" Power Amp's (Large Signal Amp) "

• Compared to S-S Amp :-

1) Deal with Large Signals.

2) The power devices have large size, high power dispator, high rating :-

For ex.	S-S Tran.	Power Tran.
$I_{C\,max}$	0.8 A	7A
$V_{CE\,max}$	40 V	250V
$P_{o\,max}$	1.2 W	45W
β	100 → 30	20 → 70

بما انها كبيرة لذلك بحاجه نعمل تبريد للجهاز عشان ما يحترق

* Note:- Some times, heat sink is used to disspate the exclussive heat and make the device work in safe operating Region (SOR)

3) The most important parameters in P.A. is Conversion efficiency (η)...

Subject .... / /

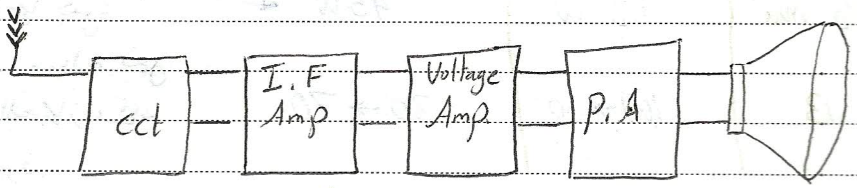
* $\eta\% = \dfrac{\text{Signal Load power}}{\text{DC. source power}} \times 100\% = \dfrac{\overline{P}_L}{\overline{P}_s} \times 100\%$

$\overline{P}_L$: Ave. Ac. load power delivered to load

$\overline{P}_s$: Ave. Ac. power supply by the DC. source (V_{cc})

• ال P.A بتسحب الpower من ال DC
وبتحولها إلى :
① Ac load powr (o/p)
② power dissipated بال Tran. أو بالresistors

4) Normally, P.A is located as ~~final~~ final stage in electronic sys. such as radio receiver..



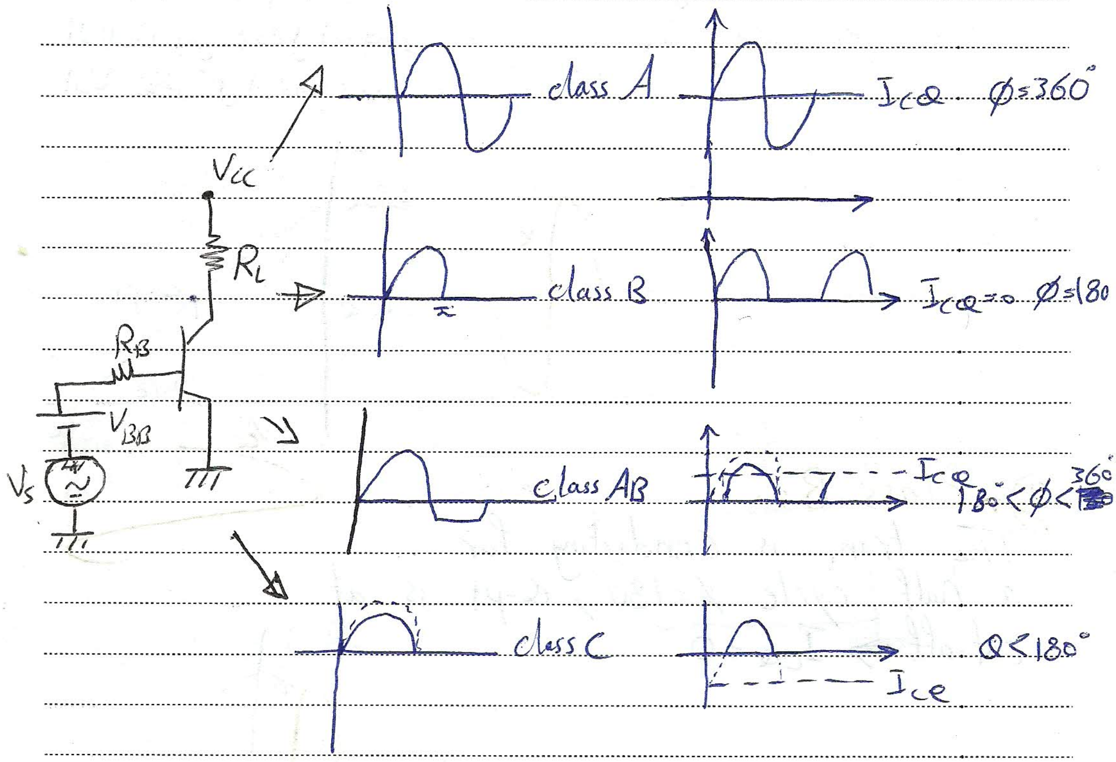
• بيكون عادة اللود (load) ~~عالي~~ قليل عشان نسحب تيار كبير.

* Classification of power Amp's :-

• صنفت على اساس
انه كم الفترة الزمنية الي بيكون
فيها ال Tran. شغال (on)..

Subject .... / /

• يعتمد نوع ال class على موقع ال Qpoint



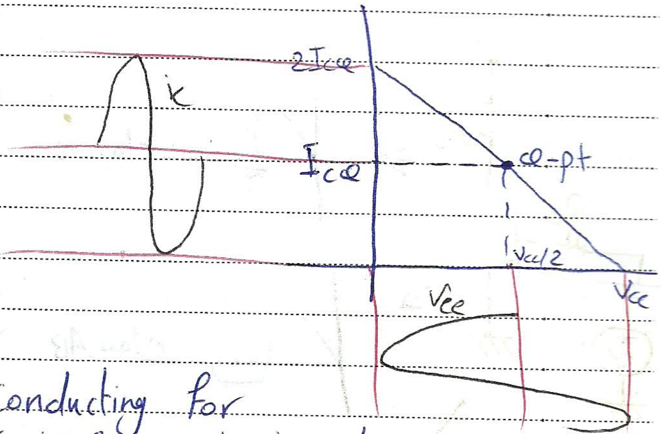
• There are four main classis according to percentage time for the conducting transistor for asinosoidal signal.

1) Class A :- The tran. is conducting for a full cycle i.e the conducting angle $\phi = 360°$, Ideally the Q-pt must be in the center of the DC. l.l

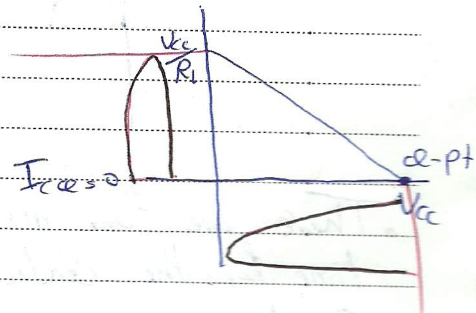
Subject .... / /

• and must $i_{cp} < I_{CQ}$
عشان ما يصير Class AB

• طبعاً احنا بنحكي ideally
انه ال Q-pt لازم تكون بنصف
ال DCll بس الافضل انه نحكي
انها بتغطي كل ال signal..



2) class B:-
The tran. is conducting for a half cycle $\phi = 180°$, Q-pt is at cut-off $\Rightarrow I_{CQ} = 0$



"Class "A" power Amp's"

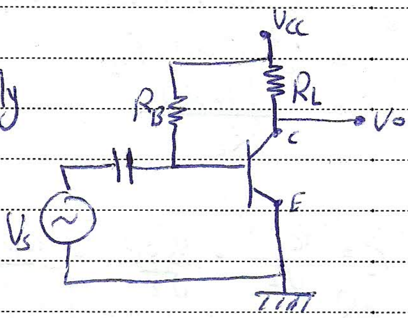
- The o/p is present for 360° i.e, the o/p will be a complete Signal.

- Ideally, the Q-pt is at the center of Dc.l.l

• مو مهم بالcenter زكم
الاهم انه الموجة كاملة...

1) Direct coupled load (series-Fed-type):

The load is connect directly between V_{cc} and Collector...



- Dc.l.l

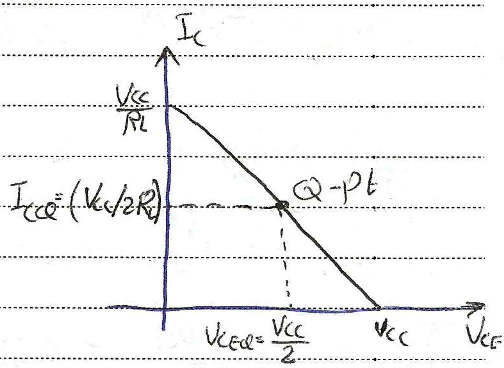
$V_{CE} = V_{cc} - I_c R_L$

for $V_{CE} = 0 \Rightarrow I_C = \frac{V_{cc}}{R_L}$, for $I_c = 0 \Rightarrow V_{CE} = V_{cc}$

- Ideally, when the Q-pt at the center of Dc.l.l:-

$I_{CQ} = V_{cc}/2R_L$

$V_{CEQ} = V_{cc}/2$



Subject .... / /

- $\eta\% = \dfrac{\overline{P_L}}{\overline{P_s}} \times 100\ \%$

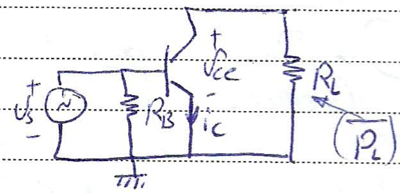
* $\overline{P_s}$ = Dc. power drawn from V_{cc}

$$\boxed{\overline{P_s} = I_{CQ} \cdot V_{cc}}$$

* $\overline{P_L}$ = Ac load power deliverd to R_L

لازم تكون كلها RMS

$$\overline{P_L} = i_c(RMS) \cdot V_{ce}(RMS)$$
$$= i_c^2(RMS) \cdot R_L$$
$$= \frac{V_{ce}^2(RMS)}{R_L}$$



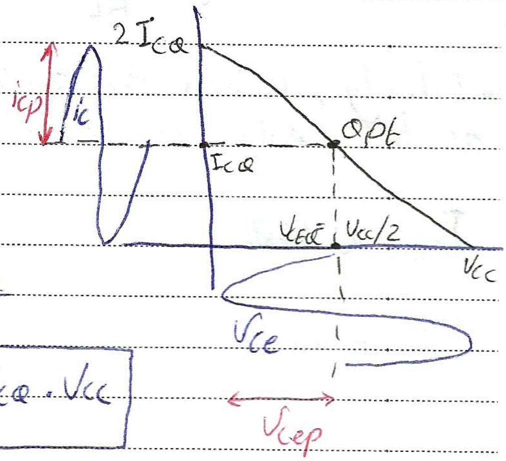
$\Rightarrow \overline{P_L} = \dfrac{i_{cp}}{\sqrt{2}} \cdot \dfrac{V_{cep}}{\sqrt{2}} = \dfrac{i_{cp} \cdot V_{ceP}}{2}$ (for sinosoidal wave)

OR

$$\overline{P_L} = \frac{(i_{cp})^2}{\sqrt{2}^2} R_L = \frac{i_{cp}^2 R_L}{2}$$

OR

$$\overline{P_L} = \left(\frac{V_{cp}}{\sqrt{2}}\right)^2 / R_L = \frac{V_{cp}^2}{2 R_L}$$



- $\overline{P_{L\,max}}$: $i_{cp} = I_{CQ}$
  $V_{cep} = V_{CEQ} = \dfrac{V_{cc}}{2}$

$$\boxed{\overline{P_{L\,max}} = \frac{I_{CQ} \cdot V_{cc}}{2 \times 2} = 0.25\, I_{CQ} \cdot V_{cc}}$$

Subject .... / /

$\therefore \eta\%_{max} = \dfrac{0.25\, V_{cc} \cdot I_{CQ}}{V_{cc} \cdot I_{CQ}} \times 100\% = \boxed{25\%}$

أعظم كفائة في class A direct coupled
هي ربع الـ DC مـ الـ V_{cc} .

• $\eta\%_{max} = 25\%$ when the Q-pt. at center of Dc.L.L

i.e $I_{CQ} = \dfrac{V_{cc}}{2R_L}$, $V_{CEQ} = \dfrac{V_{cc}}{2}$

• لا يمكن الحصول على كفائة اعلى
واذا حصلنا على كفائة اعلى من 25%
في شي غلط...

$\Rightarrow \overline{P}_L = 0.25\, \overline{P}_s$

• الـ Ac load power بتسحب فقط 25% من P_s
والباقي بيروح power dissipated in transistor & power dispitaded in R_L على شكل حرارة

• اذا ما كان في Ac signal رح ينسحب $\overline{P}_s$
بنفس القيمة ولكن رح يتوزع بقيم اكبر عـ
الـ Tran. $\uparrow P_{D\,tran.}$ ...

$\times$

1) For No Ac signal ($V_s = 0$)

$\overline{P}_s = V_{cc} \cdot I_{CQ} = \underbrace{I_{CQ}^2 R_L}_{P_D \text{ in } R_L \text{ as heat}} + \underbrace{I_{BQ}^2 R_B}_{P_D \text{ in } R_B} + \underbrace{I_{CQ} V_{CEQ}}_{P_D \text{ in Tran.}}$

but it can be neglectid cause it's very small

2) When Ac signal is applied, the $\overline{P}_s$ is redistributed as:-

$\overline{P}_s = V_{cc} \cdot I_{CQ} = \overline{P}_L + I_{CQ}^2 R_L + P_{D\,tran} + I_{BQ}^2 R_B$

where $P_{D\,tran} = \overline{P}_s - P_{DR_L} - P_{DR_B} - \overline{P}_L$

it's very small
So we neglict it...

Subject .... / /

- Transistor Rating :-

$V_{CE} = V_{CC} - I_C R_C$ (Dc.l.l)

الـ rating يعني حساب أعلى تيار وأعلى فولتية وأعلى P.D بيتحملها الـ Tran.

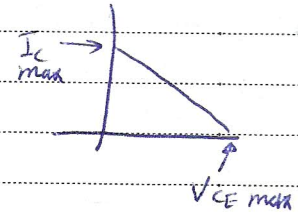
taken from Dc.l.l

1) $V_{CE}\,max$:

for $I_C = 0 \Rightarrow \boxed{V_{CE} = V_{CC}}$

2) $I_C\,max$:

for $V_{CE} = 0 \Rightarrow \boxed{I_{Cmax} = V_{CC}/R_L}$



3) $P_D\,max$:-

P_D in Tran is max when there is not Ac Signal

$\Rightarrow \boxed{P_{Dmax} = I_{CQ} \cdot V_{CEQ}}$

Ex. A class (A) using a BJT with $B = 25$, $V_{BE} = 0.6$ Volt, with a speaker of $10\,\Omega$ and $R_B = 0.5\,K\Omega$ as shown in the figure:

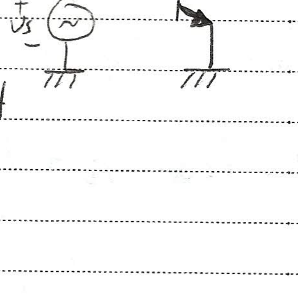
If the Ac derives a peak collector current of (0.4 A)?

1) Find Q-pt possition?

2) Calculate $\overline{P_S}$, $\overline{P_L}$, $\eta\%$, P_{DR_L}, $P_{D\,tran.}$?

3) Draw Dc.l.l & Ac.l.l with output Voltage & current swing?

4) specified tran. rating?



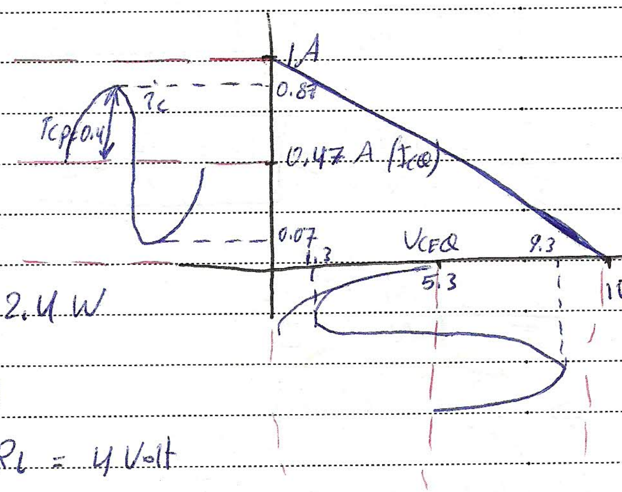
Subject .... / /

<u>Sol.</u>

- $I_{BQ} = \dfrac{10 - 0.6}{0.5K} = \boxed{18.8\ mA}$
- $I_{CQ} = \beta I_{BCQ} = (25)(18.8\ mA) = \boxed{0.47\ A}$
- $V_{CEQ} = V_{CC} - I_C R_L = \boxed{5.3\ Volt}$
- $\bar{P}_s = I_{CQ} \cdot V_{CC} = \boxed{4.7\ W}$
- $\bar{P}_L = \left(\dfrac{I_{CP}}{\sqrt{2}}\right)^2 R_L = \boxed{0.8\ W} = \dfrac{V_{cep}^2}{R_L} = i_{cp} \cdot V_{cep}$
- $\eta\% = \dfrac{\bar{P}_L}{\bar{P}_s} \times 100\% = \dfrac{0.8}{4.7} \times 100 = \boxed{17\%}$

• η قيمتها معقولة
لا يمكن الحصول على
η أعلى من 25% وتكون
عندما الـ Q-pt بنص الـ D.C.L.L

- $P_{DR_L} = I_{CQ}^2 \cdot R_L = (0.47)^2 \times 10 = \boxed{2.2\ W}$
- $P_{D\,tran.} = \bar{P}_s - \bar{P}_L - P_{DR_L} = 4.7 - 0.8 - 2.2$
  $= \boxed{1.7\ W}$
- $V_{CE\,max} = 10\ Volt$
- $I_{C\,max} = \dfrac{10}{10} = 1A$
- $P_{D\,max} = I_{CQ} \cdot V_{CEQ} = 2.4\ W$

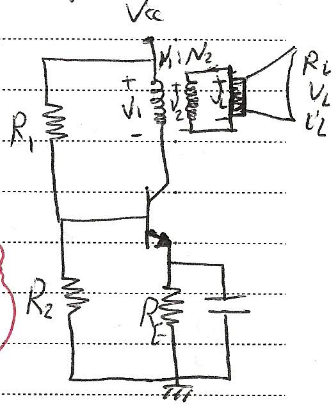


بدون AC
دائماً كان في AC
بتقل P_D في الـ BJT

- $i_{cp} = 0.4\ A$
- $V_{cep} = i_{cp} \cdot R_L = 4\ Volt$

Subject .... / /

"Class (A) Transformer coupled Amp"

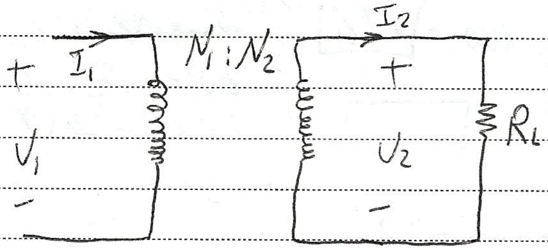


* Compared to direct coupled:
for the same $\overline{P_L}$, the transformer coupled requiures less $\overline{P_S}$ (No power dissipated as $I_{CQ}^2 \cdot R_L$)
and sence $\frac{\overline{P_L}}{\overline{P_S}\downarrow} = \eta \uparrow$ so $\eta_{transform} > \eta_{direct}$

• ربطنا الـ load بالـ secondary

• هون ما بخسر power على شكل حرارة بـ R_L يعني ما رح نخسر $I_{CQ}^2 R_L$ يعني P_S بتقل والكفاءة بتزيد

• for Ideal transformer :-



• $\frac{V_1}{V_2} = \frac{N_1}{N_2} \Rightarrow \boxed{V_1 = \frac{N_1}{N_2} V_2}$

• $\frac{I_1}{I_2} = \frac{N_2}{N_1} \Rightarrow \boxed{I_1 = \frac{N_2}{N_1} I_2}$

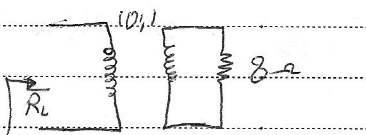
• $\frac{V_1}{I_1} = \left(\frac{N_1}{N_2}\right)^2 \frac{V_2}{I_2}$

$\Rightarrow \overline{R_L} = a^2 R_L$

$\overline{R_L}$: Ac reflected impeadence seen from primary side

a: $\frac{N_1}{N_2}$

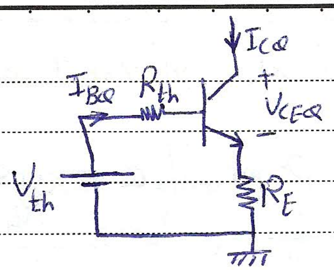
ex.



$\overline{R_L} = \left(\frac{10}{1}\right)^2 (8) = 800\ \Omega$

Subject .... / /

D→ Dc. analysis:-



- $R_{th} = R_1 // R_2$
- $V_{th} = \dfrac{V_{CC} R_2}{R_1 + R_2}$
- $I_{BQ} = \dfrac{V_{th} - V_{BE}}{R_{th} + (\beta + 1) R_E}$
- $I_{CQ} = \beta I_{BQ}$

resistance for the (inductor)(primary coil)

- $V_{CEQ} = V_{CC} - I_{CQ} r_{dc} - I_E R_E$

for a very small R_E & negleglble r_{dc}

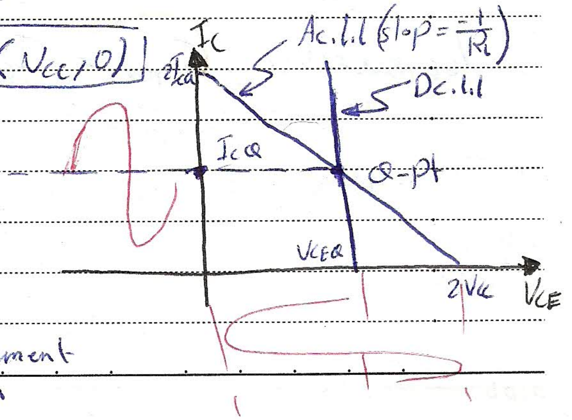
$$\boxed{V_{CEQ} = V_{CC}}$$

- Dc.l.l

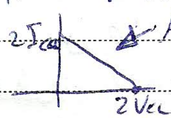
$V_{CE} = V_{CC} - I_C r_{dc} - I_C R_E$

for $V_{CE} = 0 \Rightarrow I_C = \dfrac{V_{CC}}{r_{dc} + R_E} \approx \infty$ (for negligible r_{dc} & R_E) $\boxed{(0, \infty)}$

for $I_C = 0 \Rightarrow V_{CE} = V_{CC}$ $\boxed{(V_{CC}, 0)}$



• عشان احصل على أكبر output ممكن



تكون حدود الـ Ac.l.l

وبنقدر نحصل على هذا

الـ output لأنه الـ coil عبارة عن

storage element بيخزن الـ Vcc وفي شغله Vcc

من الـ source بيصير الـ 2Vcc ...

njpb

Subject .... / /

- Dc and Ac intersect at Q-point.

$\Rightarrow$ at Q-point, $I_{CQ} = \frac{V_{CEQ}}{R_L} = \frac{V_{CC}}{R_L}$

- $\boxed{I_{CQ} = \frac{V_{CC}}{R_L}}$, $\boxed{V_{CEQ} = V_{CC}}$, $\boxed{R_L = \frac{V_{CC}}{I_{CQ}}}$

tak
Pro
D.c.l

- $\eta\%$ max :-

$\eta\% = \frac{\overline{P_L}}{\overline{P_s}} \times 100$ ممكن نحسبها من الـ primary أو الـ sec. حسب المعطيات

$\overline{P_s} = V_{CC} \cdot I_{CQ}$, $\overline{P_L}$ = from primary $= \frac{V_{cp}}{\sqrt{2}} \cdot \frac{i_{cp}}{\sqrt{2}}$

$\Rightarrow \overline{P_L}_{max} = \frac{V_{CC}}{\sqrt{2}} \cdot \frac{I_{CQ}}{\sqrt{2}} = \frac{I_{CQ} \cdot V_{CC}}{2}$

$\Rightarrow \eta\%_{max} = \frac{\overline{P_L}_{max}}{\overline{P_s}} = \frac{I_{CQ} \cdot V_{CC}}{2 I_{CQ} \cdot V_{CC}} \times 100 = \boxed{50\%}$

- Tran. rating :

أسوأ حالة انه يذهب كل اشي بالـ Tran.

$V_{CE\,max} = 2V_{CC}$, $I_{C\,max} = 2I_{CQ}$, $P_{D\,max} = V_{CC} \cdot I_{CQ}$

- يعني لو كان الـ $V_{CC} = 10$ لازم أجيب Tran. بيتحمل 20

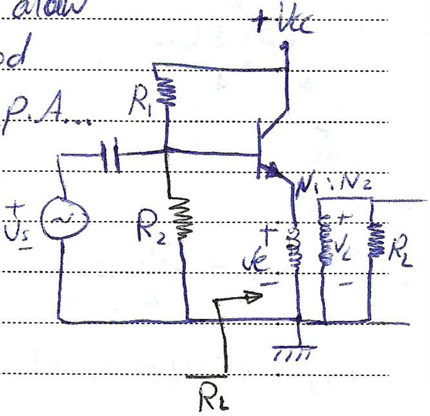
- لا يمكن الحصول أعلى من 50% وتكون 50% اذا كانت الـ peak Collector Voltage = V_{CC}

Subject .... / /

"Transformer - Coupled EMitter follower class A P. Amp's"

- Since EMetter follower (C.C) has alow output resistance So it is very good cct. to be Used as an o/p stage P.A...

