ElCoM
ELECTRICAL COMPUTER MECHATRONICS

تقدم لجنة ElCoM الاكاديمية

دفتر لمادة:

الكترونيات الاتصالات

من شرح:

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جزيل الشكر للطالب:

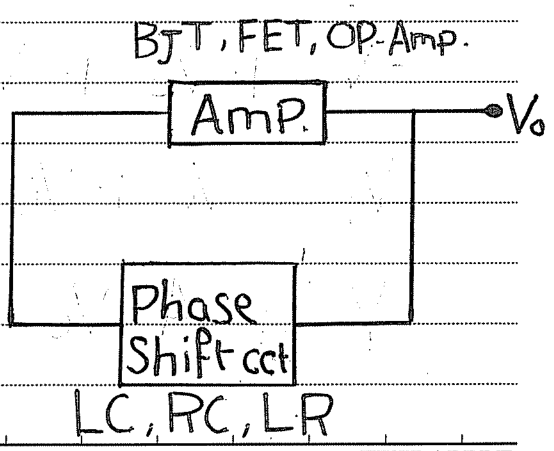
عدنان حوراني

Oscillators :- (Signal generators)

[Sinusoidal oscillators]

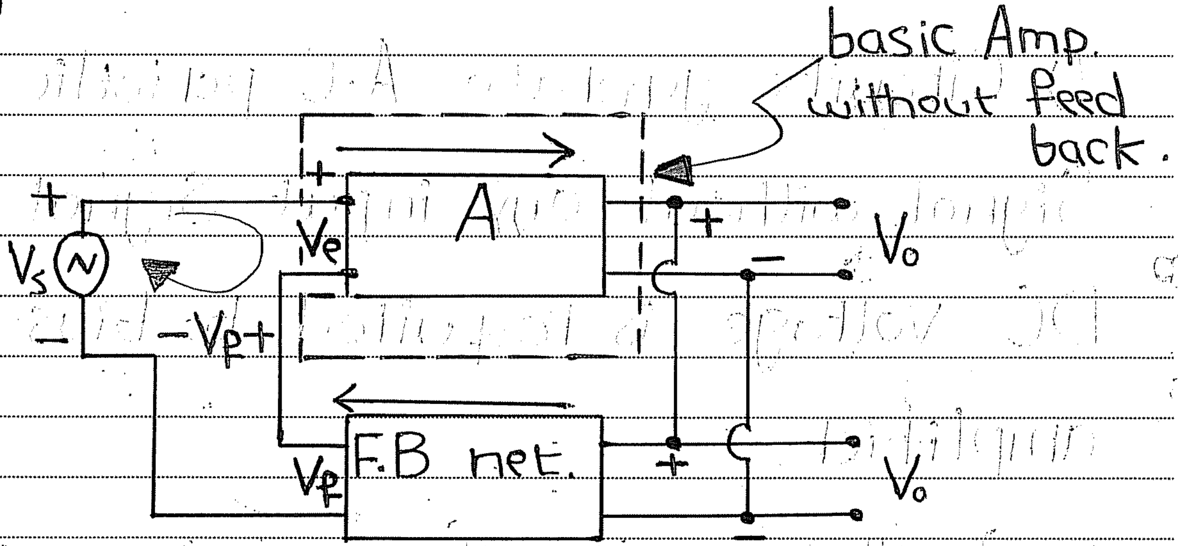
1) Circuits generate A.C periodic output Signal without any input Signal, Only DC voltage is required to bias the amplifier.

2) Oscillator Circuit Contains amplifier to give the required gain and phase Shift Circuit (RC, LC, LR) to give the required phase Shift.



NO.

3) It is a feed back amplifier use Positive feed back.



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

$$V_e = V_s \mp V_f \begin{cases} V_e = V_s - V_f \text{ (-ve feedback)} \\ V_e = V_s + V_f \text{ (+ve feedback)} \end{cases}$$

→ assume -Ve feed back:

$$-V_s + V_e + V_f = 0$$

$$V_s = V_e + V_f$$

$$V_o = A\, V_e$$

NO.

$V_e = V_s - V_f$

$V_f = B V_o$

$V_o = A(V_s - B V_o)$

$V_o(1 + BA) = A V_s$

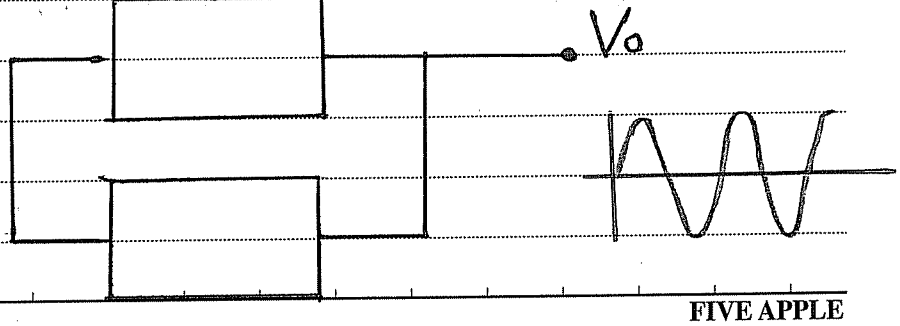
$$\frac{V_o}{V_s} = \frac{A}{1+BA}$$

↳ gain of Feedback Amp.

If $BA = -1$, $\frac{V_o}{V_s} = \infty$;

either $V_o = \infty$ (is not Correct, because V_o has a Certain Value)

Or $V_s = 0$ (No input Signal).



NO.

$BA = -1$

$|BA| = 1 \ , \ \angle 180^\circ$.

→ +ve feed back :

$\frac{V_o}{V_s} = \frac{A}{1-BA}$, $BA = 1$

$|BA| = 1 \ , \ \angle 360^\circ$.

Oscillation Conditions :-

(Barkhusin Conditions)

1] $|BA| = 1$ (magnitude Condition)

$\frac{1}{B}$ = gain عندما تُعطي A

2] $\angle AB = 0 \mp n \cdot 2\pi$, n : int

(Phase Condition) .

