تقدم لجنة ElCoM الاكاديمية

دفتر لمادة:

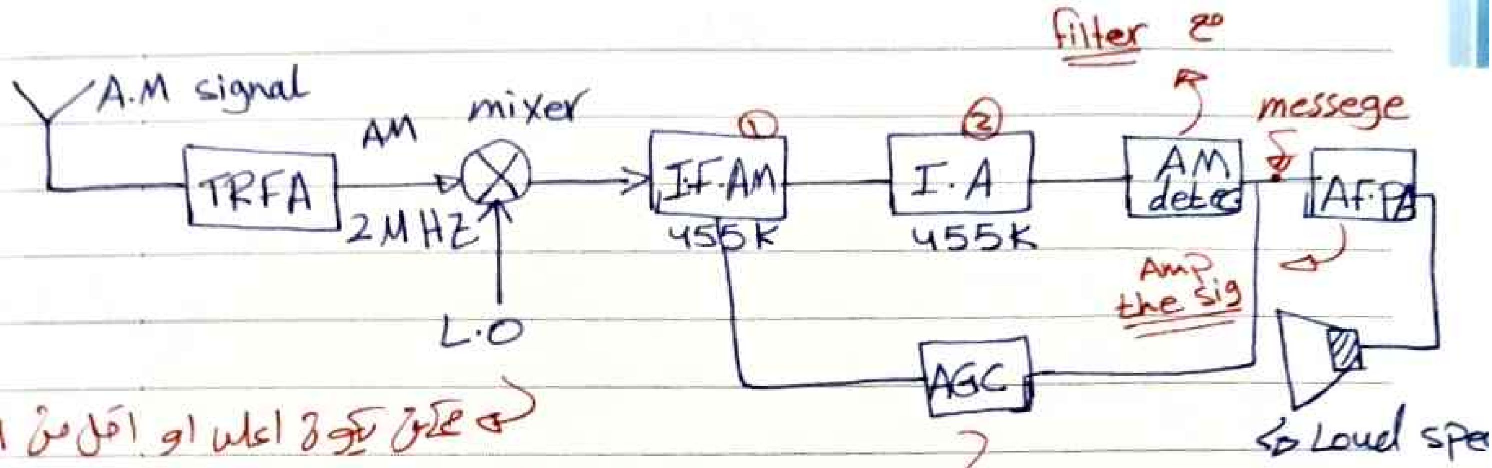
الكترونيات الاتصالات

من شرح:

د. هادي العيثاوي

جزيل الشكر للطالب:

محمد صباح



← عكس يكون اعلى او اقل من 2M

f_1+f_2 OR f_1-f_2 OR $2f_1$ OR $2f_2$

Auto Gain controller

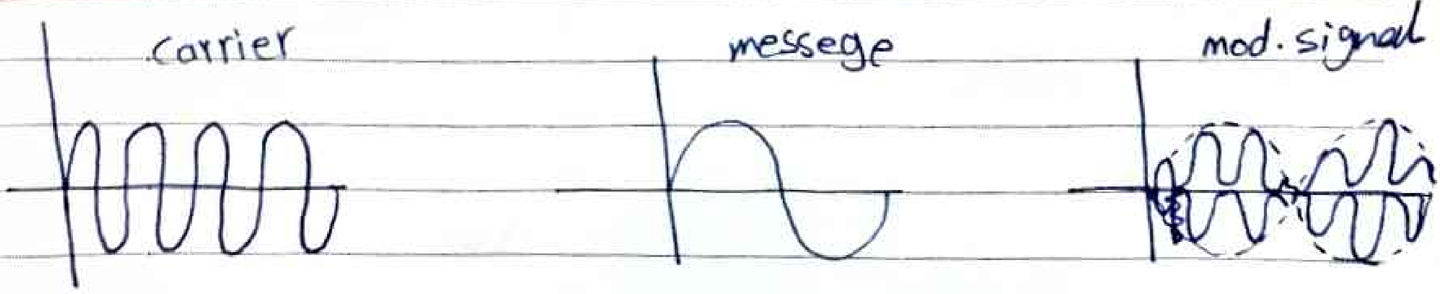
← اذا ال mess. كانت كبيرة بتفوت على AGC ويعطيني -ve feed back ويقلل ال Gain ل ①&② ويصير تقل

والعكس صحيح اذا دخل عندي قوة قليلة جدًا اقل من ال DC

oscillators

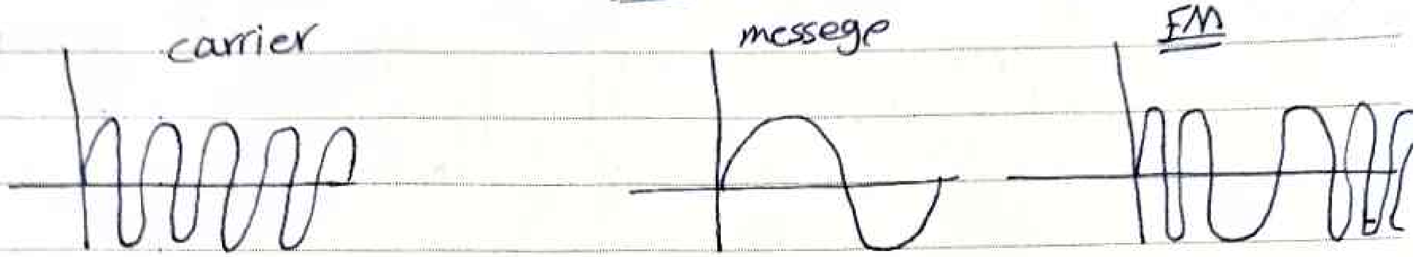
- LR osci. ← بتأثرو بدرجة الحرارة والعمر
- Rc oscill.
- crystal osci.

AM-modulation



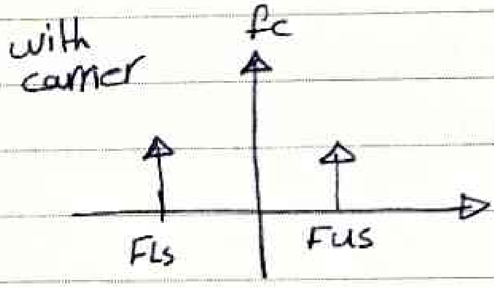
* crystal oscillator ⇒ ما بتأثر بدرجة الحرارة ولا بالعمر

FM



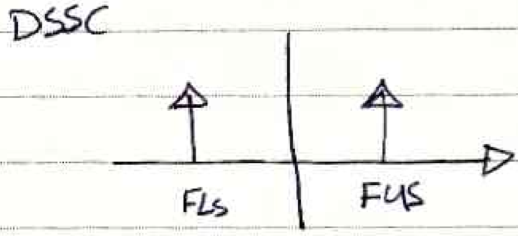
$F_c \Rightarrow$ 50% Power $\Leftarrow$

F_{ls} & F_{us} $\Rightarrow$ 25 & 25%

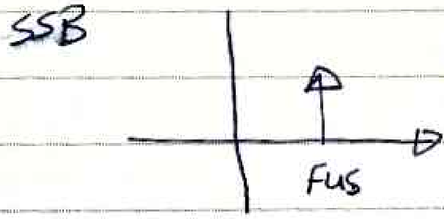


$P_T = 60\,W$

F_{ls} & F_{us} $\Rightarrow$ 50% power $\Leftarrow$



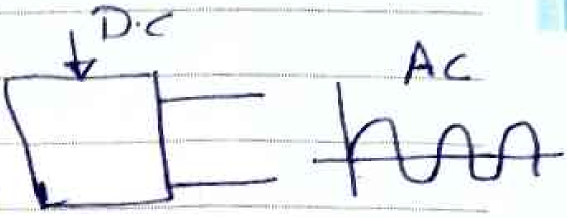
F_{us} $\Rightarrow$ 100% Power $\Leftarrow$



B → function of frequency
→ frequency dep. element (L & C or RL or RC)

3

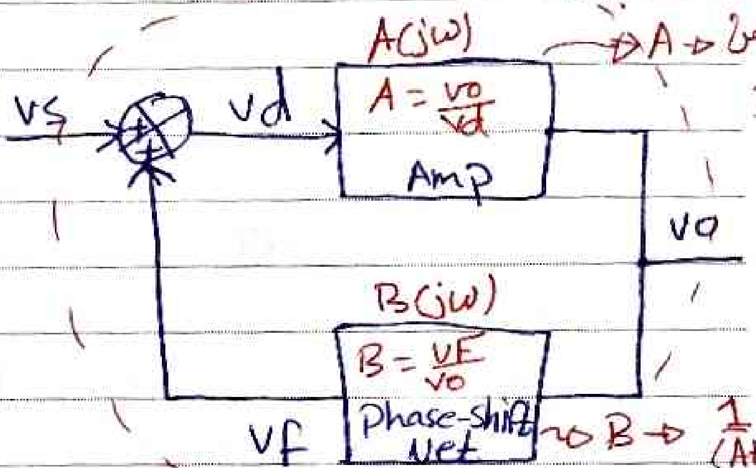
* **oscillators** (signal generator)



(1) Electronic cct produces an Periodic A.C signal with a certain Amplitude & frequency, without A.C input signal only D.C is required for biasing the Active Devices.

(2) It is a feedback Amp contains Amplifier & Phase shift Network (The F.B is Positive F.B).

$vd = vs + vf$ (+ve F.B) ✓
$vd = vs - vf$ (−ve F.B)



A → أكبر من 1

B → أقل من 1 (Attenuation)

→ F.B Amp

$vo = A(jw) \cdot vd$
$vd = vs + vf$
$vf = B(jw) \cdot vo$

$\Rightarrow vo = A(jw)\,[vs + B(jw)\,vo]$
$\quad = A(jw)\,vs + A(jw)B(jw)\,vo$

A or B →
(1) * op-Amp → INV / non-INV
(2) * BJT → C.E / C.B
(3) * mosfet → C.S / C.G

$vo * (1 - A(jw)B(jw)) = A(jw) \cdot vs$

gain for F.B Amp

$$\frac{vo}{vs} = A_F = \frac{A(jw)}{1 - A(jw)B(jw)}$$

if $A(jw)B(jw) = 1$, then $A_F = \infty = \frac{vo}{vs}$

either $vo = \infty$ OR $vs = 0$

لكي تعوض [illegible]
بعطيني $A > 1$

* تصبح الدائرة oscillator اذا كانت ال Amp ال $A*B = 1$
أيضاً يجب ان تكون حاصل جمع ال phase يساوي $0°$ or $360°$

دارة تعطيني OR بدون I/P بس محتاجة DC I/P عشان اغذي الدارة
$\Rightarrow$ for biasing.

but v_o can't be ∞ so v_s must be Zero
i.e the cct will give v_o without v_s (No I/P).

* oscillation conditions

① mag. condition :- $|A(jw)| \cdot |B(jw)| = 1$, ~~n2π~~
② Phase condition :- $\angle A(jw) + \angle B(jw) = 0, n2\pi$; n :- Intiger
$A \rightarrow$ gain > 1
$B \rightarrow$ Attenuation < 1

* to satisfy oscillation condition
1) $A = \frac{1}{B}$

2) $\angle A + \angle B = 360$

either A & B $\rightarrow$ Inverting (gives $180°$)
or A & B $\rightarrow$ non-Inverting (gives zero)

since $A \rightarrow A(jw)$, $B \rightarrow B(jw)$
at a certain value of w, The oscillator condition will be satisfied. This value is called freq of oscillator w_o

① RC-oscillator
B cct $\rightarrow$ RC cct
Amp cct $\rightarrow$ BJT Amp, FET Amp, OP-Amp $\Rightarrow$

- kcL at node ⓒ $\Rightarrow I_1 = I_f^{\approx 0} + I_2 \Rightarrow \frac{0 - V^-}{R_1} = \frac{V^- - V_o}{R_2}$, $V^- = V^+ = V_d$

$\Rightarrow \frac{0 - V_d}{R_1} = \frac{V_d - V_o}{R_2} \Rightarrow \frac{V_o}{V_d} = \left(1 + \frac{R_2}{R_1}\right)$ → non-Inv. op-Amp. ✓

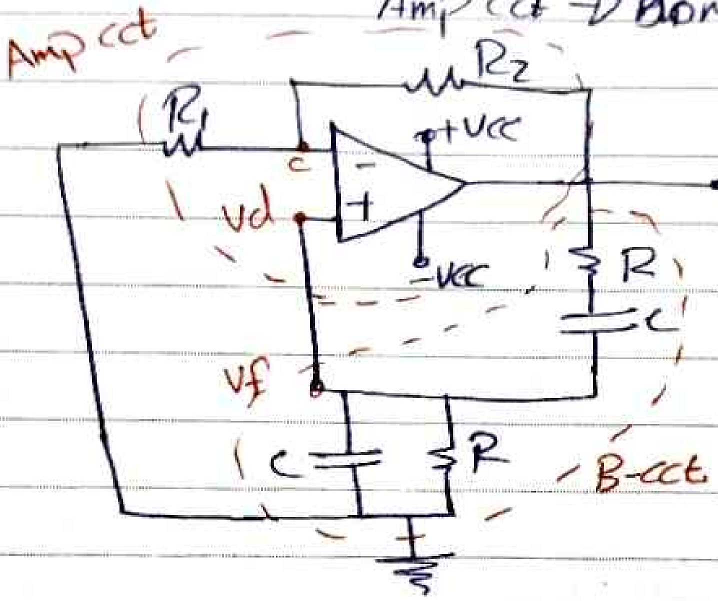
$\boxed{5}$

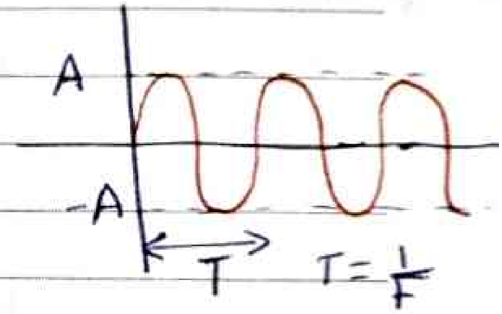
---

* WIEN – Bridge oscillator:-

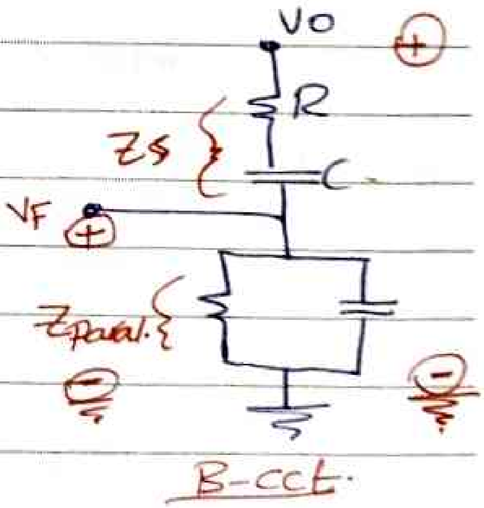
in this oscillator → B cct → gives Zero phase

Amp cct → Non-Inverting gives Zero phase





$$B = \frac{V_f^{\to o/p}}{V_{o \to i/p}} = \frac{Z_P}{Z_P + Z_S}$$



- $Z_S = R + \frac{1}{j\omega C}$

- $Z_P = \frac{R \cdot \frac{1}{j\omega C}}{R + \frac{1}{j\omega C}} = \frac{R}{1 + j\omega CR}$

$$\Rightarrow B = \frac{\frac{R}{1 + j\omega CR}}{\frac{R}{1 + j\omega CR} + R + \frac{1}{j\omega C}} * (1 + j\omega CR) = \frac{R}{R + \left(R + \frac{1}{j\omega C}\right)(1 + j\omega CR)}$$

$$B = \frac{R}{R + R(1 + j\omega CR) + \frac{1}{j\omega C}(1 + j\omega CR)}$$

$\Rightarrow$

or * 2 C.E $\Rightarrow 2 * 180° = 360°$
* 2 C.S

6

$$\Rightarrow B = \frac{R}{R + R + jwCR^2 + \frac{1}{jwC} + R}$$

$$B = \frac{R}{3R + j\left(wCR^2 - \frac{1}{wC}\right)}$$

* since Amp is Non-inverting & gives $\phi = 0°$ so $\underline{B}$ cct must give $\phi = 0°$, to satisfy phase-condition

* B-cct will give Zero phase when J-Term = 0

$\Rightarrow wCR^2 = \frac{1}{wC}$

$w^2C^2R^2 = 1 \Rightarrow w_o = \frac{1}{RC}$

$\Rightarrow f_o = \frac{1}{2\pi RC}$, freq of oscillator

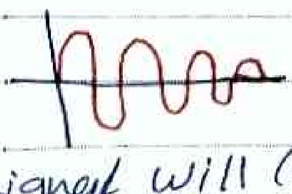
$\Rightarrow$ at this freq. $B = \frac{R}{3R} \Rightarrow B = \frac{1}{3}$, to satisfy $|BA| = 1 \Rightarrow$ so $A_{min} = 3$.

- For NoN-Inverting Amp

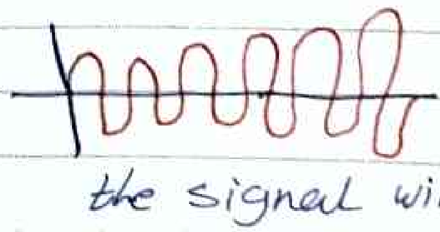
$A = 1 + \frac{R_2}{R_1} = 3 \Rightarrow \left(\frac{R_2}{R_1}\right)_{min} = 2$

$\Rightarrow R_2 = 2R_1$

* IF ▫ BA < 1 ▫ BA >> 1



the signal will (o/p) be damped



the signal will be out of controll (unstable)

$\Rightarrow$

* Practically (for design purpose) we should make $|A\beta|$ over than 1 by 5% to avoid ~~to~~ ~~to~~ Loss (gain شرط ال عشان)

7

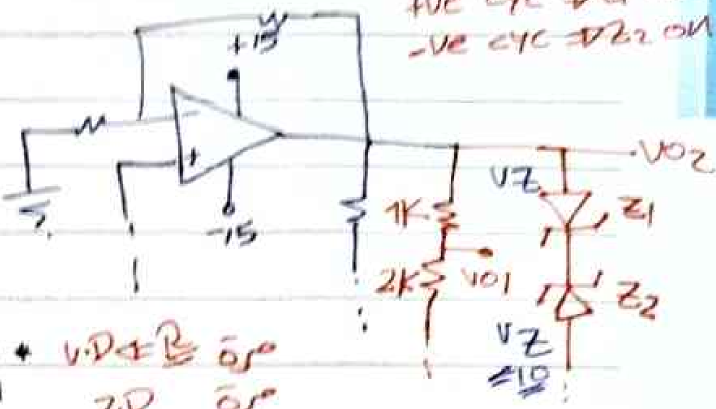
desired o/p

$V_{O1} = \frac{15 \cdot 2K}{3K} = 10K$

+ve cyc

$V_{O2} = V_{Z_1} + V_{A_2}$ (Ideal)

+ve cyc D_{Z1} on
-ve cyc D_{Z2} on



* مرة V.D + β + k بركب ZD او Volt.Reg عشان 8 اخذ
مرة ZD ال o/p اللي بديا اياه

EX:- Design a WIEN-Bridge oscillator to give 20KHz o/p use op-Amp, $f_o = \frac{1}{2\pi RC}$

Let $C = 0.01\,\mu F$.

* صورة هو اعطاني الـ R

$R = $ _ _ (B-cct)

* IN W.B $\left(\frac{R_2}{R_1}\right)_{min} = 2$

Let $R_1 = 1K\Omega$ (Amp cct), $R_2 = 2R_1$

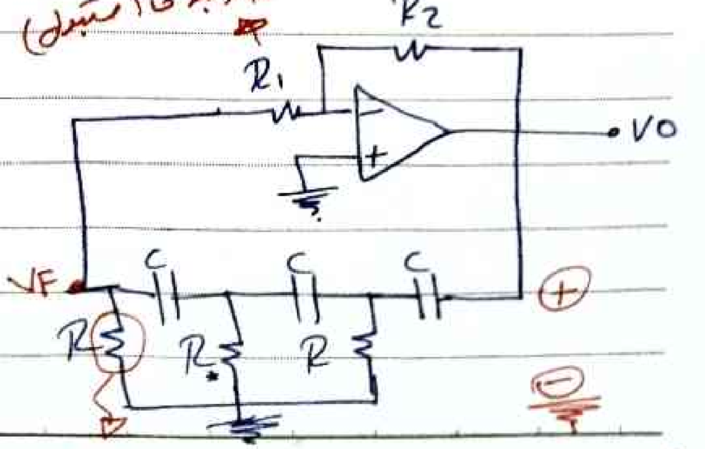
$\therefore R_2 = 2K\Omega$

② Phase-shift oscillator

Amp → 180°, B-cct → 180°

$R_1 \parallel R = R_*$

R (بعد ما ستبدل)



* هنا ال R's بيعطوني 180° بحيث كل وحدة منهم بتعطيني 60°
بحيث انه ما دوائر ال Rc
ال max. shift = 90°
فبفرض انه بيعطيني 60° درجة
عشان 2 يصعب اوصل ال Ideal

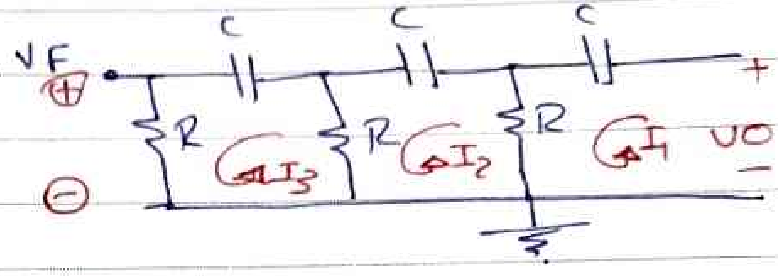
* بصير اتحكم بقيمة المقاومة و استبدل R_1 و R بحيث انه 2 تشتغل تشغيل

→ ① gain for op-Amp ② phase shift = 60°

* هنا في هذه ال cct ال VF راجعة على ال VC بسبب بالاصل تمر بال Rc cct ويصير فيه phase shift

يعني $180° + 180° = 360°$ $\boxed{8}$ → +ve F.B

$$B = \frac{V_F}{V_O}$$



$$I_1\left(R + \frac{1}{j\omega C}\right) - I_2 R = V_O \quad (1)$$

$$I_2\left(2R + \frac{1}{j\omega C}\right) - I_1 R - I_3 R = 0 \quad (2)$$

$$I_3\left(2R + \frac{1}{j\omega C}\right) - I_2 R = 0 \quad (3)$$

$$V_F = I_3 R \quad (4)$$

$$\rightarrow \omega_0 = \frac{1}{\sqrt{6}\, RC} \quad , \quad \therefore f_0 = \frac{1}{2\pi\sqrt{6}\, RC}$$

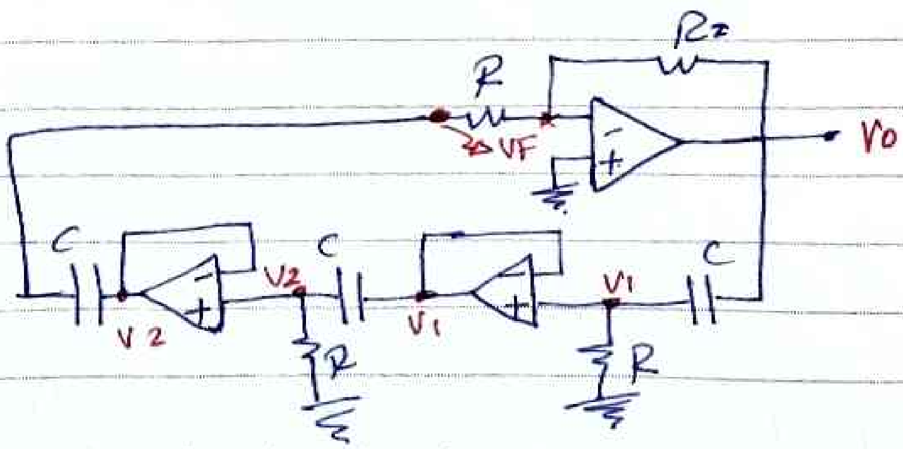
→ freq. of oscillator

* in this cct $\Rightarrow B = \frac{-1}{29}$, $|B| = \frac{1}{29}$

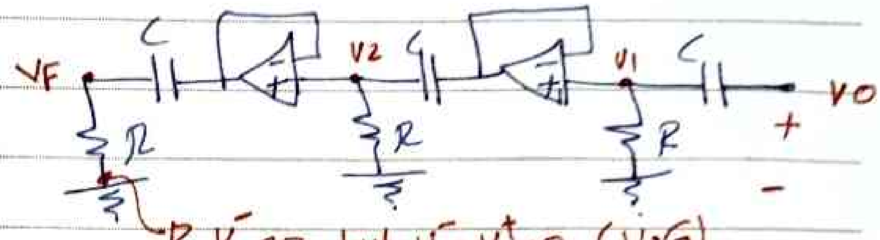
to satisfy $|BA| = 1$ → $A_{min} = 29$

for Inv. Amp → $A = \frac{-R_2}{R_1}$, $\therefore \left(\frac{R_2}{R_1}\right)_{min} = 29$

* with no Load effect a voltage follower (Buffer) is used



$$B = \frac{V_f}{V_o} = \frac{V_f}{V_2} * \frac{V_2}{V_1} * \frac{V_1}{V_o}$$



$$\Rightarrow \frac{V_1}{V_o} = \frac{R}{R + \frac{1}{jwC}} \quad (V\cdot D)$$

$\Rightarrow V^- \approx 0$ but $V^- = V^+ = 0$ ($V\cdot G$)

$$= \frac{1+jwCR}{1+jwCR} = \frac{V_2}{V_1} = \frac{V_f}{V_2}$$

$$\Rightarrow B = \left(\frac{jwCR}{1+jwCR}\right)^3 = \frac{j^3 w^3 C^3 R^3}{(1+jwCR)(1+jwCR)^2}$$

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

*since Amp is inverting & gives 180° so B-cct must give 180° to satisfy $\angle A + \angle B = 360$; B will give 180° when Real term $= 0$

$$1 - 3R^2C^2w^2 = 0$$

$$\therefore w_o = \frac{1}{\sqrt{3}RC} \quad \Rightarrow \therefore f_o = \frac{1}{2\pi\sqrt{3}RC} \Rightarrow \text{freq. of oscillation.}$$

$\Rightarrow$ at this frequency :- $\left(w_o = \frac{1}{\sqrt{3}RC}\right)$ $\left(-\frac{1}{8}\right)$ answer

$$B = \frac{-w^3R^3C^3 \div w^3C^3R^3}{(3wRC - w^3C^3R^3)} = \cancel{33w}\ B = \frac{-1}{\frac{3}{w^2R^2C^2} - 1}$$

$$= \left.\frac{-1}{\frac{3}{w^2R^2C^2} - 1}\right|_{w=w_o} \Rightarrow \frac{-1}{\frac{1}{\left(\sqrt{3}RC\right)^2 \cdot \frac{1}{R^2C^2}} - 1} = \frac{-1}{9-1} = \boxed{\frac{-1}{8}}$$

$\Rightarrow$

* To satisfy $|BA| = 1$

$|A|_{min} = 8$, For Inverting Amp: $|A| = \frac{R_2}{R}$

$\therefore \left|\frac{R_2}{R}\right|_{min} = 8 \Rightarrow \underline{R_2 = 8R}$

Ex:- Design a Phase shift-oscillator to have $f_o = 20\ KHZ$. use $C = 0.01\ \mu F$.

Sol:-

$$f_o = \frac{1}{2\pi\sqrt{3}RC} \Rightarrow R = \frac{1}{2\pi f_o\sqrt{3}C} = \frac{1}{2\pi * 2*10^4 * 10^{-8} * \sqrt{3}}$$

$$= \frac{10^4}{1.72 * 2\pi * 2} = 0.48\ K\Omega$$

$$|A|_{min} = 8 \Rightarrow R_2 = 8R = 8 * 0.48 = 3.84\ K\Omega.$$

LC - oscillators

① Use LC cct as F.B cct and Amp

② At Resonant, LC cct. gives the required Phase & the Amp. gives the required gain.

احفظ

Hartley oscillator (2L + 1C)

Colpitts oscillator (2C + 1L)

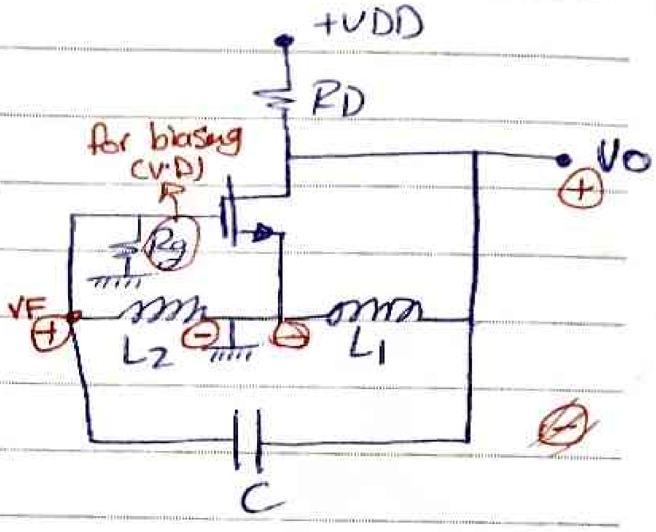
$\Rightarrow$

* R_g → we put it to protect the gate
* LC operates at higher freq. than RC

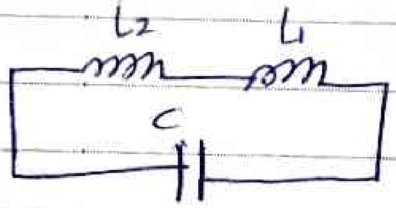
11

(3) the Amp can be FET, BJT, op-Amp

(1) Hartley oscillator



* at Resonant frequency
LC-ckt gives 180°



$$\Rightarrow j(\omega L_1 + \omega L_2) + \frac{1}{j\omega C} = 0$$

$$j\omega(L_1 + L_2) = -\frac{1}{j\omega C} = \frac{j^2}{j\omega C}$$

$V_F = V_{L2}$, $V_o = V_{L1}$

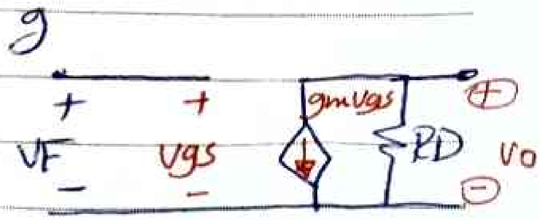
$$\Rightarrow j\omega(L_1 + L_2) = \frac{j}{\omega C} \Rightarrow \omega_o = \frac{1}{\sqrt{C(L_1+L_2)}}$$

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

gain of $\beta = \frac{V_F}{V_O} = \frac{j\omega L_2}{j\omega L_1} = \frac{L_2}{L_1}$ $\left(V_F = \frac{V_o \cdot j\omega L_2}{j\omega L_1}\right)$ (v.D) ??

* to satisfy $|\beta A| = 1 \Rightarrow |A| = \frac{1}{\beta} = \frac{L_1}{L_2}$

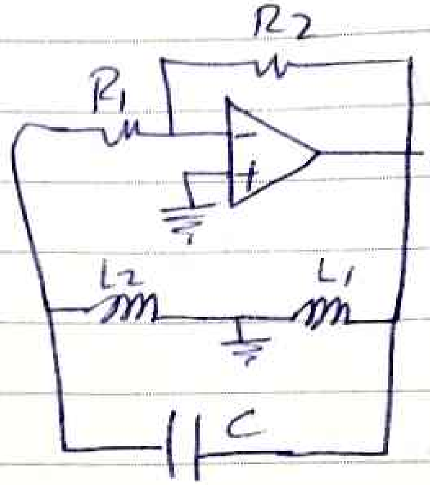
$$A = \frac{V_o}{V_{gs}} = -g_m R_D$$



$$\therefore |g_m R_D| = \frac{L_1}{L_2} \quad , g_m = 2\sqrt{K_n I_D}$$

⇒

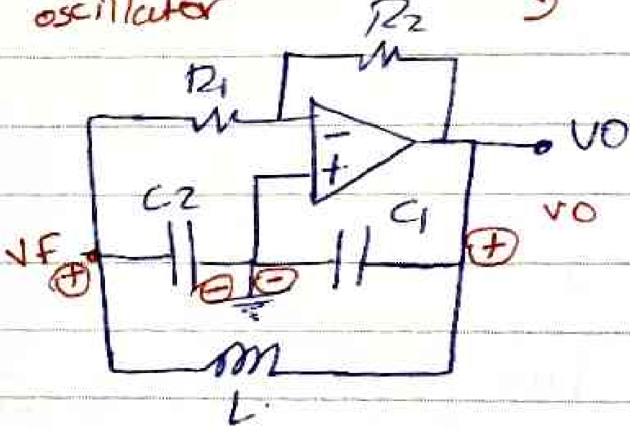
* $A = \frac{V_O}{V_d} = \frac{V_O}{[V_{gs}\ V_F]} \Rightarrow \boxed{A = \frac{V_O}{V_F}}$, $v_{gs} = V_F$



$$\Rightarrow \left|\frac{R_2}{R_1}\right| = \frac{L_1}{L_2}$$

② Colpitts oscillator

اذا اتعكست ال ± ؟ مارح تشتغل كـ oscillator



* At Resonance ⇒ Reactive part $=0$

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

$$\Rightarrow \frac{1}{j}\left(\frac{1}{wC_1} + \frac{1}{wC_2}\right) = +jwL$$

$$\Rightarrow w_0 = \frac{1}{\sqrt{L\,C_{eq}}} \rightsquigarrow f_0 = \frac{1}{2\pi\sqrt{LC_{eq}}}$$, freq of oscillator

$$C_{eq} = \frac{C_1 \cdot C_2}{C_1 + C_2}$$

$$\rightsquigarrow B = \frac{V_f}{V_o} = \frac{\frac{1}{jwC_2}}{\frac{1}{jwC_1}} \Rightarrow \frac{C_1}{C_2}$$

to satisfy $|BA| = 1$

$A = \frac{C_2}{C_1}$, for Inv. Amp.

