 10k}{50k} = \frac{100k}{50k} = \boxed{2V}$

- KVL: $-V_{th} + I_B R_{th} + V_{BE} = 0$

$I_B = \frac{2 - 0,6}{8k} = \boxed{0,175\ mA}$

$I_C = \beta I_B = 40 * 0,175 = \boxed{7\ mA}$

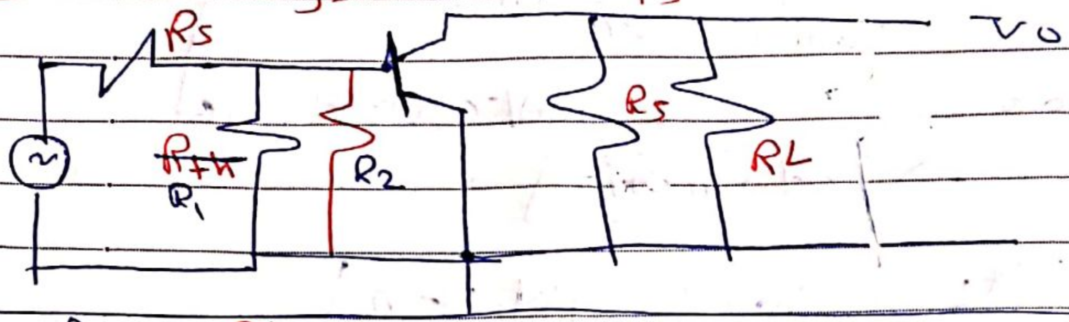
- $-V_{CC} + I_C R_C + V_{CE} = 0$

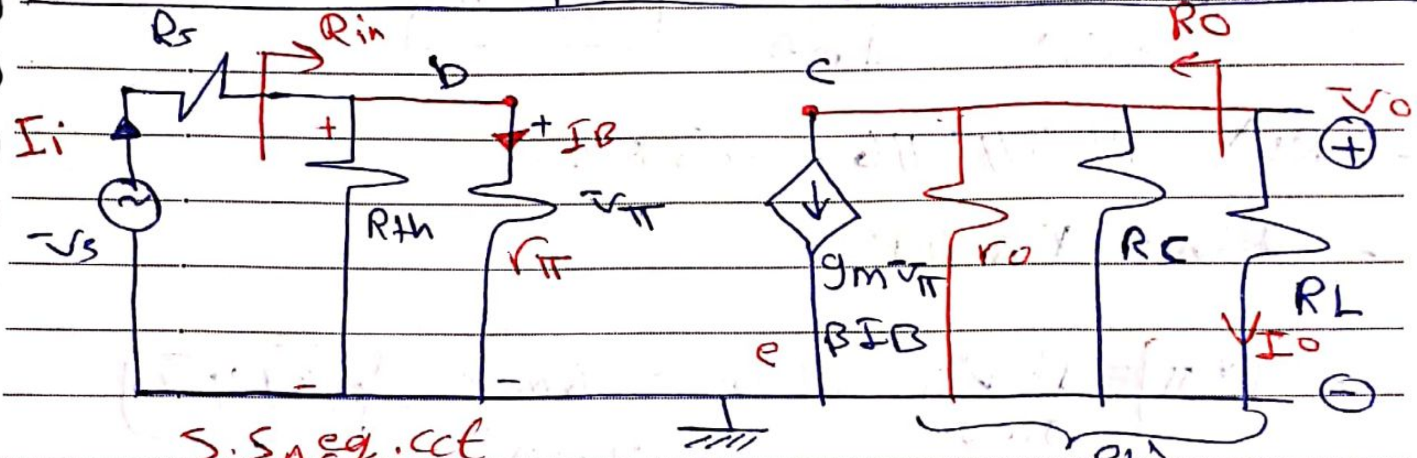
$V_{CE} = 10 - 7mA \cdot 1K = \boxed{3V}$

$I_B > 0$, $V_{CE} > V_{BE}$ F.W.M.L

A.C. cct.

(*) A.C analysis: all caps and D.C → S.C.





S.S A.C eq. cct

(*) ملاحظة هامة : Io ← يمر في آخر مقاومة بأخذها RL
او يمر فيها هامش RL / وجود بال RC

$$Av : \frac{V_o}{V_s} = \frac{V_o}{V_\pi} * \frac{V_\pi}{V_s}$$

$$\frac{V_o}{V_\pi} = \frac{-g_m \cancel{v_\pi} * R_L'}{\cancel{v_\pi}} = -g_m R_L' \quad : \quad R_L' = r_o // R_C // R$$

$$v_\pi = \frac{V_s * (R_{th} // r_\pi)}{(R_{th} // r_\pi) + R_s} \Rightarrow \text{Voltage Devider}$$

Let $R_{in} = R_{th} // r_\pi$

$$v_\pi = \frac{V_s * R_{in}}{R_{in} + R_s} \rightarrow \frac{V_\pi}{V_s} = \frac{V_s R_{in}}{R_{in} + R_s}$$

$$\boxed{Av = -g_m R_L' * \frac{V_s R_{in}}{R_{in} + R_s}}$$

$$\boxed{g_m} = \frac{I_{CQ}}{V_T} = \frac{7mA}{26mV} = \frac{7}{26} A/V$$

$$\frac{7}{26} * 1000$$

نحولها لـ mA/V ⇐

$$\Rightarrow \boxed{270\ mA/V}$$

$$\boxed{r_o} = \frac{V_A}{I_{CQ}} = \frac{100V}{7mA} = \boxed{14,3 k\Omega}$$

- $R_L' = 14,3 // 1 // 6 = 0,8\ k\Omega$.
- $R_{in} = r_\pi // R_{th} =$
- $\boxed{r_\pi} = \frac{\beta V_T}{I_{CQ}} = \frac{100 * 26mV}{7mA} = \boxed{0,37 k\Omega}$
- $R_{in} = 0,37 // 8 = 0,35\ k\Omega$.
- $A_V = -270 * 0,8 * \frac{0,35}{0,35+0,15} = -151 = \frac{V_o}{V_s}$

$$\boxed{V_o = -151\ V_s}$$

(*) A_I = Current gain: $\frac{I_o}{I_i} = \frac{I_o}{I_B} * \frac{I_B}{I_i}$

$$I_o = -\frac{\beta I_B * (r_o // R_c)}{(r_o // R_c) + R_L} \Rightarrow \text{Let } \boxed{R_c' = r_o // R_c}$$

$$\boxed{\frac{I_o}{I_B} = \frac{-\beta \cdot R_c'}{R_c' + R_L}}$$

$$\frac{I_B}{\cancel{I_i}} = \frac{I_i * R_{th}}{R_{th} + r_\pi} \Rightarrow \boxed{\frac{I_B}{I_i} = \frac{R_{th}}{R_{th} + r_\pi}}$$

$$A_I = \frac{I_o}{I_B} * \frac{I_B}{I_i} = \frac{-\beta R_C'}{R_C' + R_L} * \frac{R_{th}}{R_{th} + r_\pi} \simeq -5.$$

- $R_{in} = R_{th} \parallel r_\pi = 0.35 \, k\Omega.$

- R_{in} (seen by signal generator) $= 0.35K + R_s = 0/$
- $R_{ib} = r_\pi.$

$$\boxed{R_o \Rightarrow \left. \frac{v_x}{I_x} = R_o \right|_{v_s = 0} \Rightarrow r_o \parallel R_C = 0.9 \, k\Omega.}$$

since $v_s = 0, \; v_\pi = 0$

(*) A_v and A_I Relations:

(1) $A_v = \frac{v_o}{v_s} = \frac{I_o \cdot R_L}{I_i (R_s + R_{in})} = \boxed{A_I \cdot \frac{R_L}{R_s + R_{in}}}$

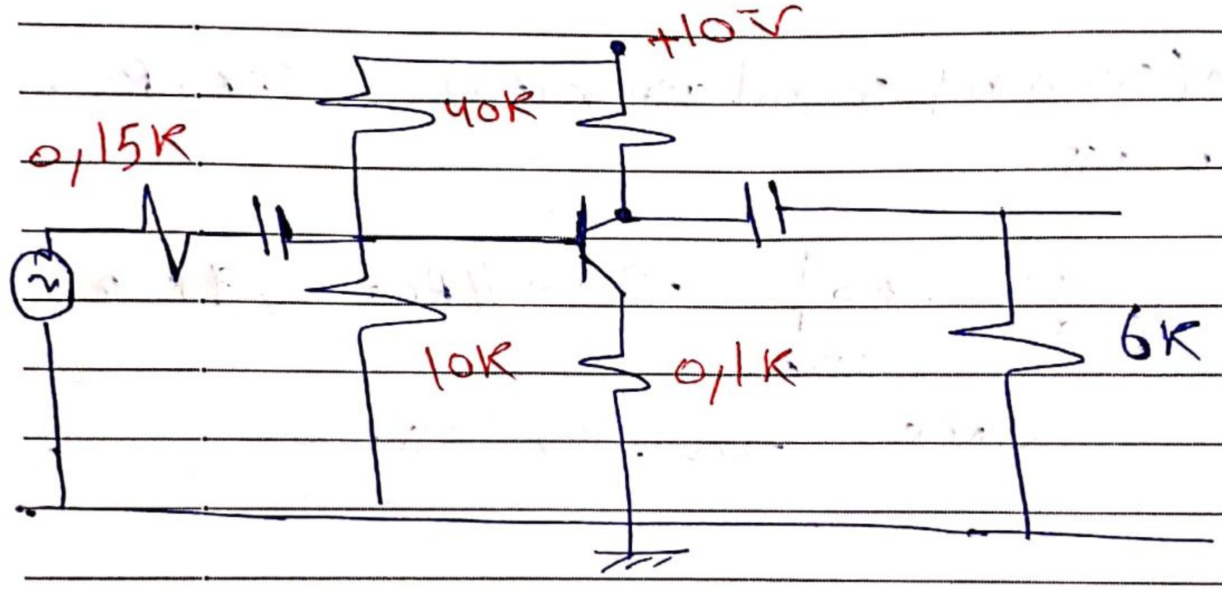
(2) $A_I = \frac{I_o}{I_i} = \frac{\frac{v_o}{R_L}}{\frac{v_s}{R_s + R_{in}}} = \boxed{A_v \cdot \frac{R_s + R_{in}}{R_L}}$

- نحن مش داكر صفر ولا حي ، خارج بالعلاقة هاي ↑

((محاضرة))
((1/12))

في الدارة السابقة لو أنا رفعت قيمة ال β لـ 60، الـ I_B رح يطلع 0.175mA ما رح يتغير، الـ I_C رح يصير 10.5mA بالتالي $V_{CE}=-0.5$، وهاي مشكلة لأنو ال Transister رح يصير في ال (Sat Region).

(Very sensitive to β variation).



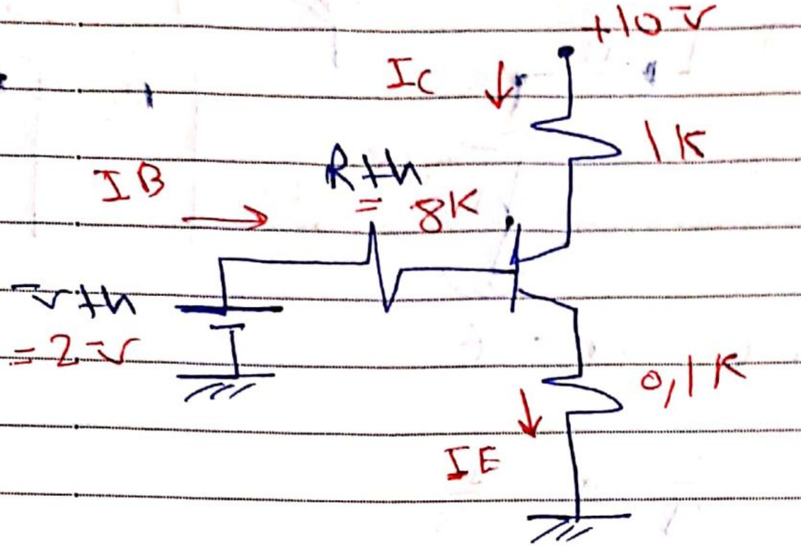
$\beta = 60$, $V_{BE} = 0.6\,V$

① Find I_B, I_C, V_{CE}.

② Draw S.S.A.C. equ. cct

③ Find A_V, A_I, R_{in}, R_{in_b}, R_o.

* D.C. Analysis :- All Capacitors O.C :



$R_{th} = 8K\Omega$

$\Rightarrow (R_1 // R_2)$.

$V_{th} = \frac{10 \times 10K}{50K}$

$= 2V$.

KVL: $-V_{th} + I_B R_{th} + V_{BE} + (\beta+1) I_B \times 0{,}1K = 0$

$$\boxed{I_B = 0{,}09\,mA}$$

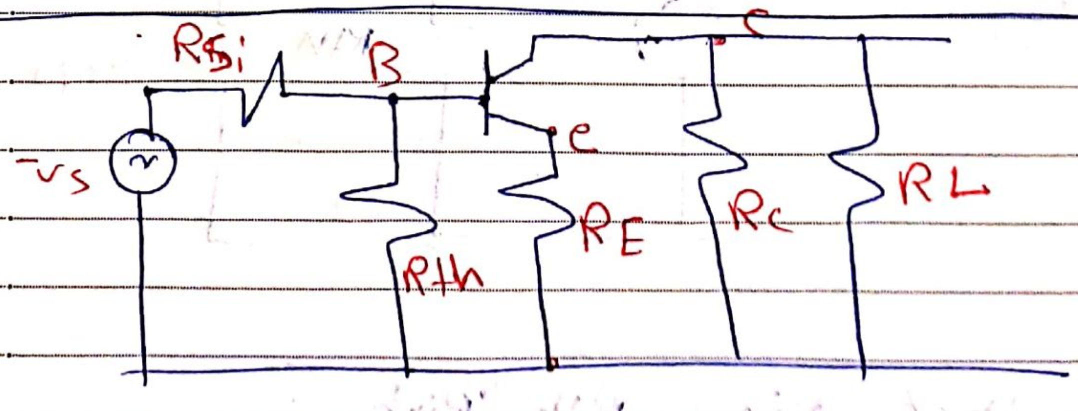
$I_C = \beta I_B = 5{,}4\,mA$.

KVL: $-10 + I_C R_C + V_{CE} + (\beta+1) I_B \times 0{,}1K = 0$

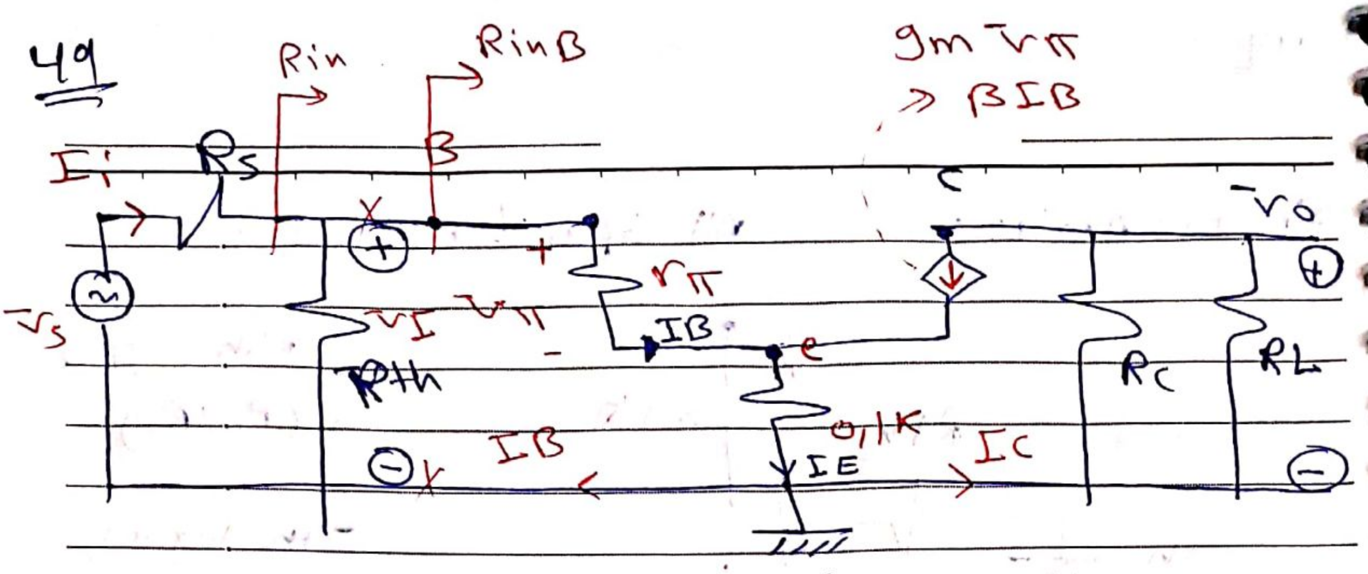
$$\boxed{V_{CE} \simeq 4V}$$

(RE is used to stabilize Q-pt, against β variation) (Advantage).

*



A.C cct.



S.S.A.C equ cct

(*) $A_v = \frac{v_o}{v_s} = \frac{v_o}{v_I} * \frac{v_I}{v_s}$

- $v_o = -\beta I_B (R_C \parallel R_L)$

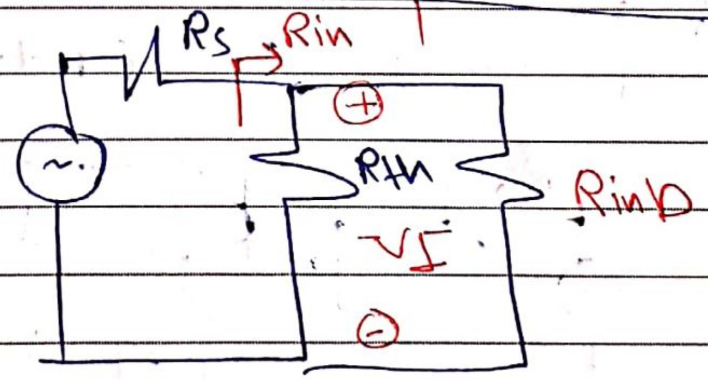
- $v_I = v_\pi + (\beta+1) I_B R_E \Rightarrow v_I = I_B r_\pi + (\beta+1) I_B R_E$

$v_I = I_B (r_\pi + (\beta+1) R_E)$

(1)

$$\frac{v_o}{v_I} = \frac{-\beta \cancel{I_B} (R_C \parallel R_L)}{\cancel{I_B}(r_\pi + (\beta+1) R_E)} = \boxed{\frac{-\beta (R_C \parallel R_L)}{r_\pi + (\beta+1) R_E}}$$

- $\boxed{\frac{v_I}{v_s}} \Longrightarrow$



- Note that $\boxed{R_{in} = R_{th} \parallel R_{inb}}$.

and $R_{inb} = \frac{v_I}{I_B}$

Rin

$\Longrightarrow$ voltage devider $\Rightarrow \boxed{v_s * \frac{(R_{th} \parallel R_{inb})}{R_s + (R_{th} \parallel R_{inb})} = v_I}$

(*) Then: $v_I = \frac{v_S * R_{in}}{R_S + R_{in}} \Rightarrow \boxed{\frac{v_I}{v_S} = \frac{R_{in}}{R_S + R_{in}}}$

- Then $A_v = \frac{v_o}{v_I} * \frac{v_I}{v_S} =$

$$\boxed{\frac{-\beta (R_C // R_L)}{r_\pi + (\beta+1) R_E} * \frac{R_{in}}{R_S + R_{in}}} = A_v$$

- $R_{ib} = \frac{v_I}{I_b} = \frac{v_\pi + (\beta+1) I_B R_E}{I_B} = \frac{I_B r_\pi + (\beta+1) I_B R_E}{I_B}$

$R_{ib} = \frac{\cancel{I_B}(r_\pi + (\beta+1) R_E)}{\cancel{I_B}} = \boxed{r_\pi + (\beta+1) R_E}$

- $r_\pi = \frac{\beta V_T}{I_C} = \frac{60 * 26\,mV}{5{,}4\,mA} = \boxed{290\,\Omega}$

- $R_{ib} = 290 + 61 * 1k = \boxed{6{,}129\,k\Omega}$

- $R_{in} = 6{,}\cancel{19}\,21 // 8 = \ldots\ k\Omega$

$A_v = -7{,}71$

"RE reduces A_v but increases R_{in}"

Advantage

51

$$R_o = \frac{v_x}{I_x}\Bigg|_{v_s=0}, \quad v_\pi = 0, \quad g_m v_\pi = 0$$

D.C.S ⇒ O.C

$$\boxed{R_o = R_C = 1K\Omega}$$

$$A_I = \frac{I_o}{I_i} = \frac{\frac{v_o}{R_L}}{\frac{v_s}{R_s+R_{in}}} = \boxed{A_v \cdot \frac{R_s+R_{in}}{R_L}}$$

C.D.R

OR

$$A_I = \frac{I_o}{I_b} * \frac{I_b}{I_s}$$

$$\frac{I_o}{I_b} = \frac{-\beta I_b * R_C}{(R_L+R_C) * I_b} = \frac{-\beta R_C}{(R_L+R_C)}$$

current devision Rule.

$$\frac{I_b}{I_s} \Rightarrow$$

Current division.

$$\boxed{I_s = I_i} \dashrightarrow \underline{\text{source}} \text{ ال}$$

$$I_b = \frac{I_i * R_{th}}{R_{th}+R_{inb}} \Rightarrow \frac{I_b}{I_i} = \frac{R_{th}}{R_{th}+R_{inb}}$$

$$\boxed{A_I = \frac{I_o}{I_b} = \frac{-\beta R_C}{R_L+R_C} * \frac{R_{th}}{R_{th}+R_{inb}}}$$

52

*

فيها نتيجة لـ Av:

For $\beta >> 1$, $(\beta+1)R_E >> r_\pi$

$R_{in} >> R_s$.

- $A_v \simeq - \dfrac{(R_C // R_L)}{R_E}$

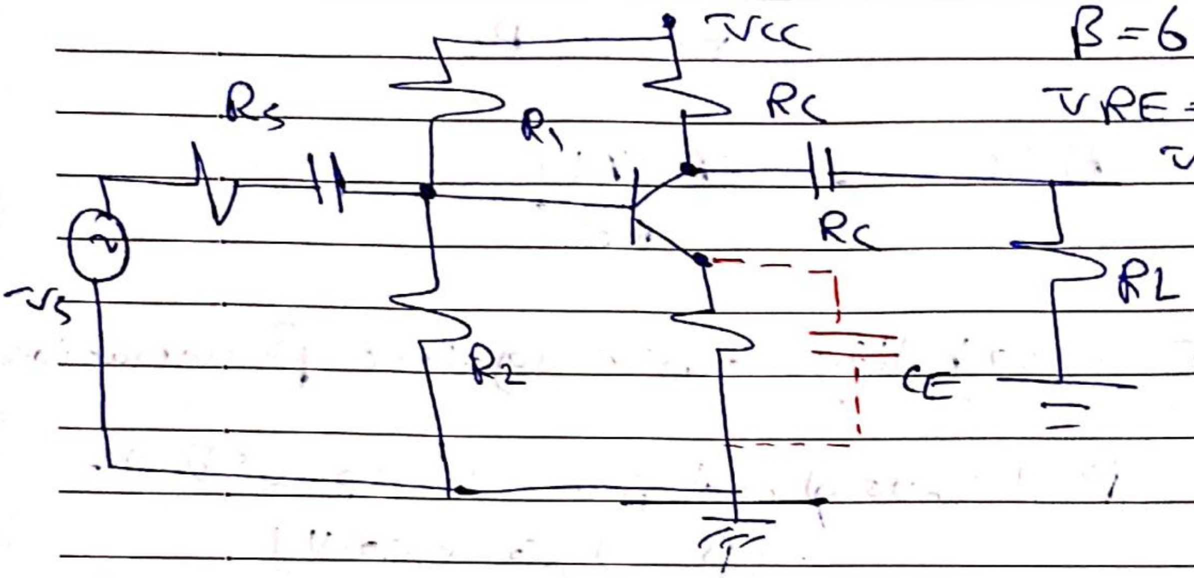
R_E - stabilize , A_v against β variation

- لاحظ كيف صار الـ Av ليس له علاقة بالـ β
(لا يعتمد على قيم الـ β) .

"محاضرة 6/ 13"

iii) C.E with by pass capacitor.

(الدارة الماضية كانت أصلها (ضايع R_E



$\beta = 60$

$V_{BE} = 0.6\,V$

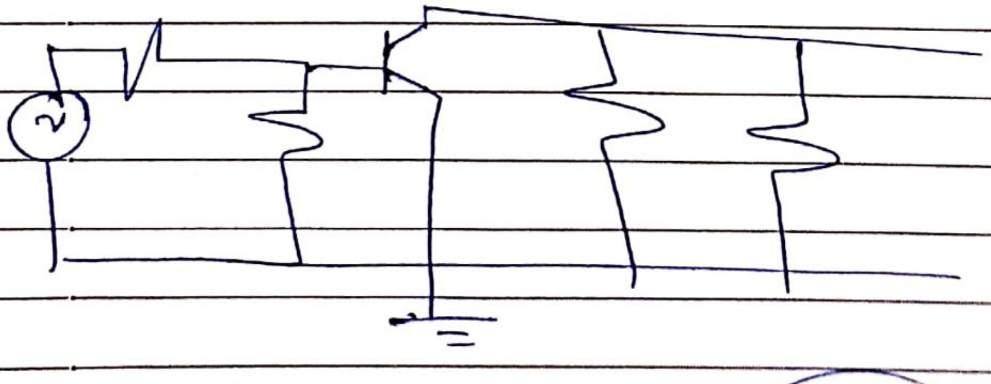
$V_A = \infty$

① For D.C Analysis : CE → O.C

R_E is present and stabilize Q-pt.

② For A.C analysis : CE → S.C → RE → S.C

and the cct is analyzed as basic Common Emitter Amp.



$$A_v = -g_m R_C \| R_L \cdot \frac{R_{in}}{R_{in}+R_s}$$

كالعادة

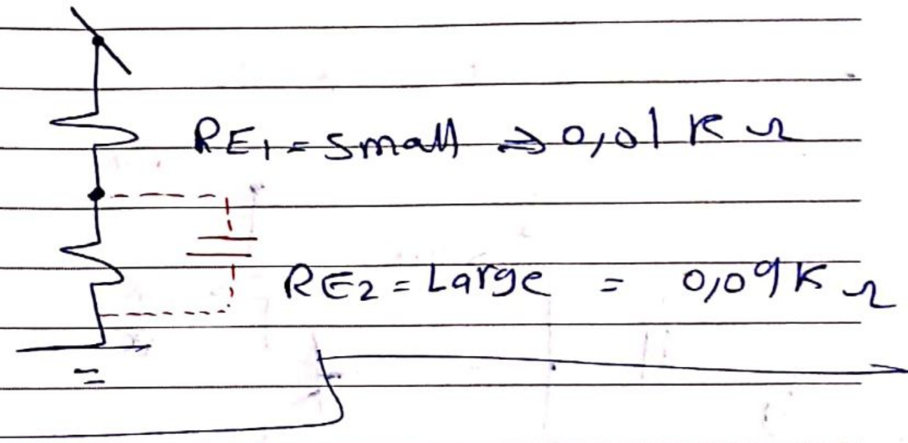
Scanned by CamScanner

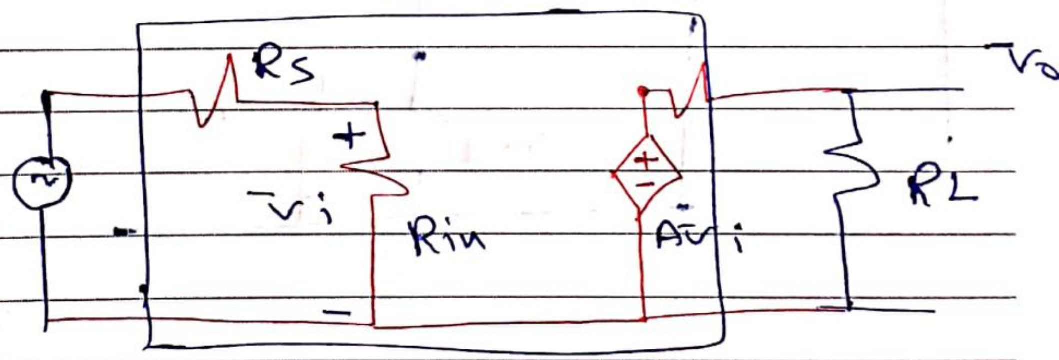
⊛ هنا المشكلة اللي بدي أحلها أنا بدي أقسم الـ RE لجزء كبير وجزء صغير، والجزء الكبير أوصله مع CE عشان أضرب عصفورين بحجر واحد،

منه أحافظ على الـ Av تظل عالي وما بدي منه Rin تنخفض انخفاض كبير.

بهاي الصورة Rin ما تقل كثير

Av ← عالي





ideal voltage Amp ⇒ $R_{in} = \infty$, $R_o = zero$

هدول هو الصفات الـ ideal voltage Amp

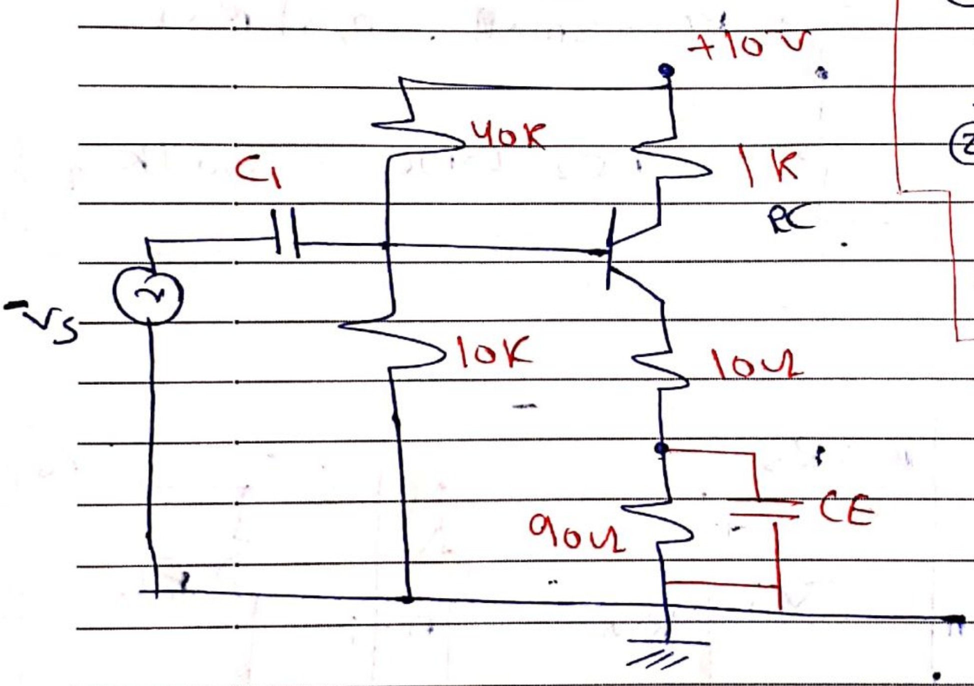
$$v_i = \frac{v_s \cdot R_{in}}{R_{in} + R_s}, \quad v_o = \frac{A\, v_i\, R_L}{R_o + R_L}$$

55

* to gain all advantages of RE and minimize it's disadvantages : RE is usually made of 2 parts small value and Large value .

- then connect CE across Large value.

- For the cct shown:



① Find: I_{CQ}, V_{CEQ}

② Draw s.s. AC equ cct

③ Find A_V, A_I, R_{in}, R_o

* write DC and AC equations and find their slopes.

لاتنسى راتنا:

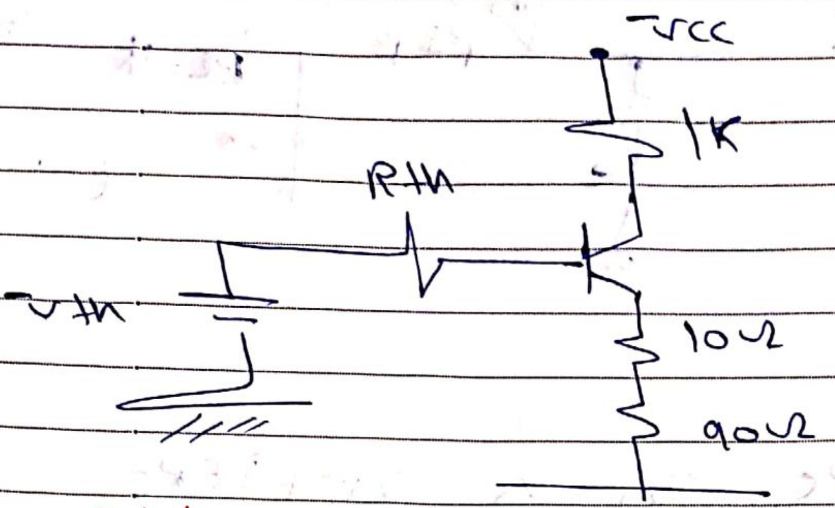
$R_{th} = 0.1(\beta+1)R_E$

For Design Bias stable cct:

① For D.C. Analysis:

$I_{CQ} = 5.4m$

$V_{CEQ} = 4V.$



D.C. cct

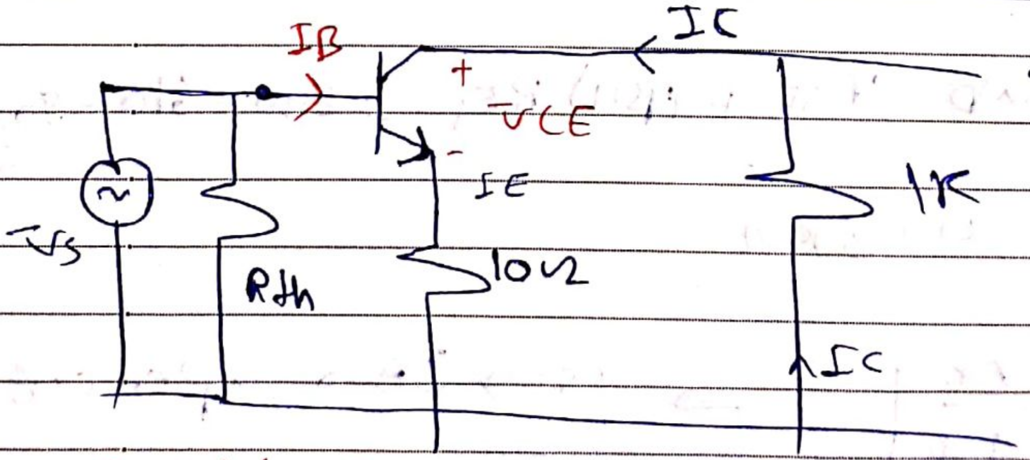
D.C.L.L

$$-V_{CC} + I_C R_C + V_{CE} + \frac{(\beta+1)}{\beta} I_C R_E = 0$$

$$V_{CE} = V_{CC} - I_C\left(R_C + \frac{\beta+1}{\beta} R_E\right)$$

slope for D.C.L

- نعوض في معادلة (D.C.L.L) ، بالتالي نحط DCQ, ICQ
لأنهم هدول نقاط بس بالخط، إنت بتطلع شكل عام.