- Given V_{cc}, β, V_{BE}, To Design acct for a certain specification.



Ex. Design a class A transformar Coupled E.F to deliver 4 Watt to 8 Ω load.
Use a BJT with $\beta = 50$, $V_{BE} = 0.6$ Volt, the available $V_{cc} = 25$ Volt, the peak emitter current i_{ep} Not more than $0.8\, I_{cQ}$ ($i_{ep} = 0.8\, I_{cQ}$) & peak emitter Voltage $V_{ep} = 0.8 V_{cc}$?

1) Draw the cct diagram.
2) Calculate the turn ratio $a = \frac{N_1}{N_2}$, $\bar{P}_s$, $\eta\%$?
3) spesified the reqired tran. rating? (I_{cmax}, V_{CEmax}, P_{Dmax})
4) Draw, DC & AC load line with emitter Voltag & current Swing?

We will Use this

$$a = \frac{N_1}{N_2} = \frac{V_e}{V_L} = \frac{i_L}{i_e} = \frac{\sqrt{R_L'}}{R_L}$$

- $V_{ep} = 0.8 V_{cc} = (0.8)(25) = 20V$
- $\bar{P}_L = \frac{V_{Lp}^2}{2R_L} \Rightarrow V_{Lp} = \sqrt{R_L P_L 2} = \sqrt{(8)(4)(2)} = 8$ Volt

$$\Rightarrow a = \frac{V_{ep}}{V_{Lp}} = \frac{20}{8} = \frac{2.5}{1} = 2.5 : 1$$

njpb

Subject .... / /

- $\overline{P_s} = V_{cc} \cdot I_{CQ}$, $I_{CQ} = \frac{i_{ep}}{0.8}$, $\frac{i_{ep}}{i_{Lp}} = \frac{N_2}{N_1} = \frac{1}{a}$

$\Rightarrow i_{ep} = \frac{i_{Lp}}{a}$

$i_{ep} = 8 I_{CQ}$

$\frac{V_e}{R_L}$, $\frac{i_{Lp}}{a}$

- $i_{Lp} = \frac{V_{Lp}}{R_L} = \frac{8}{8} = 1A$

$\Rightarrow i_{ep} = \frac{1}{2.5} = 0.4A$

$\Rightarrow I_{CQ} = \frac{0.4}{0.8} = \frac{1}{2} = 0.5A$

- $\overline{P_s} = (25)(0.5) = 12.5$ Watt

- $\eta\% = \frac{\overline{P_L}}{\overline{P_s}} \times 100\% = \frac{4}{12.5} \times 100 = 32\%$

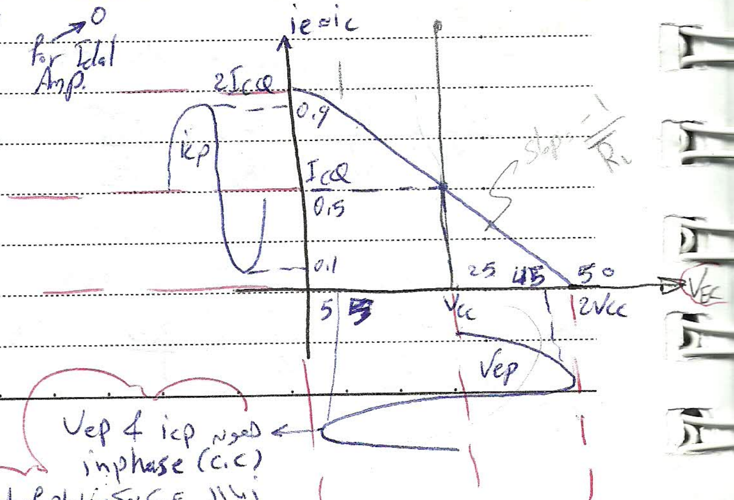
- $V_{CE\,max} = 2V_{cc} = 50$ Volt , $I_{C\,max} = 2I_{CQ} = 1A$
- $P_{D\,max} = \overline{P_s} = V_{cc} \cdot I_{CQ} = 12.5$ Watt

- $V_{cc} - V_{CE} - I_E r_{dc} = 0$

for $I_E = I_C$, $I_C = 0 \Rightarrow \boxed{V_{CE} = V_{cc}}$

$V_{CE} = 0 \Rightarrow i_C = \frac{V_{cc}}{r_{dc}} = \frac{V_{cc}}{0} = \infty$

for Ideal Amp.



Subject .... / /

- $\overline{R_i} = a^2 R_L = (2.5)^2 (8) = 50\,\Omega.$

- if $R_{th} = 2K\Omega$ find R_1 & R_2 :

$$V_{th} = \frac{V_{cc} R_2 R_1}{R_1 + R_2 R_1} \Rightarrow \boxed{V_{th} = \frac{V_{cc} R_{th}}{R_1}}$$

- $R_{th} = \dfrac{R_1 R_2}{R_1 + R_2}$, $V_{th} - I_B R_{th} - V_{BE} = 0$

$V_{th} = (0.7) + (0.01)(2) = 0.72$

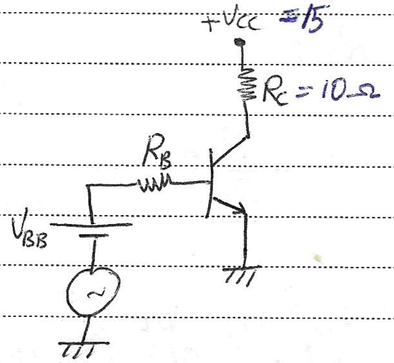
$$R_1 = \frac{V_{cc} \cdot R_{th}}{V_{th}} =$$

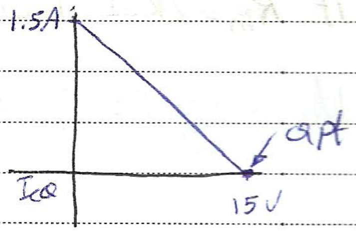
$$R_2 = \frac{R_1 R_{th}}{R_1 - R_{th}} =$$

*

Subject .... / /

"Class (B) power Amp's"





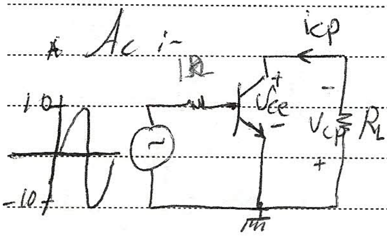
• لازم تكون ال Q-pt في كلاس (B) تقع في ال cutoff

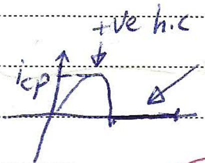
• $I_B = \dfrac{V_{BB} - V_{BE}}{R_B}$

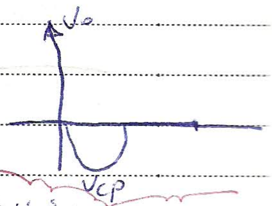
• When $V_{BB} = V_{BE} \Rightarrow I_B = 0 \Rightarrow I_C = 0 , V_{CE} = V_{CC}$

$\Rightarrow$ The Q-pt in cutoff ...

* Ac :-



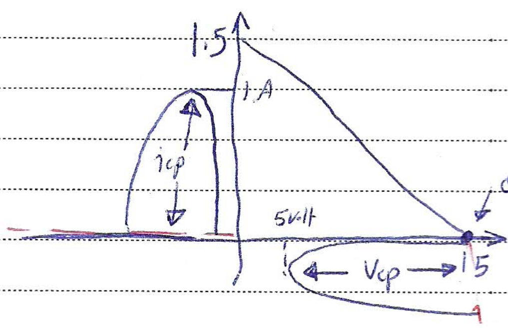


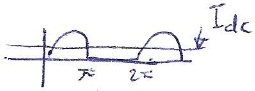


• يعني بشتغل كأنه half wave rectifier

• $V_{cp} = 10$ Volt.

• $i_{cp} = \dfrac{V_{cp}}{R_L} = 1A$





Subject .... / /

- $\overline{P_S} = V_{cc} \cdot I_{dc}$

~~halfwave~~ ال halfwave ع الريا

$I_{dc} = \frac{i_{cp}}{\pi}$ = Dc. Value ≡ avg. Value

- $\overline{P_L} = i_c(rms) \cdot V_{cp}(rms)$

$= \frac{i_{cp}}{2} \cdot \frac{V_{cp}}{2} = \frac{i_{cp} \cdot V_{cp}}{4}$

$I_{c\,rms} = \frac{i_{cp}}{\sqrt{2}}$ full wave

But

$i_c(rms) = \frac{i_{cp}}{2}$ half wave

$\Rightarrow \eta\% = \frac{\overline{P_L}}{\overline{P_s}} \times 100\%$

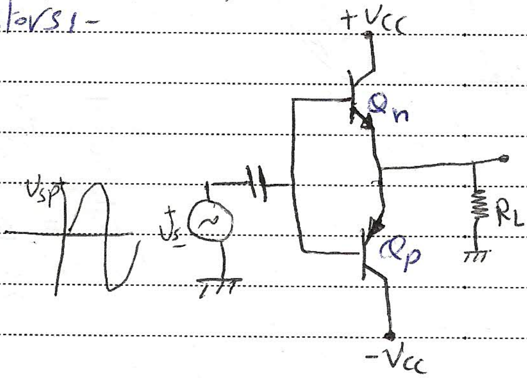
- partically, class B single stage is not Used, So ~~Bo~~ two transistors are Used in push-pull arrangement to process the whole input signal.

These tran's can be:

1) Complementary (NPN with PNP) (P channle with N chan.)
2) The same type but it is required to use aphase spliting cct.

* Complementary class-B push-pull power Amp. :-

- assuming Ideal transistors:-

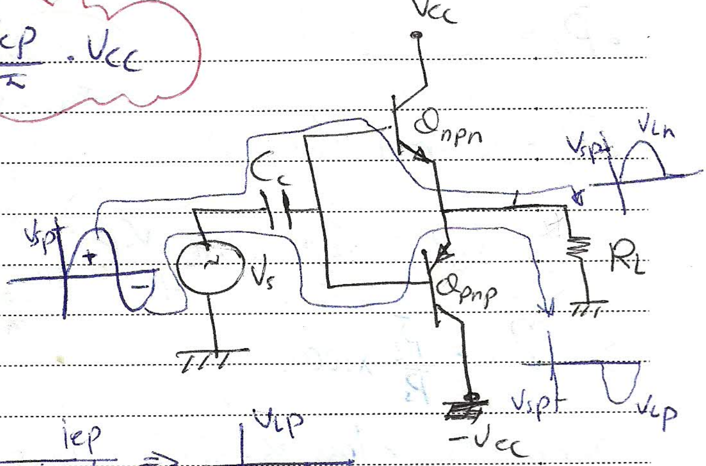


- in +ve h.c.
- $V_{Ln} = V_{sp}$ $(V_{BE} = 0)$
- $i_{en} = \frac{V_{Ln}}{R_L} = \frac{V_{sp}}{R_L}$

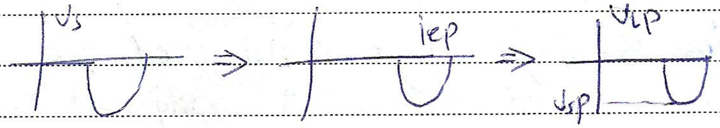
njpb

Subject .... / /

- $\bar{P}_{s\oplus} = I_{dc} \cdot V_{cc} = \frac{i_{cp}}{\pi} \cdot V_{cc}$

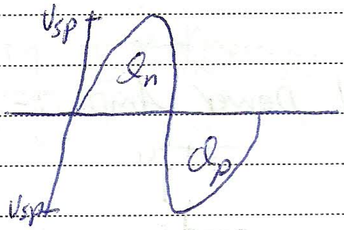


- in -ve h.c. :-



$$\bar{P}_{s\ominus} = \frac{-i_{ep}}{\pi} \cdot -V_{cc} = \frac{i_{eP}}{\pi} \cdot V_{cc}$$

* For a whole input cycle :-



- $\bar{P}_L = \frac{V_{L(rms)}^2}{R_L} = \left(\frac{V_{LP}}{\sqrt{2}}\right)^2 / R_L$

$$\bar{P}_L = \frac{V_{LP}^2}{2 R_L}$$

- $\bar{P}_s = \bar{P}_{s\oplus} + \bar{P}_{s\ominus}$

$$\bar{P}_s = \frac{2\, i_{ep}}{\pi} \cdot V_{cc}$$

Subject / /

① for $V_s = 0$, Q_n & Q_p are off, $I_B = I_C = 0$ (cut off)

② During +ve h.c of V_s, $Q_n \rightarrow$ on, $Q_p \rightarrow$ off, a +ve h.c of a current will flow in Q_n & R_L causing a +ve h.c load voltage ...

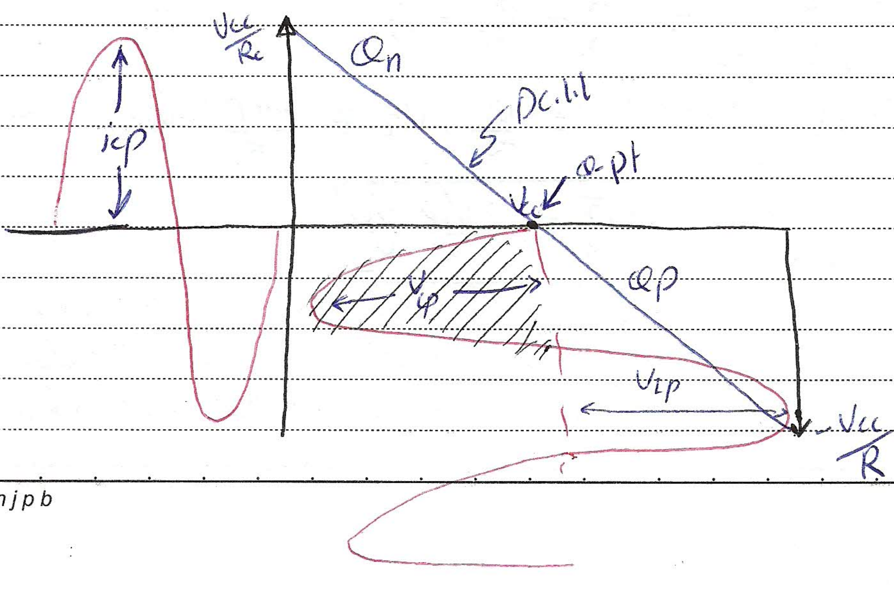
③ During -ve h.c of V_s, $Q_n \rightarrow$ off, $Q_p \rightarrow$ on, a -ve h.c of current & voltage will be processed by Q_p.

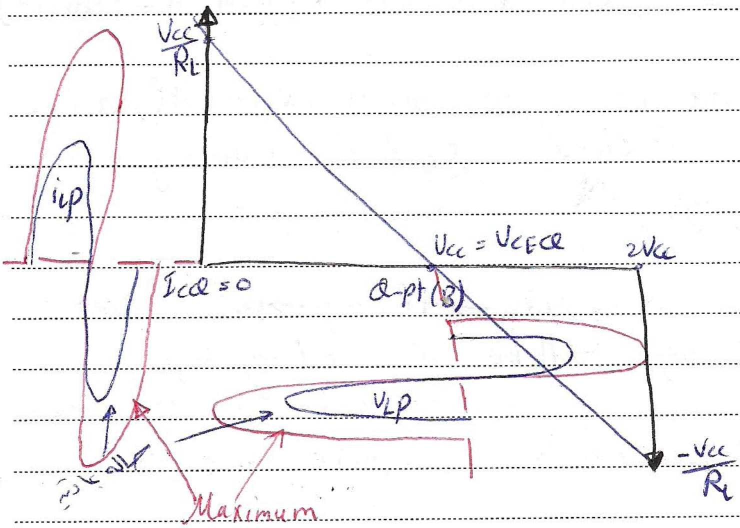
④ The load Voltage will be a complete cycle.

⑤ for +ve H.c the Dc. power from +Vcc is $\bar{P}_{s\oplus} = \frac{i_{cP}}{\pi} \cdot V_{cc}$

⑥ " -ve " " " " " -Vcc " $\bar{P}_{s\ominus} = \frac{i_{cP}}{\pi} V_{cc}$

⑦ The total $\bar{P}_s = \bar{P}_{s\oplus} + \bar{P}_{s\ominus} \Rightarrow \eta\% = \frac{P_L}{\bar{P}_s} \times 100\%$





$$\eta\% = \frac{\overline{P}_L}{\overline{P}_s} \times 100\% \;\longrightarrow\; \frac{V_L^2}{R_L},\; I_L^2 R_L,\; V_L . I_L$$

$$\overline{P}_L = \frac{V_{L(rms)}^2}{R_L} = \frac{V_{Lp}^2}{2R_L}$$

$$\overline{P}_s = \overline{P}_{s\oplus} + \overline{P}_{s\ominus}$$

$$= \frac{i_{Lp}}{\pi} . V_{CC} + \frac{-i_{Lp}}{\pi} . -V_{CC}$$

$$\boxed{\overline{P}_s = \frac{2 V_{Lp} V_{CC}}{\pi R_L}}$$

* for max η_{max}, V_L must be equal V_{CC}.

لازم يكون η_{max} او $\bar{P}_L$ اعلى اشي
يعني V_{Lp} اعلى اشي يعني $\boxed{V_{CC} = V_{Lp}}$

- $\bar{P}_{L\,max} = \dfrac{V_{CC}^2}{2R_L}$

- $\bar{P}_s = \dfrac{2V_{CC}^2}{\pi R_L}$

كل ما زاد الـ power بزيد $\boxed{V_{CC}}$ ؟؟؟

- $\eta_{max}\% = \dfrac{\bar{P}_{L\,max}}{\bar{P}_{s\,max}} = \dfrac{\cancel{V_{CC}^2}}{2\cancel{R_L}} \times \dfrac{\pi \cancel{R_L}}{2\cancel{V_{CC}^2}} = \dfrac{\pi}{4} \times 100 = \boxed{78.5\%}$

- $P_{D\,(\text{each tran})} = \dfrac{\bar{P}_s - \bar{P}_L}{2}$

* Notes:-

1) The cct. is (C.C) (E.F) $\Rightarrow \underline{A_V = 1 = \dfrac{V_L}{V_i}}$

$\Rightarrow V_L = V_i$ (for $V_{BE} = 0$)

- $V_i = 10 \Leftarrow V_L = V_i$ ويعطيك R_L وتحسب P_L
- يعطيك R_L & P_L $\Leftarrow V_L \Leftarrow V_L = V_i$

2) For max $\bar{P}_L$, $V_{Lp} = V_{CC}$ wich measure $\underline{V_{i\,peak} = V_{CC}}$

Ex. for the cct shown, $V_{CC} = \pm 6V$, $R_L = 4\Omega$, $V_s = 5\sin\omega t\, V$,

1) Calculate $\bar{P}_L$, $\bar{P}_s$, $\eta\%$, $P_{D(\text{each Tran})}$?
2) sketch, Ac & Dc.l.l with V_L, i_L swings?
3) what must be the peak i/p Voltage for max $\eta\%$?

Subject .... / /

Sol. • $\overline{P_L} = \dfrac{V_{Lp}^2}{2R_L}$, since $A_V = 1 \Rightarrow V_{Lp} = V_{sp} = 5$ Volt

$= \dfrac{5^2}{2(4)} = \dfrac{25}{8} = 3.125$ W

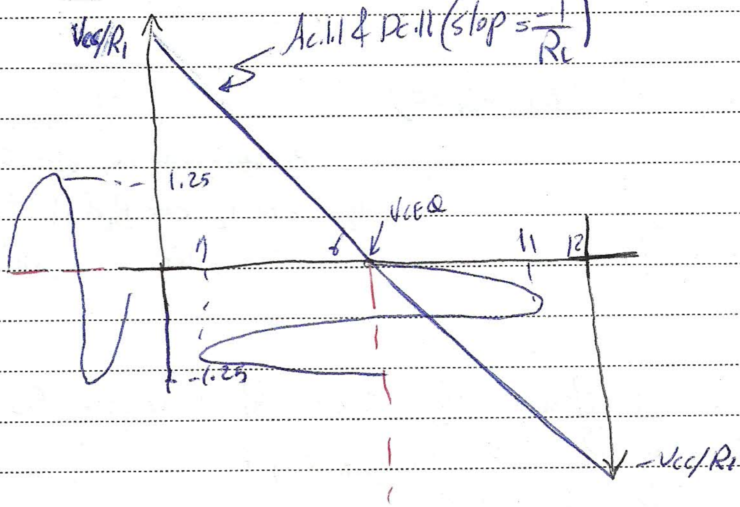
• $\overline{P_S} = \dfrac{2 V_{Lp} V_{CC}}{\pi R_L} = \dfrac{(2)(5)(6)}{4\pi} = \dfrac{15}{\pi} = 4.7$ W

• $\eta\% = \dfrac{3.125}{4.7} \times 100\% = 66\%$

• $P_{D\,each} = \dfrac{\overline{P_S} - \overline{P_L}}{2} = \dfrac{4.7 - 3.125}{2} = \cancel{0.78\text{ W}}$ 0.82 W

• هعوم الـ A.C.L.L نفس الـ D.C.L.L
لأنه نفس الـ R_L بيمر فيها نفس
التيار بالجهتين.

• $I_{C\,max} = V_{CC}/R_L$
• $V_{CE\,max} = V_{CC}$



• هعوم (η) أعلى من الـ A class لأنه $\overline{P_S}$ في (B) أقل فـ (η) أعلى..

• لأنه في (A) سواء أعطينا (Ac) أو ما أعطينا رح نسحب ($V_{CC} \cdot I_{CQ}$) لأنه الـ Q-pt بالمنتصف njRb
أما في (B) لو في Ac بتسحب ولو ما في ما بتسحب من المصدر الـ (Dc) وبناخد الـ avg للـ $i_{cp} = V_{CC} \cdot \frac{i_{cp}}{\pi}$

* Note $\overline{P}_s(\text{class } B) < \overline{P}_s(\text{class } A)$ [for the same P_L]

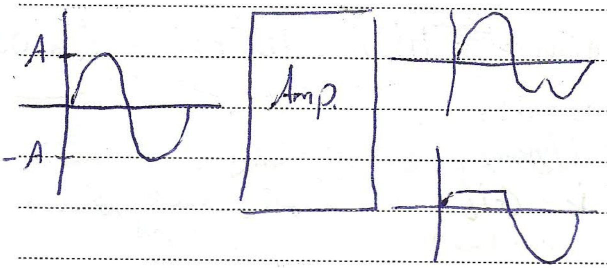
"Distortion in power Amp's"

تشويه

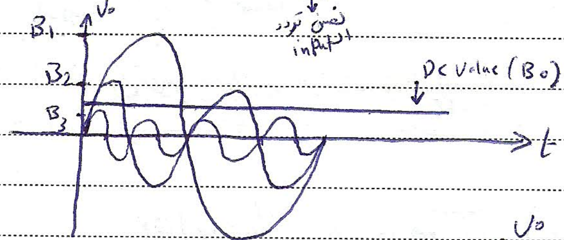
- Deformation in the shape of O/P Signal.

1) Non linear distortion:-

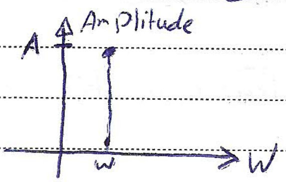
- Due to the non linear device C/C when it's driven by a large signal.

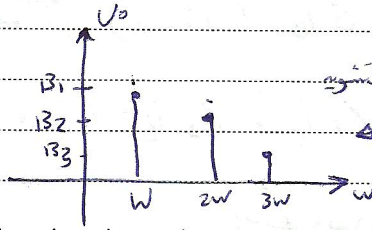


$$V_o(t) = B_0 + B_1 \sin \underbrace{\omega t}_{\text{نفس تردد الـ input}} + B_2 \sin 2\omega t + B_3 \sin 3\omega t - - -$$



- احنا بس بيهمنا الـ fundamental لانها نفس تردد الـ input





لو كان في تشويه طلعت هيك ←

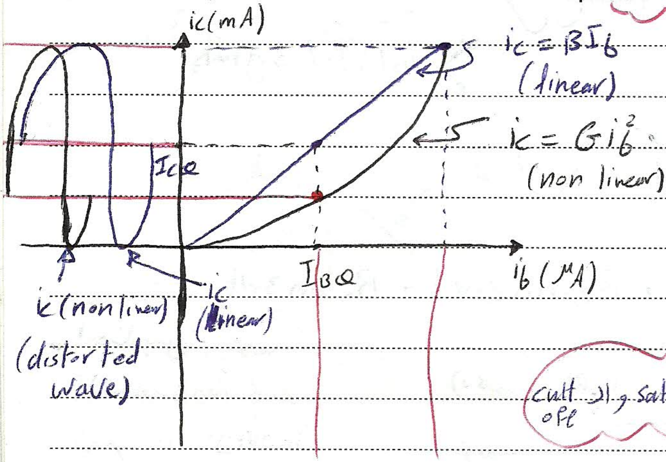
(spectrum of (V_i))   Ampl. عبارة عن مع Frequency ← (spectrum of V_o)

Subject: اشارات ترددها مضاعفات تردد ال input

* Harmonics :- Unwanted signals having frequancy multiple of the freq. of input signal (fundemental)

- $2w \rightarrow 2^{nd}$ harmonic — $D_2\% = \frac{B_2}{B_1} \times 100\%$ (2^{nd} harm. distortion)
- $3w \rightarrow 3^{rd}$ " — $D_3 = \frac{B_3}{B_1} \times 100\%$ (3^{rd} har. distortion)
- ⋮
- $nw \rightarrow n^{th}$ " — $D_n = \frac{B_n}{B_1} \times 100\%$ (n^{th} " ")

* Total harmonic distortion: $THD\% = \sqrt{D_2^2 + D_3^2 + \cdots D_n^2} \times 100\%$



- لما يكون ال ic small signal رح تكون ال BJT في ال linear اما لما تعطي large signal رح يصير non linear
- لانه ال Q-pt رح يصير تتحرك بين ال sat وال cut off

- $i_c = G i_b$ (linear) There is no distortion
- $i_c = G_1 i_b + G_2 i_b^2$ (NoN linear) There is an dist.