$A = -\frac{R_2}{R_1} \Rightarrow |A| = \frac{R_2}{R_1}$, $\therefore \frac{R_2}{R_1} = \frac{C_2}{C_1}$

لو لازم هاي النسبة تتحقق عندي واذا ما تحققت ال cct مارح تشتغل كـ oscillator ⇒

Ex:- Design a colpitts oscillator to oscillate at 50 KHz, The Amp gain must not exceed 10. Calculate all Req. component values, & Draw vo(t) ??

sol:-

$\Rightarrow f_o = \frac{1}{2\pi\sqrt{L(C_{eq})}}$

$\frac{R_2}{R_1} = \frac{C_2}{C_1} = 10$

$\Rightarrow R_2 = 10R_1$, let $R_1 = 1K\Omega$

$R_2 = 10K\Omega$

$\Rightarrow C_2 = 10C_1$, Let $C_1 = 0.01\,\mu F$

$C_2 = 0.1\,\mu F$

$\Rightarrow C_{eq} = \frac{C_1 \cdot C_2}{C_1 + C_2} \Rightarrow \frac{0.001}{0.11}\,\mu F$

$f_o = \frac{1}{2\pi\sqrt{L\,C_{eq}}} \Rightarrow L \cdot C_{eq} = \frac{1}{4\pi^2 f_o^2}$

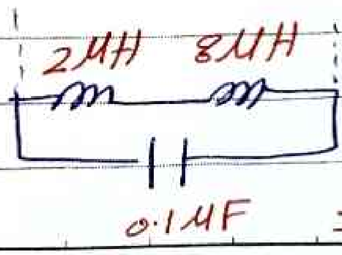
$\Rightarrow \frac{1}{4 * 10 * 25 * 10^8} = L \cdot C_{eq}$

$10^{-11} = L \cdot C_{eq} \Rightarrow L = \cdots$

Ex:- Given $K_n = 2mA/V^2$, $I_D = 4.5\,mA$

Determine f_o , R_D.

sol:-



$\Rightarrow$

$$f_o = \frac{1}{2\pi\sqrt{C(L_1+L_2)}} = \frac{1}{2\pi\sqrt{10^{-7}*10*10^{-6}}}$$

$$= \frac{10^6}{2\pi} = \frac{1000}{2\pi}\ KHZ \simeq 160\ KHZ$$

$$\Rightarrow |A| = \frac{L_1}{L_2} = 4 = g_m R_D$$

$$\Rightarrow g_m = 2\sqrt{k_n I_D} = 2\sqrt{4.5*2} = 6\frac{mA}{V}$$

$$\Rightarrow R_D = \frac{4}{6*10^{-3}} = 0.666\ K\Omega.$$

---

crystal oscillator

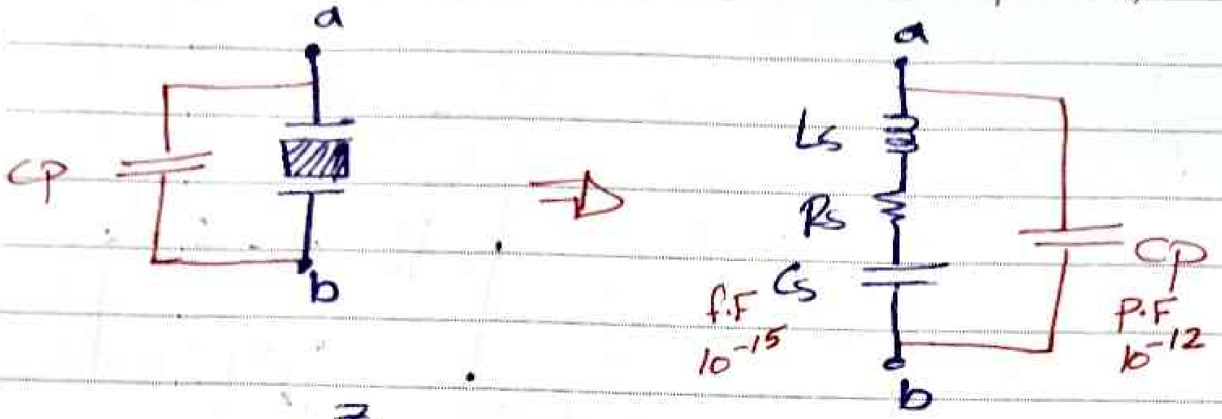
- In RC & LC oscillators f_o depends on L, C, R & since these elements are affected by Temp & aging so f_o of these oscillator are NOT stable or has poor freq. stability. — X-tal

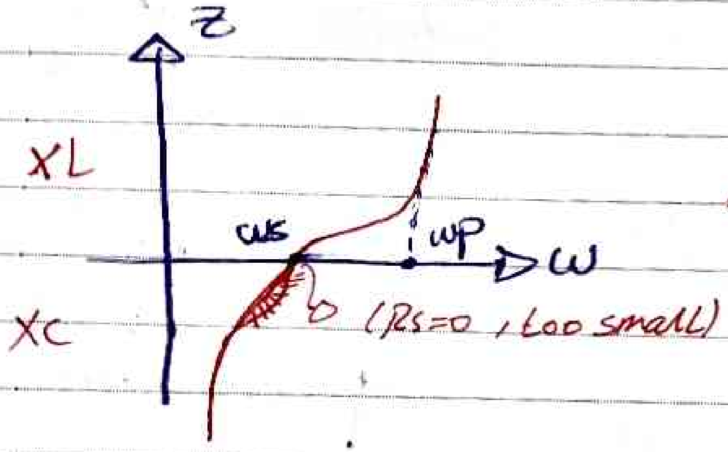
- to have high freq. stability ⇒ oscillators are used.
  ⇒ advantage

* use the pizoelectric material such as Quartz and it is based on inverse Pizoelectric effect. (when Quartz is subjected to E-field from the cct. it will generate an AC o/p signal), with freq. determined by the parameter of the Quartze crystal (C_s, L_s) due to series Resonant cct. ⇒

* $C_P >> C_S \Rightarrow$ practically

C_P:- no physical existence (atmosphere)





* ω_o (series) $\Rightarrow R_s$ (too small ≈ 0

* ω_o (parallel) $\Rightarrow \infty \Rightarrow$ O.C

$\Rightarrow$ for $\omega < \omega_s \rightarrow$ Cap

$\omega_s < \omega < \omega_p \rightarrow$ inductive

$$\omega_s = \frac{1}{\sqrt{L_s \cdot C_s}} \Rightarrow f_s = \frac{1}{2\pi\sqrt{L_s \cdot C_s}} \quad \text{(series - Resonance freq)}$$

$$\omega_p = \frac{1}{\sqrt{L_s \cdot C_{eq}}} = \frac{1}{\sqrt{L_s \cdot \frac{C_s \cdot C_P}{C_s + C_P}}}$$

$$\Rightarrow f_p = \frac{1}{2\pi\sqrt{L_s \cdot \frac{C_s \cdot C_P}{C_s + C_P}}}$$

- but $C_P >> C_s$ (Practically), $C_{eq} \approx C_s$

$$\therefore f_o = f_s = \frac{1}{2\pi\sqrt{L_s \cdot C_s}} \Rightarrow$$

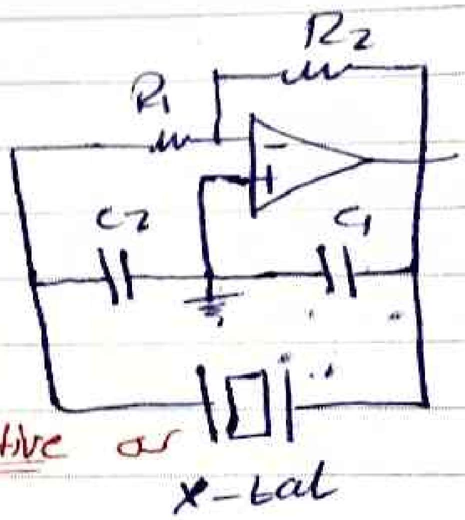
[*] بلورة الـ crys. oscillator بتعطيني تردد ثابت وغير قابل للتغيير وهاد الكسر

→ dissadvantages

[16]

$$f_0 = \frac{1}{2\pi\sqrt{L_s \cdot C_s}}$$

(crystal colpitts oscyllator)

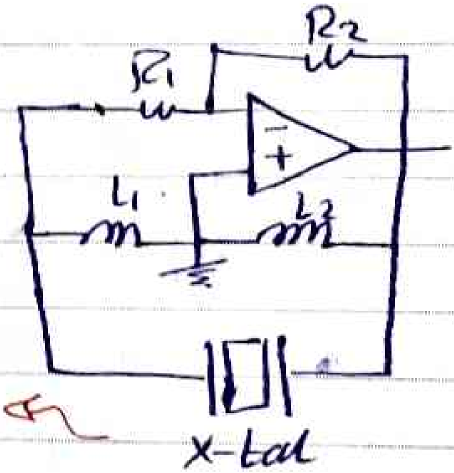


C_1, C_2 → +ve feed back

X-tal → مسؤول عن تردد الموجة

Inductive or

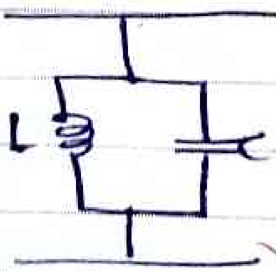
(crystal hartley oscillator).

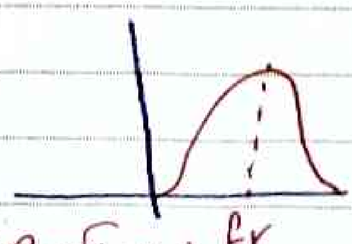


acts as capacitance

* freq multiplyer → doubler (II)
  → tribller (III)

→ I choose L&C to increase the desired Resonance freq.





ـــ بدي كبرها كثيراً كيف نتخلص من الضـ

* نختار الـ LC بحيث تعطي resonant freq المطلوب (العجيب)

⇒

[*] to increase the desired freq ⇒ freq. multiplier

[*] to decrease " " " ⇒ Dawn comter freq

* crystal osci. f_o depends on C_s, L_s which are Parameter of X-tal Quartz, each crystal has certain dimension and a certain polarization so it has certain value, for $\boxed{C_s, R_s, L_s}$, but these parameters are not affected by Temp. & Time so f_o is ① very stable, ② high (small value of C_s, L_s). → advantages.

* Disadvantages
① Fixed freq.
② Fragile (...)

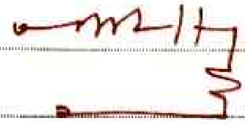
EX:- calculate f_s, f_p, Q for a X-tal oscillator with $R = 200\Omega$, $C_s = 10\,fF$, $L_s = 1H$, $C_p = 10\,pF$.

Sol:-

$$f_s = \frac{1}{2\pi\sqrt{L_s \cdot C_s}} = \frac{1}{2\pi\sqrt{1 * 10 * 10^{-15}}} = \frac{10^7}{2\pi}$$

$$Q = \frac{\omega_s \cdot L_s}{R_s} = \frac{2\pi * 1.6 * 10^6 \cdot 1}{200}$$, Q:- selective factor

$$= 1.6\pi * 10^4$$



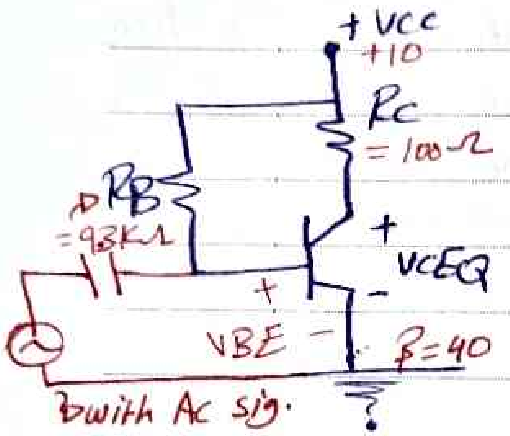
$$f_p = \frac{1}{2\pi\sqrt{L_s C_{eq}}} \quad , C_{eq} = \frac{C_s \cdot C_p}{C_s + C_p} = \text{----}$$

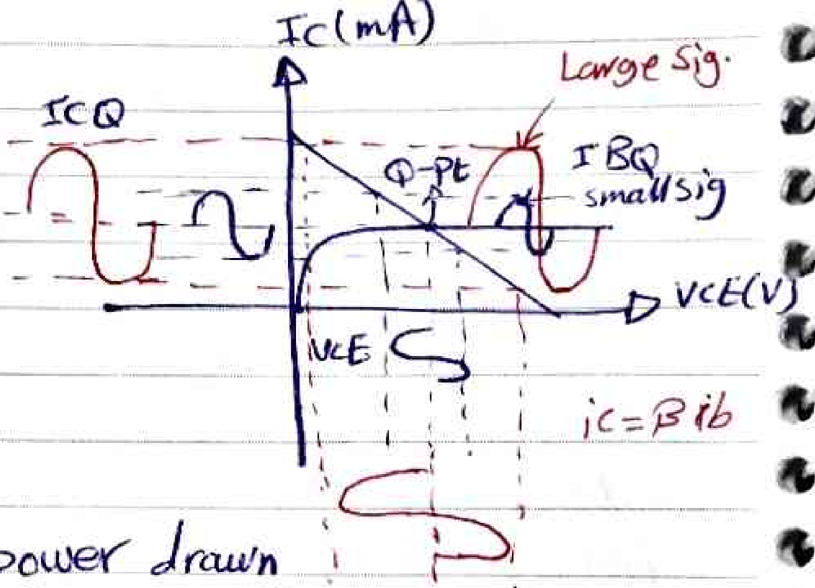
→ osci. freq $\simeq f_s$ (because f_p too small)

⇒

→ high P.D → large current & volt. sig
→ the component is large → بسبب كبر قيمة ال P.D عشان تشتغل الحرارة واكل لنو بركب $\boxed{18}$ Heating sink عشان نزيد مساحة سطح ال Trans

Power Amplifiers
(Large signal Amps)





→ $\overline{P_S} = I_{CQ} \cdot V_{CC}$ (D.C power drawn from D.C source)

$$I_{BQ} = \frac{(10-0.7)V}{9.3K} = 1mA$$

$$I_{CQ} = 40 * 0.1 = 40\,mA$$

$$\overline{P_S} = 40 * 10 = 400\,mW$$ → مصدر الطاقة اللي نسحبها

→ $V_{CEQ} = 10 - 0.1 * 40 = 6V$

- without A.C → $\overline{P_S} = \underbrace{\overset{240\,mW}{I_{CQ} \cdot V_{CEQ}}}_{\text{for trans.}} + \underbrace{\overset{16\,mW}{I_{CQ}^2 R_C}}_{\text{for Res (Heating)}}$

- with A.C

Some of $\overline{P_S}$ will be converted to A.C Load power delivered to Load

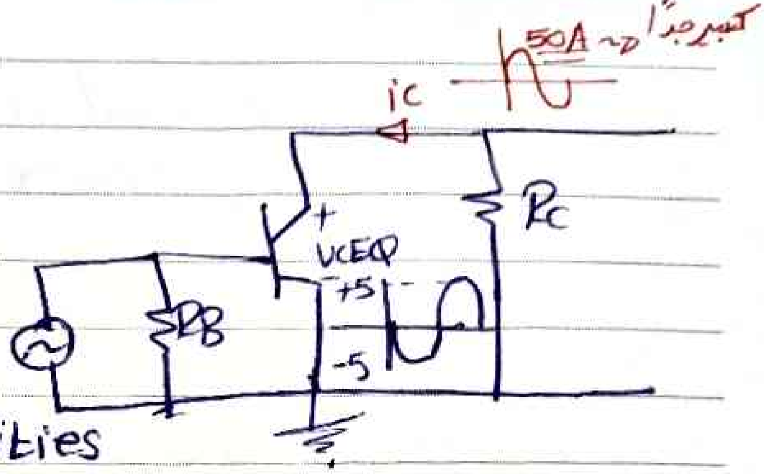
→ $\overline{P_S} = I_{CQ}^2 R_C + \overline{P_L} + P_D$ (trans)

$\boxed{*}$ بدون ال Ac بيكون ال Trans حرارته عالية بسبب ~~عدم و~~ كله ال P.Dissipation

* Big size trans have a high rating values (I, V, P)

$\Rightarrow P_{avg} = I_C \cdot V_{CEQ}$
$= I_C^2 \cdot R_C$
$= \dfrac{V_{CEQ}^2}{R_C}$

but these quantities are in RMS



(C.E)

* compared to S.S Amps.

① P.A deal with large current & voltage signal and use the hole D.C.L.L

② The size of power components are large to handle the high power dissipation.

③

	S.S BJT	Power BJT
$I_{C\,max}$	1A	20A
$V_{CE\,max}$	30V	250V
P_D	1.5W	50W
β	40 → 300	20 → 50

④ The most important parameter in P.A is the conversion efficiency

$$\eta = \frac{\bar{P}_L}{P_s} * 100\%$$

* heat sink can used to distribute temp.

class A → max effeciency = 50 % → the o/p is full wave
→ one trans is used
Class B → we use complementary.

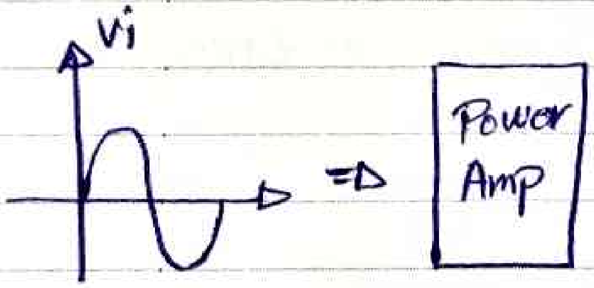
20

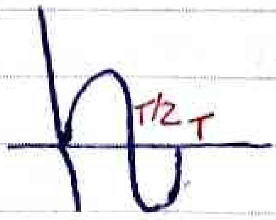
$\overline{P_L}$:- A.C Average Load power
$\overline{P_S}$:- D.C Average power draw from D.C source

* In general P.A is used to increase the Power of the A.c signal. It draws D.c power from D.c sources and converte some of these Power $\overline{P_S}$ into A.c Average Power delivered to Load.

* Classes of P.A.

o/p power



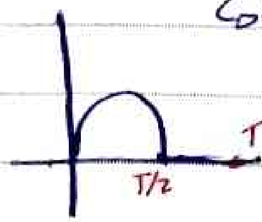


* class-A → $\phi_C = 360^\circ$

↳ conduction Angle

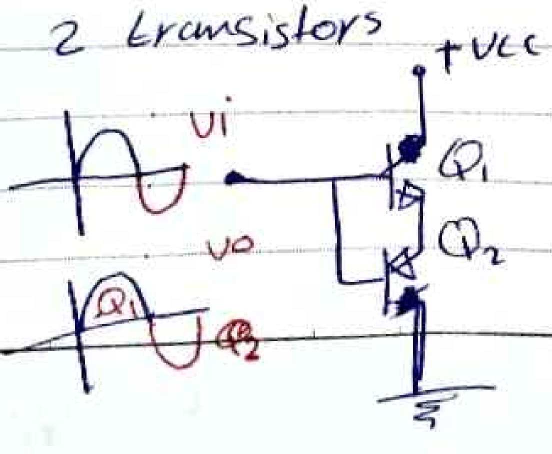
Audio freq P.A

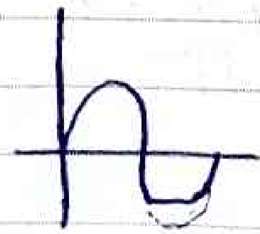
* in class A I used 1 transistor



* in class B I use 2 transistors

* Class-B → $\phi_C = 180^\circ$



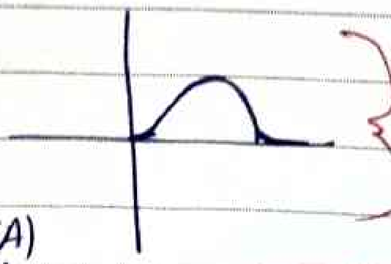


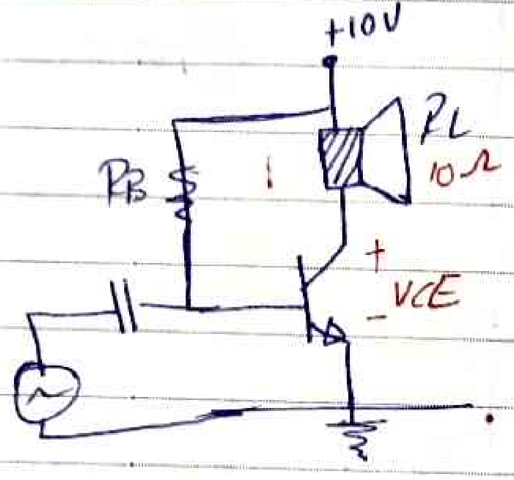
*class-AB → $180^\circ < \phi_C < 360^\circ$

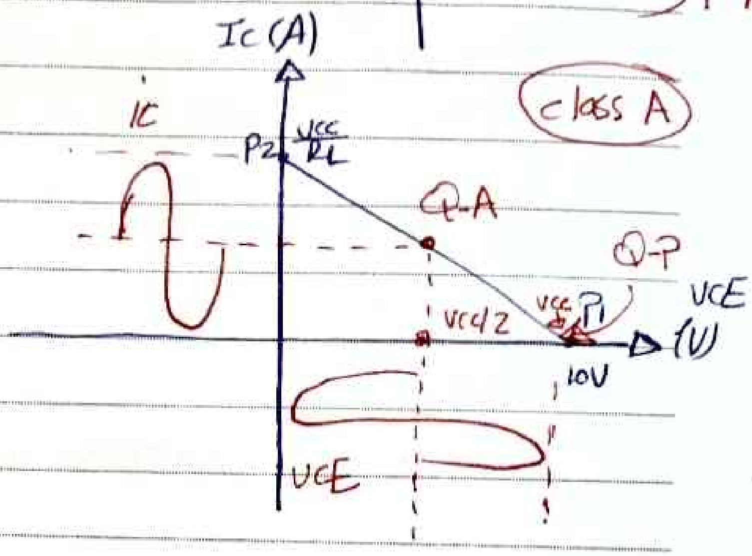
class AB → we use one transistor

class C → high effeciency

* class C → $\phi c < 180°$





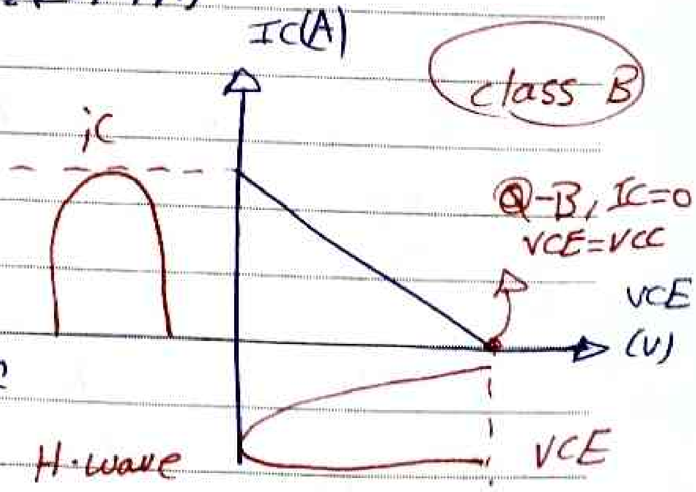


$\Rightarrow -10 + I_C R_C + V_{CE} = 0$

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

① For $I_C = 0$, $V_{CE} = 10V$, $P_1 (10V, 0)$

② for $V_{CE} = 0$, $I_C = \frac{10}{10} = 1A$, $P_2 (0, 1A)$



① class-A:- Q-pt ideally at center of D.C.L.L [ic flows for 360° (full-cycle)].

② class-B:- Q-pt at cutt off $I_{CQ} = 0$ [ic flows for 180° (half-cycle)]

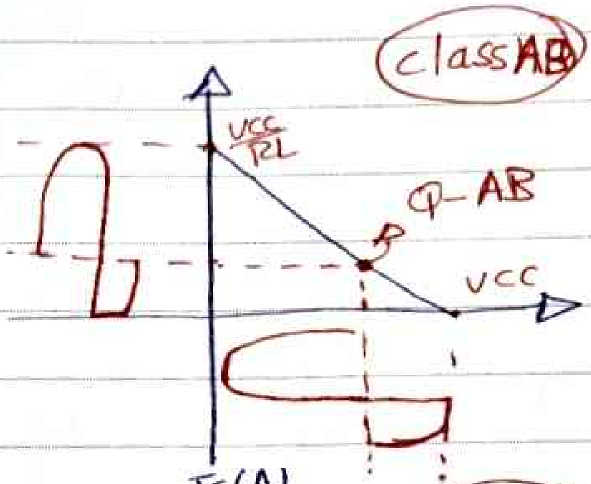
③ class-AB:- Q-Pt between A & B Position [ic flows for > 180 & < 360°].

⇒

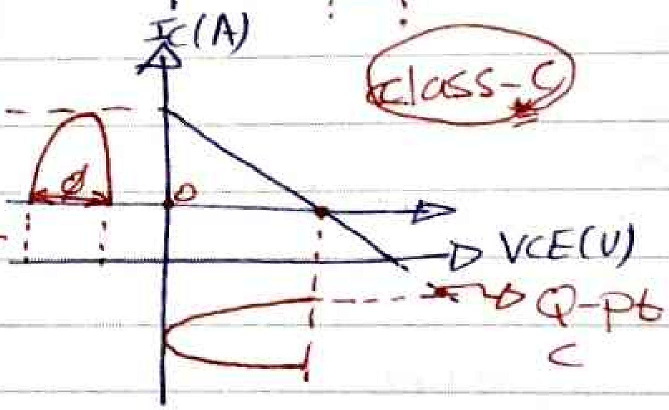
* $I_{CQ} = 50\%$ → class A (Ideal)
* $I_{CQ} = 0\%$ → class B

* I_{CQ} → between 0 and 50% → AB

4) class-C :- Q-pt down the cutoff, ic flows for $<180°$

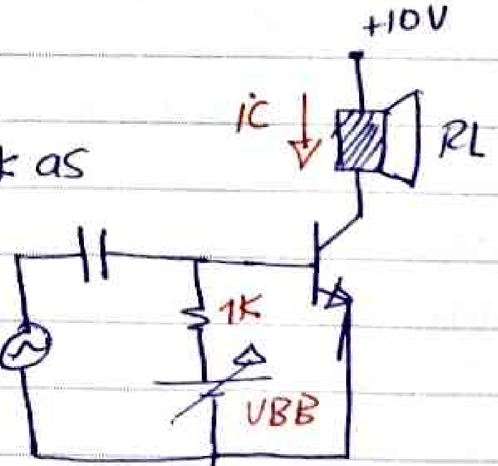


نقصها لانو ال ic بلش من فوق



---

* This cct can be designed to work as ideal class-A, B or AB, by choosing the proper value of ICQ



$\beta = 25$

$V_{BE} = 0.7V$

1) for ideal class-A

$$I_{CQ} = \frac{V_{CC}}{2R_L} = 0.5A$$

$$I_{BQ} = \frac{0.5}{\beta} = \frac{0.5}{25} = 0.02A$$

From D.C $\Rightarrow$ $-V_{BB} + I_B R_B + V_{BE} = 0$

$\Rightarrow$

* class-C :- the Q-pt under the cutt of.

$I_B = \frac{V_{BB} - V_{BE}}{R_B} = 0.02A \Rightarrow \boxed{V_{BB} = 8.7A}$

② For ideal class-B , $I_{CQ} = 0$, $I_{BQ} = 0$

$\Rightarrow V_{BB} = 0.4 * 0 + 0.7V$

$\therefore V_{BB} = 0.7V$

③ for class_AB

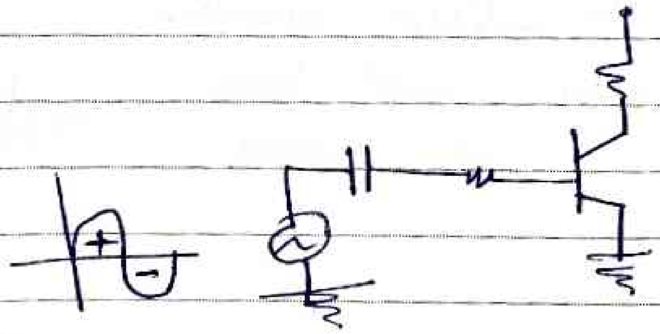
$0 < I_{CQ} < 0.5A$, let $I_{CQ} = 0.25A$

$I_{BQ} = \frac{0.25}{25} = 0.01A$

$\Rightarrow V_{BB} = 0.01 * 0.4 + 0.7 = 4.7V$

$I_B = \frac{0 - V_{BE}}{R_B}$

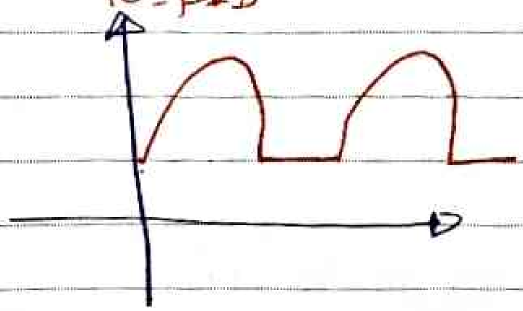
$\Rightarrow I_B < 0 \Rightarrow$ off



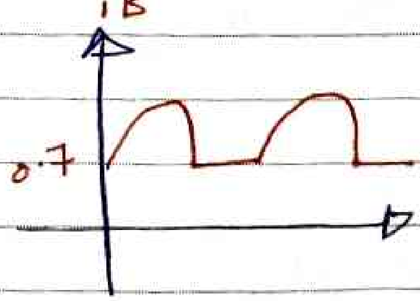
$-V_i + I_B R_B + V_{BE} = 0$

$\Rightarrow I_B = \frac{V_i - V_{BE}}{R_B}$, V_i must be $> V_{BE}$ to operate the diode (on).

$i_C = \beta I_B$



i_B



* $\overline{P_S}$ → Dc. source

class - A

o/p is present for 360° (full- cycle)

Direct coupled (series-Fed)

↓

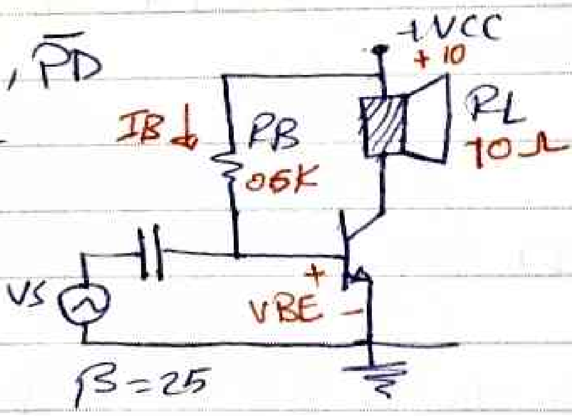
the load is connected direcly between vcc & collector.

Transformer coupled

Ex:- ① calculate $\overline{P_S}$, $\overline{P_L}$, $\eta\%$, $\overline{P_D}$

② Draw D.C.L.L & A.C.L.L with ic & vce swings.

↳ when the i/p signal drives a peak collector current $i_{CP} = 0.45A$



$\beta = 25$

$V_{BE} = 0.6$

Sol:-

$\overline{P_S}$:- Average D.c power drawn from D.c source

$$\overline{P_S} = V_{CC} \cdot I_{CQ}$$

$$I_{CQ} = \beta I_{BQ}$$

$$-V_{CC} + I_B R_B + V_{BE} = 0$$

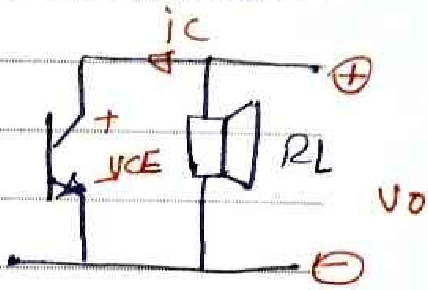
$$\Rightarrow I_B = \frac{(10-0.6)V}{0.5K} = \frac{9.4V}{0.5K} = 18.8\ mA$$

⟹

$\Rightarrow I_{CQ} = \beta I_B = 25 * 18.8 = 0.47\,A \quad , V_{CEQ} = 5.3V$

$\bar{P_S} = 10 * 0.47 = 4.7W.$

* $\bar{P_L}$:- Avarage A.c power delivered to Load



$\bar{P_L} = ic(rms) \cdot Vce(rms)$

$= \frac{icP}{\sqrt{2}} \frac{VceP}{\sqrt{2}} = \frac{icP \cdot VceP}{2}$

$\bar{P_L} = ic(rms) \cdot RL$

$= \left(\frac{icP}{\sqrt{2}}\right)^2 \cdot RL \qquad \Rightarrow \bar{P_L} = \frac{Vce^2(rms)}{RL}$

$= \left(\frac{VceP}{\sqrt{2}}\right)^2 * \frac{1}{RL} = \left(\frac{0.45}{\sqrt{2}}\right)^2 * 10 = 1.0125W$

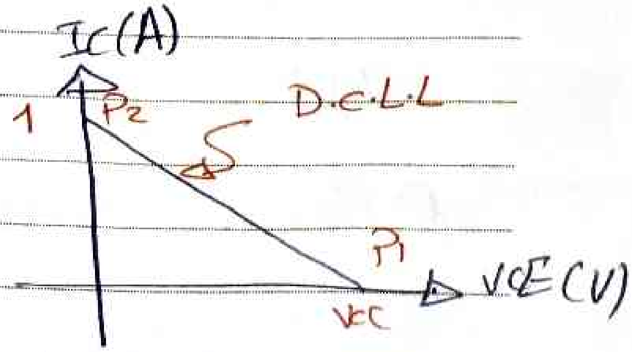
$\Rightarrow \eta = \frac{\bar{P_L}}{\bar{P_S}} * 100\% = \frac{1.0125}{4.7} = 21\%$

$\Rightarrow \bar{P_S} = \bar{P_L} + I_{CQ}^2 R_L + P_{D\,tr.}$

$\Rightarrow PD(tr) = \bar{P_S} - I_{CQ}^2 R_L = 4.7 - (0.47)^2 * 10 - 1.0125$

$= \underline{1.47W}$

* Transistor ratings



$-Vcc + I_C R_L + V_{CE} = 0$

$\Rightarrow V_{CE} = Vcc - I_C R_C$

$\Rightarrow$

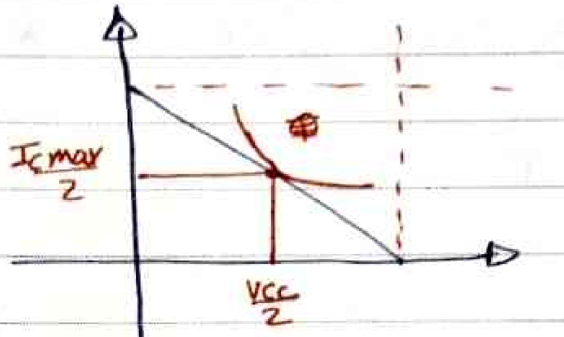
$P_{D(tr)} = 1.47$ ⇝ the power dissipated in the trans. in this cct.