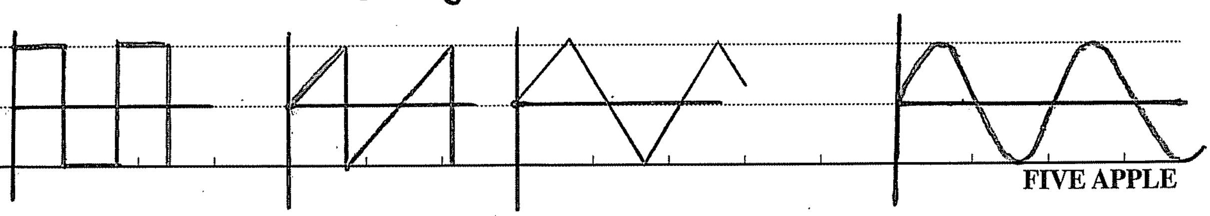
. non-inverting إمّا أن يكون كلاهما inverting أو كلاهما

NO.

* $V_s = 0$, it's mean that the CCt. will give a Certain O/p without AC input Signal.
* gain is function of freq.
* The Value of A and B depends on freq.
* The Conditions will be Satisfy at the Certain Value of ω.

Oscillators

- **NonSinusoidal** (relaxiation oscillator)
  - based on Charging and disCharging of Cap.
- **SinuSoidal**
  - based on Oscillation Condition.

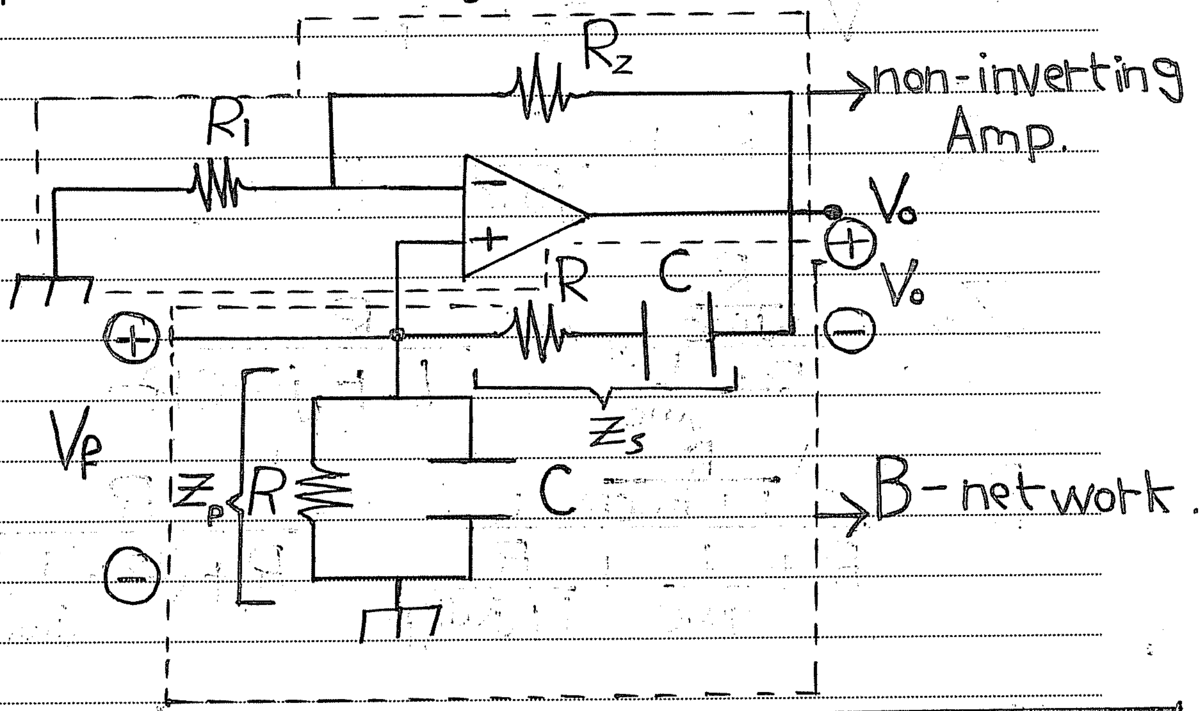


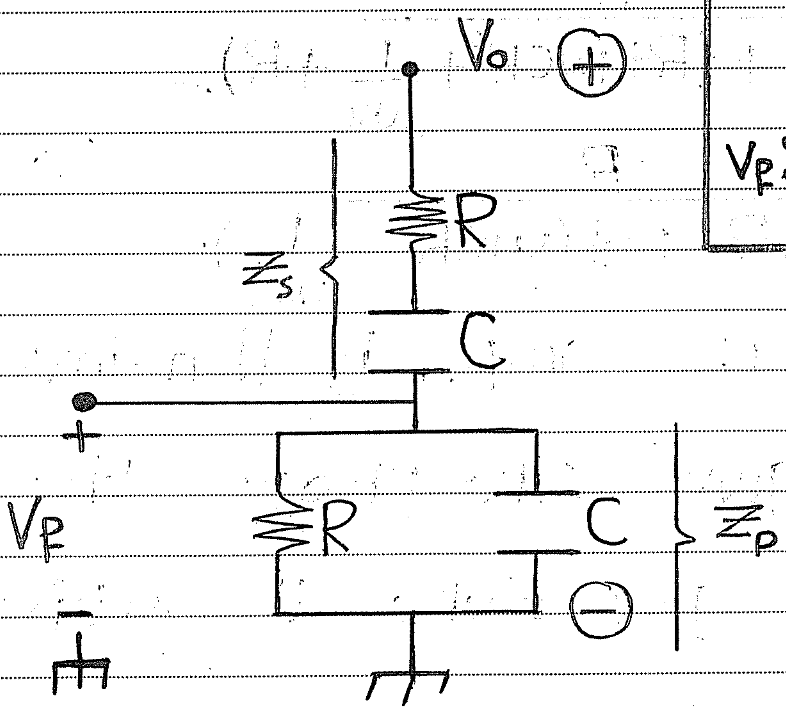
NO.

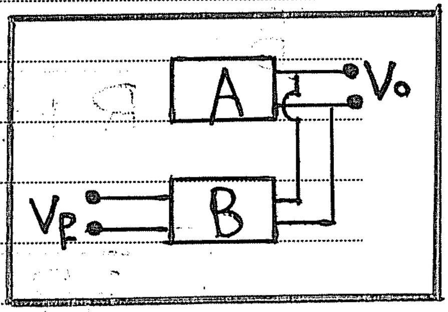
Sinusoidal Oscillator

- RC - Oscillator. (Amp. + RC - CCt.)
  - wien-bridge Oscillator.
    - $\angle A = 0^\circ$
    - $\angle B = 0^\circ$
  - Phase-Shift Oscillator.
    - $\angle A = 180^\circ$
    - $\angle B = 180^\circ$
- LC - Oscillator. (Amp. + LC - CCt.)
  - Hartley Oscillator.
  - Colpitts Oscillator.
  - Crystal Oscillator.