ابسط انواع ال NoN linear

Subject .... / /

Now let $i_b = I_{bm} \cos \omega t$

1) for linear operations $\Rightarrow i_c = (i_b \cos \omega t)\, G_1 = B_1 \cos \omega t$

2) for non linear,

$i_c = G_1 I_{bm} \cos \omega t + G_2 I_{bm}^2 \cos^2 \omega t$

$= B_1 \cos \omega t + \cancel{B}\, G_2 I_{bm}^2 \frac{1}{2}(1 + \cos 2\omega t)$

$= B_1 \cos \omega t + \underbrace{\frac{G_2 I_{bm}^2}{2}}_{\substack{B_0 \\ ([illegible])}} + \underbrace{\frac{G_2 I_b^2}{2}}_{B_2 = B_0} \cos 2\omega t$

$\Rightarrow i_c = B_0 + B_1 \cos \omega t + B_2 \cos 2\omega t$

$B_0 \downarrow$ Dc, $B_1 \cos \omega t \downarrow$ 1^{st} harmonic, $B_2 \cos 2\omega t \downarrow$ 2^{nd} harmonic

Ex. for a certain P.A, the o/p current is given by

$i_c = 2 + 5 \sin \omega t + 4 \sin 2\omega t + 3 \sin 3\omega t$ (A), $R_L = 10\,\Omega$,

1) Find D_2 %, D_3 %, THD % ?

2) Find $\overline{P_L}$?

$B_0 = 2$, $B_1 = 5$, $B_2 = 4$, $B_4 = 3$

$D_2 = \frac{B_2}{B_1} \times 100\,\% = \frac{4}{5} \times 100 = 80\,\%$

Subject .... / /

$$D_3 = \frac{B_3}{B_1} \times 100 = \frac{3}{5} \times 100 = 60\%$$

$$THD\% = \sqrt{D_2^2 + D_3^2} \times 100\% = 100\%$$

2) $$P_n = I^2 R = \left(\frac{I_m}{\sqrt{2}}\right)^2 \cdot R = \frac{B_n^2}{2} \times R_L$$

$$\Rightarrow \bar{P}_L = P_1 + P_2 + P_3$$

power of fundamental

" " 2^{nd}

" " 3^{rd}

$$\bar{P}_L = \frac{B_1^2}{2} R_L + \frac{B_2^2}{2} R_L + \frac{B_3^2}{2} R_L$$

$$= \left(\frac{25}{2} + \frac{16}{2} + \frac{9}{2}\right)(10) = \boxed{250\,W}$$

OR $$P = \frac{B_1^2}{2} R_L + \frac{B_2^2}{2} R_L + \frac{B_3^2}{2} R_L$$

$$= \frac{B_1^2}{2} R_L \left(1 + \frac{B_2^2}{B_1^2} + \frac{B_3^2}{B_1^2}\right)$$

لو كان معنا THD ش

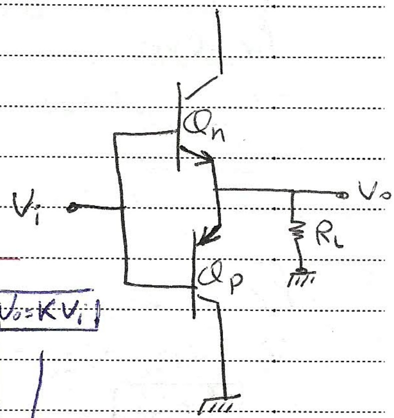
$$= P_1 (1 + THD^2) = \frac{25}{2} \times 10 (1 + 1)$$

$$= \boxed{250\,W}$$

[illegible] B_0 [illegible] P_L [illegible]

2) Cross over distortion :-

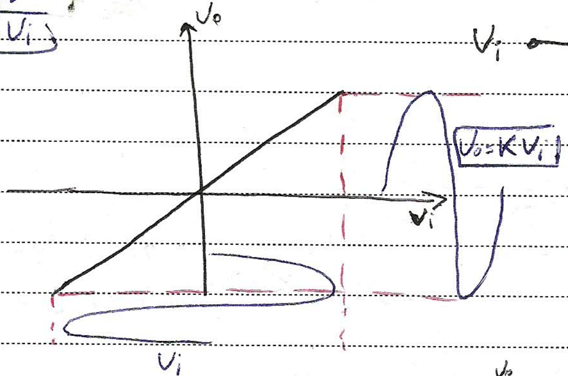
occure only on class B, but non linear occure in any power Amp.



Ⓐ for $V_{BE} = 0$

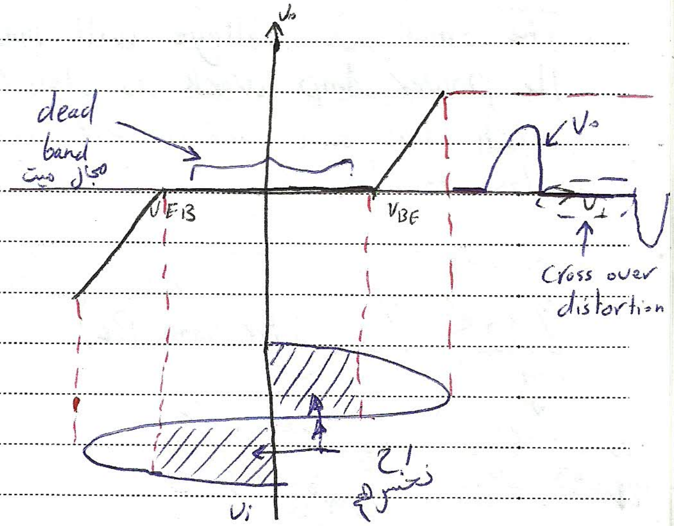
$V_i - V_{BE} - V_o = 0$

$\Rightarrow \boxed{V_o = V_i}$



Ⓑ For $V_{BE} \neq 0$

- A distortion hapen in class B only because the Q-pt is at the origin.



- It's due to the finit value of V_{be} wich is inherent in BJT.
متأصلة

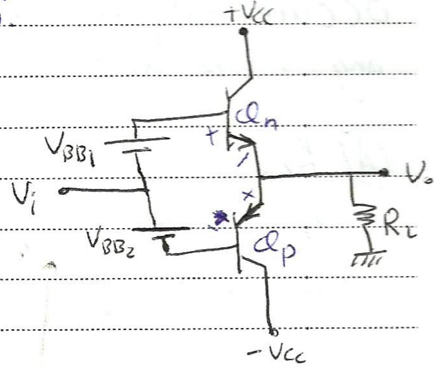
- بسبب وجود V_{BE} ولا يمكن التخلص منها أبداً
- مثلاً في class A الـ Q-pt بتكون فوقه فموجود V_{BE} القليل لا يؤثر أما في classB

njpb

فال Q-pt عند الـ صفر فأي تغير بسيط راح يأثر...

Subject .... / /

- It can be elemenated by applying a small Dc Voltage equal & opposit to V_{be} as shown.



- for Q_n:

$-V_i - V_{BB} + V_{be} + V_o = 0$

$\Rightarrow \boxed{V_o = V_i}$

$\therefore$ no C.R.D

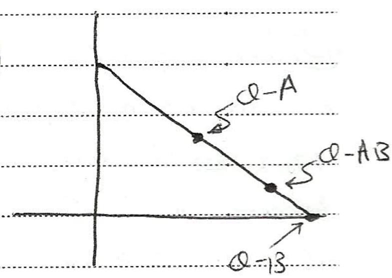
- For Q_p:

$V_i - V_{BB_2} + V_{EB} - V_o = 0$

$\Rightarrow \boxed{V_i = V_o}$

- هلا لما نغط V_{BB} راح يصير عنا شوية I_B
وراح يطلع I_C وراح ترتفع الـ Q-pt شوية لفوق

- The small Dc Voltage will make the power Amp work as class (AB) wich has a convertion eff. very close to class B.



$\eta_{AB} < \eta_B$ (for same R_L)

راح تسحب $\bar{P}_s$
يعني $\eta \downarrow \Leftarrow \uparrow \bar{P}_s$

لانها ما بتسحب $\bar{P}_s$ الا لما تعطيها signal

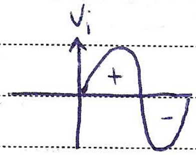
- يعني classAB عبارة عن classB بس ما فيها distortion

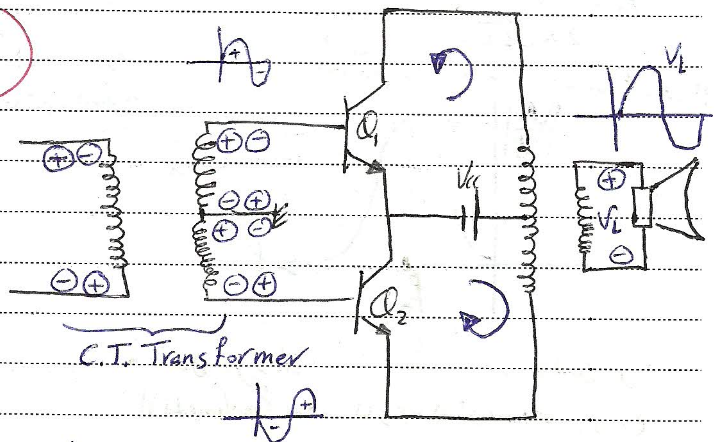
njpb

"Class B Using Same type of Tran."

By Using "Transformer coupled class B push pull P.A"

$\eta_{max} = 78.5\%$



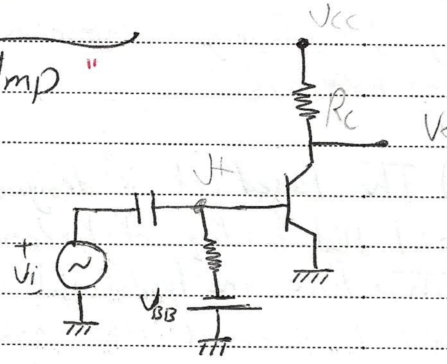


• Q_1 will prosess +ve H.C of V_i.

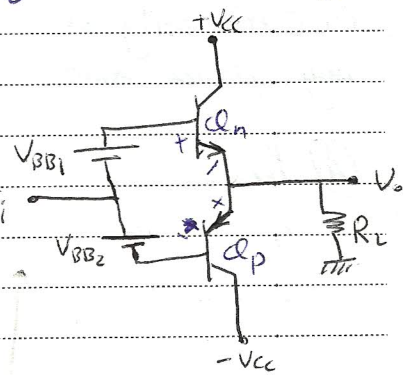
• Q_2 will prosess -ve H.C of V_i.

"Class-C power Amp"

• The BJT will be on for a small Condition angle $\phi_c < 180^\circ$ and only when $V_i > V_{BE} + V_{BB}$



• It can be elemenated by applying a small Dc. Voltage equal & opposit to V_{be} as shown.



• for Qn:

$-V_i - V_{BB} + V_{be} + V_o = 0$

$\Rightarrow \boxed{V_o = V_i}$

∴ no C.R.D

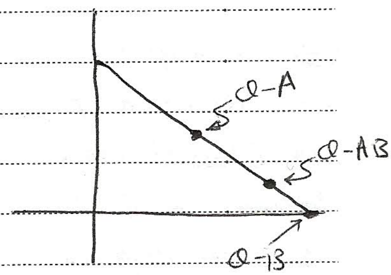
• for Qp:-

$V_i - V_{BB_2} + V_{EB} - V_o = 0$

$\Rightarrow \boxed{V_i = V_o}$

• هلا لما نغط V_{BB} راح يصير مثا شوية I_B وراح يطلع I_C وراح ترتفع الـ Q-pt شوية لفوق

• The small Dc. Voltage will make the power Amp. work as class (AB) wich has a convertion eff. very close to class B.



$\eta_{AB} < \eta_B$ (for same RL)

• يعني classAB عبارة عن classB بس ما فيها distortion

راح تسحب $\bar{P}_s$
يعني $\eta \downarrow \Leftarrow \uparrow \bar{P}_s$

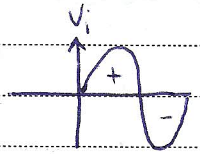
لانها ما بتسحب $\bar{P}_s$ الا لما تعطيها signal

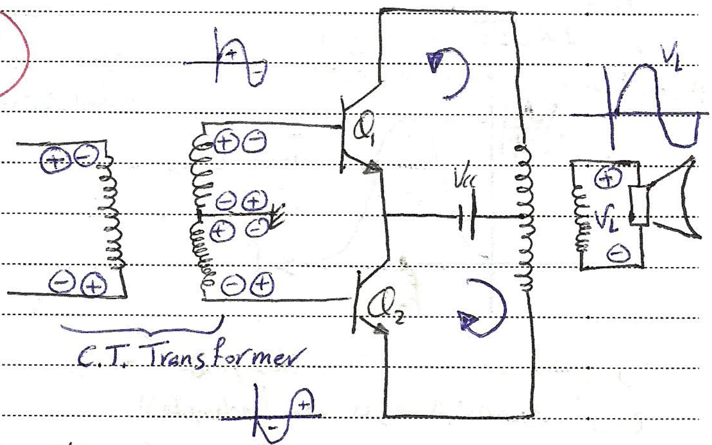
Subject .... / /

"Class B Using Same type of Tran."

By Using "Transformer coupled class B push pull P.A"

$\eta_{max} = 78.5\%$



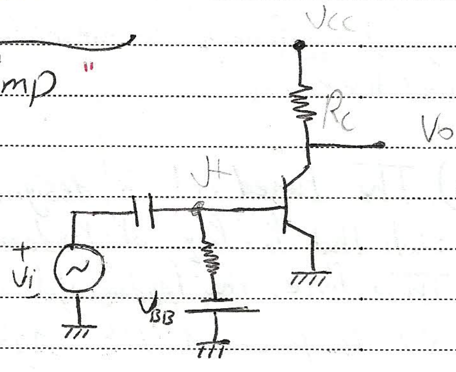


- Q_1 will prosess +ve H.C of V_i.

- Q_2 will process -ve H.C of V_i.

"Class-C power Amp"

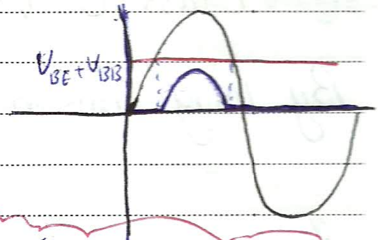
- The BJT will be on for a small Condition angle $\phi_c < 180°$ and only when $V_i > V_{BE} + V_{BB}$



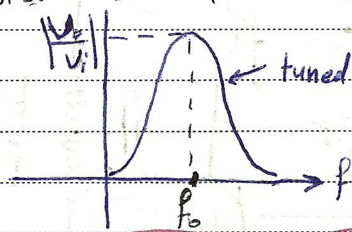
1) normally, class c is Used in Radio freq. Amp's. where the load is parallel tuned cct. with a resnonent freq.

$$f_o = \frac{1}{2\pi\sqrt{LC}}$$ ← بغل

أغير قيمهم عشان أخليها بتساوي الـ f تبعت الـ...

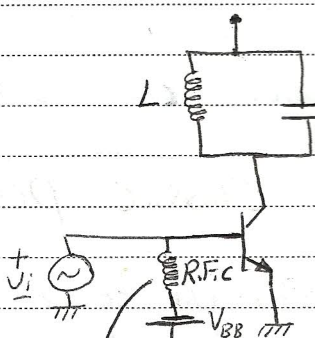


• هاي موجة مشوهة وعملياً بيستخدموها بالـ R.F وليس بالـ odio.f وكفاءتها والـ power كبيران.



• بنعمل design بحيث f_o يساوي ~~يساوي~~ تردد الـ fandamental تبعت الموجة المشوهة يعني بس (ح) نكبر الـ fund. harmonik ...

2) The o/p of class (C) is very distorted Signal (Less than half cycle) Containing fundamentals and harmonics.



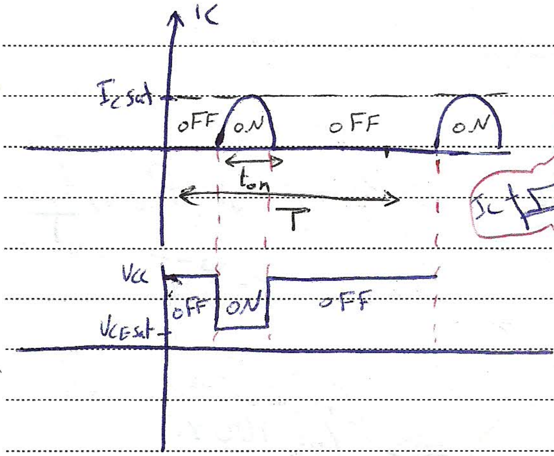
3) The tuned cct. is designed such that f_o = freq. of fundamental. There force, the fundamental component will be processed with a high power and high conversion eff (η)...

Radio freq. Chock
⇒ short for Dc.
⇒ open " Ac.

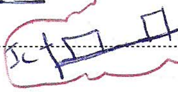
Subject .... / /

4) The BJT will ~~to~~ be on for avery short time (t_{on}).

5) The (i_c) waveform will be semiller to a small pulse of magnitude $\approx \boxed{i_{c\,sat}}$ and $\boxed{V_{CE} = V_{CE\,sat}}$



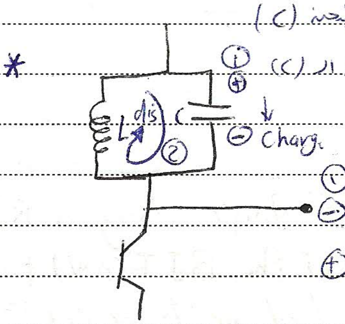
عشان الحسابات اح نحسب انه I_c pulse ←

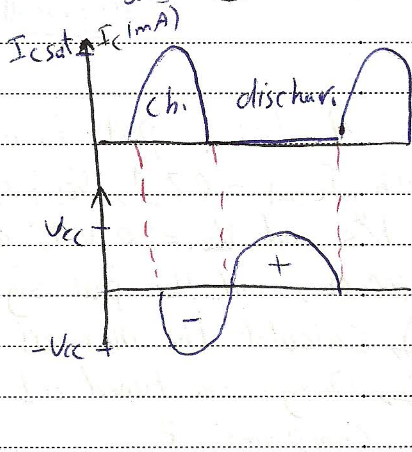


① لما يجي $I_{C\,sat}$ يعني BJT ON ⟸ اح يشحن (C)

② لما يصير الـBJT ← off ⟸ اح ~~...~~ يفرغ الـ (C)

*





6) The energy will be transerable bet. C&L resulting in a sinosoidal o/p Voltage of freq. = freq. of fundamental.

- $\overline{P}_{L\,max} = \left(\frac{V_{cc}}{\sqrt{2}}\right)^2 / R_L = \frac{V_{cc}^2}{2R_L}$

- $\overline{P}_s = \overline{P}_L + P_{D(ON)}(Avg)$

- $P_{D(ON)} = \underbrace{I_{C\,sat} \cdot V_{CE\,sat}}$ $\Rightarrow$ $P_{D(ON)}(Avg) = P_{D(ON)} \frac{t_{on}}{T}$

هاي بس للفترة اللي بيكون فيها ON

للموجة كاملة مو بس لل ON

$$\Rightarrow \eta\% = \frac{\overline{P}_L}{\overline{P}_L + P_{D(ON)}(Avg)} \Rightarrow \eta\% = 100\%$$

very small

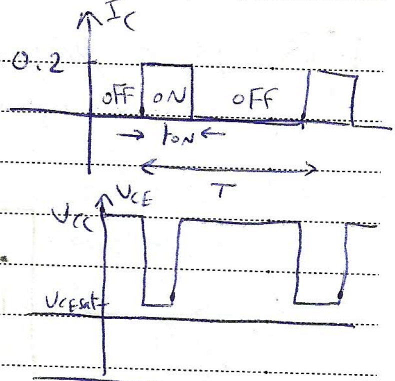
Ex. A class-C P.A. is used in R.F. Amp. Using a BJT with $I_{C\,sat} = 0.2\,A$, $V_{CE(sat)} = 0.3$ Volt, if the BJT (ON) time is $1\,\mu s$ and $V_{cc} = 20$ Volt, and the total Load are tuned cct is $100\,\Omega$, and the iput signal has a freq. of $100\,KHz$

1) Calculat the max eff.

2) Design the tuned cct. to process the fundamental Components?

Subject .... / /

$$\eta\% = \frac{\overline{P}_{L\,max}}{\overline{P}_{L\,max} + P_{D(ON)(Avg)}}$$



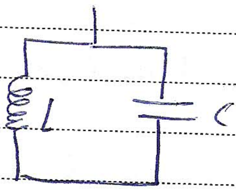
- $T = \frac{1}{f} = \frac{1}{100\times10^3} = \boxed{10\,\mu s}$

- $P_{D(ON)} = V_{CE\,sat} \cdot I_{C\,sat} = \boxed{0.06\ W}$

- $P_{D(avg)} = P_{D(ON)} \frac{t_{ON}}{T} = (0.06)\frac{(1)}{10} = \boxed{0.006\ W}$

- $P_L = \frac{V_{CP}^2}{2R_L} \Rightarrow P_{L\,max} = \frac{V_{CC}^2}{2R_L} = \frac{400}{(2)(100)} = \boxed{2\ watt}$

- $\eta\% = \frac{2}{2+0.006} \times 100 = 99\%$



- $f_o = \frac{1}{2\pi\sqrt{LC}}$, $LC = \frac{1}{4\pi^2 f_o^2}$

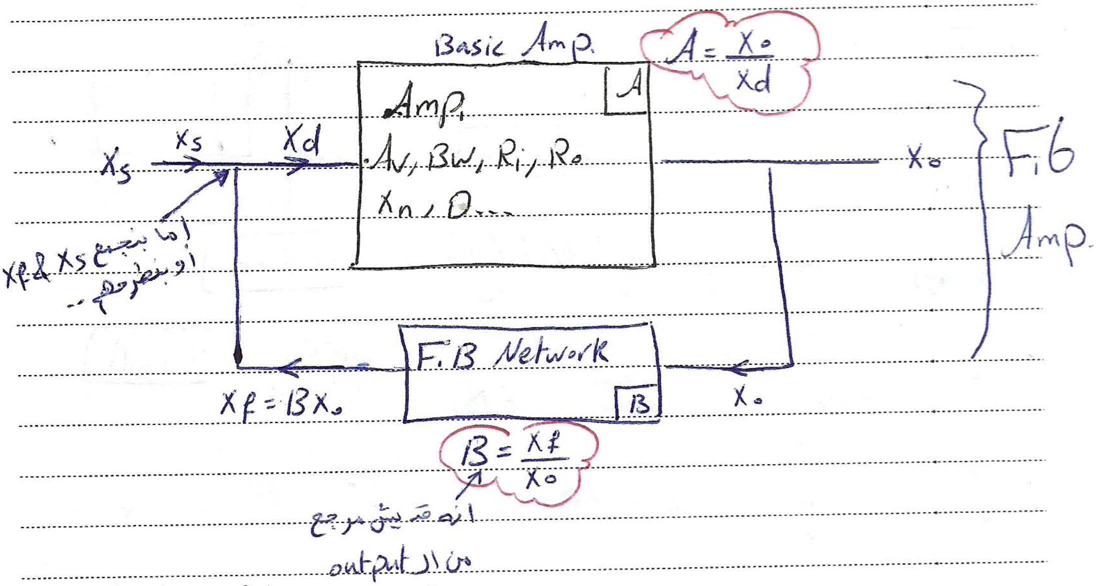
$$\Rightarrow LC = \frac{1}{(4)(10)(4\times10^{10})} = 2.5\times10^{-12}$$

let $\boxed{C = 1\,nF} \Rightarrow \boxed{L = 0.633\ mH}$

Ch 12 : "Feedbak and Stability"

Subject .... / /

FB : is a process of returning back aportion of o/p to the input, to modify Amp. parameters.



*For the f.b sys. shown :-

- $A \rightarrow$ Transfere gain (Voltage or current) of the basic Amp.
- $A = \frac{X_o}{X_d}$ ← output signal / ← difference signal (Error signal), $X_d = X_s \pm X_f$
- X_s : external source signal
- X_f : feed back signal, $X_f = B X_o$
- B ; F.B. Factor (ratio) for feed back Net. $1 > B > 0$

• اذا جمعناهم ⇐ +ve f.b
• " طرحناهم ⇐ -ve f.b

njpb

* Types of F.B :-

① +ve f.b : when x_f aids (added) to x_s, then $X_d = X_s + X_f$ and this is called +ve f.b.