$P_{D\,max} = 25$ ⇝ the power dissipated in the trans.

⇒ For $I_C = 0$

$V_{CE} = V_{CE\,max} = V_{CC}$

$\therefore V_{CE\,max} = 10\,V$



⇝ PD max for transistor

⇒ For $V_{CE} = 0$

$I_C = I_{C\,max}$

$\therefore I_{C\,max} = \frac{V_{CC}}{R_L} = 1A$

⇒ Provment for PD max

$P_D = I_C V_{CE} = I_C(V_{CC} - I_C R_L)$

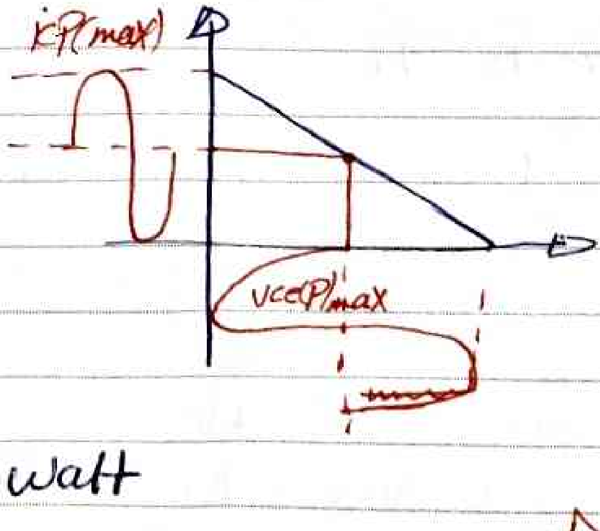
$P_D = I_C \cdot V_{CC} - I_C^2 R_L$

⇝ نشتق لإيجاد النقط الحرجة

$\Rightarrow \frac{\partial P_D}{\partial I_C} = V_{CC} - 2 I_C R_L = 0$

$I_C = \frac{V_{CC}}{2R_L}$ ⇝ $V_{CE} = V_{CC} - \frac{V_{CC}}{2R_L} \cdot R_L = \frac{1}{2} V_{CC}$

⇝ $P_{D\,max}$ occurs at centre of D.C.L.L



$\therefore V_{CE} = \frac{V_{CC}}{2} = 5\,V$

$I_C = \frac{I_{C\,max}}{2} = 0.5\,A$

$\Rightarrow P_{D\,max} = 5 * 0.5 = 2.5$ watt

⇒

* at Q-pt being in the centre of the D.C.L.L

~~I_{Cm}~~ ⇝ $\frac{P_L}{P_S}$ $\boxed{\eta = max}$ ⇝ at class-A

* if $P_L = 10 \rightarrow P_s = 40$
$P_s = 100 \rightarrow P_L = 25$

* $i_{CP} \rightarrow$ given

$P_s(avg) = cons = I_{CQ} V_{CC}$ لـ نتحقق اعظم كفاءة للدائرة

$\eta = \frac{\bar{P}_L}{\bar{P}_s} \Rightarrow \eta = \frac{\bar{P}_{L(max)}}{\bar{P}_s}$

$\bar{P}_L = \frac{V_{CEP}}{\sqrt{2}} \cdot \frac{i_{CP}}{\sqrt{2}}$

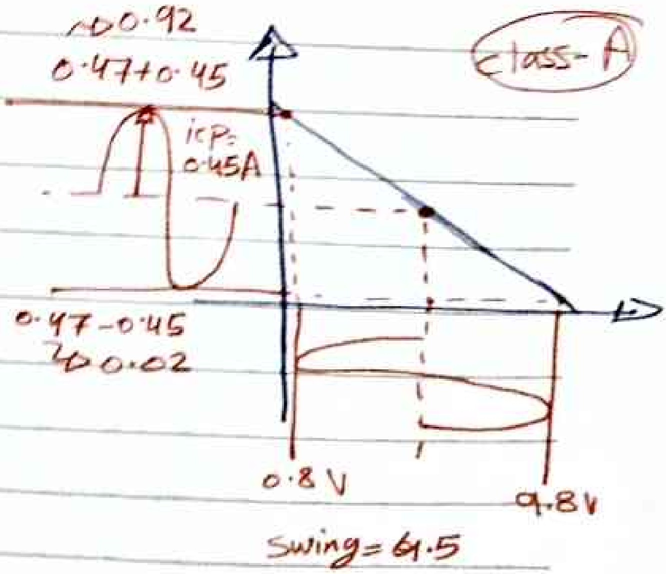
→ for max $\bar{P}_L$

→ $V_{CEP(max)} = \frac{V_{CC}}{2}$, $i_{CP(max)} = I_{CQ}$

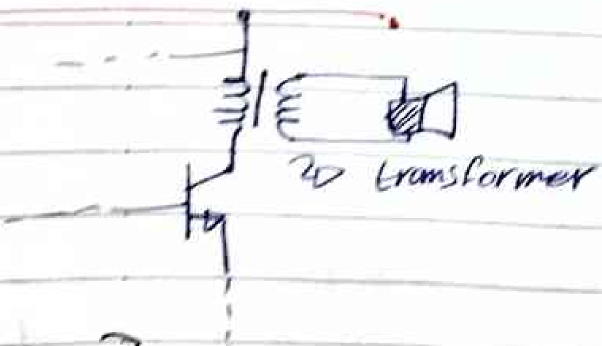
$\bar{P}_{L(max)} = \frac{V_{CC}}{2\sqrt{2}} \cdot \frac{I_{CQ}}{\sqrt{2}} = 0.25\, V_{CC} I_{CQ}$

$\eta = \frac{0.25\, V_{CC} I_{CQ}}{V_{CC} I_{CQ}} \times 100\% = \underline{25\%} \rightarrow max$

* Draw $i_C(o/p)$ & $V_{CE}(o/p)$.



→ the o/p here is complete sign wave → so this class is class A
→ and it's less using



→

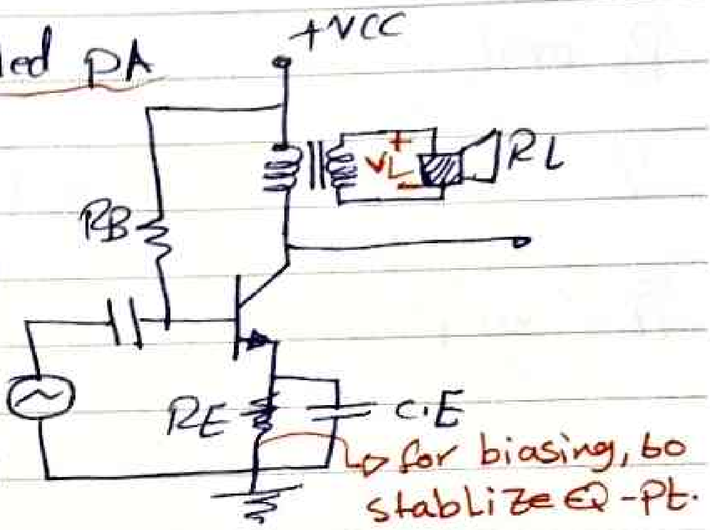
$\Rightarrow$

$I_{CQ}^2 * R_{C(coil)} = 0$ becuase the $R_C = 0$ becuase ideally so there is no

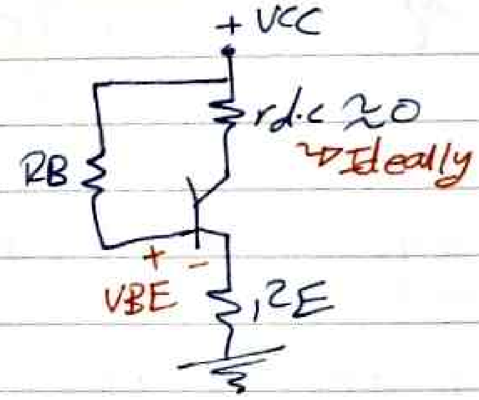
* ازا بدي Load يسحب 1watt يعني ال direct.coup بتحتاج $\overline{P_s} = 4watt$

اما في ال trans.coup 2، بتحتاج اقل. $\boxed{28}$

* **Class-A transformer-coupled PA**



In this class, the Load is connected in the Secondery of transformer, so ther is No $I_{CQ}^2 R_L$ dissipated in Load which means Less $\overline{P_s}$ is drawn for the same $\overline{P_L}$ (compared to direct coupled).
There fore $\eta\%$ for this class is $> \eta$ for direct-coupled P.A.



$\rightarrow \overline{P_s} = V_{CC} \cdot I_{CQ}$

$I_{CQ} = \beta I_{BQ} \rightarrow$

$\rightarrow I_B = \dfrac{V_{CC} - V_{BE}}{R_B + (\beta+1) R_E}$

$\rightarrow \overline{P_L} = ??$

* From secondery side.

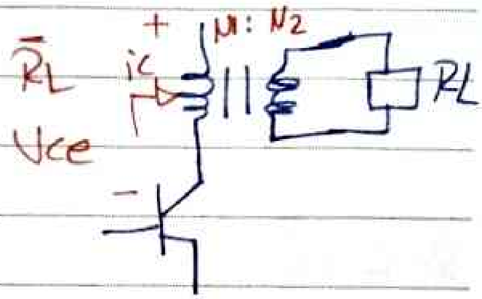
v_L, i_L, R_L

$$\rightarrow \overline{P_L} = i_L(rms) \cdot V_L(rms)$$
$$= i_L^2(rms) \cdot R_L$$
$$= \frac{V_L^2(rms)}{R_L}$$

$$\overline{P_L} = \frac{V_{LP} \cdot i_{LP}}{2} = \frac{i_{LP}^2}{2} R_L = \frac{V_{LP}^2}{2R_L}$$

$\Rightarrow$

* From primary side



$\overline{P_L} = V_{ce(rms)} \cdot i_{c(rms)}$

$= i_{c(rms)} \cdot \bar{R}_L$

$= \dfrac{V_{ce(rms)}}{\bar{R}_L}$

→ $\bar{R}_L$:- A.C reflected Resistance

* D.C & A.C.L.L

→ D.C.L.L

$-V_{CC} + I_C r_{dc} + V_{CE} + I_E R_E = 0$

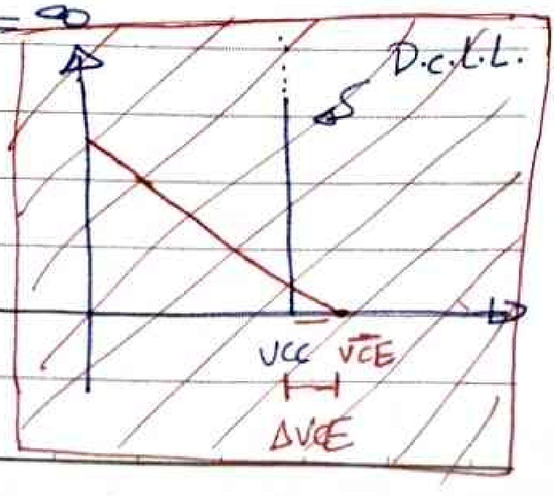
$V_{CE} = V_{CC} - I_C(\underbrace{r_{dc} + R_E}_{0}) = 0 \quad (I_C \approx I_E)$

→ for ideal coil, $r_{d.c} = 0$ & for small R_E

→ $V_{CE} \approx V_{CC}$.

$I_C = \dfrac{V_{CC}}{r_{d.c} + R_E} - \dfrac{V_{CE}}{r_{d.c} + R_E} = b + mx$

→ for $(r_{d.c} + R_E) \approx 0$, slope $= \infty$



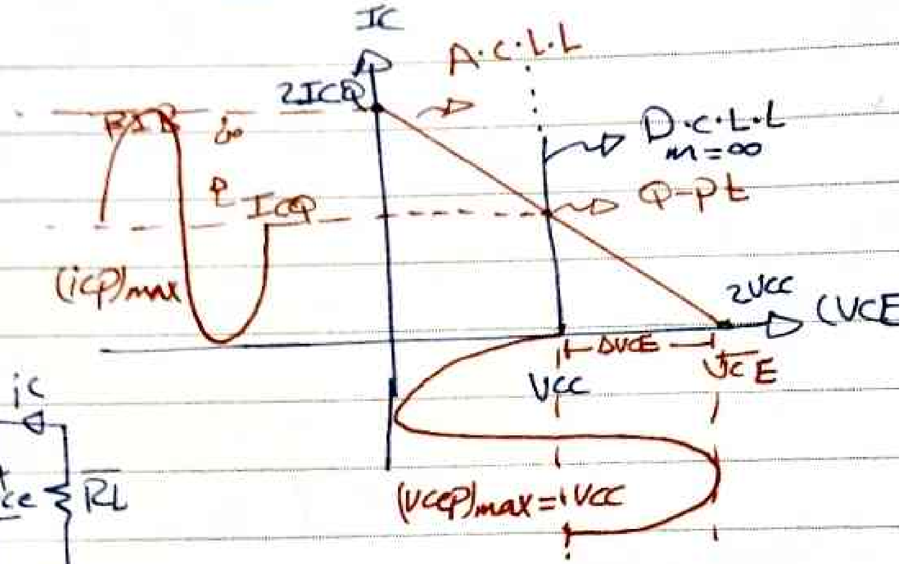
① For $I_C = 0$, $V_{CE} = V_{CC}$

$(V_{CC}, 0)$ P_1

② for $V_{CE} = 0$, $I_C = \dfrac{V_{CC}}{r_{d.c} + R_E} \approx \dfrac{V_{CC}}{0}$

$(0, \infty)$ P_2 $\quad = \infty$

⟹



Q-pt:-

$V_{CEQ} = V_{CC}$

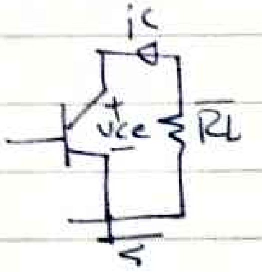
$I_{CQ} > 0$

⇒ A.C.L.L

$v_{ce} + i_c \bar{R}_L = 0$

$v_{ce} = -i_c \bar{R}_L$

⇒ slope $= -\frac{1}{\bar{R}_L}$



$\Rightarrow \bar{V}_{CE} = V_{CEQ} + \Delta V_{CE}$

$|slope| = \frac{1}{\bar{R}_L} = \frac{\Delta I_C}{\Delta V_{CE}}$

$\Rightarrow \Delta V_{CE} = I_C \cdot \bar{R}_L$

$= I_{CQ} \cdot \bar{R}_L$

* At Q-pt:-

$I_{CQ} = \frac{V_{CEQ}}{\bar{R}_L} = \frac{V_{CC}}{\bar{R}_L}$

$V_{CC} = I_{CQ} \cdot \bar{R}_L$

$\therefore \Delta V_{CE} = V_{CC} \Rightarrow \bar{V}_{CE} = 2V_{CC}$

* η_{max} %

$\eta\% = \frac{P_L}{P_S} * 100\% \Rightarrow \eta_{max}\% = \frac{\bar{P}_{L(max)}}{\bar{P}_S} * 100\%$

⇒

$$\bar{P_s} = I_{CQ} \cdot V_{CC}$$

$$\bar{P_L} = \frac{V_{ceP} \cdot i_{cP}}{2} \Rightarrow \bar{P_L}(max) = \frac{V_{CC} \cdot I_{CQ}}{2}$$

$$\therefore \eta_{max}\% = \frac{0.5\, \cancel{V_{CC}} \cdot \cancel{I_{CQ}}}{\cancel{I_{CQ}} \cdot \cancel{V_{CC}}} * 100\% = 50\%$$

---

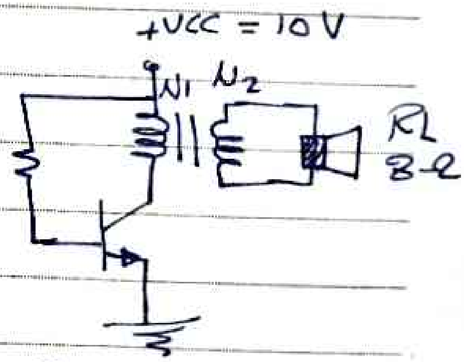
* BJT ratings.

1) $V_{CE\,max} = 2V_{CC}$

2) $I_{C\,max} = 2I_{CQ}$

Ex:- Design the cct. to give Load power, $\bar{P_L} = 4W$ & $\eta = 40\%$

1) Find (N_1/N_2), R_B
2) specify the required BJT ratings
3) sketch D.C, A.C & voltage & current swings.



$\beta = 20$, $V_{BE} = 0.6V$

Sol:-

$$\eta = 0.4 = \frac{\bar{P_L}}{\bar{P_s}} \Rightarrow \bar{P_s} = \frac{4}{0.4} = 10\,W$$

$$\bar{P_s} = I_{CQ} \cdot V_{CC} \Rightarrow I_{CQ} = \frac{10W}{10} = 1A$$

$$I_{BQ} = \frac{I_{CQ}}{\beta} = \frac{1}{20} = 0.05A$$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} \Rightarrow R_B = \frac{V_{CC} - V_{BE}}{I_B}$$

* بسبب ان الدائرة تشتغل على $\eta = 40\%$ وهي اقل من العادية $= 50\%$ كـ ان ه
صافي ال P_o ، η بكون اقل

$$\Rightarrow R_B = \frac{(10 - 0.6)}{0.05A} = \frac{9.4}{50} * 10^3 = 188\,\Omega$$

* $\frac{N_1}{N_2} = a = \sqrt{\frac{\bar{R}_L}{R_L}}$

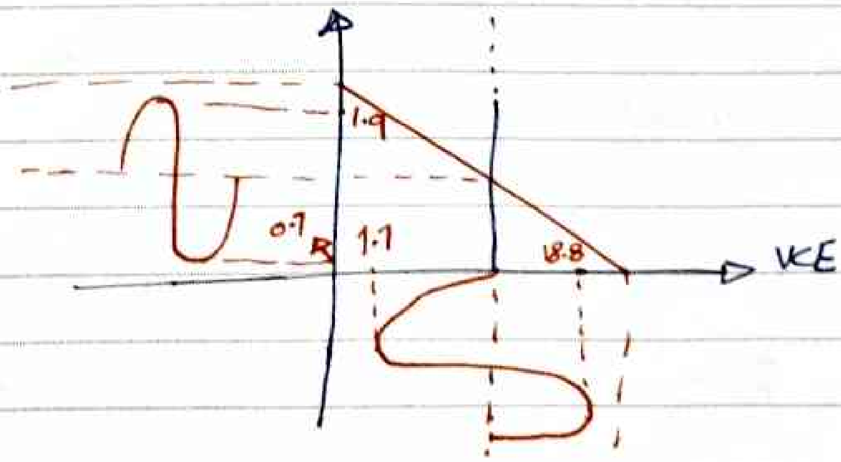
$$\bar{R}_L = \frac{V_{CC}}{I_{CQ}} = \frac{10V}{1A} = 10\,\Omega$$

$$\Rightarrow a = \sqrt{\frac{10}{8}} = \sqrt{1.25} = \underline{1.1}$$

② $V_{CE\,max} = 2V_{CC} = 20V$
$I_{C\,max} = 2 I_{CQ} = 2A$ } ratings.

③ $\bar{P}_L = \frac{i_{LP}^2}{2} \cdot R_L \Rightarrow i_{LP} = \sqrt{\frac{2P_L}{R_L}} = \sqrt{\frac{2*4}{8}} = 1\,A$

$$\Rightarrow \frac{i_{LP}}{i_{CP}} = \frac{N_1}{N_2} \Rightarrow i_{CP} = \frac{1}{1.1} = 0.9A$$



* class-A $\Rightarrow I_{CQ} \neq 0 \Rightarrow P_S \neq 0 \Rightarrow$ دائماً بسحب P_S

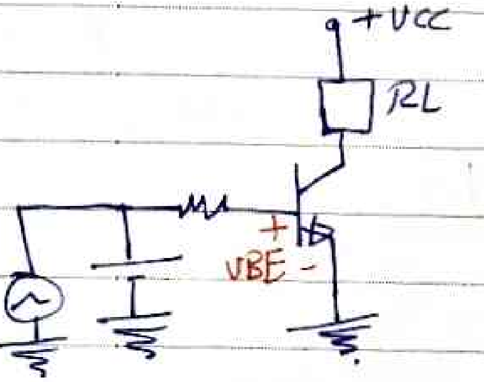
* if AC signal → $\overline{P}_s$ صار بحسب $\overline{P}_L$ و بعطي] in class B
* if no " " → ما في $\boxed{\text{لانه بكون ال Q-pt على ال cutt-off}}$

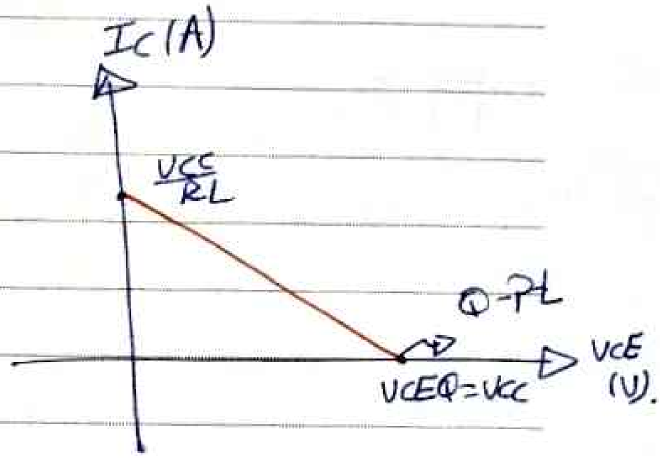
33

* in class-A always use $\overline{P}_s$ بسبب موقع ال Q-pt

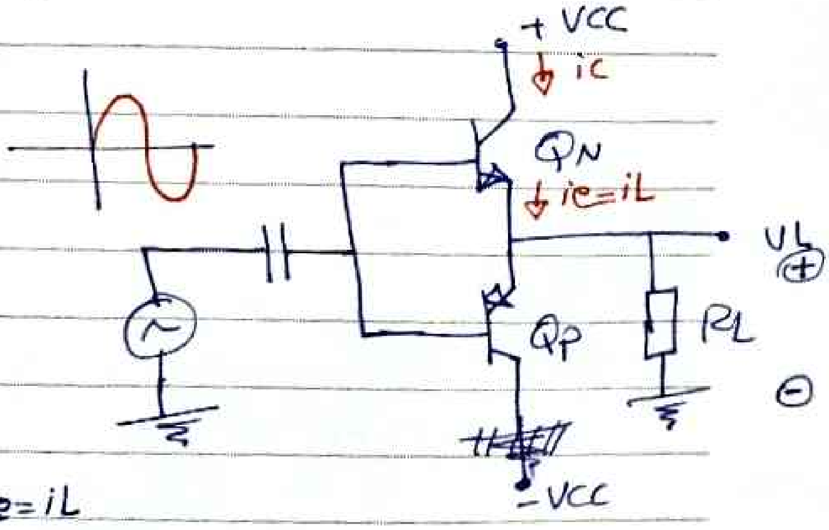
class-B power Amp.

- Q-pt at cutt-off

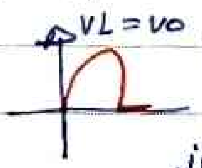


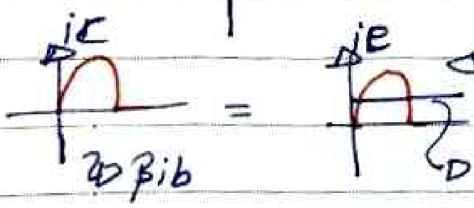


① complementary-class B P.A
(using two Types of Transistors [NPN & PNP] or [n-channel & p-channel]).



① For +ve H.c
QN → ON, QP → off

$V_L =$  $V_L = i_L \cdot R_L$

 $=$ → $ie = iL$

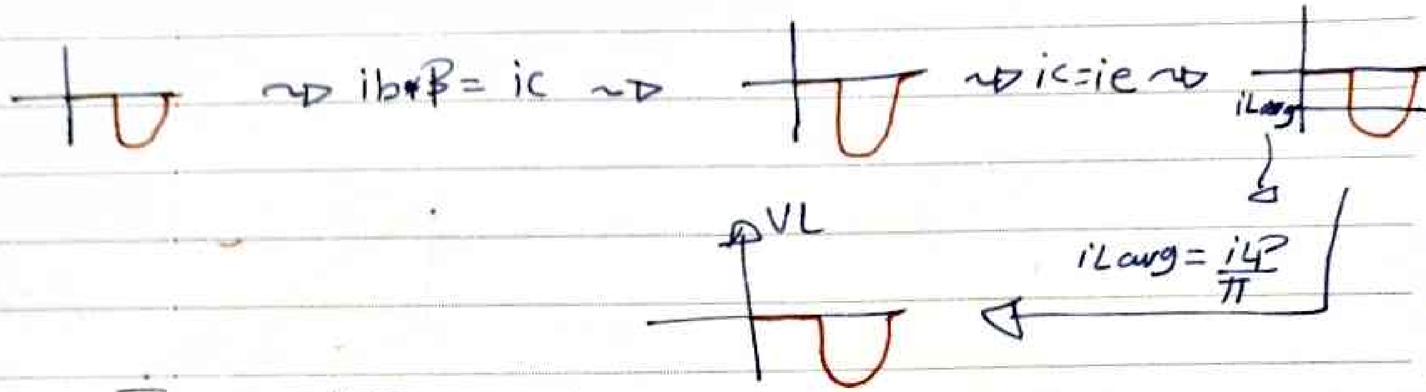
→ βib → $I_{L\,avg} = \frac{i_{LP}}{\pi}$ ⇒ $\underline{ic = ie \simeq iL}$

$$\Rightarrow \overline{P}_s (+) = I_{L\,avg} \cdot V_{CC} = \frac{i_{LP}}{\pi} \cdot V_{CC} = \frac{V_{LP}}{R_L \cdot \pi} \cdot V_{CC} \;.$$

⇒

* $\eta_{\text{class-B}} >> \eta_{\text{class-A}}$

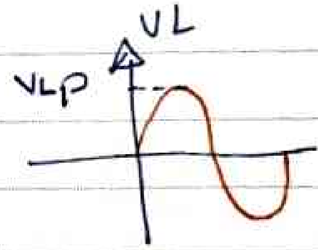
② For -ve H.C



$\Rightarrow \overline{P_S}(-) = -\frac{i_{LP}}{\pi} * (-V_{CC})$

$= \frac{i_{LP}}{\pi} V_{CC}.$

* $\underline{V_L}$ during the ~~tot~~ all period ⇒



$$\Rightarrow \overline{P_S} = \overline{P_S}(+) + \overline{P_S}(-) = \frac{2 i_{LP}}{\pi}\cdot V_{CC}$$

$$= \frac{2V_{LP}}{R_L\cdot\pi}\cdot V_{CC}$$

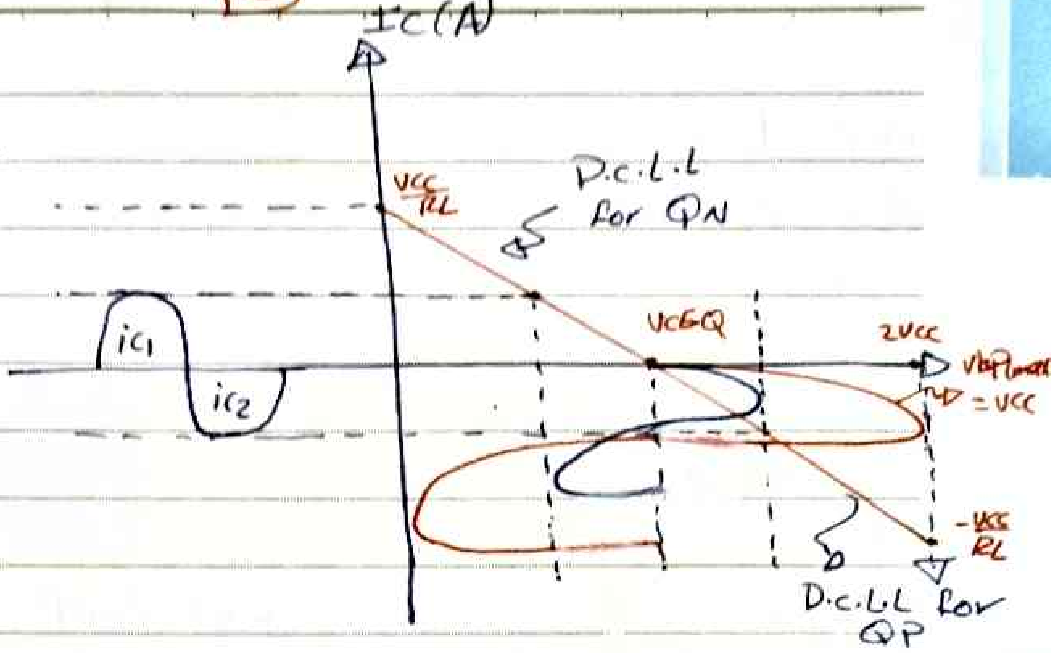
$$\Rightarrow \overline{P_L} = \frac{V_L^2(rms)}{R_L} = \left(\frac{V_{LP}}{\sqrt{2}}\right)^2 * \frac{1}{R_L} = \frac{V_{LP}^2}{2R_L}$$ in general.

$$\Rightarrow \eta\% = \frac{\overline{P_L}}{\overline{P_S}} * 100\% = \frac{V_{LP}^2}{2R_L} * \frac{R_L\cdot\pi}{2V_{LP}\cdot V_{CC}} = \frac{V_{LP}\cdot\pi}{4V_{CC}}\%$$

⇒

i_{C1} → From +ve H.C

i_{C2} → From -ve H.C



phase shift because C.C (Emitter follower) for VCE

$\boxed{*}$ For η_{max} , $V_{LP} = V_{CC}$

$$\overline{P_L} = \frac{(V_{CC})^2}{2 R_L}$$

$$\eta_{max} = \frac{\pi}{4} \times 100\% = 78.5\%$$

---

① Since the cct is emitter-follower (C.C)
For Max $\eta\%$, $V_{LP} = V_{CC}$
i.e $V_{iP} = V_{CC}$

② P_D (each trans) $= \dfrac{\overline{P_S} - \overline{P_L}}{2}$

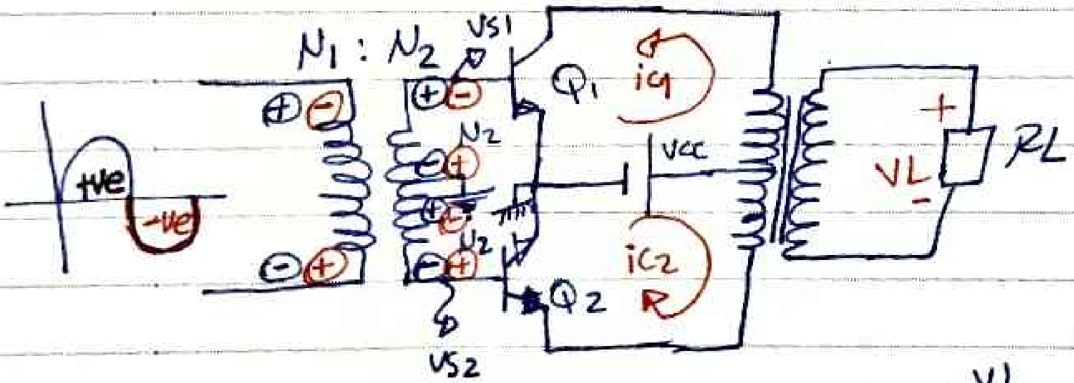
Ex:- $V_{CC} = \pm 5V$, $v_i = 4 \sin \omega t$ (v)
$R_L = 4\ \Omega$, (Assume $V_{BE} = 0$) ⇒

* class-B ⟹ η% should be less than 78.5%

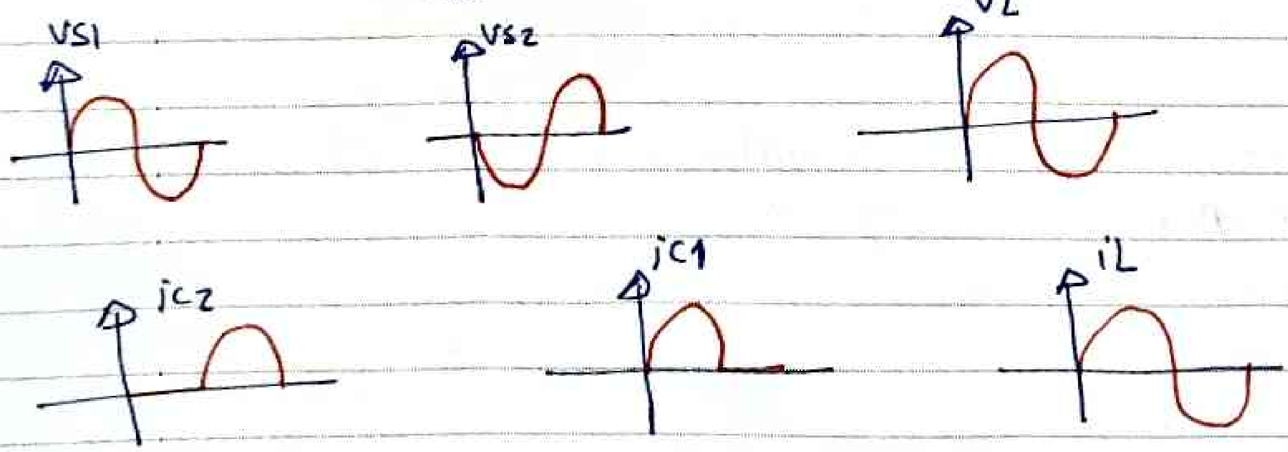
① Find $\overline{P_L}$, $\overline{P_s}$, P_D (each)
② sketch A.C & D.C. L.L with v_L & i_L swing.
③ Find peak i/P voltage which gives max η%

class-B push-pull

* using same-Type of Transistor.