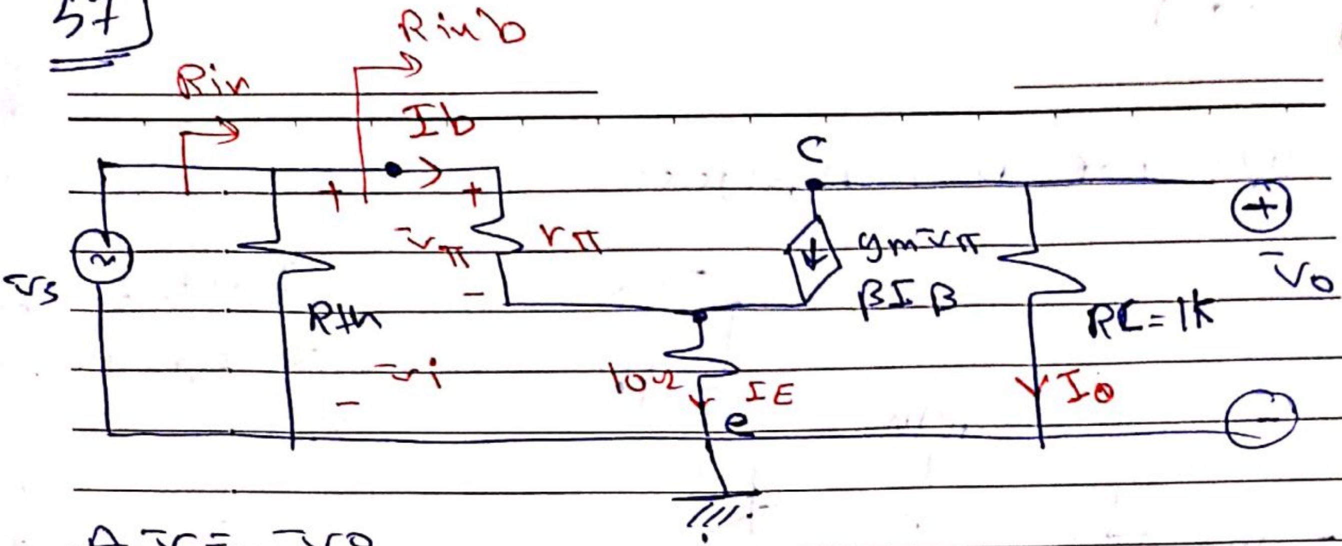


A.C cct

A.C.L.L ⇒ $V_{CE} + \frac{(\beta+1)}{\beta} I_C R_E + I_C R_L = 0$

$$\boxed{V_{CE} = -I_C\left(\frac{\beta+1}{\beta} R_E + R_L\right)}$$

57]



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

$v_o = -\beta I_B R_C$, $v_i = v_s = v_\pi + I_E R_E$

$v_i = I_b r_\pi + (\beta+1) I_B R_E$

$v_i = I_b(r_\pi + (\beta+1) R_E)$

$A_v = \frac{v_o}{v_i} = \frac{-\beta \cancel{I_B} R_C}{\cancel{I_B}(r_\pi + (\beta+1) R_E)} = \boxed{\frac{-\beta R_C}{r_\pi + (\beta+1) R_E}}$

$R_{in} = R_{th} \parallel R_{inb}$

$R_{inb} = r_\pi + (\beta+1) R_{E1} = 290 + 610 \simeq 900\Omega$

$R_{in} = 0,8 k\Omega$

$R_o \Rightarrow \frac{v_x}{I_x}\Big|_{v_s=0} \Rightarrow v_s = 0, I_B = 0$, open cct

$R_o = R_C = 1k\Omega$.

* ال RE تعمل على تقليل ال A_v ، كلما زادت
ال RE ال A_v تقل .

* وظيفة ال RE ← stabilize
Q-pt .

* دارة ال C.E ، زاوية الطور 180° .

* دارة ال C.E $A_v > 1$, $A_I > 1$

- (Voltage + Current Amp)

- Rc (Moderate) Ro دايمًا
(اعتيادي)

- Rin = Moderate.

① C.E with RE (reduce A_v, stabilize
Q-pt)
وتكبر ال R_{in} .

② C.E with RE Capacitor
تقلل ال Rin ، وتكبر ال A_v .

First انتهى ال

Qutami

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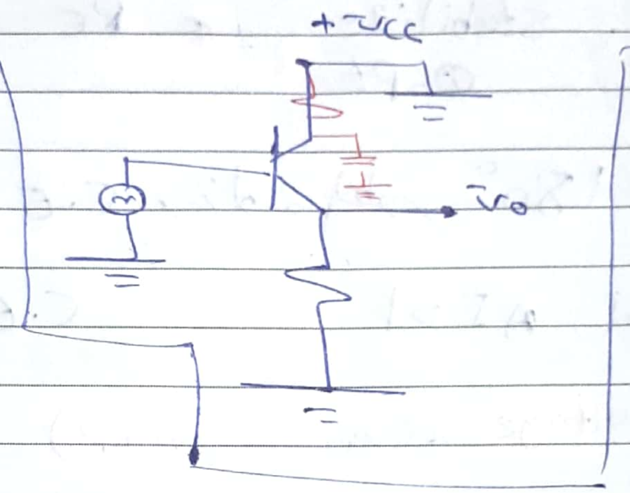
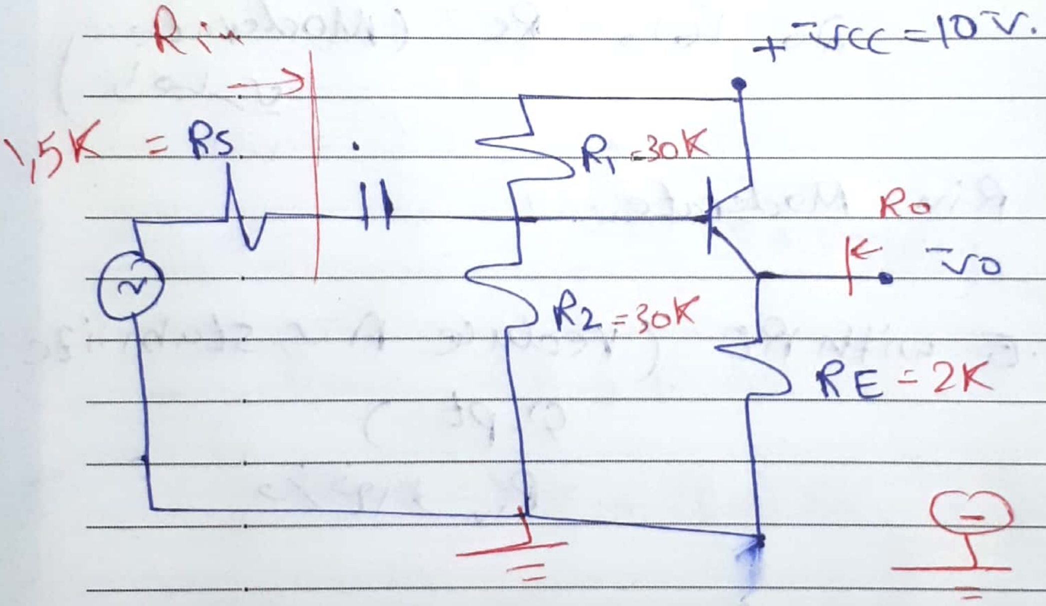
"14"

(*) Common-Collecter Amp [C.C [emitter-follower]]

$v_i \to$ base
$v_o \to$ from (e) C → Common Terminal





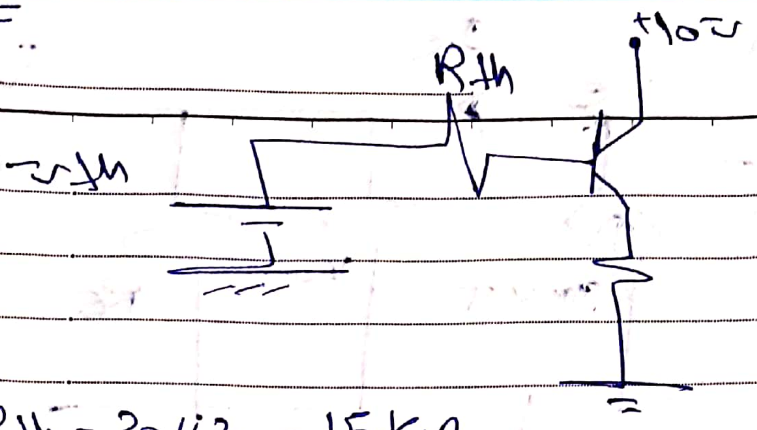
$\beta = 100$, $V_{BE} = 0{,}7\ V$

$V_A = 200\ V$.

1) Determine, I_{CQ}, V_{CEQ}.

2) Draw s.s.A.C equ cct and A_V, A_I, R_{in}, R_b, R_o.

60



$R_{th} = 30 // 30 = 15 k\Omega.$

$V_{th} = 5V.$

KVL: $-V_{th} + I_B R_{th} + V_{BE} + (\beta+1) I_B R_E = 0$

$I_B = 0,02 mA$

$I_C = \beta I_B = 100 * 0,02 = \boxed{2mA}$

$I_E = (\beta+1) * I_B = \boxed{2,02 mA}$

KVL: $-V_{CC} + V_{CE} + I_E R_E = 0$

$\boxed{V_{CE} = 5,96V}$

D.C.L.L equation:

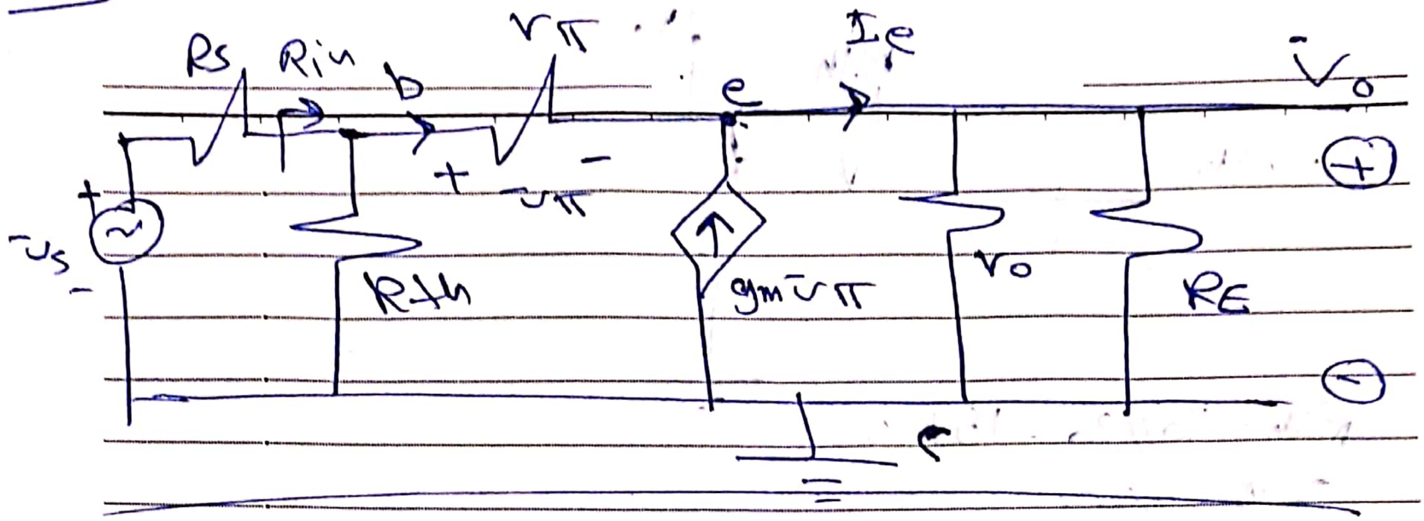
$-10 + V_{CE} + I_E R_E = 0$

$V_{CE} = 10 - \frac{101}{100} R_E I_C$

$slope \Rightarrow \frac{-\beta}{(\beta+1) R_E}$

$\boxed{\left.\begin{array}{l} Slope_{AC} = slope_{D.C} \end{array}\right\} \Rightarrow}$ in Common Collector.

61)



$$A_v = \frac{v_o}{v_s} = \frac{v_o}{v_i} * \frac{v_i}{v_s}$$

$$v_o = (\beta+1) I_b \cdot (r_o \| R_E)$$

$$\boxed{\begin{aligned} -v_I + v_\pi + v_o &= 0 \\ v_I &= I_b r_\pi + (\beta+1) I_b (r_o \| R_E) \end{aligned}}$$

$$\frac{v_o}{v_i} = \frac{(\beta+1)\cancel{I_b}(r_o \| R_E)}{\cancel{I_b}(r_\pi + (\beta+1)(R_E \| r_o))} = \frac{(\beta+1)(r_o \| R_E)}{(r_\pi + (\beta+1)(r_o \| R_E))}$$

$$\frac{v_i}{v_s} = \frac{R_{in}}{R_{in} + R_s}$$

$\Rightarrow R_{in} = R_{th} \| R_{ib}$

$$R_{ib} = \frac{v_i}{I_b} = r_\pi + (\beta+1)(r_o \| R_E)$$

$$A_v = \frac{(\beta+1)(r_o \| R_E)}{r_\pi + (\beta+1)(r_o \| R_E)} * \frac{R_{in}}{R_{in} + R_s} = \frac{v_o}{v_s}$$

Scanned by CamScanner

62

$A_v < 1$, $\phi = \text{zero}$

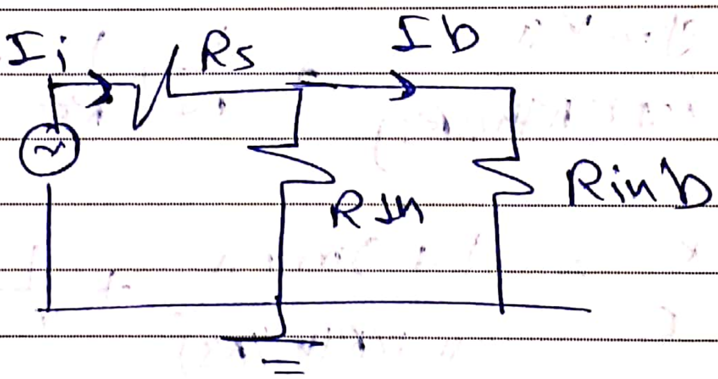
If $(\beta+1)(r_o \parallel R_E) \gg r_\pi$

$R_{in} \gg R_s$, $A_v \simeq 1 \Rightarrow v_o \simeq v_s$

[emitter-follower] هذه الدارة لا تكبر الفولتية لكنها تكبر التيار

$$A_I = \frac{I_o}{I_{in}} = \frac{I_o}{I_b} * \frac{I_b}{I_{in}}$$

$$I_o = \frac{(\beta+1) \cdot I_b * r_o}{r_o + R_E}$$



$$I_b = \frac{I_i * R_{th}}{R_{th} + R_{inb}} \Rightarrow \frac{I_b}{I_i} = \frac{R_{th}}{R_{th} + R_{inb}}$$

$$A_I = \frac{(\beta+1) \cdot r_o}{r_o + R_E} * \frac{R_{th}}{R_{th} + R_{inb}}$$

- For $r_o \gg R_E$
  $R_{th} \gg R_{ib}$
  $A_I \simeq (\beta+1) \Rightarrow \max$

only we can use it as ~~voltage~~ Current Amp but Not voltage Amp.

b3)

- $R_{in} = R_{th} \parallel R_{ib} \Rightarrow$ high.

$R_o = \frac{v_x}{I_x}\Big|_{v_s=0}$ $\Rightarrow$ KCL @ Node d
$\sum I_{in} = \sum I_{out}$

$$I_x + g_m v_\pi = \frac{v_x}{R_E} + \frac{v_x}{r_o} + \frac{v_x}{r_\pi + (R_s \parallel R_{th})}$$

$$\boxed{v_\pi = -\frac{v_x \cdot r_\pi}{r_\pi + (R_{th} \parallel R_s)}}$$

$$\frac{I_x}{v_x} = \frac{g_m r_\pi}{r_\pi + (R_{th} \parallel R_s)} + \frac{1}{r_o} + \frac{1}{R_E} + \frac{1}{r_\pi + (R_s \parallel R_{th})}$$

$$\frac{1}{R_o} = \frac{I_x}{v_x} = \frac{1 + g_m r_\pi}{r_\pi + (R_{th} \parallel R_s)} + \frac{1}{r_o} + \frac{1}{R_E}$$

$$\frac{1}{R_o} = \frac{1+\beta}{r_\pi + (R_{th} \parallel R_s)} + \frac{1}{r_o} + \frac{1}{R_E}$$

$$\boxed{R_o = \frac{r_\pi + (R_{th} \parallel R_s)}{\beta + 1} \parallel r_o \parallel R_E}$$

$\Rightarrow$ low

Resistance Reflection Rule

64

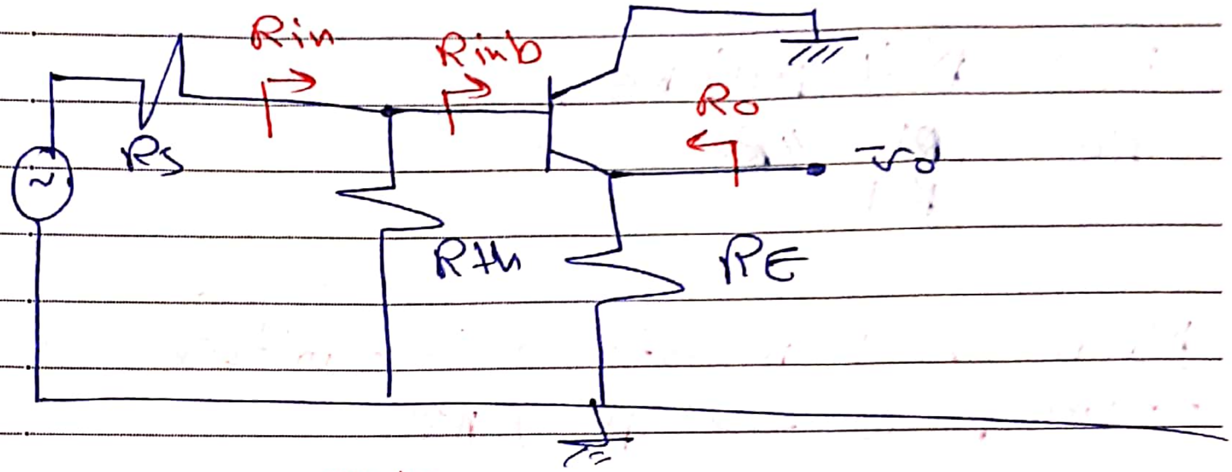
⊛ خواص ال C.C ⇐ [Emitter follower]

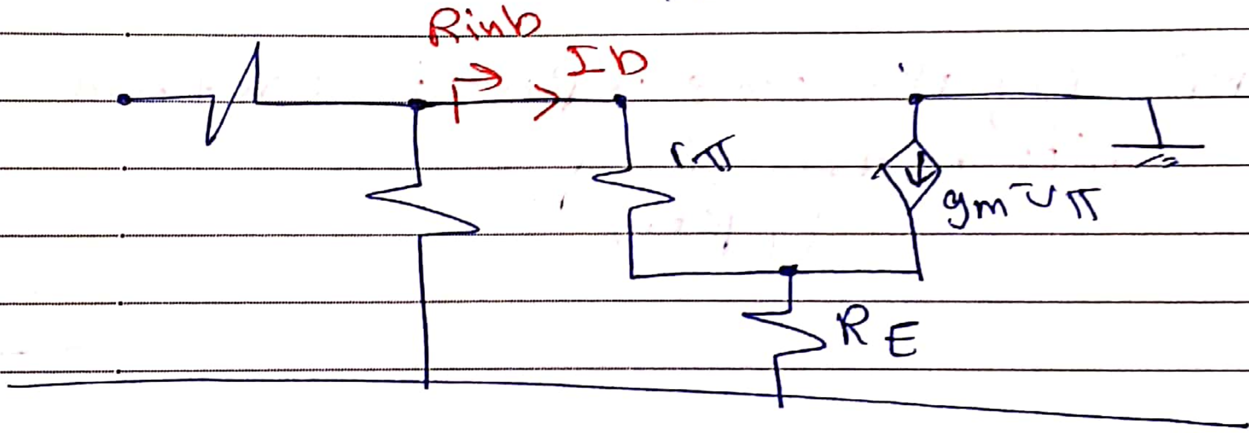
$A_v < 1$, $A_I > 1$, R_{in}: high, R_o: Low

$\phi = \text{Zero}$

(15) محاضرة

⊛ Resistance Reflection Rule (RRR):



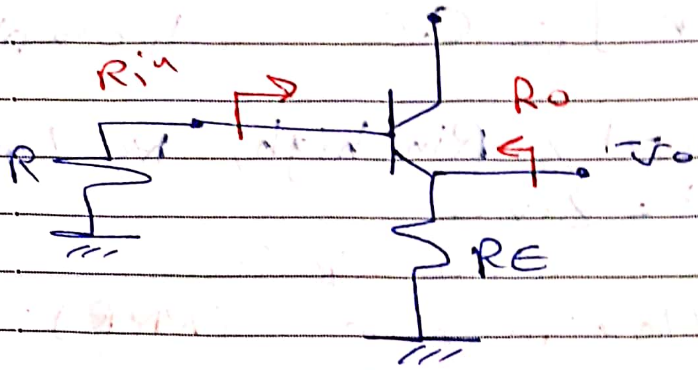


إذا نقلنا من ال Emitter

لل Base ⇐ $(\beta+1) * R$

$I_e = (\beta+1) I$

$$R_{ib} = r_\pi + (\beta+1) R_E$$



$R_{in} = R \parallel (\beta+1) R_E$

$R_o = \frac{(R)}{\beta+1} \parallel R_E$

RRR: Any Resistance in Emitter Seen from base $\Rightarrow (\beta+1) R_E$

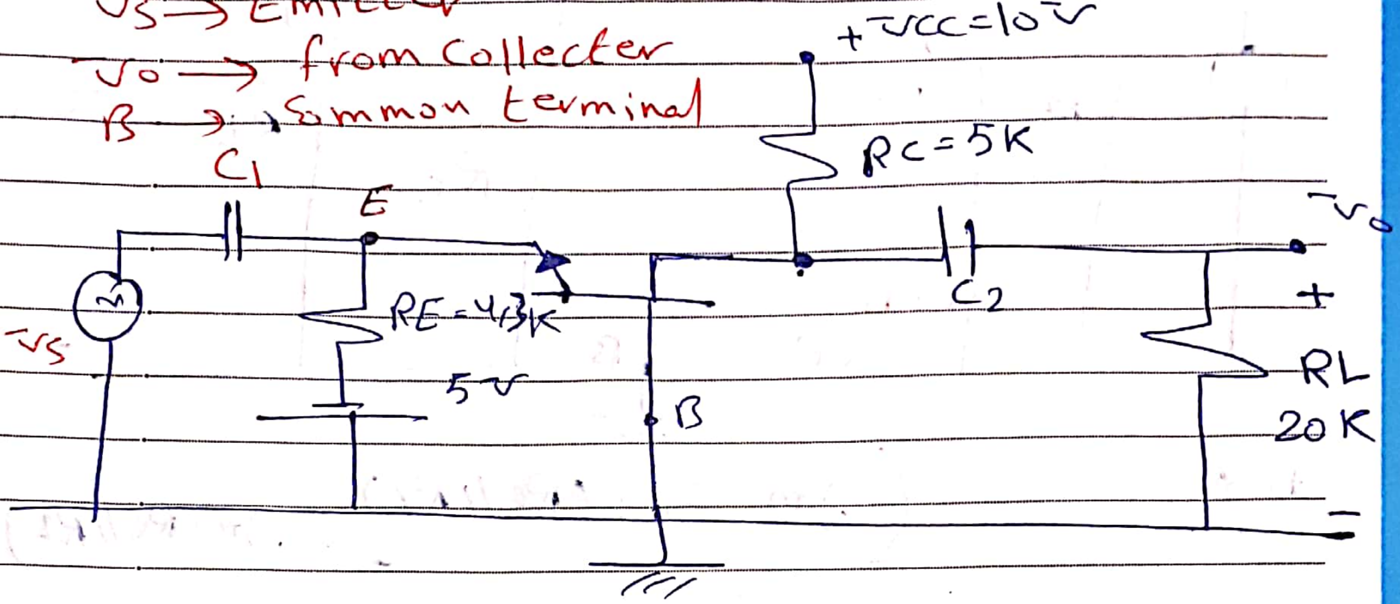
IRRR: Any Resistance in Base is seen from emitter as $\frac{R}{(\beta+1)}$

inverse

66

⊛ Common-Base Amp (C.B) Amp.

$V_s \rightarrow$ Emitter
$V_o \rightarrow$ from Collecter
$B \rightarrow$ Common terminal



$\beta=100, \; V_{BE}=0.7V, \; V_A=\infty.$

Find ⇒ ① I_C, V_{CE}.
② Draw A.C ~~ckt~~ eq cct.
③ A_v, R_{in}, R_o

KVL: $V_{BE}+I_E R_E-5=0$

$$I_E=\frac{5-V_{BE}}{R_E}=\frac{5-0.7}{4.3K}=1mA$$

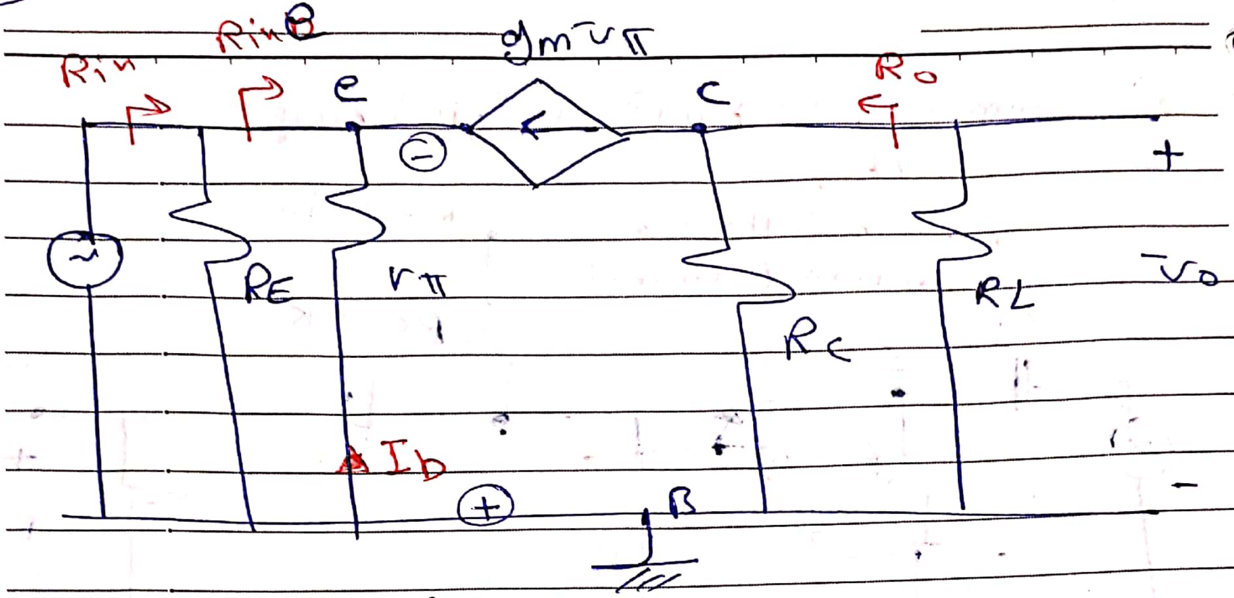
$I_C=\alpha I_E=0.99mA$

KVL:

$-10+I_C R_C+V_{CE}+I_E R_E-5=0$

$$I_C=\frac{10-I_E R_E+5}{\cancel{R_E}}=\frac{10-1\times4.3+5}{\cancel{5K}}$$

$$\boxed{V_{CE}=5.75V}$$



$$A_v = \frac{v_o}{v_s} = \frac{(-g_m v_\pi)(R_C \| R_L)}{-v_\pi} = g_m (R_C \| R_L)$$

Note that $A_v > 1$, ϕ = zero.

$$R_o = \frac{v_x}{I_x} \Rightarrow \text{when } v_s = 0,\ v_\pi = 0$$

$g_m v_\pi = 0$.

dep C.S is O.C.

$R_o = R_C$

لو كان فيه r_o

$\boxed{R_o = R_C \| r_o}$

$$R_{ie} = \frac{v}{I} = \frac{-v_\pi}{-I_e} = \frac{v_\pi}{I_e}$$

$$\frac{v_\pi}{(\beta+1) I_b} = \frac{v_\pi}{(\beta+1) * \frac{v_\pi}{r_\pi}} = \frac{r_\pi}{\beta+1}$$

(ازا بدك بار RRR ، انت بتطلعهن من Emitter وتقاطعه بار Base .)

$$\Rightarrow R_{in} = R_E // R_{ie} \Rightarrow \boxed{R_E // \frac{r_\pi}{\beta+1} = R_{in}}$$

Rin For Common Base is Low. $\Leftarrow$ Note that

C.P.R

$$- A_I = \frac{I_o}{I_i} = \frac{-g_m v_\pi * R_c}{R_c + R_L}$$

$$v_\pi = -I_i * R_{in} = -I_i \left(\frac{r_\pi}{(\beta+1)} // R_E \right)$$

But $\frac{r_\pi}{\beta+1} << R_E$

i.e $R_{in} \simeq \frac{r_\pi}{\beta+1}$

$$v_\pi = -I_i * \frac{r_\pi}{\beta+1}$$

$$I_o = \left(\frac{g_m r_\pi}{\beta+1} * \frac{R_c}{R_c+R_L} \right) * I_i$$

$$\frac{I_o}{I_i} = A_I = \frac{\beta}{\beta+1} * \frac{R_C}{R_C+R_L}$$

For No $R_L \Rightarrow A_I(Max) \simeq \frac{\beta}{\beta+1} \simeq \alpha$

Note that:

$\boxed{A_I < 1}$, $A_I \simeq 1 = \frac{I_o}{I_i}$

" Current follower "

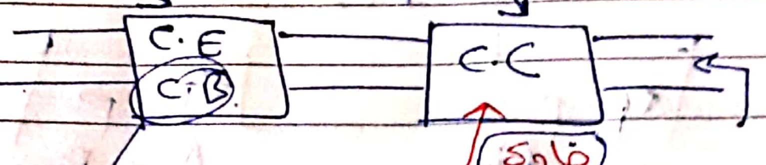
"16 لا تحاضرة ، قم"

⊛ Summary for S.S BJT Amp:

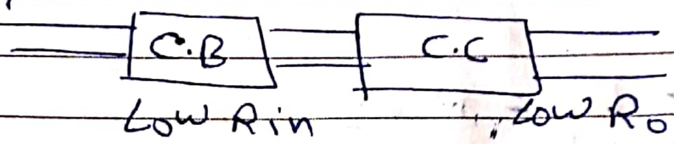
Amp	A_V	A_I	ϕ	R_{in}	R_o
C.E	>1	>1	180°	moderate	moderate to high
C.C	<1	>1	0	high	Low
C.B	>1	<1	0	Low	moderate to high

$A_v > 1$, Low R_o , $\phi = 0°$

كلها بتعطي $A_v > 1$



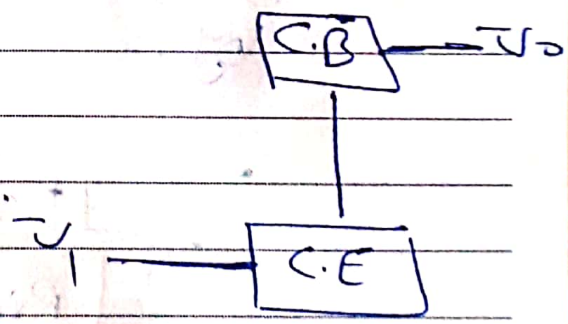
لو عايز $\phi = 0$



(*) we must use Multistage if we want specific output that can't get by single stage.