. This type of F.B is used in oscillater (signal generator)

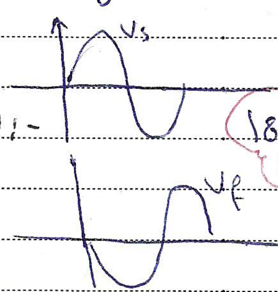
② -ve f.b : when x_f opposes x_s ~~resulting in~~

⇒ $X_d = X_s - X_f$, used to modify Amp. parameters....

* Negative Feedbak :-

This f.b happen when x_f opposes x_s resulting in

$X_d = X_s - X_f$



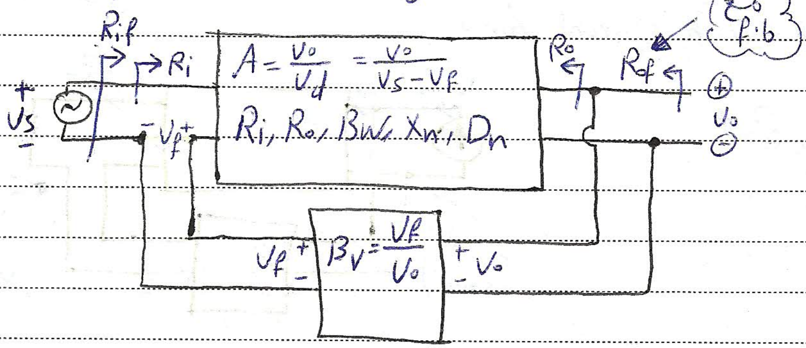
180° ph. shift

- Types of -ve F.b (Topolegy) (Connection) :-

. Since X_s & X_o can be voltages (V_s, V_o) or currents (I_s, I_o), there are 4 possibilities of connection.

i.e four types of -ve f.b.

1) → When $X_s = V_s$, $X_o = V_o$, this topology is called "series - parallel" oR "Voltage series"



Subject .... / /

- Without F.B: $V_d = V_s$

- With F.B:-

$-V_s + V_s + V_f = 0 \Rightarrow \boxed{V_d = V_s - V_f}$

- i.e V_f oppose V_s , $V_f = B_V \cdot V_o$

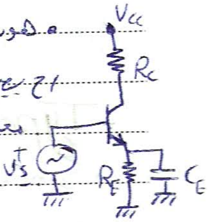
- $\frac{V_o}{V_s} = A_{vf}$ gain of F.B. Amp.

ex. of -ve f.b:-

- هون لما نشيل ال (C)

اح يصير R_E علي V_f وتكون

معاكسة لـ V_s



with(C) ~~without(C)~~ $A_V = -g_m R_C$

without (C) $\Rightarrow A_V = \frac{-R_C}{R_E} \downarrow$

- $R_i = r_\pi$
- $R_i = r_\pi + (\beta+1) R_C \uparrow$

2) $X_s = I_s$, $X_o = I_o$, It is called (parralel_series) (current_shunt)

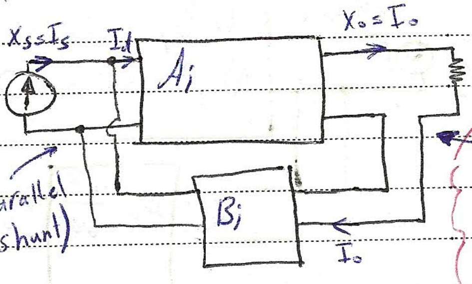
o/p I/P

نوع الـ signal اللي بدي أسحبها

طريقة ربط الـ input

- Used with current Amp.

- $R_i \downarrow$, $R_o \uparrow$



parallel (shunt)

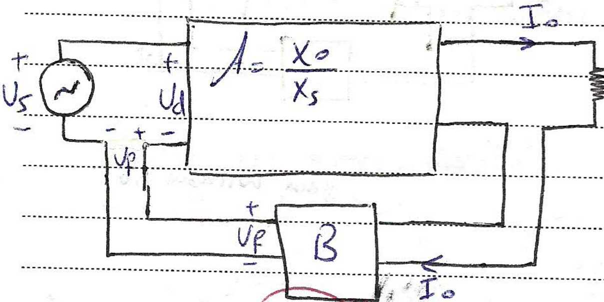
ربطناها series عشان بدنا نسحب current

Subject .... / /

3) → $X_s = V_s$, $X_o = I_o$, Called
(current_siries) (sireis_series)

siries
• Used with: Transconductance Amp., $R_i \uparrow$ & $R_o \uparrow$

• بشكل عام التوازي يقلل R
• التوالي يزيدها

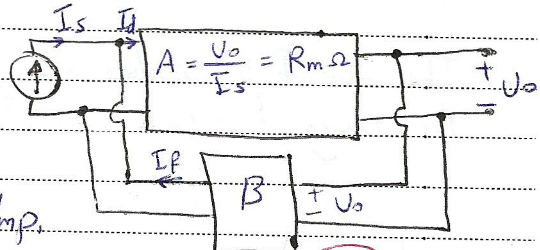


لازم يكون ال loop مغلقة عشان يمر تيار

• $B = \frac{V_f}{I_o}$ (Ω)

• $A = \frac{I_o}{V_s}$ ℧ = Gm

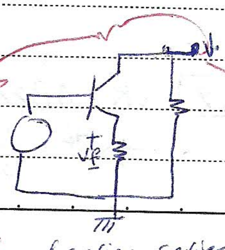
4) → $X_s = I_s$, $X_o = V_o$
(parallel_parallel) (Voltage_shunt)



• Used with transresistance Amp.

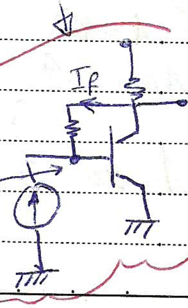
$B = \frac{I_f}{V_o}$ ℧

• $R_i \downarrow$, $R_o \downarrow$



(series series)

(par_par)

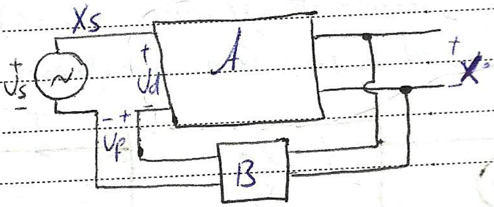


هون بنرجع تيار

Subject .... / /

"Effects of -ve feedback on Amp. parameters"

① Reduce Amp. gain:-



$X_o = A X_d$

$X_d = X_s - X_f$

$X_f = B X_o$

$\Rightarrow X_o = A(X_s - B X_o)$

$X_o = A X_s - A B X_o$

$X_o(1 + AB) = A X_s \Rightarrow \frac{X_o}{X_s} = \frac{A}{1+AB} = A_f$

gain without f.b

gain with f.b

f.b. factor

- $A_f \rightarrow$ gain with F.b (closed loop gain)
- $A \rightarrow$ " without " (open " ")
- $B \rightarrow$ F.b. factor

- The -ve F.b reduce the gain.
- for heavy feed back $AB >> 1 \Rightarrow A_f = \frac{1}{B}$

Ex. An Amp. has 9% -ve f.b ($B = 0.09$), calculat the gain after F.b when

① $A = 100$

$A_f = \frac{A}{1+AB} = \frac{100}{1 + 0.09 \times 100} = 10$

② $A = 1000$ $A_f = \frac{1000}{1 + 0.09 \times 1000} = \frac{1000}{91} = \boxed{10.9}$ oR $AB >> 1 << 90$

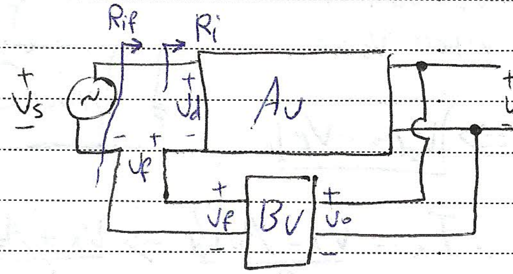
$\Rightarrow A_f = \frac{1}{B} = \frac{1}{0.09} = \boxed{10.9}$

Subject .... / /

(2) Controll the imput and output impeadance:-

- It Can dic↓ or inc↑ the Amp. impeadance depending on the topology (connection) where the siries connection inc↑ the imp. & The parallel (shunt) dic↓ the imp.

- Conseder the siries - parallel connection:-



- $V_s = V_f + V_d$
  $= V_d + B_v V_o$
  but $V_o = A V_d$

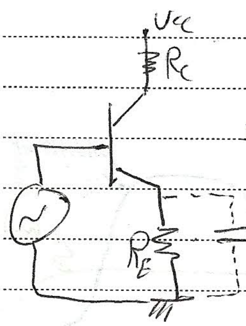
$\Rightarrow V_s = V_d + B_v A V_d$
$= V_d (1 + B_d V_d)$

Devided by $I_i \Rightarrow \dfrac{V_s}{I_i} = \dfrac{V_d}{I_i}(1 + B_v A_v)$

$\uparrow$ R_{if} $\uparrow$ R_i

$\Rightarrow R_{if} = R_i (1 + A_v B_v)$

*Note :-



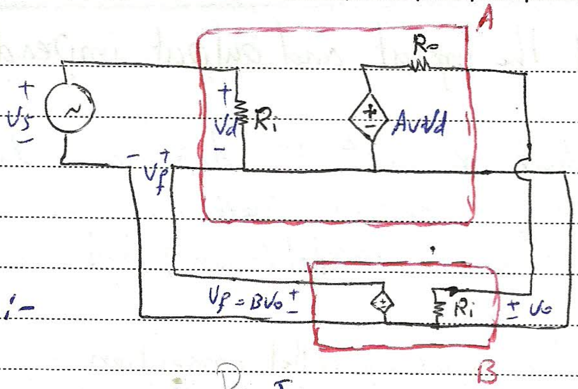
- $A_v = -g_m R_C$, $R_i = r_\pi$ } CE present (no f.b)

$\Rightarrow$ - $A_{vf} = \dfrac{R_C}{R_E}$

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

} without CE - -ve f.b siries Connection

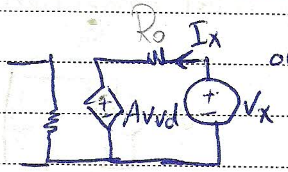
$A_v \downarrow$, $R_i \uparrow$



- to find R_{of} :-
- $V_s = V_d + V_f$

when $V_s = 0$

$\Rightarrow \boxed{V_d = -V_f}$



عشان نحسب R_o بنحط V_x بالoutput

وبيطلع I_x وبتكون $R_o = \left.\dfrac{V_x}{I_x}\right|_{V_s=0}$

- $I_x = \dfrac{V_x - A_v V_d}{R_o} \Rightarrow \dfrac{V_x + A_v V_f}{R_o} = \dfrac{V_x + V_o B A_v}{R_o}$

$$I_x = \frac{V_x (1 + B A_v)}{R_o}$$

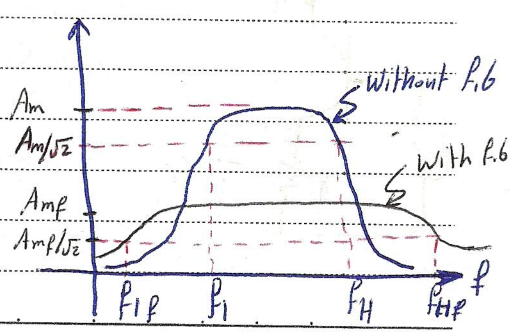
$\Rightarrow R_{of} = \dfrac{V_x}{I_x}$

$$R_{of} = \frac{R_o}{1 + B A_v}$$

$\therefore$ Shunt Connection Reduce impeadance...

③ Extend the Bandwedth of Amp. :-

- Since −ve f.b reducess the gain, So it inc↑ the B.W.



• $f_L, f_H, B.W$ (Without F.B)

• $f_{Lf}, f_{Hf}, B.W_f$ (With F.B)

• ال $-ve$ F.b بيقلل f_L وبيزيد f_H

$$f_{Lf} = \frac{f_L}{1+BA} , \quad f_{Hf} = f_H(1+BA)$$

• $B.W = f_H - f_L \approx f_H$ (for $f_H \gg f_L$)

$$\therefore (B.W)_f \approx (B.W)(1+BA)$$

4 Reduce NoN linear distortion :-

$$D_f = \frac{D}{1+BA}$$

D → distortion without F.b

D_f → distortion with F.b

• بشكل عام ال non linear distortion بيحصل بكل ال Amp^s ماعدا class B

• because $-ve$ F.b reduce Amp gain.

• بسبب ال NoNlinear هو العلاقة الغير خطية بين I_B & I_C بسبب ال larg input signals فرح تتحرك ال Q-pt بين ال Sat و ال Cutoff فبتدخل ال Tran. مرحلة ال non liner ولكن لما نحط ال $-ve$ F.b ال gain بيقل وبتصير ال Q-pt تتحرك حول ال Center لل D.c.l.l

~~5 Reduce Amp Internal noise and impro~~

Subject .... / /

(5) Reduce Amp. Internal Noise and Improve S/N ratio:

$$\boxed{X_{nf} = \frac{X_n}{1+BA}}$$

X_n ← internal noise without f.b

X_{nf} ← internal noise with f.b

• الـ Noise هي UnWanted signal

بس بتفرض علينا والها

مصدرين بشكل عام:

(1) داخلية (حرارة بالمقاومات

والـ BJT's..

(2) خارجية مثل أختلاف تراكيز الهواء والغبار...

• Thermal noise is generated in Active and passive devicess such as resisters.

(6) Increase Amp. gain stability:

$$\boxed{\frac{dA_f}{A_f} = \frac{dA/A}{1+BA}}$$

• $A \rightarrow$ Amp. gain without f.b

• $A_f \rightarrow$ " " with "

• $\frac{dA}{A} \rightarrow$ Fractional change in gain without f.b.

• $\frac{dA_f}{A_f} \rightarrow$ " " " with ".

• Due to ageing and temp. effect the Amp. gain deviate or change but if -ve F.b is used it can stabelized Amp. gain.

• يعني لو صممنا والـ Amp والـ gain = 100

لو جينا بعد سنة رح نلاقيه 90 لأنه ازدياد عمر الـ Component وكثرة الاستخدام تؤدي

إلى ازدياد الحرارة فرح يختلف أدائها $\frac{\Delta A}{A} = \frac{100-90}{100} = 0.1$ أما لو عملنا نفس الـ Amp مع -ve f.b

لو جينا بعد سنة رح نلاقي الـ gain = 98 $\frac{\Delta A_f}{A_f} = \frac{100-98}{100}$

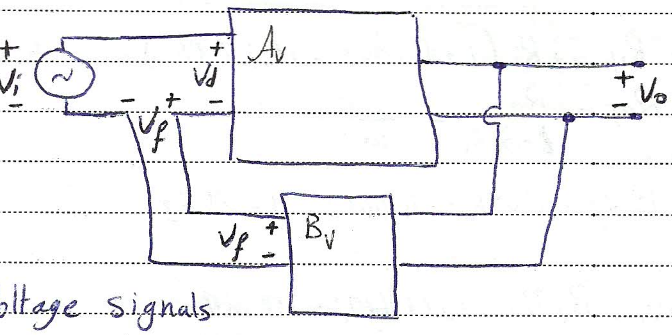
$= 0.02$ ← قل الـ gain stability

Ex. An Amp. has again of 100, if for a certain reason the gain reduce to 80., Now if -ve f.b of $B = 9\%$ is Used Calculate $\frac{dA_f}{A_f}$?

- $\frac{dA}{A} = \frac{100-80}{100} = 20\%$
- $\frac{dA_f}{A_f} = \frac{dA/A}{1+BA}$
- $1+BA = 1+(0.09)(100) = 10$

$\Rightarrow \frac{dA_f}{A_f} = \frac{20\%}{10} = 2\%$

(1) Series shunt F.B:-

- 

- Used with Voltag Amp.'s

- $X_s, X_o, X_f, X_d \rightarrow$ Voltage signals

- $A = A_v = \frac{V_o}{V_d}$
- $B = B_v = \frac{V_f}{V_o}$ (Voltage ratio)

- $A_{vf} = \frac{A_v}{1+B_v A_v}$
- $D_f = \frac{D}{1+B_v A_v}$
- $X_{nf} = \frac{X_n}{1+B_v A_v}$

Subject .... / /

- $(B.W)_f = (B.W)(1 + B_v A_v)$
- $R_{if} = R_i(1 + B_v A_v)$
- $R_{of} = \dfrac{R_o}{1 + B_v A_v}$

Ex.: An Amp. has $A_v = 10^5$, $A_{vf} = 100$, $R_i = 10K\Omega$, $R_o = 20\,\Omega$, $B.W = 100\ KHz$. When series shunt f.b is applied

1) Find Amp. parameters after feed back.
2) If $V_o = 10$ Volt, find V_d, V_s, V_f?

- ممكن يحكيلك انه نوعه Voltage Amp. فاعرف على طول انه series_shunt

Sol.:

1) $100 = \dfrac{10^5}{1 + B_v A_v} \Rightarrow 1 + B_v A_v = 1000$

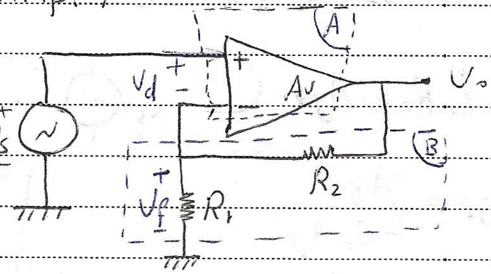
$\Rightarrow B_v A_v = 999 \Rightarrow B_v = \dfrac{999}{10^5} \approx 0.0099$

- $R_{if} = R_i(1 + B_v A_v) = 10K(1000) = 10\ M\Omega$
- $R_{of} = \dfrac{R_o}{1 + B_v A_v} = \dfrac{20K}{1000} = 20\,\Omega$
- $BW_f = (100KHz)(1000) = 100\ MHz$

2)
- $V_f = B_v V_o = (0.01)(10) = 100\ mV$
- $V_d = \dfrac{V_o}{A_v} = \dfrac{10}{10^5} = 100\ \mu V = 0.1\ mV$
- $V_s = V_d + V_f = 0.1\ mV + 100\ mV = 100.1\ mV$

Subject .... / /

* Series_shunt in op Amp. Amp. :-



- $V_f = \dfrac{V_o R_1}{R_1 + R_2}$

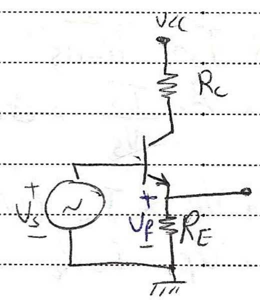
$\dfrac{V_f}{V_o} = \dfrac{R_1}{R_1 + R_2} = \beta$

Vs يعاكس Vf اي f.b -ve لان .

- open loop gain $= A_V \approx A_o \times 10^5$

- $A_{vf} = \dfrac{A_V}{1 + B_V A_V} \approx \dfrac{1}{B_V} \Rightarrow A_{vf} = \dfrac{R_1 + R_2}{R_1} = \left(1 + \dfrac{R_2}{R_1}\right)$

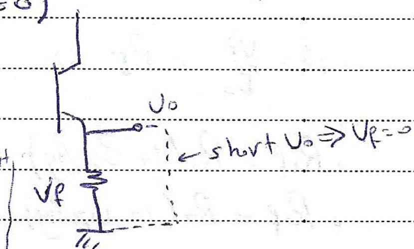
* series_shunt in transestors cct :-

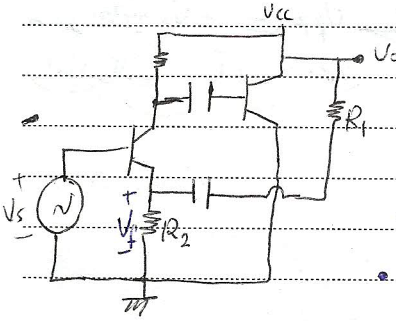


- $B = \dfrac{V_f}{V_o} = 1$

- here V_f in sieries with V_s & oppositt it in sign $\Rightarrow$ -ve f.b.
- V_f is depend on V_o (if $V_o = 0 \Rightarrow V_f = 0$)

∴ sieries_shunt.





- here V_f oppsit $V_o \Rightarrow$ -ve f.b

- $B = \dfrac{V_f}{V_o} = \dfrac{R_2}{R_1 + R_2}$

ex, if R_i is grows from $(1 \to 5)$ find R_1, R_2 ?

- $\underset{5}{R_{if}} = \underset{1}{R_i}(1 + B_V A_V) \Rightarrow B_V = \left[\left(\dfrac{R_{if}}{R_i}\right) - 1\right] / A_V$ ✓

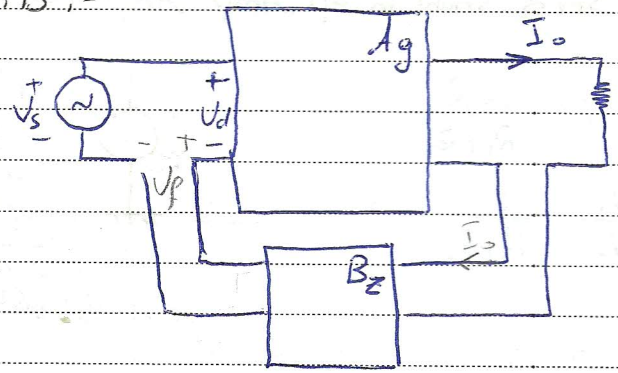
- $\beta = \dfrac{R_2}{R_1 + R_2}$ Assuming $R_1 = -$ $\Rightarrow$ $R_2 = -$

njpb • sieris – shunt
$R_i \uparrow$, $R_o \downarrow$, $A_v \downarrow$ ....

if $V_o = 0$
$\Rightarrow V_f = 0$

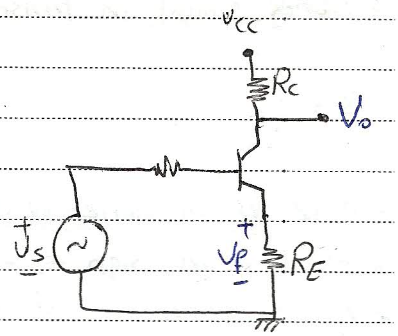
Subject .... / /

(2) Series_Series F.B :-



- $R_i \uparrow, R_o \downarrow, A_g \downarrow$
- $A_{gf} = \frac{A_g}{1 + B_Z A_g}$
- $A = \frac{I_o}{V_d} = A_g \; \mho$
- $\beta = \frac{V_f}{I_o} = B_Z \; \Omega$
- $A.\beta$ (Unitless)

* In Trans's cct's :-



- $A = \frac{I_o}{V_s} = G_m = A_{gf} \; \mho$
- $V_f \propto I_o$ (when $I_E = 0 \Rightarrow V_f = 0$)
- $V_f = I_o R_E$
- $\beta = \frac{V_f}{I_o} = R_E \; \Omega$
- $R_{if} = R_i (1 + B_Z A_g)$
- $R_{of} = R_o (1 + B_Z A_g)$

$\cancel{R_{of} = \frac{R_o}{1+}}$

- لو حطينا $V_o = 0 \Leftarrow V_f \neq 0$
- اما لو كانت $I_o = 0 \Leftarrow V_f = 0$

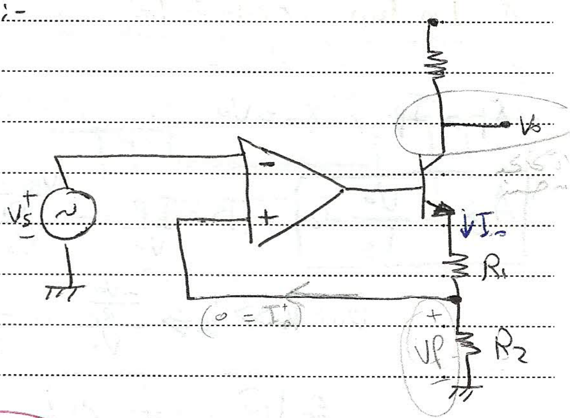
- $A_{gf} = \frac{A_g}{1 + B_Z A_g} \rightarrow \frac{I_o}{V_d}$

* In op-Amp. cct's :-

• $V_f \propto I_o$

• $\beta = \dfrac{V_f}{I_o} = \dfrac{R_2 I_o}{I_o} = R_2 \ \Omega$

• $A_{gf} = \dfrac{I_o}{V_s}$



• بشكل عام أول اشي بتشوف نوع V_f، اذا كنت مرجع الـ لوب توالي اذاً مرجع فولتية واذا كنت مرجع الى نود توازي اذاً مرجع تيار.

• بالنسبة ~~للـ~~ للـ output اذا ماخذ من لوب توالي اذاً ماخذ تيار، واذا كنت ماخذ من نود توازي اذاً ماخذ فولتية.