Q_1 & Q_2 operates at +ve.

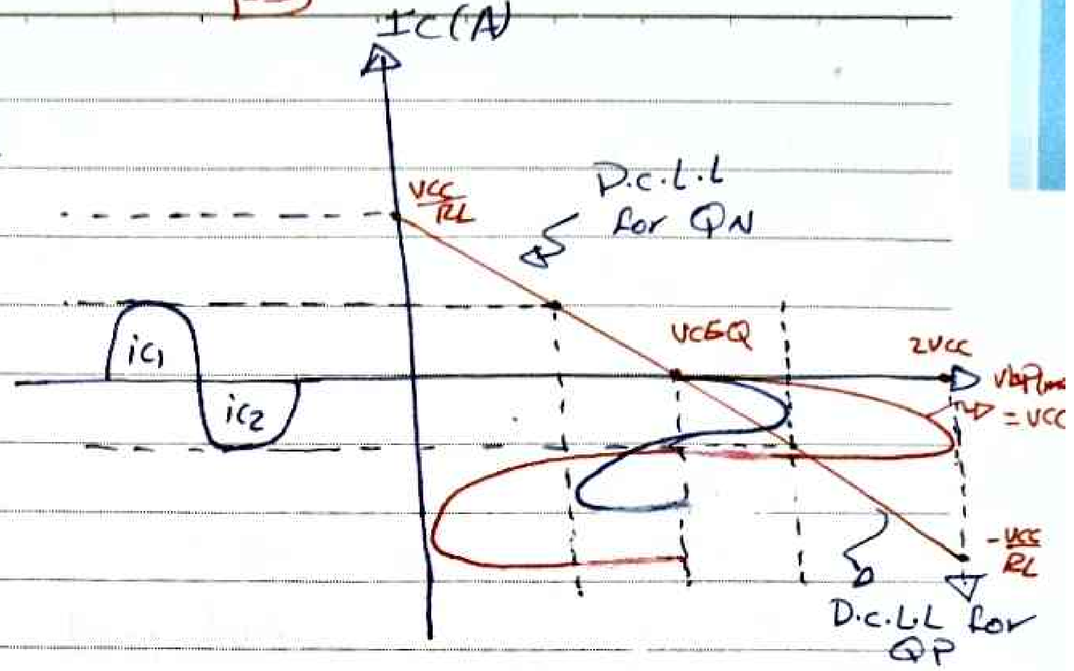


⟹ $i_L = i_{C1} - i_{C2}$

D.C.L.L & A.C.L.L → علاقتهما ايه ?

35

i_{c1} → From +ve H.C
i_{c2} → From -ve H.C



(*) For η_{max} , $V_{LP} = V_{CC}$

$$\overline{P_L} = \frac{(V_{CC})^2}{2 R_L}$$

$$\eta_{max} = \frac{\pi}{4} \times 100\% = 78.5\%$$

(1) Since the cct is emitter-follower (C.C)
For Max $\eta\%$, $V_{LP} = V_{CC}$
i.e. $V_{iP} = V_{CC}$

(2) P_D (each trans) $= \dfrac{\overline{P_S} - \overline{P_L}}{2}$

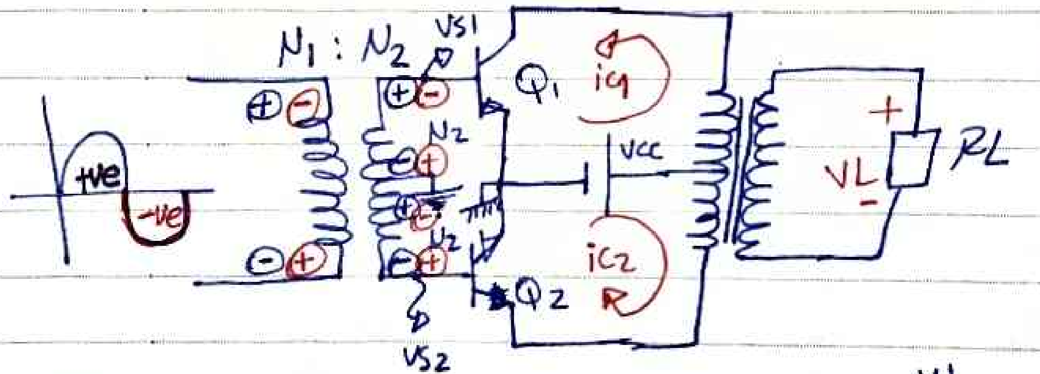
Ex:- $V_{CC} = \pm 5V$, $v_i = 4 \sin \omega t$ (v)
$R_L = 4\ \Omega$, (Assume $V_{BE} = 0$) →

* class-B ⇒ $\eta\%$ should be less than 78.5%

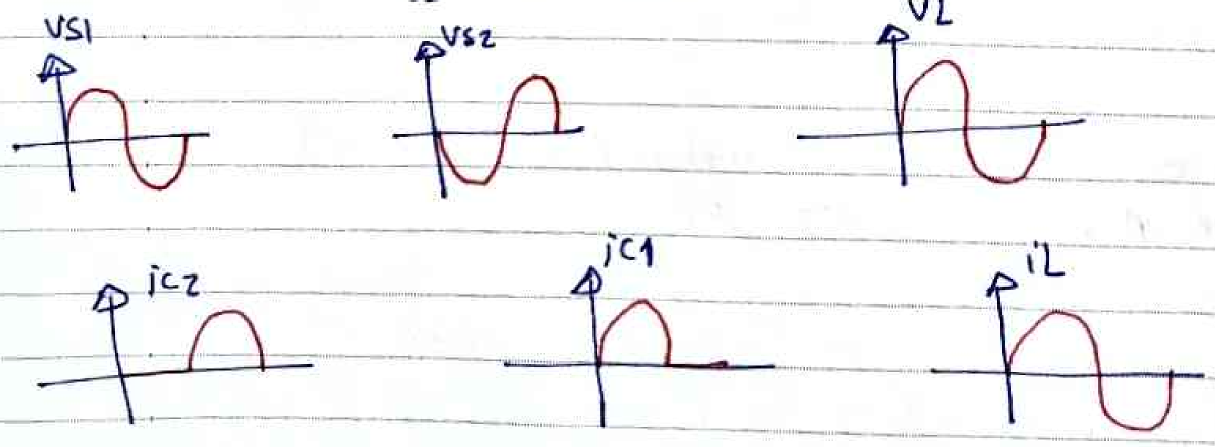
① Find $\overline{P_L}$, $\overline{P_S}$, P_D (each)
② sketch A.C & D.C. L.L with v_L & i_L swing.
③ Find peak i/p voltage which gives max $\eta\%$

class-B push-pull

* using same-Type of Transistor.



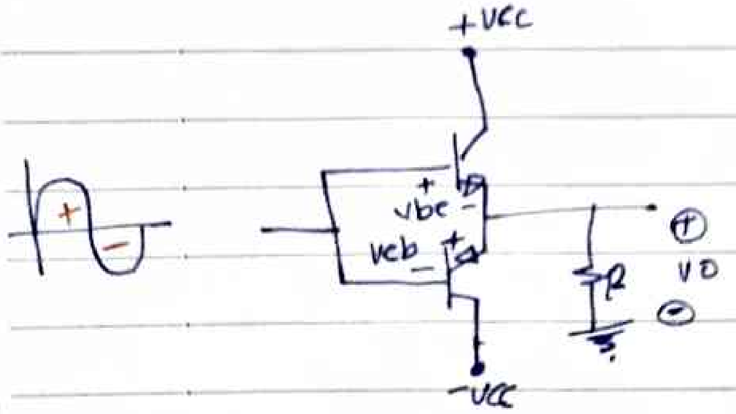
Q_1 & Q_2 operates ab +ve.

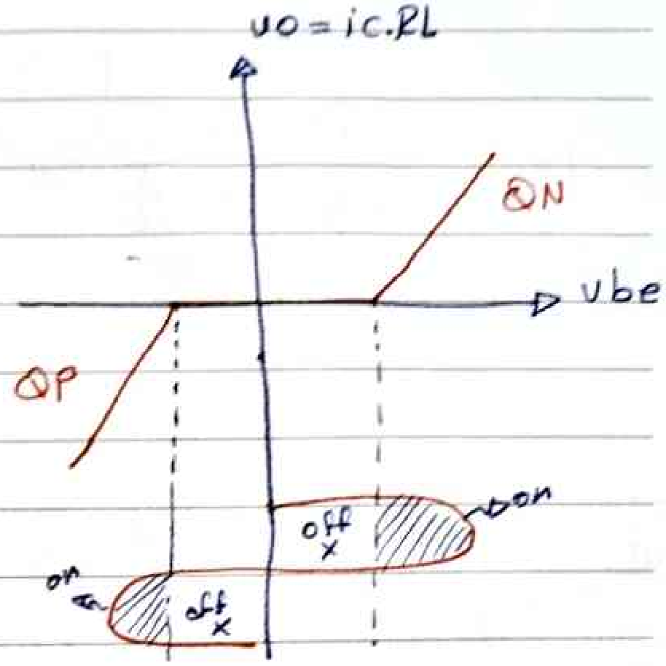


$\Rightarrow i_L = i_{c1} - i_{c2}$

* class-AB ⇒ يحل مشكلة ال distortion في ال class-B
* if $v_{be} = 0$ ⇒ $v_{i/p} = v_{o/p}$

37



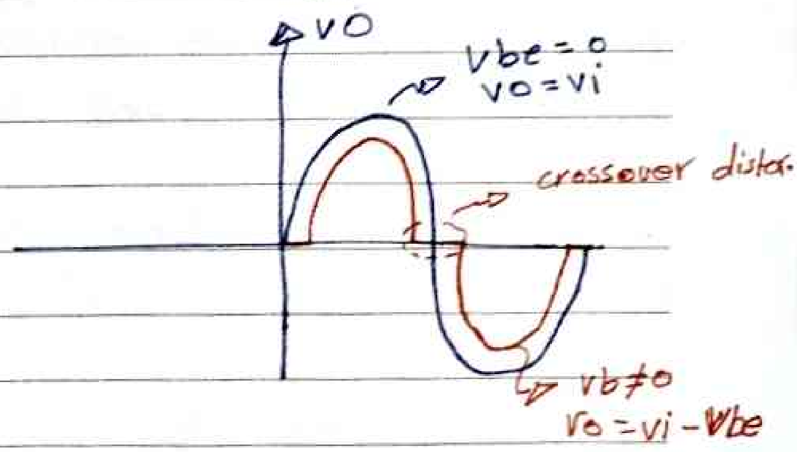


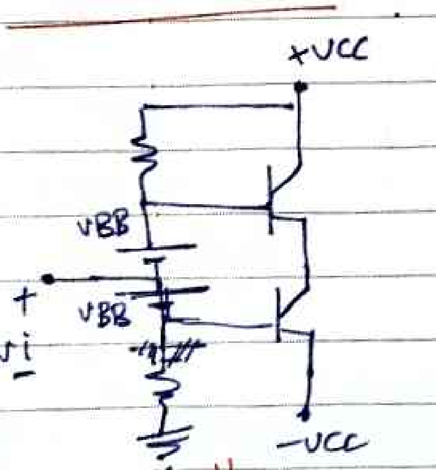
* +ve ⇒ $-v_i + v_{be} + v_o = 0$

$v_o = v_i - v_{be}$

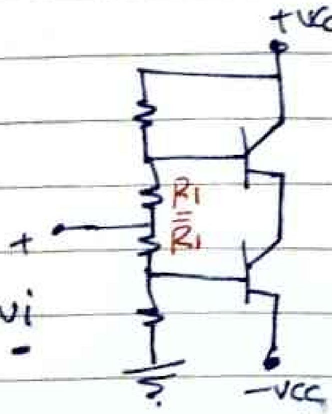
* -ve ⇒ $v_i - v_{eb} + v_o$

$v_o = -v_i + v_{be}$

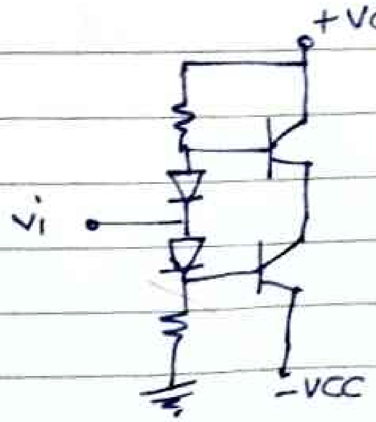




2 voltage source
(X)



* R ⇒ makes voltage drop, but the Res. affected by temp. & has not fixed value



أحسن واحد

Diode ftrag Same

* so Here I used Diodes (because they affected equally by Temp.

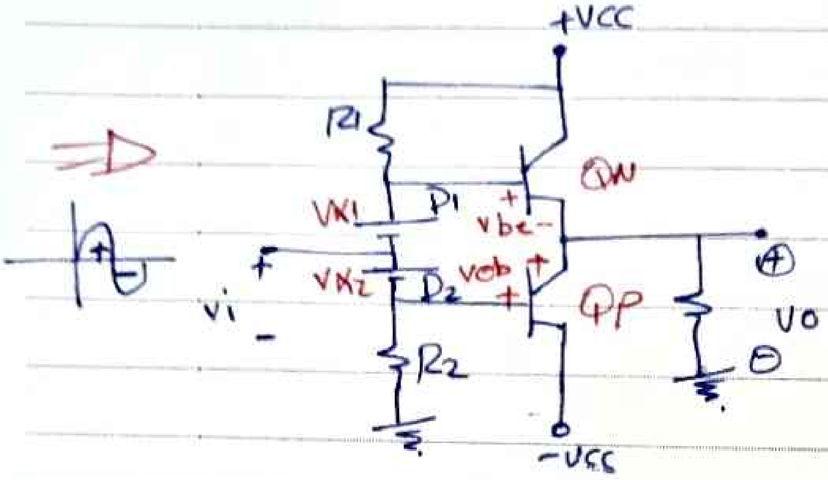
because ① finite value of vbe
② Q-pt at cutoff

* class-B يعني crossover dist ✓

* أما الباقي non-Linear dist ✓

it happens only when signal cross the x-axis

$\boxed{38}$



$Vx = Vbe = Veb$

① Q-pt between A & B positibjo, $I_{CQ} \neq 0$ (becuase there are I_B).

② The o/p Vo & Io flows for >180° & <360°

③ $\eta_{AB} > \eta_A$ but $< \eta_B$ (very close to class-B)

④ Practically two compensating diode (of the same Type of BJT) are used with $Vx = vbe$

* crossover distortion تكملة

① occurs only in class-B, becuase Q-pt at cutt off.

② it is due to Vbe of the BJT which results in distortion at crossover Regn.

③ it could be canceled by applying small D.C voltage equal opposite to Vbe

بدل اللي فوق ④

* Load → parallel Tuned cct → (the o/p will be a sins. not pulse)
→ when the Load is R

* BJT → works as a switch

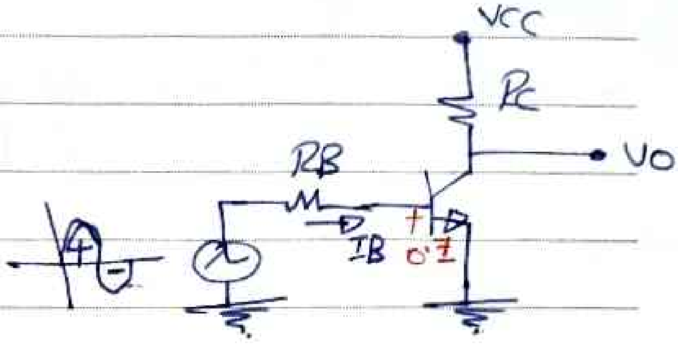
* class-c works as
  - → P.A
  - → Modulator.

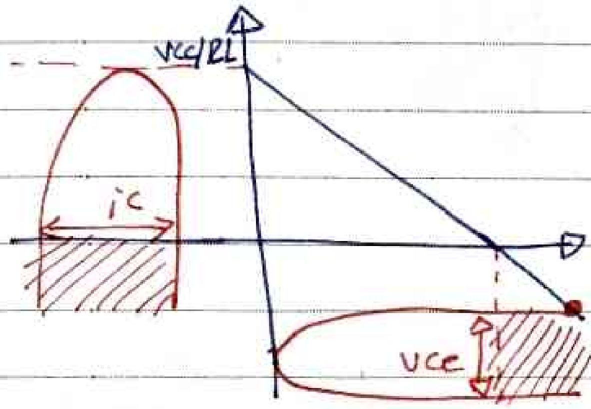
39

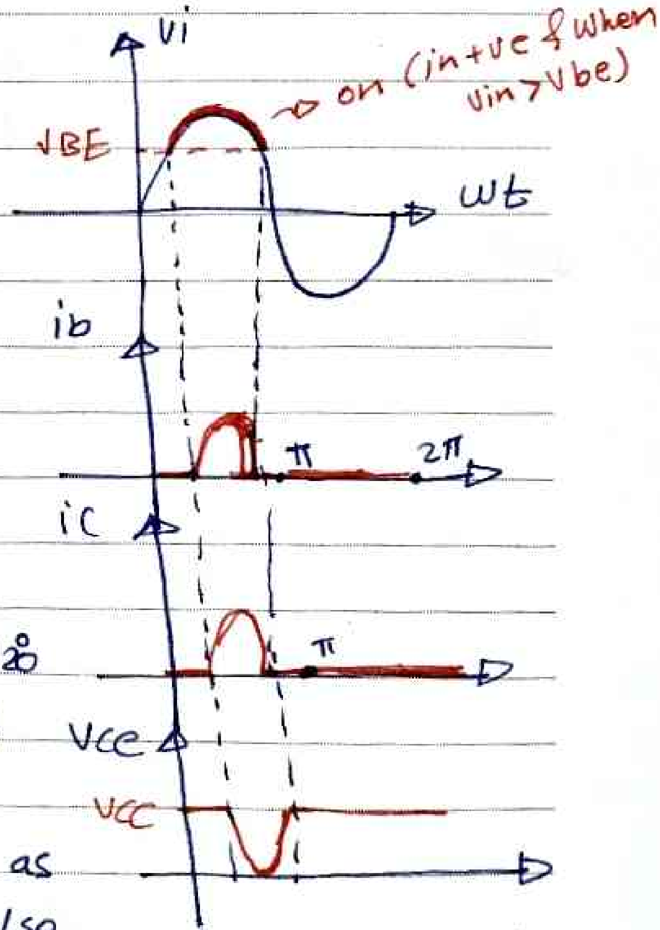
Class-c P.A

$-Vi + IB\,RB + VBE = 0$

$IB = \dfrac{Vi - VBE}{RB}$







① Q-pt down the cut-off

② Active device (BJT, FET) conducts for < 180°, $80° < \phi c < 120°$

③ Normally the Load is a parallel Tuned cct

④ the BJT ~~is on(sat)~~ will work as switch, the ic form will a pulse form. when BJT is ON (sat)
$IC = IC\,sat$, $VCE = VCE(sat)$
when it is off $IC = 0$, $VCE = VCC$

* عم يشتغل ك switch
  - → ON → sat
  - → off → off

⑤ At Resonance freq. of LC cct, $fr = \dfrac{1}{2\pi\sqrt{LC}}$, the tuned cct will Produce a sine-wave o/p with Amp $\pm VCC$

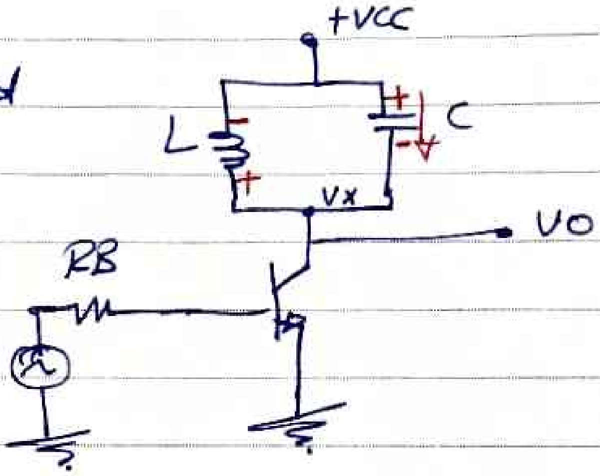
⟹

* flywheel effect of parallel LC (self oscillating)
→ happens at Resonance → AC o/p sig with Resonant freq

* high Level modulation $\Rightarrow$ mod: جهد & Power تكبير

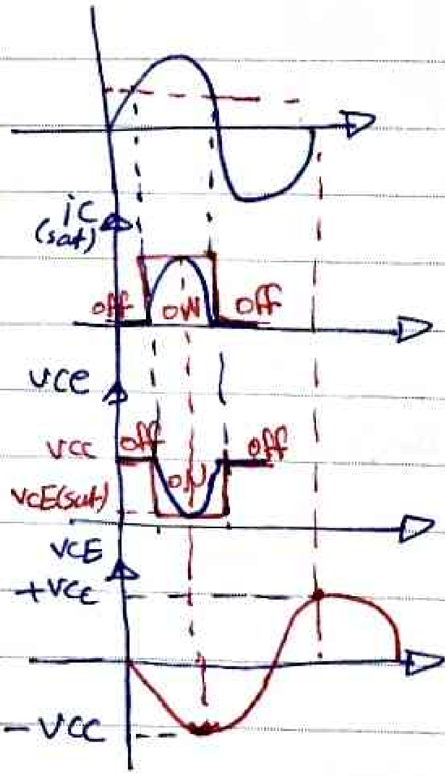
[40]

and $f = f_r = \frac{1}{2\pi\sqrt{LC}}$, due to flywheel effect.



* when trans is on the current will through the cap & it will charge until max = VCC
$\rightarrow$ trans(on) $\rightarrow$ $VX = +VCC$

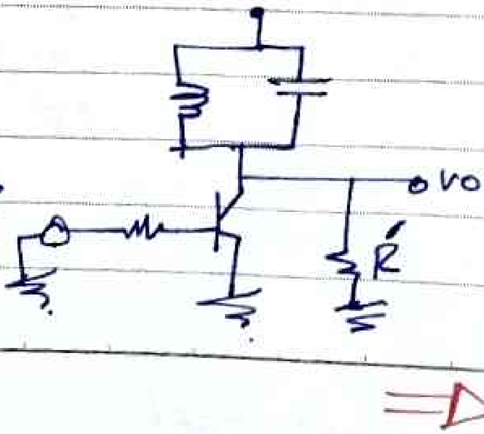
* when trans is off the cap will discharge in L
$\rightarrow$ so trans(off) $\rightarrow$ $VX = +VCC$



R effect $\leftarrow$

Tuned LC effect $\leftarrow$
$\rightarrow f = f_r$

$$P_{L max} = \left(\frac{V_{CC}}{\sqrt{2}}\right)^2 * \frac{1}{R'}$$



$\Rightarrow$ R' :- Total effective Resistance across Tuned cct

$\Rightarrow$

$Q_c \downarrow \rightarrow eff \uparrow$

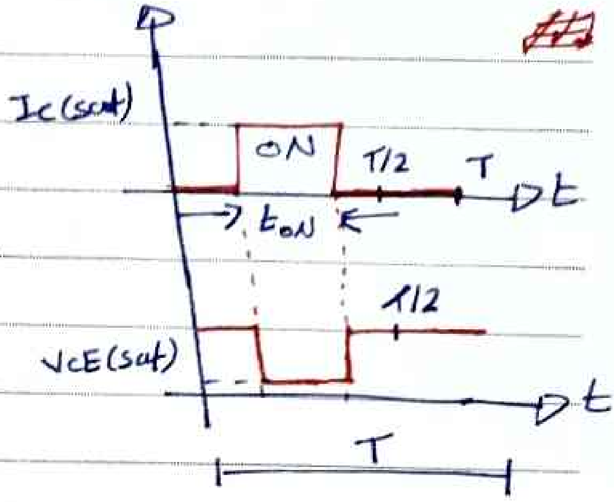
41

$\overline{P_L}_{max} = \frac{V_{CC}^2}{2R'}$

$\overline{P_S} = \overline{P_L} + P_{D\,avg}(BJT)$

$\eta\% = \frac{\overline{P_L}}{\overline{P_S}} * 100\%$

$P_{D\,avg}(BJT) = \frac{P_D(ON)\, t_{ON}}{T}$



$P_D(ON) = I_C(sat) \cdot V_{CE}(sat)$, $T = \frac{1}{f_{input}} \rightarrow$ هو اللي بيحدد OFF / ON

EX:- a class-C P.A has input signal of freq = 50 kHz the BJT is ON for 2 μs. and has: $I_C(sat) = 0.2$ A $V_{CE}(sat) = 0.3$ V, given $V_{CC} = 20$ V & the total effective Res = 100 Ω.

1. calculate $\overline{P_L}, \overline{P_S}, \eta\%$
2. Design the Tuned ccf to process the i/p signal.

SoL:-

$\overline{R} = 100\,\Omega$

$\overline{P_L} = \frac{V_{CC}^2}{2R'} = \frac{400}{200} = 2\,W$

$P_D(avg)(BJT) = P_D(ON) = \frac{t_{on}}{T}$

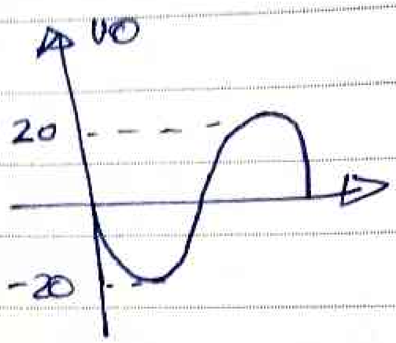
$T = \frac{1}{f} = \frac{1}{50*10^3} = 20\,\mu s$

$\overline{P_D}(avg) = (0.2 * 0.3)\frac{2}{20} = 0.06 * 0.1$

$= 0.006\,W \Rightarrow$

* if we want it to give double freq or Tripple $\Rightarrow$ n freq $= \frac{1}{2\pi\sqrt{LC}} \rightarrow$ Design

$$\eta = \frac{2w}{2+0.006} * 100\% = 99\%$$



② $f_r = 50\ kHz$

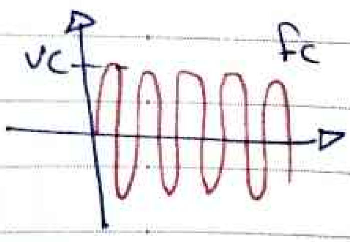
$$f_r = \frac{1}{2\pi\sqrt{LC}} \quad , \text{let } C = 1nF$$

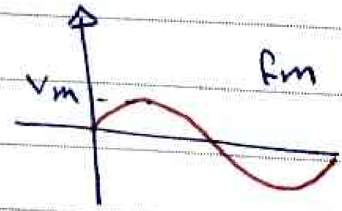
$$L = \frac{1}{2\pi^2 f_r^2 C} = \frac{1}{4*10*25*10^8*10^{-9}} = \frac{1}{100}\ H = 10mH$$

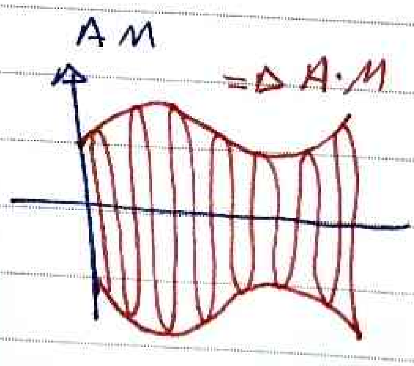
AM Modulator

* modulation :- changing certain cl's of carrier's according to Amp. of the message signal.

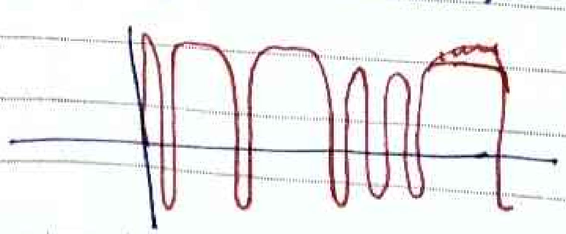
1)- In AM :- the Amp of the message change the Amp of the carrier





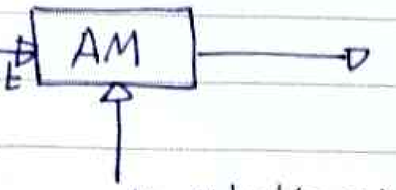


2)- In FM :- the Amp of the messege signal change the freq of carrier



★ LSF & USF → if Vam has a single freq → one freq } $\underline{\underline{m=1}}$ أعلى power لكل تردد ★
★ LSB & USB → " " " a band of " " }
→ Band (group of freq. [L]) $\boxed{43}$

we changed the Amp of carr. & that is the definition of AM.



$V_c(t) = V_c \sin 2\pi f_c t$

$V_{out} = (V_c + V_m \sin 2\pi f_m t)\sin 2\pi f_c t$
$= V_c(1 + m \sin 2\pi f_m t)\sin 2\pi f_c t$

$V_m(t) = V_m \sin 2\pi f_m t$

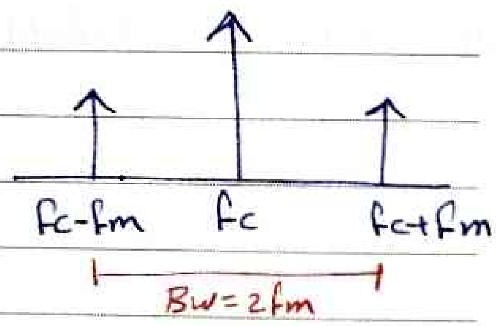
* V_c :- Amp of carrier
* m :- mod index $= \frac{V_m}{V_c}$
* f_c :- freq of carrier
* f_m :- " " message

Ex:- $V_{am} = 5(1 + 0.8 \sin 2\pi 10^3 t)\sin 2\pi 10^6 t$
$\downarrow V_c$ $\quad \downarrow m$, $V_m = V_c \cdot m = \underline{4}$

★ for $m = 1$

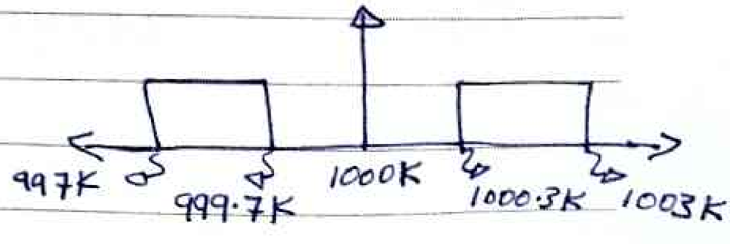
$P_{fc} = \frac{2}{3} P_T$

$P_{LFS} = P_{USF} = \frac{1}{6} P_T$

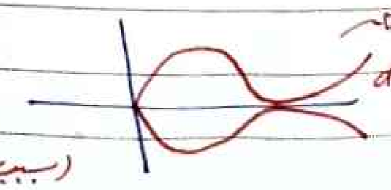


⊟ If $V_m(t)$ has a single freq f_m then V_{am} has LSF & USF
⊟ If $V_m(t)$ has a band of freq such as voice signal $(0.3 \to 3)K$ then V_{am} has USB & LSB

Ex:- $f_c = 1000\,K\,Hz$
$f_m = (0.3 \to 3)K$



★ $m \to$ maximum $= 1$



→ لو اعلى من 1 ع يصير في distor. & overlap

لأنو بتغير بمقدار

★ $BW_{AM} = 2 f_m \to \pm f_m$ (بسبب كده)

f_m :- max freq in message signal.

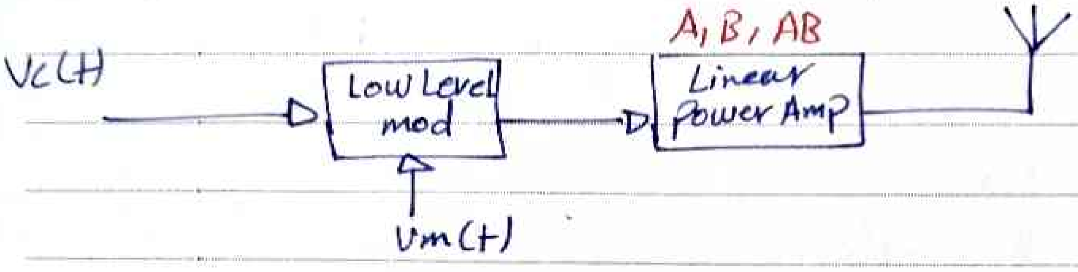
* we use PIN Diode for High frequency.

$V_C > V_m \rightarrow$ ok $\rightarrow \mu < 1$ $\boxed{44} \rightarrow$ [illegible]

$V_m > V_C \rightarrow$ distortion

modulat. index $\rightarrow \mu = \frac{mp}{A} = \frac{V_m}{V_C} > 1$

(*) Low Level modulator :- both amplit. & power of AM signal are Low, so Linear power Amp is required.