Wien-Bridge Oscillator







NO.

$$B = \frac{V_f}{V_o} = \frac{Z_P}{Z_S + Z_P}$$

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

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

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

$$B = \frac{R}{R + (R + j\omega CR^2 + \frac{1}{j\omega C} + R)}$$

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

Since the amp. is Non-inverting and give Zero Phase, the B.net must give Zero to Satisfy $\angle AB = 0°$.

NO.

$\angle B = 0^\circ$ when j-terms $= 0$,

$$\omega C R^2 - \frac{1}{\omega C} = 0$$

$$\omega^2 C^2 R^2 = 1$$

when $\omega_0 = \frac{1}{RC}$

$\therefore f_0 = \frac{1}{2\pi RC}$ (Freq. of Oscillation)

At this freq. :

$$|B| = \frac{1}{3}.$$

To Satisfy $|BA| = 1$, $A_{min} = 3$.

$A = 1 + \frac{R_2}{R_1} = 3$ → for non-inverting amp.

$\therefore \left(\frac{R_2}{R_1}\right)_{min} = 2$, $\boxed{R_2 = 2R_1}$

NO.

يُمكن استبدال الـ OP-Amp بـ :

Common base

أو

Common gate

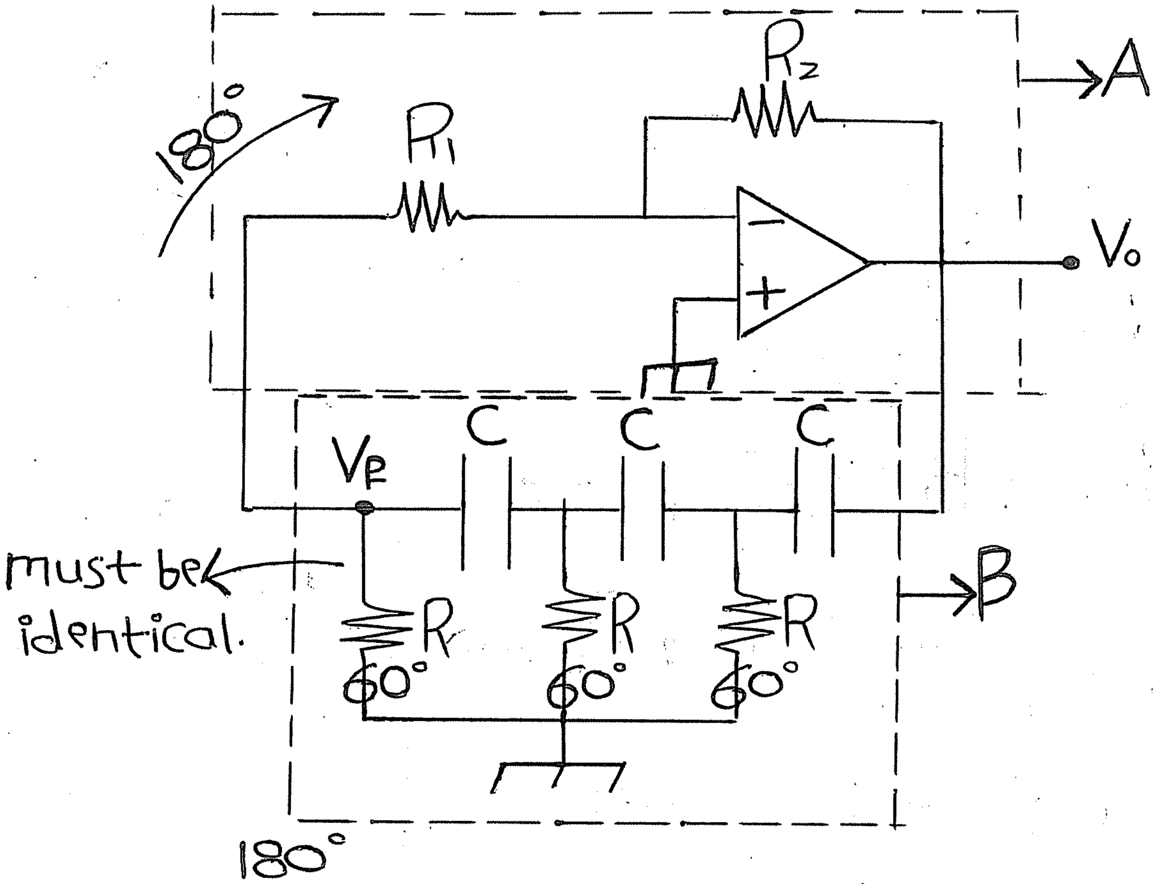
أو

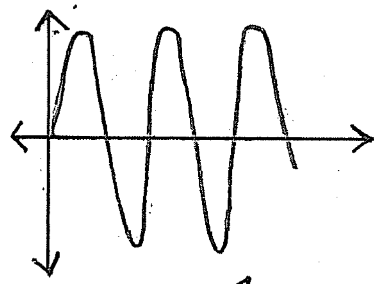
two Stages Common Source or

Common Emmitter.

FIVE APPLE

Phase Shift Oscillator :