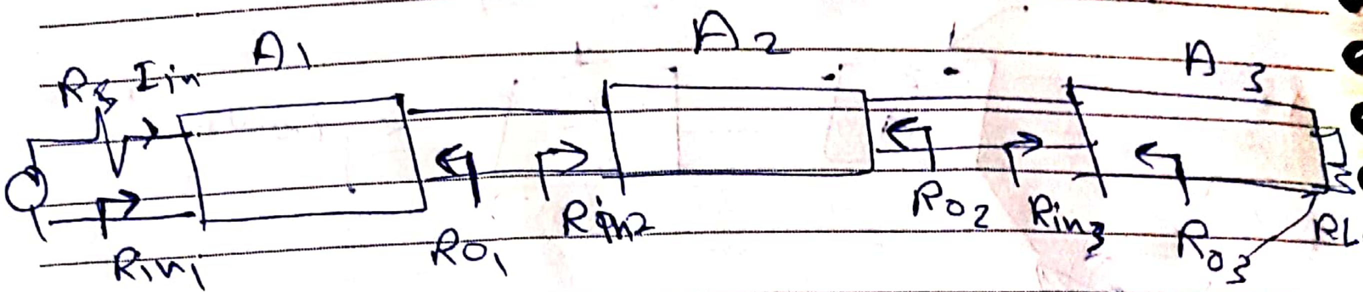
Multistage

Cascade — Cascode



" إجباري "

wideband Amp ⇐ تطبيقاتها



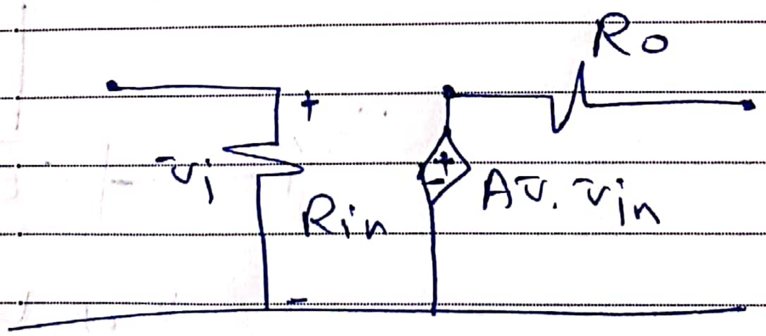
$R_{in\,total} = R_{in1}$

$R_{o\,total} = R_{o3}$

$A_v = \dfrac{v_L}{v_s}$ → بدك تاخذ بعين الاعتبار ال RL الي بتفوت عالدارة وبعدها

$$A_I = \frac{I_o}{I_{in}} = \frac{\frac{v_o}{R_L}}{\frac{v_s}{R_s+R_{in1}}} = \boxed{A_v \cdot \frac{R_s+R_{in}}{R_L}}$$

(*) any voltage Amp can be Represented by :-



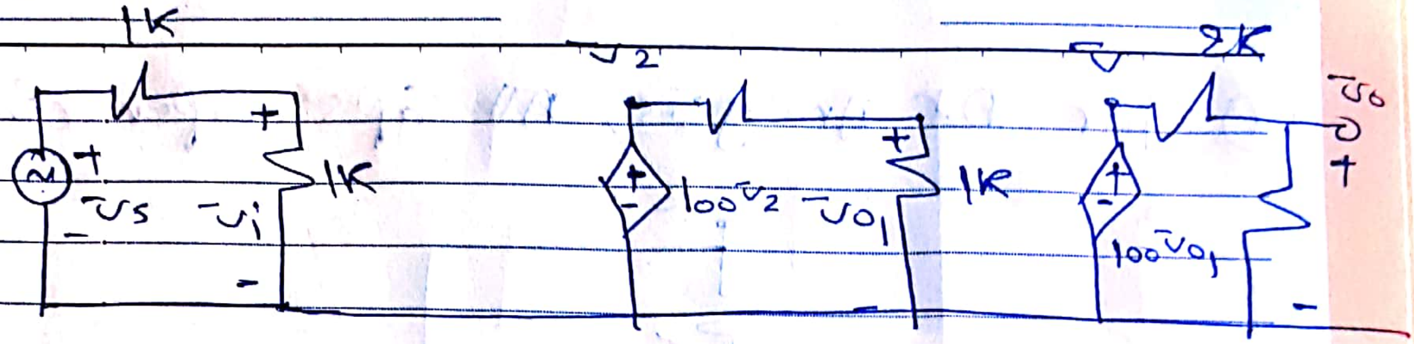
$A_v = 100$

$R_{in} = 1K$

$R_o = 2K$

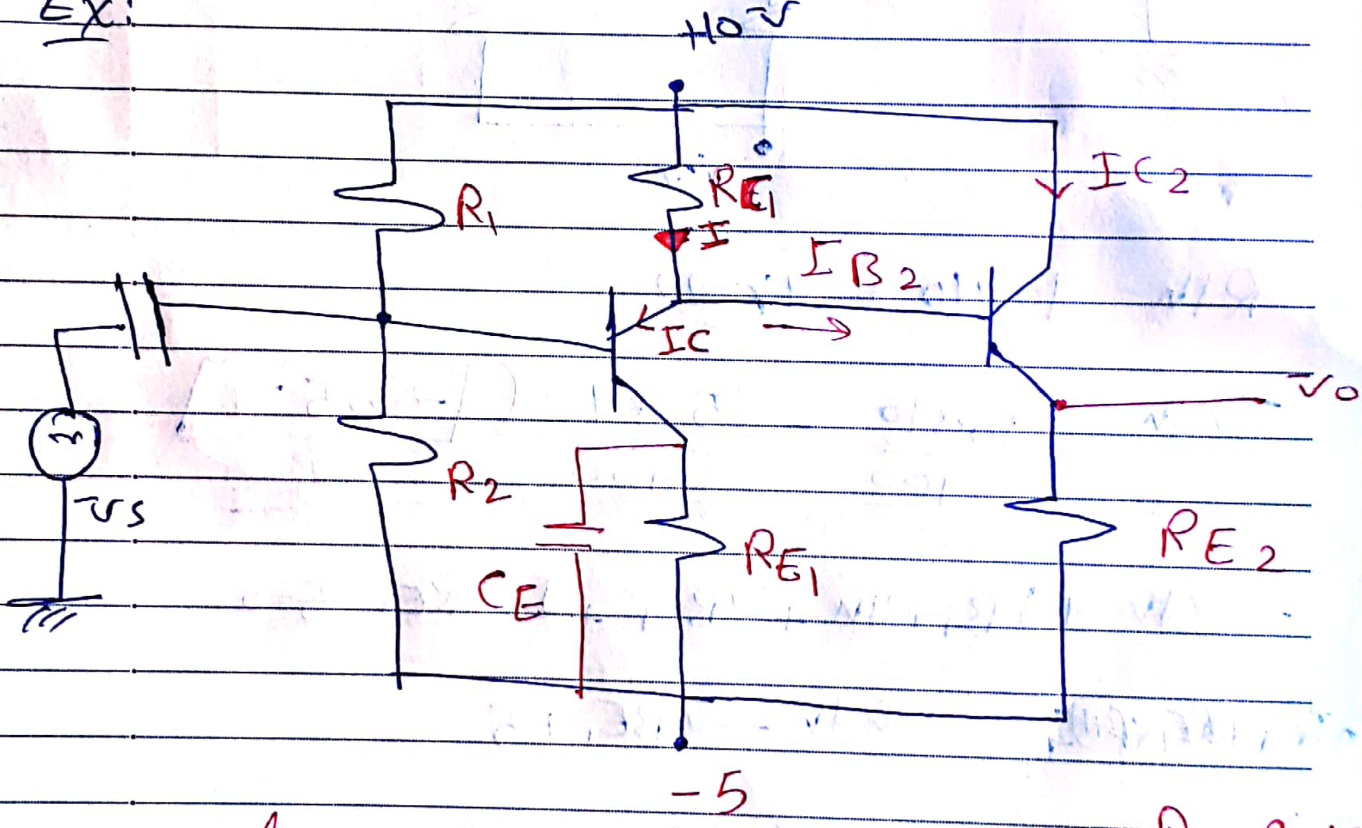
$A_v = \frac{1}{2} * 100 * \frac{1}{2} * 100 * \frac{1}{2}$ $\quad \frac{v_o}{v_1} * \frac{v_1}{v_{o1}} \cdots$

72



$\frac{R_i}{1K}$ $\frac{R_o}{2K}$

Ex:



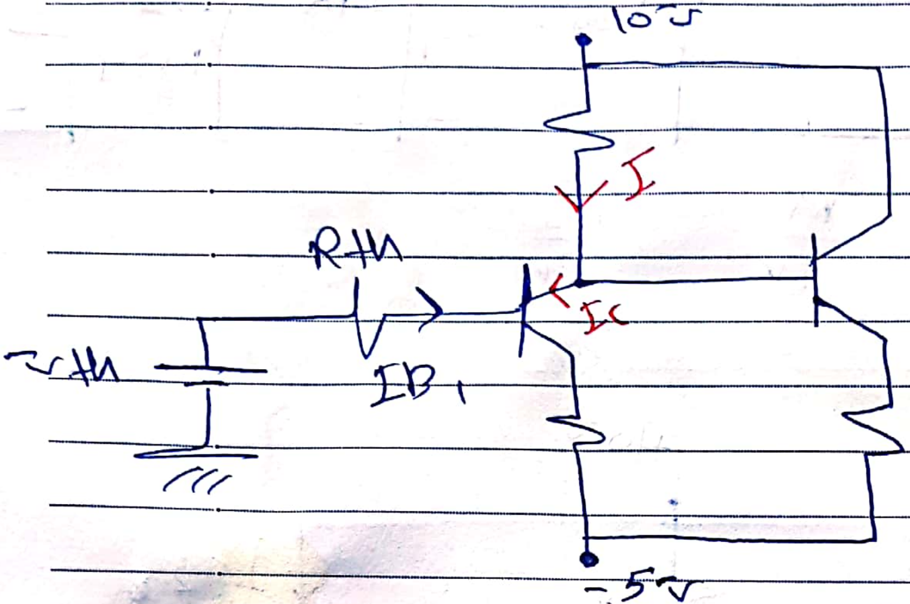
① Q_1 and Q_2 are identical with $\beta = 100$, $V_{BE} = 0.7V$, $V_A = 100V$.

① find I_{B1}, I_{C1}, V_{CE1}, I_{B2}, I_{C2}, V_{CE2}

② Draw S.S.A.C equ. cct and find A_{v1}, A_{v2}, A_v, R_{in}, R_o, R, R_o, R_{i2}

$R_1 = 90K$
$R_2 = 10K$
$R_{C1} = 5K$
$R_{E1} = 0.7K$
$R_{E2} = 1K$
$V_{BE} = 0.7V$

* For D.C Analysis, All Caps opencet



$R_{th} = 90 // 10 = 9 k\Omega$

$v_{th} = \frac{10 * 10}{100} - \frac{(5 * 90)}{100} = \boxed{-3,5 \, v}$

$-v_{th} + I_{B_1} R_{th} + v_{BE_1} + I_{E_1} R_{E_1} - 5 = 0$

$R_{th} I_{B_1} + R_{E_1} \cdot (\beta + 1) I_{B_1} = v_{th} - v_{BE_1} + 5$

$I_{B_1} = \frac{-3,5 + 5 - 0,7}{9 + 101 * 0,7} = \frac{0,8}{79,7} = \boxed{0,01 \, mA}$

$I_{C_1} = \beta I_{B_1} = 1 mA$

$-10 + I \, R_{C_1} + v_{CE_1} + I_{E_1} R_{E_1} - 5 = 0$

$\cancel{v_{CE_1} = 14,3 - I R_{C_1}}$

$I_2 \Rightarrow$ KCL at node C_1:

$$I = I_{C_1} + I_{B_2}$$

$$\frac{10 - V_C}{R_{C_1}} = 1m + ?$$

$$\Rightarrow -V_C + V_{BE} + (\beta+1) I_{B_2} R_{E_2} - 5 = 0$$

$$\frac{5 + V_C - V_{BE}}{(\beta+1) R_{E_2}} = I_{B_2}$$

$$I_{B_2} = \frac{V_{C_1} + 4{,}3}{101 \times 1K}$$

$$\Rightarrow \frac{10 - V_C}{R_{C_1}} = 1m + \frac{V_{C_1}}{101} + \frac{4{,}3}{101}$$

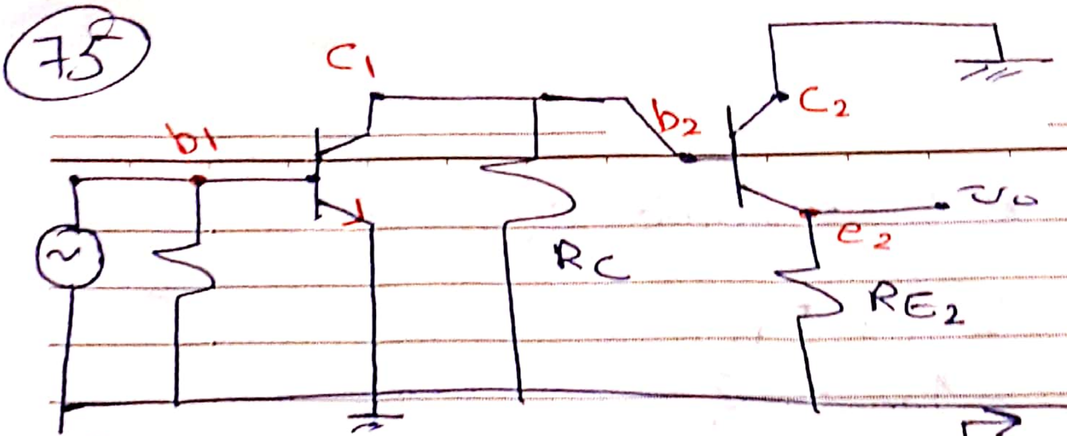
$$\boxed{V_{C_1} = 4{,}5\,V}$$

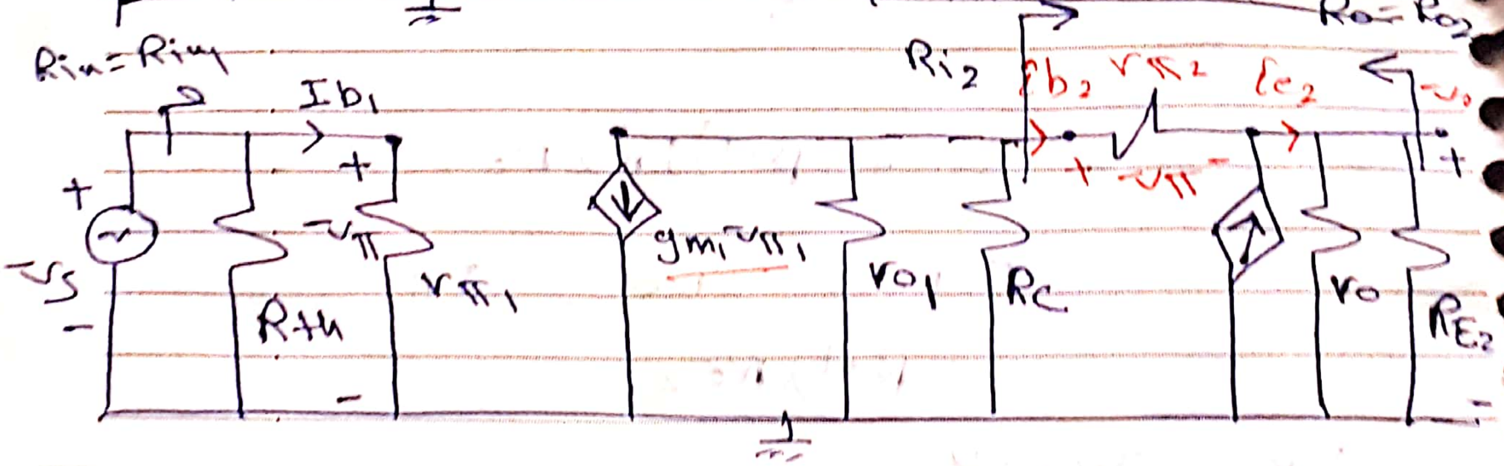
$$I_{B_2} = \frac{4{,}5 + 4{,}3}{101K} = \boxed{0{,}08\,mA}$$

$$I = \frac{10 - 4{,}5}{5K} = 1{,}1\,mA$$

V_{CE_1} ✓ , V_{CE_2} ✓

75





$$A_{v1} = \frac{v_{o1}}{v_s} \quad , \quad A_{v2} = \frac{v_o}{v_{i2}}$$

$$A_{vT} = \frac{v_o}{v_{i2}} \times \frac{v_{o1}}{v_s} = A_{v2} \times A_{v1}$$

$$v_o = (\beta+1) I_{b2} (r_{o2} \parallel R_{E2})$$

$$-v_{i2} + v_\pi + v_o = 0$$

$$v_{i2} = I_{b2} r_{\pi 2} + (\beta+1) I_{b2} (r_{o2} \parallel R_{E2})$$

$$A_{v2} = \frac{v_o}{v_{i2}} = \frac{(\beta+1) \cancel{I_{b2}} (r_{o2} \parallel R_{E2})}{\cancel{I_{b2}} (r_{\pi 2} + (\beta+1)(r_{o2} \parallel R_{E2}))}$$

$$A_{v2} = \frac{(\beta+1)(r_{o2} \parallel R_{E2})}{(r_{\pi 2} + (\beta+1)(r_{o2} \parallel R_{E2}))}$$

76

$v_{o1} = -g_{m1} v_{\pi 1} (r_{o1} \parallel R_C \parallel R_{in2})$

$R_{in2} = R_{inb2} = \dfrac{v_i}{I_{b2}} = r_{\pi 2} + (\beta+1)(r_{o2} \parallel R_{E2})$

"by Resistance Reflection Rule"

$v_s = v_{\pi 1}$

$\Rightarrow A_{v1} = \dfrac{-g_{m1} \cancel{v_{\pi 1}} (r_{o1} \parallel R_C \parallel R_{in2})}{\cancel{v_{\pi 1}}}$

$A_{v1} = -g_{m1} (r_{o1} \parallel R_C \parallel R_{in2})$

$A_{vT} = \dfrac{-g_m (R_C \parallel r_{o1} \parallel R_{in2}) * (\beta+1)(r_{o2} \parallel R_{E2})}{r_{\pi 2} + (\beta+1)(r_{o2} \parallel R_{E2})}$.

$A_I = \dfrac{I_o}{I_i} = \dfrac{\dfrac{v_o}{R_{E2}}}{\dfrac{v_s}{R_{in}}} = A_v * \dfrac{R_{in}}{R_E}$

$R_{in} = R_{th} \parallel r_{\pi 1}$.

$R_{o1} = R_C \parallel r_{o1}$

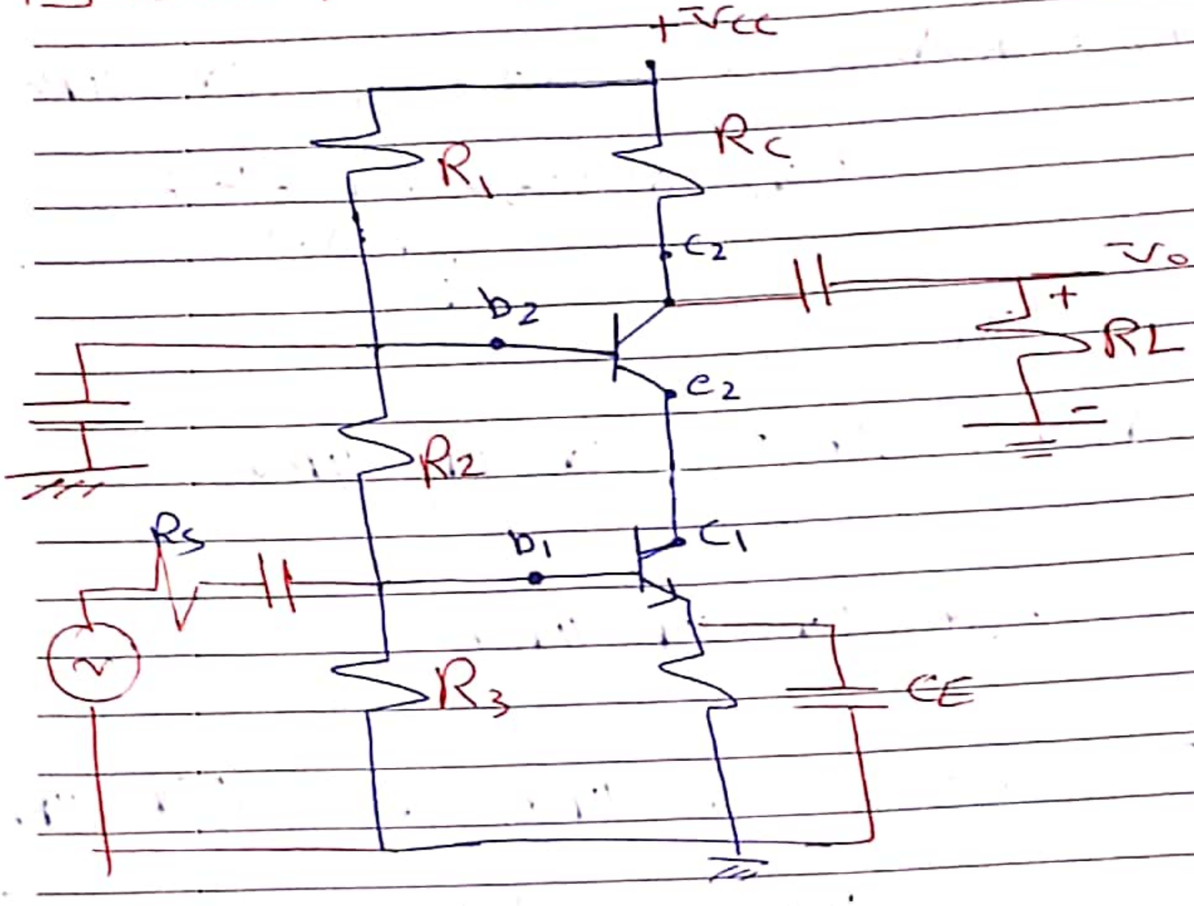
$R_{in2} = R_{inb2} = (r_{\pi 2} + (\beta+1)) * (r_{o2} \parallel R_{E2})$

$R_o = R_{o2} = \dfrac{v_x}{I_x} \Big|_{v_s = 0}$

when $v_s = 0$, $v_{\pi 1} = 0$, $g_{m1} v_{\pi 1} = 0$ $\Rightarrow$ IRRR $\Rightarrow R_o = R_{o2} = \dfrac{(r_{o1} \parallel R_C) + r_{\pi 2}}{(\beta+1)} \parallel r_{o2} \parallel R_{E2}$

" معا مرة 17 "

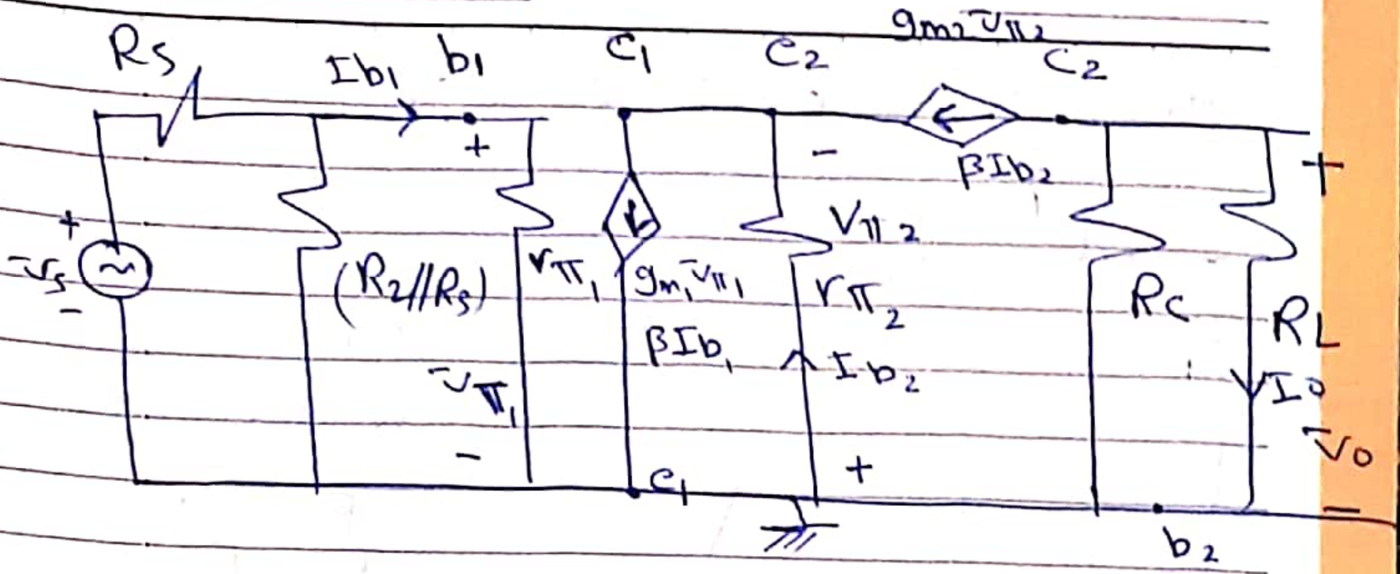
[2] Cascode Multistage:



⊗ لا ننسى بان التركيب تاعنا Cascode ثابت

"C.E + C.B"

78



$$\Rightarrow \frac{v_o}{v_s} = Av = \frac{v_o}{v_{\pi 2}} * \frac{v_{\pi 2}}{v_{\pi 1}} * \frac{v_{\pi 1}}{v_s}$$

$$\frac{v_o}{v_{\pi 2}} = -g_{m2}(R_C // R_L)$$

KCL at Node (e)

$$I_{C2} + I_{b2} = I_{e2}$$

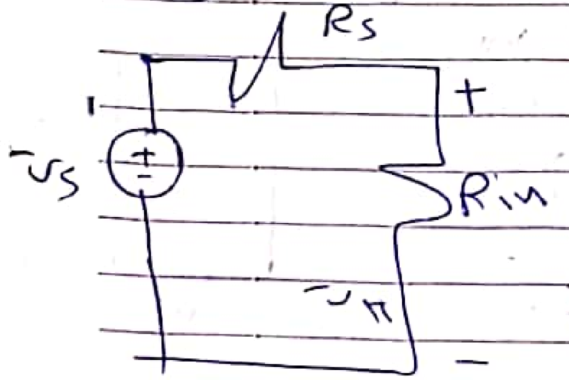
$$g_{m2} v_{\pi 2} + \frac{v_{\pi 2}}{r_{\pi 2}} = g_{m1} v_{\pi 1}$$

$$v_{\pi 2}\left(\frac{g_{m2} r_{\pi 2} + 1}{r_{\pi 2}}\right) = g_{m1} v_{\pi 1}$$

$$\boxed{\frac{v_{\pi 2}}{v_{\pi 1}} = \frac{r_{\pi 2}\, g_{m1}}{\beta + 1}}$$ $\Rightarrow$ remember $g_m r_\pi = \beta$

Scanned by CamScanner

$\frac{v_{\pi_1}}{v_s} \Rightarrow$ voltage devider.



$$v_\pi = \frac{v_s \times R_{in}}{R_{in}+R_s}$$

$$\boxed{\frac{v_\pi}{v_s} = \frac{R_{in}}{R_{in}+R_s}}$$

$$A_v = -g_{m_2}(R_C // R_L) \times \frac{r_{\pi_2} g_{m_1}}{(\beta+1)} \times \frac{R_{in}}{R_{in}+R_s}$$

$$A_v = -\underbrace{\frac{\beta}{\beta+1}}_{\simeq 1} g_{m_1}(R_C // R_L) \times \frac{R_{in}}{R_{in}+R_s}$$

$$A_v = \frac{-g_{m_1}(R_C // R_L) \times R_{in}}{R_{in}+R_s}$$

$$R_{in} = (R_2 // R_3) // R_{in\,b}$$

$$\boxed{R_{in} = (R_2 // R_3) // r_{\pi_1}}$$

$\boxed{R_o = R_C} \Rightarrow$ Common Base

$R_C // r_o \leftarrow r_o$ لو كان في

(80) (*) لا تنسَ إن الـ r_π بين الـ Base والـ Emitter
$+$ $-$

(*) // // إن الـ r_o بين الـ C والـ E.

(*) الـ A_v للـ Cascode
C.B + C.E ⟸ هي نفس الـ A_v
تاعت الـ C.E ليش؟

$$R_{o1} = \infty$$

$$R_{in2} = \frac{r_{\pi 2}}{\beta+1}$$

لأن الـ C.B دخل عليه تيار وليسه توليفة وهي
ما بتكبر تيار الـ $A<1$.

وإذا كان في سؤال Design أو Analysis
بالـ D.C ⟸ لازم تاخذ " Hint " النتيجة
واللي هي $I_C = I_E$

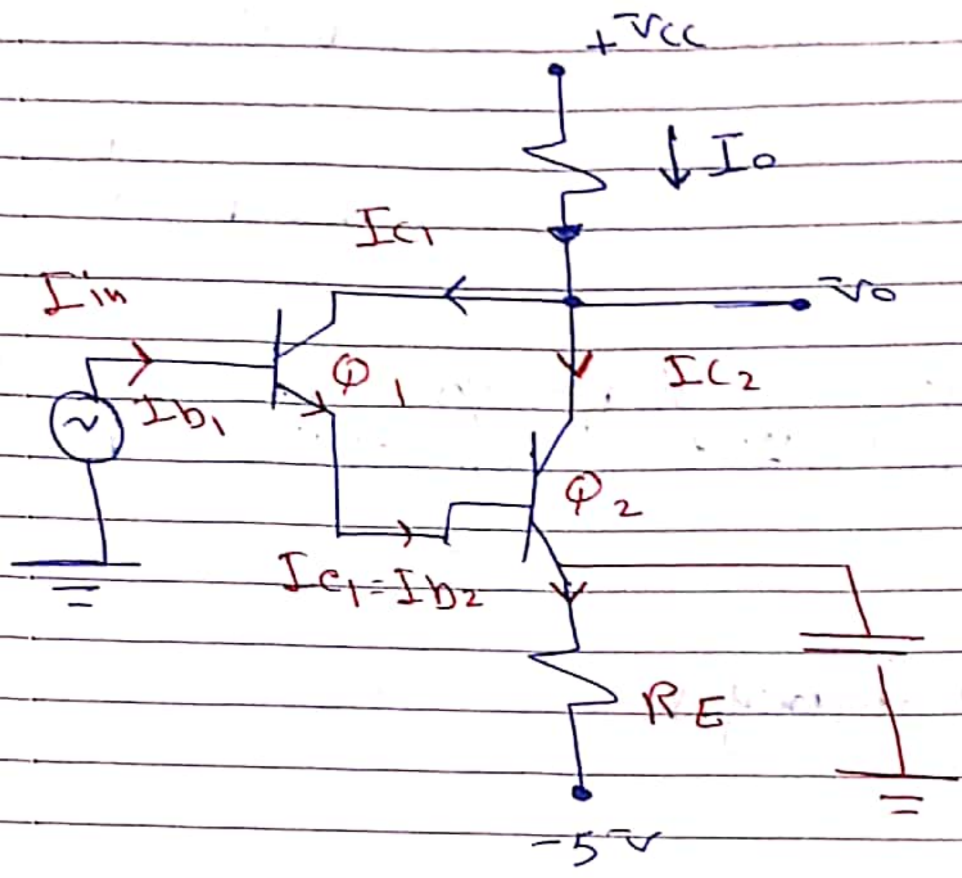
(*) دائماً الـ Cascode تستخدم for high frequency.

81

"Highst Current gain"

3 Darlington pair Configuration:

"Very high AI".



$I_o = I_{C_1} + I_{C_2}$

$= \beta I_{b_1} + \beta I_{b_2}$

but $I_{b_2} = I_{e_1} = (\beta+1) I_{b_1}$

$I_{b_1} = I_{in}$

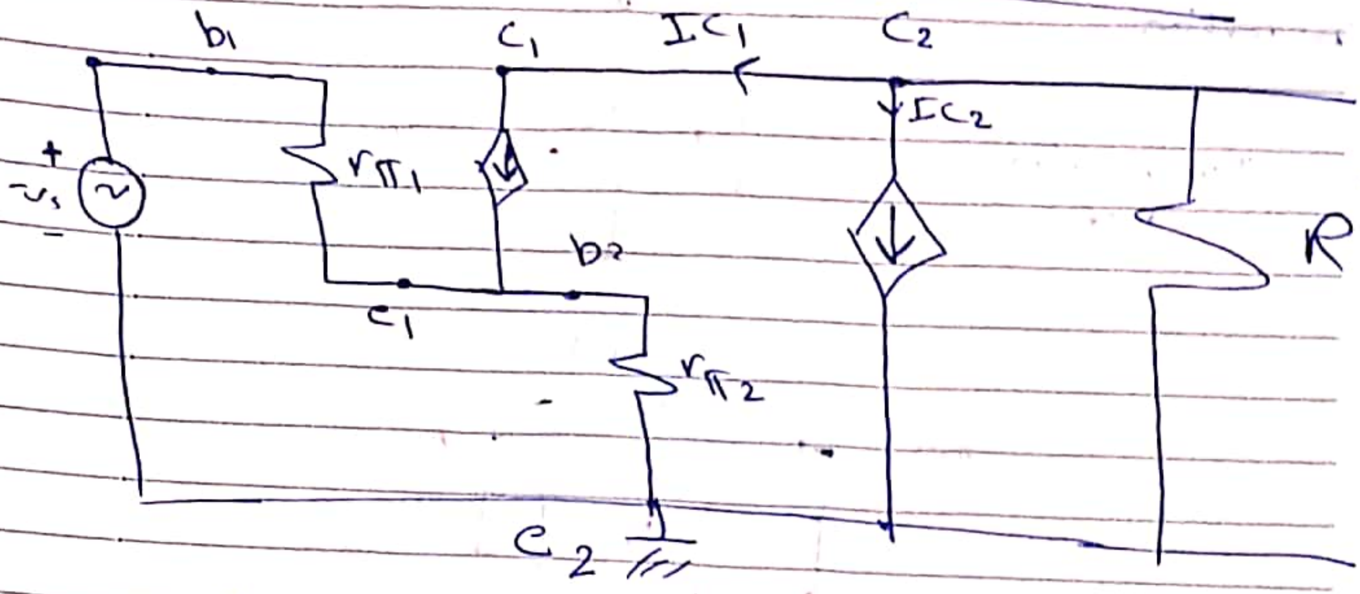
$I_o = \beta I_{b_1} + \beta(\beta+1) I_{b_1}$

$I_o = \beta I_{in} + \beta^2 I_{in} + \beta I_{in}$

$\frac{I_o}{I_{in}} = AI = \beta^2 + 2\beta \simeq \boxed{AI = \beta^2}$

82

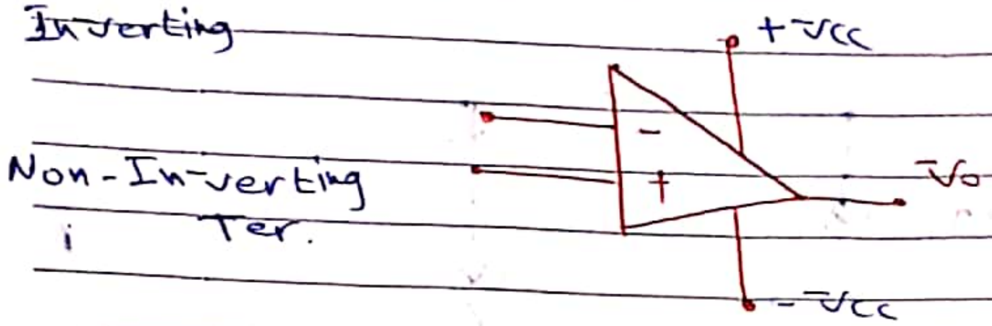
$$A_v = \frac{V_o}{V_s} = \frac{I_o R_C}{I_{in} R_{in}} = A_I \times \frac{R_C}{R_{in}}$$

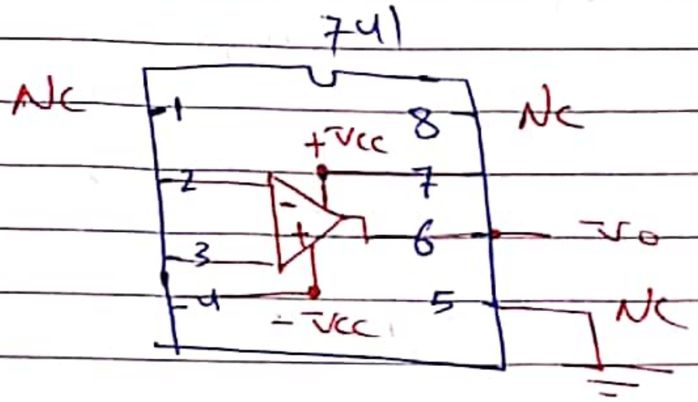


S.S.A.C equ cct.

"18 [illegible]"

Operational Amplifier : (op.Amp)

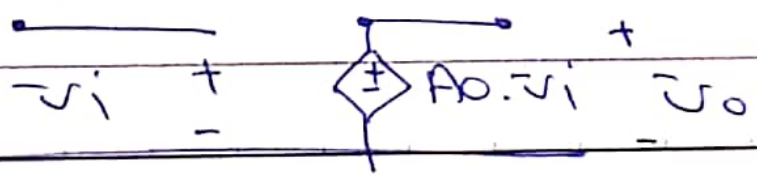




PIN - Diagram.