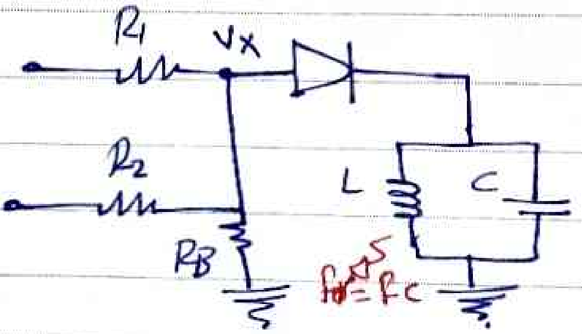


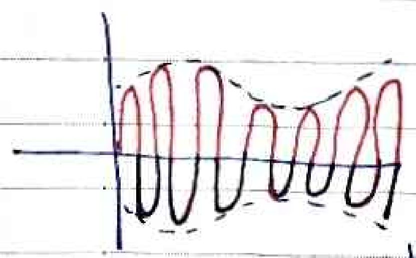
(1) Diode modulator

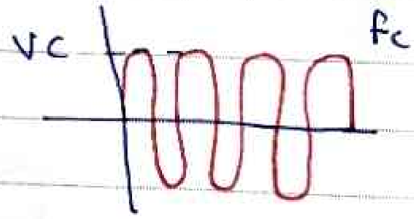
$V_1 = V_C(t) = V_C \sin(2\pi f_c t)$

$V_2 = V_m(t) = V_m \sin(2\pi f_m t)$

$V_X = V_1 + V_2$



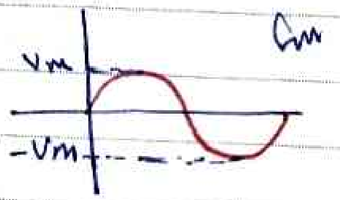




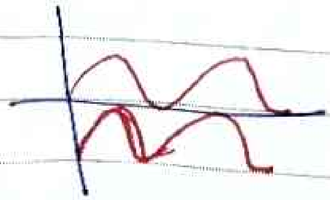
wheel effect from tune cct.

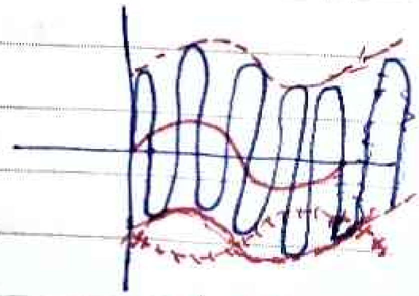
$V_m > V_C$

fc نقص time



if $V_m = V_C$





composite sig.

ك pulse ترد عليه ب pulse بيغني العتبة معا كمل

f_r ⇒ must equal f_c
Q ⇒ gives $2f_m$

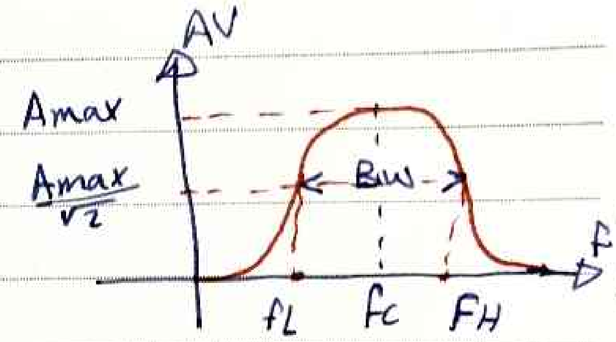
$\boxed{44}$

in AM there are f_c / f_c+f_m / f_c-f_m

→ fr= fresonant

$f_r = f_c = \frac{1}{2\pi\sqrt{LC}}$

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



Q must be choosen such that

$B.W = \frac{f_r}{Q} \geq 2f_m$

if $(B.W) \geq 2f_m$

* for weak signal we use Diodes with small V_K as Germanium

* if $(B.W)_{T.C} < 2f_m$
will be freq distortion

$V_{o1} = A(\overset{\text{Gnd}}{\cancel{V_2}} - V_1)$

$V_{o1} = A(-V_1) \Rightarrow \underline{V_{o2} = A(V_1)}$

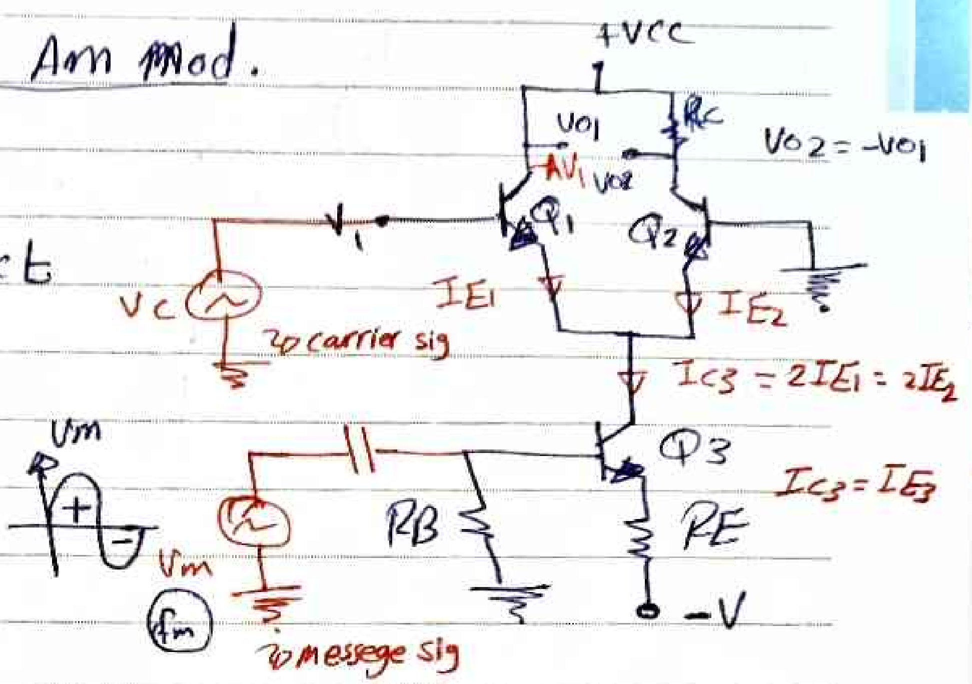
$\boxed{15}$

② Diffrential Amp Am Mod.

* $V_{o2} = -V_{o1} = A \cdot V_1$

when $V_1 = V_c = \sin 2\pi f_c t$

$V_{o2} = A[V_c \sin 2\pi f_c t]$



* IB3 (without modulating sig.)

$\rightarrow I_{B3} = \dfrac{V - V_{BE}}{R_B + (\beta+1)R_E}$

$I_{C3} = \beta I_{B3}$

* when modulating sig is applied

↳ ① For +ve H.C of Vm

$I_B\uparrow = \dfrac{V_m + V - V_{BE}}{(\beta+1) R_E}$

$I_C\uparrow, I_E\uparrow, A\uparrow$, Amp of $V_c\uparrow$

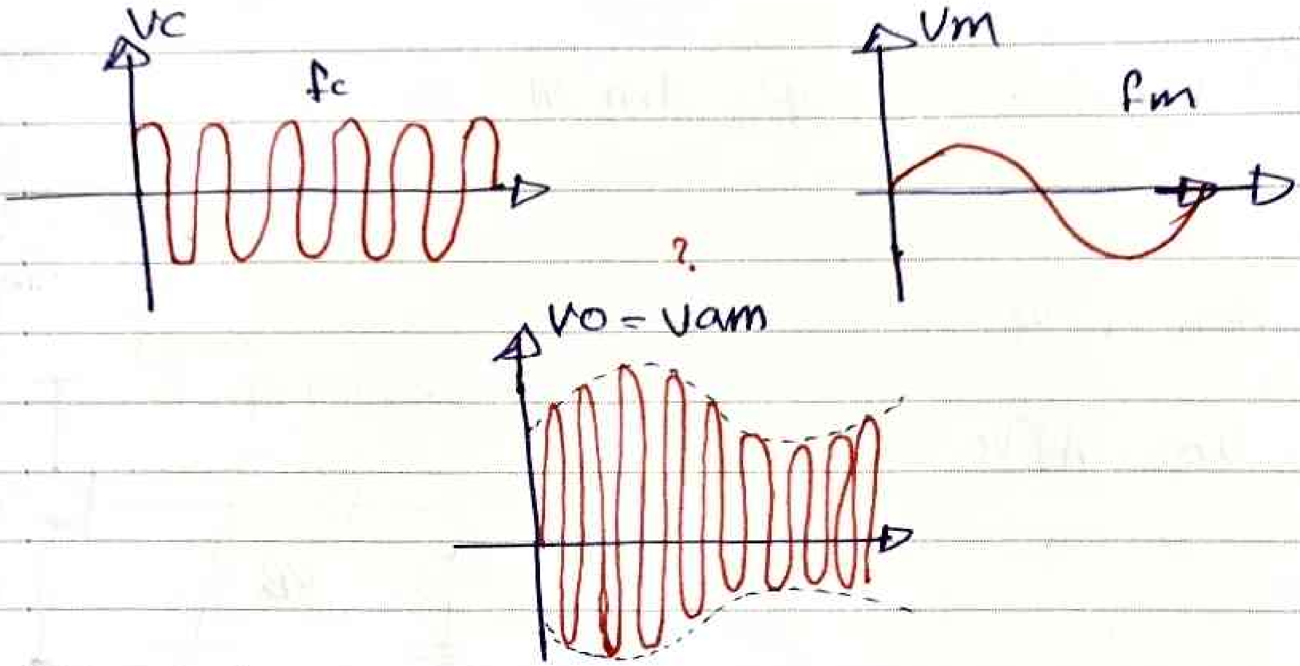
↳ ② For -ve H.C of Vm

$I_B\downarrow = \dfrac{V - (V_m + V_{BE})}{(\beta+1)(R_E)}$

$I_C\downarrow, I_E\downarrow, A\downarrow$, Amp of carrier $\downarrow$

* V_o = carrier multiply by gain

* its available in IC Form
* it has a gain [IE change gain]



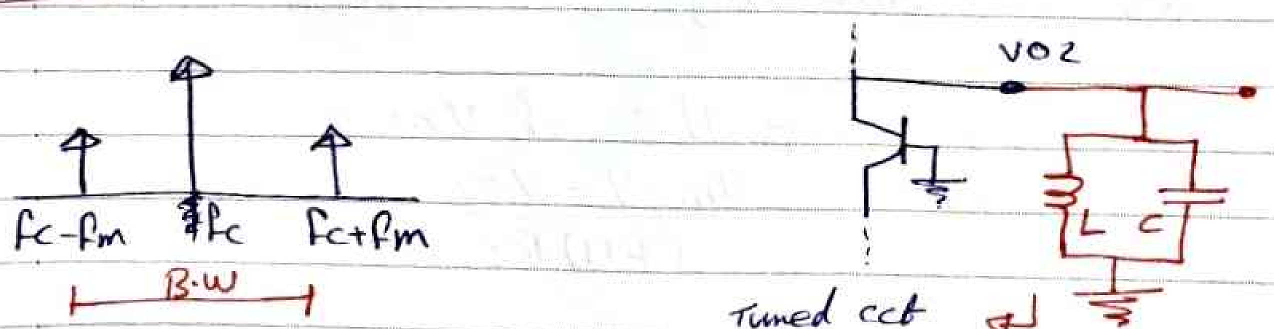
* compared to Diode mod, this mod has the advantages of gain & available in I.C Form

How

$$A = \frac{Rc \cdot IE}{K}$$

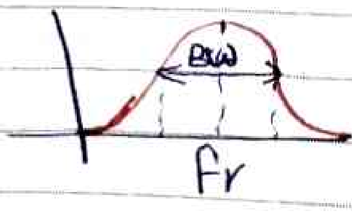
$Rc \to \Omega$

$IE \to mA$



$$fr = fc = \frac{1}{2\pi\sqrt{LC}}$$

$$B.W = \frac{fr}{Q} \geq 2fm$$



* Bandwith cutting $\to$ causing a distortion signal (BW $\ngeq$ fm)

* Def. mod better than Diode mod.

47

* to obtain all the information a Tuned cct must be connected & designed such that

$$f_r = \frac{1}{2\pi\sqrt{LC}} = f_c$$

$$Q = \frac{f_r}{B.W} \quad \text{(must be choosen)}$$

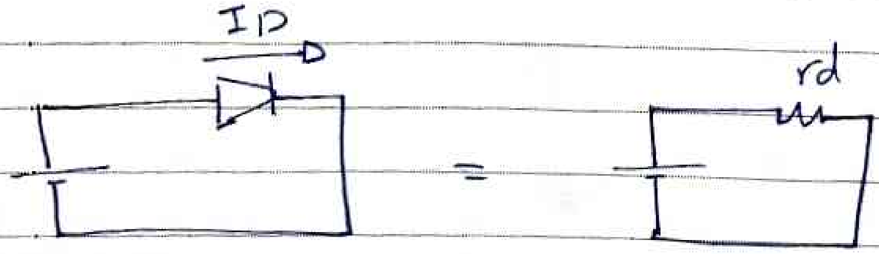
$= 2f_m$.

such that $(B.W)_{TC} = \frac{f_r}{Q} \geq (B.W)_{AM}$

(3) PIN Diode Mod.

(Very High freq, ultra H.F, microwave Freq.) $> 100MHz$

* PIN Diodes :- special TYPe diode
- very high speed diode
- used as a voltage variable resistor For U.H.F.
  (behaves as a resistance depends on F.W current).



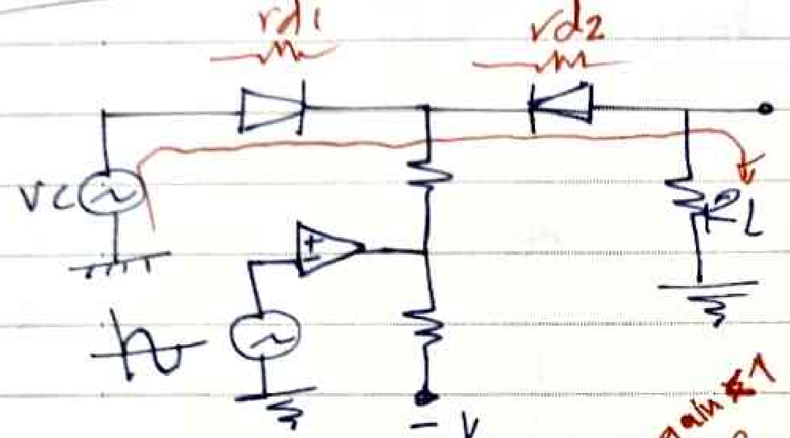
$$r_d \propto \frac{1}{I_D}$$

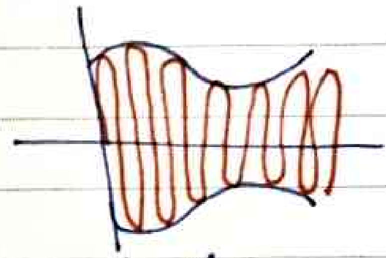
$\Rightarrow$

* The mod cct :-

$(V - D)$

$$v_o = \frac{v_c R_L}{r_{d1} + r_{d2} + R_L}$$



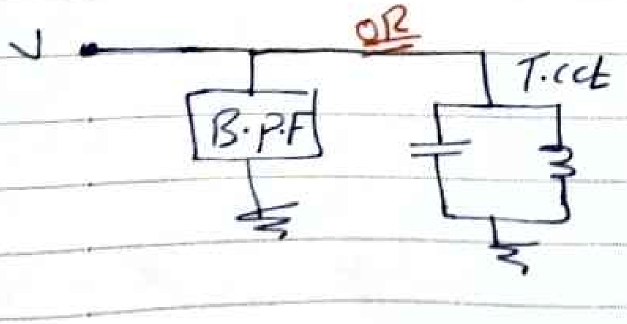


$r_d \propto \frac{1}{I_D}$

* This cct make Attenuator, & the importance of it → modulating

① In this mod :- the Amp of message signal change the value of ID & rd, so the Amp of o/p will be changed according to Amp of message

② this is an R.F Attenuator.



→ can be used & in this cct we dont need it.

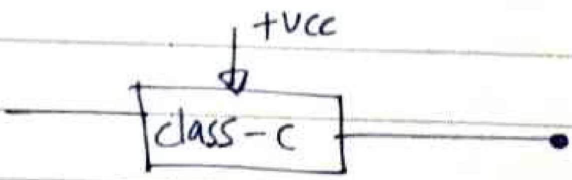
why?

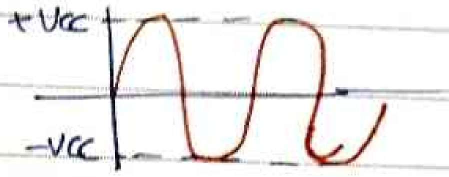
FAM → $f_c = f_r$, $BW_{AM} \to 2f_m$

* we dont need a Linear power Amp.

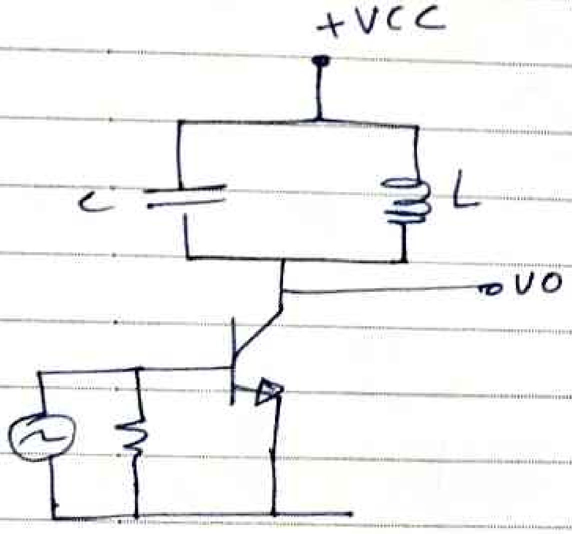
High-Level modulator.

The mod. happens in the final class-c Power Amp. in AM Tx.

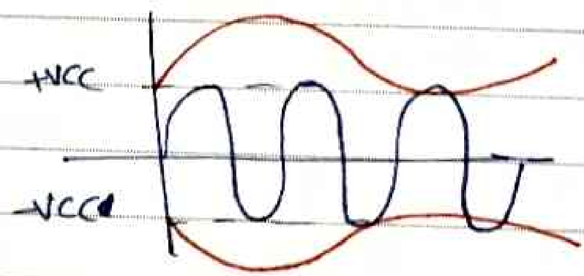




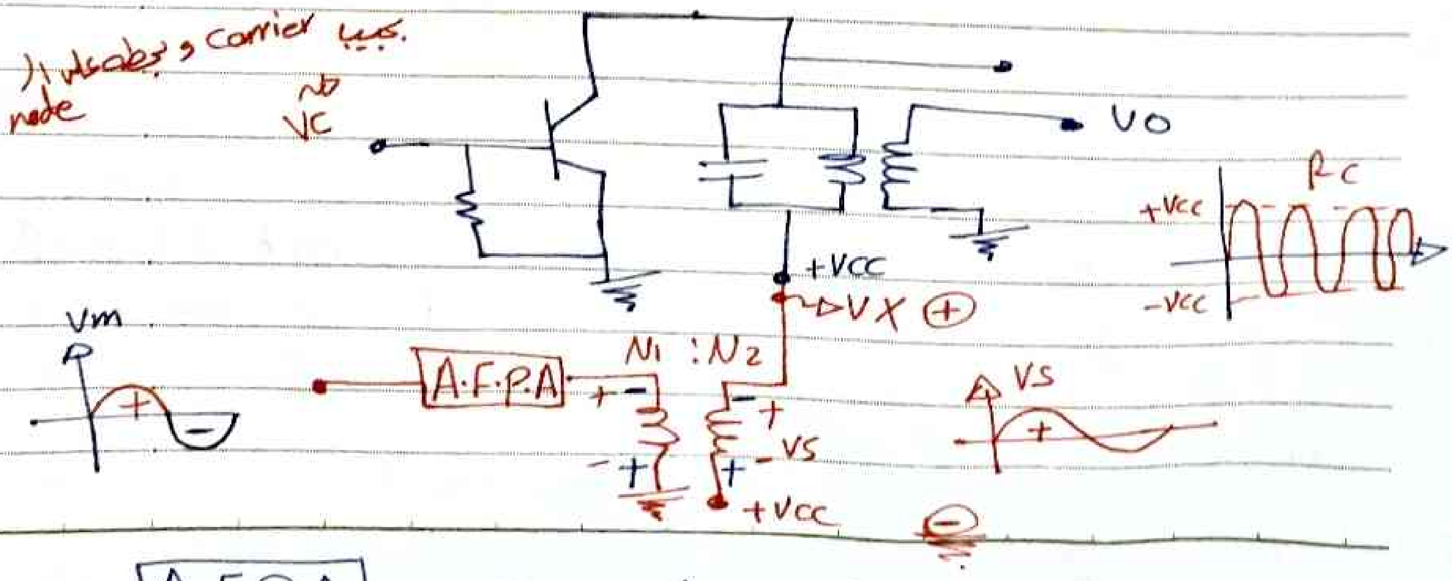
$$f = f_r = \frac{1}{2\pi\sqrt{LC}}$$



?



$f = f_r$



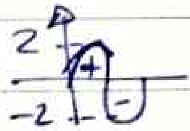
$\boxed{A.F.P.A} \rightarrow$ Power Amp of vm

* في هذه الدارة خلينا ال V_{CC} تعتمد على ال mod. sig.

* وال freq لالها هو نفسه لل Tuned cct or $f = f_c = f_r$

$\boxed{50}$

For +ve V_m



, $N_1 : N_2 = \underline{1:1}$

& $\underline{V_{CC} = 5}$

$\rightarrow$ +ve of $V_m \Rightarrow$ +ve of V_S

$-V_{CC} + V_S + V_X = 0$

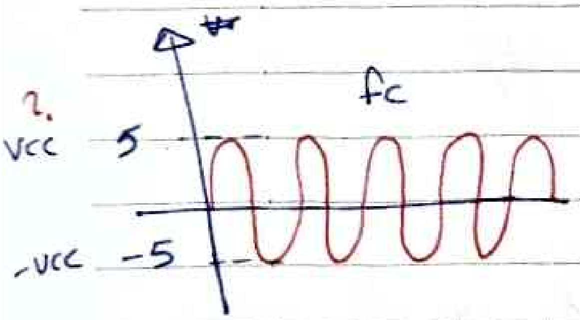
$\Rightarrow V_X = V_{CC} + V_S = 5 + 2 = 7$

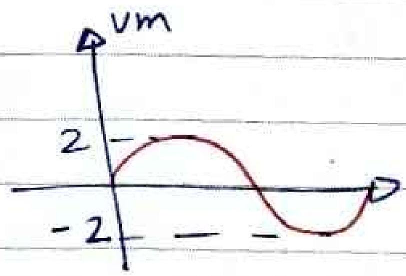
For -ve V_m

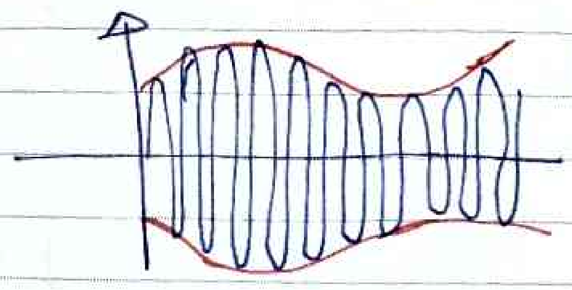
$\rightarrow$ -ve $V_m \Rightarrow$ -ve of V_S

$-V_{CC} + V_S + V_X = 0$

$\Rightarrow V_X = V_{CC} - V_S = 5 - 2 = 3$







$f = f_c = f_r$

* To obtain 100% mod. index the peak value of secondery voltage must be equal Vcc

not dc voltage

$\rightarrow$ +ve H.C $\rightarrow 2V_{CC}$ $\qquad$ $\rightarrow$ -ve H.C $\rightarrow$ 0

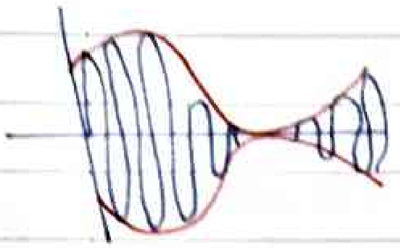
* قد يطلب Vm التي تجعله 100% وليس Vs، نجيبها بـ $N_1 : N_2$ بالعملية عشان class-C

* الذي يضاف ويطرح هو $\underline{V_S}$ ويعتمد على $\underline{N_1 : N_2}$

* لا نحتاج الى ال power Amp بحيث اني باخذها من ال o/p لل Y ← وال o/p

* To have modulated Index equal 1 Vs should be equal the Vcc

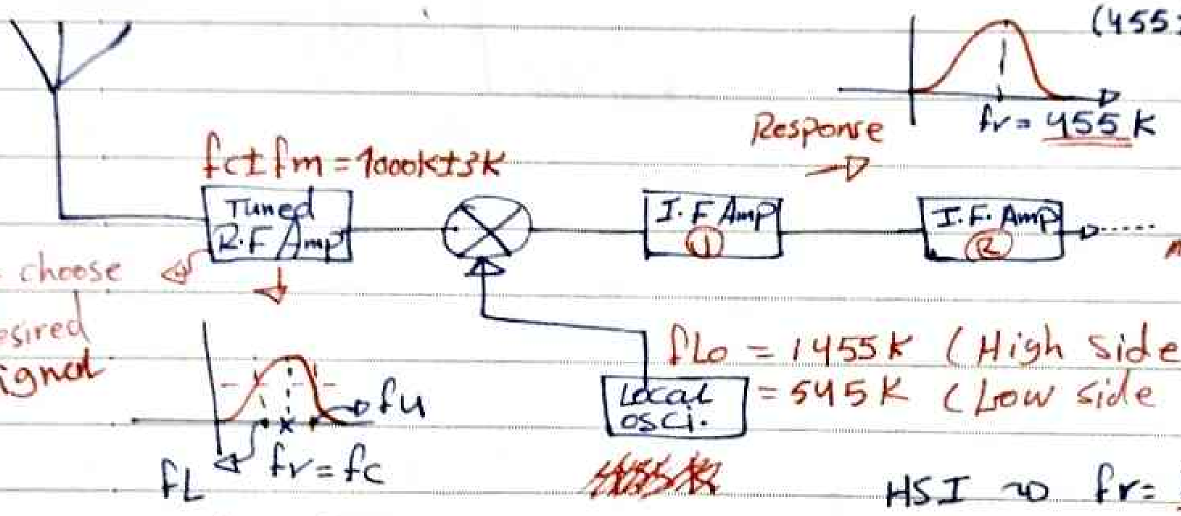
51



* BW must be $2f_m$ for Tune cct.

AM Demodulation

for mod sig = 1000 K



→ Down freq. conversion

عملناها عشان ال

تزيد ال gain

وتصير more stable

to choose desired signal

$f_{LO} = 1455K$ (High side injection) HSI

$= 545K$ (Low side injection) LSI

HSI → $f_r = f_{LO} - f_r$

$455 = 1455 - 1000$

LSI → $f_r = f_r - f_{LO}$

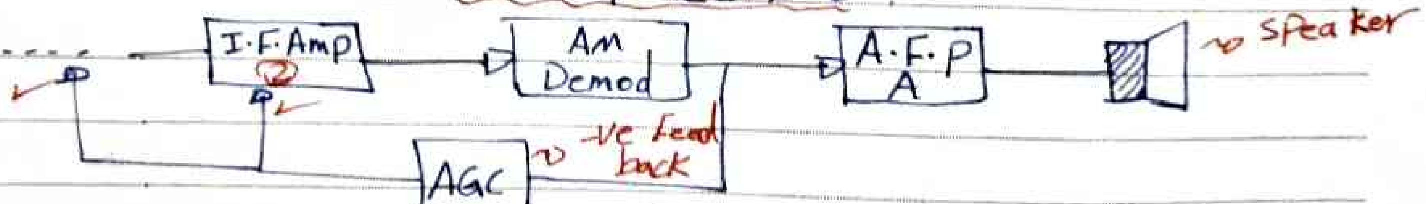
$455 = 1000 - 545$

$(B.W)_{TRF} = \frac{f_r}{Q} \geq 2f_m$

ليش ?? لازم ال BW → لازم تساوي mod sig or 2FM → خلاص لازم يكون أكبر عشان ال distor.

* 455 ⇒ high gain & high stability & image regection

AM. sup. het R.t



→ Automatic gain controll, which controlled the gain reached by the speaker

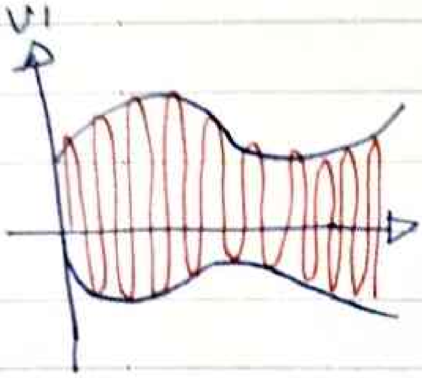
اذا كان ال gain عالي بنفوت على AGC ← وبصير -ve وبنفوت على IF Amp وبقلل ال gain والعكس صحيح

freq ↓, gain ↑, image (proplem not solved)

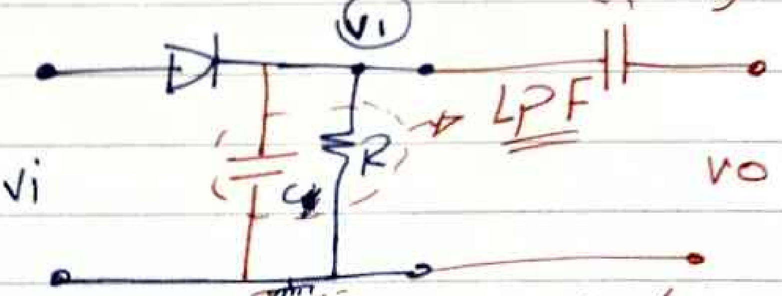
* operating freq ↑, stability ↑ (better), image (proplem solved) gain ↑

*the AM demod. recieves the sig. from I.F. Amp

AM Demodulator
(Diode mod. or Envelop Detector)

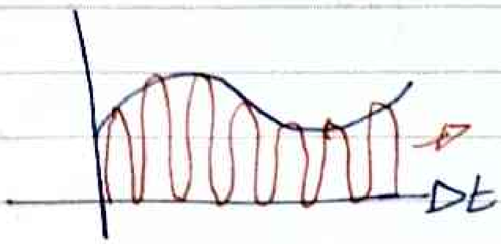


بنضيفها عشان اتخلص من ال D.C offset



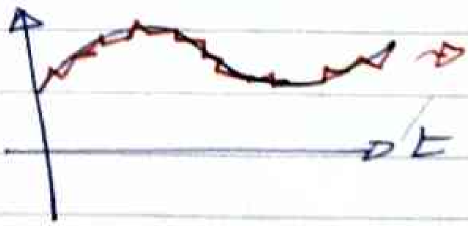
بنركب ال cap عشان اتخلص من ال carr. بحيث ال carr. يذهب الى ال Gnd عن طريق ال cap من خلال عملية الشحن والتفريغ

⟹ V_1



→ to remove the carr. we add C*

⟹ after adding C*

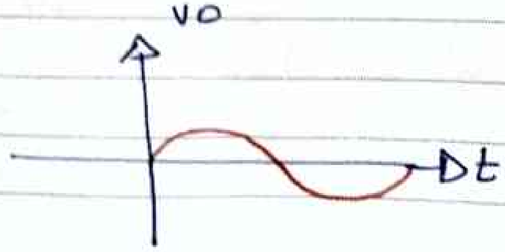


→ ripple

in HWR

$V_r = \frac{V_m}{fCR}$

⟹ after adding C_1



⟹

diode works as a H.W rectifier, ripple at H.W bigger than F.W

so we use F.W (better) improve

* For High operating freq, the ripple must be small so I can detect it $\rightarrow$ so I use F.W Rectefier.