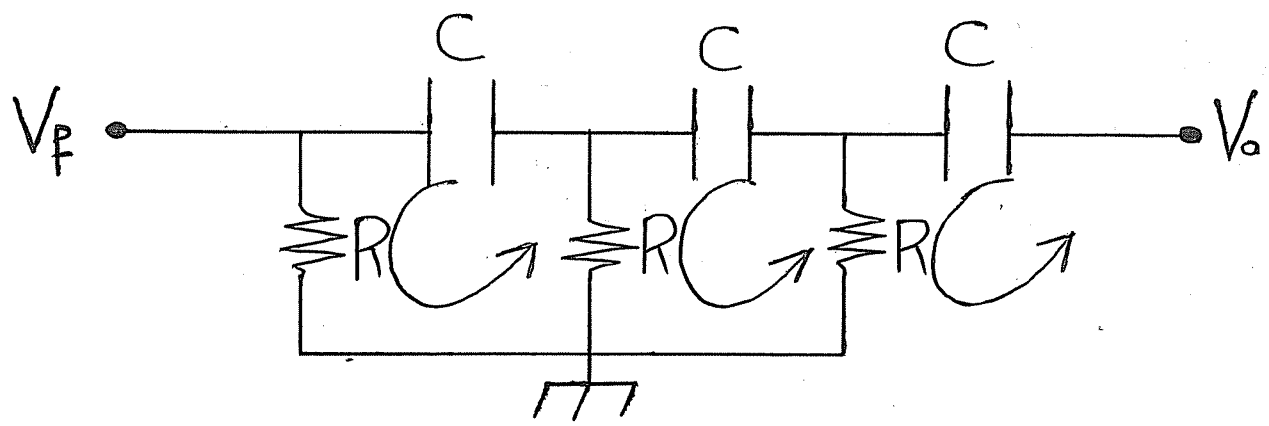


$$f = \frac{1}{2\pi\sqrt{6}\,RC}$$

each RC Section gives 60°, So the B-Net. gives 180°.

Inverting Amp. → 180°.

So $\angle A \cdot B = \angle A + \angle B = 360°$.



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

$$\omega_o = \frac{1}{\sqrt{6}\,RC}$$

$$f_o = \frac{1}{2\pi\sqrt{6}\,RC}$$, freq. of Oscillation.

at this freq. : $B = \frac{-1}{29} \rightarrow |B| = \frac{1}{29}$

To Satisfy $|BA| = 1$, $A_{min} = 29$

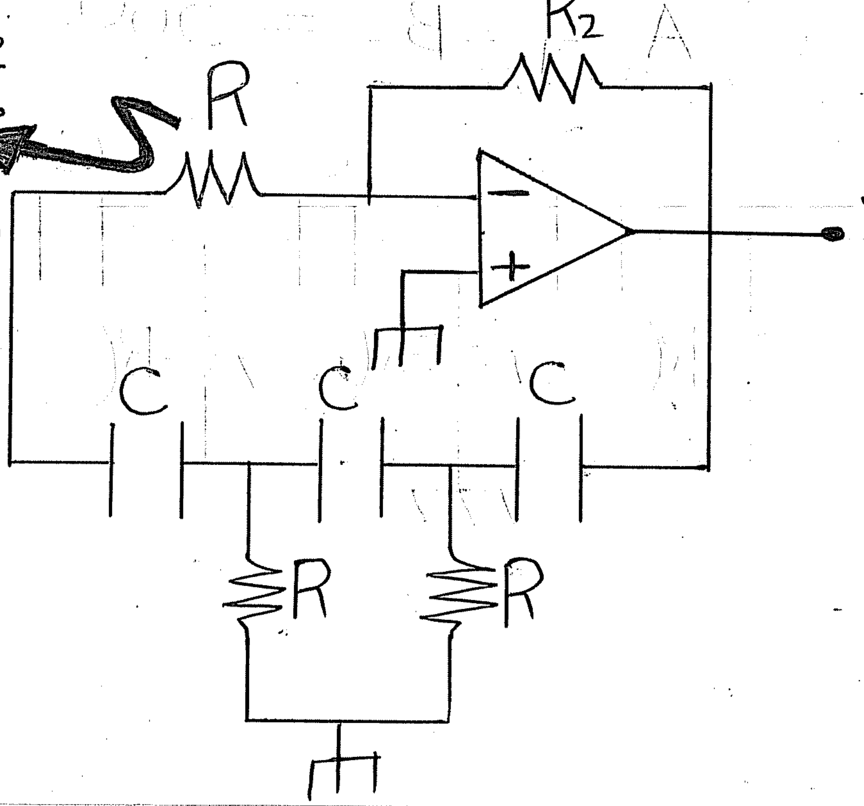
For inverting Amp. : $|A| = \frac{R_2}{R_1}$

So, we must Choose $\frac{R_2}{R_1} = 29$.

$$\boxed{R_2 = 29 R_1}$$

note :

gain Control أُمثل الـ
Res. (R_1)
وتمثل الـ (R) الأخيرة
من الـ RC •



Exp.: Design a phase-Shift Oscillator to Oscillate at 10 kHz.

$$f_o = \frac{1}{2\pi\sqrt{6}RC}, \quad \text{Choose } C = 0.01\mu F.$$

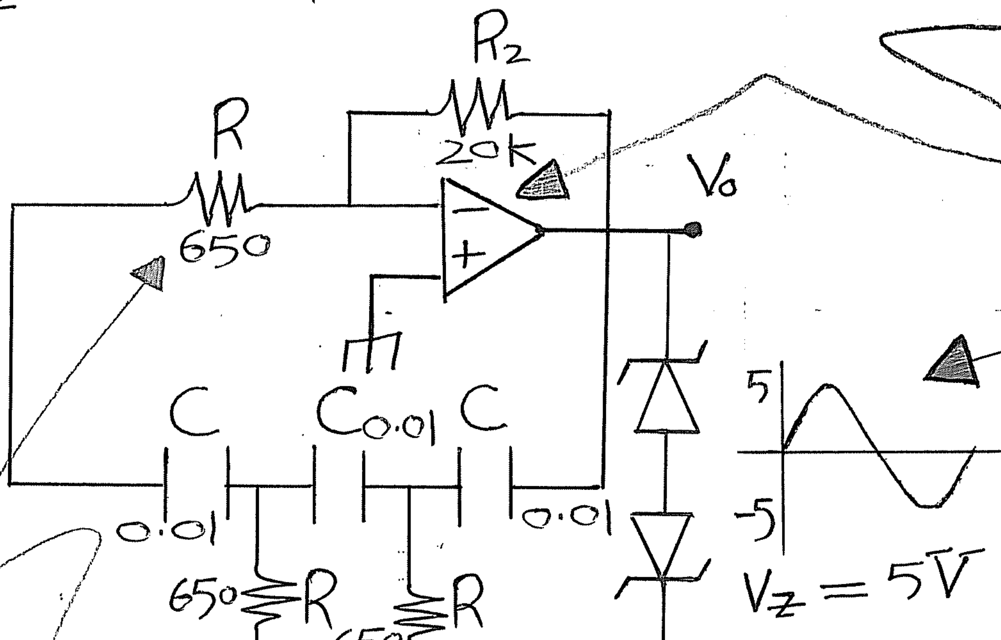
$$R = \frac{1}{2\pi\sqrt{6}f_o C}$$

$$= \frac{1}{2\pi\sqrt{6}\times 10^4 \times 0.01\times 10^{-6}} = \frac{10^4}{15} \cong 650\,\Omega.$$

for this Oscillator:

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

$$R_2 = 29R_1 = 29 \times 650 = 20\,k\Omega.$$



نستطيع استبداله بـ
Common Emitter or Common Source

إذا أردنا أن نُحدد الـ o/p بـ 5V نربطه مع Zener diode

إذا استخدمنا CE

$R_{th} = R_1 // R_2$

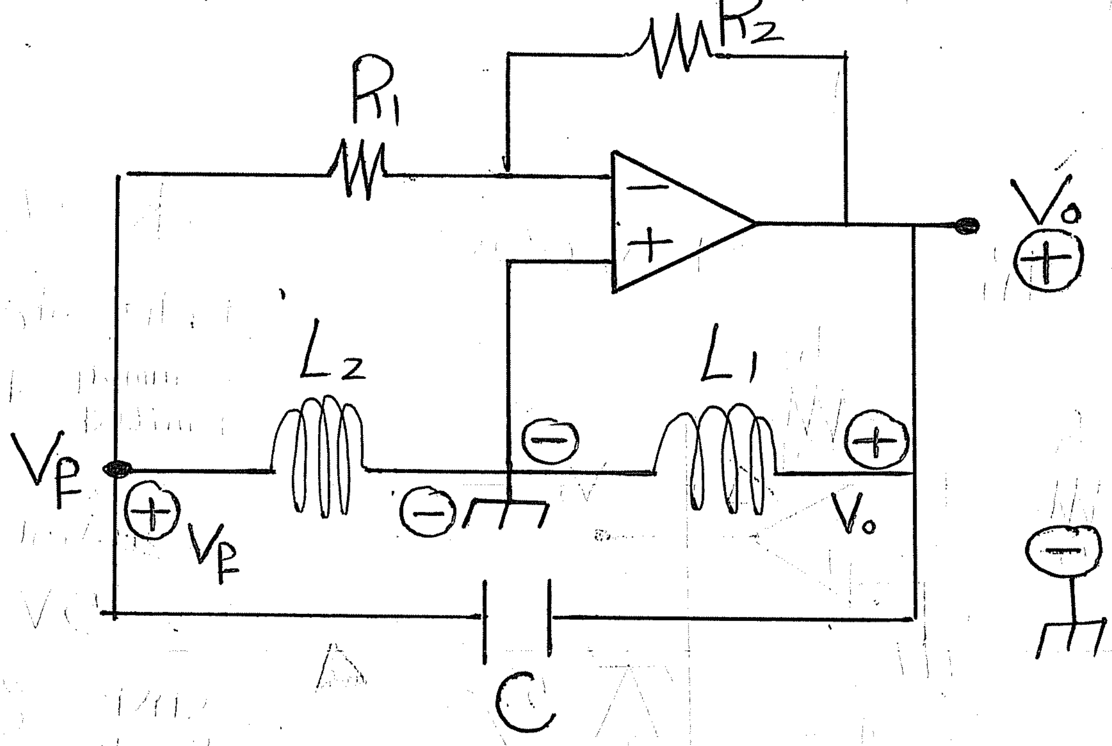
LC - Oscillator :

B → LC cct.

A → Op-Amp , BJT , FET .

1] Hartley oscillator.
2] Colpitts oscillator.
3] Crystal oscillator.

Hartley Oscillator :- [2L + 1C]



$\angle A = 180°$

$\angle B = 180°$ at Resonce .

→ For LC cct. at Resonce :

$$X_L = X_C$$

[j-term = 0]

$$jwL + \frac{1}{jwC} = 0$$

$$jw(L_1 + L_2) = \frac{-1}{jwC}$$

$$-w^2 C(L_1 + L_2) = -1$$

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

$$f_o = \frac{1}{2\pi\sqrt{(L_1 + L_2)C}}$$; Freq. of OSCillation.

$$B = \frac{V_F}{V_o} = \frac{X_{L_2}}{X_{L_1}} = \frac{L_2}{L_1}$$

$$|B| = \frac{L_2}{L_1}$$

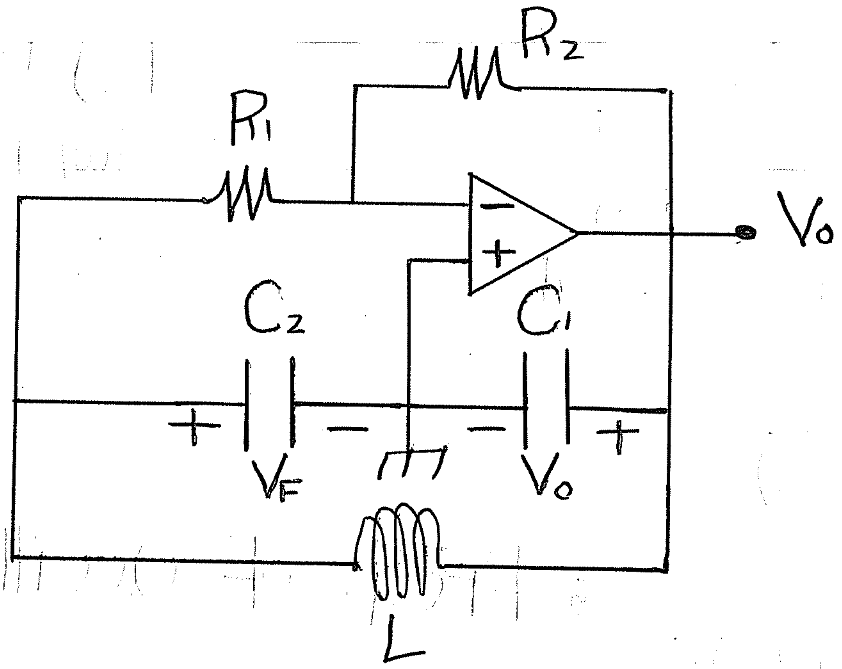
$$|A| = \frac{R_2}{R_1}$$

To Satisfy $|BA| = 1$:-

$$\boxed{\frac{R_2}{R_1} = \frac{L_1}{L_2}}$$

تُعطى C بالسؤال / ويُعطى الـ gain ← $\frac{R_2}{R_1}$ / نستخدم العلاقة $\frac{R_2}{R_1} = \frac{L_2}{L_1}$ لايجاد
قيمة L_1 و L_2 . (نفرض L_1 ونحسب L_2)
أو نجد معادلتين : $L_1 = ?L_2$
$L_1 + L_2 = ..$
ثم نحسب قيمة L_1 و L_2 .