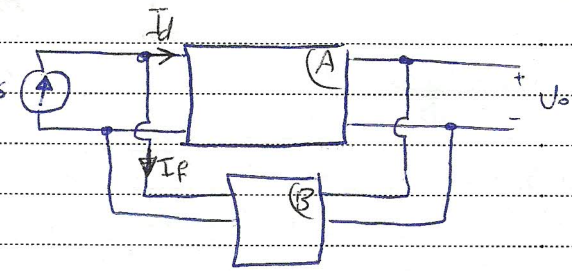
• V_f بتعتمد على I_o وليس V_o لانه لو شورتنا V_o رح تضل $V_f \neq 0$ أما لو صارت $I_o = 0 \Rightarrow V_f = 0$

③ Shunt-shunt F.b :-

• $A = \dfrac{V_o}{I_d} = A_Z \ \Omega$

• $B = \dfrac{I_f}{V_o} = B_g \ \mho$

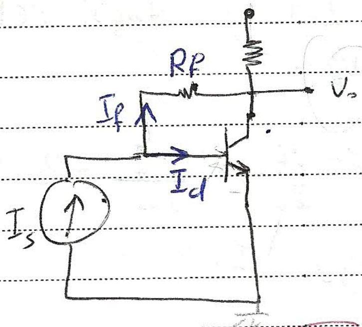
• B.A (Unitless)



• $A_{zf} = \dfrac{A_z}{1 + B_g A_z}$ • $R_{if} = \dfrac{R_i}{1 + B_g A_z}$ • $R_{of} = \dfrac{R_o}{1 + B_g A_z}$

Subject .... / /

* In Tan's cct's :-



- $x_f = I_f$, $x_o = V_o$

- $\boxed{A_Z = \frac{V_o}{I_s}\ \Omega}$ • $B = \frac{I_f}{V_o} = \frac{\frac{V_{BE} - V_o}{R_f}}{V_o}$

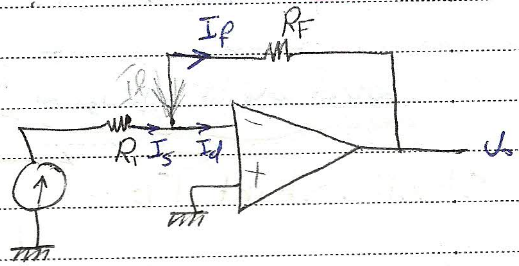
but $V_o >> V_{BE} \Rightarrow \frac{\frac{-V_o}{R_F}}{V_o} = \frac{-1}{R_f}$

$\therefore \boxed{B = \frac{-1}{R_F}\ \mho}$

• هون Is قل وصار Id
لأنه If لازم تكون معاكسة ال
لأنه -ve F.b ...

• مأخذ من نود ⇐ مأخذ فولتية
• مرجع إلى نود ⇐ مرجع تيار

* In op-Amp ~~A~~cct's :-



$I_d = 0$

$I_s = I_f$

$\Rightarrow A_{Zf} = \frac{1}{B}$

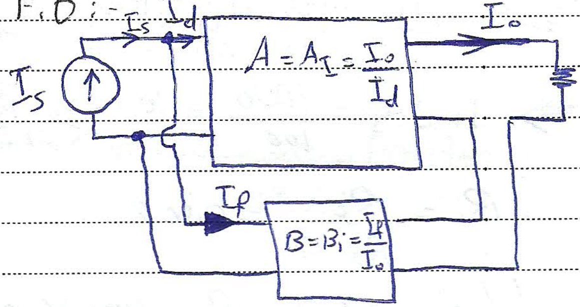
$A_{Zf} = \frac{V_o}{I_i} = \frac{V_o}{I_f}$

$= \frac{V_o}{B V_o} = \boxed{\frac{1}{B} = A_{Zf}}$

$A_{Zf} = \frac{V_o}{I_i} = \frac{-I_f \cdot R_F}{I_i} = -R_F$

$B = \frac{-1}{R_F}$

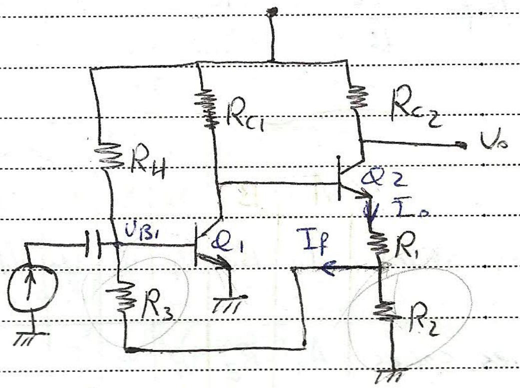
(4) Shunt - Series F.b :-



- Used with Current Amp.
- $A_{If} = \dfrac{I_o}{I_s}$
- $R_i \downarrow$, $R_o \uparrow$, $A_{If} \downarrow$
- $A_I = \dfrac{I_o}{I_d}$
- $A_{If} = \dfrac{A_I}{1 + B_i A_i}$

~~$I_f = I_o$~~

* In Trans. cct's :-



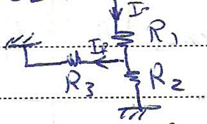
$$I_f = \frac{I_o R_2}{R_2 + R_3}$$

here we assume that $R_3 \parallel R_2$ because ;

$V_{C1} \gg V_{B1}$, $V_{e2} \approx V_{C1}$

$\Rightarrow V_{e2} \gg V_{b1} \Rightarrow V_{b1} \simeq 0$ compared with V_{e2}

$$\therefore \frac{I_f}{I_o} = B = \frac{R_2}{R_2 + R_3}$$



$$I_f \simeq \frac{I_o R_2}{R_2 + R_1}$$

R_1 [illegible] B .

Ex. The cct shown has $R_i = 10K\Omega$, $R_o = 1K\Omega$, $A_I = 1000$, it's required to make the gain $= 100$, find R_2, R_3 are requires to that, also find R_{if}, R_{of} ?

Subject .... / /

Sol. $A_I = 1000$, $A_{If} = 100$, $A_{If} = \dfrac{A_I}{1+B_iA_i}$

$\Rightarrow 1 + BA_I = \dfrac{1000}{100} = 10 \Rightarrow \boxed{B = 0.009}$

. $B_i = \dfrac{R_2}{R_2 + R_3} = 0.009$

let $R_2 = 9K\Omega$, $R_3 = 991\ K\Omega$

. $R_{if} = \dfrac{10}{10} = 1K\Omega$, $R_{of} = 1 \times 10 \cancel{\times 10} = 10K\Omega$

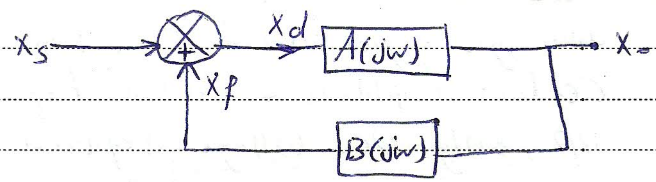
* *

F.B.T	A	B	Xf	Xs	Xo	Xd	Rif	Rof	Amp.
series_shunt	A_V	B_V	V_f	V_s	V_o	V_d	$R_i(1+BA)$	$\dfrac{R_o}{1+B_VA_V}$	Voltag Amp.
series_series	A_g	B_Z	V_f	V_s	I_o	V_d	$R_{xf}(1+B_ZA_g)$		Transcondactance Amp.
shunt_sieries	A_i	B_i	I_f	I_s	I_o	I_d	$\dfrac{R_i}{1+B_iA_i}$	$R_o(1+B_iA_i)$	current Amp.
shunt_shunt	A_Z	B_g	I_f	I_s	V_o	I_d	$\dfrac{R_{xf}}{1+B_gA_Z}$		Trans.resistanse Amp.

"Osillators (signal generator)"

1) Sinosoidal osillator :-

- عبارة عن F.b Amp. بتستخدم +ve f.b
- $A(jw)$
- $B(jw)$
- A & B is fn. of freq.
- بتعطيا الـ Ac. Amplitude & freq.
  بدون ما تعطيها input signal



- $X_o = A(jw)\, X_d$
- $X_d = X_s + X_f$
- $X_f = X_o\, B(jw)$

$$\Rightarrow X_o = A(jw)\,[X_s + X_f]$$
$$X_o = A(jw)\,[X_s + X_o B(jw)]$$
$$X_o = A(jw) X_s + A(jw) X_o B(jw)$$
$$X_o - A(jw) B(jw) X_o = A(jw) X_s$$
$$X_o (1 - A(jw) B(jw)) = A(jw) X_s$$

$$A_f = \frac{X_o}{X_s} = \frac{A(jw)}{1 - A(jw) B(jw)}$$

- when $|A(jw)\, B(jw)| = 1$
- $A_f = \frac{X_o}{X_s} = \infty$ (but $X_o \neq \infty$ (finite) so $A_f = \infty$ means that $\underline{X_s = 0}$ i.e no input signal)

Subject .... / /

- This Condetion will be satisfied at a certain Value of (w) Called w_o (Frequancy of osilation) i.e the F.b Amp. will give an o/p Ac Signal With a certain Amplitude and a certain freq. without any input
  i.e it will work as an oscillator...

- Oscillator ; a F.B a Amp Use +ve feed.b and gives periodical Ac output signal with a Certain Amplitude & certain freq. Without any Ac i/p , only D.C. Voltage required for basic Amp.

- Oscillation Condetions (Barkhausan Condition):

1) Magntude Condition :-

$$|A(jw)\,B(jw)| = 1$$

$\Rightarrow$ loop gain $= 1$, $A_{min} = \frac{1}{B}$, $A > 1$ Amp.
$B < 1$ passive cct.

ممكن تكون أكبر بـ (5%)

- هاي الـ Two conditions مو دايمًا
  بس at single freq

2) Phase condition :-

$$\angle A(jw)\,B(jw) = 0^\circ, 360^\circ = 2\pi n \quad , n = 0, 1, 2 \cdots$$

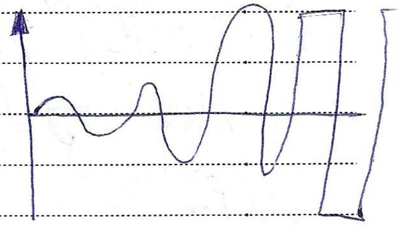
- قيمة الـ (w) اللي بتصير
  فيها هاي الـ Two Condetions
  تسمى W_o

1) $\angle A = 0^\circ$, $\angle B = 0^\circ \Rightarrow \angle A.B = 0^\circ$

2) $\angle A = 180^\circ$, $\angle B = 180^\circ \Rightarrow \angle A.B = 360^\circ$

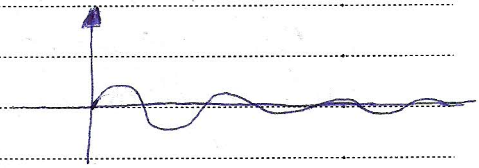
• If $BA \gg 1$:

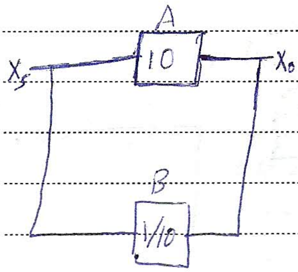
This will give uncontrolled o/p and drives the Amp. into Saturation

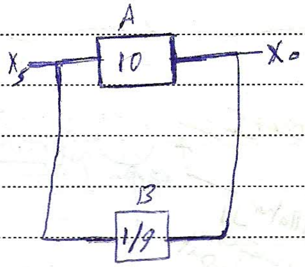


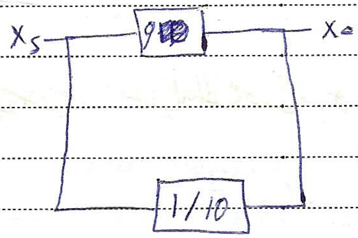
• If $BA \ll 1$:

The osc. will start and will be clamped (die)









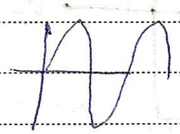
$AB = 1$ $\quad$ $AB > 1$ $\quad$ $AB < 1$

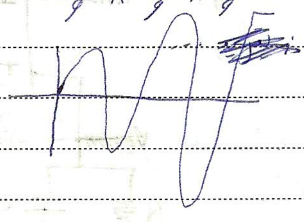
∴ stable

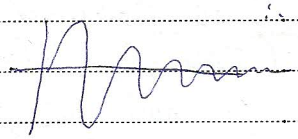
السيجنال بتضرب في 10
بعدين بتتقسم ع 10 فبتضل
زي ما هي

بتضرب في 10 وبتتقسم
ع 9 فبتزيد كل مرة
$\frac{10}{9} \times \frac{10}{9} \times \frac{10}{9} \ldots$

بتضرب في 9 بعدين
بتتقسم ع 10 فبتقل
$\frac{9}{10} \times \frac{9}{10} \times \frac{9}{10}$







Subject .... / /

* The required Conditions :-

① $|BA| = 1$ (magnitude condition)

practically $|BA| = 1 + 5\ \%$

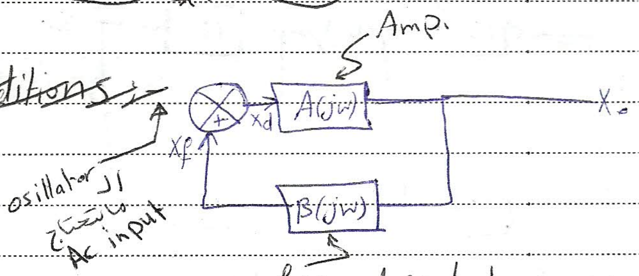
② for phase condition :-

Either Both Amp. & B-Network has 180° phase ~~$\angle AB = 0, 360$~~ shift or Both Amplifire & B-Net. has Zero phase.

i.e. A & B inverting oR A & B noninverting

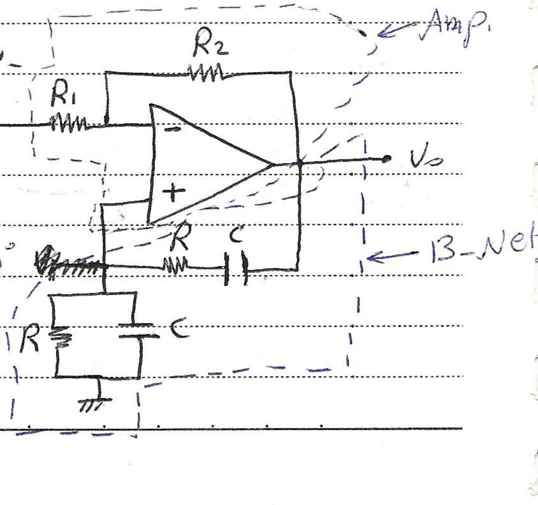
—— * ——

* ~~Oscillation Conditions :-~~



freq. dependent passive cct (RC, RL, LC)

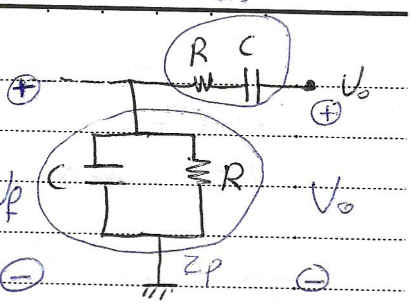
① Wien_Bridge oscillator :-



- A is noninverting Amp. (zero ph_shift)

$\Rightarrow$ B must give ph_shift = 0° to satisfy $\angle BA = 0°$

* derive an expression for β



$$V_f = \frac{V_o Z_p}{Z_p + Z_c}$$

$$\frac{V_f}{V_o} = \frac{Z_p}{Z_p + Z_s} = \beta$$

• $$Z_p = \frac{R \, \frac{1}{jwC}}{R + \frac{1}{jwC}} = \frac{R}{1 + jwRC}$$

• $$Z_c = R + \frac{1}{jwC}$$

$$\Rightarrow \beta = \frac{(R/1+jwRC)}{\left(R + \frac{1}{jwC}\right) + (R/1+jwRC)} = \frac{R}{(1+jwRC)\left[\left(R + \frac{1}{jwC}\right) + (R/1+jwRC)\right]}$$

$$= \cancel{\frac{R}{3R + 2jwR^2}} = \frac{R}{R + \frac{1}{jwC} + jwR^2C + R + R}$$

$$= \frac{R}{3R + jwR^2C + \frac{1 \times j}{jwC \times j}} = \frac{R}{3R + jwR^2C - \frac{j}{wC}}$$

$$\beta = \frac{R}{3R + j\left(wR^2C - \frac{1}{wC}\right)}$$

Subject .... / /

∴ The B will give zero phase when (J) term = 0

i.e $W_0 R^2 C = \frac{1}{W_0 C} \Rightarrow W_0^2 R^2 C^2 = 1$

$\Rightarrow W_0 = \frac{1}{RC}$ "freq. of oscillation"

$f_0 = \frac{1}{2\pi RC}$

At this freq $B = \frac{R}{3R + j0} = \frac{R}{3R} = \frac{1}{3}$

& ph. shift = 0

$\angle B = 0°$, $|B| = 1/3$

∴ To satisfy $|BA| = 1$ $A_{min} = 3$

for non inverting Amp. $A = 1 + \frac{R_2}{R_1}$

$1 + \left(\frac{R_2}{R_1}\right)_{min} = 3 \Rightarrow \boxed{R_{2\,min} = 2R_1}$

Ex. Design a wien-Bridge oscillator to give a freq of oscillation of 10K-Hz?

let $C = 0.1\mu F$, $R = \frac{1}{2\pi f C} = \frac{1}{(2)(\pi)(10^4)(10^{-6})}$

$\boxed{R = 160\ \Omega}$

Subject .... / /

. to satisfy magnitude condition $A_{min} = 3$, $R_2 = 2R_1$

let $\boxed{R_1 = 1K\Omega}$, $\Rightarrow$ $\boxed{R_2 = 2K\Omega}$

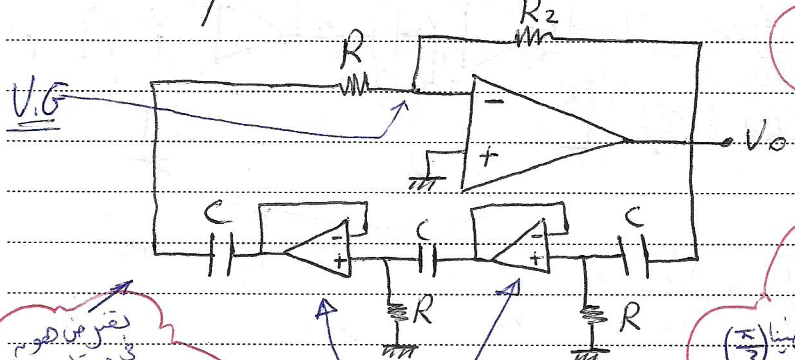
• لاحظ انه باقي AC input signal بس بنعطي D.C على الـ op Amp الـ V_{cc} عشان نشغل الـ Transistors

• ممكن يعطيك cct ويكون $R_2 \neq 2R_1$ وانت تحل زي الاهبل وبالاخر يطلع غلط...

* Note :-
if we want to use BJT oR Mosfet insted of the op Amp in wien bridg we must use :-
Common base for BJT
Common Gate " Mosfet
& non inverting for op-Amp

to give ph-shift = 0° from Amp.

* "Phase shift oscillator"



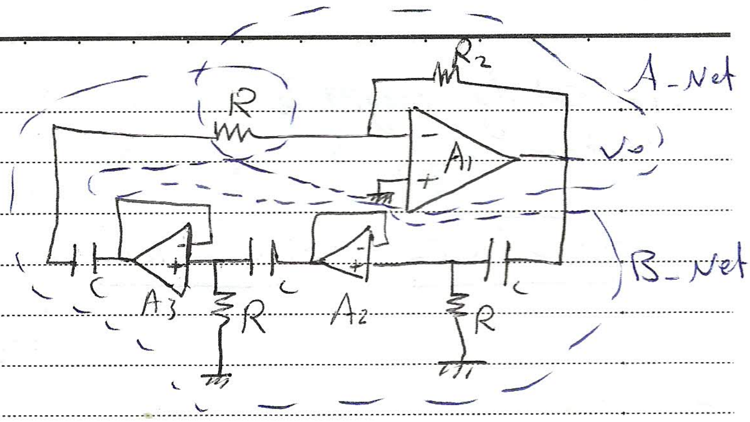
• أكبر زاوية بين C و R هي $\frac{\pi}{2}$ لما يكونوا Ideal واحنا عمليًا ماهي R,C بيكونوا Ideal فعشان نحصل على زاوية 180 بنستخدم 3 R,C وكل واحد بيعطينا $\left(\frac{\pi}{3}\right)$

نفترض من هون في مقاومة بس لـ V نفصلها R الي نوعها فنشيلها ونحط الـ (C) مع الـ (R) الي نوعه

Buffers عشان نشيل الـ loading affect

57

Subject .... / /



- Amp gives 180° (Inverting)

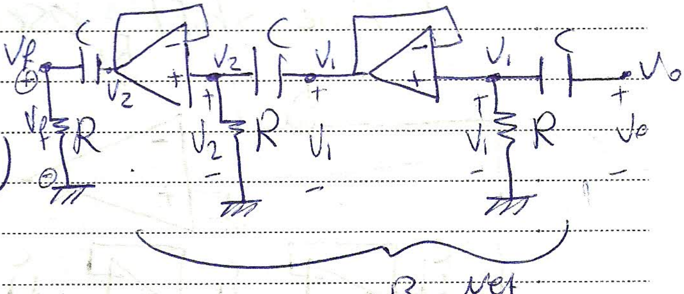
  ∴ β_Net must give also 180°.

- each RC section can give 60° at certain freq

- A_1 is basic Amp.
- A_2, A_3, is Buffers used to solve loading proplem...

اول شي بنطلع expression للـ β وبنشوف متى الـ ph.sh لـ β بيكون 180 وبنطلع الـ freq of oscillation بعدين بنعوض (ω) في β وبنوجد الـ β mag

- Rem~~ae~~ember that for buffer ($R_i = \infty$, $R_o = 0$, $A_V = 1$) (Ideal buff.)



$$\beta = \frac{V_f}{V_o} = \frac{V_f}{V_2}\,\frac{V_2}{V_1}\,\frac{V_1}{V_o}$$

Subject .... / /

$$\beta = \left(\frac{R}{R+\frac{1}{jwC}}\right)\left(\frac{R}{R+\frac{1}{jwC}}\right)\left(\frac{R}{R+\frac{1}{jwC}}\right)$$

. V_1 on R_1

. V_o on R_1 & C_1

$\Rightarrow V_1 = \frac{V_o R_1}{R_1 + \frac{1}{jwC}}$

$\Rightarrow \frac{V_1}{V_o} = \frac{R}{R + jwC}$

. V_1 on R_2 & C_2

$\Rightarrow V_2$ on R_2

$\Rightarrow \frac{V_2}{V_1} = \frac{R_2}{R + \frac{1}{jwC_2}}$

⋮

$$= \left(\frac{RjwC}{jwRC+1}\right)^3$$

$$= \frac{-jw^3R^3C^3}{(1+jwRC)(1+jwRC)^2}$$

$$= \frac{-jw^3R^3C^3}{(1+jwRC)(1+2jwRC+j^2w^2R^2C^2)}$$

$$= \frac{-jw^3R^3C^3}{1+2jwRC-w^2R^2C^2+jwRC-2w^2R^2C^2-jw^3R^3C^3}$$

$$= \frac{-jw^3R^3C^3}{1-w^2R^2C^2-2w^2R^2C^2+j(2wRC+wRC-w^3R^3C^3)}$$

$$= \frac{j^3w^3R^3C^3}{(1-3w^2R^2C^2)+j(3wRC-w^3R^3C^3)}$$

~~For~~ β to give ph-shif = 180 the Real part

must equal Zero ...

$$1-3w_o^2R^2C^2=0 \Rightarrow w_o^2R^2C^2=\frac{1}{3}$$

$$\Rightarrow w_o = \frac{1}{\sqrt{3}RC}$$

Subject .... / /

$\Rightarrow f_o = \dfrac{1}{2\pi\sqrt{3}\,RC}$ "freq. of oscillation"

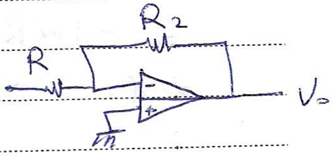
. At this freq. $\beta = \dfrac{j^2 W^3 R^3 C^3}{3WRC - W^3R^3C^3}$

$= \dfrac{j W^2R^2C^2}{3 - W^2R^2C^2}$

$\Rightarrow \beta = \dfrac{j\left(\frac{1}{3R^2C^2}\right)R^2C^2}{3 - \frac{1}{3R^2C^2}R^2C^2} = \dfrac{j^2(1/3)}{3-\frac{1}{3}} = \dfrac{-1/3}{3-1/3}$

$= \dfrac{-1}{8}$

$\Rightarrow \angle\beta = 180^\circ \;,\; |\beta| = \dfrac{1}{8}$



To satisfy $|\beta A| = 1 \Rightarrow |A_{min}| = 8$

For inverting Amp. $|A| = \left(\dfrac{R_2}{R_1}\right)_{min} = 8 \Rightarrow \boxed{R_2 = 8R_1}$

Ex. Design the ph-sh. oscillator shown in fig. to have $f_o = 10KHz$?

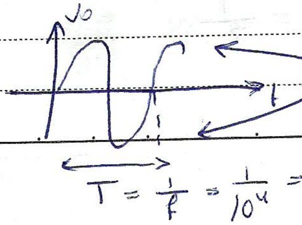
$f_o = \dfrac{1}{2\pi\sqrt{3}\,RC}$, let $C = 0.01\,\mu F$

$\Rightarrow R = \dfrac{1}{2\pi\sqrt{3}\times 0.01\times 10^{-6}\times 10^4} = \dfrac{10^4}{2\pi\times 1.73} = 920\,\Omega$

For the oscillator $A_{min} = 8 = \dfrac{R_2}{R_1} \Rightarrow R_2 = 8R_1$

$= 8\times 920\,\Omega$

$= 7.4K\Omega$



لا يتعدى V_{cc} لل op-Amp.