$V_r \propto \frac{1}{F}$

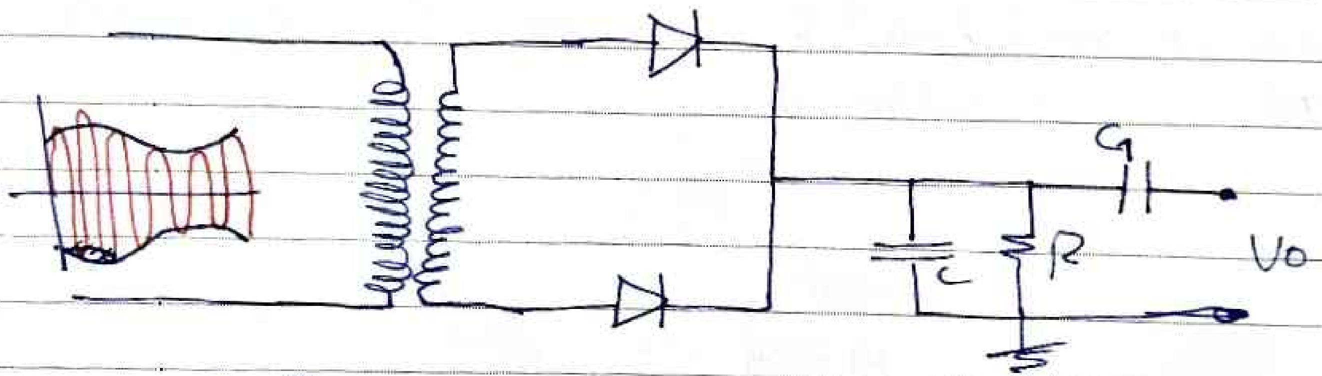
53

Rc $\rightarrow$ Low pass filter

$T_m << RC << T_c$

$T_m = \frac{1}{f_m}$, $T_c = \frac{1}{f_c}$

* to reduce ripple in detected message and for High operating freq. Full wave Rect. can be used



in FWR

$$V_{rF} = \frac{V_m}{2 f_c R} = \frac{V_{rH}}{2}$$

① For the same V_m, f, C, R

$V_{rF} = \frac{1}{2} V_{rH}$

② For the same V_r, V_m, R

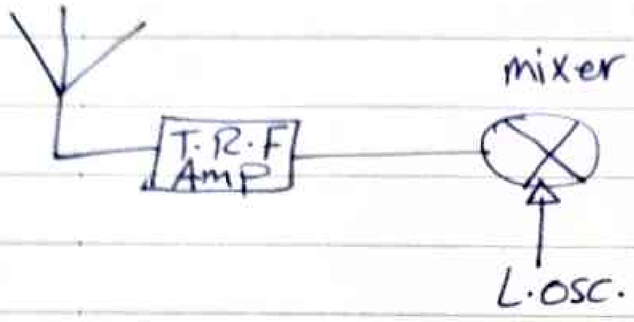
$C_F = \frac{1}{2} C_H$ ✓

* reciev. selectivity: the ability of select certain freq from group of frequencie's

* Q↑ → BW ↓ , $Q = \frac{fr}{BW}$

* reciever sensetivelies:- the min I/P sig which the reciever can detict (units in micro volt)

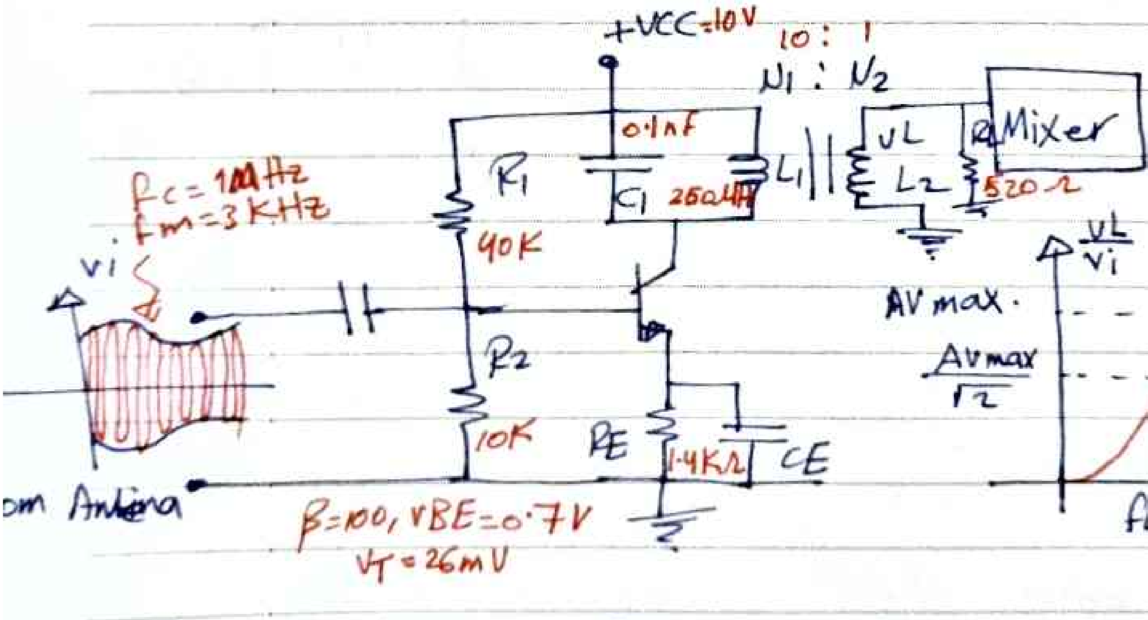
→ depends on gain for reciever. g↑, sens.↑ $\boxed{54}$

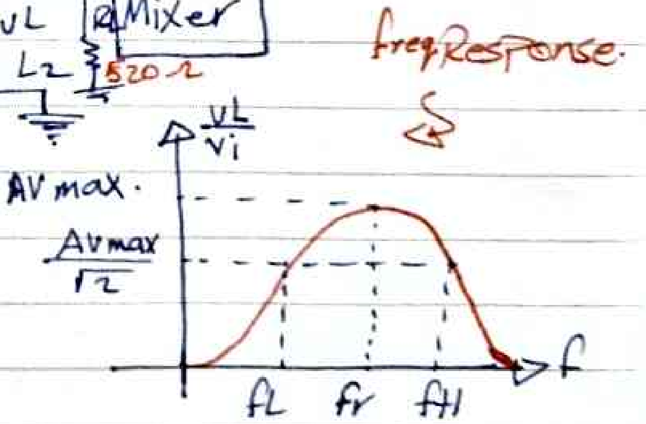


* Tuned RF Amp.

① improve selectivity & sensetivity of Rx (Reciever)

② Prevent reradiation of Local oscillator signal via antina (Leak through).





$$fr = \frac{1}{2\pi\sqrt{L_1C_1}} = fc$$

$$B.W = \frac{fr}{Q} \geq (B.W)\,fm$$

$$(B.W)_{TRF} \geq 2fm \Rightarrow$$

١- selector تيجي اكثر اشي من ال T.R.F *

٢- gain for reciever = gain(T.RF) * gain(mixer) * g(T.RF) --- *

$V_o = -g_m V_\pi \bar{R}_L \rightarrow A_V = -g_m \bar{R}_L \quad , \quad g_m = \frac{I_{CQ}}{V_T}$? هل يساوي

$V_i = V_\pi$

$\rightarrow A_V = -\frac{I_{CQ} \bar{R}_L}{V_T}$ $\rightarrow$

55

Ex:- For the brevious figure , Find:-

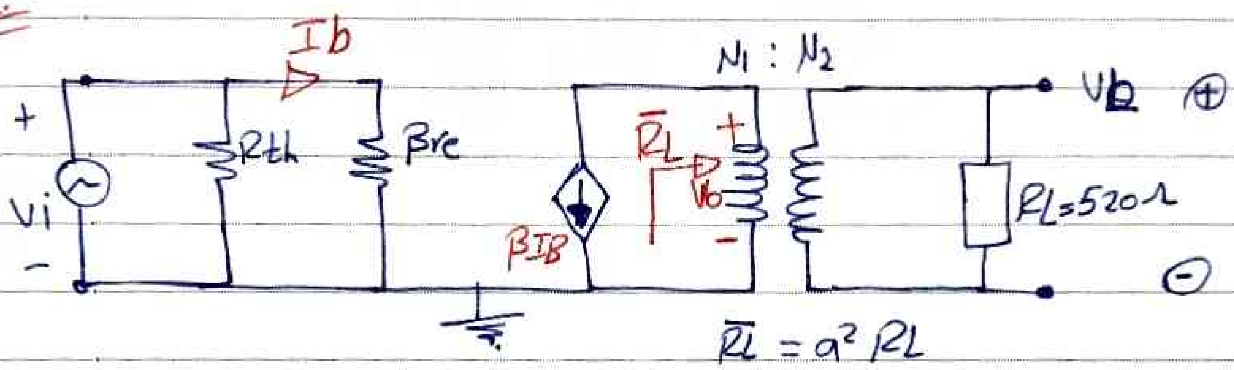
① calculate $A_{V\max}$, f_r , B.W , Q

② Draw freq Response

③ can this cct. process mod. signal of 3KHz

ازا بتقبل Procs. لازم ال BW يساوي او اكبر 6KHz

Sol:-



$\bar{R}_L = a^2 R_L$

$A_{V\max} = \frac{V_L}{V_i} = \frac{V_L}{V_o} \cdot \frac{V_o}{V_i}$

$\frac{V_L}{V_o} = \frac{N_2}{N_1} = \frac{1}{a}$

$V_o = -\beta I_b \bar{R}_L \quad , \quad V_i = I_b \cdot \beta r_e$

$\frac{V_o}{V_i} = -\frac{\bar{R}_L}{r_e} \Rightarrow \therefore A_{V(\max)} = \frac{1}{a}\left(\frac{-\bar{R}_L}{r_e}\right)$

$\bar{R}_L = a^2 R_L \quad \rightarrow A_V = -\frac{\bar{R}_L I_E}{V_T}$

$A_{V(\max)} = \frac{-a R_L}{r_e} \rightarrow |A_{V(\max)}| = \frac{a R_L}{r_e}$

$\Rightarrow r_e = \frac{V_T}{I_E} \quad , \quad I_E = \frac{V_E}{R_E} \quad , \quad V_E = V_B - V_{BE}$

$\Rightarrow V_B = \frac{V_{CC} \cdot R_2}{R_1 + R_2} = \frac{10 * 10}{50} = 2V$

$V_E = 2 - 0.6 = 1.4\,V \rightarrow$ so $I_E = \frac{1.4V}{1.4K} = 1mA$

$\Rightarrow$

for design $f_{resonse} = \bar{f}_{carrier}$

① Ⓐ $jwL // \frac{1}{jwC}$

$= \frac{jwL / j}{1 - w^2LC / j} = \frac{wL}{j(w^2LC - 1)}$

$\boxed{56}$

$w_o = \frac{1}{\sqrt{LC}}$

② Ⓑ $w_o = f_o . 2\pi$

$= \frac{2\pi}{2\pi\sqrt{LC}} = \frac{1}{\sqrt{LC}}$

$re = \frac{26mV}{1mA} = 26\Omega$

$|Av(max)| = \frac{10 * 520}{26} = \underline{\underline{200}}$

$\rightarrow Q = \frac{\bar{R}_L}{w_o L}$ (parallel Tuned cct)

$\rightarrow w_o = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{250 * 10^{-6} * 10^{-10}}} = \frac{10^8}{\sqrt{250}} = \frac{100}{16}$ M rad/sec

$w_o = 6.3 * 10^6$ rad/sec

$\rightarrow \bar{R}L = a^2 RL = 100 * 520 = 52000\,\Omega$

$\rightarrow Q = \frac{5200}{6.3 * 10^8 * 250 * 10^{-10}} = 33$

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

$\hookrightarrow f_o = f_c = f_r = \frac{1}{2\pi\sqrt{LC}} = 1M\,Hz$

$B.W = \frac{1MHz}{33} \Rightarrow B.W = 30\,KHz$

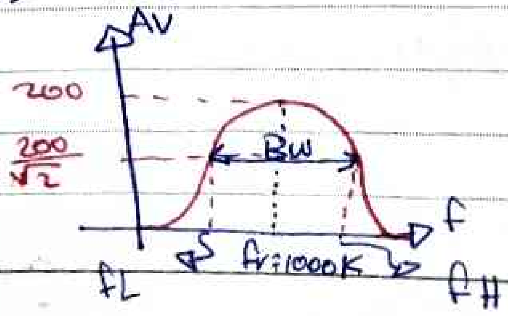
Since $(B.W)_{TC} > (B.W)_{message}$

$30K > 6K$

$\therefore$ This cct can process " " ...

$f_L = f_r - \frac{B.W}{2} = 1000 - 15 = 985K$

$f_H = f_r + \frac{B.W}{2} = 1000 + 15 = 1015K$



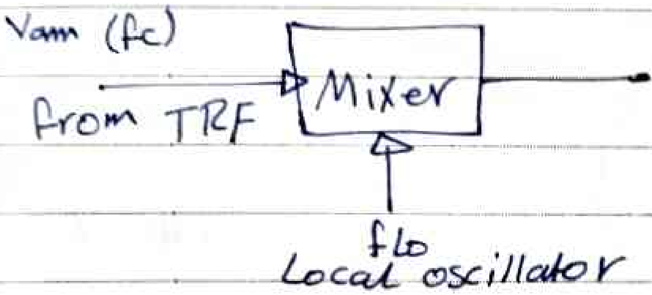
* Diode & BJT mixer → they are exponential.

$I_D = I_s e^{\frac{V_D}{nV_T}}$ → $I_B = I_D = I_{diode}$

* العلاقة اللي بتوصفلي ازا ال device
[57] V & I علاقته lin or non-lin or squ

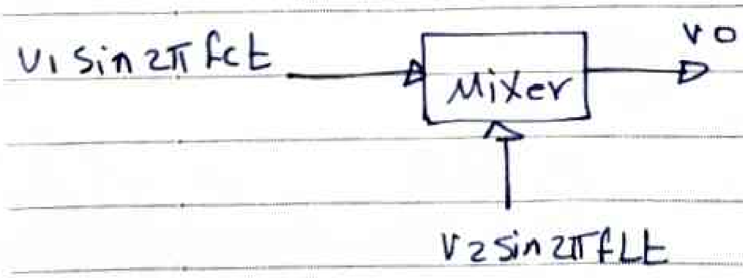
Mixer

* Defenition:- it is non-Linear cct. receives two freq. (fc, flo) and produce diffrent freq's. depending on Type of mixer.



① Diode & BJT Mixer produces infinit # of freq. becuase they are exponentially devices.
(flo, fc, flo−fc, flo+fc, 2flo, 2fc, 3flo, 3fc, - - - - - - - -)

② FET Mixer produces (fc, flo, fc+flo, fc−flo, 2fc, 2flo) becuase FET is square-law device ($I_D = K_n(V_{GS} - V_{TN})^2$)



$v_o = Av_i + Bv_i^2$

$= A(V_1 + V_2) + B(V_1 + V_2)^2$

$= AV_1 fc + AV_2 fLo +$
$B(V_1^2 \sin^2 fc + V_2^2 \sin^2 fLo)$

$= fc + fLo + 2fc + 2fLo + (fLo - fc) + (fLo + fc)$

we choose this freq

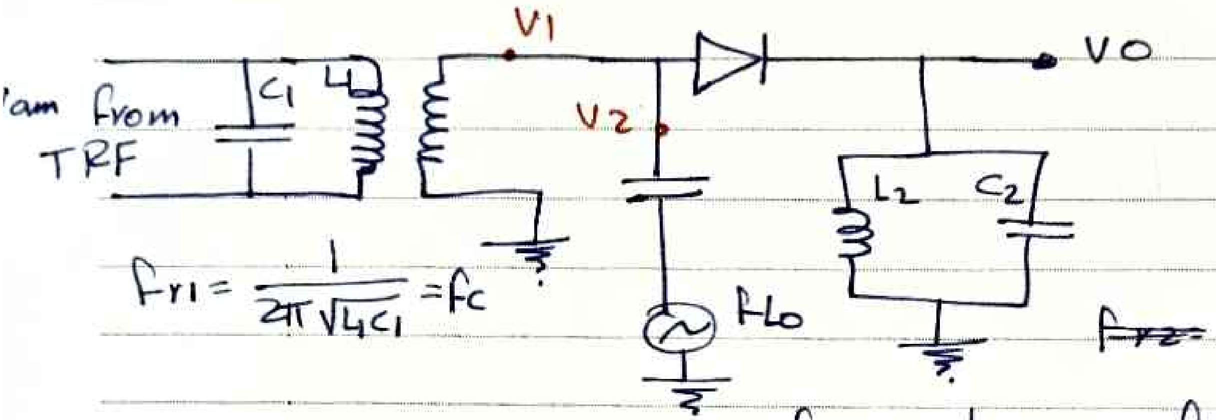
by (Tuned cct OR Band pass Filter on (flo−fc))

for gain & stab.

* In Mixers we always use FET Mixer not BJT ore diode

* نختار دايماً الـ (flo-fc) عايركب B.P.F او Tuned cct. → Down freq. conversion.

① Diode Mixer



$$f_{r1} = \frac{1}{2\pi\sqrt{L_1C_1}} = f_c$$

~~f_{r2}~~

$$f_{r2} = \frac{1}{2\pi\sqrt{L_2C_2}} = f_c - f_{LO} \quad (LSI)$$
$$\text{or } = f_{LO} - f_c \quad (HSI)$$

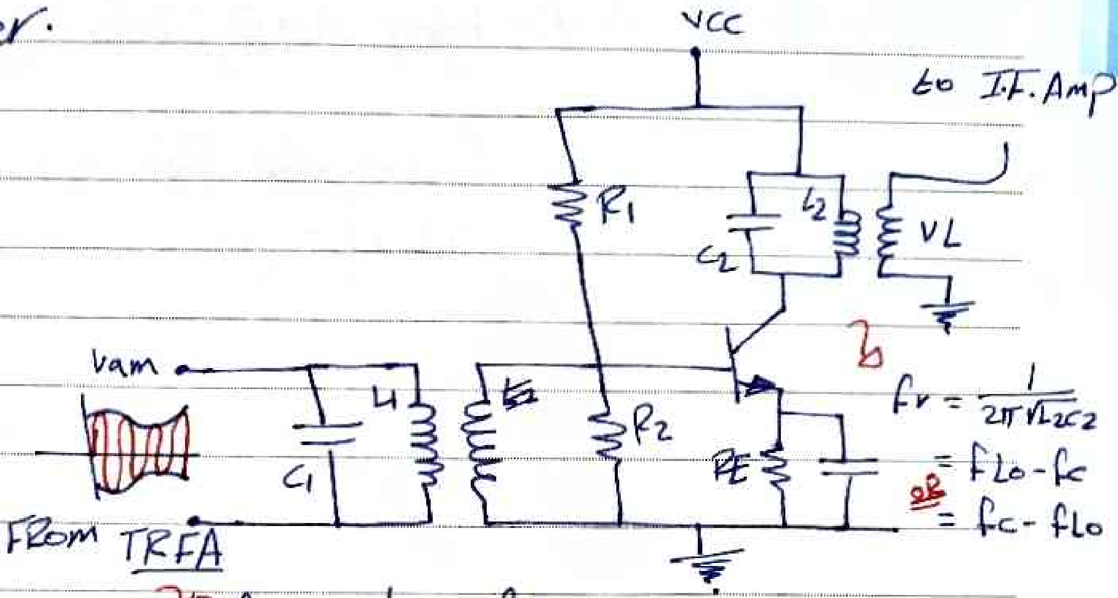
* Disadvantage :-

① No gain
② exponential Device
③ Noisy Device

* Advantages :-

① simple
② No power consumption

② BJT Mixer.



$f_r = \frac{1}{2\pi\sqrt{L_2C_2}}$

$= f_{Lo} - f_c$

or

$= f_c - f_{Lo}$

$\rightarrow f_r = \frac{1}{2\pi\sqrt{L_1C_1}} = f_c$

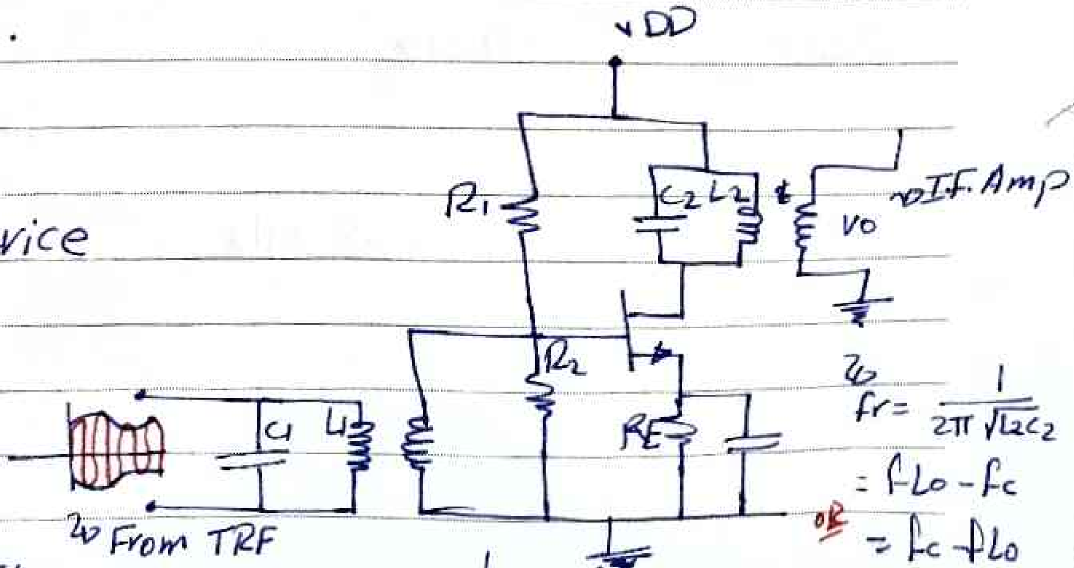
* Advantages

① gain

* Disadvantages

① Noisy ② exponential device ③ Power consumption.

③ FET Mixer.



* Advantages

① Low Noise device

② square Low :

③ gain

* disadvantages

① Power consumption

$f_r = \frac{1}{2\pi\sqrt{L_2C_2}}$

$= f_{Lo} - f_c$

or

$= f_c - f_{Lo}$

$\rightarrow f_r = \frac{1}{2\pi\sqrt{L_1C_1}} = f_c$

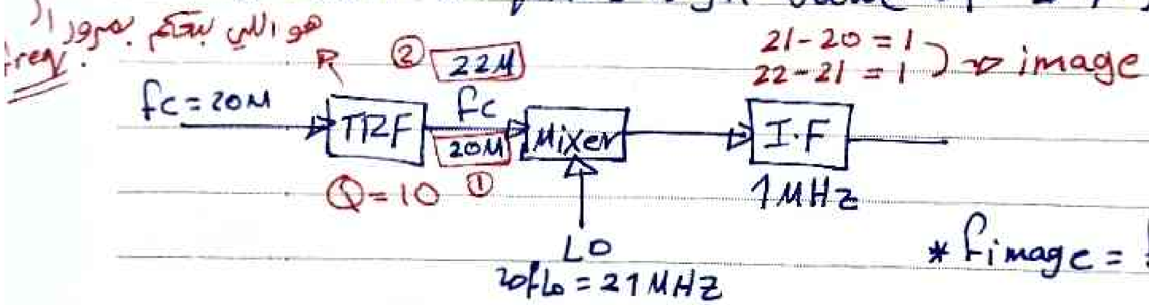
* FET Mixer → best one

→ no noise because $I_G = 0$ (عازلة gate)

Intermediate Freq. Amp (I.F. Amp)

* Provides the Bulk size of Rx. gain (Improve Rx sensetivity & selectivity).

* How to choose I.F. Freq?
we must compromize between high gain & stability (which requires low value of I.F) & good Image Rejection (Requires high value of I.F).



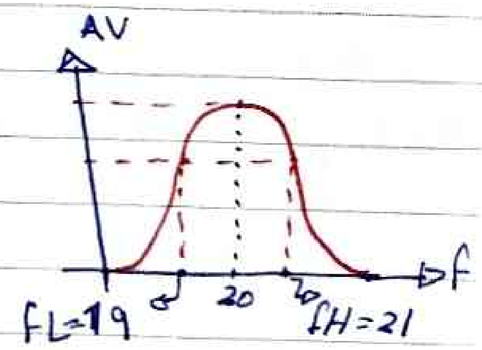
* $f_{image} = f_{sig.} + 2 f_{I.F}$

TRF

$f_c = 20\,MHz$

$Q = 10$

$B.W = \frac{20}{10} = 2\,MHz$



* for I.F = 0.4 MHz
$f_{image} = 20 + 2 * 0.4 = 20.8\,MHz$ → 19 → 21 Bw تمر لانها

* For F.I.F = 1 MHz
$f_{image} = 20 + 2 * 1 = 22\,MHz$ → 22 MHz is out of TRF (B.W), → Does not pass to Mixer. لا تمر

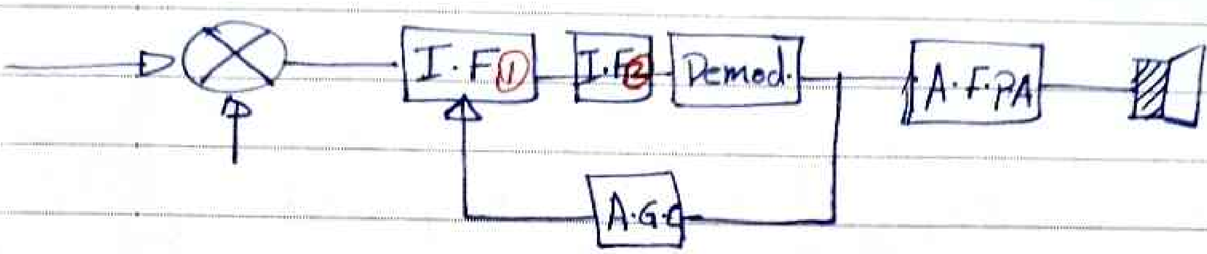
For AM Brodcasting → $f_{I.F} = 455\,KHz$
For FM 〃 → $F_{IF} = 10.7\,MHz$ *

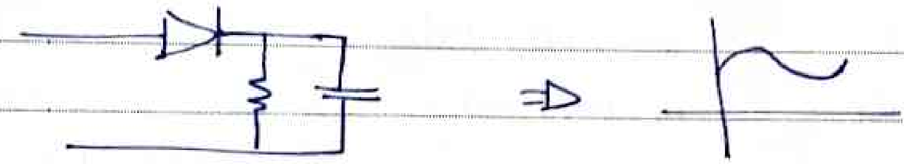
trans 1 · trans 2

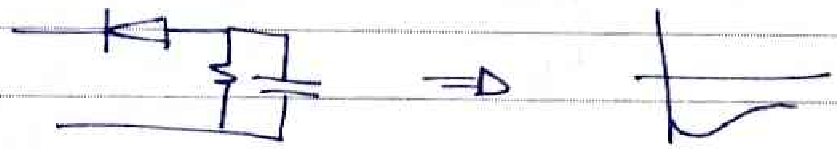
* اذا عندي محطة استقبال استقبلت 22 أو 20 ، 2 توخذ الشين وما رح تصير عم لانه الفرق بيساوي 1 ، بس انا بدي مرة trans 1 بس مشان 3 ... بزيد ال IF عشان توخذ من ال Trans. اللي بدي اياه

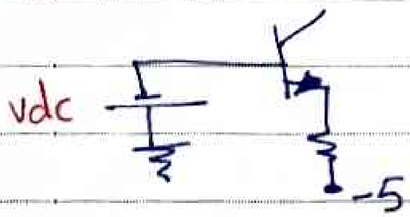
* A.G.C $\Rightarrow$ -ve feedback control system

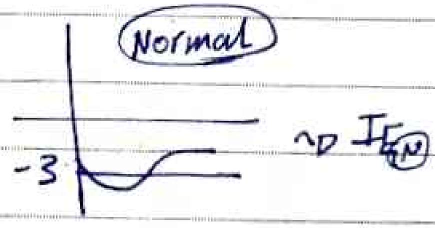
Automatic gain control (A.G.C)



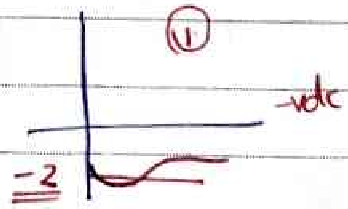








* $I_{EN} = \dfrac{5 - 3 - V_{BE}}{R_E}$

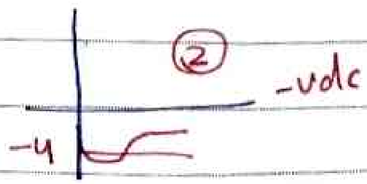


* $I_{E1} = \dfrac{5 - 2 - V_{BE}}{R_E}$

$A_V = g_m R$

$\Rightarrow I_{E1} > I_{EN} \Rightarrow \quad g_m = \dfrac{I_C}{V_T}$

$I_{E1}\uparrow,\ I_C\uparrow,\ g_m\uparrow,\ A_V\uparrow$ (for weak signal)



* $I_{E2} = \dfrac{5 - 4 - V_{BE}}{R_E}$

$\Rightarrow I_{E2} < I_{EN} \Rightarrow I_{E2}\downarrow,\ I_C\downarrow,\ g_m\downarrow,\ A_V\downarrow$

(for strong signal)

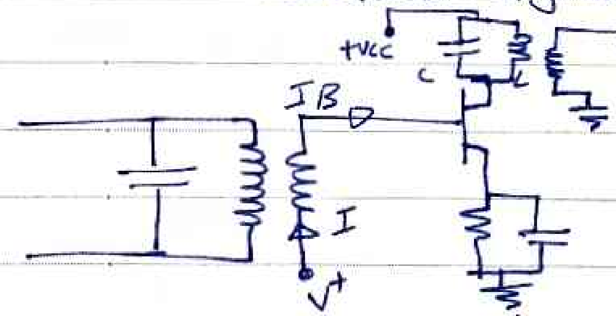
* A.G.C $\Rightarrow$ weak signal $\Rightarrow$ -ve F.B $\Rightarrow$ $I_E\uparrow$, $A_V\uparrow$, (voice$\uparrow$)
  $\Rightarrow$ strong signal $\Rightarrow$ -ve F.B $\Rightarrow$ $I_E\downarrow$, $A_V\downarrow$, (voice$\downarrow$)

dynamic range :- the highest strong signal & the Lowes weak signal that the reciever recieves.

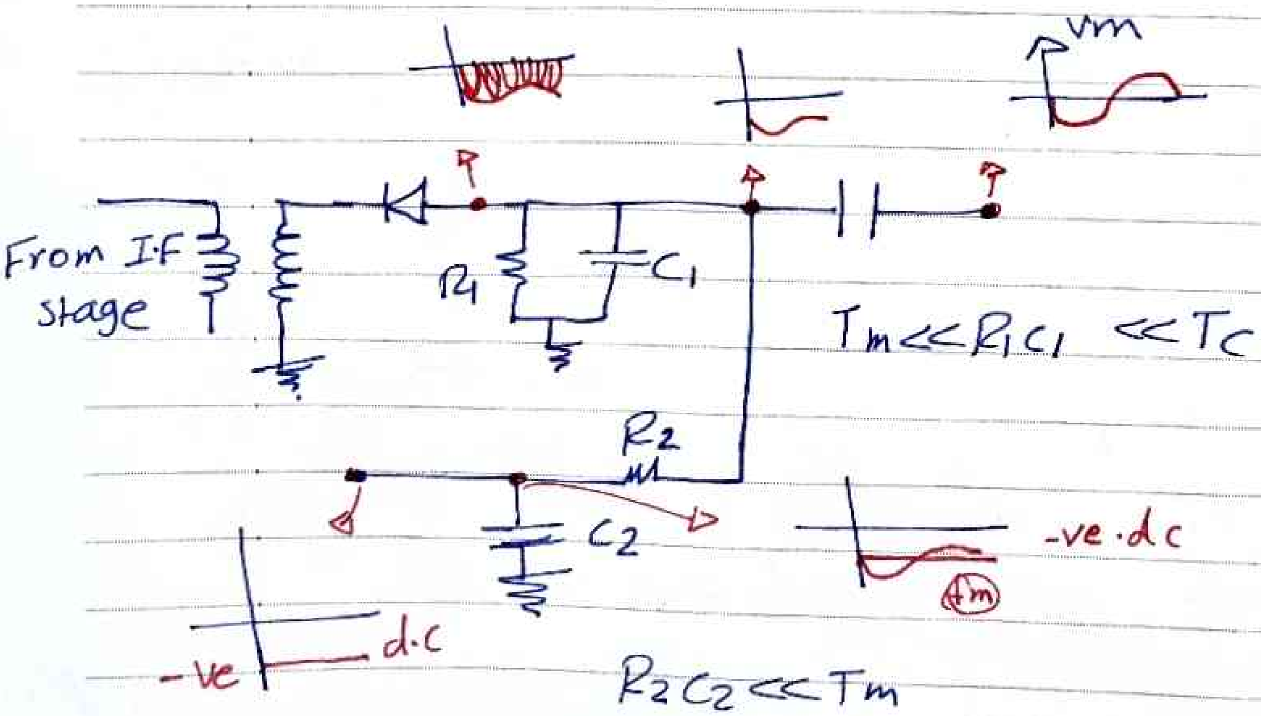
[62]

AGC

* Defenition :- A F.B control system used to Automatically control the gain of Rx to receive a strong. and weak signal It improve the dynamic range of Rx. ⟶Rec.
It changes the gain of I.F stage, Mixer, RF Amp . According to the received signal, (strong or weak).