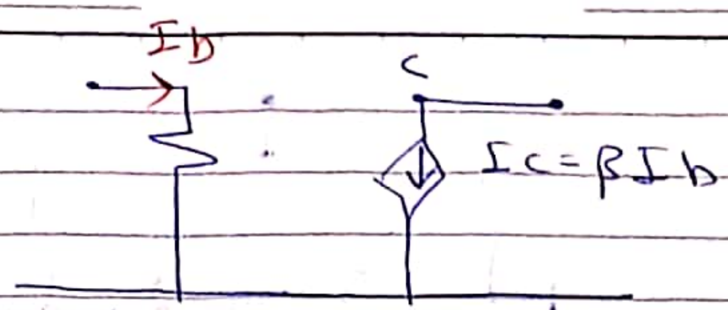
op. Amp : very high gain voltage Amp Contain multistage directly Connected to BJT and FET Compared.

it is a voltage Controlled voltage source "VCVS" ⇒ $V_o \propto V_i$

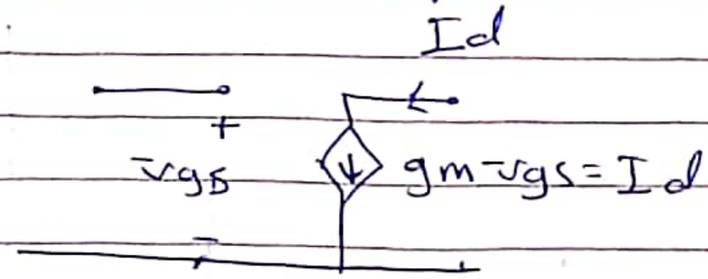


$V_o = A_o . V_i$, A_o: open Loop , gain

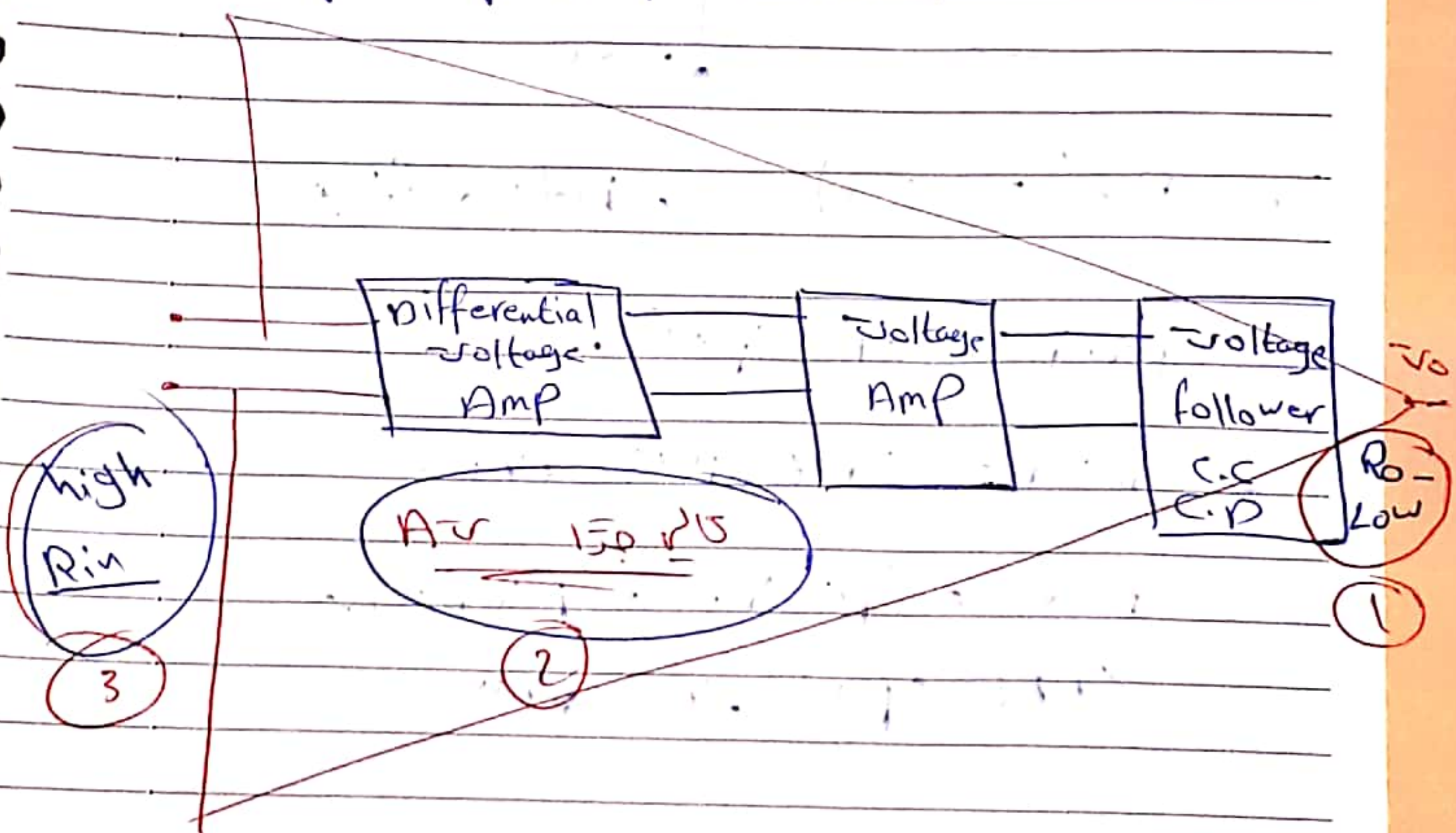
* BJT ⟹
C.C.C.S

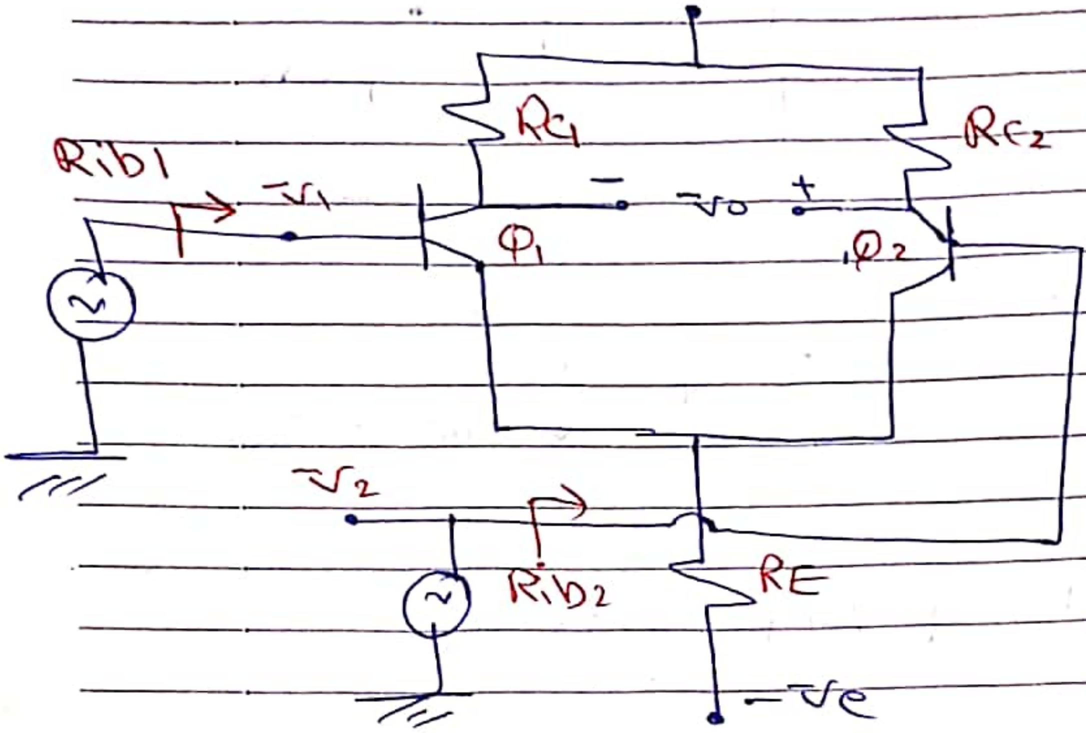


* FET ⟹
V.C.C.S



- the simple op-Amp contains:





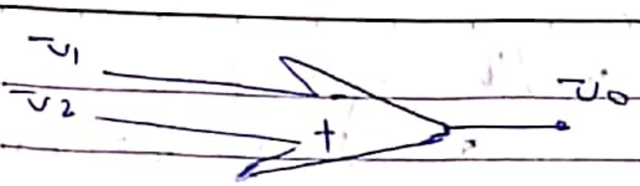
$v_o = A_d(v_2 - v_1)$, A_d: diff gain.

$R_{inb1} = 2R_E(\beta+1) + r_{\pi 1}$

$R_{inb2} = 2R_E(\beta+1) + r_{\pi 2}$

$R_{id} = (R_{inb1}) + (R_{inb2}) =$
$4R_E(\beta+1) + r_{\pi 1} + r_{\pi 2}$.

Rin بس لشرار
very ← op-Amp لل
high.



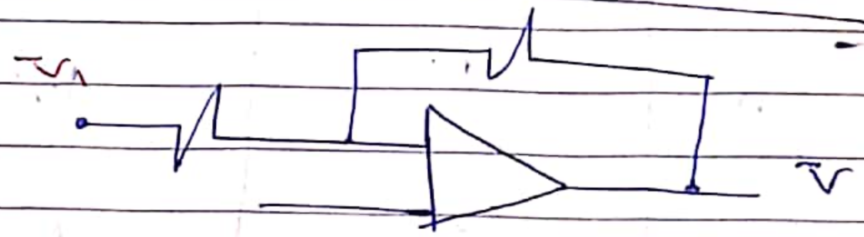
open Loop gain

$$\frac{v_o}{v_2 - v_1} = A_o \rightarrow \text{very high}$$

Ao : تعتبر هوية الـ Amp (تعتمد على التصنيع)

Av : تتأثر بالـ cct كاملة

Closed Loop



Av → قليل

* نقطة مهمة بالـ op-Amp ⇐ مش بس يكبر الـ A.C وكمان يكبر الـ D.C لأنه :

الـ system ⇐ Directly Connected to each other

" يعني مش في Capacitors بينهم "

* كانت الـ op-Amp الـ Ao , Av

كاملة ، لأنه الـ system بتكون من كذا

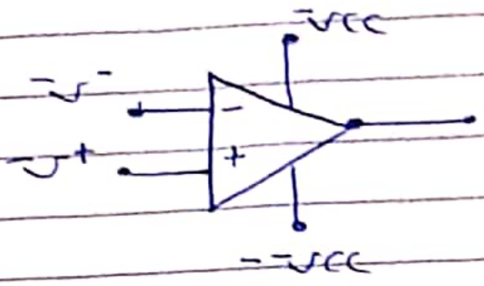
مراحل تكبير الـ Av تكون كبير بالتالي قدرا كاملة

* ال Ao، وال Band width تتغير بال op Amp
كله بيعتمد على التصنيع.

* op-Amp characteristics.

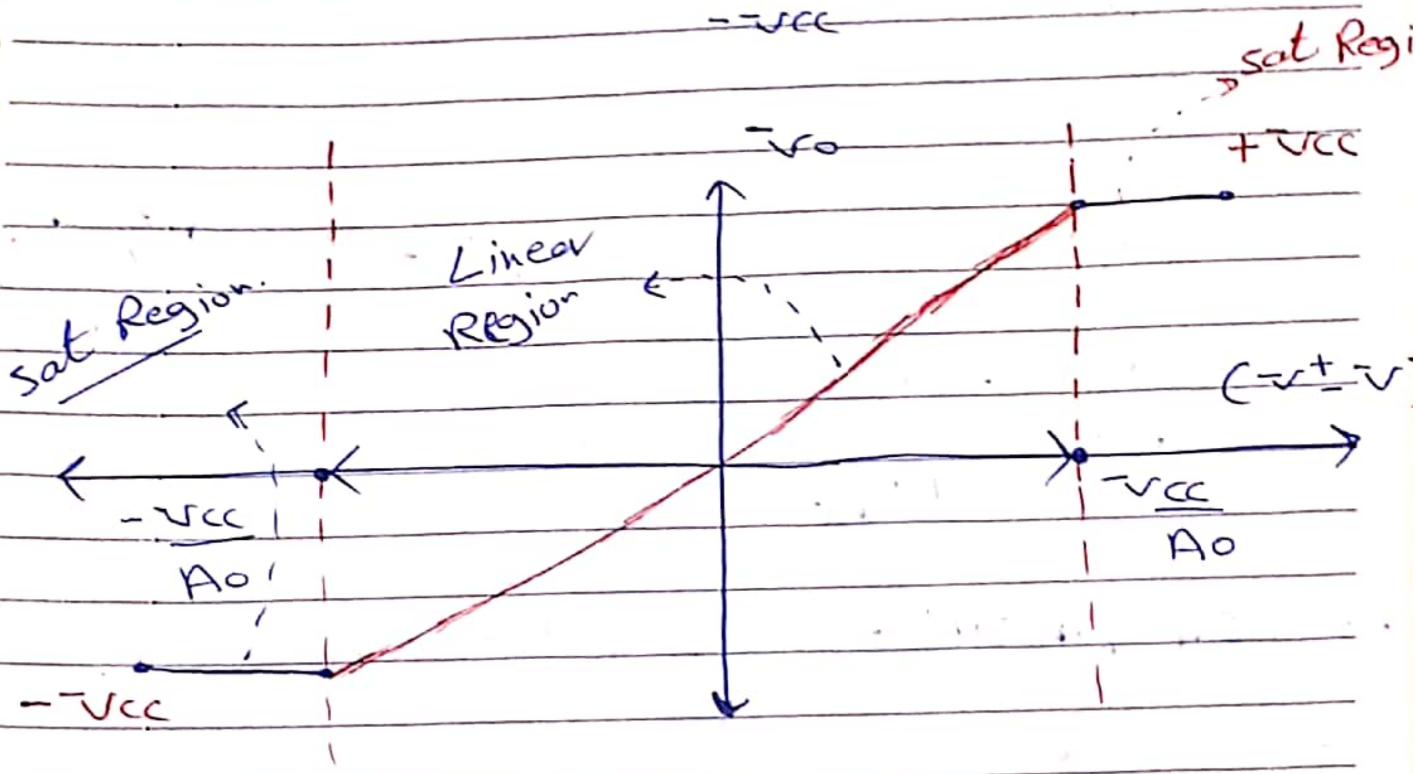
		ideal	Real (741 Bipolar op-Amp)
open Loop gain	A_o	∞	10^5
Input Resistance	R_{in}	∞	$2\,M\Omega$
out put Resistance	R_o	0	$70\,\Omega$
Band width	B.W	∞	1 MHz
Input Current	bias	Zero	10 nA

Transfer characteristics of op-Amp.



$V_o = A_o(V^+ - V^-)$

$= A_o \cdot V_{d}$



$V_o(max) = \mp V_{cc} = A_o(V^+ - V^-)$

ideally $A_o = \infty$.

(i) for $V^+ > V^- \Rightarrow V_o = +V_{cc}$.

(ii) for $V^+ < V^- \Rightarrow V_o = -V_{cc}$.

$\rightarrow (V \pm V^-)_{max} = \frac{V_{cc}}{A_o}$

$\rightarrow (V^+ - V^-) = -\frac{V_{cc}}{A_o}$.

① if $\Rightarrow$ $-\frac{V_{cc}}{A_o} < V^+ - V^- < \frac{V_{cc}}{A_o}$

$V_o = A_o(V^+ - V^-)$

↳ Linear Region.

$V_o \propto V^+ - V^-$

$V_d = V^+ - V^-$

② Saturation Region: $V_o \not\propto V_d$ (out put ثابت ال)

$-\frac{V_{cc}}{A_o} > V^+ - V^- > \frac{V_{cc}}{A_o}$

↳ $\boxed{V_o = \mp V_{cc}}$

Ex: For $\mu A\,741$: $V_{cc} = \mp 15\,V$, $A_o = 10^5$.

① Linear Region:

$-\frac{V_{cc}}{A_o} < V_d < \frac{V_{cc}}{A_o} \Rightarrow \frac{15}{10^5} < V_d < \frac{15}{10^5}$

$-150\,\mu V < V_d < 150\,\mu V$

$V_o = A_o . V_d = A_o(V^+ - V^-)$

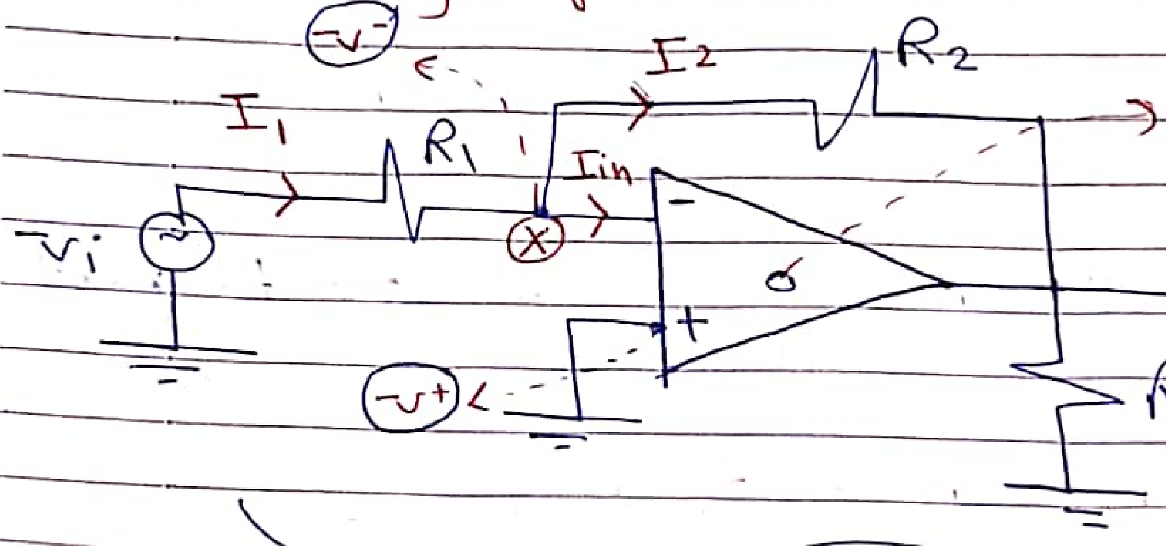
② Saturation Region: $150\,\mu V > V_d > 150\,\mu V$

$V_o = \pm V_{cc}$

* op-Amp Applications:

(A) Linear Applications:

[1] inverting Amplifier.



اسمها inverti
op-Amp

inverting Amplifier. هاي كل الدارة اسمها

- KCL @ Node (x): $\quad \sum I_{in} = \sum I_{out}$

$$I_1 = I_2 + I_{in}$$

$$\frac{v_i - v_x}{R_1} = \frac{v_x - v_o}{R_2} + \text{zero}$$

Note: I_{in} is zero because $R_{in} = \infty$

$$I_{in} = \frac{V^+}{R_{in}} = \frac{\text{كرز}}{\infty} = \text{zero}$$

(*) $v^+ = v^-$ ⇒ (virtual short)

قولتلك من اول قد كلام / يعني دايره ماخذ للإشارة نفسها

(*) $v^+ = v^- = \text{zero}$ (virtual ground)

كلها / يعني دايرة v^- ← حتى ايصير للأرض.

(91) توضيح :

$v_o = A_o(v^+ - v^-)$

$v^+ - v^- = \frac{v_o}{A_o}$ $\Rightarrow$ For ideal op-Amp

$A_o = \infty$

$v^+ - v^- = \frac{v_o}{\infty} = zero \Rightarrow v^+ = v^-$

virtual short $\leftarrow$ short

- then if v^+ or v^- is Connected to ground

$v^+ = v^- = 0$ virtual ground.

⊛ Assuming ideal op-Amp then:

$I_{in} = 0$, $v^+ - v^- = zero$ (V.G)

$v_x = v^- - v^+ = zero$

$$\frac{v_i - \cancel{v_x}}{R_1} = \frac{\cancel{v_x} - v_o}{R_2} + \cancel{I_{in}}$$

$$\frac{v_i}{R_1} = \frac{-v_o}{R_2} \Rightarrow v_o = -\frac{R_2}{R_1} v_i$$

$$\boxed{\text{then } A_v = \frac{v_o}{v_i} = -\frac{R_2}{R_1}}$$

A_v: Closed Loop gain.

(92)

$R_{in} = \frac{v_i}{I_1}$

$-v_i + I_1 R_1 + (\cancel{v^- - v^+}) = 0$ zero

$\frac{v_i}{I_1} = R_1$

$\boxed{R_{in} = R_1}$

(*) هذا الـ op-Amp يكبر فولتية فقط ولا يكبر تيار

(*) Let $R_2 = 10K$, $R_1 = 2K$, find A_v, R_{in}:

$A_v = -\frac{R_2}{R_1} = -5$, $R_{in} = R_1 = 2K\Omega$.

$I_1 = I_2 = \frac{v_i - v_x}{R_1} = \frac{v_i}{R_1} = \frac{4\sin\omega t}{2k} = \boxed{2\sin\omega t \text{ mA}}$

because $I_i = 0$ ideally.

Let $v_i = 4\sin\omega t$

$v_o = -\frac{R_2}{R_1} v_i \Rightarrow -\frac{10}{2}(4\sin\omega t)$

$= -20\sin\omega t$ Volt

$I_L \Rightarrow$ هنا لاحظ انت كيف راح ل v_o

سالبة ، صار التيار I_L ، ، موجب طالع طالعة

لنفرض انها $R_L = 20K$

$I_L = \frac{0 - v_o}{R_L} = \frac{20\sin\omega t}{20K} = \boxed{1\sin\omega t \text{ mA}}$

93

(x) $R_o = R_o(\text{op-Amp}) = \text{zero (ideally)}$

- Note that :

$I_o = I_2 + I_L$

$I_o = 2\sin\omega t + 1\sin\omega t = \boxed{3\sin\omega t \ \text{mA}}$

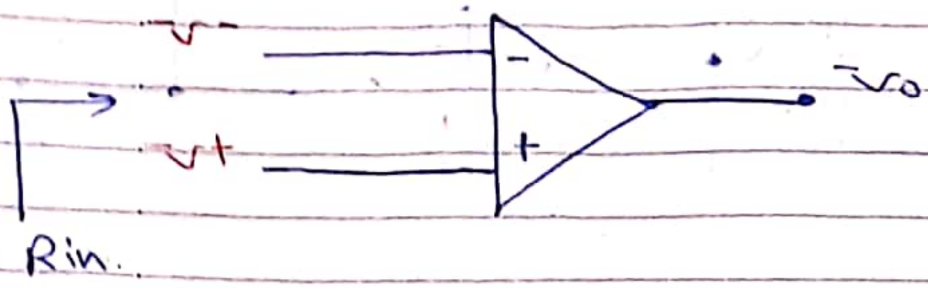
(x.) هاي الحالة إلها اسم (op-Amp) ⟸ بنسميه } Sink Current

لأنه بيدخل التيار نحو الداخل ، لو كان خارج بنسميه
source

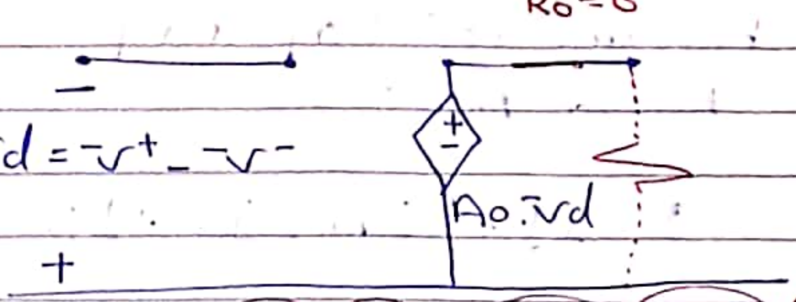
qu   "20 [illegible]"

- For ideal op Amp:

$R_i = \infty$, $R_o = \text{zero}$, $A_o = \infty$, $B.W = \infty$



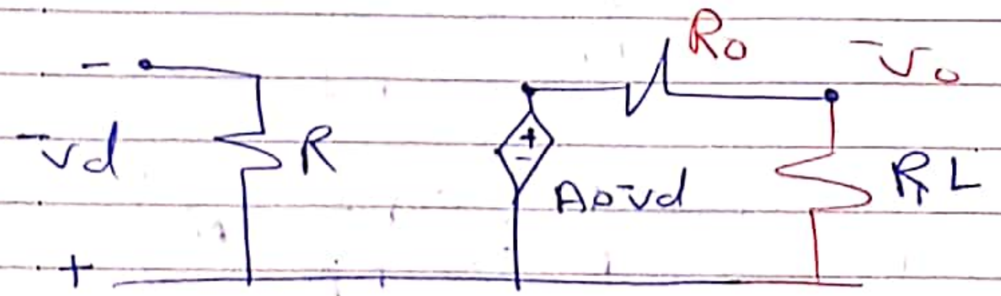
$R_{in} = \infty$
$R_o = \text{zero}$ } $v_d = v^+ - v^-$



$v_o = A_o . v_d \Rightarrow$ Note: v_o is indep on RL.

- For Non_ideal op-Amp:

$R_i \neq \infty$, $R_o \neq \text{zero}$, $A_o \neq$, $B.W \neq 0$

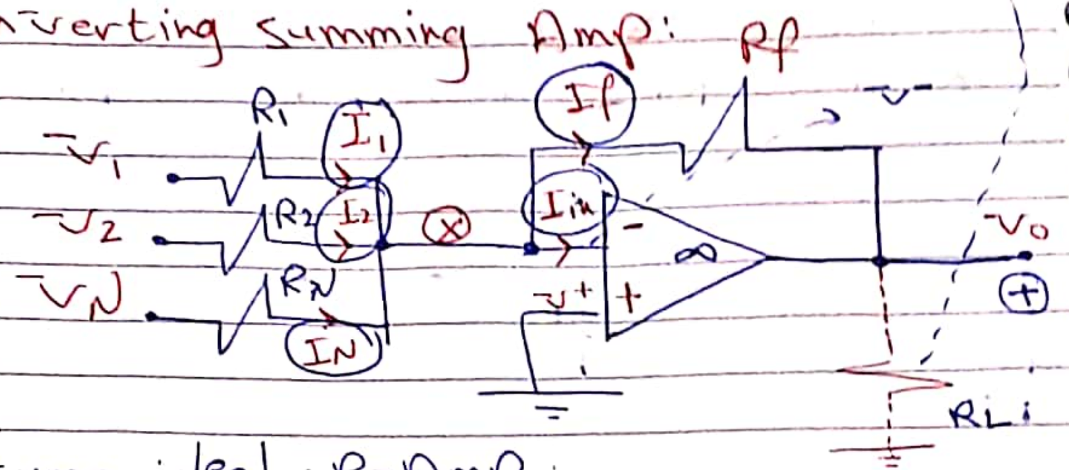


$RL \propto v_o$, v_o depends on RL

$v_o = \frac{A_o v_d * RL}{RL + R_o}$, $v_d = v^+ - v^-$

(95) ما تأثر لا فقط A_v إلا بـ نقطة تؤثر على R_L, I_L.

② Inverting summing Amp:



(*) Assume ideal op-Amp:

KCL @ Node x:

$$I_1 + I_2 + I_N = I_f + I_{in}$$

$$\frac{V_1 - V_x}{R_1} + \frac{V_2 - V_x}{R_2} + \dots + \frac{V_N - V_x}{R_N} = \frac{V_x - V_o}{R_f} + I_{in}$$

ideal Amp $\qquad$ virtual

$$\boxed{I_{in} = \text{zero}, \quad V_x = V^+ = V^- = \text{zero}}$$

$$\frac{V_1}{R_1} + \frac{V_2}{R_2} + \dots \frac{V_N}{R_N} = -\frac{V_o}{R_f}$$

$$V_o = -\left(\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2 + \frac{R_f}{R_N} V_N\right)$$

For the same amplification factor for each signale choose $R_1 = R_2 = R_N = R$

then: $\boxed{V_o = -\frac{R_f}{R}\left(V_1 + V_2 + \dots V_N\right)}$

96

* Note: $v_1, v_2, v_N \Rightarrow$ Can be AC or dc.

Ex: (1) Design a cct to procedure $v_o = -(5v_1 + 10$

$v_o = -15(v_1 + v_2)$

(2) draw $v_o(t)$ for each Case: if $v_1 = 2\sin\omega t$, $v_2 = -$

Sol:

$$-(5v_1 + 10v_2) = -\left(\frac{R_f}{R_1} v_1 + \frac{R_f}{R_2} v_2\right)$$

$$\frac{R_f}{R_1} = 5, \quad \frac{R_f}{R_2} = 10 \Rightarrow$$

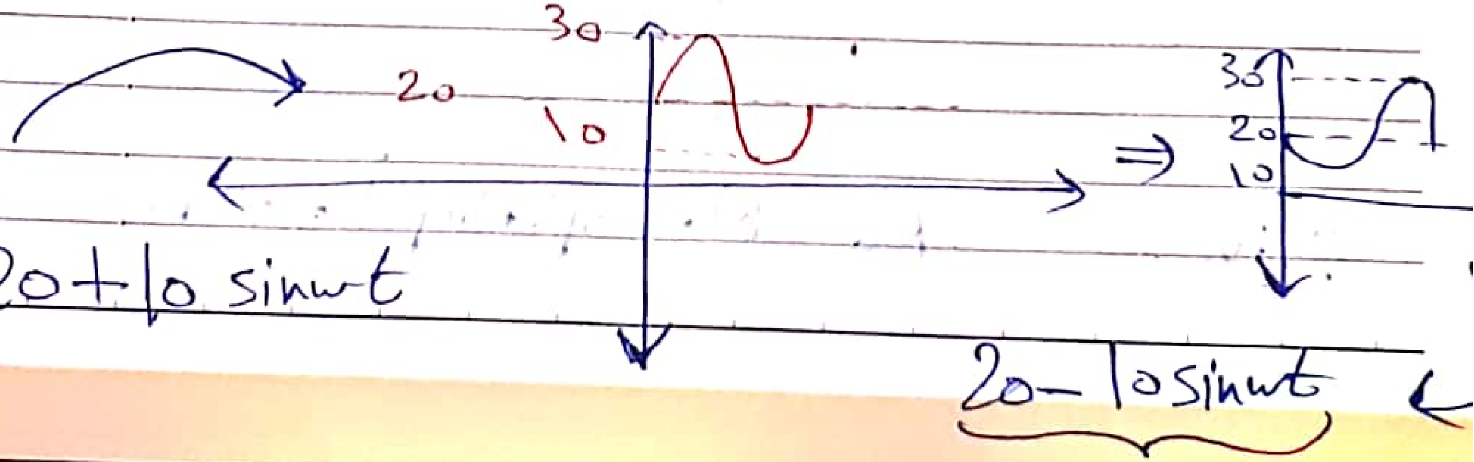
$$R_f = 5R_1, \quad R_f = 10R_2$$

$\boxed{\text{Let } R_f = 10\,k\Omega}$ → إذا صنا رها لم يقبل القيمة الطرفين
وانها تكون قيمتها مش صغيرة.

then $R_1 = 2\,k\Omega$, $R_2 = 1\,k\Omega$.

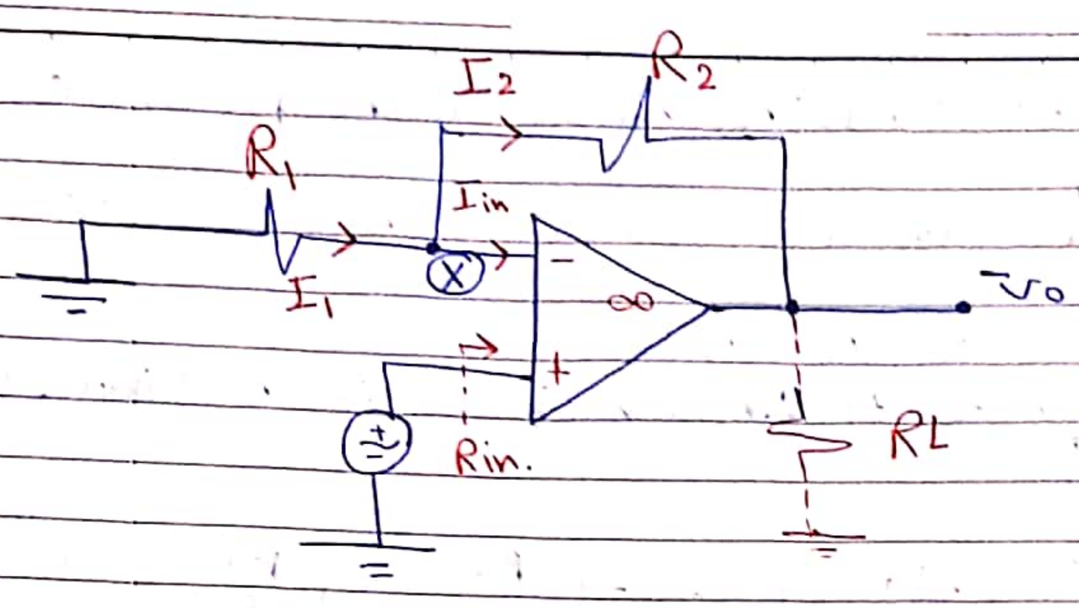
(2) $v_o = -(5 \times 2\sin\omega t + 10 \times -2)$

$v_o = 20 - 10\sin\omega t$



97

3 Non-Inverting Amp.



$$I_1 = I_{in} + I_2$$

$$\frac{-v_x}{R_1} = \frac{v_o - v_x}{R_2} + I_{in} \Rightarrow I_{in} = \text{zero}$$

$v_x = v^+ = v^- = v_i$

(virtual short)

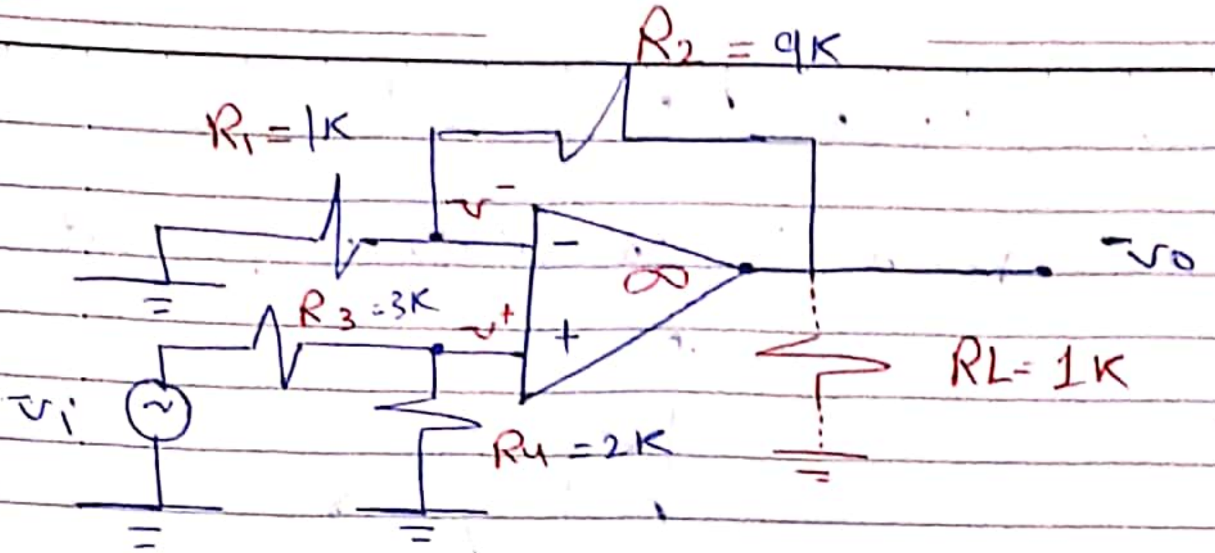
$$\frac{-v_x}{R_1} = \frac{v_o}{R_2} - \frac{v_x}{R_2}$$

$$\frac{-v_i}{R_1} = \frac{v_o}{R_2} - \frac{v_i}{R_2}$$

$$\frac{v_o}{R_2} = v_i\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$\boxed{\frac{v_o}{v_i} = A_v = 1 + \frac{R_2}{R_1}}$$

$R_{in} = \infty$, $R_o = R_o\,(\text{op-Amp}) = \text{zero}.$



$$\boxed{v_o = v_1 = v^+ \quad \text{في ال} v_1 \text{ :}}$$

$$v_o = \left(1 + \frac{R_2}{R_1}\right) \cdot v^+$$

$$\boxed{v^+ = \frac{v_i * R_4}{R_3 + R_4}}$$

$$v_o = \left(1 + \frac{R_2}{R_1}\right) * v_i * \frac{R_4}{R_3 + R_4}$$

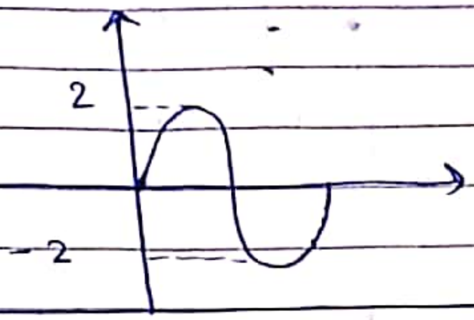
$$\frac{v_o}{v_i} = A_v = \left(1 + \frac{R_2}{R_1}\right)\left(\frac{R_4}{R_3 + R_4}\right)$$

- if $v_i = 0{,}5 \sin(\omega t)$. Calculate and draw $v_o(t)$, A_v.