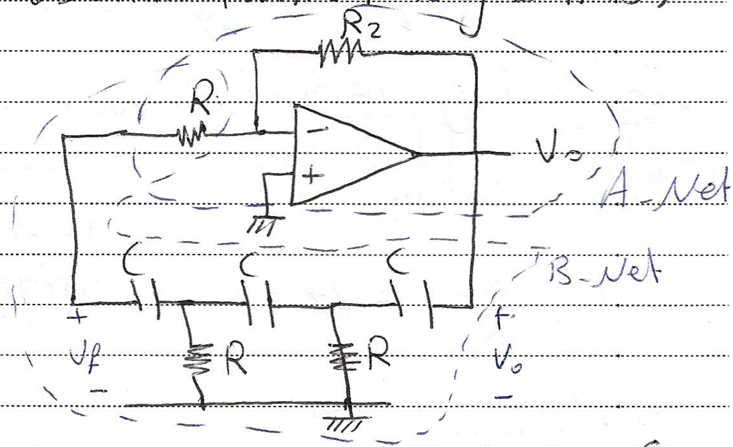
$T = \dfrac{1}{f} = \dfrac{1}{10^4} = 0.1ms$

ولو كان BJT بنحط
٢ زينر بما يتعدى V_Z

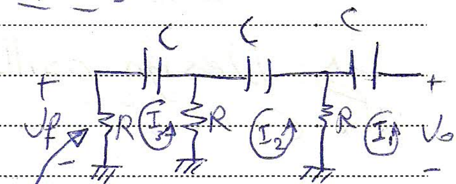
njpb

* Phase shift oscillator (without using Buffers)

- The same as the last oscillator but here we don't use Buffers in B_Network



To find expression for β



- ال B-cct هيك أصلاً ولكن
عشان نوفر مقاومات بنربطها
مع المقاومة اللي فوق وبنشيل الهاي

$$\beta = \frac{V_f}{V_o}$$

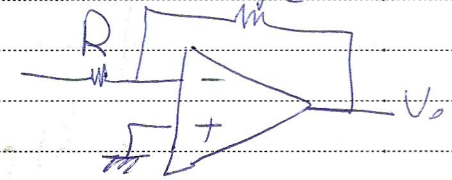
- $I_1 \frac{1}{jwC} + (I_1 - I_2) R - V_o = 0$
- $V_o = I_1 \left(\frac{1}{jwC} + R\right) - I_2 R$ --- (1)
- $\left(\frac{1}{jwC} + 2R\right) I_2 - I_1 R - I_3 R = 0$ --- (2)
- $\left(\frac{1}{jwC} + 2R\right) I_3 - I_2 R = 0$ --- (3)

$\beta = \text{———}$

by setting J-term = 0 to give 180° This will give

$$W_o = \frac{1}{\sqrt{6} RC} \Rightarrow \boxed{f_o = \frac{1}{2\pi \sqrt{6} RC}}$$

- At this freq. $\beta = \frac{-1}{29} \Rightarrow |\beta| = \frac{1}{29}$ and $\angle\beta = 180^\circ$
- To satisfy $|\beta A| = 1$, $|A_{min}| = 29$
- For inverting Amp.

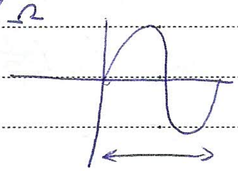


$$|A| = \frac{R_2}{R_1} = 29$$

$$\Rightarrow \boxed{R_{2min} = 29 R_1}$$

Ex. Design osillator shown, to have $f_o = 20KHz$
Use $C = 0.01\ \mu F$

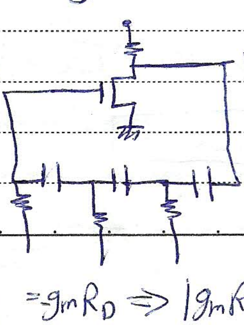
- $R = \frac{1}{2\pi\sqrt{6} \times 10^{-8} \times 2 \times 10^{4}} = 324\ \Omega$
- $\frac{R_2}{R} = 29 \Rightarrow R_2 = 29 \times 324 = 9.4K\Omega$



$T = \frac{1}{f} = 50ms$

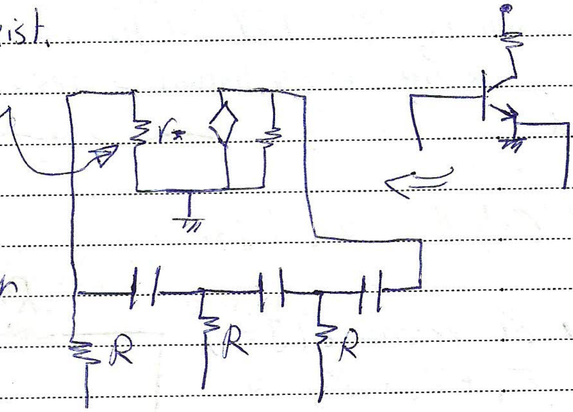
- if we want to replace the op-Amp by Mosfet: oR by C.E in BJT.

C. Source

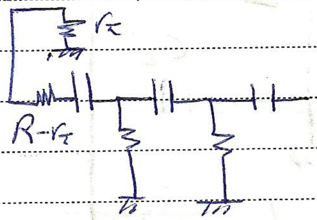


$A = \frac{V_o}{V_{gs}} = -g_m R_D \Rightarrow |g_m R_D| = 29$

• if we use C.E we will face a problem that is (r_π) is exist.



To solve this problem We connect the 3rd capacitor directly with r_π & put between them a resistor it's value is $R - r_\pi$



$$\Rightarrow R - r_\pi + r_\pi = R$$

"Tuned Oscillators"

Use Amplifiers and LC cct's.

op-Amp. BJT Mosfet

* There are Two Kinds of Tuned oscillators :-

1) Colpitts oscillator (2C + 1L)

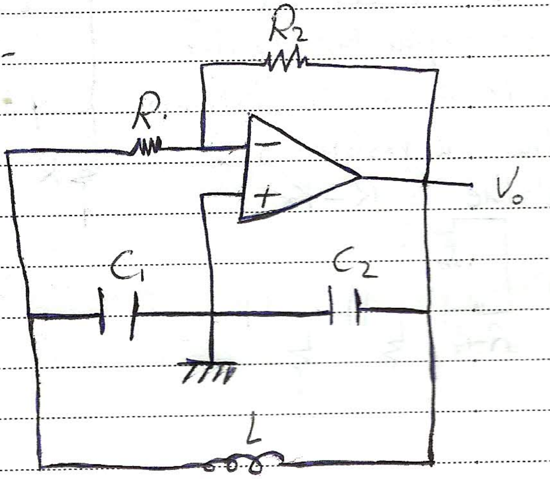
2) Hartly oscillator (2L + 1C)

Subject .... / /

* In the Tuned oscillators the phase condition will be satisfied at the resonent freq of the tuned cct...
∴ freq of oscillation = resonance freq.

*

* Colpitts oscillator :-



* at resonance (J = 0)

$Z_1 + Z_2 + Z_3 = 0$

$\frac{1}{jwC_1} + \frac{1}{jwC_2} + jwL = 0$

$-jwL = \frac{1}{jwC_1} + \frac{1}{jw}$

$-jwL = \frac{1}{jw}\left(\frac{1}{C_1} + \frac{1}{C_2}\right)$

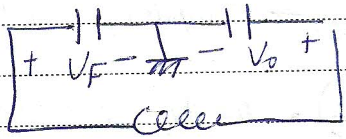
$\Rightarrow wL = \frac{1}{w}\left(\frac{1}{C_1} + \frac{1}{C_2}\right) \Rightarrow w^2 = \frac{1}{L}(1/C_{eq})$

$\frac{1}{C_1} + \frac{1}{C_2} = \frac{C_1 + C_2}{C_1 C_2} = 1/C_{eq}$

$\Rightarrow \boxed{W_o = \frac{1}{\sqrt{L C_{eq}}}}$, wher $C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$

$\Rightarrow \boxed{f_o = \frac{1}{2\pi\sqrt{C_{eq} \cdot L}}}$ (frequancy of oscillation)

• $\beta = \frac{V_f}{V_o} = \frac{1/jwC_1}{1/jwC_2} = \boxed{\frac{C_2}{C_1}}$



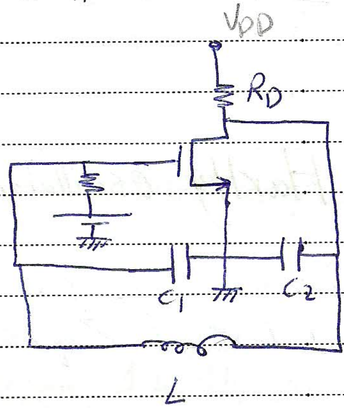
• to have $|A\beta| = 1 \Rightarrow \boxed{A_{min} = \frac{C_1}{C_2}}$

Subject .... / /

& this in inverting op-Amp $|A| = \frac{R_2}{R_1}$

$$\Rightarrow \boxed{\frac{R_2}{R_1} = \frac{C_1}{C_2}}$$

Ex. Design a Colpitts oscillator to give $f_o = 100KHz$
Use Mosfet biased at $I_D = 1mA$, $K_n = 1mA/V^2$, Assume
$(C_1 = 4C_2)$ find L, R_D?

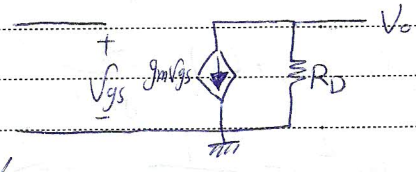


- $f_o = \frac{1}{2\pi\sqrt{L C_{eq}}}$, $C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$

- $\beta = \frac{V_f}{V_o} = \frac{1/jwC_1}{1/jwC_2} = \frac{C_2}{C_1}$

$\beta = \frac{C_2}{C_1} = \frac{\cancel{C_2}}{4\cancel{C_2}} = \frac{1}{4}$

$|A\beta| = 1 \Rightarrow A$ must be 4.



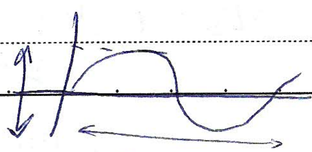
$A_{min} = 4$ and ~~$|A| = |g_m V_{gs}|$~~
$|A| = |g_m R_D| = 4$
$g_m = 2\sqrt{K_n I_D} = 2\sqrt{1} = 2 mA/V$

$\therefore \boxed{R_D = 2K\Omega}$

let $L = 1\mu H \Rightarrow C_{eq} = \frac{1}{4\pi^2 f_o^2 L} = \frac{1}{4 \times 10 \times 10^{10} \times 10^{-6}} = \frac{10^{-5}}{4}$

$= 0.25 \times 10^{-5} F = 2.5 \mu F$

Maximum output Voltage is V_{DD}



$T = \frac{1}{f_o}$

Subject .... / /

إذا كان $R_D = 2.1 \Longrightarrow A = \cancel{4}\ 4.2$

$A_{min} = \frac{1}{B} = 4$

but $A = 4.2 = 4 + 5\%$

$|AB| = 1.05$ ✓

بتزبط يصير oscillator

لأ عادي لو كان عنا $+5\%$

• ممكن يجيب سؤال هل هاي السيركت بتعمل كـ oscillator ولا لأ وجاب $R_D = 4$ مثلاً

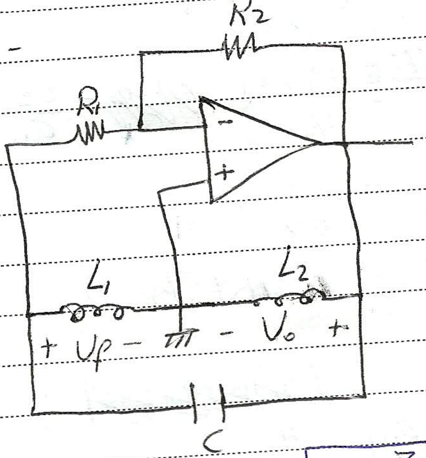
بنطلع $\beta = \frac{C_2}{C_1} = \frac{1}{4}$ مثلاً في المثال السابق

وبنطلع $A = g_m R_D = 2 \times 4 = 8$

$AB = 2$ not 1

$\therefore$ it doesn't work as an oscillator, the solution is dec↓ the value of R_D

* Hartly oscillator :-



• In raisonance freq. J term of $Z_{eq} = 0$.

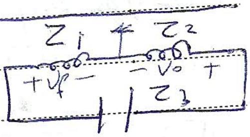
$$jwL_1 + jwL_2 + \frac{1}{jwC} = 0$$

$$\cancel{j}w_o(L_1 + L_2) = \frac{\cancel{1}}{\cancel{j}w_oC}$$

$$w_o^2 = \frac{1}{C(L_1+L_2)} \Rightarrow w_o = \frac{1}{\sqrt{C(L_1+L_2)}}$$

$$\therefore f_o = \frac{1}{2\pi\sqrt{C(L_1+L_2)}}$$

$$\cdot\ \beta = \frac{V_f}{V_o} = \frac{Z_1}{Z_2} = \frac{jwL_1}{jwL_2} = \frac{L_1}{L_2}$$



$$V_f = \frac{V_o Z_1}{Z_1 + Z_3}$$

$$\frac{V_f}{V_o} = \frac{Z_1}{Z_1 - Z_1 - Z_2}$$

$$\beta = \frac{Z_1}{-Z_2}$$

$$\therefore |\beta| = \frac{Z_1}{Z_2}$$

To satisfy $|A\beta| = 1$, $A_{min} = \frac{L_2}{L_1}$

For inverting Amp. $A = \frac{R_2}{R_1}$

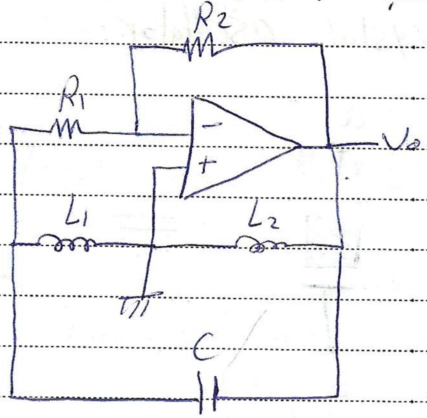
$\Rightarrow \left(\frac{R_2}{R_1}\right)_{min} = \frac{L_2}{L_1}$

* If L_1 & L_2 has Mutual independance M, then the frequancy of oscillation will be

$f_o = \frac{1}{2\pi\sqrt{C(L_1+L_2 \pm M)}}$, where M : Mutual independance
$M = K\sqrt{L_1 + L_2}$
K = Coupling Co eff.

Ex. Use An Ideal op-Amp. to design A hartly osc. to oscillate at (200 KHz).
The max. gain for Amp. must not exceed 10. ?

For $A = 10$
to satisfy $|A\beta| = 1$
$\Rightarrow \beta = \frac{1}{10}$



$\beta = \frac{V_f}{V_o} = \frac{L_1}{L_2} = \frac{1}{10}$

$L_2 = 10 L_1$
let $\boxed{L_1 = 1\,\mu H} \Rightarrow \boxed{L_2 = 10\,\mu H}$

Subject .... / /

$$\therefore C = \frac{1}{4\pi^2 f_o^2 (L_1+L_2)^2} = \frac{1}{4\pi^2(200)^2(11\mu)^2} = 5.2\,mF$$

- $A = 10 = \frac{R_2}{R_1}$, let $\boxed{R_2 = 5\,K}\,\Omega \rightarrow \boxed{R_1 = 0.5\,K\Omega}$

—————— x ——————

"CRYStal Oscillator"

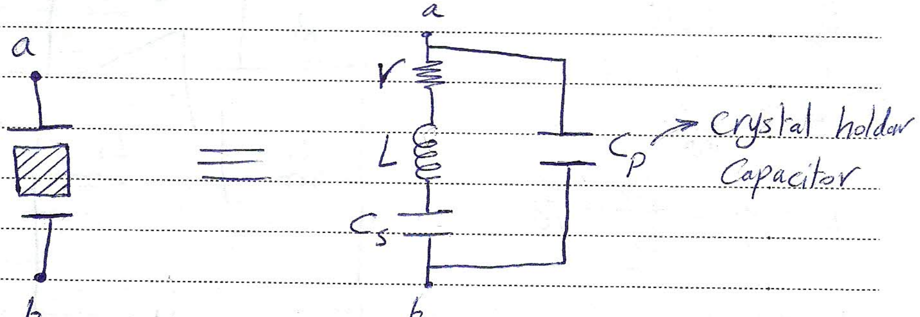
★ Frequancy Stability :-

$$F.S = \frac{\Delta f}{f_o}$$

- ΔF is Deviation in frequancy
- ΔF is due to
  1) Temp. 2) aging effect

• كل أنواع الـ oscillators السابقة بتتأثر بالحرارة والزمن وبتتغير فيها الـ (f_o) لذلك اذا أردنا f_o ثابت بنستخدم crystal oscillator

★ Crystal Oscillator :-



X-tal ~~oscillator~~ sympol

X-tal equevelanet cct.

* It is based on using quartze crystal wich is a piezoelectric material works as a series resonant cct.

* The parameters r, L, C_s depend on crystal dimentions and polarization.

* When a voltage is applied across the crystal it will give an a.c. input signal of frequancy:

$$f_o = \frac{1}{2\pi\sqrt{L C_s}}$$

- L : in order of tens of Heneries.
  C_s : (series cap.) in the range of 0.001 pF.

- This oscillator has a very high quality factor

$$Q = \frac{w_o L}{r}$$ in the order of 10^4

* Advantages and disadvantages of X-tal osc. :-

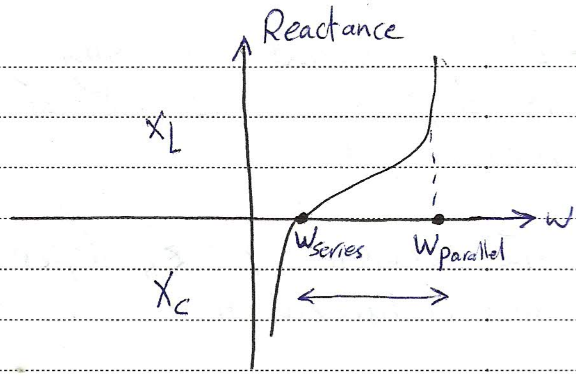
1) high freq.
2) Very stable freq.

1) Fixed freq → كل Xtal-oscillator ليها (f) ثابت
2) Fragile → سهل الكسر

ولا تتغير

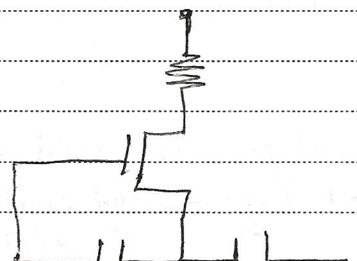
Subject .... / /

- $W_{o_{s,p}} = \frac{1}{\sqrt{LC_{s,p}}}$



- When series (s) (W_s)
  Reactance $= 0$
- When parallel (p) (W_p)
  Reactance $= \infty$
- When w between W_s & W_p the Reactance is inductive so the cryst. can be substituted as inductance.
- when w between 0 & W_s the Reactance is Capacitive so the cryst. can be substituted as capacitance

Note :-
The x-tal Can be behaves as an inductave or Capacitive element so it can be Used to replace Inductor in ColPits osc. or capacitor in hartly osc.



للحصول على f مختلف
ولكن من نفس الدائرة
نستخدم Freq. Counter أي أنه
نقسم الـ (f) 2 أو 4 وهكذا

njpb

Subject .... / /

Ex. Calculate the freq. and Q of a crystal osc. with $L = 10H$, $C_s = 1 \underset{10^{-15}}{F}$, $r = 200\,\Omega$?

$$f_o = \frac{1}{2\pi\sqrt{10\times1\times10^{-15}}} = \frac{10^7}{2\pi} = 1.6\,MHz$$

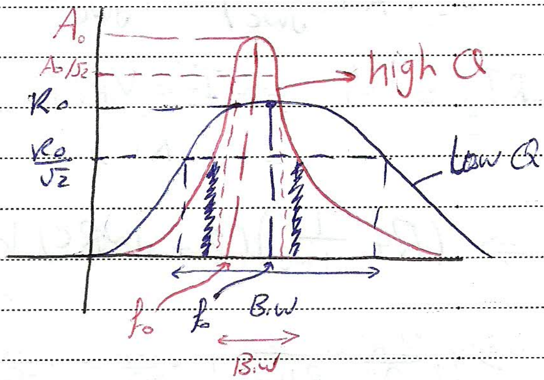
$$Q = \frac{w_o L}{r} = \frac{2\pi\times1.6\times10^6\times10}{200} = 5\times10^5$$

Series resonant cct.

$$Q = \frac{f_o}{B.W}$$

كلما قلت r ⇐ زادت Q ⇐ أصغر L

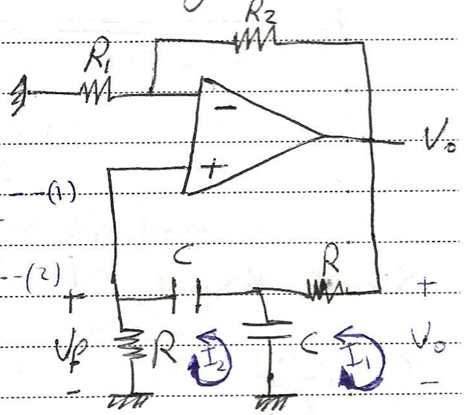
Q يدل على مدى الـ narrow الـ cct



*

Subject .... / /

Ex: Derive an exp. for the Transfer function B_Net ($B = \frac{V_f}{V_o}$) and find expressions for oscillation freq (f_o) and min. gain required by the Amp. to oscillation and use C = 0.01F to design the cct to give $f_o = 10KHz$ (find R, R_2, R_1)?



- $V_o - RI_1 - (I_1 - I_2)\frac{1}{jwC} = 0$

$\Rightarrow V_o = I_1(R + \frac{1}{jwC}) - I_2\frac{1}{jwC}$ --(1)

- $I_2(R + \frac{2}{jwC}) - I_1\frac{1}{jwC} = 0$ --(2)

- $RI_2 = V_f$, $\Rightarrow I_2 = V_f/R$
- $I_1 = I_2(2 + jwRC)$

$$\Rightarrow (R + \frac{1}{jwC})(2 + jwRC)\frac{V_f}{R} - \frac{V_f}{(R)(jwC)} = V_o$$

$$\Rightarrow \left[\left(\frac{2\cancel{R}}{\cancel{R}} + \frac{2}{RjwC} + \frac{jwR^2C}{\cancel{R}} + \frac{\cancel{R}}{\cancel{R}}\right) - \frac{1}{jwRC}\right]V_f = V_o$$

$$\Rightarrow \beta = \frac{V_f}{V_o} = \frac{1}{3 + \frac{2}{jwRC} + jwRC - \frac{1}{jwRC}}$$

$$\beta = \frac{1}{3 + jwRC - j\frac{2}{wRC} + j\frac{1}{jwRC}}$$

$$\beta = \frac{1}{3 + j(wRC - \frac{2}{wRC} + \frac{1}{wRC})}$$

Subject .... / /

$\therefore \boxed{\beta = \frac{1}{3 + j\left(WRC - \frac{1}{WRC}\right)}}$

- The Amp. is noninverting Amp. (ph-shift = 0)
  So β will give zero phase shift if (J Term = 0)

- $W_0RC = \frac{1}{W_0RC} \Rightarrow W_0^2 = \frac{1}{\sqrt{R^2C^2}} \Rightarrow W_0 = \frac{1}{RC}$

$\therefore \boxed{f_0 = \frac{1}{2\pi RC}}$

- in this freq $\beta = \frac{1}{3} \Rightarrow$ to give $|\beta A| = 1$

$\boxed{A_{min} = 3}$

- $R = \frac{1}{(2\pi)(f_0)(C)} = \boxed{795.77\ \Omega}$

- $|A|_{(non\ inverting)} = \cancel{\frac{R_2}{R_1} = 3}\ \left(\frac{R_2}{R_1} + 1\right) = 3$ "NoN inverting op-Amp"

let $\boxed{R_1 = 1K\Omega} \Rightarrow \boxed{R_2 = 2K\Omega}$

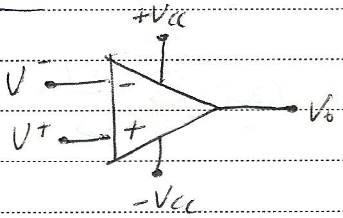
"NON Sinosoidal oscillators (Relaxation osc's)"

It depends on charging & discharching of cap.

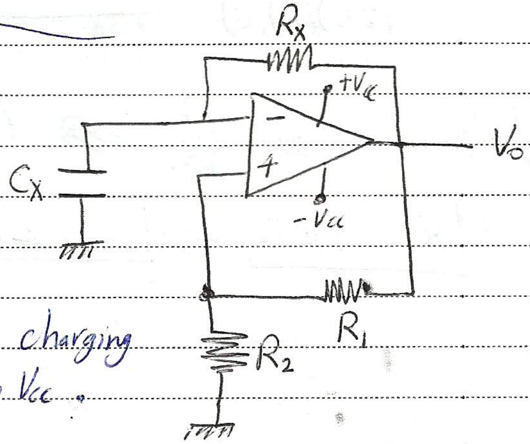
1) Astable MTV 2) Monostable MTV ← multivibrator
3) Bistable MTV

* Astable MTV :-

- The op-Amp work as a comparator



- The comparator :-
- $V_o = A_o(V^+ - V^-)$
- $V_{o(max)} = \pm V_{cc}$
- for Ideal op-Amp ($A_o = \infty$) ;
  1) if $V^+ > V^- \Rightarrow V_o = +V_{cc}$
  2) if $V^- > V^+ \Rightarrow V_o = -V_{cc}$



① when $V_o = +V_{cc}$;

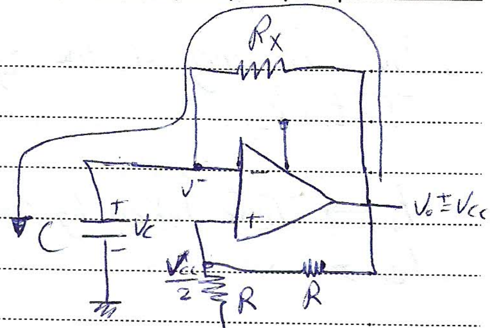
$V^+ = \dfrac{V_{cc} R_2}{R_1 + R_2}$ (if $R_1 = R_2$)

$\Rightarrow V^+ = \dfrac{V_{cc}}{2}$

- The cap. C_x start charging Through R_x aiming to V_{cc} .