Colpits Oscillator : [2C + 1L]



→ $\angle A$ → 180°

→ $\angle B$ → 180° at Resonce.

$$X_L + X_c = 0$$

$$j\omega L + \frac{1}{j\omega(C_1+C_2)} = 0$$

$$j\omega L = \frac{-1}{j\omega(C_1+C_2)}$$

$$-\omega^2 L = -\frac{1}{(C_1+C_2)} \rightarrow \omega_0 = \frac{1}{\sqrt{L(C_1+C_2)}}$$

$$f_0 = \frac{1}{2\pi\sqrt{L(C_1+C_2)}}$$, Freq. of oscillation.

$$|B| = \frac{V_F}{V_o} = \frac{\frac{1}{j\omega C_2}}{\frac{1}{j\omega C_1}} = \frac{C_1}{C_2}$$

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

To Satisfy $|BA| = 1$:- $\boxed{\frac{R_2}{R_1} = \frac{C_2}{C_1}}$

hint : $gain = \frac{R_2}{R_1} = 10$ / $C_1 + C_2 =$ ونجد معادلة L نفرض قيمة / $f_o = 10$

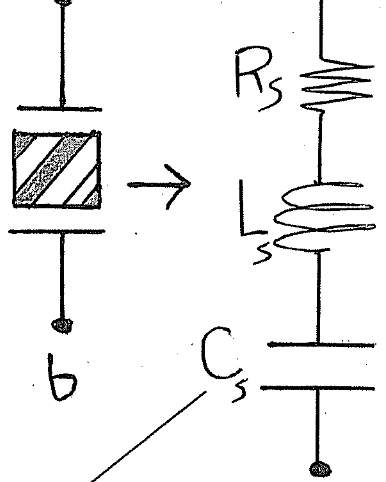
نجد معادلة(٢) من العلاقة $\frac{R_2}{R_1} = \frac{C_2}{C_1}$ / ثم نجد C_1 و C_2 .

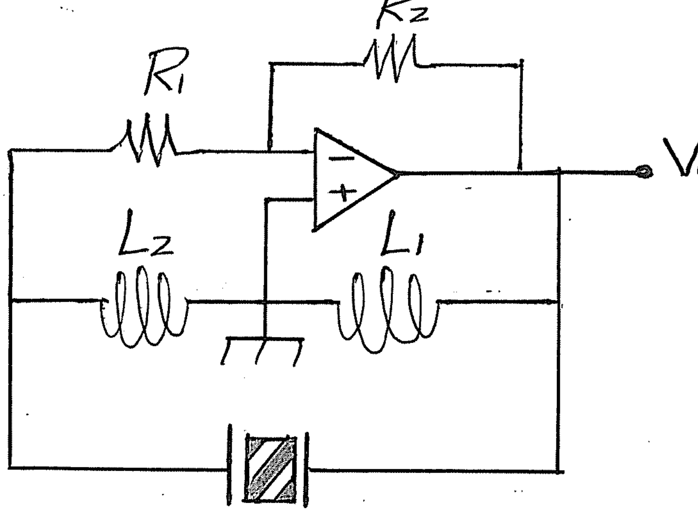
→ **Freq. Stability**: The ability of oscillator to produce a constant freq. o/p as long as possible.

For RC and LC, the components R, C, L are varied due to voltage varaition, Temp, and aging; So the freq. stability of RC and LC oscillator are **NOT** very good.

\# To obtain high and stable output freq we use Crystal Oscillator.

→ Crystal Oscillator: It is an oscillator using quartze crystal as phase shift CCt.

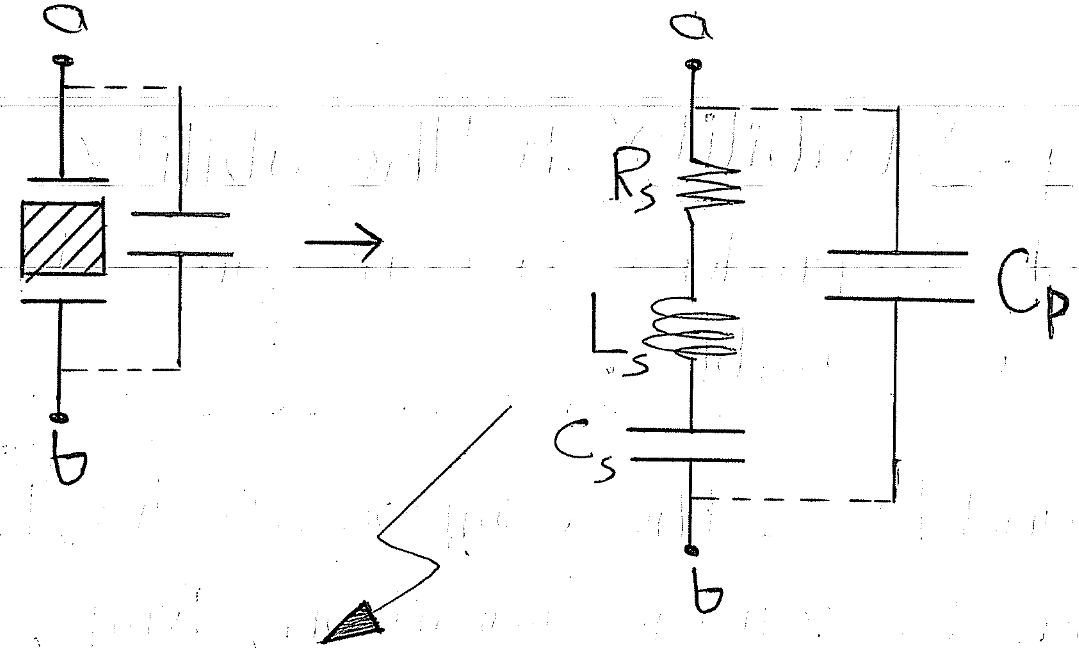




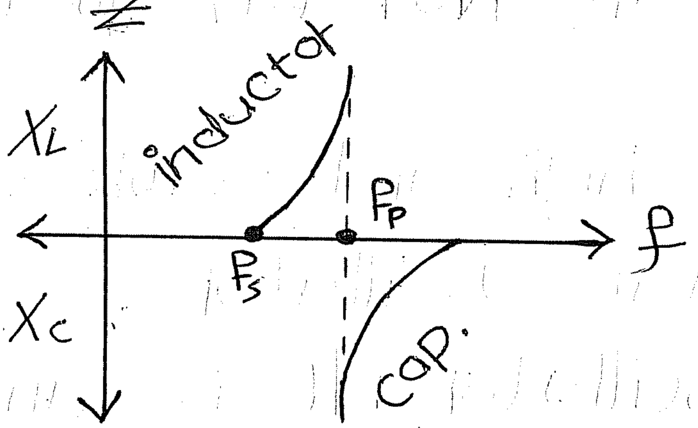
$$f_s = \frac{1}{2\pi\sqrt{L_s \cdot C_s}}$$