(9a)

$$A_v = (1+9)\left(\frac{2}{5}\right) = 4$$

$$V_o = A_v \times V_i = 4 \times 0.5 \sin\omega t = \boxed{2\sin\omega t \ V}$$



⊗ لاحظ معي :

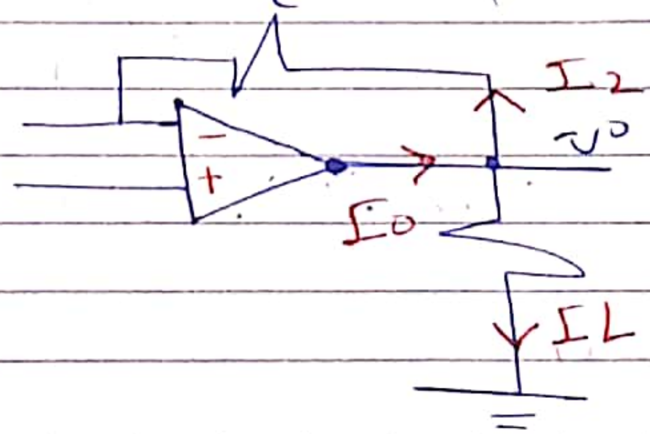
$$V^+ = V^- = \frac{V_i \times R_4}{R_3 + R_4}$$

$$= \frac{0.5 \sin\omega t \times 2K}{5K} = \boxed{0.2 \sin\omega t \ V}$$

$V_o > V^+ \Rightarrow I_2$ معناها التيار راح من V_o لل V^+ .

وكمان لاحظ تيار ال RL رح يكون نازل نزول لأنه ال V_o موصلة للأرضي باتجاه الأرض

Source current of op-Amp



100

$I_L = \frac{V_o}{R_L} = \frac{2\sin\omega t}{1K} = 2\sin\omega t \ mA$

$I_2 = \frac{V_o - zero}{R_1 + R_2}$ oR $\frac{V_o - V^-}{R_2}$

$I_2 = \frac{\sin\omega t\,(2 - 0{,}2)}{9K} = \boxed{0{,}2 \sin\omega t \ mA}$

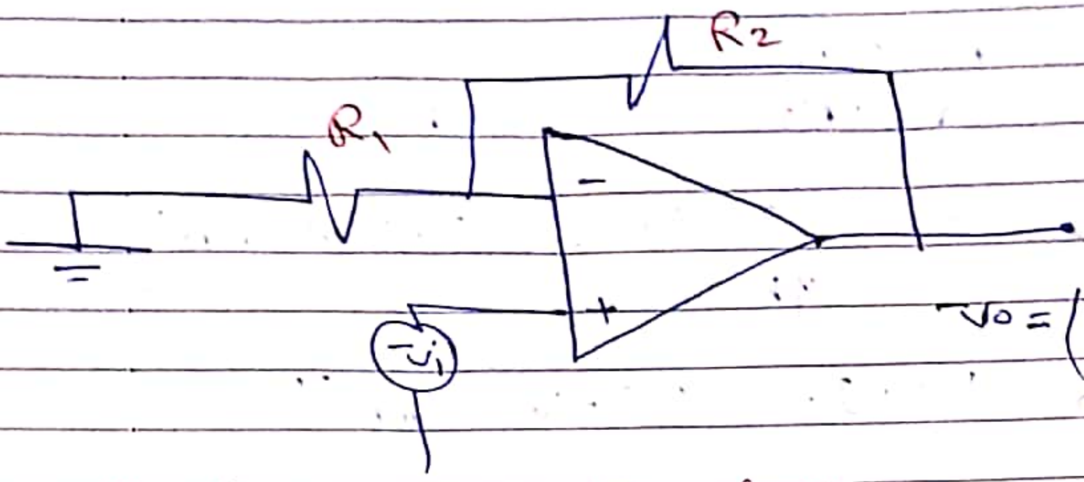
$I_o = I_L + I_2 = \boxed{2{,}2 \sin\omega t \ mA}$

oP-Amp (source Current).

١٥١ "٢١ ٦/٥ محاضرة"

[4] Voltage follower (Buffer):

- special Case of non-inverting Amp.

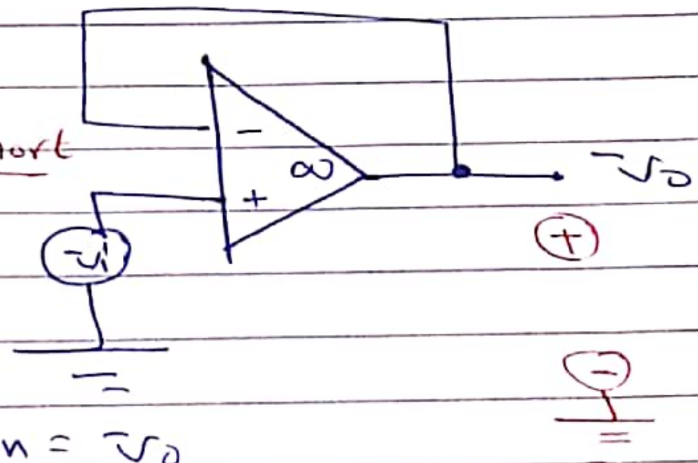


$v_o = \left(1+\frac{R_2}{R_1}\right) v_i$

OR if $R_1 = \infty$ // if R_2 is short:

$\boxed{v_o = v_i}$ OR $\boxed{v_o = v_i}$

$v^+ = v^- \Rightarrow$ virtual short

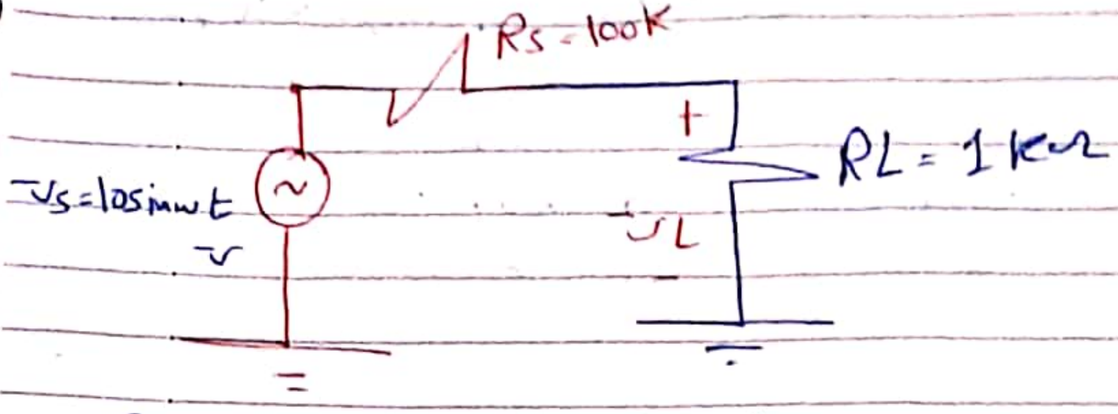


$v^+ = v^- = v_{in} = v_o$

$A_v = 1$, $R_{in} = \infty$, $R_o = \text{zero}$, $\phi = \text{zero}$, Ideal voltage follower.

* لشو بنستعمل الـ (Voltage follower) ؟

It is Used to minimize loading effect
~~without Buffer.~~

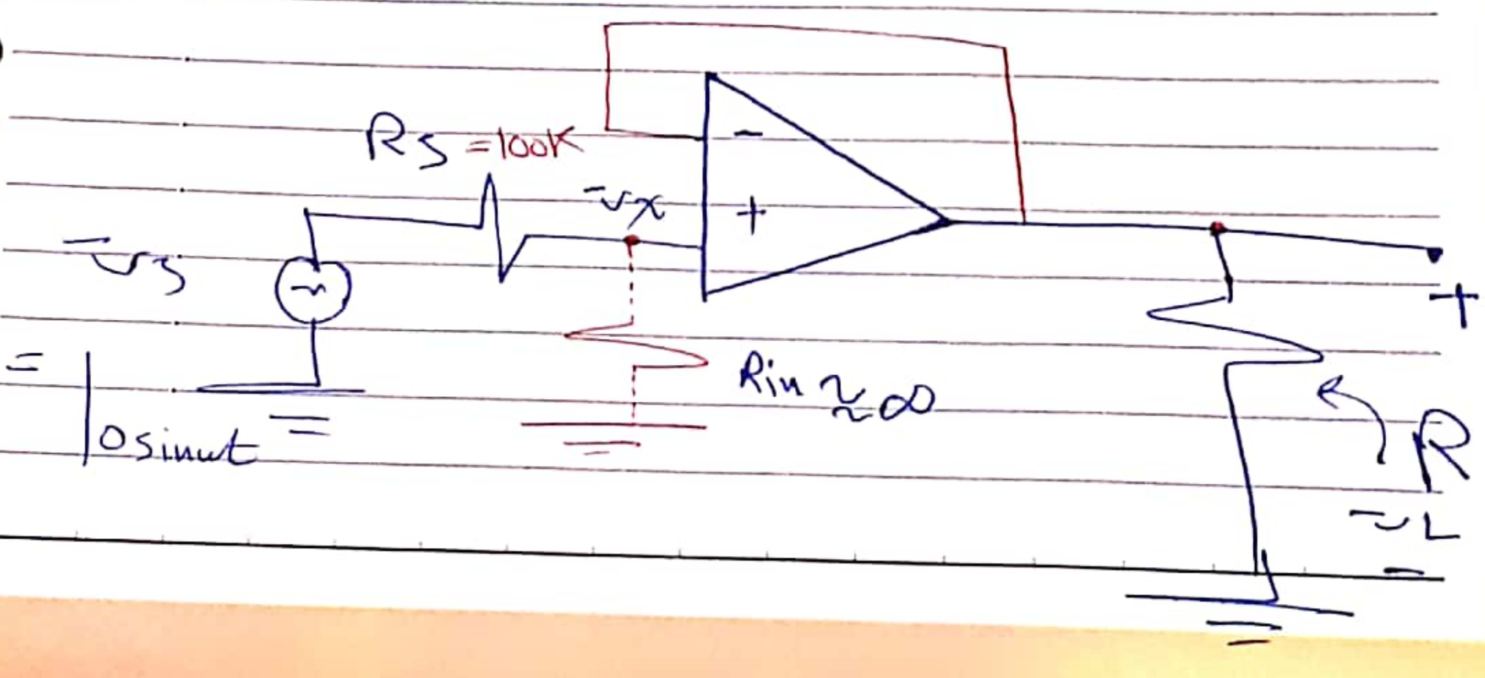


① without Buffer:

$$v_L = \frac{v_s \times R_L}{R_s + R_L} = \boxed{0.1 \sin \omega t \ v}$$

sever loading effect

- to minimize Loading effect a buffer Can be Used:



103

$$v_x = v_s \frac{R_{in}}{R_s + R_{in}} \Rightarrow v_x = \frac{v_s}{1 + \frac{R_s}{R_i}} \quad R_i \to \infty$$

$\boxed{v_x = v_s}$ $\Rightarrow$ هاد هو الهدف تبعنا انه نقلل التأثير عل v_i .

$$v_s = v_x = v^+ = v^- = v_L$$

$$v_L = v_s = 10\sin\omega t \ v$$

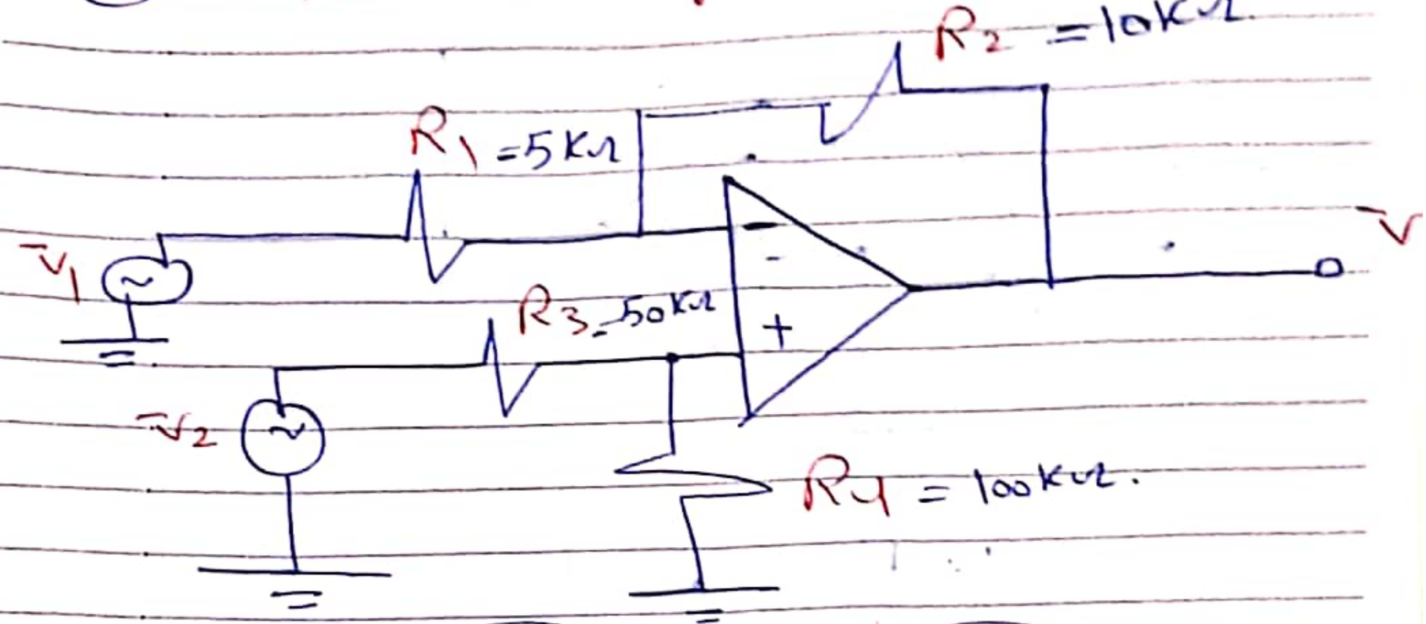
No Loading effect.

voltage follower

- إذا فعلياً استفدنا من هاي ميزتين تبعت الـ
الأولى هي انه الـ $R_{in} = \infty$ بالـ ، الثانية هي انه الـ

$$v_i = v_o = \boxed{}$$ وكأنه $A_v = 1$

5) Difference Amp:

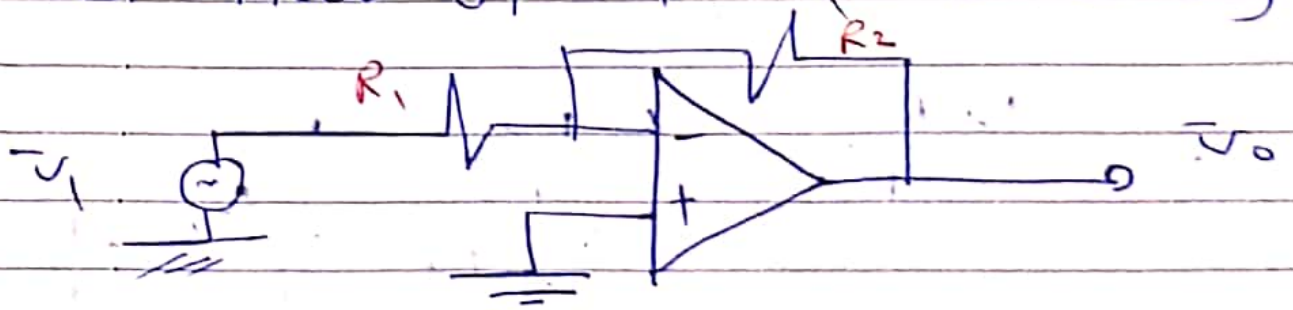


الهدف: نطلع $v_o = A_d(v_2 - v_1)$

حيث A_d differential gain

* Use super position:

① effect of v_1 : (v_2 = zero).

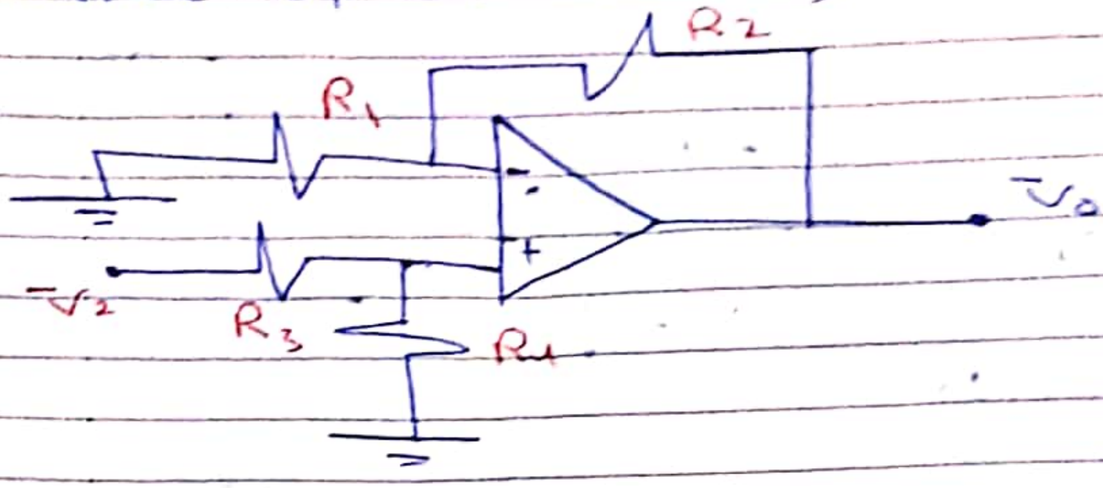


هاد الإشي بنعرفه "Inverting Amp"

$$v_o = -\frac{R_2}{R_1} v_1$$

T05

(2) effect of v_2 : ($v_1 = 0$)



$$v_{o2} = \left(1 + \frac{R_2}{R_1}\right) * v^+$$

$$v^+ = \frac{v_2 * R_4}{R_3 + R_4}$$

$$v_{o2} = \left(1 + \frac{R_2}{R_1}\right)\left(\frac{v_2 \cdot R_4}{R_3 + R_4}\right)$$

$$v_o = v_{o1} + v_{o2}$$

$$= \left(1 + \frac{R_2}{R_1}\right)\left(\frac{\frac{R_4}{R_3}}{1 + \frac{R_4}{R_3}}\right)(v_2) - \frac{R_2}{R_1} v_1$$

Choose $\frac{R_2}{R_1} = \frac{R_4}{R_3}$

– then $v_o = \left(1+\frac{R_2}{R_1}\right)\left(\frac{\frac{R_2}{R_1}}{1+\frac{R_2}{R_1}}\right) v_2 - \frac{R_2}{R_1}$

$v_o = \frac{R_2}{R_1}\left(v_2 - v_1\right)$

$v_o = \boxed{A_d\left(v_2 - v_1\right)}$

A_d: Differential voltage gain.

$A_d = \frac{v_o}{v_2 - v_1} = \frac{R_2}{R_1}$

صعيبة برشا $\Leftarrow \left(\frac{R_4}{R_3} . \frac{R_2'}{R_1}\right)$ بدونها / بها

Let $v_1 = 1,5\,v$, $v_2 = 2\,v$

then $\Rightarrow$ $v_o = \left(\frac{R_2}{R_1}\left(v_2 - v_1\right)\right)$

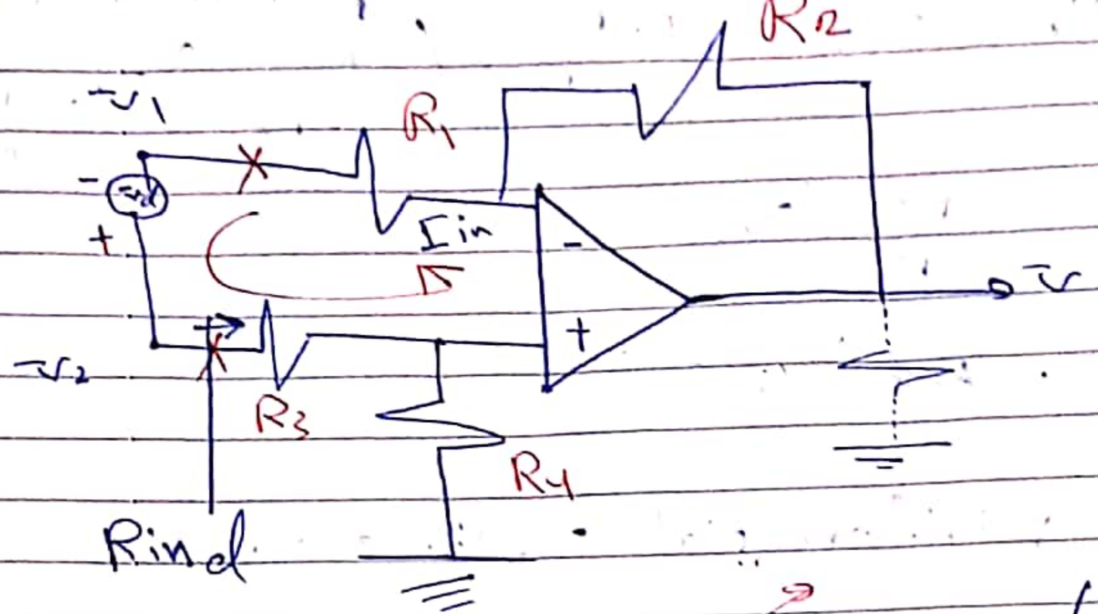
$= \frac{10}{5}\left(2 - 1,5\right) = 1\,v$

Let $R_2 = 8\,k\Omega$, $R_1 = 4\,k\Omega$

$R_4 = 3\,k\Omega$, $R_3 = 1\,k\Omega$

$v_o = \left(1+\frac{R_2}{R_1}\right)\left(\frac{\frac{R_4}{R_3}}{1+\frac{R_4}{R_3}}\right) v_2 - \frac{R_2}{R_1} v_1$

$\boxed{v_o = 1,5\,v}$



KVL: $-v_d + (\cancel{v^+ - v^-}) + I_{in}(R_1 + R_3) = 0$

$\frac{v_d}{I_i} = R_3 + R_1 = R_{id}$

Q) Design an diff Amp to have $A_d = 50$ and $R_{in} = 20\,k\Omega$.

Sol: $R_{in} = R_1 + R_3$

كده طالع
حل السؤال

Let $\frac{R_2}{R_1} = \frac{R_4}{R_3} \Rightarrow$ and $R_2 = R_4$, $R_1 = R_3$

$\Rightarrow 20K = 2R_1 = 2R_3$

$\boxed{R_1 = R_3 = 10\,k\Omega}$

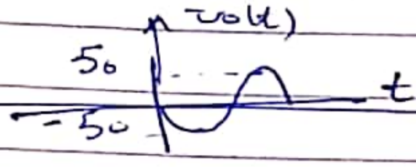
108]

$A_d = \frac{R_2}{R_1} \Rightarrow 50 = \frac{R_2}{10K} \rightarrow \boxed{R_2 = R_4 = 500\,K\Omega}$

② For $v_2 = 2\sin\omega t$, $v_1 = 3\sin\omega t$
Calculate and draw $v_o(t)$.

Sol: $v_o(t) = A_d(v_2 - v_1)$

$v_o(t) = 50(-\sin\omega t) = \boxed{-50\sin\omega t \; v}$



Second

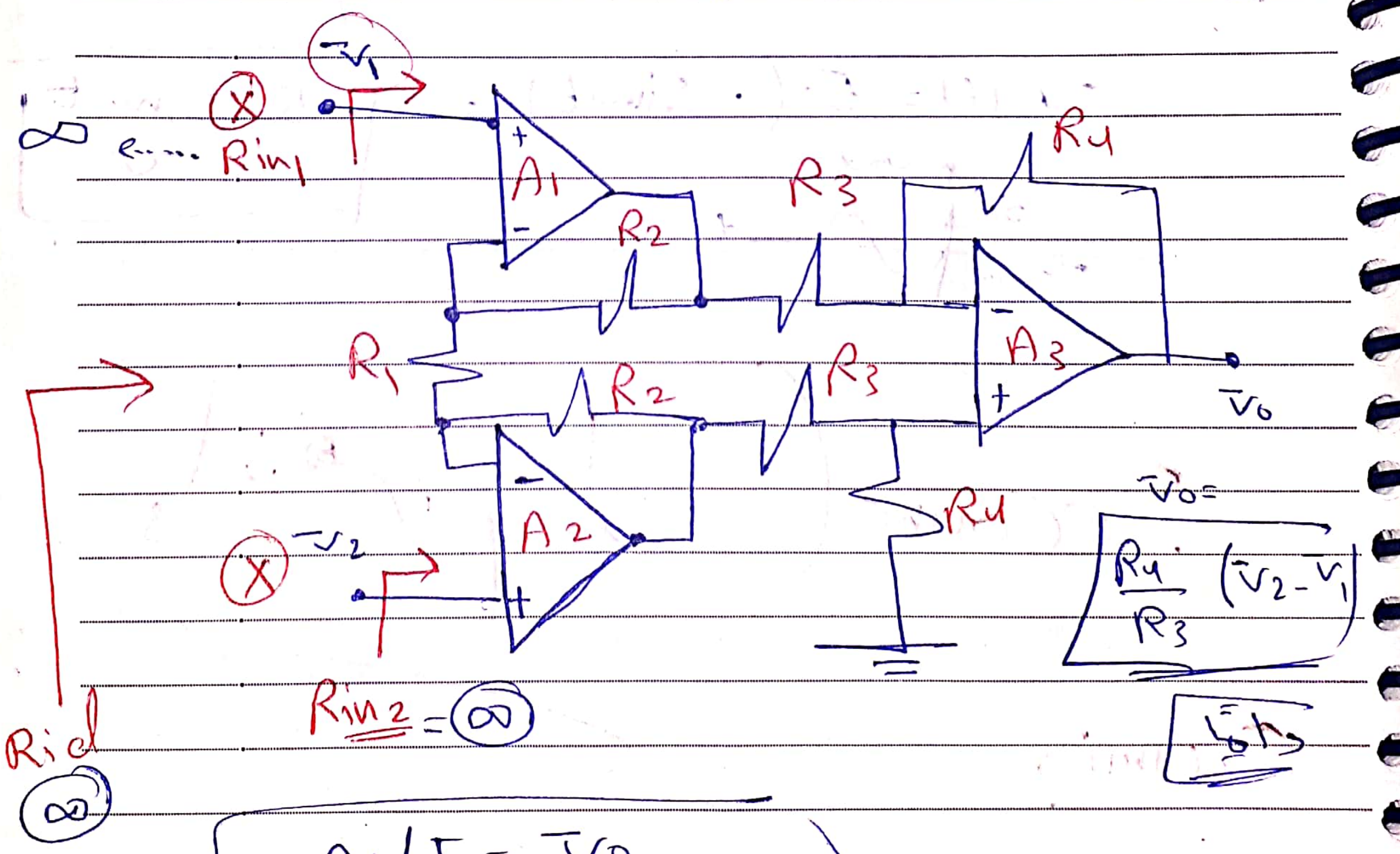
Outami

109 محاضرة ① فاينال /

⊛ Instrumentation Amplifier:

1. A_1 and A_2 (Non-Inverting Amplifier)
2. $A_3 \Rightarrow$ Differential Amplifier,

⊛ إذا أردنا قيمة عالية لل A_v أو R_{in} ، لازم نقبل بقيم عالية جدًا لل R_2 أو R_1 ، وهاي بتعمل مشكلة ، واحنا بدنا هيك ، لهيك السبب انوجد ال Instrumentation Ampl !



$$V_o = \frac{R_4}{R_3}(V_2 - V_1)$$

$$A_{dI} = \frac{V_o}{V_2 - V_1}$$

* proparties of Instrument Amplifier:

* It is Used to achieve:

تغير بتغير R_1 فقط

1. very high R_{in}.
2. High gain (Adjastable and single element dependent gain). (Advantage)

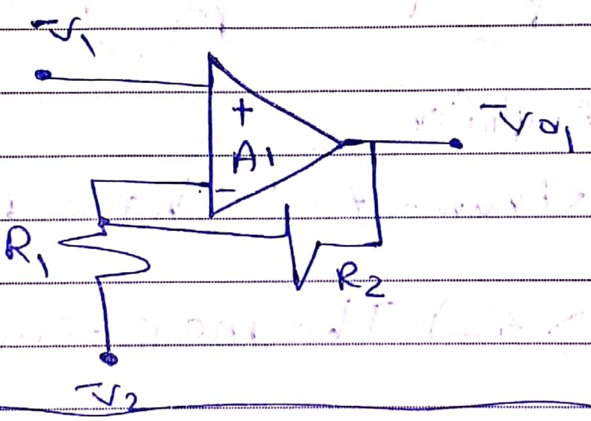
Using resnabole Resistance values ($k\Omega$)

* Using super position:

- For A_1, v_{o_1}?

(i) effect of v_1 ($v_2 = 0$)

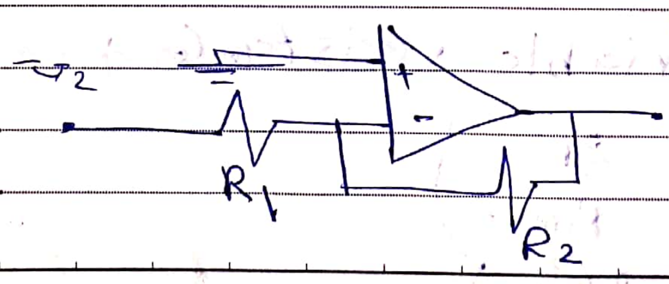
(Non-Inverting)



$$\boxed{v_{o_1}' = \left(1 + \frac{R_2}{R_1}\right) v_1}$$

(ii) effect of v_2 ($v_1 = 0$)

$$v_{o_1}'' = -\frac{R_2}{R_1} v_2$$



$$\boxed{v_{o_1} = \left(1 + \frac{R_2}{R_1}\right) v_1 - \frac{R_2}{R_1} v_2}$$

111

باستخدام نفس الورقة :

$$\boxed{v_{o2} = \left(1+\frac{R_2}{R_1}\right)v_2 - \frac{R_2}{R_1}v_1}$$

$$v_o = \frac{R_4}{R_3}\left[\left(1+\frac{R_2}{R_1}\right)v_2 - \frac{R_2}{R_1}v_1 - \left[\left(1+\frac{R_2}{R_1}\right)v_1 - \frac{R_2}{R_1}v_2\right]\right]$$

بعد ترتيب المعادلة ⇐

$$\boxed{\frac{v_o}{v_2 - v_1} = A_{dI} = \frac{R_4}{R_3}\left(1+\frac{2R_2}{R_1}\right)}$$ متغيرة

Ex: Design an Instrument Amplifier to have Ad ranging from (5 → 500), The max available resistance 100 kΩ.

$Ad(Min) = 5$

$Ad(Max) = 500$

A_3

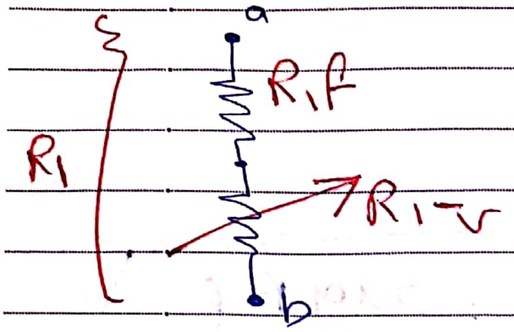
Let R_1 variable resistance :

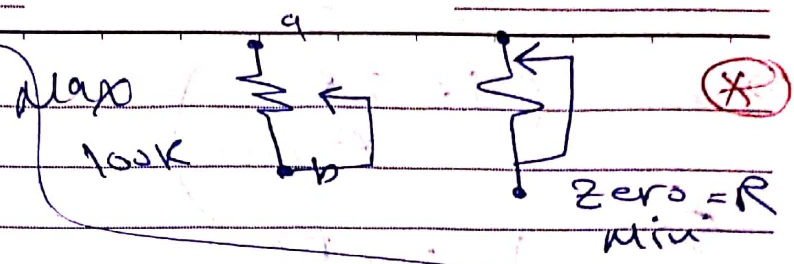
$$Ad_{Min} = \frac{R_4}{R_3}\left(1+\frac{2R_2}{R_{1max}}\right)$$

$$Ad_{max} = \frac{R_4}{R_3}\left(1+\frac{2R_2}{R_{1Min}}\right)$$

112

$(0 \longrightarrow 100)$





سويت هيك لكان ←

لأتخلص من مشكلة ال zero بالمقام.

$$\boxed{R_1 = R_1 f + R_1 v}$$

* Choose a potentiometer: of $100k\Omega$

let the gain of $A_3 = 2 = \frac{R_4}{R_3}$

$$5 = 2\left(1 + \frac{2R_2}{R_1 max}\right)$$

$$\boxed{2R_2 = 1.5\, R_1 max} \Rightarrow 2R_2 = 1.5(100 + R_1 f)$$

$$\boxed{2R_2 = 150 + 1.5\, R_1 f}$$

$R_1 max = 100k + R_1 f$

$R_1 min = R_1 f$.