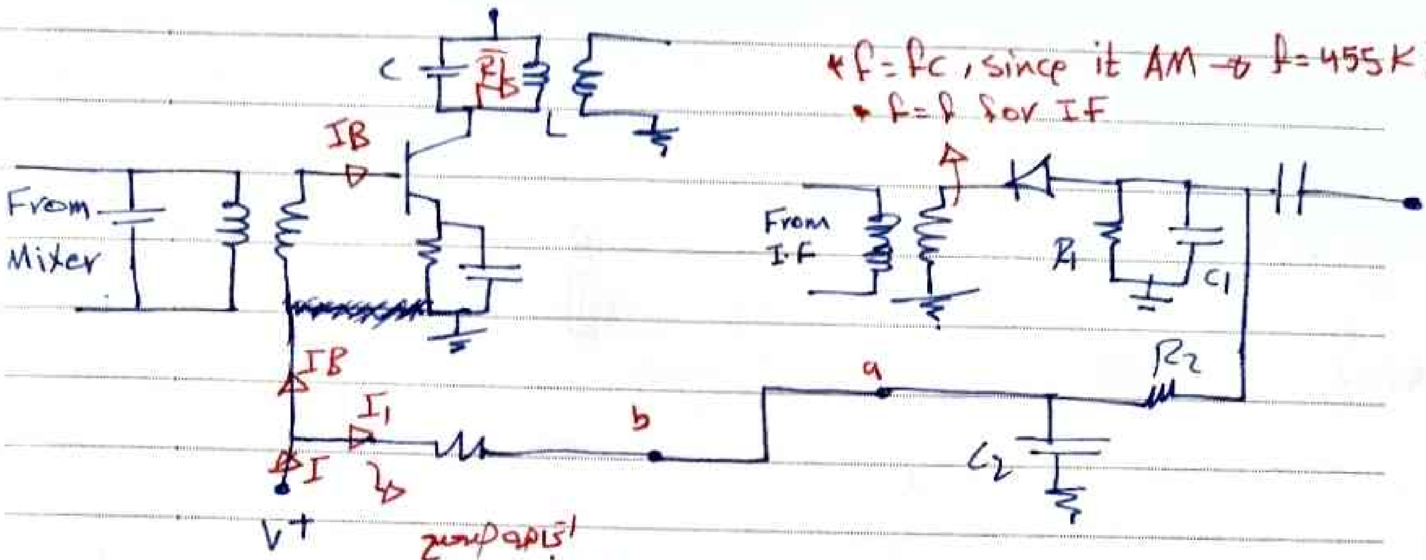
$$I_B = \frac{V^+ - V_{BE}}{(\beta+1)R_E} = I$$



$T_m \ll R_1C_1 \ll T_C$

$R_2C_2 \ll T_m$

$$T_m = \frac{1}{f_m}$$



* f = fc , since it AM → f = 455 KHz
* f = f for IF

a → +ve , b → +ve

* before F.B

$$I_B = \frac{V^+ - V_{BE}}{(\beta+1)R_E} = I \quad , \quad I_C = \beta I_B \, , \; |A_V| = g_m R_L$$

$$\& \; g_m = \frac{I_C}{V_T}$$

* with -ve F.B

$I = I_1 + I_B$

$I_B = I - I_1$

* Normally :- the mod. signal gives : $V_{dc} = -2V$

$$I_B = \frac{V^+ - V_{BE} - 2}{(\beta+1)R_E} \Rightarrow I_C = \beta I_B \, , \; A_V$$

① For strong signal $V_{d.c} = -3 V_{d.c}$

$I_B \downarrow , I_C \downarrow , g_m \downarrow , A_V \downarrow$

-3

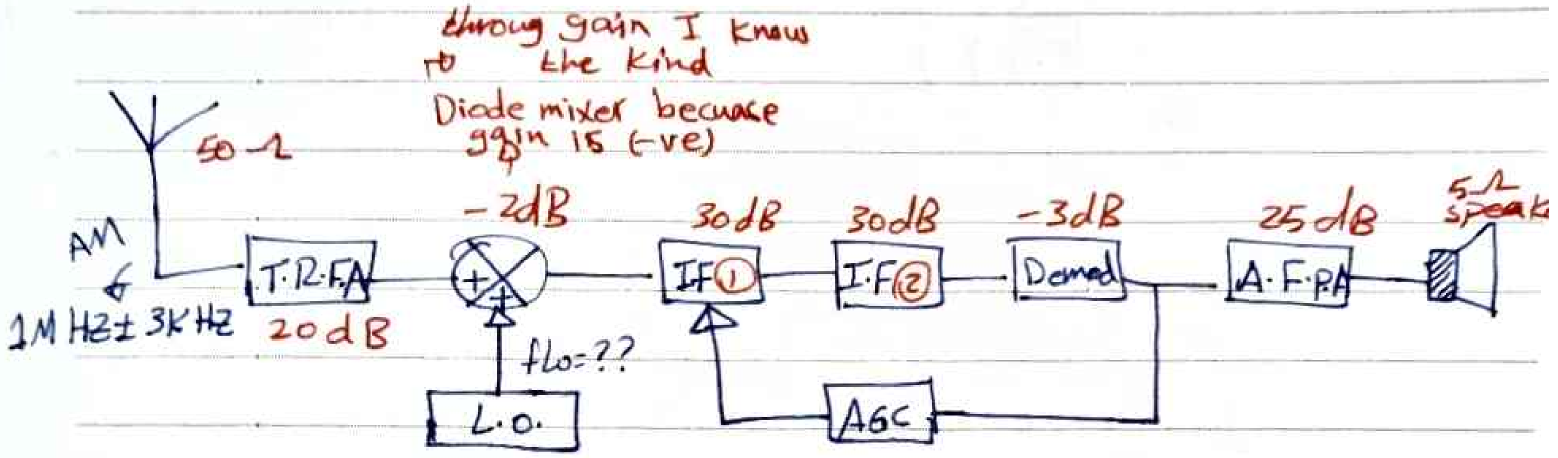
② For weak signal ; $V_{d.c} = -1 V_{dc}$

$I_B \uparrow , I_C \uparrow , g_m \uparrow , A_V \uparrow$

-1

⇒

* I.F :- the main stage that changes the gain.
* function of R_1 , R_2 , C_1 , C_2 ?



① Total power gain = $20 - 2 + 30 + 30 - 3 + 25 = 100\,dB$

② for $P_o = 5W$, Find V_i (rms) min.

Sol:

$$PG = 10 \log \frac{P_o}{P_i}$$

$$100 = 10 \log \frac{P_o}{P_i} \Rightarrow \frac{P_o}{P_i} = 10^{10}$$

$$\Rightarrow P_i = \frac{P_o}{10^{10}} = \frac{5}{10^{10}} = 50\ nW$$

$$\Rightarrow P_i = \frac{V_i^2}{R} \Rightarrow V_i = \sqrt{P_i * R} = 10^{-5}\sqrt{250}$$

$$= 5 * 10^{-5}\sqrt{10} \Rightarrow V_i\,(rms)\,min = 160\ \mu V$$

③ For $V_i = 50\ \mu V$ (rms), calculate V_o (rms).

H.W. $P_i \rightarrow P_o \rightarrow P_o = \frac{V_o^2}{R} \rightarrow V_o = ----$ ✓

④ if AM = 1 MHz ± 3 KHz & I.F fixed at 450 KHz, calculate flo when it is
* HSI
* LSI

⟹

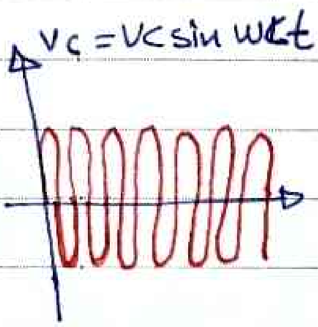
⇒ HSI :- $I.F = f_{LO} - f_c$ → $f_{LO} = 1450\ KHz$

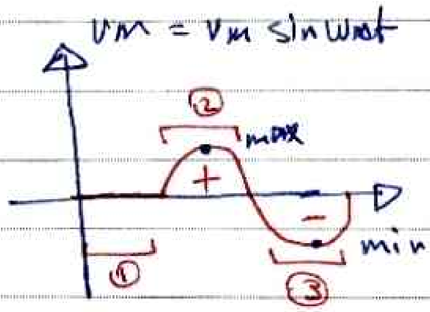
LSI :- $I.F = f_c - f_L$ → $f_{LO} = 550\ KHz$

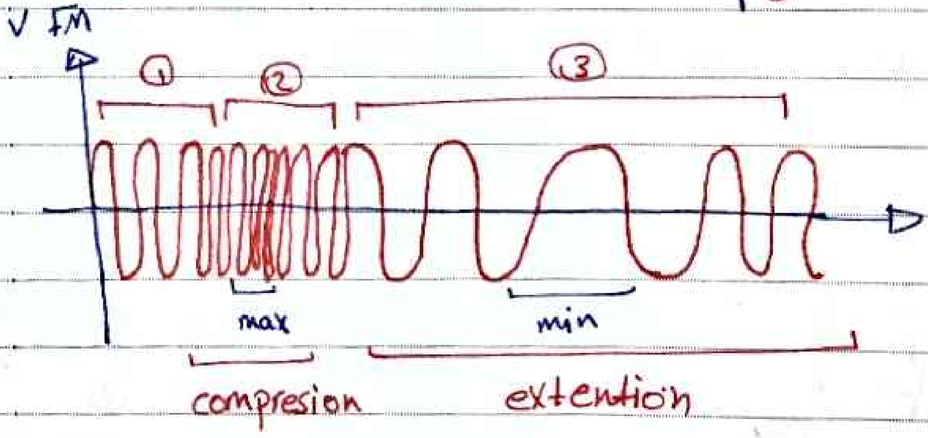
In general $I.F = f_{LO} \pm f_c$

Frequency Modulation

FM







$V_{FM} = V_c \sin(w_c t + m_f \sin w_m t)$

- V_c = carrier Amp.
- w_c = " freq.
- $m_f = \frac{f_d}{f_m}$

f_d :- freq. deviation

f_m :- (max freq. in message signal)

$w_m = 2\pi f_m$ (message freq).

⇒

* $V_{FM} = 10 \sin(10^7 t + 4 \sin 6\pi * 10^3 t)$

$V_C = 10V$

$f_c = \frac{w_c}{2\pi} = \frac{10^7}{2\pi} = 1.6MHz$

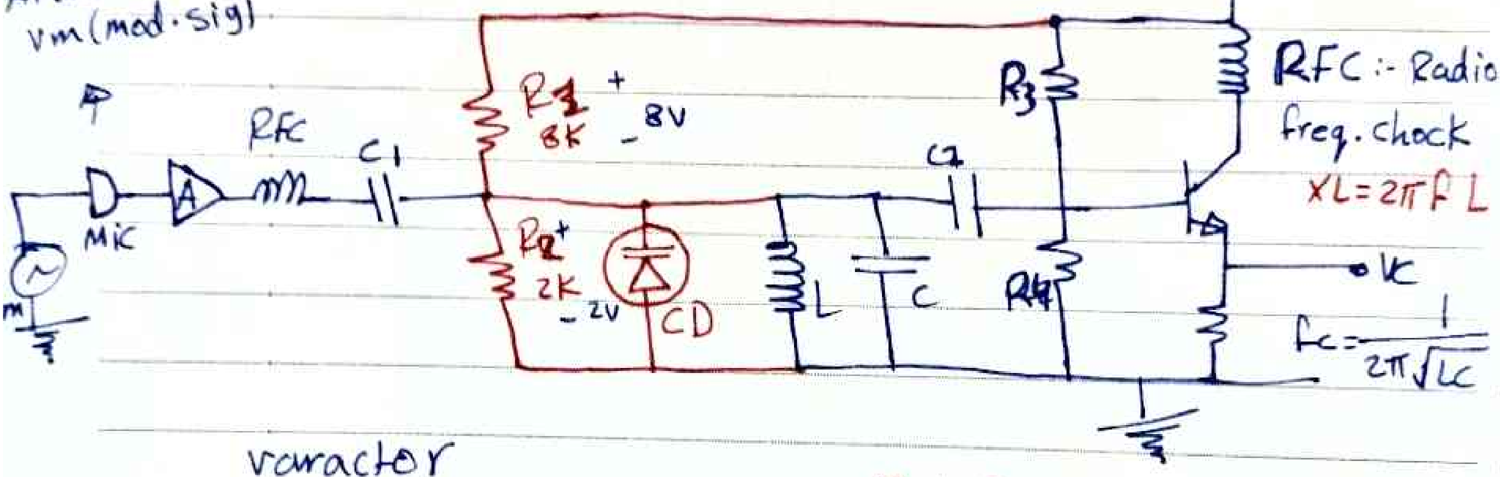
$f_m = 3 * 10^3\ Hz = 3KHz$

$m_f = \frac{f_d}{f_m} = 4$

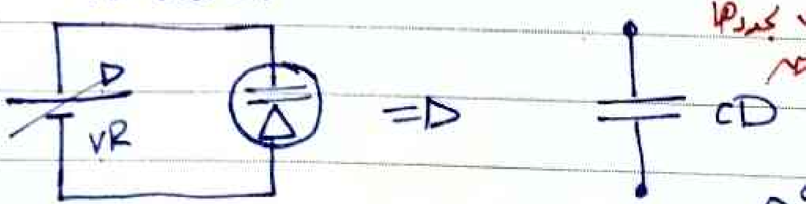
$f_d = m_f \cdot f_m = 4 \cdot 3 = 12\ KHz$

① LC FM Mod. FM Mod.

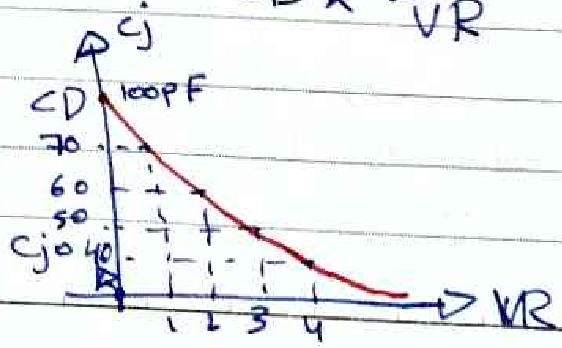
After we add vm (mod. sig)



varactor



$CD \propto \frac{1}{VR}$



if I want CD = 60 pF then VR Fixed at 2 Volt.

$C_2 \rightarrow$ coupling & blocking

① without Varactor

$$f_c = \frac{1}{2\pi \sqrt{LC}}$$

② with varactor

$$f_c = \frac{1}{2\pi \sqrt{L(C+C_D)}}$$

* C_1 → blocking for D.C
* RFC → Isulating f_c from f_m
  → O.C for f_c
  → S.C for f_m
* R_1 & R_2 → biasing for varactor
* A → Audio freq. Amp
* varactor → behaves as a voltage variable cap. (C_D)
* L, C → determine carrier freq.
* R_3 & R_4 → biasing for BJT

① without varactor

$$f_c = \frac{1}{2\pi \sqrt{LC}}$$

② with varactor (without V_m)

$$f_c = \frac{1}{2\pi \sqrt{L(C_D+C)}}$$

C_D :- varactor cap.

⇒

* Poor freq stab. (becuase f_c depends on L & C, and they are dep on aging & temp). ⇝ disadvantage

* good freq. deviation ⇝ advantage

→ to make good freq. stab. ~~whe~~ we replace it by X-tal

→ but it also decrease ⇒ small freq deviation

→ & to solve this prop we use multiplyer. to make the new fd = old fd * multiplier

(3) when V_m is applied

(I) During +ve H.C

$V_m \uparrow$, $V_R \uparrow$, $C_D \downarrow$, $f_c \uparrow \Rightarrow f_c^+$

(II) During -ve H.C

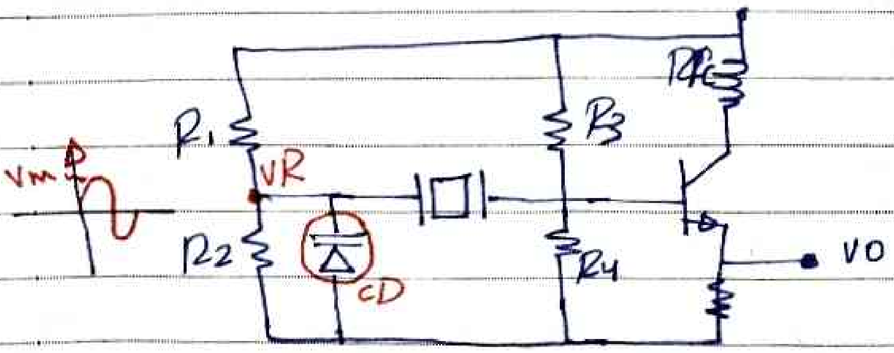
$V_m \downarrow$, $V_R \downarrow$, $C_D \uparrow$, $f_c \downarrow \Rightarrow f_c^-$

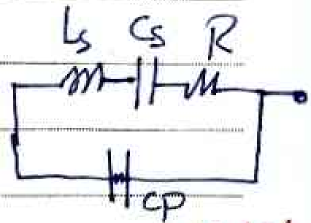
$$f_d = f_c^+ - f_c$$

$$f_d = f_c - f_c^-$$

* $m_f = \dfrac{f_d}{f_m}$

X-tal FM mod.





X-tal

→ $f = \dfrac{1}{2\pi\sqrt{L_s \cdot C_s}}$

(1) without varactore

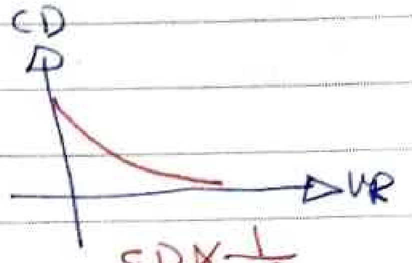
→ $f_c = \dfrac{1}{2\pi\sqrt{L_s \cdot C_s}}$

* it has a Low freq. deviation

② with varactor

* صحيح مربوطين series
بس الـ eq = paral.

→ $f_c = \dfrac{1}{2\pi\sqrt{L_S(\underbrace{C_S // C_D}_{C_{eq}})}}$



$C_D \propto \dfrac{1}{V_R}$

(*) with mod signal. (when I apply V_m at I/P)

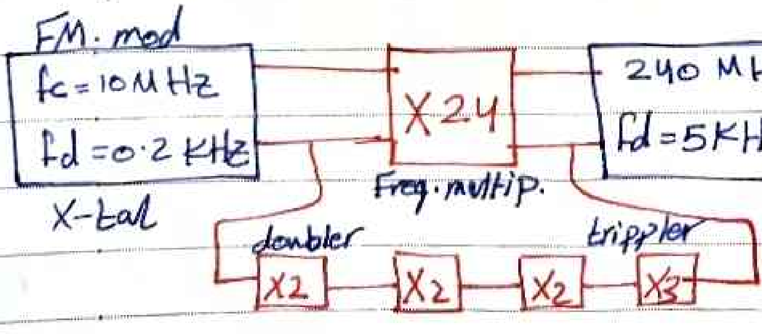
(I) when $V_m \uparrow$, $V_R \uparrow$, $C_D \downarrow$, $C_{eq} \downarrow$, $f_c^{\oplus} \uparrow$

(II) when $V_m \downarrow$, $V_R \downarrow$, $C_D \uparrow$, $C_{eq} \uparrow$, $f_c^{\ominus} \downarrow$

i.e The freq of carrier will increase & decrease according to mod. signal and an FM signal is generated

---

* compared to LC FM mod. (LC vs X-tal)
X-tal FM mod. has a superior freq. stability. but it produces a small freq. deviation (hundred Hz).
→ This proplem can be solved by using freq. multiplier.



⇒

* the freq. multiplier are exist in form of Low doubler or trippler. → why?? ⇒ answer

* I/P → Tuned cct & o/P Tuned cct and tuned at the same freq & there are Air core Trans → so V_1 & V_2 ~~& V_3~~ are 90° p.sh. with V_3 & V_i

71

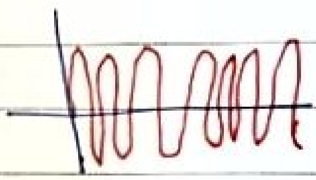
(4) To make f↑ with Vm↑ & f↓ with Vm↓
→ an Inverter can be used.

FM Demodulation

(1) Foster seely descriminator.
→ the figure in the sheet.

[1] T : Air-core tuned I/P, tuned o/P RF Trans.
[2] C_6 & C_5 are choosen very Large → so $V_i = V_3$
→ shorted.

* fm signal
$f_c \mp f_d \rightarrow f_c^{+} > f_c$
$f_c^{-} < f_c$



[3] for $f_i = f_c$ both I/p & o/P Tuned cct are tuned at $f_r = \frac{1}{2\pi\sqrt{L_1C_1}} = \frac{1}{2\pi\sqrt{L_2C_2}} = f_c$

* V_1 & V_2 are 180° Phase-Shift (C-T Trans.)
→ because centre Tapped Trans.

* V_1 & V_2 are 90° phase shift with V_i
(For Air-core Trans. with Tuned I/P & Tuned o/P and at Resonance

* Since $V_i = V_3$ → So V_1, V_2 are 90° phase shift with V_i or V_3

* D_1 & D_2 → short.

* Vx :- is a voltage that propotionally direct with f

o/p side → $V_x \propto f$ → I/P side

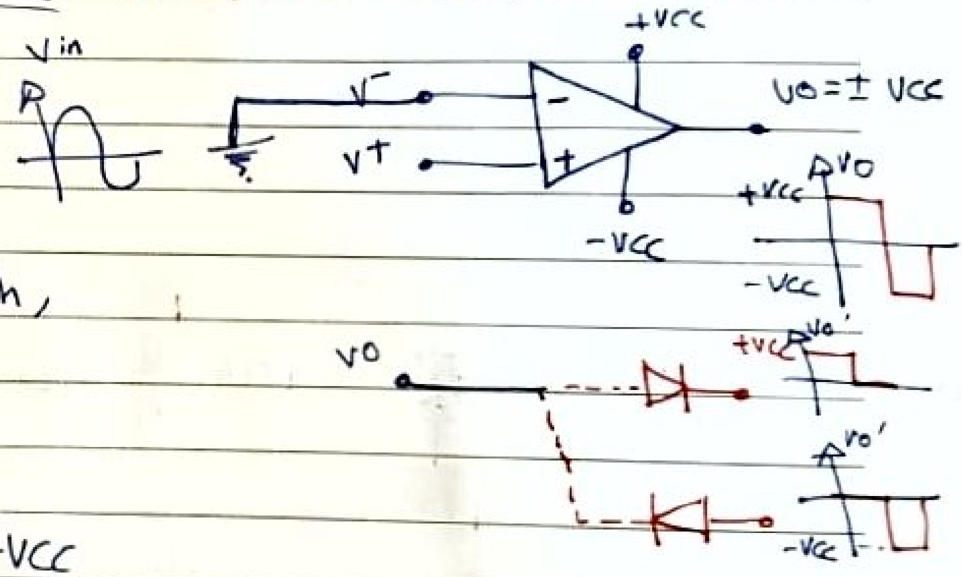
* Disadvantage :-

① it is affected by, the Amp of I/P signal (sensitive) [o/p]

② it is not exist in form of Integrated cct.

② Pulse Averaging FM Demod.

Zero-crossing Detector (comparator, open Loop).



$V_o = A_{od}(V^+ - V^-)$

A_{od} is very high,

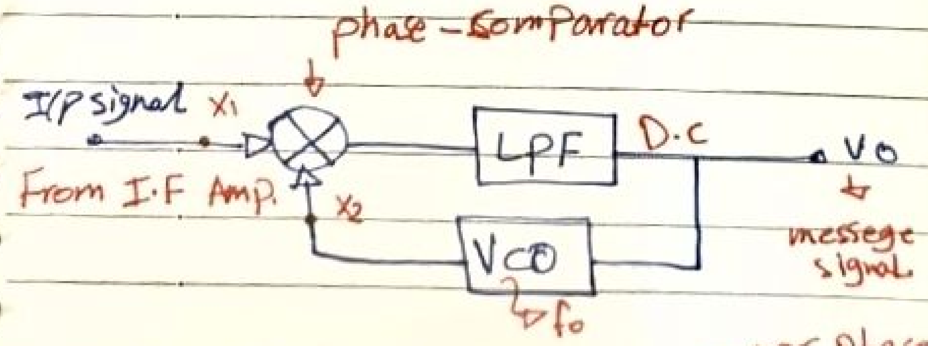
ideally ∞

① for $V^+ > V^-$

$V_o = +V_{CC}$

② for $V^- > V^+$, $V_o = -V_{CC}$

③ PLL FM Demod.



* VCO → carries ~~idea~~

so the I/P of VCO

OR the o/P of LPF should

equal the message sig

⇒

* if the freq's are equall → there is no o/P [or phases]

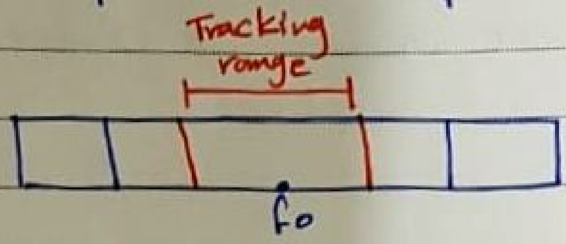
* if there is a diffrence in freq's → there will be o/P that through the LPF → D.C voltage

* it's insensetive with Amp with I/P signal.
* it's exsit in form of Intigrated cct. } disadvantage

73

① For No I/P, vco will operate in Free running mode fo

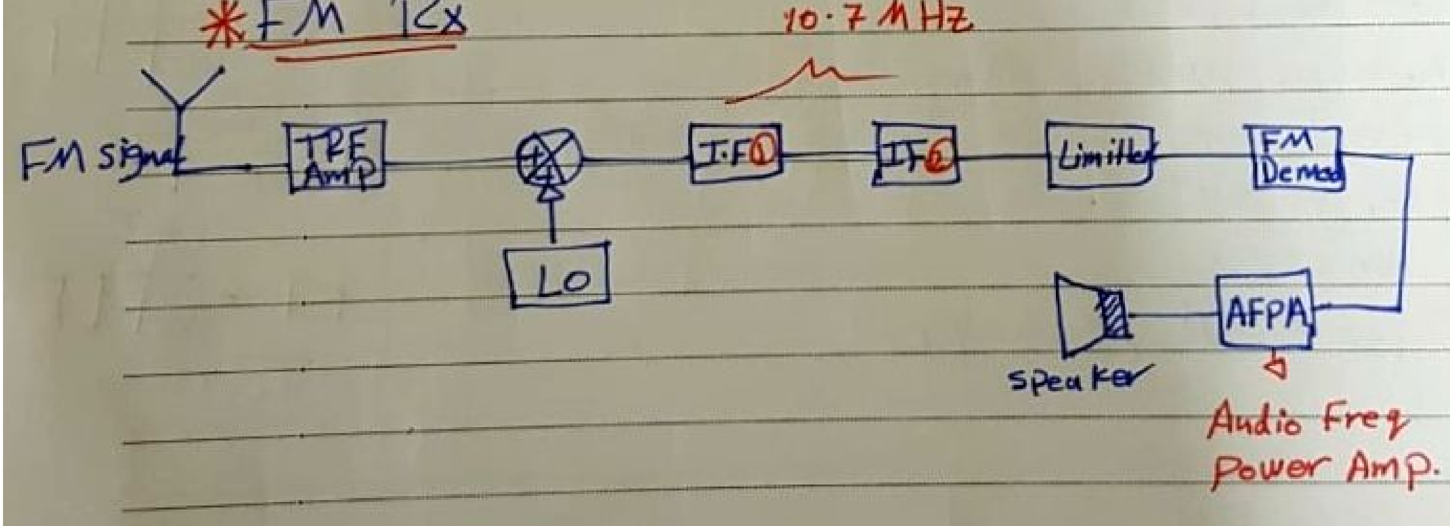
Lock-In Range.



* when PLL is in Tracking Range (o/p freq of vco = Freq. of I/P FM signal.)

↳ this means the I/P to vco is a message signal

*FM Rx



*operating freq for fm > operating freq for AM

* x_1 → I/P = message + carrier / x_2 → should equal I/P

ال VCO دايمًا بيطلعلي carr. وعشان احقق المعادلة لازم ال I/P لازم يكون messege. sig.

* if there is no R_c → $I = \frac{V_{CC}}{R_{D\cdot c} \to \text{Trans}} = \frac{V_{CC}}{0} = \infty$

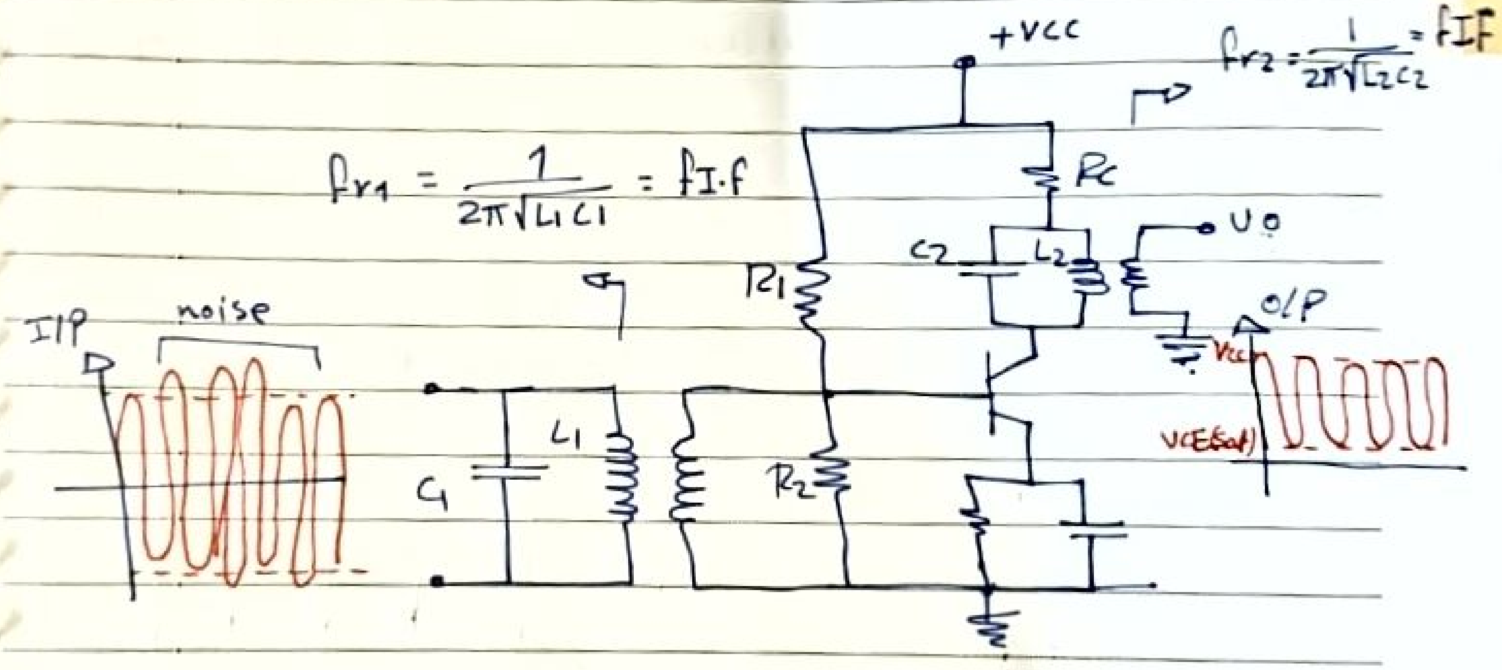
so we choose it Low to ensure the trans to entre the sat. mode & we choose it high $\boxed{7Y}$ to controll the current.

* Limitter

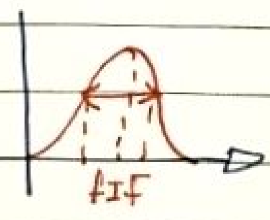
a cct. which produces a constant Amp. o/p basically a BJT cct. in which the BJT works as an switch (between sat & cutt-off giving o/p ∄ $V_{CE(sat)} < V_o < V_{CC}$).

$f_{r2} = \frac{1}{2\pi\sqrt{L_2C_2}} = f_{IF}$

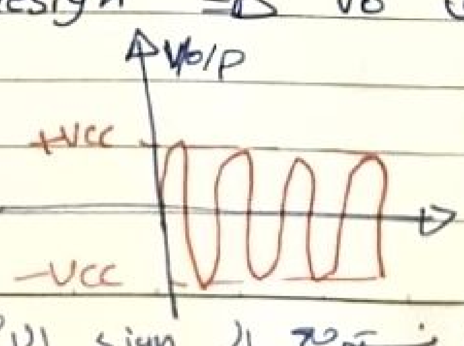
$f_{r1} = \frac{1}{2\pi\sqrt{L_1C_1}} = f_{I.f}$



$(B.W)_{TC} = \frac{f_{r2}}{Q} \geq (B.W)_{FM}$ signal → for design



→ after the design ⇒ vo will be



→ بنعمل design عشان نسترجع ال sign الأصلية sinsoidal messeg sig.

* there is 2 way to calculate $(B.W)_{F.M}$

① $(B.W)_{FM} = 2(f_m + f_d)$
$= 2f_m(1 + m_f)$

f_m :- max freq of messeage
f_d :- Freq. Deviation

② $(B.W)_{FM} = 2N.f_m$

N = we choose the # of $B > 1\%$.

mf	B_1	B_2	B_3	B_4	B_5	B_6
2	0.5	0.3	0.2	0.1	0.25	0.d
5						

* في معادلة ناقصة ☹

* inhence the high freq comp. of messeg sig. & improves SNR
↳ pre-ampassis

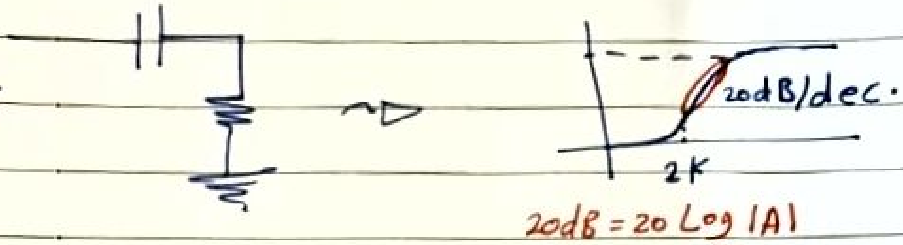
Pre-emphasis & De-emphassis ccts

* Voice - Signal
(0.3 → 3) KHZ → the noise effect on the high freq comp (3K) causing a poor SNR

→ exist in trans.

Pre-emphassis → FM Mod.