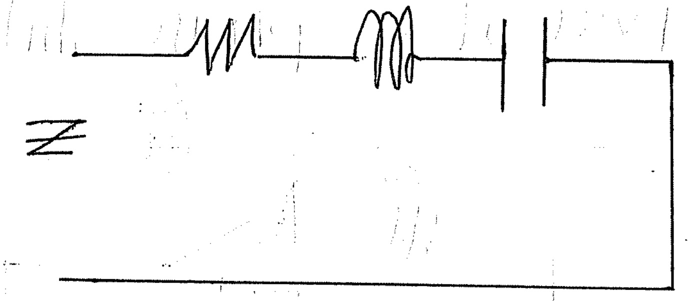
Series Resonant CCt.

نحتاج Carrier و local osci. له تردد ثابت



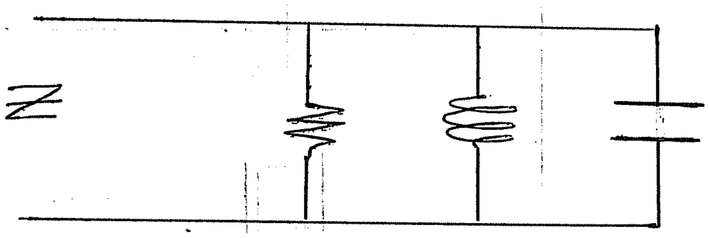
Parallel Resonant cct.





at Resonant:

$Z = R$.



at Resonant:

$Z = \infty$.

quartze Crystal is One of pizo electric material which behaive as electro-mechanical system when it is Subjected to electric field. Electrically, it is represented by Series RLC cct. and when holder capacitor (C_p) is Considered it works as parallel RLC cct..

- If we consider the impedance of the Crystal it Can work in Series mode as a Series Resonant cct. with Resonant freq.:

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

, where L_s and C_s are parameters of Crystal quartze.

Since C_s, L_s, R_s are not affected by Temp., Voltage variation, aging, So the freq. of Crystal oscillator are very stable. (X-tal oscillator has a very high freq. stability).

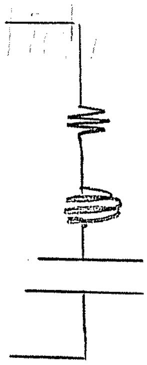
Also, the values of L_s, R_s, C_s are very small so freq. of oscillation is high (MHz) range but the value of L_s, R_s, C_s are fixed according to X-tal dimensions, so each X-tal produce a certain freq.. ↖ disadvantage.

- If the crystal works in parallel mode, it behaives as parallel tuned cct., with resonant freq.: $f_p = \frac{1}{2\pi\sqrt{L_s C_{eq}}}$.

$$C_{eq} = \frac{C_s \cdot C_p}{C_s + C_p}.$$

Example: a quartze – crystal has $R_s = 100\,\Omega$, $C_s = 0.3\,P.F$, $L_s = 3\,mH$, $C_p = 0.6\,P.F$

Calculate f_s, f_p, Q_s.



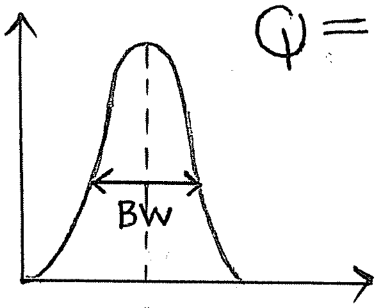
$$Q_s = \frac{\omega_s L_s}{R_s}$$

$$f_s = \frac{1}{2\pi\sqrt{L_s \cdot C_s}} = \frac{1}{2\pi\sqrt{3\times10^{-3}\times0.3\times10^{-12}}}$$

$$= \frac{10^8}{2\pi\times3} \approx 5\,MHz.$$

$$Q = \frac{2\pi\times5\times10^6\times3\times10^{-3}}{100}$$

$$\cong 999$$



$$Q = \frac{f_r}{BW}$$

$$C_{eq} = \frac{0.6 * 0.3}{0.6 + 0.3} = \frac{0.18}{0.9} = 0.2\,P.F.$$

$$f_p = \frac{1}{2\pi\sqrt{3\times10^{-3}\times0.2\times10^{-12}}} = \frac{10^8}{2\pi\sqrt{6}}$$