113

$$500 = 2\left(1 + \frac{2R_2}{R_{1min}}\right)$$

$$\frac{500}{2} - 1 = \frac{2R_2}{R_1 f}$$

$$249 = \frac{2R_2}{Rf} \Rightarrow \boxed{2R_2 = 249\,Rf}$$

$$150 + 1{,}5\,Rf = 249\,Rf$$

$$\boxed{0{,}6\,k\Omega = Rf}$$

$$\boxed{R_2 = 75k}$$

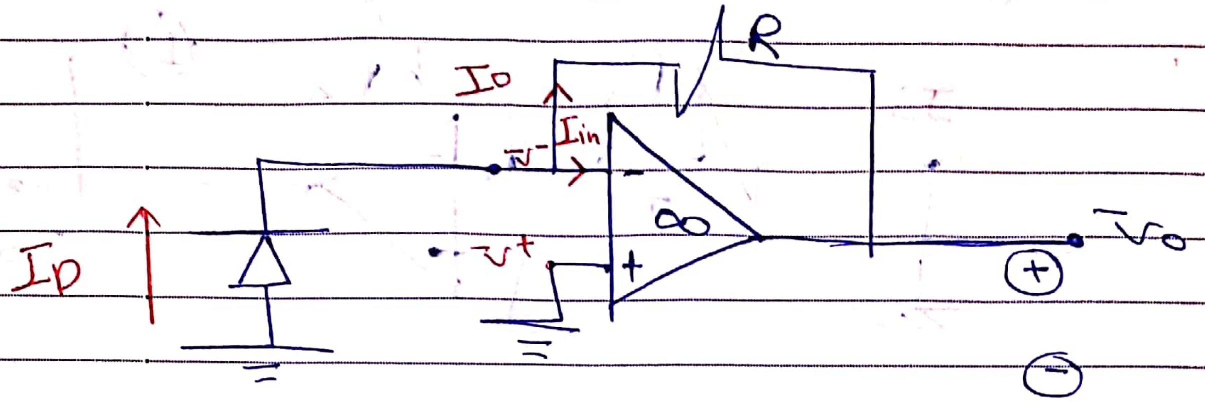
$$\frac{R_4}{R_3} = 2 \Rightarrow \text{Let } R_3 = 1k\Omega$$

$$R_4 = 2k\Omega$$

114

محاضرة ② تماثل

7 Current-to-voltage Converter: (I-to-V)



$$I_D = I_o + I_{in}$$

$$I_D = \frac{v^- - v_o}{R} + I_{in}$$

but $I_{in} = 0$, $v^- = v^+ = 0$ } ideal op-Amp }

$$I_D = \frac{-v_o}{R} \Rightarrow \boxed{v_o = -I_D \cdot R}$$

$v_o \propto I_D \Leftarrow$ الفولتية تتناسب طردياً مع I_D

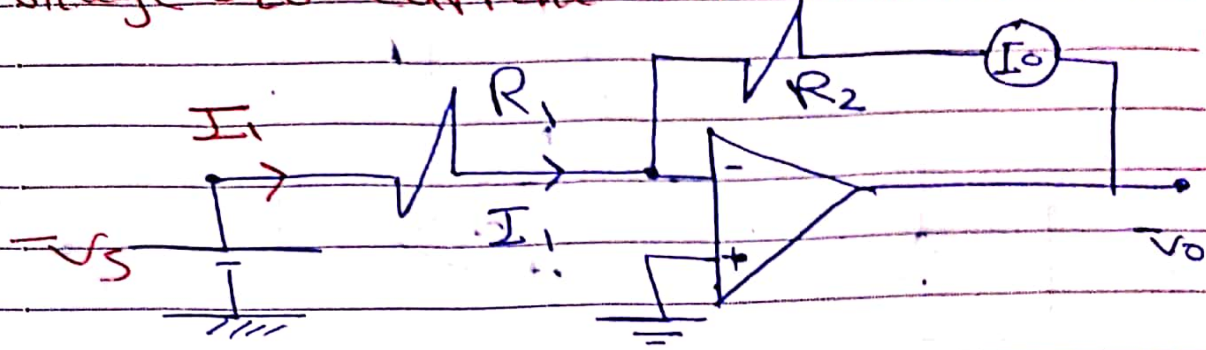
For $R = 5\,k\Omega \Rightarrow$

I_D (mA)	v_o (v)
1	−5
⋮	
3	−15
⋮	

115

(V-to-I)

[8] Voltage-to-Current Converter:



$I_1 = I_{in} + I_o \Rightarrow$

$\frac{V_s - V}{R_1} = I_o \Rightarrow I_o = I_1$

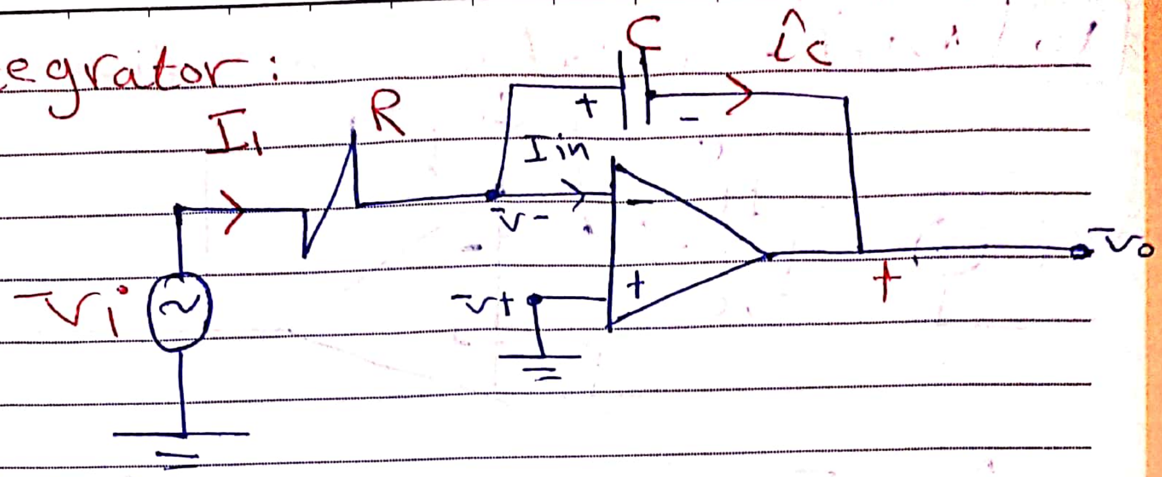
$\boxed{\frac{V_s}{R_1} = I_o} \Rightarrow I_o \propto V_s$

Let $R_1 = 2k\Omega$

V_s	I_o (mA)
2	1
8	4
10	5

116

9) Integrator:



$I_1 = i_c + I_{in}$ ⟶ $I_{in} = \text{zero}$

$$\frac{v_i}{R} = C \cdot \frac{dv_c}{dt}$$

$\boxed{v_c = -v_o}$

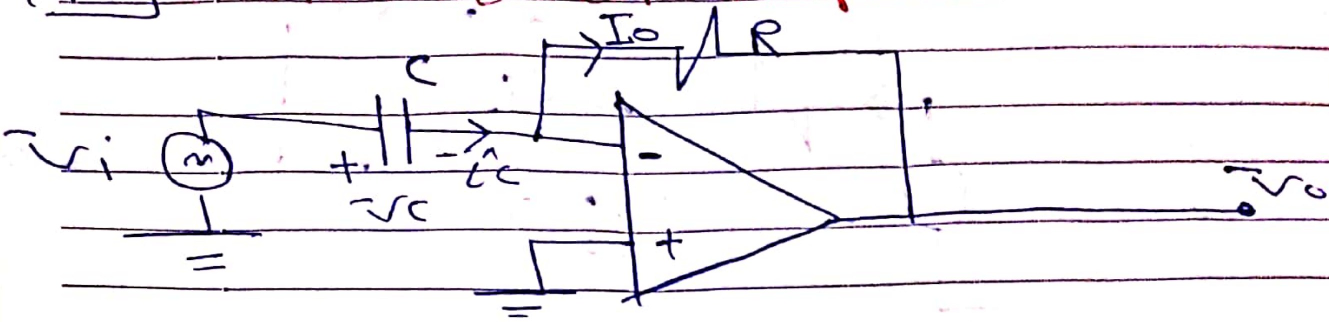
$$\frac{v_i}{R} = -C \cdot \frac{dv_o}{dt}$$

$$-\frac{v_i}{RC} = \frac{dv_o}{dt} \Rightarrow \boxed{v_o = -\frac{1}{RC}\int v_i \cdot dt}$$

Note: $I_{in} = 0$, $v^- = v^+ = 0$ ⟶ ideal op-Amp.

117

10 Differentiator Amplifier:



$i_c = I_o$ ---> since $i_{in} = \text{zero}$

$$C.\frac{dv_c}{dt} = -\frac{v_o}{R} \Rightarrow C.\frac{dv_i}{dt} = -\frac{v_o}{R}$$

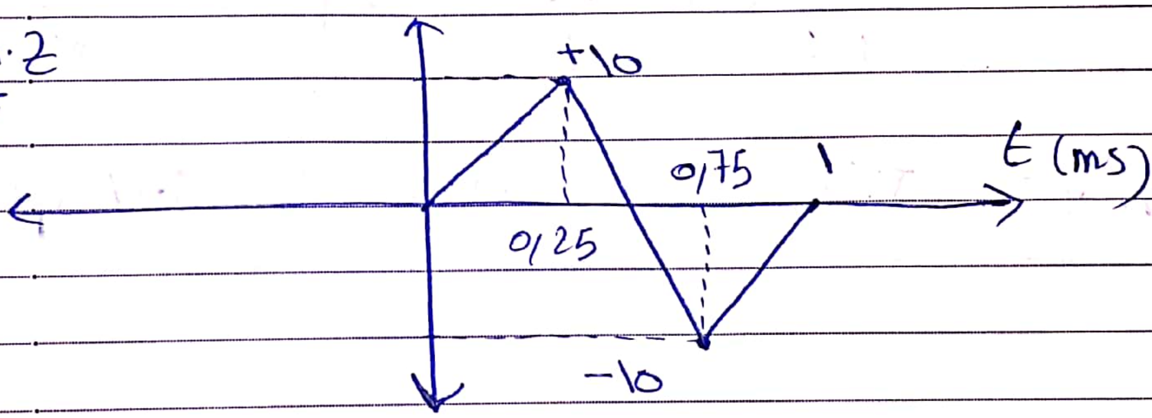
$$-\frac{v_o}{RC} = \frac{dv_i}{dt} \Rightarrow \Rightarrow \boxed{v_o = -RC\frac{dv_i}{dt}}$$

Ex: Draw $v_o(t)$ for v_i shown:

$f = 1\,kHz$

$R = 1\,k\Omega$

$C = 1\,\mu F$



(x) ركز : مشتقة ال ramp $\Leftarrow$ sequare wave

118

① for $0 < t < 0{,}25$

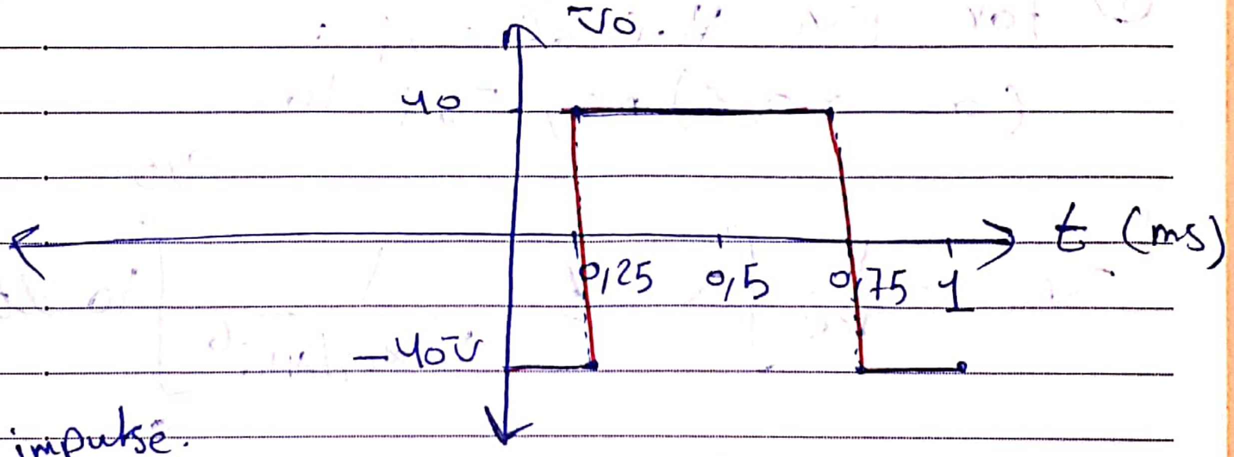
$$v_o = -RC\frac{\Delta v_i}{\Delta t} = -10^{3} \times 10^{-6} \times \frac{10}{0{,}25 \times 10^{-3}} = \boxed{-40\,v}$$

for $0{,}25 < t < 0{,}75$

$$v_o = -RC \cdot \frac{\Delta v_i}{\Delta t} = -10^{3} \times 10^{-6} \times \frac{20}{-0{,}5 \times 10^{-3}} = \boxed{+40\,v}$$

for $0{,}75 < t < 1$

$$v_o = -RC\frac{\Delta v_i}{\Delta t} = -10^{3} \times 10^{-6} \times \frac{10}{0{,}25 \times 10^{-3}} = \boxed{-40\,v}$$



impulse.

out put ↑ ال ← Square ال Input ال ⊛

[119]

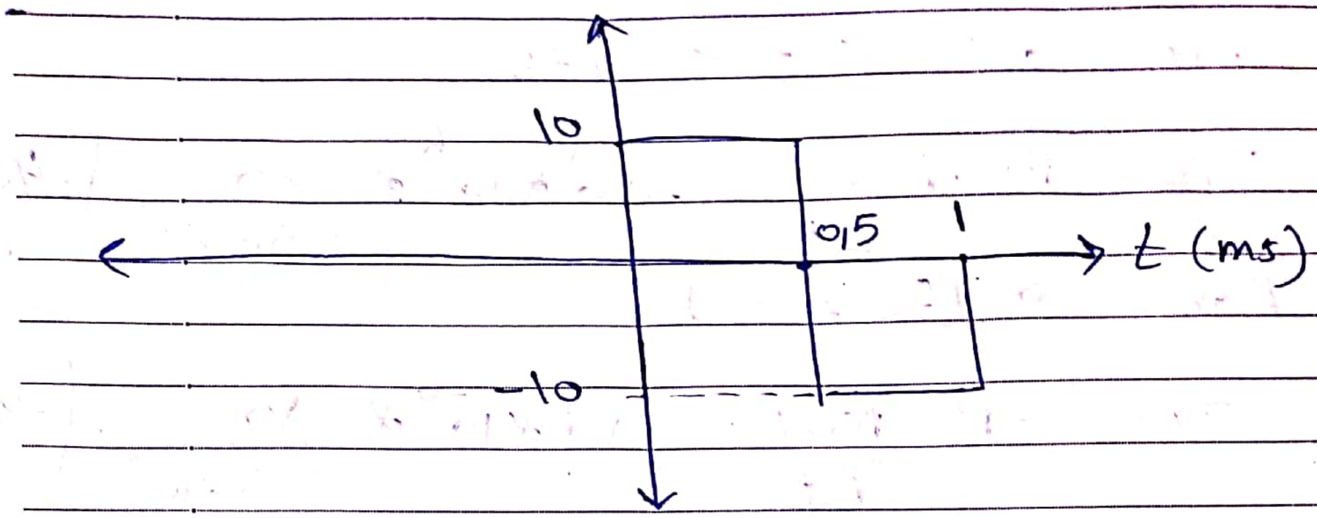
For integration Amp.

Draw $v_o(t)$ for i/P shown in figure:

Let $\Rightarrow$ $R = 1K\Omega$

$C = 0.1\,\mu F$

$f = 1KH.z$



① for +ve H.C of v_i:

$(0 \longrightarrow 0.5)$ ms, $v_i = 10$

$$v_o = -\frac{1}{RC}\int v_i\,dt = \frac{-1}{1K \times 0.1 \times 10^{-6}}\int_0^{0.5} 10\,dt$$

$v_o = -50v.$

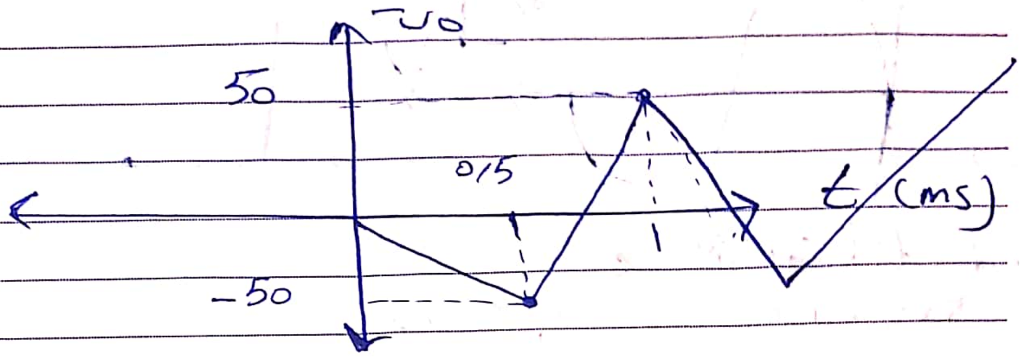
Ramp $\Longleftarrow$ Sequare wave ال volt : نتر ⊛

$\boxed{120}$

② for $-ve$ H.C of v_i $(0.5 < t < 1)$ ms:

$$v_o = -\frac{1}{10^{3} \times 10^{-7}} \int -10 \, dt = \boxed{v_o = +50\,V}$$

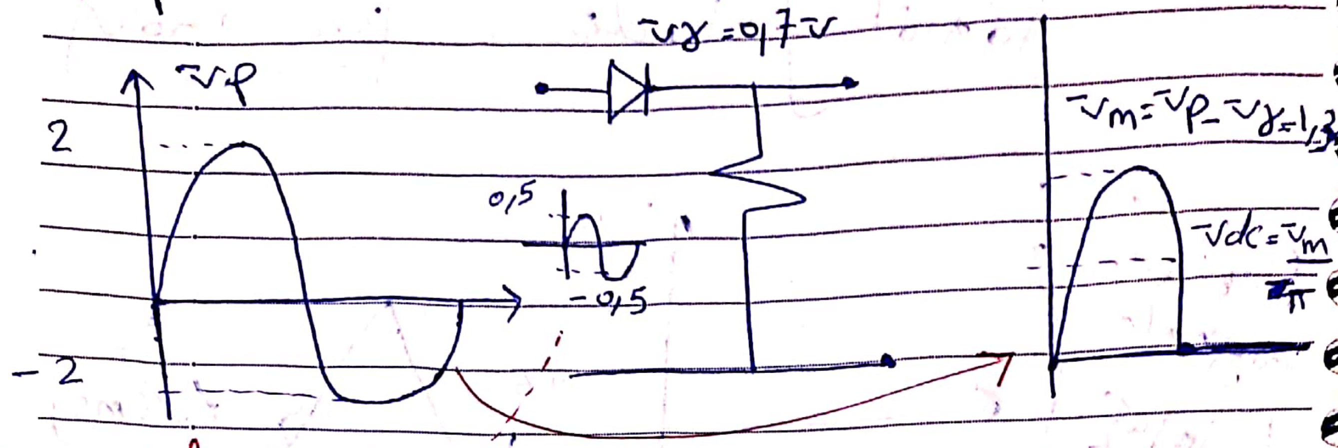
Periodic signale



محاضرة / رقم ٣ فاينال

* Non-Linear Applications :

1 precision Rectifier :



No rectification because $\Rightarrow v_p < v_\gamma$.

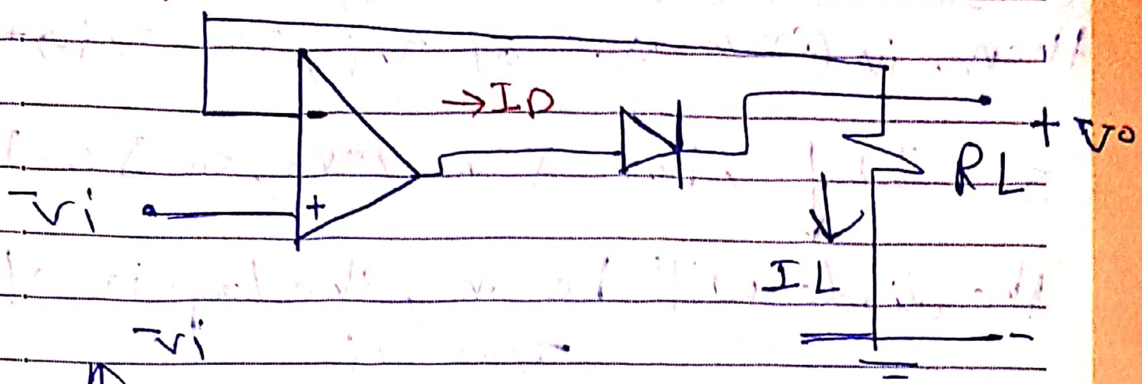
ما بنقدر نسوي rectification لأنه $v_p < v_\gamma$.

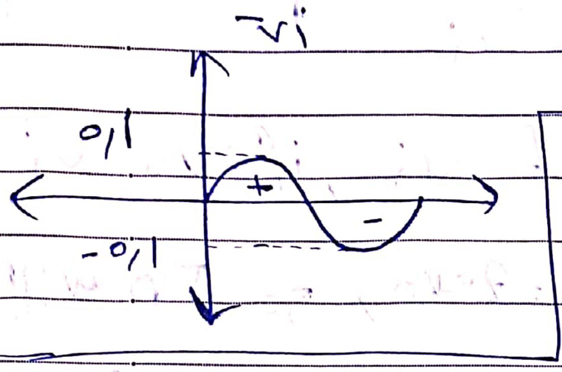
cct. Used to rectify signal with $v_p < v_\gamma$.

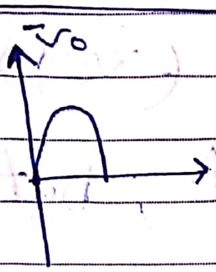
* هاي الإشي بيقودنا لإستنتاج فكرة كالتالي :

الهدف / تبعنا (H.W precision Rect) $\Leftarrow$ إنه أقدر أعمل Rectification لل signal الي بتكون فيها v_p أقل من v_γ ، هاي هو الإشي الرئيسي //

* H.W precision Rect:







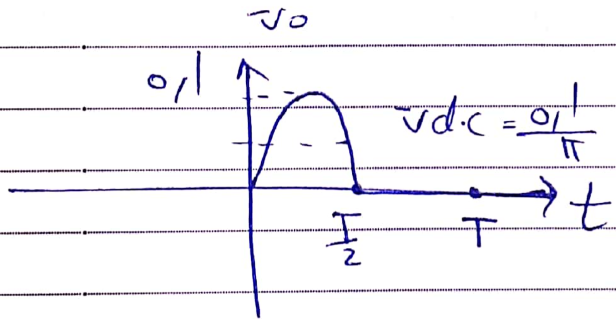
$I_D = I_L$

Diode on

* أما لما يكون ال تيار I_L ↑ ، بيكون ال Diode ،

Reverse ⇐ بالعكس ال Diode off ⇐ $I_L = I_R = zero$

بالعكس $v_o = zero$ ⇐



$v_{d.c} = \frac{0,1}{\pi}$

$v_o = v_i \Rightarrow$ +ve H.C

1 since the cct is voltage follower ($V_o = V_i$)
then, in (+)ve H.C of V_i, $V_o = V_i \rightarrow$ +ve H.C

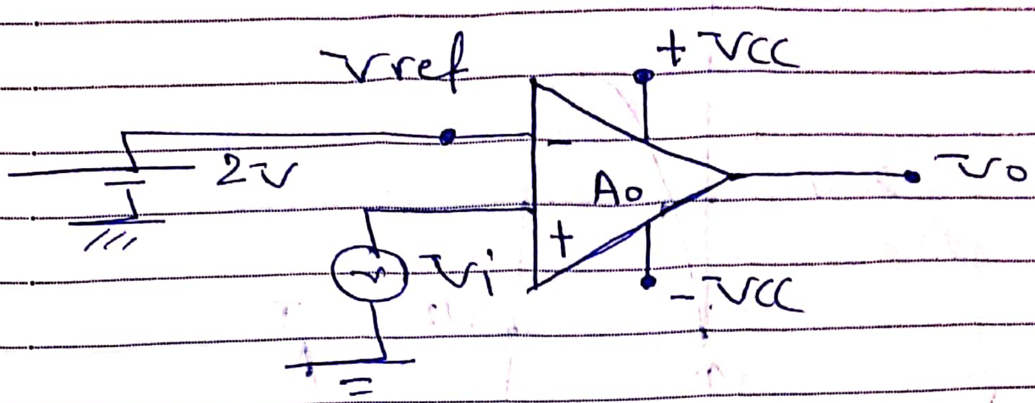
- so $I_L \downarrow$, but I_{in} = zero, so $I_D = I_L$
the diode will be on, the Loop is closed
$V_o = V_i$.

2 In (-ve) H.C of V_i, if $V_o = V_i$
, $I_L \uparrow$, but I_{in} = zero, so I_D will
be negative, i.e the diode is off
then the Loop is open V_o = zero.

1|24

[2] Voltage Comparator:

[1] op.Amp is Used in open_Loop.



[2] $V_o = \pm V_{cc}$.

* In general $V_o = A_o(V^+ - V^-) \Rightarrow A_o \propto V_d$.

[1] When $V^+ > V^- \Rightarrow V_d$ is positive.

But $A_o = \infty$ (ideal op-Amp).

$V_o = +V_{cc}$

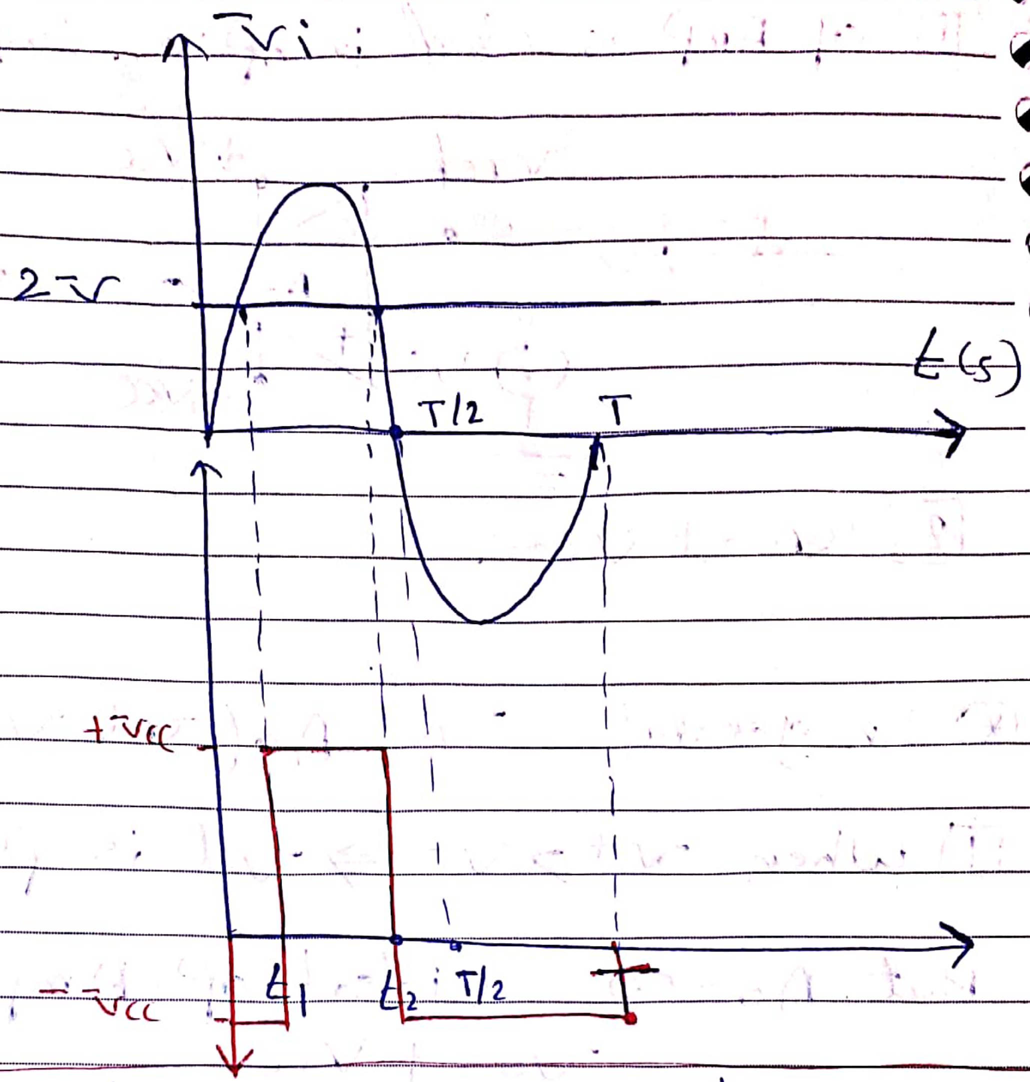
[2] if $V_+ < V^-$, V_d is $-ve$

$V_o = A_o(-V_d) = -V_{cc}$

① for this figure:

الأساس هو :

$v_o = A_o(v^+ - v^-)$



① for $0 < t < t_1 \Rightarrow v^- > v^+$ then

v_d is $-ve$, $\Rightarrow v_o = -v_{cc}$

② for $t_1 < t < t_2 \Rightarrow v^+ > v^-$

v_d is $+ve$, $v_o = +v_{cc}$

③ for $t_2 < t < T \Rightarrow v^+ < v^-$, v_d is $-ve$

$v_o = -v_{cc}$

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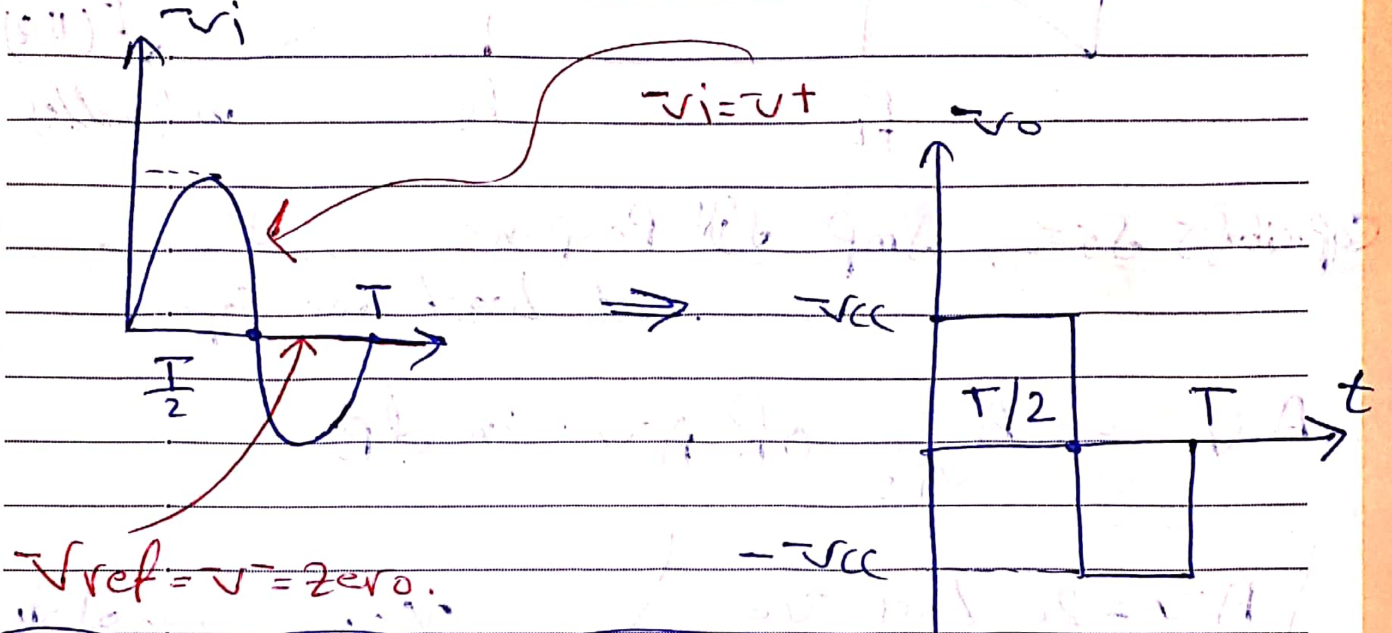
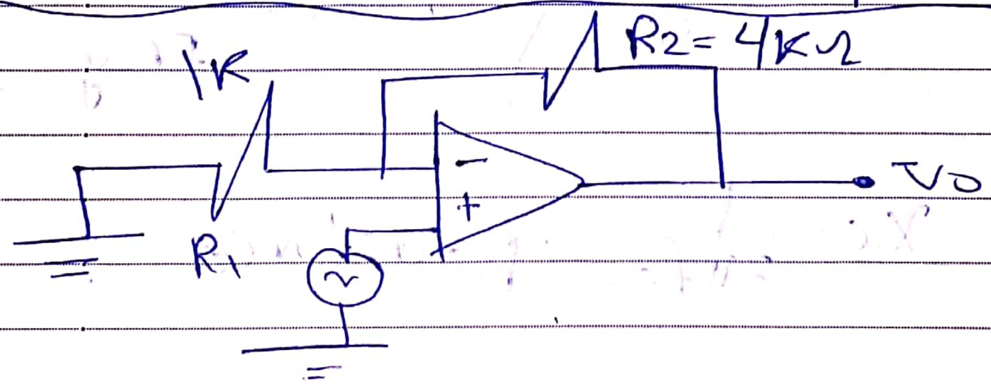
if V_{ref} = zero (V_{dc}) ⊛

symmetrical square wave ⇐ هلأ بطلع عنا الموجة

when V_{ref} = zero ⇒ the cct is Called "Zero Crossing detector"

"كاشف نقاط التقاطع الصفري"





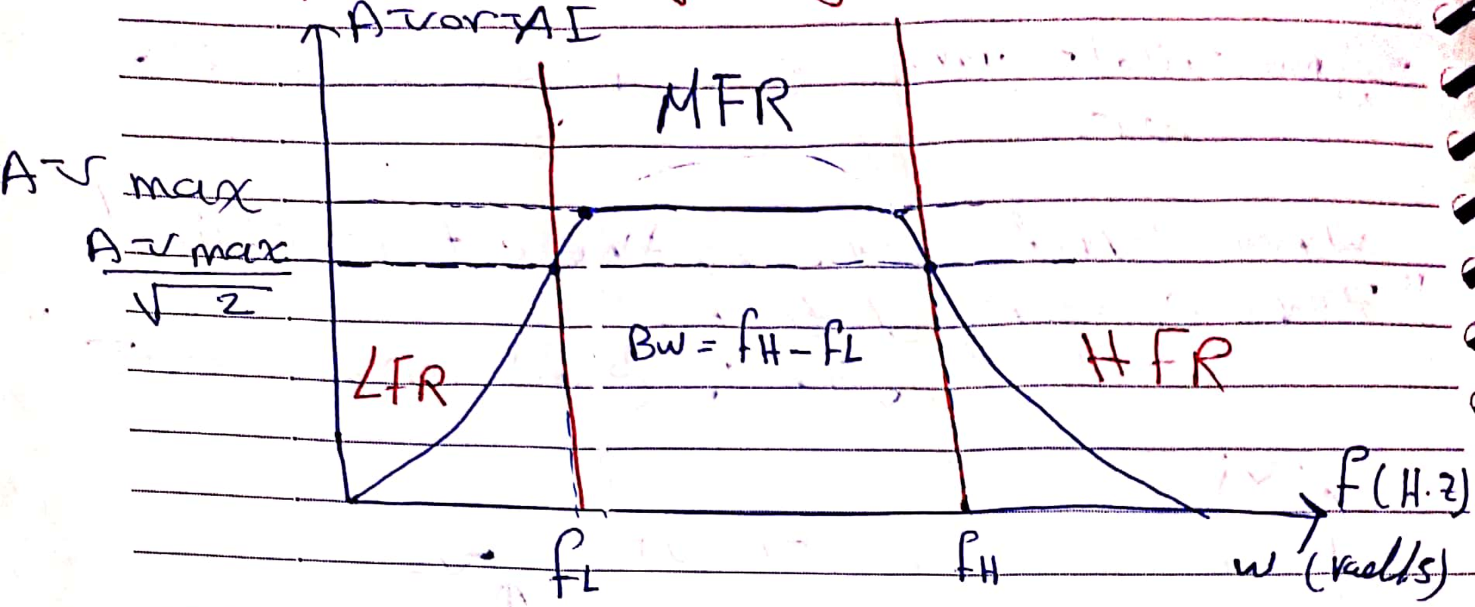
⇒ Non Inverting

R_2 → short ⇒ voltage follower

R_2 → open ⇒ voltage Comparator

V^- = zero (Zero Crossing detector.)