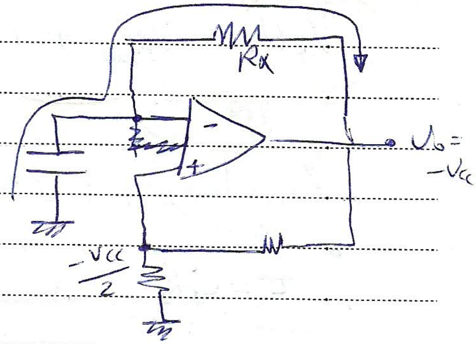
تسعى للوصول

- But when V_c exceed $\frac{V_{cc}}{2}$ then $V^- > V^+$ and the Comparator change the state and gives $V_0 = -V_{cc}$

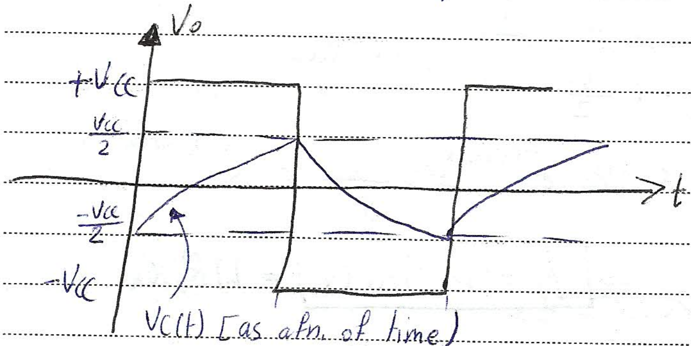


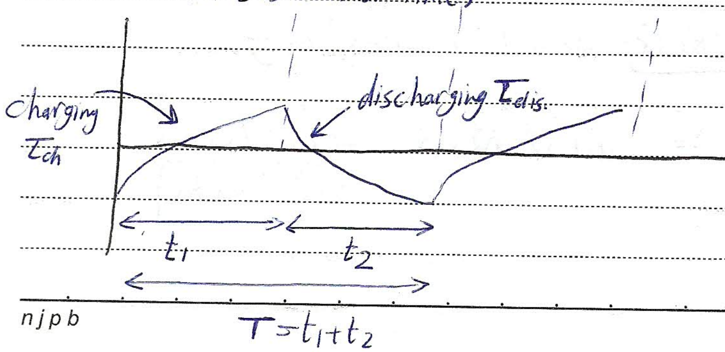
(charging)

- Now when $V_0 = -V_{cc}$, $V^+ = \frac{-V_{cc}}{2}$ and C_x will discharging through R_x aiming to $-V_{cc}$ but when V_c exceed $-V_{cc}/2$, the Comp. will change the state and gives $V_0 = +V_{cc}$



& The cct will be repeated...





$T = t_1 + t_2$

- The frequancy of the square wave is $f = \frac{1}{T}$ and $T = t_1 + t_2$.

$t_1 \rightarrow$ Time taken by C_X to charge from $\frac{-V_{cc}}{2}$ to $\frac{V_{cc}}{2}$

$t_2 \rightarrow$ " " " " " discharg " $\frac{V_{cc}}{2}$ to $\frac{-V_{cc}}{2}$

* In general, the cap. Voltage $V_c(t)$ is given by:-

$$V_c(t) = V_{final} + (V_{inetial} - V_{final})\, e^{-t/\tau}, \qquad \tau: \text{time Const.}$$

- For charging: (to find t_1):-

القيمة التي تهدف ال (C) للوصول اليها ..

- when $t = t_1$, $V_c(t) = \frac{V_{cc}}{2}$, $V_{inetial} = \frac{-V_{cc}}{2}$, $V_f = +V_{cc}$
  $\tau = C_X R_X$,

$$\Rightarrow \frac{V_{cc}}{2} = V_{cc} + \left(-\frac{V_{cc}}{2} - V_{cc}\right) e^{-t_1/R_X C_X}$$

$$\cancel{-}\frac{\cancel{V_{cc}}}{\cancel{2}} = \cancel{-}\frac{3}{\cancel{2}} \cancel{V_{cc}}\, e^{-t_1/R_X C_X} \Rightarrow \frac{1}{3} = e^{-t_1/R_X C_X}$$

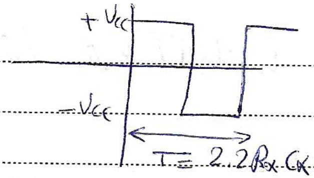
$$\Rightarrow \ln 3 = \frac{t_1}{R_X C_X} \Rightarrow \boxed{t_1 = (\ln 3) R_X C_X} = 1.1\, R_X C_X$$

$\& \boxed{t_2 = (\ln 3) R_X C_X}$ also (for discharging).

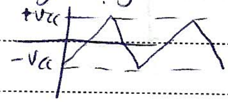
$$T = t_1 + t_2 = 2(\ln 3)\, R_X C_X = (\ln 9)\, C_X R_X$$
$$\approx \boxed{2.2\, C_X R_X}$$

Subject .... / /

$\therefore \boxed{f = \dfrac{1}{2.2 R_x C_x}}$

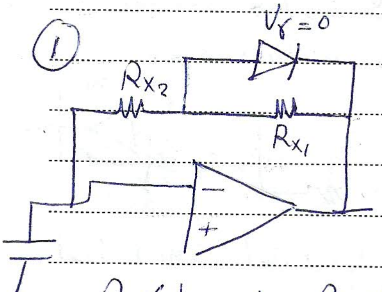


• اذا أخذنا output من ال inverting (V^-) رح نحصل على output بشكل تعرجي triangle



• ال output اللي بيطلع بيكون symmetric واذا بدنا output ليس symmetric لازم نخلي زمن الشحن لا يساوي زمن التفريغ يعني $t_2 \neq t_1$ $\boxed{\text{بالعب بقيمة } R_x}$

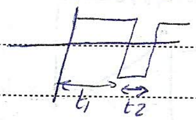
1



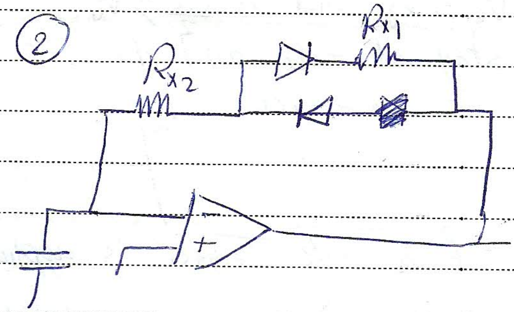
$R_x(\text{charging}) = R_{x_1} + R_{x_2}$

$R_x(\text{discharging}) = R_{x_2}$

$\therefore t_1 > t_2$



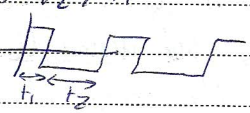
2

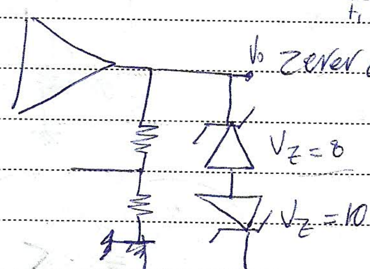


$R_x(\text{charging}) = R_{x_2}$

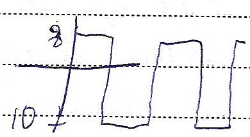
$R_x(\text{discharging}) = R_{x_1} + R_{x_2}$

$\therefore t_2 > t_1$



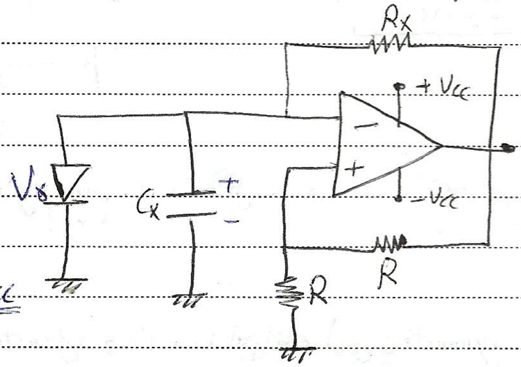


• اذا ما بدي $\pm V_{cc} = V_0$ بحط zener diods



Subject .... / /

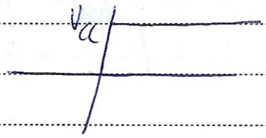
* Monostable (MMTV):- (one shot cct):-

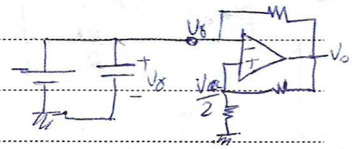


① when $V_o = +V_{cc}$

$V^+ = \frac{V_{cc}}{2}$

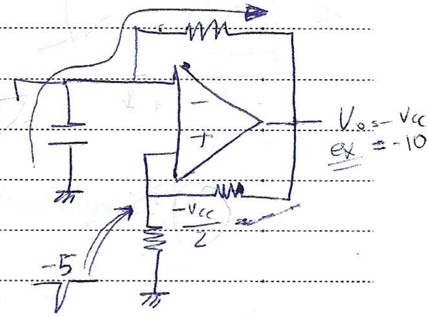
C_x will start charging aiming $\underline{V_{cc}}$ but when $V_c = V_\gamma$, The diod will be $\underline{on}$ so $V_C = V_\gamma$ and if $\frac{V_{cc}}{2} > V_\gamma$ i.e. $(V^+ > V^-)$, the output stay at $+V_{cc}$ and the cct remains in this state. i.e. $V_o = +V_{CC}$





② if a -ve Trigger is applied at ⊕ terminal such that to make $V^+ < V_\gamma$ the comparator will change the state and make $V_o = -V_{cc}$ (i.e. $V^+ = \frac{-V_{cc}}{2}$)

③ the Cap. Cx will discharge throgh R_x aiming $-V_{cc}$ but when V_c try to exceed $\frac{-V_{cc}}{2}$ the Comp. chang the state given $V_o = +V_{cc}$ & The cycle will be repeated. if we applied another -ve triggure otherwice the output will be $+V_{cc}$ ...

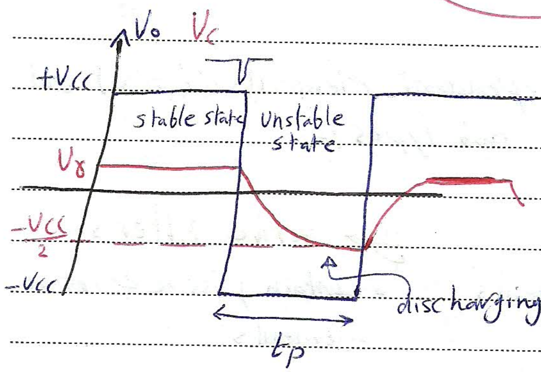


لازم أتأكد انه ال -ve trigger
راح تخلي $V^+ < (V^- \equiv V_\gamma)$

يعني لو أعطيت مقدارها -1 Volt
راح تخلي $V^+ = 4$ لساتها $V^+ > V_\gamma$ أما لما نعطيها -5
راح يصير $V^+ = 0$ $V_o < 0$ ⇐ راح ينقلب ال Comp

Subject .... / /

• عشان نقلب ال comp. لازم يكون $V^+ < V^-$ لو وصلنا trigure على +ve
ال V^- مارح يزيد لأنه مربوط مع diode وال voltage مهما زادت رح تضل V_γ
أما لو حطينا -ve trig. على V^+ رح يقل ---



* The pulse duration (t_p) can be found as follow :-

$$V_c(t) = V_f + (V_{in} - V_f)\, e^{-t/\tau},$$

when $t = t_p$, $V_c(t) = \frac{-V_{cc}}{2}$, $V_{initial} = V_\gamma$, $V_f = -V_{cc}$

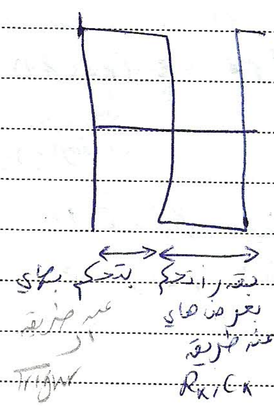
$$\frac{-V_{cc}}{2} = -V_{cc} + (V_\gamma + V_{cc})\, e^{-t_p/\tau} \quad , \text{for } V_{cc} \gg V_\gamma$$

$$\Rightarrow \frac{1}{2} = e^{-t_p/\tau} \Rightarrow t_p = \tau \ln 2$$

$\therefore$ $\boxed{t_p = 0.69 R_x C_x}$

عرض ال ~~pts~~ pulse

let C_x = —
R_x = —



$f_{output} = f_{trigure}$

• عشان أحصل على موجة كاملة بـ (one trigures per cycle)

Subject .... / /

* Active filters :-

- Filters :- selective ccts. allow certain bands of frequancies to pass (pass band) and reject athor bands (stop band).

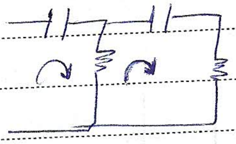
- It Contain a freq. dependent elements (L or C) but In general there are two types :-

1) passive filters

- have only passive elements
- No gain (max. gain is 1)
- No power supply.
- تعاني
  Suffer from loading.
- كبيرة الحجم
  Bulky and not integrable

2) Active filters

- Contain passive & Active elements.
- there is a certain gain.
- power supply is required for biasing
- No loading affect.
- Integrable...



ما بنقدر نستخدم
(R & C & L) لا,
فاذا بدنا 2^{nd} order
حيصير عنا loading...

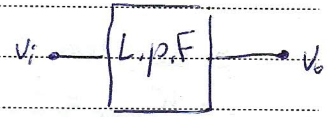
(L) عادة بيكون حجمه كبير
فما بنقدر نعملها بـ IC's

(Buffers) بنستخدم

• According to frequancy band, it can be classified as :-

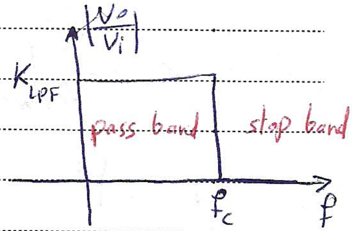
① Low pass filter :-

• pass band extend from $(0 \to f_c)$, where f_c : cutoff frequancy...

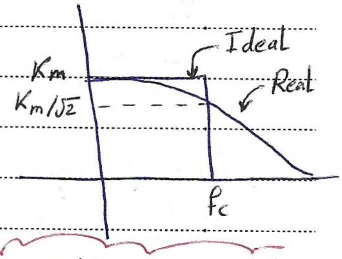


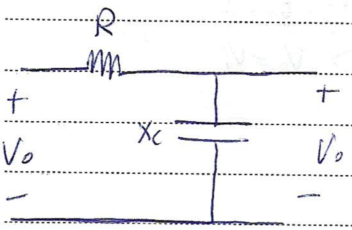
• $K_{LPF\,(max)} = 1$ for passive filters.

• $K_{LPF\,(max)} > 1$ for Active filters.



• f_c : the freq. at wich $\frac{V_o}{V_i} = \frac{K_m}{\sqrt{2}}$, wher $K_m = \left|\frac{V_o}{V_i}\right|_{max}$





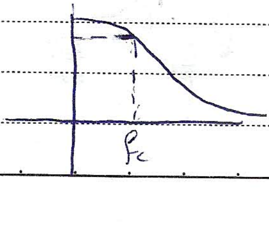
• كل الترددات الأقل من f_c بتمر
والأكبر منه f_c ما بتمر

$X_C = \frac{1}{2\pi f_C}$, $V_o = \frac{V_i X_C}{X_C + R}$

when $f = 0 \Rightarrow X_S = \infty \Rightarrow V_o = V_i \Rightarrow \frac{V_o}{V_i} = 1$

when $f = \infty \Rightarrow X_S = 0 \Rightarrow V_o = 0 \Rightarrow \frac{V_o}{V_i} = 0$

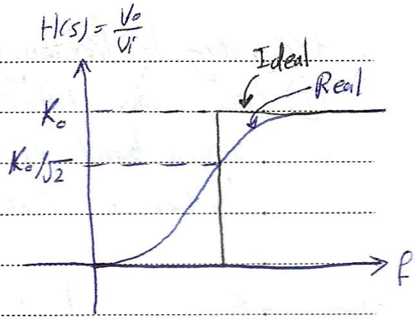
ex L.P.F



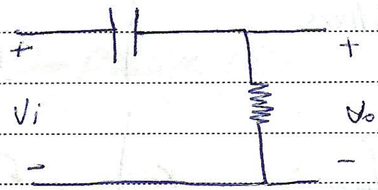
عشان نستنتج f_c $\frac{V_o}{V_i} = \frac{1}{\sqrt{2}}$

Subject .... / /

② High pass filter (H.P.F) :-

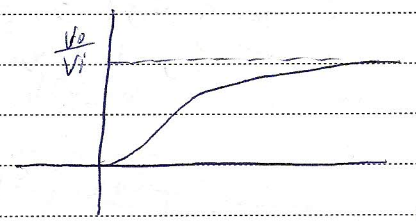


- K_o : max. gain of H.P.F.
- $K_{o\,max} = 1$ for passive filters.
- $K_o = \frac{V_o}{V_i}\Big|_{w=\infty}$

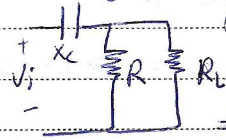


- $\frac{V_o}{V_i} = \frac{R}{X_c + R}$, $X_c = \frac{1}{2\pi f c}$

- in low frequency ($f=0$) $\Rightarrow X_c = \infty \Rightarrow V_o = 0$
  in High " ($f=\infty$) $\Rightarrow X_c = 0 \Rightarrow V_o = V_i$

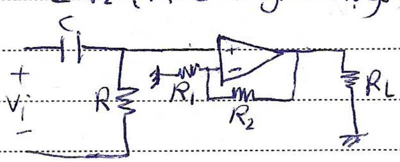


- المشكلة بال passive.F انه في loading
  يعني بعد ال filter عنا R_L

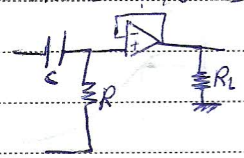


$\Rightarrow f = \frac{1}{2\pi(R_L+R)c}$

ولو بدنا gain بنحط R_1 & R_2 & الBuffer



فرح تتغير (f) أما بال Active بنحط Buffer

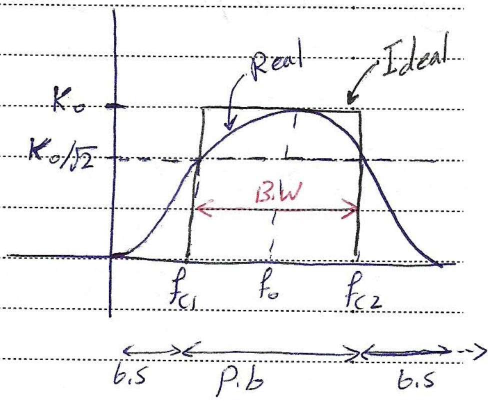


$f = \frac{1}{2\pi Rc}$

Subject .... / /

③ Bandpass filter (B.P.F)

- freq. Range $f_{c1} \rightarrow f_{c2}$
  $B.W = f_{c2} - f_{c1}$



- It has a center freq. (f_o) related to B.W by sellectivity

$$Q = \frac{f_o}{B.W}$$

- B.P.F. Can be constructed from cascading L.P.F and H.P.F. Such that

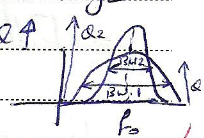
$$f_{cL} > f_{cH}$$

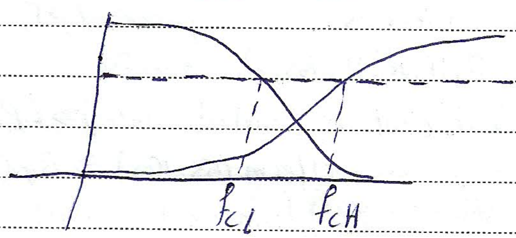
$$K_o = \left|\frac{V_o}{V_i}\right|_{W = W_o}$$

كل ما كان ال f_o (slemp)  راح يكون أفضل

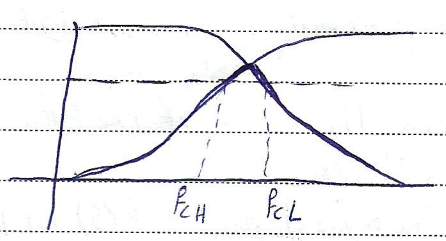
$B.W \uparrow \rightarrow Q \downarrow$

$B.W \downarrow \rightarrow Q \uparrow$





$f_{c1} < f_{cH}$ ليس B.P



$f_{cL} > f_{cH}$ (B.P) بتزبط

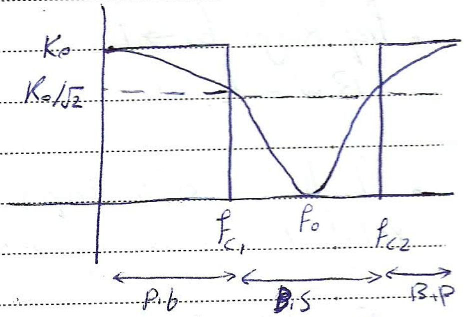
- L.P.F max gain at $W = 0$
  H.P.F " " $W = \infty$
  B.P.F " " $W = W_o = 2\pi f_o$

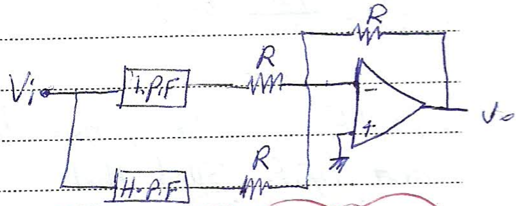
njpb

V_i → [L.P.F] → [H.P.F] → V_o

Subject .... / /

(4) Band stop or Band reject (B.S.F, B.R.F) :-





بنجمعهم ما بنطرحهم زي ال B.P

* Filter transfere fn. :- $H(s) = \frac{V_o(s)}{V_i(s)}$

$H(s) = \frac{N(s)}{D(s)}$; $N(s)$: Indecates filter responce (L.P.F, H.P.F, B.P.F, B.S.F).