HPF



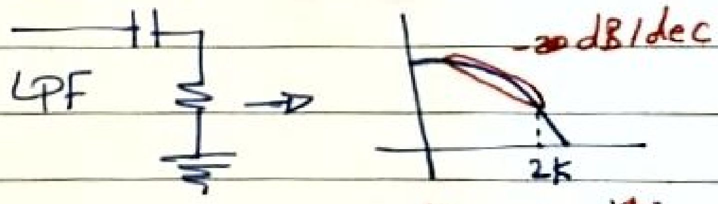
$20dB = 20 \log_{10} |A|$

$\Rightarrow \underline{A = 10}$

→ so the gain = 10
so I multiply the Amp of High freq by the gain & thats improves SNR

FM-Demod → de-emphassis

LPF



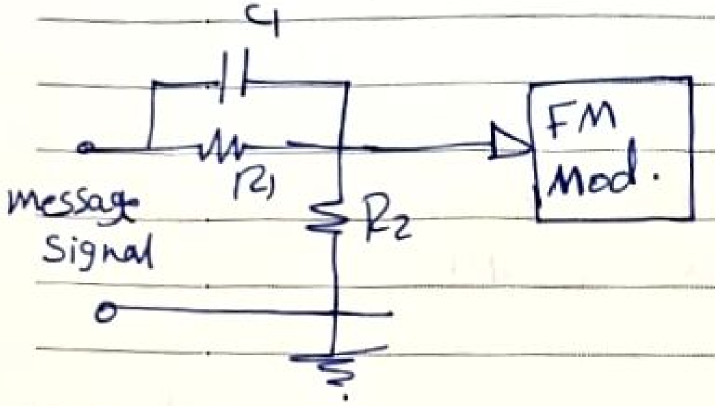
$-20\,dB = 20 \log |A|$

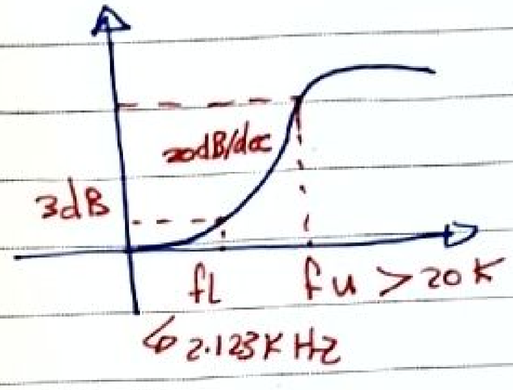
$\Rightarrow A = \frac{1}{10}$

* Pre-emphassis cct.

a HPF connected befor FM Mod. used to enhance H.F components of message signal & improve the S/N ratio of transmitted FM signal. It is in Tx side.
For commertial FM broadcasting It is designed for freq > 2.123 KHZ

⇒





$$f_L = \frac{1}{2\pi C_1 R_1} = 2.123\ KHz$$

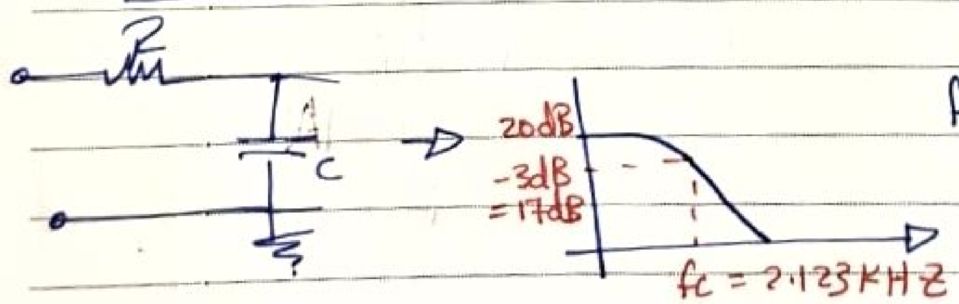
$$R_{eq} = R_1 // R_2$$

$$f_u = \frac{1}{2\pi C_1 R_{eq}} > 20K$$

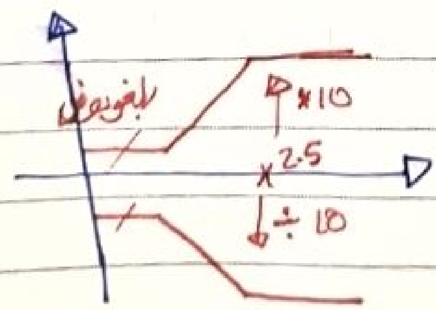
---

* deoampassis cct

a LPF used in FM Rx. to offset the effect of pre-ampassis cct. in FM Tx.



$$f_c = \frac{1}{2\pi RC} = 2.123\ KHz$$



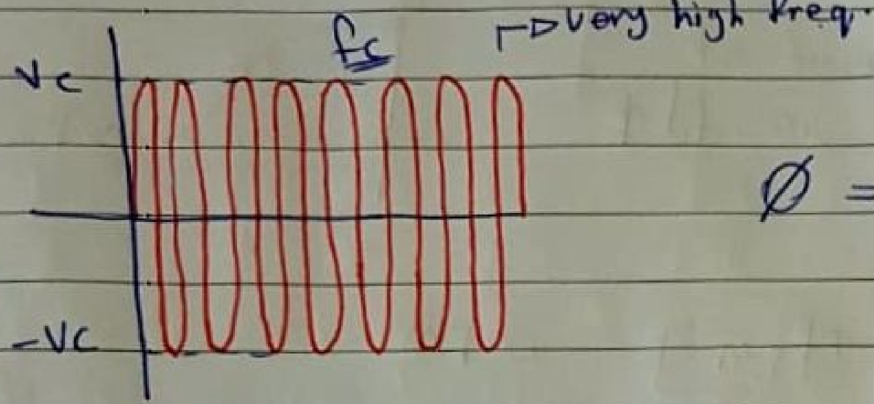
الـ Freq ال 2 تمر زي ما هي ←

$\rightarrow 2.5 \cancel{* 10} \div 10 = 2.5$

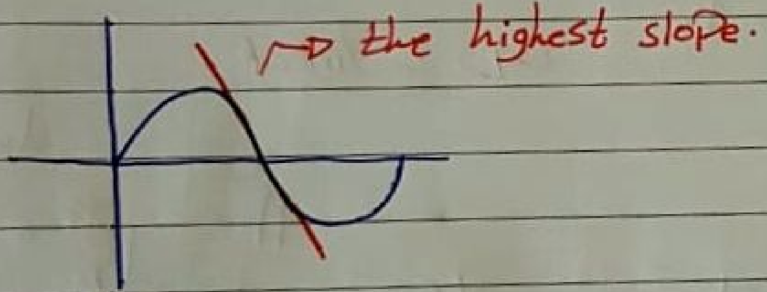
تابع

* Phase Modulation :- (Indirect FM generation)

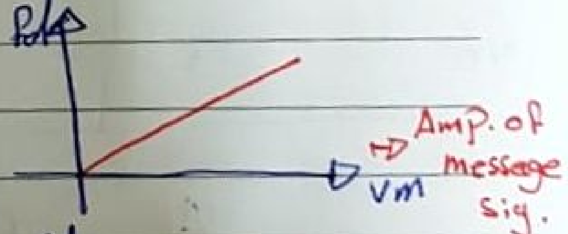
In PM, the Phase of carrier is changed according to Amplitude of Mod. signal

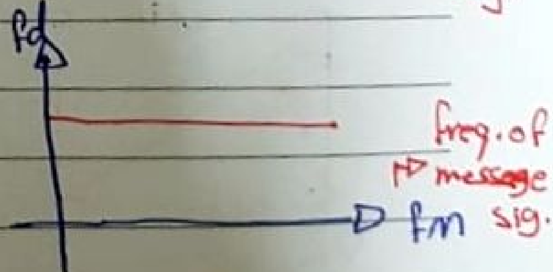


$$\phi = \frac{\Delta V}{\Delta t}$$

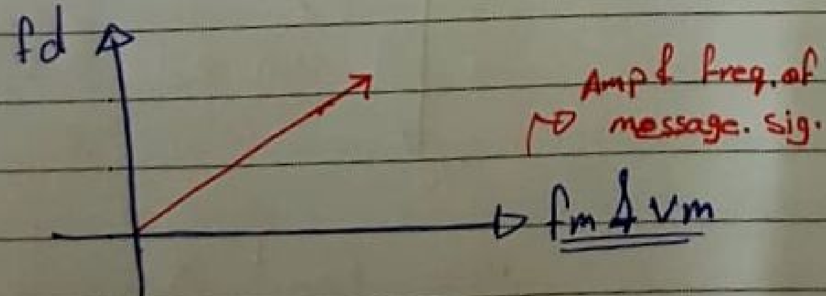


* In FM





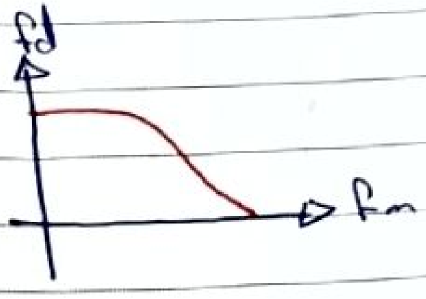
* In PM



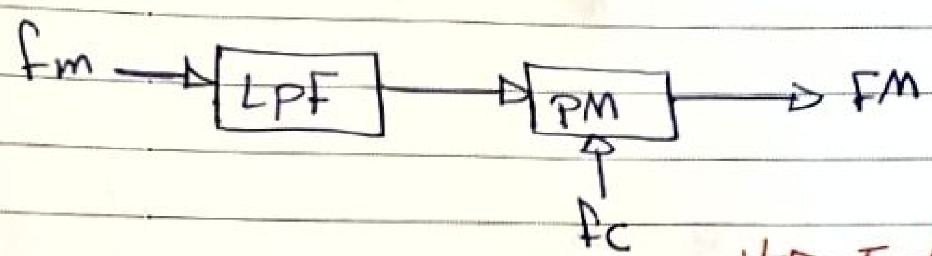
* in PM the modulation depends on vm & fm

=▷

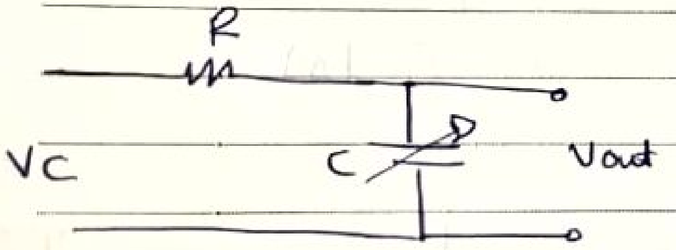
☒ اذا لعبنا تأثير ال freq. نستطيع تحصيل FM
وذلك من خلال استخدام LPF حيث يعاكس
زيادة ال deviation بإنتقال ال Amp.

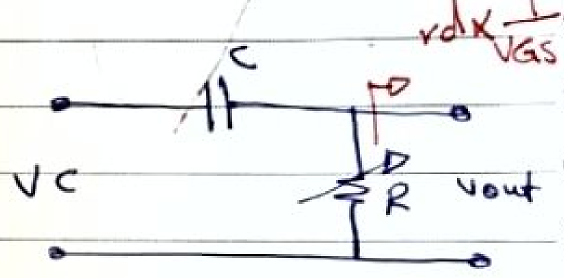


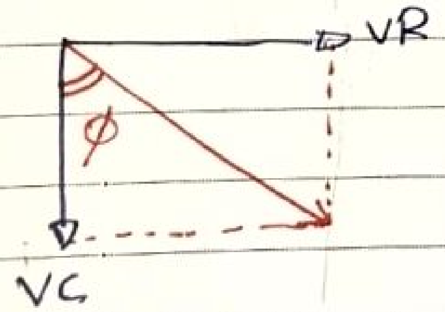
⇒ High freq. component of modulating signal, gives fd ↑

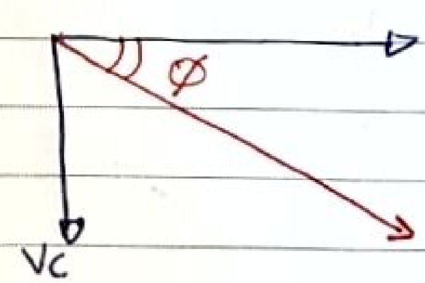


⇒ Indirect









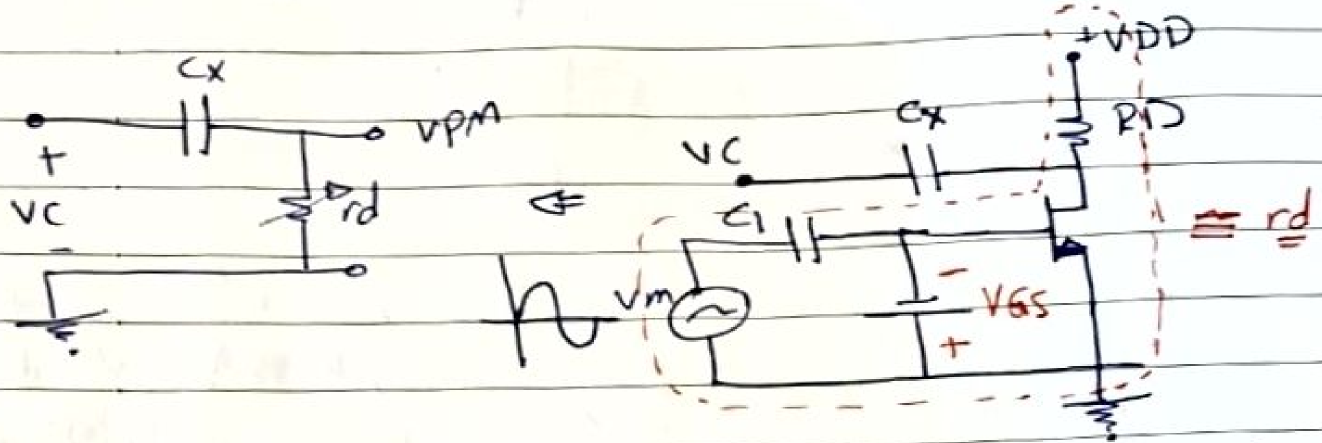
$$\phi_c = \tan^{-1}\frac{X_c}{R}$$

$$\phi_c = \tan^{-1}\frac{R}{X_C}$$

ل نستخدم FET كمقاومة متغيرة
لتغيير الزاوية لل عن طريق Amp for mes. sig.

① Armstrong PM :-

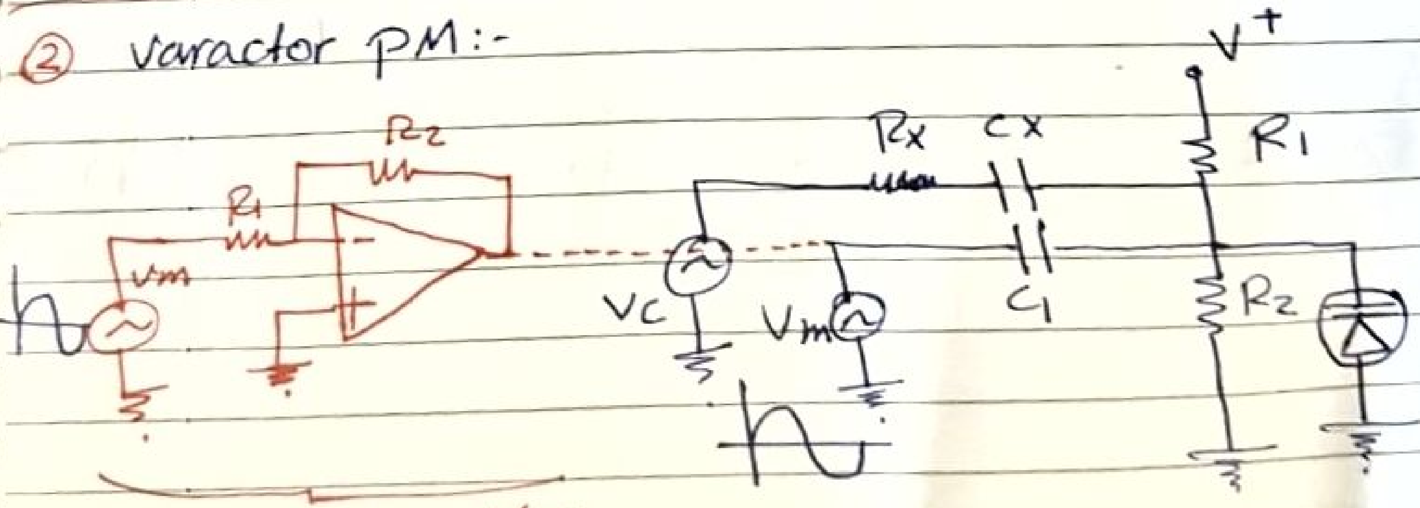
JFET is biased in Linear Region , $rd \propto \frac{1}{V_{GS}}$ & behaves as a volt. variable resis.



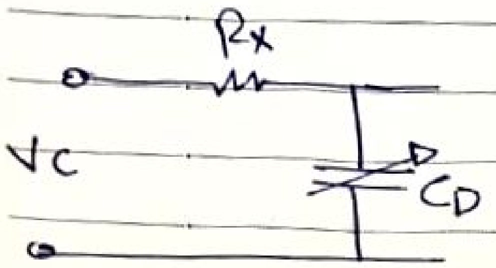
1. In +ve H.C of vm , VGs ↑ , rd ↓ , Øc ↑
2. In -ve H.C of vm , VGs ↓ , rd ↑ , Øc ↑
3. The Phase of carrier (Øc) increasing / decreasing according to the Amp. of message signal .

$\hookrightarrow \phi = \tan^{-1} \frac{X_C}{rd}$ — $45° = \tan^{-1} \frac{1}{1}$, $30° = \tan^{-1} \frac{1}{2}$ $\quad \phi_c \propto \frac{1}{rd}$

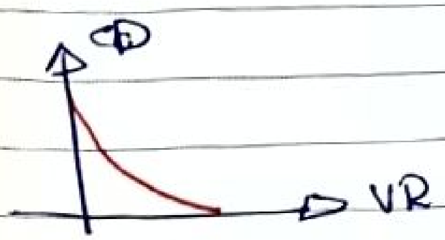
② varactor PM:-



Invertor (we add it)



$\Rightarrow \phi_c = \tan^{-1} \frac{R}{X_{CD}}$



$C_D \propto \frac{1}{V_R}$

1. When $V_m \uparrow \rightarrow V_R \uparrow,\ C_D \downarrow,\ X_{CD} \uparrow,\ \phi_c \downarrow$
2. When $V_m \downarrow \rightarrow V_R \downarrow,\ C_D \downarrow,\ X_{CD} \downarrow,\ \phi_c \downarrow$
3. To make $\phi_c \uparrow$ with $V_m \uparrow$ & $\phi_c \downarrow$ with $V_m \downarrow$ then, message signal is applied via an Inverting Amp.

* $X_C = \frac{1}{2\pi f C}$

* $C_X \rightarrow$ S.C for f_c & O.C for $\rightarrow f_m$, DC

* $C_1 \rightarrow$ S.C for f_m & O.C for $\rightarrow f_c$, DC

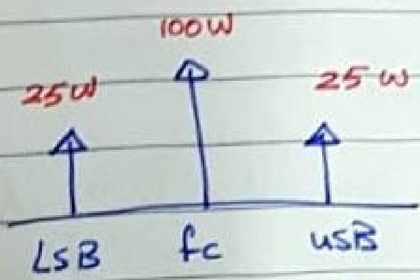
* اذا ادخلنا ال Vm على LPF قبل المودلتر يتم التحويل الى FM

* ال Information تكون على ال LSB & USB

82

SSB

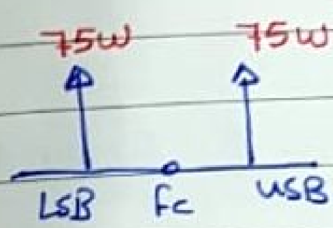
* $P_{Tx} = 150$ w
* $m = 100\%$



* conventional Am * ← مسافة بث قليلة (الاقل)

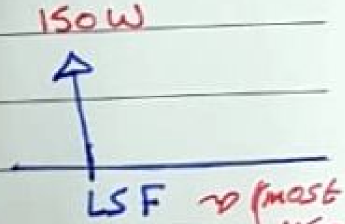
ال information موجودة على ال U & L

* $P_{Tx} = 150$ W



* DSB-SC * ← مسافة بث متوسطة

* $P_{Tx} = 150$ W



→ most likly use lower

* SSB * ← مسافة بث عالية (الكبرى)

* To transmitt with 25 W

PT conventional ⇒ $P_{Tx} = 150$ W

DSB-SC ⇒ $P_{Tx} = 50$ W

SSB ⇒ $P_{Tx} = 25$ W

* fading ⟹ الـ Transmitted sig. لما تنبعث بالهواء رح تنعكس عن الغلاف الجوي وتتغير الـ freq لأنها بس بالـ SSB مش موجودة

$\boxed{83}$ ↳ Interference بصير

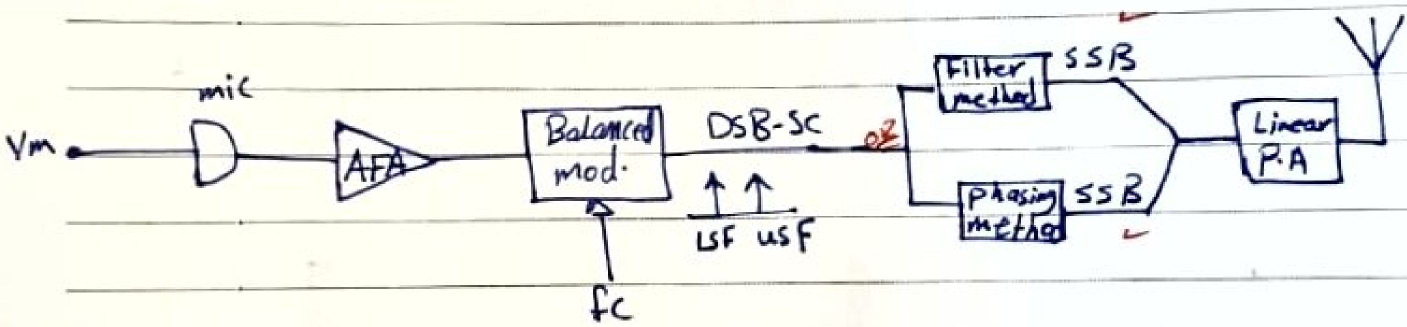
SSB c/cs

(Becuase ~~small B.w ⟹ SNR↑~~)

⟹

1. small B.w & small Noise
2. high spectral effeciency — أكبر مسافة بين سيغنالين
3. high Power & Long distance Transmission
4. No fading

SSB Generator



* (Ring), (Lattice), Balanced modulator.

تكملة

1. if Vm is applied only (Vc=0)
   1. In +ve H.C of Vm
      D_1 & D_3 ⟶ ON
      D_2 & D_4 ⟶ off
   2. No current in T_2 Primary, No flux & No Vout.

⟹

II In $-ve$ H.C of V_m

D_2 & D_4 are ON

D_1 & D_3 are off

⇒ No current in T_2 primary, No flux & No vout

2 if V_c is applied only ($V_m = 0$)

I for $+ve$ H.C of V_c

D_1 & D_2 → ON

D_3 & D_4 → off

⇒ $I_{D1} = -I_{D2}$ (opposes each other)

⇒ the resultant flux is zero, No vout ($V_o = 0$)

II for $-ve$ H.C

D_3 & D_4 → ON

⇒ $I_{D3} = -I_{D4}$, so the resultant flux $= 0$ & No vout ($V_o = 0$)

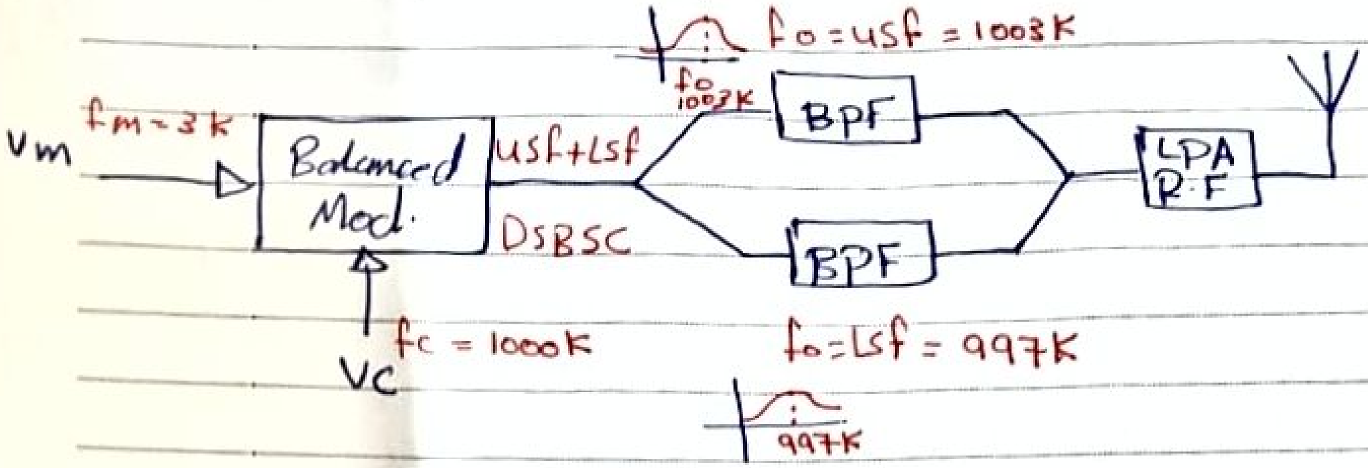
SSB Generation

1 Filler Methode :-
- → 2 band pass filter
- → single BPF & 2 carrier

2 Phasing Methode :

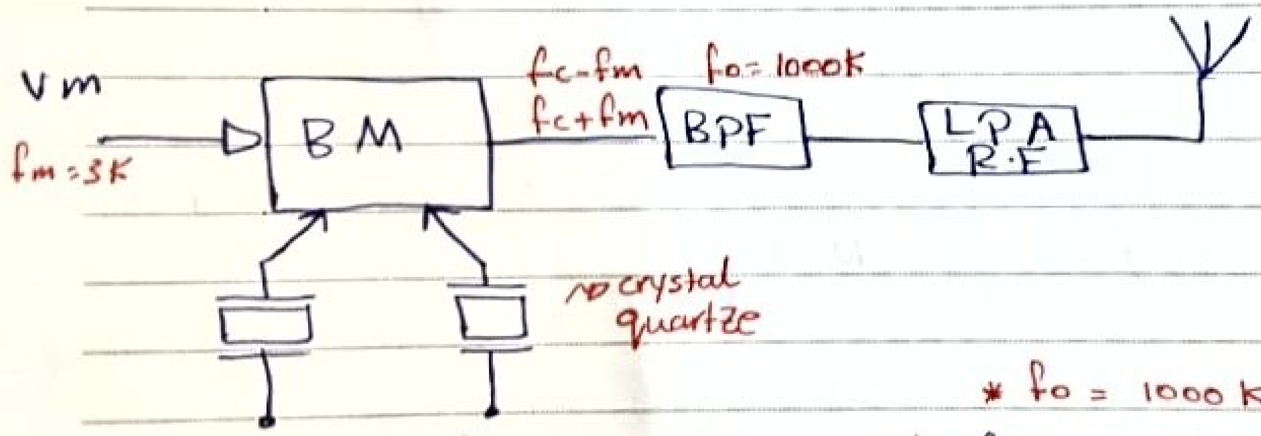
⇒

Filter Methode (2 BPF)



* we use switches (choose one BPF

Filter Method (1BPF & 2 carrier)



$f_{c1} = 997K$ USF

$f_{c2} = 1003K$ LSF

* $f_o = 1000K$ (we choose it)

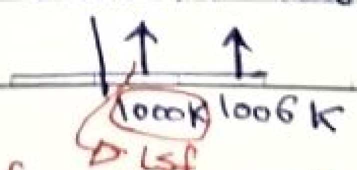
→ $f_{c1} = 997K$, $f_m = 3K$

→ $f = 1000K$, $f = 994K$

* we use filters of crystal to achieve High freq. & stability.

→ $f_{c2} = 1003K$, $f_m = 3K$

→ $f = 1006K$, $f = 1000K$



~~for BPF.~~

كو آلية اختيار ال USF & LSF حسب ال fo

$\cos A \cos B = \frac{1}{2}[\cos(A-B) + \cos(A+B)]$

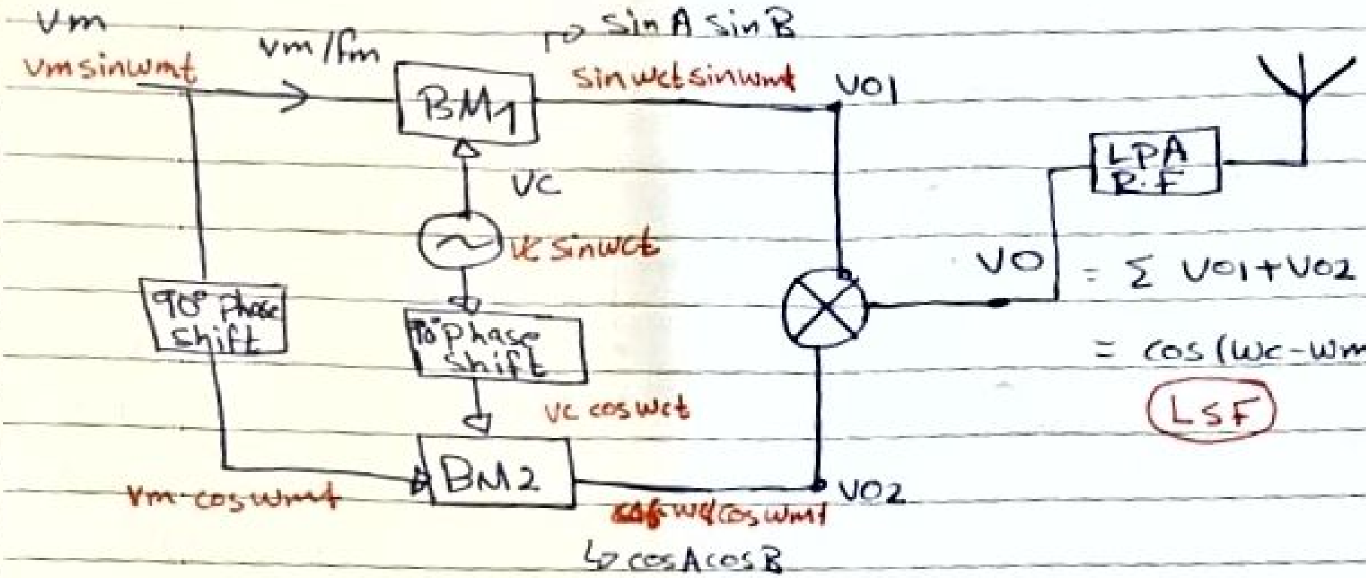
$\sin A \sin B = \frac{1}{2}[\cos(A-B) + \cos(A+B)]$

$\cos A \sin B = \frac{1}{2}[\sin(A$

محتاج التأكد !!

$\boxed{86}$

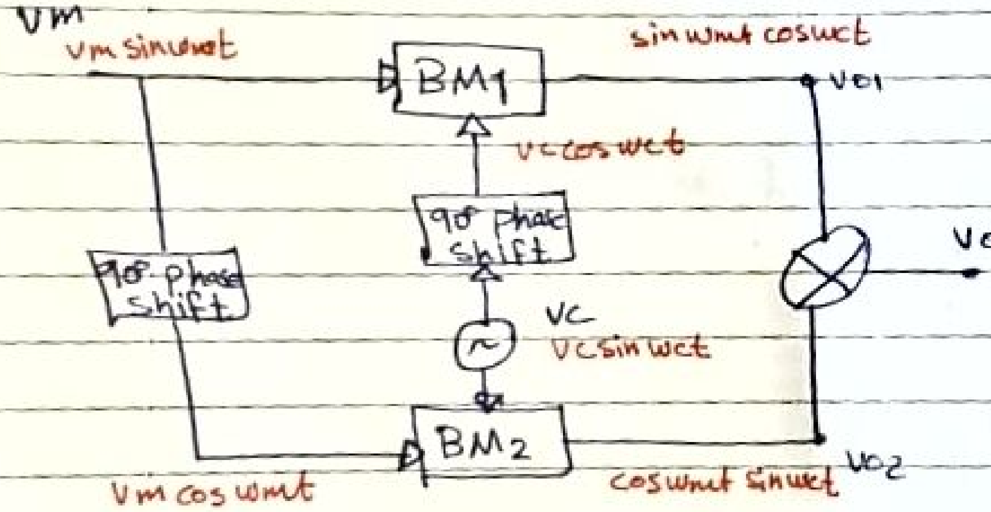
2 Phasing Methode :-



$= \Sigma\ V_{o1} + V_{o2}$

$= \cos(w_c - w_m)t$

LSF



$V_o = \Sigma\ V_{o1} + V_{o2}$

$= \sin(A+B)$

$= \sin(w_c + w_m)t$

USF

من عندي

* لو ادخل sin على BM2 في الدائرة الاولى هيطلع USB
* لو عمل douple phase shift بتاع ال output هيطلع 4 terms

$\frac{1}{2}\cos(A-B) + \frac{1}{2}\cos(A-B) + \frac{1}{2}\sin(A+B) + \frac{1}{2}\sin(A+B)$

$= \cos(w_c - w_m)t + \sin(w_c + w_m)t$

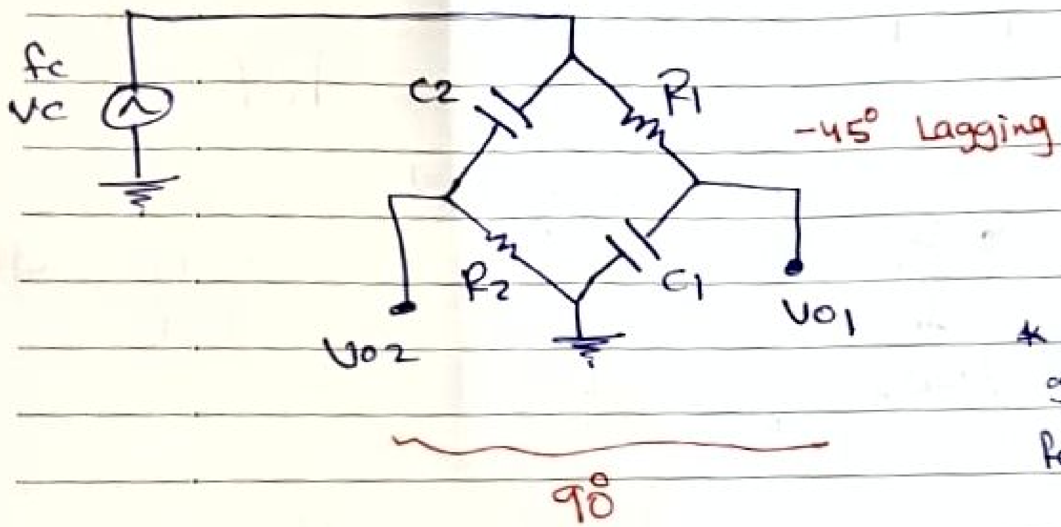
$\equiv$ DSBSC

$\Rightarrow$

* any LCR cct. gives → $0 < \phi < 90$ Phase shift.

87

* Phase shifter. (RF phase shifter).



vm
(0.3 → 3k)
* we want it to gives phase shift for certain freq.

⇒ at $f = f_c$

when $X_{C1} = R_1$ & $X_{C2} = R_2$

then $\phi_1 = -45°$

$\phi_2 = 45°$

$$X_{C1} = \frac{1}{2\pi f_c C_1} = R_1$$

$$X_{C2} = \frac{1}{2\pi f_c C_2} = R_2$$