* Amplifier frequency Response:



Capacitors تأثير , Amp الى Response الـ , حكي
at least one Caps.

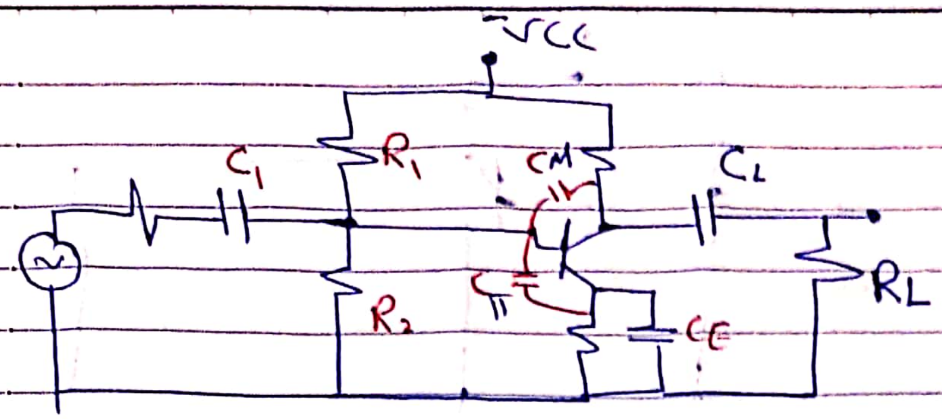
$A_v \rightarrow \frac{A_v}{v_{is}}$ or A_v: in dB

$$\boxed{A_v = 20 \log \frac{v_o}{v_s}}$$

, X_C: بتختلف مع ال freq

$$X_C = \frac{1}{2\pi f c}$$ Reactance.

[128]



C_1, C_2 : Coupling , C_E : By pass (C).

Let $C = 1\mu F$

$$X_C = \frac{1}{2\pi f C}$$

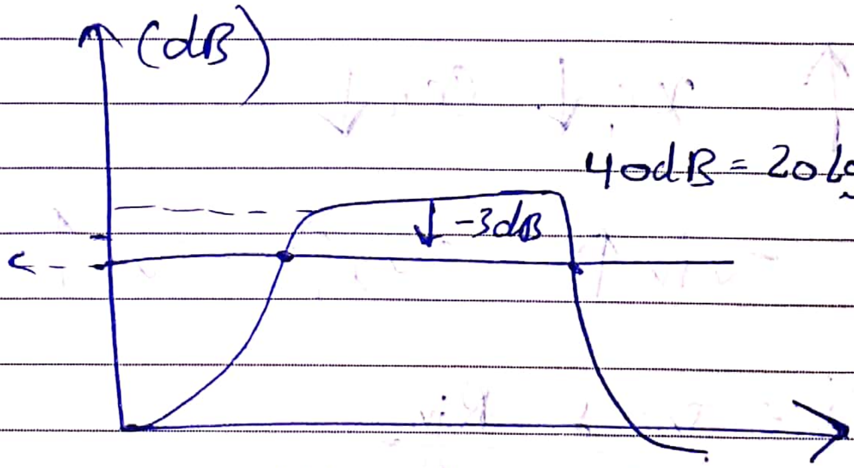
f	X_C
10 Hz →	17 KΩ
1 KHz →	170 Ω
10 KHz →	17 Ω
100 KHz →	1,7 Ω
1 MHz →	0,17 Ω

أكيد كل ما زاد ال freq
قل ال Reactance

- لاحظ كيف ذا اشتغلنا
ال Capacitor ، ال A طالع بتاعي
والتالي ، ومن ⟸ طالع بتاعي ال frequency.

$A_v(max)$

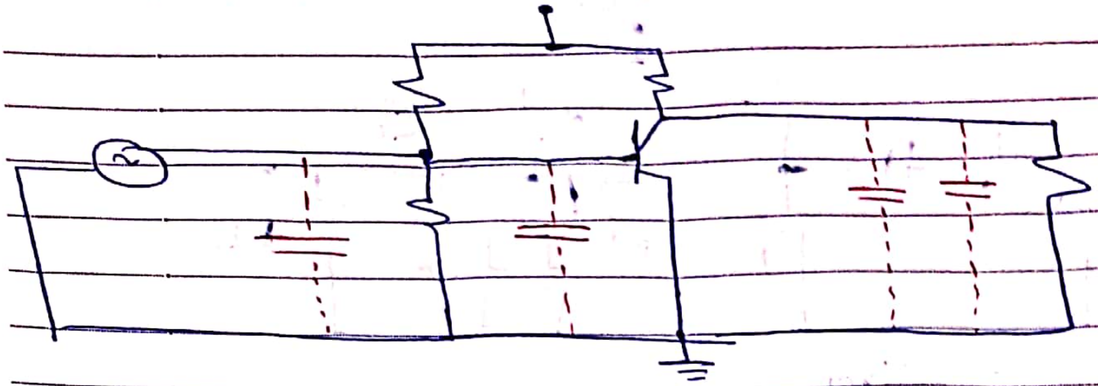
37 dB ← - -



40dB = 20 log 100 = 40 dB

$A_v = \frac{V_o}{V_s}$

MFR ⟹ Region منطقة أهم (أهم نطاق)



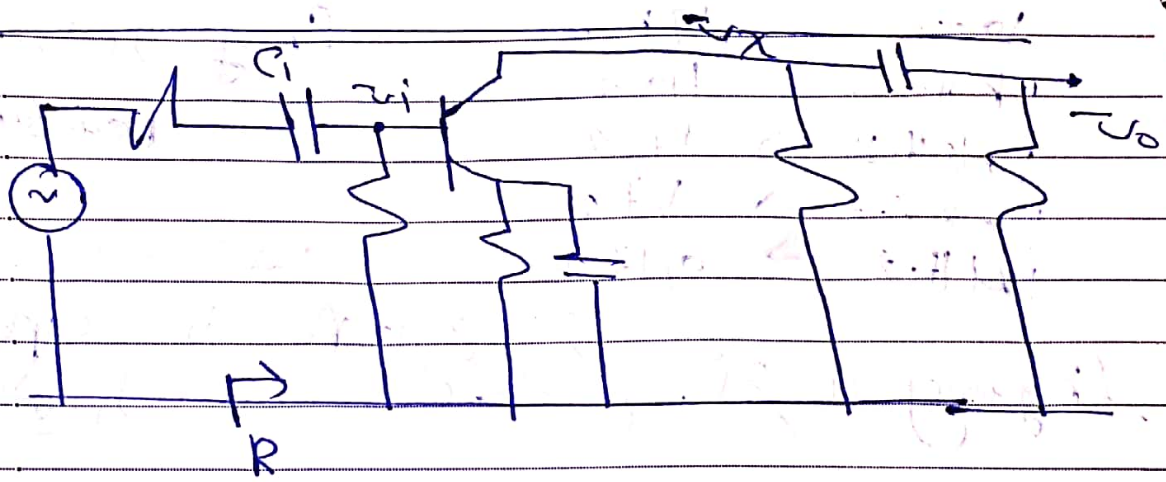
~~$A_v = -g_m R_L'$~~

$A_v = -g_m Z_L$

$Z_L = X_C // R_L'$

فتعالة

إهمالية



$f \uparrow \quad X_{C_1} \downarrow \quad X_{C_2} \downarrow$

$V_{in} \uparrow \quad V_x \uparrow \quad V_o \uparrow \quad A_v \uparrow$

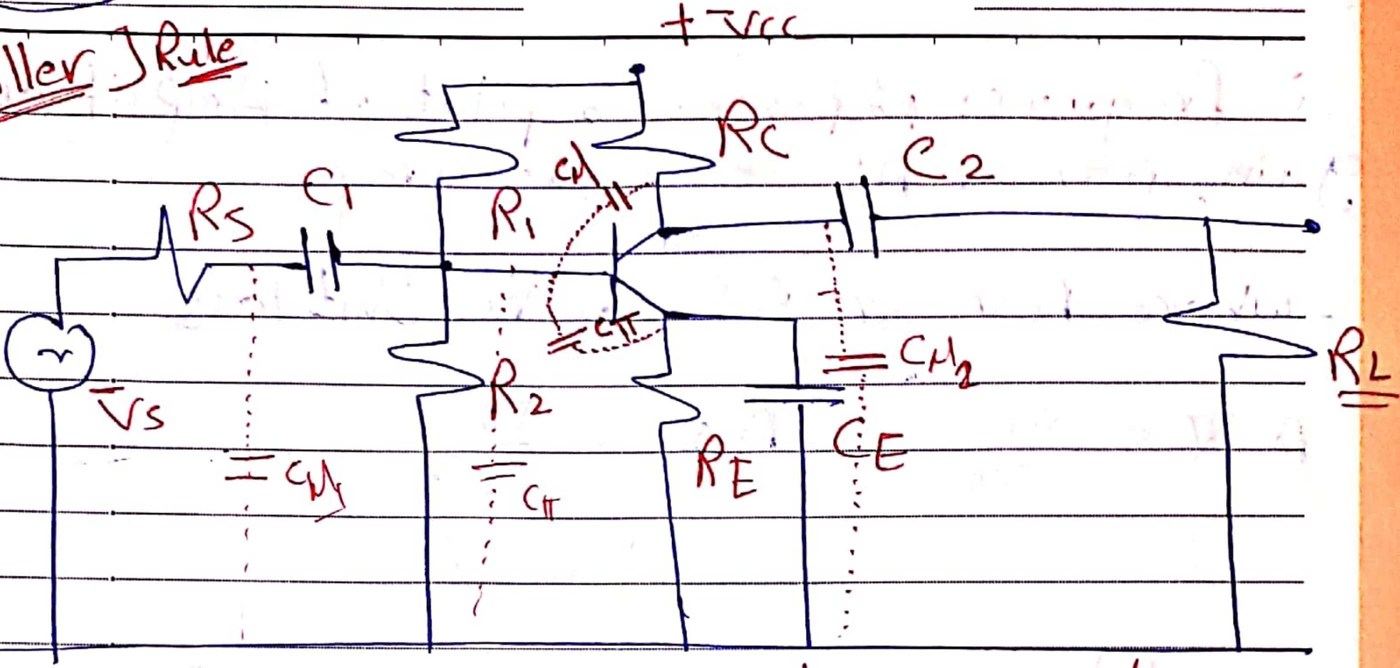
$$V_i = V_s * \frac{R_{in}}{R_{in} + R_s + X_{C_1}}$$

$V_x = K V_i$, $V_o = V_x * \dfrac{R_E}{R_E + X_{C_2}}$ $\quad A_v = \dfrac{V_o}{V_s}$

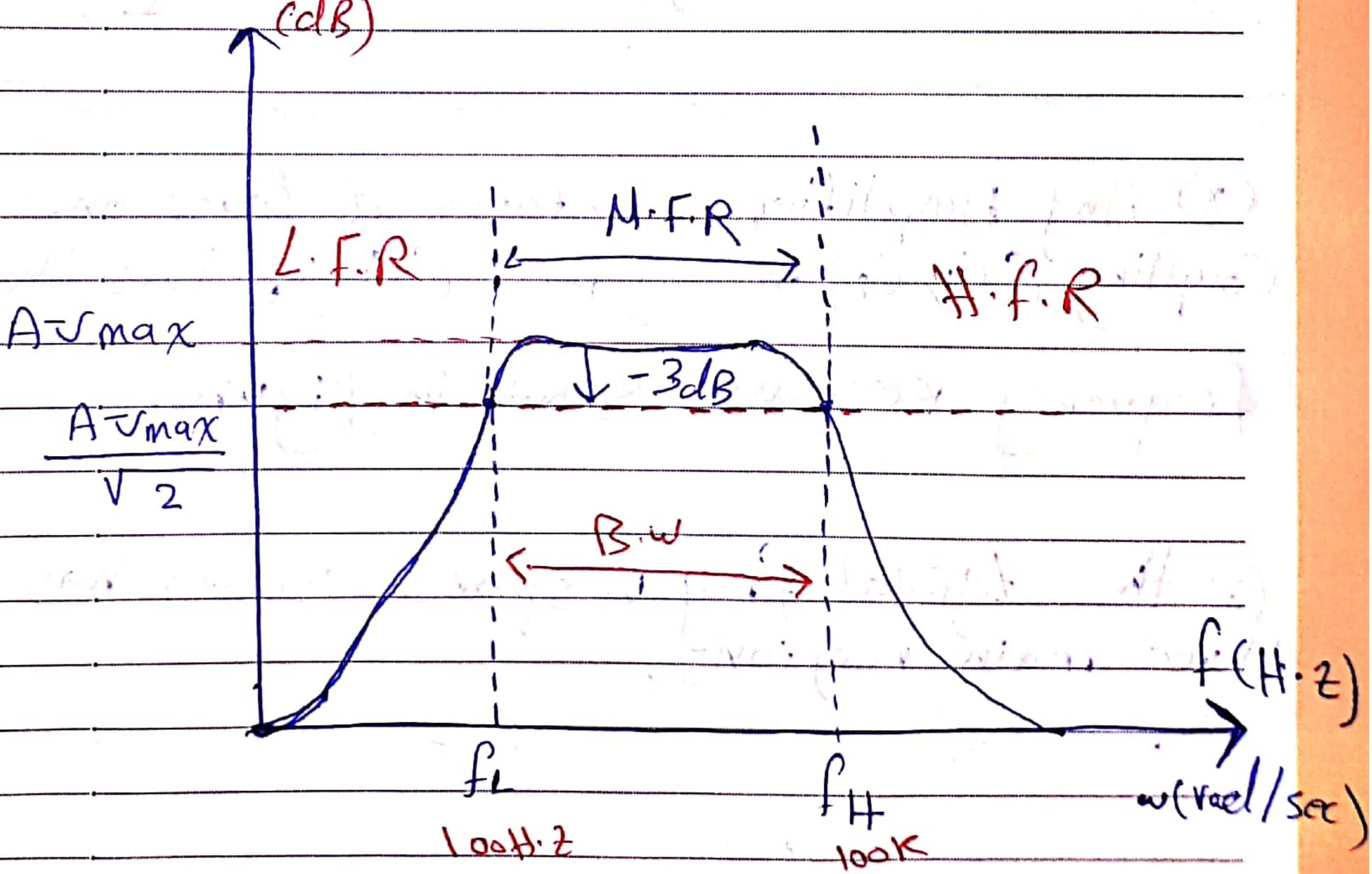
[محاضرة 5 فاينال]

130

Miller Rule



Av or AI Unitless or in dB.



131

① frequency Response: a plot of Amplifier gain A_v or A_I versius freq.

- where A_v or A_I Can be Unit less.

$$A_V = \frac{V_o}{V_s} \quad , \quad A_I = \frac{I_o}{I_s}$$

OR in dB.

$$A_v(dB) = 20 \log \frac{V_o}{V_s} \quad , \quad A_I = 20 \log \frac{I_o}{I_s}$$

* Any Amplifier Contains at least one Coupling (C_1, C_2) or by pass (C_E), has the frequency response shown in figure.

* the typical freq response shown has three main regions.

1 Low-freq Region: (LFR):

* The gain is freq dependent, such that as $f\uparrow$, $A_v\uparrow$, ($A_v \propto f$),

freq dependent: Due to the effect of coupling and by pass Capacitor.

where these Capacitors are in series path of Signal, and have Considrable reactances X_C, as $f\uparrow$, $X_C\downarrow$, more signal reach o/p i.e $V_o\uparrow$, and since $A_v = \frac{V_o}{V_s}$, and V_s is fixed, so $A_v\uparrow$.

2 Medium freq Region. (All Caps S.C)

the cct behaivous as a pure Resistive cct, with a certain gain A_{v_m} and a certain phase.

- It extends from $f_L \rightarrow f_H$, over a Band width (B.W), $f_H - f_L$, and this is the Useful range of Amplifier response.

(frequency لا تعتمد على ال
All Caps S.C لأن)

3) High freq Region:

- extends $f_H \rightarrow \infty$
- the gain is freq dependent.

such that $A_v \propto \frac{1}{f}$

as $f \uparrow$, $A_v \downarrow$.

- all Coupling & by pass Caps $\Rightarrow$ S.C
- New stray Capacitors appear effectively due physical structure of Transistor, mainly junction Capacitor C_μ (between C-B) and diffusion Capacitor C_π (B-E).

هو دل اوطي ترددات اقدر اشغل فيها (HfR اللي هي <f, MR

$A_v = g_m \cdot Z_L'$

$Z_L' = R_C // R_L // X_{C_{\mu 2}}$

$X_C = \frac{1}{2\pi f C_{\mu_2}}$

$f \uparrow$, $X_{C_{\mu_2}} \downarrow$, $Z_L \downarrow$

$A_v \downarrow$

* Since they appear in shunt connection so as $f \uparrow$, $X_C \downarrow$, $Z_i \downarrow$, $A_v \downarrow$

* The boundaries among these regions are called $\boxed{\text{Cut off frequences } (f_L, f_H)}$: (1)

(2) (−3 dB frequencies (f_L, f_H))

(3) (Half-power frequencies) (f_L, f_H).

$$P_o(f_L) = P_o(f_H) = \frac{1}{2} P_o \Rightarrow \text{Medium freq Region}$$

$$P = \frac{V^2}{R} \Rightarrow P_{mf} = \frac{V_{o\,max}^2}{R}$$

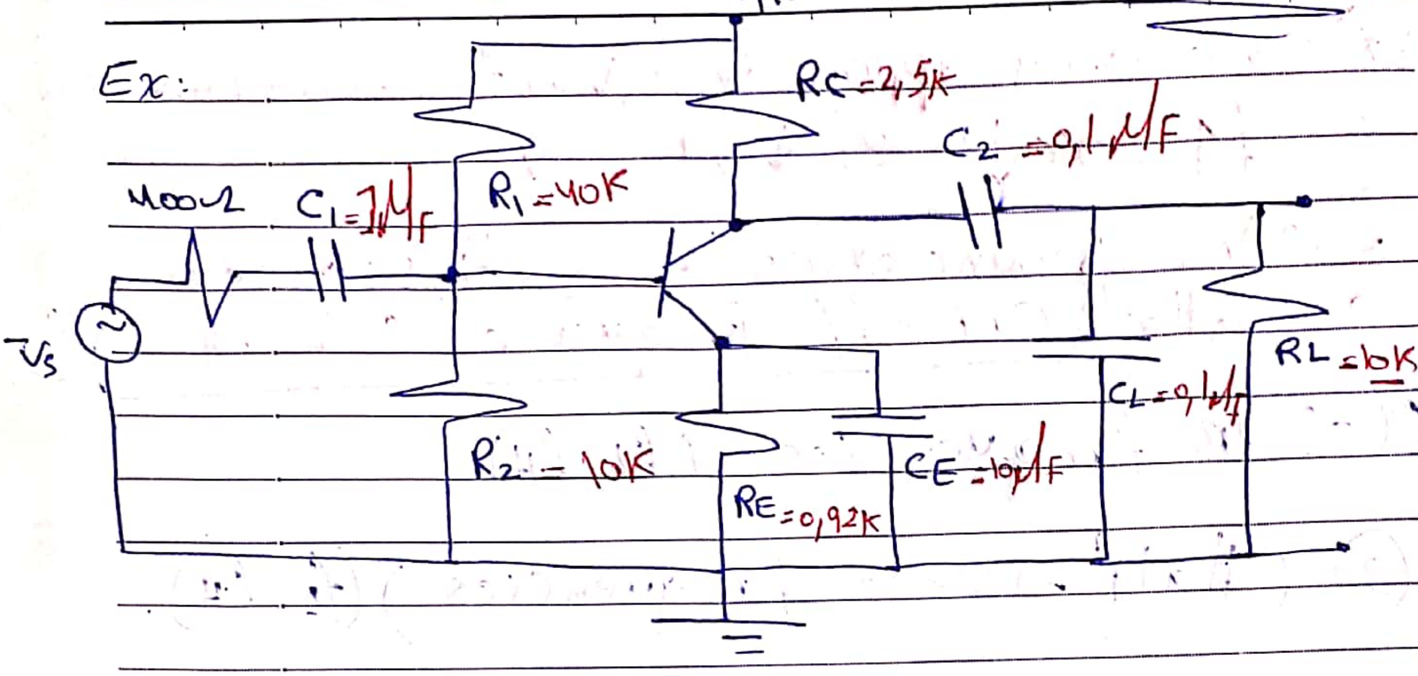
$$P_{Lf} = P_{Hf} = \frac{\left(\frac{V_{o\,max}}{\sqrt{2}}\right)^2}{R} = \frac{V_{o\,max}^2}{R} \times \frac{1}{2}$$

$$\boxed{P_{Lf} = P_{Hf} = \frac{1}{2} P_{mf}}$$

135 $C_\mu = 2pF$, $C_\pi = 20pF$

محاضرة 6
[illegible]

Ex:



$\beta = 100$, $V_{BE} = 0.7V$, $V_A = \infty$

1) Draw MF equ cct.
2) Draw H.F equ cct and F_H.
3) Draw L.f equ cct, and find f_L.
4) sketch freq Response. (Bode plot).

1) In M.F.R $\Rightarrow (C_1, C_E, C_2) \Rightarrow$ S.C

$\Rightarrow C_\mu, C_\pi, C_L \Rightarrow$ O.C

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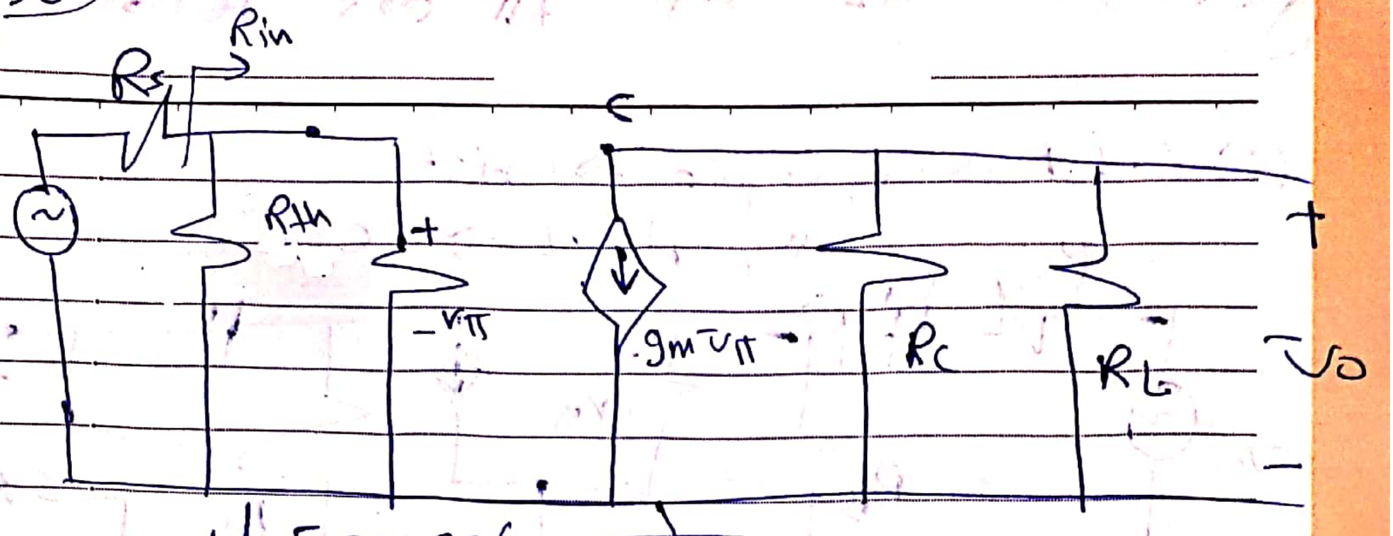
136



M.Fs equ cct

$$A_V = \frac{V_o}{V_s} = \frac{V_o}{V_\pi} * \frac{V_\pi}{V_s}$$

$$A_V = \frac{-g_m \cancel{V_\pi} (R_C // R_L)}{\cancel{V_\pi}} * \frac{R_{in}}{R_{in} + R_s} = \frac{-g_m (R_C // R_L) \cdot R_{in}}{R_{in} + R_s}$$

$$g_m = \frac{I_{CQ}}{V_T} = \frac{1{,}3\,mA}{0{,}026} = \boxed{50\ mA/V}$$

D.C Analysis ⇒ $V_{th} = 2V$, $R_{th} = 8K\Omega$

$I_B = 0{,}013\,mA$, $I_C = \beta I_B = 1{,}3\,mA$

$$r_\pi = \frac{V_T \beta}{I_{CQ}} = \frac{100 * 0{,}026}{1{,}3m} = 100 * 0{,}02K\Omega = \boxed{2\ K\Omega}$$

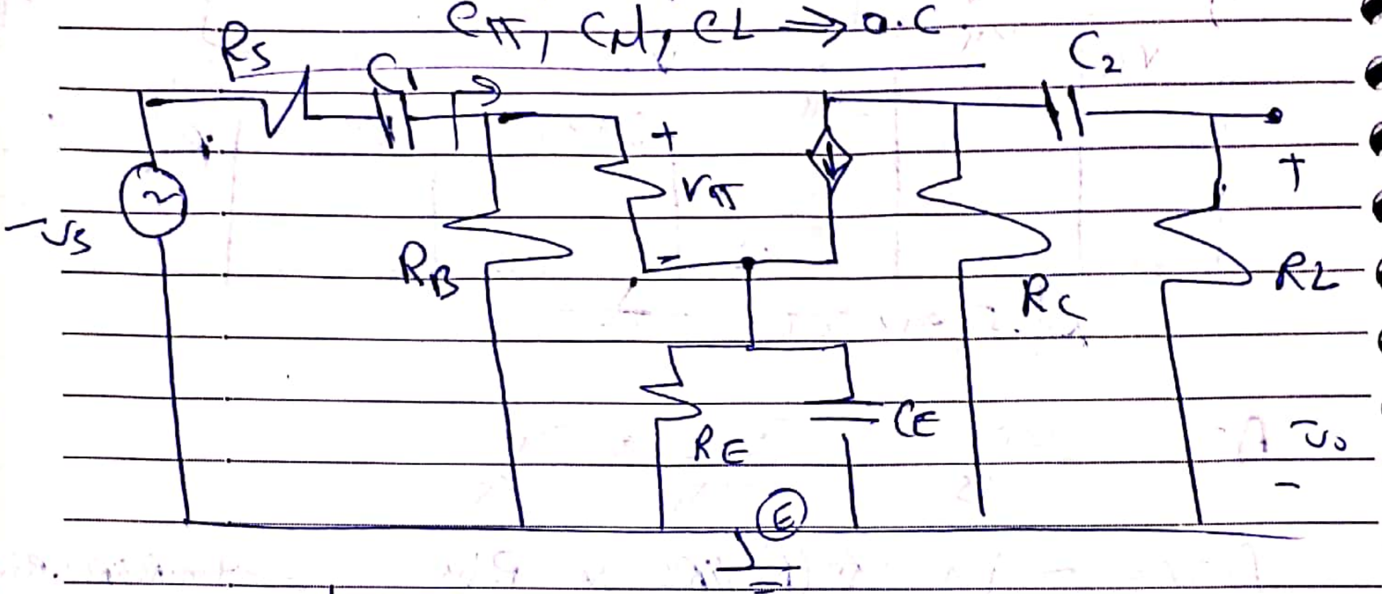
$$R_{in} = R_{th} // r_\pi = 2K // 8K = \boxed{1{,}6K\Omega}$$

$$A_V = \frac{-50 * 2 * 1{,}6}{1{,}6 + 400} = -80$$

137

f_L نحسب — f_H نحسب لوحده

② L.f.R ⇒ C_1, C_2, C_E ⇒ exist
C_π, C_M, C_L ⇒ o.c



L.F.s.s A.C equ cct

① effect of C_1 : (C_2, $C_E \to \infty$) s.c

$$f_{L_1} = \frac{1}{2\pi C_1 * R_{eq_1}} \quad , \; R_{eq_1} = R_{th} \text{ seen by } C_1$$

$$R_{eq_1} = R_s + R_{in} \quad , \quad R_{in} = R_B \parallel r_\pi$$

$$f_{L_1} = \frac{1}{2\pi (0,4 + 1,6) * 10^{-6}} = \frac{10^3}{4\pi} = 80 \cdot Hz$$

|138|

(C_1, C_E) S.C

$$f_{L_2} = \frac{1}{2\pi C_2 \cdot Req_2} \quad ; \quad Req_2 = R_L + R_C$$

$$f_{L_2} = \frac{1}{2\pi * 0{,}1 * 10^{-6} * 12{,}5K} \simeq 127 \text{ H.Z}$$

* effect of $C_E \Rightarrow (C_1, C_2) \Rightarrow$ S.C

$$f_{L_3} = \frac{1}{2\pi C_E * Req_3} \Rightarrow \left(Req_3 = \frac{(R_S // R_B) + r_\pi}{\beta + 1} // R_E\right)$$

$$f_{L_3} = \frac{1}{2\pi * 10 * 10^{-6} * 20} = \frac{10^4}{4\pi} = \boxed{800 \text{ K H.Z}}$$

- the effective of f_L is the highset value

$$\boxed{f_L = 8000 \text{ H.Z}} = 8 \text{ K.H.Z}$$

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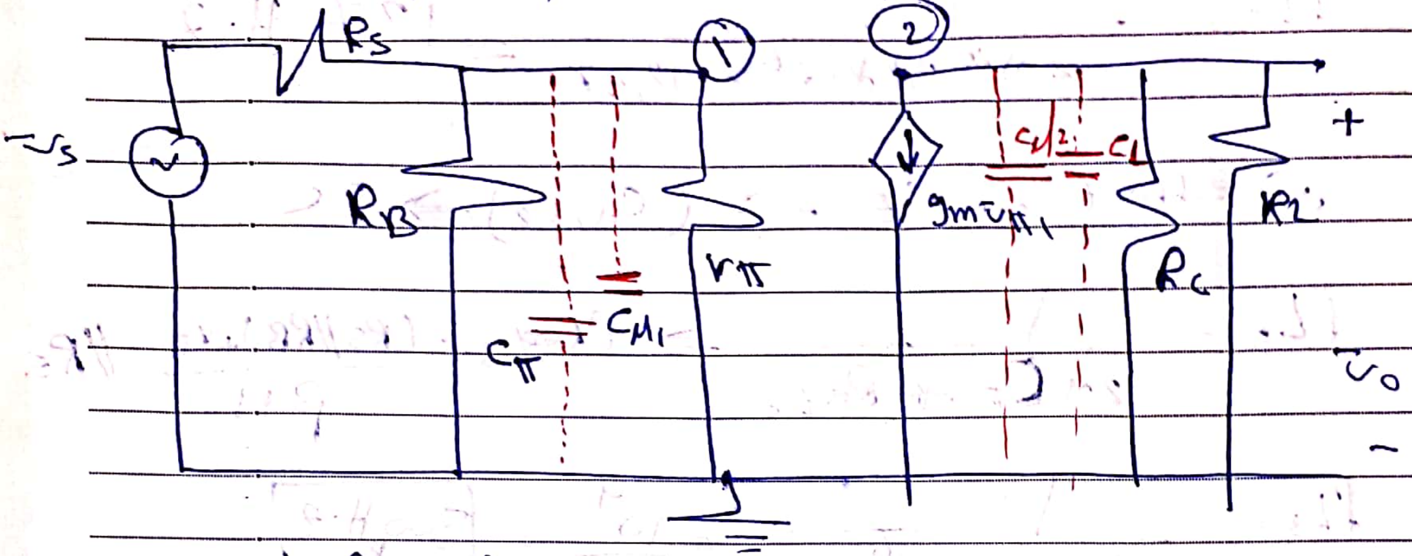
(*) High freq Region: $(C_1, C_2, C_E) \Rightarrow S.C$