ⓐ if $N(s)$ Contain Constant (5, 10, 100) ⇒ L.P.F

ⓑ " " " (S) term (5S, 10S) ⇒ B.P.F

ⓒ " " " (S^2) term ($10S^2$) ⇒ H.P.F

ⓓ " " " (Constant + S^2) term ⇒ B.S.F

* لو كان عنا مثلاً (Constant + S)
حيصير L.P + B.P

; $D(s)$: Indecates the order of the filter (1^{st}, 2^{nd}, 3^{rd}) order.

order: the highest power of (S) in $D(s)$

ex. Indicates the order of $D(s)$:

① $D(s) = s^2 + 2s + 1$: 2^{nd} order

② $D(s) = s^3 + 2s^2$ 3^{rd} order

Ex. Identify type and order of the following filter T.F:-

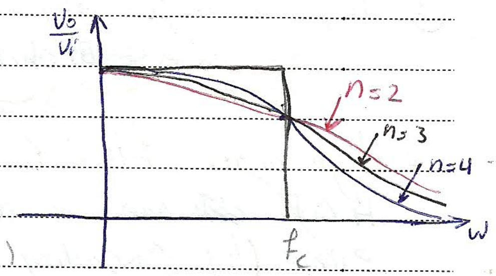
$H(s) = \dfrac{5s^2+3}{2s^2+5s+1}$ (2^{nd} order) (B.~~P~~ S.F)

$H(s) = \dfrac{\sqrt{2}\, s}{s^3+2s^2+1.5s} = \dfrac{\sqrt{2}}{s^2+2s+1.5}$ (2^{nd} order) (L.P.F)

~~~ * ~~~ * ~~~

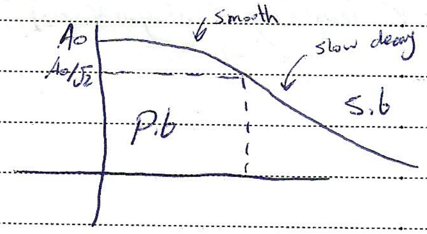
* **Filter's order :-**

- As filter order ⓝ inc↑, the responce will be ~~closer~~ Closer to ideal responce. but at the ( ) of filter complexty. على حساب



- According to filter responce there are two types:-

① Butterworth Responce:-
Smooth pass band but slow decay...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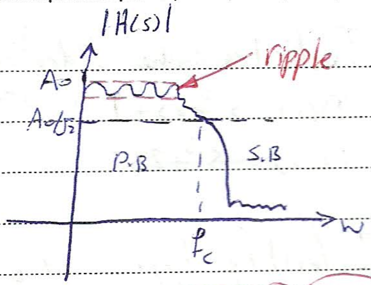
Subject .... / /

② chebyshave responce :-
Not smooth resp. in P.B
(there is a ripple in P.B)
but it has a sharp decay
in S.B.



* عاد أقرب للـ Ideal

* اذا بدي مثلا عند الـ cutoff يكون sharp الأفضل cheb. واذا بدي يكون smooth بستخدم الأول (Bultwor).

. تصنيف الـ Filter حسب الـ .

① relazation: A) passive
B) Active

② Freq. range: A) L.P.F.
B) H.P
c) B.P d) B.S

③ responce shape:- A) Bulterworth
B) chebyshave

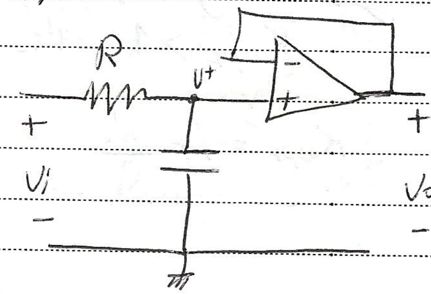
* High order filter realization:-
. H.O.F. can be realised either (by Cascading 2^{nd} order and 1^{st} order) or (Using a certain Configuration such as follow the leader Config. (F.L.F) or leap frog configurations)

Cascade $2^{nd} + 2^{nd} = 4^{rth}$ order
Cascade $2^{nd} + 1^{st} = 3^{rd}$ order

. بنقدر نحصل على أي order عن طريق cascade 1^{st} & 2^{nd} للحصول على order فردي أو 2^{nd}'s للحصول على order زوجي ..

* 1^{st} order Filter (one pole)

① L.P.F :-



A) Unity gain

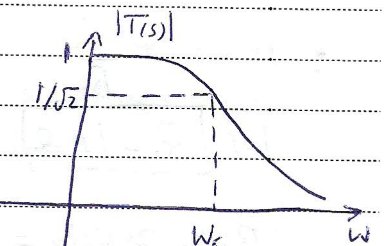
$$V^+ = V_o = \frac{V_i \frac{1}{sC}}{R+\frac{1}{sC}}$$

$$\frac{V^+}{V_i} = \frac{1}{1+RSC}$$; $S = jW$, $V^+ = V^o$ (buffer)

$$\frac{V_o}{V_i} = T(s) = \frac{1}{1+SCR}$$ ⇒ for $S=0$ ⇒ $|T(s)| = 1$

for $S=\infty$ ⇒ $|T(s)| = 0$

⇒ L.P.F



W_c → freq. at wich $|T(s)| = \frac{K_{LPF}}{\sqrt{2}}$

$$|T(s)| = \frac{1}{\sqrt{1^2+(WRC)^2}}$$

at $W = W_c$ ⇒ $|T(s)| = \frac{1}{\sqrt{2}}$

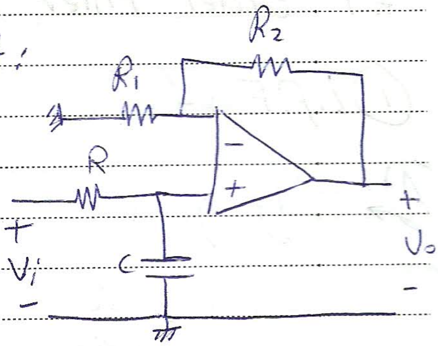
⇒ $1 + W_c^2R^2C^2 = 2$ ⇒ $W_c^2 = \frac{1}{R^2C^2}$ ⇒ $\boxed{W_c = \frac{1}{RC}}$

⇒ $f_c = \frac{1}{2\pi RC}$

Subject .... / /

B) → For gain >1 ;

$K_{OLPF} > 1$; Use this cct :



$$K_{OLPF} = 1 + \frac{R_2}{R_1}$$

Ex. Design a first order L.P.F. with again of 20dB and abandwidth of (20) KHz ?

• $K(dB) = 20 \log \frac{V_o}{V_i} \Rightarrow 20 = 20 \log\left(\frac{V_o}{V_i}\right)$

$\Rightarrow \log\left(\frac{V_o}{V_i}\right) = 1 \Rightarrow \boxed{\frac{V_o}{V_i} = 10 = |T(s)|}$

• $10 = 1 + \frac{R_2}{R_1}$

let $\boxed{R_1 = 1K\Omega} \Rightarrow \boxed{R_2 = 9K\Omega}$

• $B.W = 20KHz = f_c$; $f_c = \frac{1}{2\pi RC}$,

let $\boxed{C = 0.001\mu F} \Rightarrow R = \frac{1}{(2\pi)(2\times10^4)(0.01\times10^{-7})} = \boxed{800\Omega}$

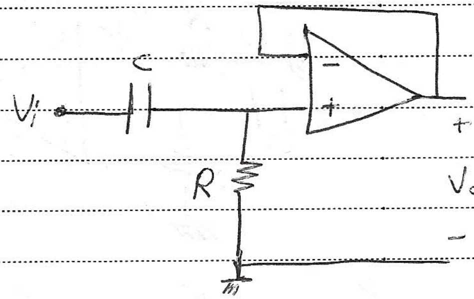
* Note :-

(Unity gain) ≡ (Zero dB) ≡ (max gain = 1)

Subject .... / /

② High pass filter :-

optain by changing ~~every~~ each (R by c) & each (c by R) transformation...



A) Unity gain :-

- $f_c = \frac{1}{2\pi RC}$

- $V^+ = V_o$; $V^+ = \frac{V_i R}{R + \frac{1}{sc}}$

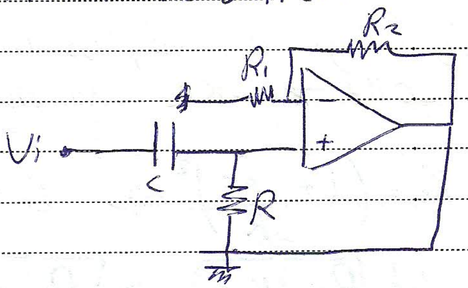
$\Rightarrow \frac{V_o}{V_i} = \frac{SCR}{1+SCR}$; when $S=\infty \Rightarrow |T(s)| = 1$

when $S=0 \Rightarrow |T(s)| = 0$

∴ H.P.F

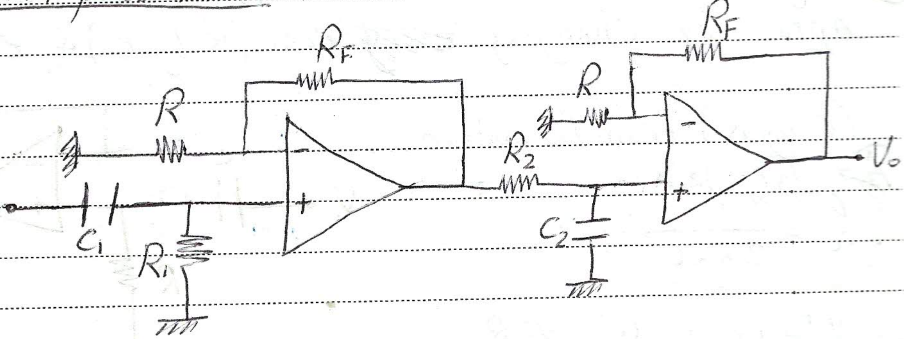
B) For gain > 1, Use Risistors in the buffer :-

$K_{o\,H.P.F} = \left(1 + \frac{R_2}{R_1}\right)$



Subject .... / /

③ Band pass filter :-



• $K_{oBPF} = K_{oLPF} \cdot K_{oHPF}$

$$= \left(1 + \frac{R_F}{R}\right)^2$$

• $f_{cL} > f_{cH}$ • $f_{cL} = \dfrac{1}{2\pi R_2 C_2}$ • $f_{cH} = \dfrac{1}{2\pi R_1 C_1}$

Ex. Design a band pass to have B.W. Ranging from 20 Hz → 20 KHz and max. gain of 25?!?

• $K_o = \left(1 + \frac{R_F}{R}\right)^2 \Rightarrow 5 = 1 + \frac{R_F}{R} \Rightarrow \frac{R_F}{R} = 4$

let $\boxed{R = 1K\Omega} \Rightarrow \boxed{R_F = 4K\Omega}$ ...

• for H.P.F $f_{cH} = 20\,Hz$, $f_{cH} = \dfrac{1}{2\pi R_1 C_1} = 20\,Hz$

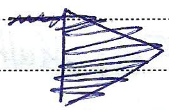
let $C_1 = 1\mu F \Rightarrow R_1 = \dfrac{1}{(2\pi)(1\times10^{-6})(20)} = \boxed{8K\Omega}$

• For L.P.F $f_{c1} = 20KHz \Rightarrow 20\times10^3 = \frac{1}{2\pi R_2 C_2}$

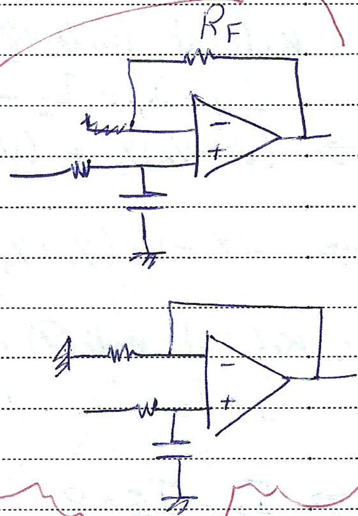
let $C_2 = 0.01\mu F \Rightarrow R_2 = \frac{1}{2\pi(20\times10^3)(0.01\mu)} = 800\,\Omega$

* Note :-

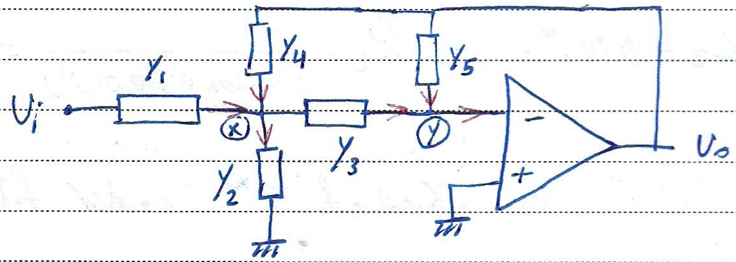
The B.P.F is a kind of 2^{nd} order filters ...



These 2 op-Amp's are buffers not Amplifieres i.e. $\boxed{\text{gain} = 1}$



* Second order filters :- (Two poles)



"General 2^{nd} order filter"

- MLNFB (Multible loop Negative feed back)

- Kcl at node x :-

$$I_4 + I_1 = I_2 + I_3$$

$$\Rightarrow (V_i - V_x)Y_1 + (V_o - V_x)Y_4 = Y_2 V_x + (V_x - \overset{V^-}{V_y})Y_3$$

$$\Rightarrow V_i Y_1 - V_x(Y_1 + Y_4 + Y_2 + Y_3) + V_o Y_4 + V^- Y_3 = 0 \quad --- (1)$$

- Kcl at node y :-

$I_3 + I_5 = I_{in}$; $I_{in} = 0$ for Ideal Amp. ($V^- = 0$ (V.G))

$$\Rightarrow I_3 + I_5 = 0 \Rightarrow (V_x - V^-)Y_3 + (V_o - V^-)Y_5 = 0$$

$$\Rightarrow V_x = \frac{-Y_5}{Y_3} V_o \quad --- (2)$$

sub ② in ① :-

$$V_o Y_4 + V_o \frac{Y_5}{Y_3}(Y_1+Y_2+Y_3+Y_4) = -V_i Y_1$$

$$V_o(Y_3Y_4 + Y_5Y_1 + Y_5Y_2 + Y_5Y_3 + Y_5Y_4) = -V_i Y_1 Y_3$$

$$\Rightarrow \frac{V_o}{V_i} = T(s) = \frac{-Y_1Y_3}{Y_3Y_4 + Y_5(Y_1+Y_2+Y_3+Y_4)}$$

∴ This cct Can be Used to velize 2^{nd} order L.P.F , H.P.F , B.P.F according to the type of Y_1, Y_2, Y_3, Y_4, Y_5 either vesistor or Capasitor...

① To velize L.P.F by MLNF.b :-

$$T(s) \text{ of L.P.F} = \frac{K_1}{s^2+K_2s+K_o} = \frac{-Y_1Y_3}{Y_3Y_4 + Y_5(Y_1+Y_2+Y_3+Y_4)}$$

$$\Rightarrow Y_1 = G_1 , Y_3 = G_3 , Y_4 = G_4 , Y_5 = SC_5$$

$$Y_2 = SC_2 \ldots$$

$$\Rightarrow T(s) = \frac{-G_1G_3}{G_3G_4 + SC_5(G_1+G_3+G_4) + S^2C_2C_5}$$

Subject .... / /

$$\therefore\ T(s) = \frac{-\frac{G_1 G_3}{C_2 C_5}}{S^2 + \frac{G_1+G_3+G_4}{C_2} S + \frac{G_3 G_4}{C_2 C_5}}$$ L.P.F 2nd order

- $K_{oLPF} = |T(s)|_{W=0 \Rightarrow S=0}$ ~~W=S=0~~

$$\Rightarrow K_{oLPF} = \frac{G_1 G_3}{C_2 C_5} \cdot \frac{C_2 C_5}{G_3 G_4} = \frac{G_1}{G_4} = \boxed{\frac{R_4}{R_1}}$$

- Compare (1) with standard 2nd order sys. equation.

$$T(s) = \frac{K}{S^2 + \frac{W_o}{Q} S + W_o^2}$$

W_o reprecents:-
1. cut off freq (f_c) for HPF and LPF.
2. center freq. (f_o) for B.P.F.

$$\Rightarrow W_o^2 = \frac{G_3 G_4}{C_2 C_5} = \frac{1}{R_3 R_4 C_2 C_5}$$

$$\Rightarrow f_c = \frac{1}{2\pi\sqrt{R_3 R_4 C_2 C_5}}$$ cutoff freq. of L.P.F

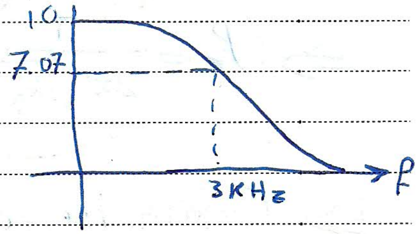
Subject .... / /

Ex. Design 2nd order LPF to have max. gain of (10) and Cut off. freq. of 3KHz, plot frequancy responce?

- $K_o = \frac{R_4}{R_1} = 10$, let $\boxed{R_1 = 1K\Omega} \Rightarrow \boxed{R_4 = 10K\Omega}$

- Use equal. Cap. design, $C_2 = C_5 = C = 0.01\mu F$.

$$f_o^2 = \frac{1}{4\pi^2 R_3 R_4 C_2 C_5} \Rightarrow R_3 = \frac{1}{4 \times \pi^2 \times 9\times10^6 \times 10^4 \times 10^{-16}} = \boxed{2.8K\Omega}$$



② To Realize 2nd order H.P.F :-

Choose $Y_1 = C_1$, $Y_3 = C_3$, $Y_4 = C_4$, $Y_2 = G_2$, $Y_5 = G_5$

(CoR from $C \rightarrow R$, $R \rightarrow C$) transformation.

$$T(s) = \frac{-C_1 C_3 S^2}{C_3 C_4 S^2 + G_5(C_1 + C_3 + C_4)S + G_5 G_2}$$

$$= \frac{-\frac{C_1 C_3}{C_3 C_4} S^2}{S^2 + \frac{G_5(C_1 + C_3 + C_4)}{C_3 C_4} + \frac{G_5 G_2}{C_3 C_4}}$$

njpb

Subject .... / /

• Compare $T(s)$ with standard 2^{nd} sys. equation...

$$K_{oHPF} = |T(s)|_{w=\infty \Rightarrow s=\infty}$$

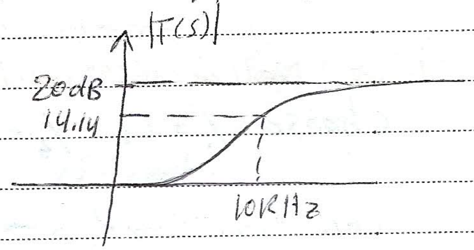
$$\Rightarrow K_{oHPF} = \frac{C_1 \cancel{C_3}}{\cancel{C_3} C_4} = \boxed{\frac{C_1}{C_4}}$$

هو ما بنقدر نستخدم equal cap. design بال لأنه رح يطلع ال gain=1

$$\bullet\ W_o^2 = \frac{1}{R_5 R_2 C_3 C_4}$$

$$\Rightarrow f_c = \frac{1}{2\pi\sqrt{R_5 R_2 C_3 C_4}}$$

Ex. Design the cct to give The freq. responce shown:-



$$20 = 20 \log \cancel{|T(s)|} K_o$$

$$\Rightarrow \boxed{K_o = 10}$$

$$\frac{C_1}{C_4} = 10,\ \text{let } \boxed{C_1 = 10\,\mu F} \Rightarrow \boxed{C_4 = 1\,\mu F}$$

$$\bullet\ \text{let } R_5 = R_2 = 1K\Omega \Rightarrow C_3 = \frac{1}{4\pi^2 f_c^2 R_5 R_2 C_4}$$

$$= \frac{1}{4\pi^2 (10\times10^3)^2 (10^6)(1\times10^{-6})}$$

$$= \cancel{253} \boxed{253.3\ PF}$$

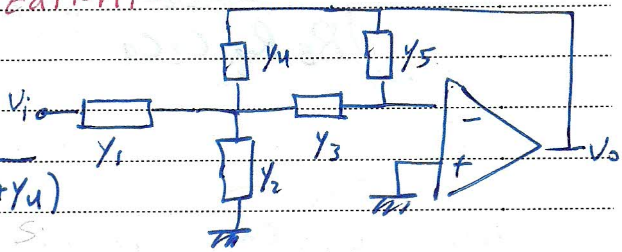
njpb

اذا كان $10dB = T(s)$

يعني $gain = 1 \Rightarrow C_1 = C_4$

Subject .... / /

③ For B.P.F Relization:-



$$T(s) = \frac{-Y_1 Y_3}{Y_3 Y_4 + Y_5(Y_1+Y_2+Y_3+Y_4)}$$

- Y_1 OR Y_3 must be cap.

$Y_1 = G_1$, $Y_3 = SC_3$, $Y_4 = SC_4$, $Y_2 = G_2$, $Y_5 = G_5$ ...

$$\Rightarrow T(s) = \frac{-G_1 S C_3}{S^2 C_3 C_4 + G_5(G_1+G_2) + S G_5 (C_3 + C_4)}$$

$$\Rightarrow T(s) = \frac{\frac{-G_1}{C_4} S}{S^2 + \frac{G_5(G_1+G_2)}{C_3 C_4} + S\frac{G_5(C_3+C_4)}{C_3 C_4}}$$

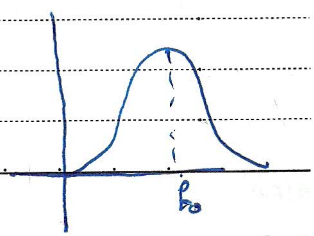
- Compare to standard 2nd order sys. eq^n

$$H(s) = \frac{KS}{S^2 + \frac{W_o}{Q} S + W_o^2}$$

$$\therefore W_o^2 = \frac{G_5(G_1+G_2)}{C_3 C_4} = \frac{\left(\frac{1}{R_1}+\frac{1}{R_2}\right)}{R_5 C_3 C_4} = \frac{\frac{R_1+R_2}{R_1 R_2}}{R_5 C_3 C_4}$$

$$= \frac{1}{R_5 C_3 C_4 (R_1 // R_2)}$$

$$\therefore W_o^2 = \frac{1}{R_5 C_3 C_4 R_{eq}}$$



njpb

Subject .... / /

$$\Rightarrow W_0 = \frac{1}{\sqrt{R_5 R_{eq.} C_3 C_4}} \Rightarrow f_0 = \frac{1}{2\pi\sqrt{R_5 R_{eq.} C_3 C_4}}$$

f_0 : center freq.

- $\frac{W_0}{Q} = \frac{C_3 + C_4}{R_5 (C_3 C_4)} = B.W$ (band width of filter)

- $Q = \frac{Q}{W_0} W_0 = \frac{R_5 (C_3 C_4)}{C_3 + C_4} \cdot \frac{1}{\sqrt{R_5 R_{eq} C_3 C_4}}$

$$= \frac{\sqrt{R_5 C_3 C_4}}{(C_3 + C_4)\sqrt{R_{eq}}}$$

- $K_{o\,B.P.F} = |T(s)|_{W = W_0}$

$$H(s) = \frac{K s}{s^2 + \frac{W_0}{Q} s + W_0^2}$$

$$= \frac{K Q}{W_0}$$

$$H(s)\Big|_{W = W_0} = \frac{K s}{(jW_0)^2 + \frac{W_0}{Q} s + W_0^2}$$

$$= \frac{G_1}{\cancel{C_4}} \cdot \frac{\cancel{C_3 + C_4}}{\cancel{R_5 (C_3 C_4)}} \cdot \frac{R_5 C_3 \cancel{C_4}}{C_3 + C_4}$$

$$= \frac{K \cancel{s}}{\cancel{-W_0^2} + \frac{W_0}{Q} \cancel{s} + \cancel{W_0^2}}$$

$$K_{o\,B.P.F} = \boxed{\frac{R_5}{R_1} \frac{C_3}{C_3 + C_4}}$$

$$= \frac{K Q}{W_0}$$

$$\frac{\Omega}{\Omega} + \frac{F}{F} = 1$$ "dosen't have a Unit" ✓

• For equal Cap. design ($C_3 = C_4 = C$):

$$K_{o\,B.P.F} = \frac{R_5}{2R_1}$$ ← سالب ومان (ح)

$$f_o = \frac{1}{2\pi C\sqrt{R_5 R_{eq.}}} \quad , \quad Q = \sqrt{\frac{R_5}{4R_{eq}}}$$ سالب ومان (ح)

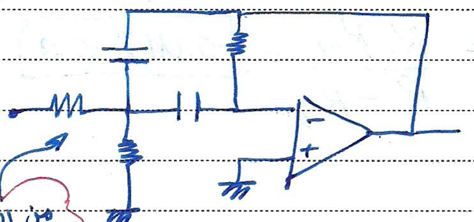
$$\frac{1}{C\cdot R} = \frac{1}{\Omega\cdot F} = f_{req.}$$ Hz

• f_o, Q, B.W are related by:-

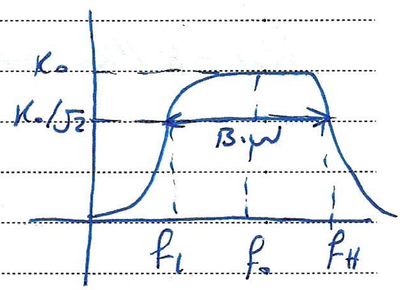
$$Q = \frac{f_o}{B.W} \; ; \text{ where } f_H - f_L = B.W$$

* For symmetric responce :-

$$f_H = f_o + \frac{B.W}{2} \quad , \quad f_L = f_o - \frac{B.W}{2}$$



من الناحية
العملية لا نفصل
أو نوصل (C)
عند ال
input Voltage ...



Subject ....   /   /

Ex. Design a 2^{nd} order B.P.F to give a center frequancy, $f_o = 20\,KHz$, $Q = 10$, $K = 20\,dB$ and sketch freq. responce (bode plote) Use equal Cap. design with $C = 1nF$?!?

- $\frac{W_o}{Q} = B.W = \frac{C_3 + C_4}{R_5 C_3 C_4} = \frac{2C}{R_5 C^2} = \frac{2}{R_5 C}$

$\Rightarrow \frac{2\pi \times 20 \times 10^3}{10} = \frac{2}{10^{-9} R_5} \Rightarrow \boxed{R_5 = 159\,K\Omega}$

- $20 = K_{dB} = 20 \log K \Rightarrow \boxed{K_o = 10}$

- $K_o = \frac{R_5}{2R_1} \Rightarrow 10 = \frac{159}{2R_1} \Rightarrow \boxed{R_1 = 7.95\,K\Omega}$

- $Q^2 = \frac{1}{4} \frac{R_5}{R_{eq}} \Rightarrow R_{eq} = \frac{R_5}{4Q^2} = \frac{159}{400} = \boxed{0.397\,K\Omega}$

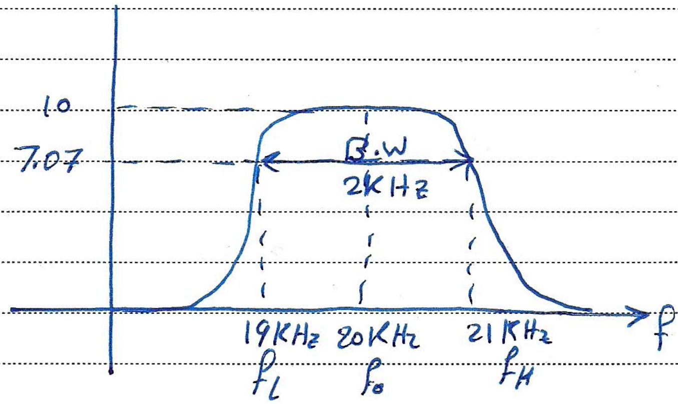
$R_{eq} = R_1 // R_2 \Rightarrow R_2 = \frac{R_1 R_{eq}}{R_1 - R_{eq}} = \boxed{0.417\,K\Omega}$

Subject .... / /

- $B.W = \frac{f_o}{Q} = \boxed{2\,KHz}$

- $f_H = f_o + 1\,KHz = \boxed{21\,KHz}$

- $f_l = f_o - \frac{B.W}{2} = \boxed{19\,KHz}$



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