$\Rightarrow C_M, C_\pi, C_L \Rightarrow$ exist



$C_{M1} = (1-K) * C_M$ $\qquad K = \frac{v_2}{v_1}$

$C_{M2} = \left(1 - \frac{1}{K}\right) * C_M$

$K = \frac{-g_m \cancel{v_\pi}(R_C \| R_L)}{\cancel{v_\pi}} = -50 * 2 = -100$

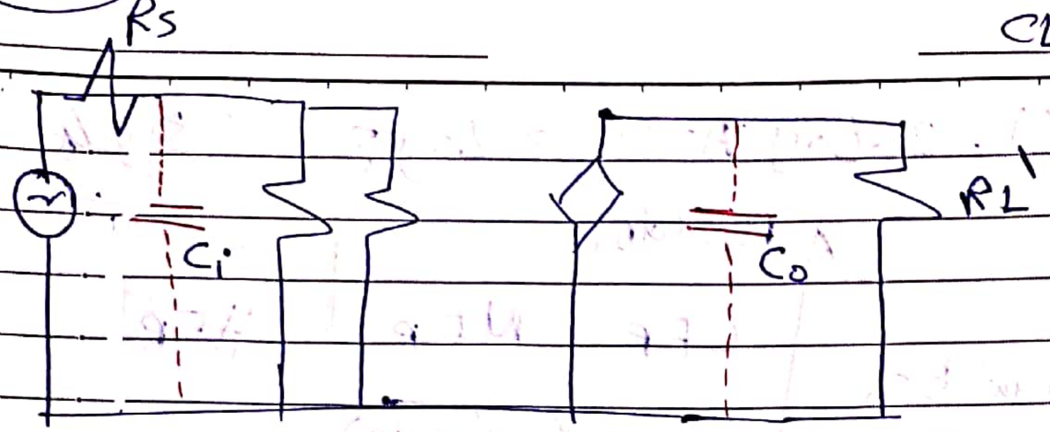
$C_{M1} = 2 * 101 = 202\,pF$

$C_{M2} = 2 * \left(1 + \frac{1}{100}\right) \approx 2\,pF$

For $K \gg 1 \Rightarrow C_{M2} = C_M$

(140)

$C_L = 10nF$



$C_i = C_\pi + C_{M1} = 222pF$

$C_o = C_L + C_{M2} = 10000\,pF + 2 \approx 10nF$

$f_{Hi} = \frac{1}{2\pi R_{eq1} C_i}$, $R_{eq1} = R_{th}$ seen by C_i

$R_{eq1} = R_S // R_{in} \Rightarrow 0{,}4 // 1{,}6 = 0{,}32K$

$f_{Hi} = \frac{1}{2\pi * 0{,}32K * 10^3 * 222 * 10^{-12}} = 2{,}2MH.z$

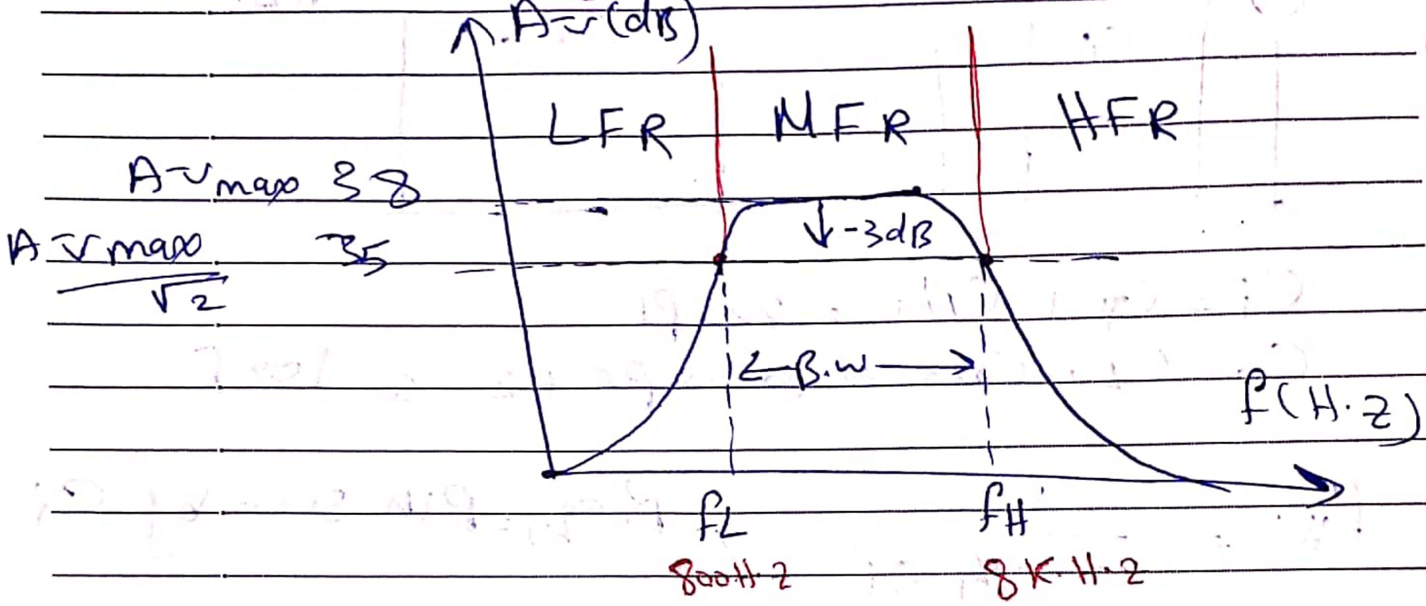
$f_{Ho} = \frac{1}{2\pi C_o R_{eq2}} \Rightarrow R_{eq2} = R_C // R_L = 2K\Omega$

$f_{Ho} = \frac{1}{2\pi * 10 * 10^{-9} * 2K} = 8KH.z$

the effective f_H is 8 KH.z

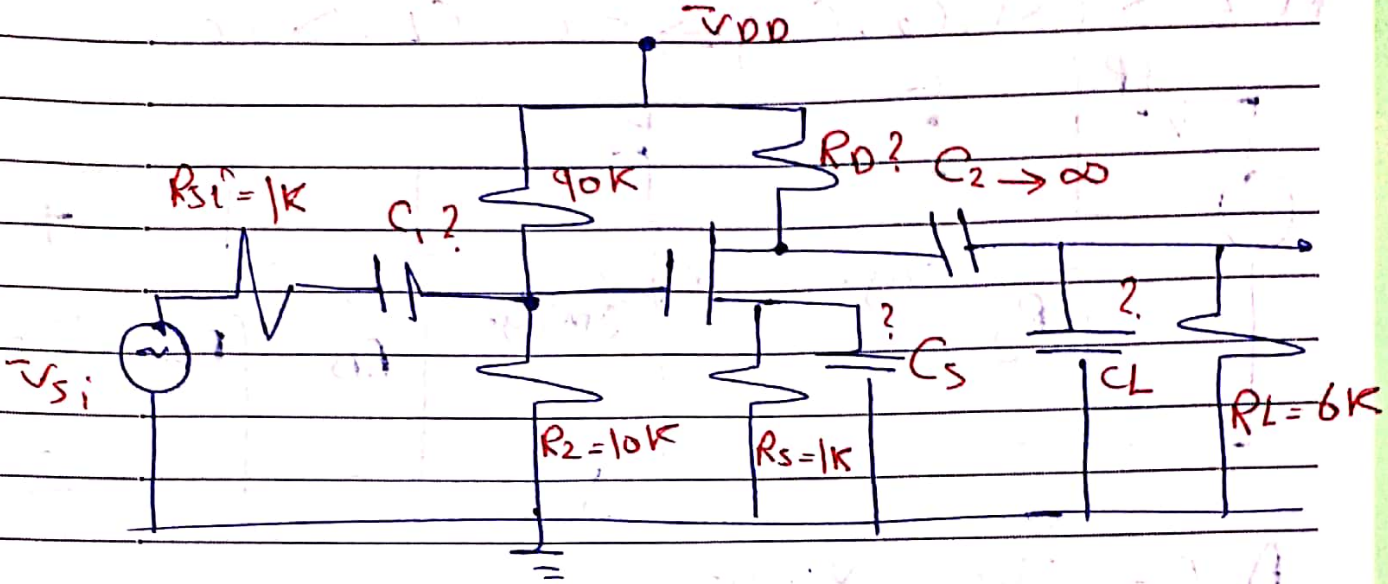
14.2

$A_v(dB) = 20 \log A_v = 20 \log 80 = 38\,dB$



تاسكي ⑧ تاني

Freq Response of FET Amplifier.

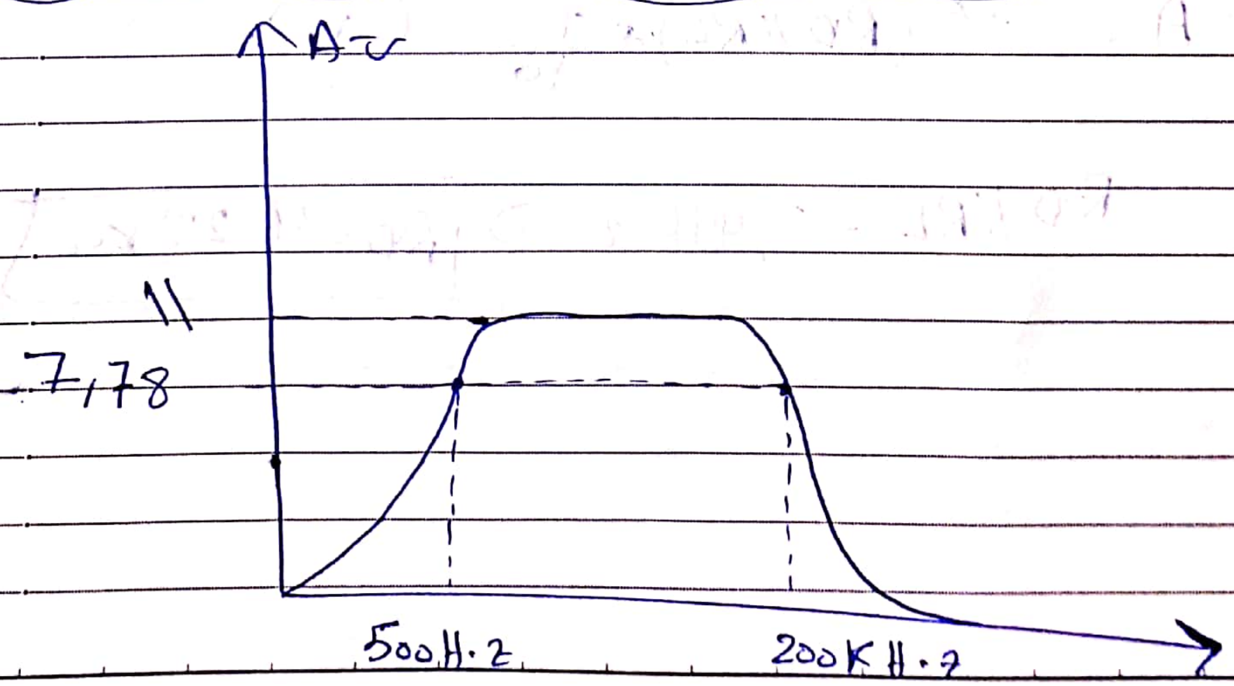


The cct is biased such that $g_m = 5 mA/v$.

① Design the cct such that, $A_v = -11$ and $f_L = 500 Hz$, $f_H = 200 KHz$.

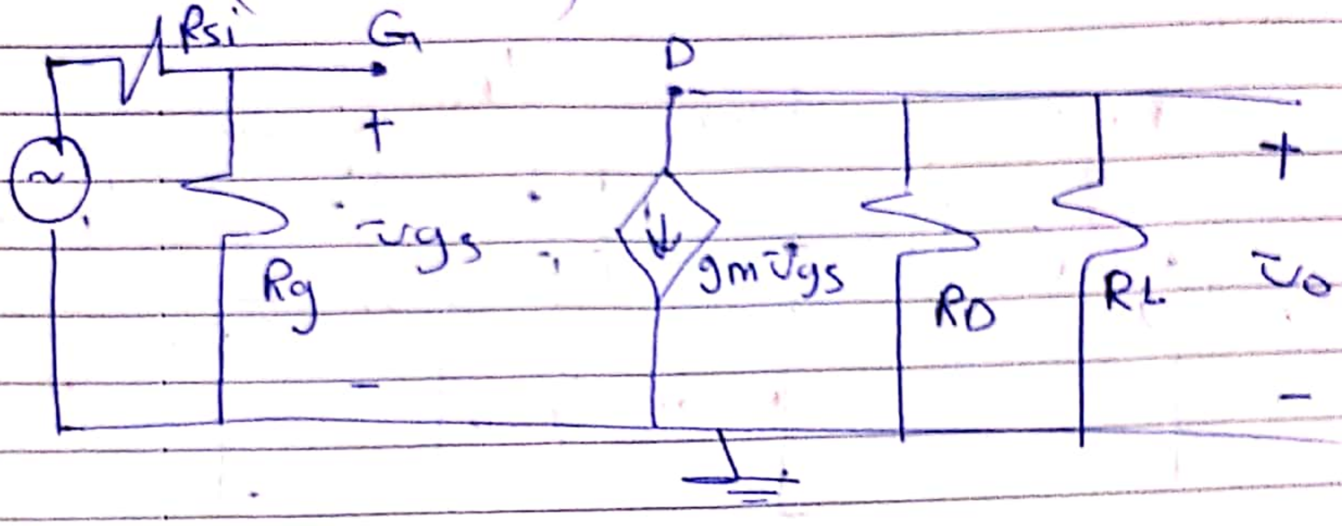
② sketch the freq Response of the Amplifier.

②



143

RD3 ⇒ $(C_1, C_2, C_s) \Rightarrow SC$, $C_L \Rightarrow OC$



$$A_v = \frac{v_o}{v_{gs}} * \frac{v_{gs}}{v_{si}}$$

$$\Rightarrow \frac{-g_m(v_{gs})(R_D // R_L)}{v_{gs}} = -g_m v_{gs}(R_D // R_L)$$

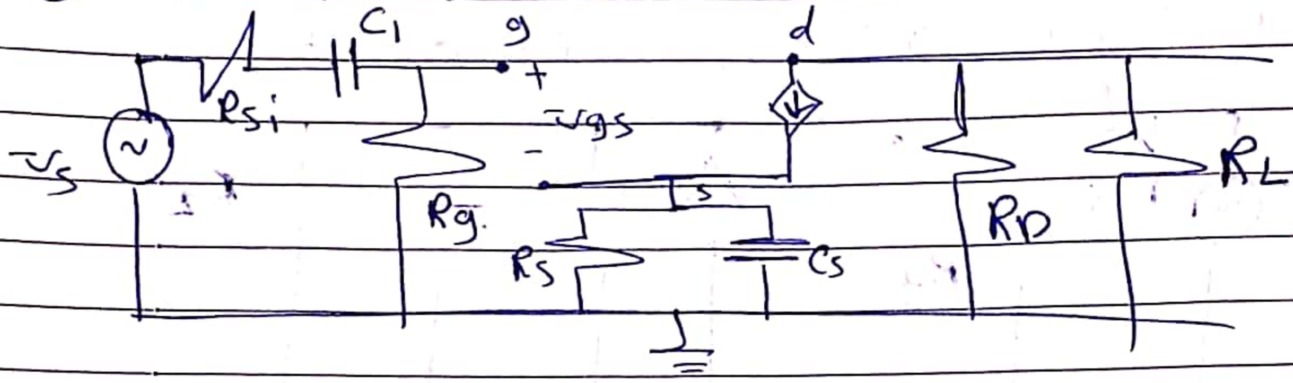
$$\frac{v_{gs}}{v_{si}} = \frac{R_g}{R_g + R_{si}}$$

$$A_v = -5(R_D // R_L) * \frac{9}{10} = -11$$

$$R_D // R_L = 2{,}44\,K\Omega \Rightarrow \boxed{R_D = 4{,}28\,K\Omega}$$

C_1, C_s exist , ~~C_2 s.c, C_L o.c~~

(*) For LFR ⇒



$$f_{L_1} = \frac{1}{2\pi C_1 R_{eq_1}} \Rightarrow C_1 = \frac{1}{2\pi f_L * R_{eq_1}}$$

$$R_{eq_1} = R_{si} + R_g = 10\,K\Omega \Rightarrow C_1 = \frac{1}{2\pi * 500 * 10*10^3}$$

$$\boxed{C_1 = 32\,nf}$$

$$\Rightarrow f_{L_2} = \frac{1}{2\pi\, C_s * R_{eq_2}} \Rightarrow C_s = \frac{1}{2\pi * 500 * 1*10^3} =$$

then ⇒ $\boxed{C_s = 0,32\,\mu F}$

- Keep $C_s = 0,32\,\mu F$, and Multiply C_1 by 1

to make f_L depends on Single Caps

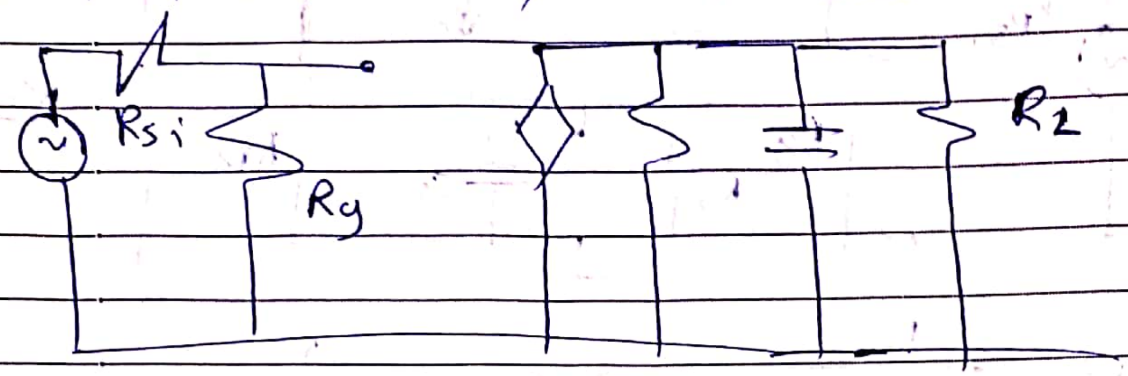
$C_1 = 320\,nf$

ثبّت المواسعة الكبيرة واضرب
المواسعة الصغيرة بـ 10 ، وليش يعني؟

كمان ما أخلي الـ A_v يعتمد على أكثر من واحد، بدل ما الحد واحد منهم
لأنه يعطيني gain أقل من العادي.

CL, High freq Region Analysis:

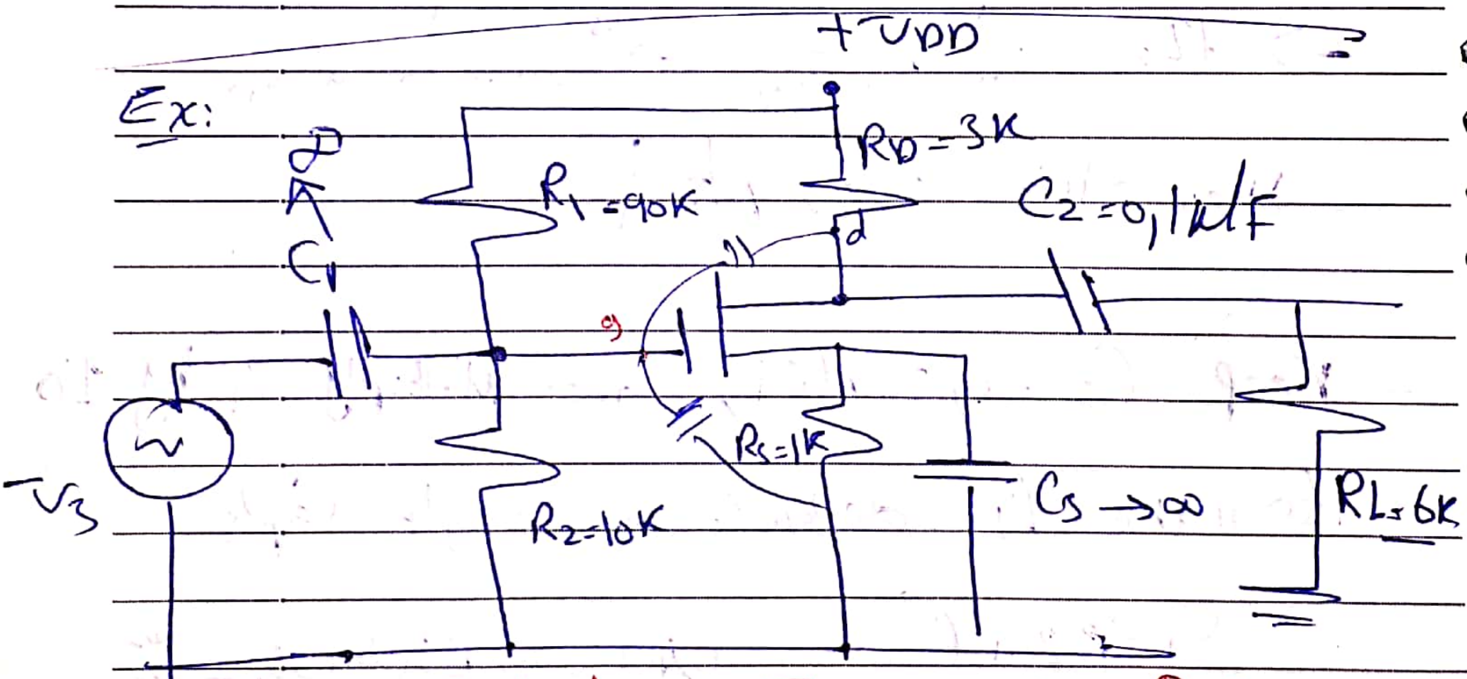
- $C_1, C_2, C_s \Rightarrow$ S.C , CL exist.



$$f_H = \frac{1}{2\pi C_L \cdot R_{eq}}$$, $R_{eq} = R_L // R_D = 2{,}44\,k\Omega$

$$C_L = \frac{1}{2\pi * 2*10^5 * 2{,}44 * 10^3} = 0{,}32\ nf$$

Ex:



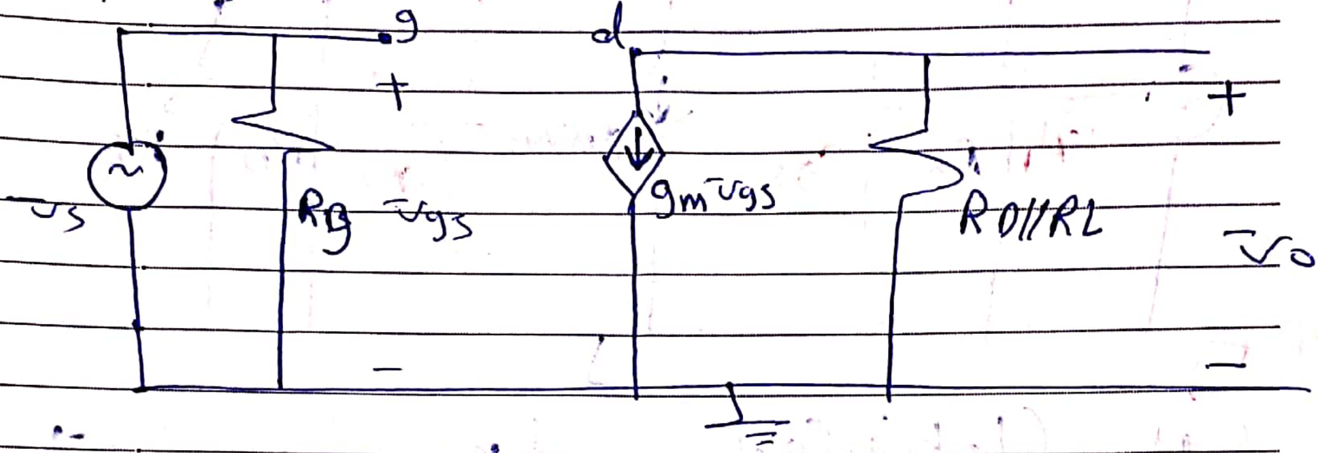
the Mosfet has $C_{gs} = 20pF$, $C_{gd} = 5pF$

$g_m = 5\,mA/V$

① Calculate A_{vm}, f_L, f_H ② sketch freq Response

① A_{vm} ? from MFR Analysis:

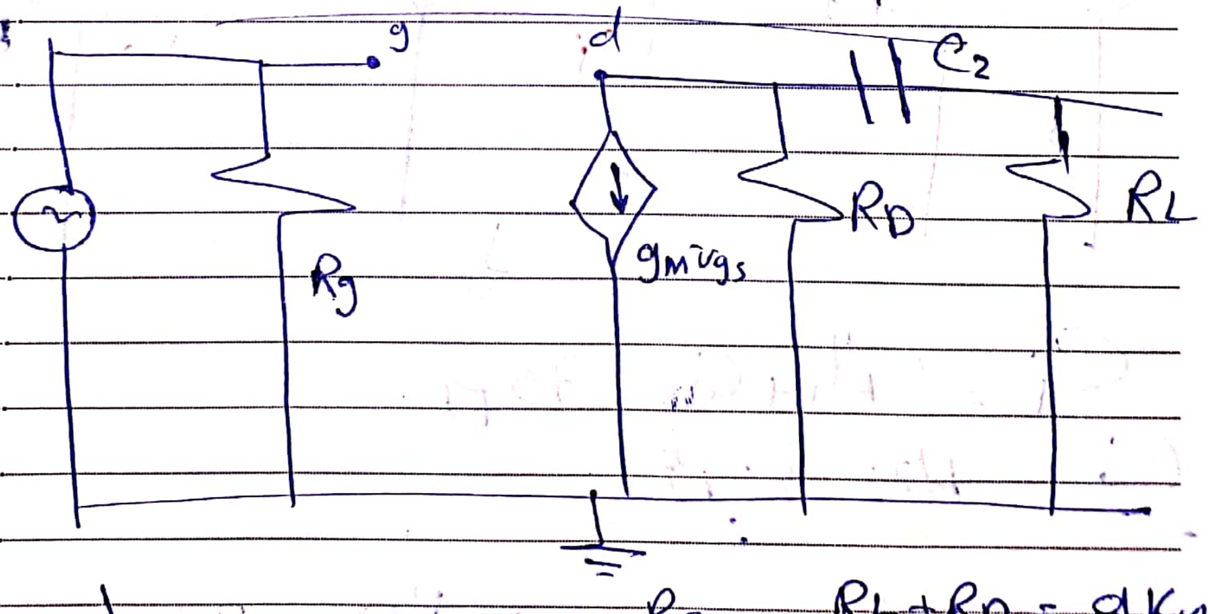
$\Rightarrow (C_1, C_s, C_2) \Rightarrow$ s.c , $C_{gs}, C_{gd} \rightarrow$ o.c



$$A_v = \frac{v_o}{v_s} = \frac{-g_m \cancel{v_{gs}} (R_D//R_L)}{\cancel{v_{gs}}} = -g_m(R_D//R_L) = -10$$

② LFR Analysis : (C_1, C_2) exist

$\Rightarrow C_1, C_s \Rightarrow$ s.c , $C_{gs}, C_{gd} \rightarrow$ o.c

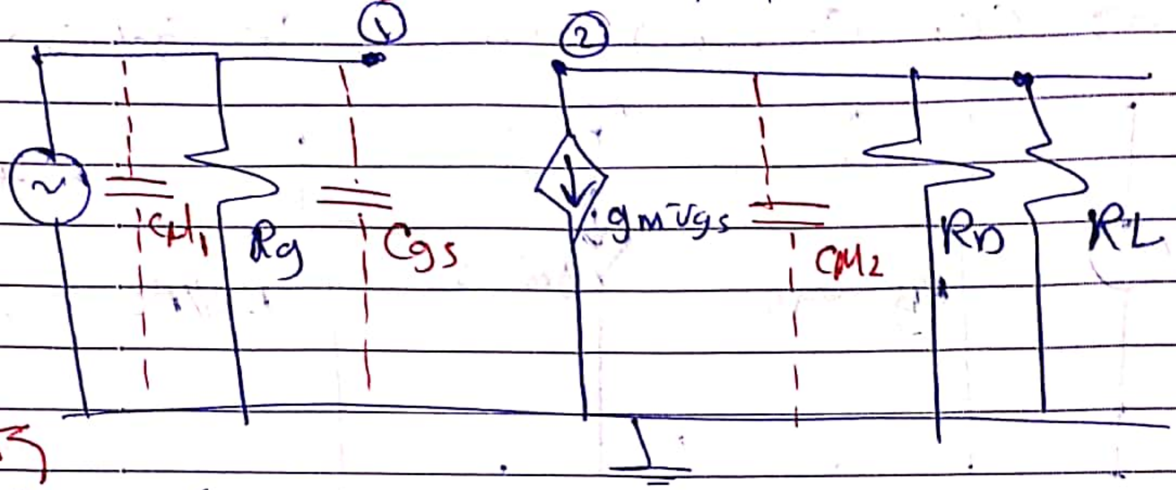


$$f_L = \frac{1}{2\pi C_2 \times R_{eq_2}} \quad , \quad R_{eq_2} = R_L + R_D = 9\,K\Omega$$

$$f_L = \frac{1}{2\pi \times 0.1\times10^{-6} \times 9\times10^{3}} = 177\ Hz$$

147

* HFR Analysis $\Rightarrow C_2, C_1, C_S \Rightarrow S.C$



55 PF

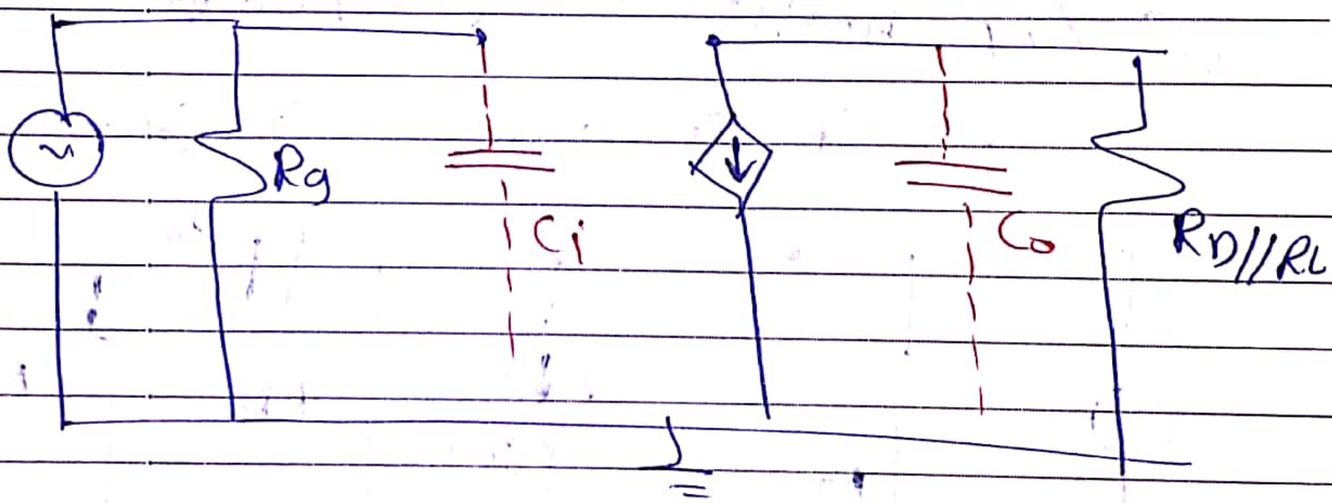
$C_{M_1} = (1-K)\, C_{gd}$

5,5 PF

$C_{M_2} = C_{gd}\left(1 - \frac{1}{K}\right)$

$K = \dfrac{-g_m v_{gs}(R_D // R_L)}{v_{gs}}$

$\boxed{K = -10}$



$C_i = C_{M_1} + C_{gs} = 75\ pF$

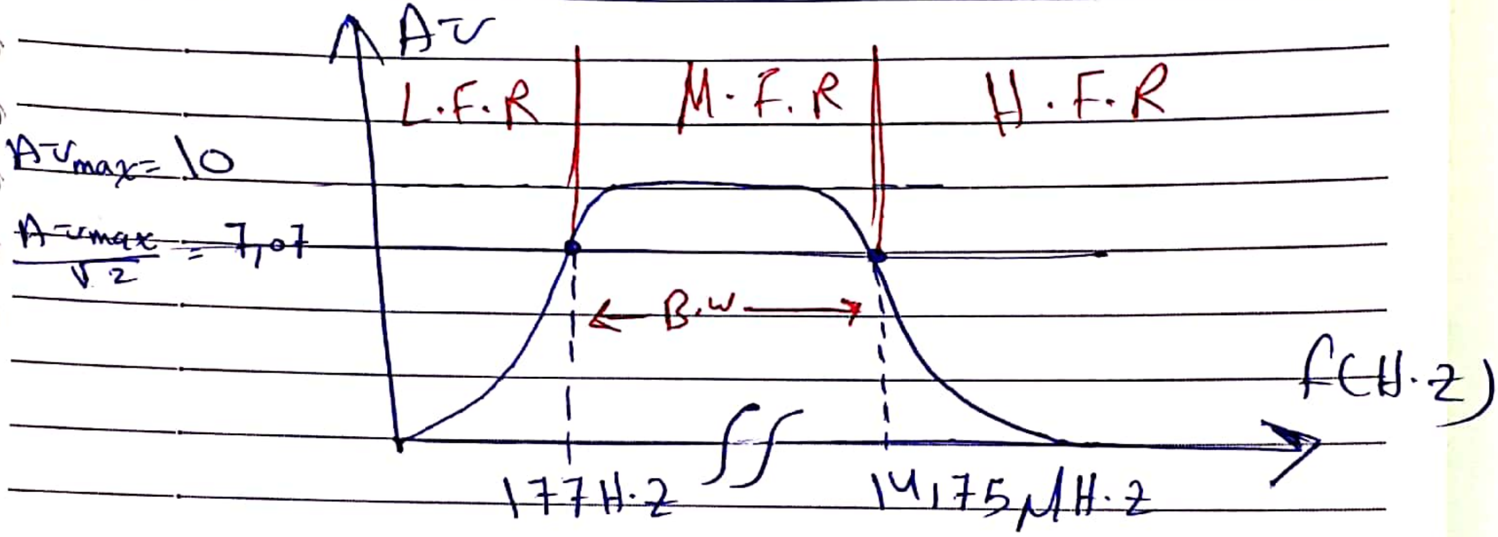
$C_o = C_{M2} = 5,5\ pF$

$f_{Hi} = \dfrac{1}{2\pi C_i \cdot R_{eq_1}}$ --> $R_{eq_1} = \text{zero}$

$f_{Hi} = \infty$

$$f_{H_o} = \frac{1}{2\pi C_o * R_{eq}} \dashrightarrow R_{eq} = R_D \| R_L = 2K\Omega$$

$$f_{H_o} = \frac{1}{2\pi * 5{,}5*10^{-12} * 2*10^{3}} = 14{,}75\ MHz$$



هيك الماده انتهت . ادعولي

Qutami