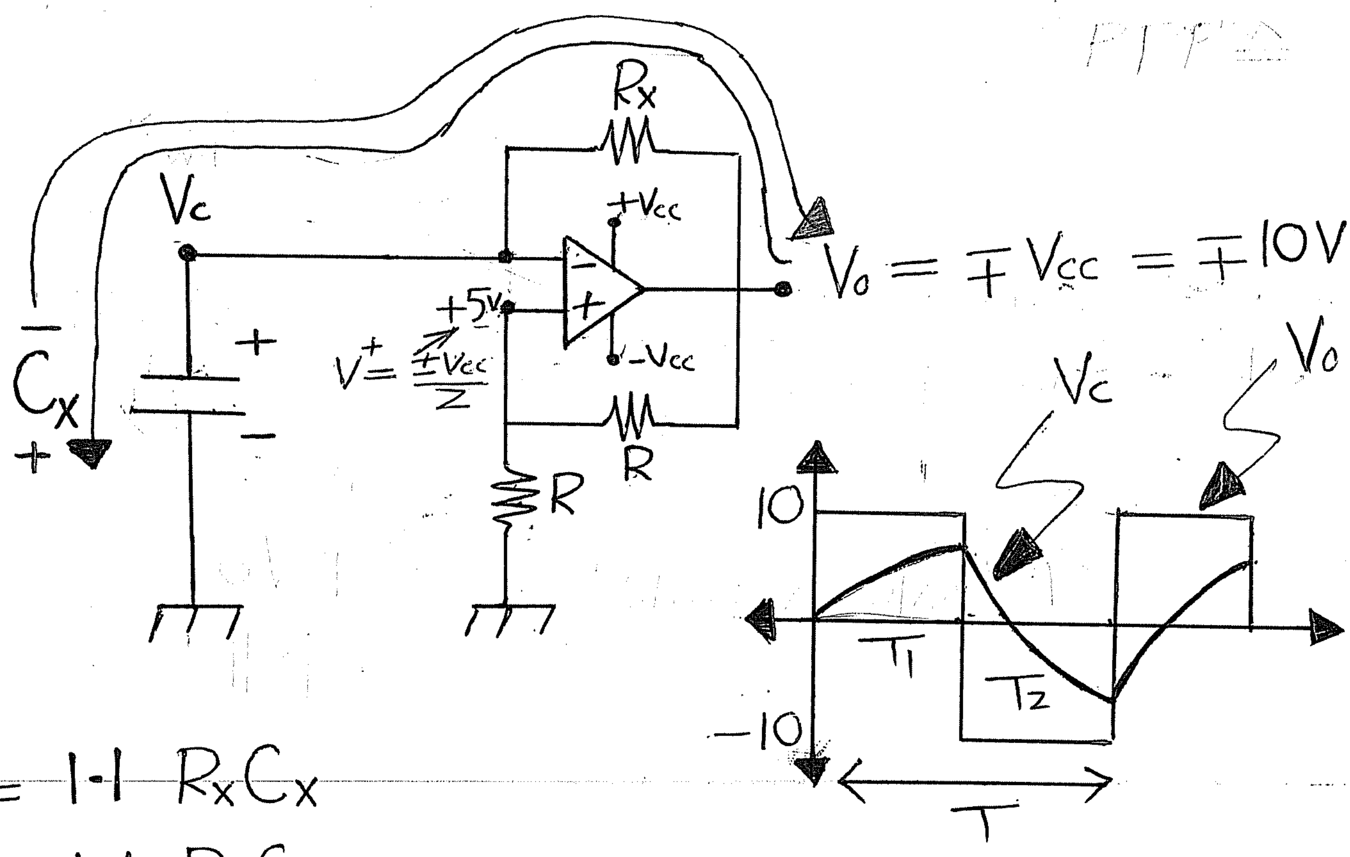
$$= 6\,MHz.$$

Non Sinusoidal Oscillator

Relaxition Oscillator

[Charging and disCharging of Cap.]

{Multivibrators}



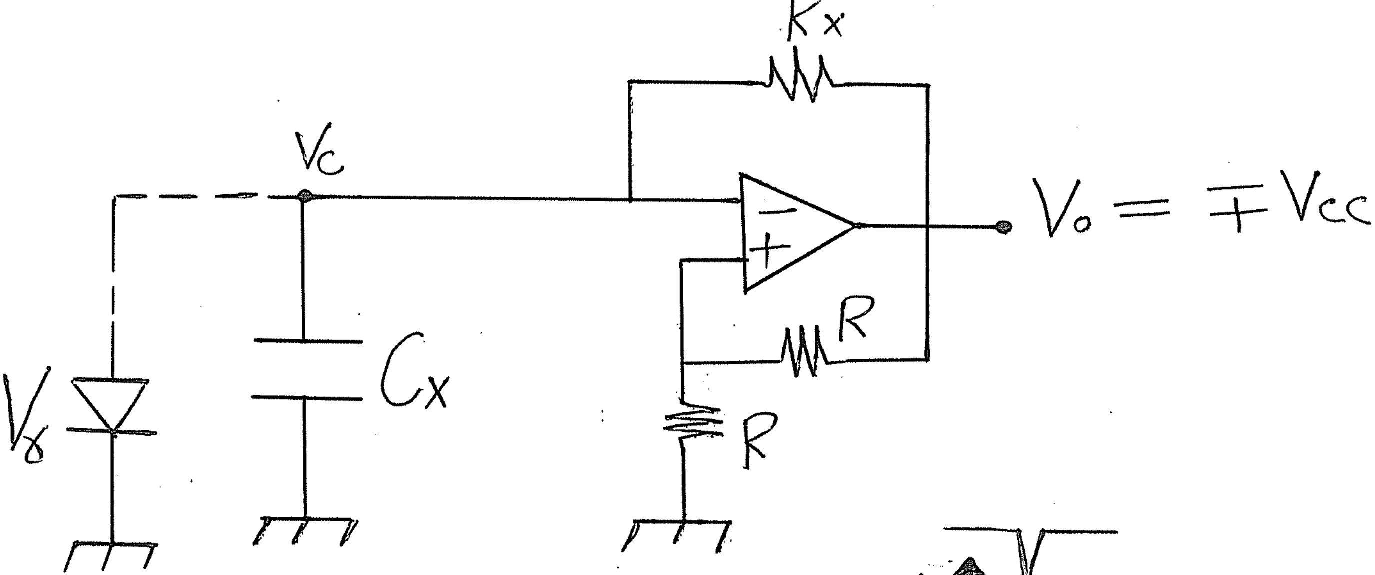
$$T_1 = 1.1\ R_x C_x$$

$$T_2 = 1.1\ R_x C_x$$

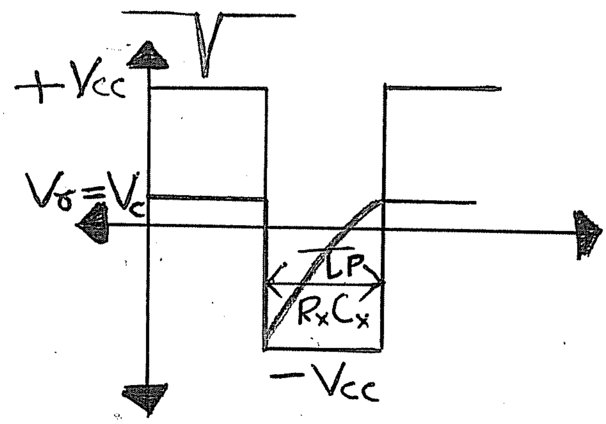
$$T = 2.2\ R_x C_x$$

$$f = \frac{1}{2.2\ R_x C_x}$$

Astable multivibrators.

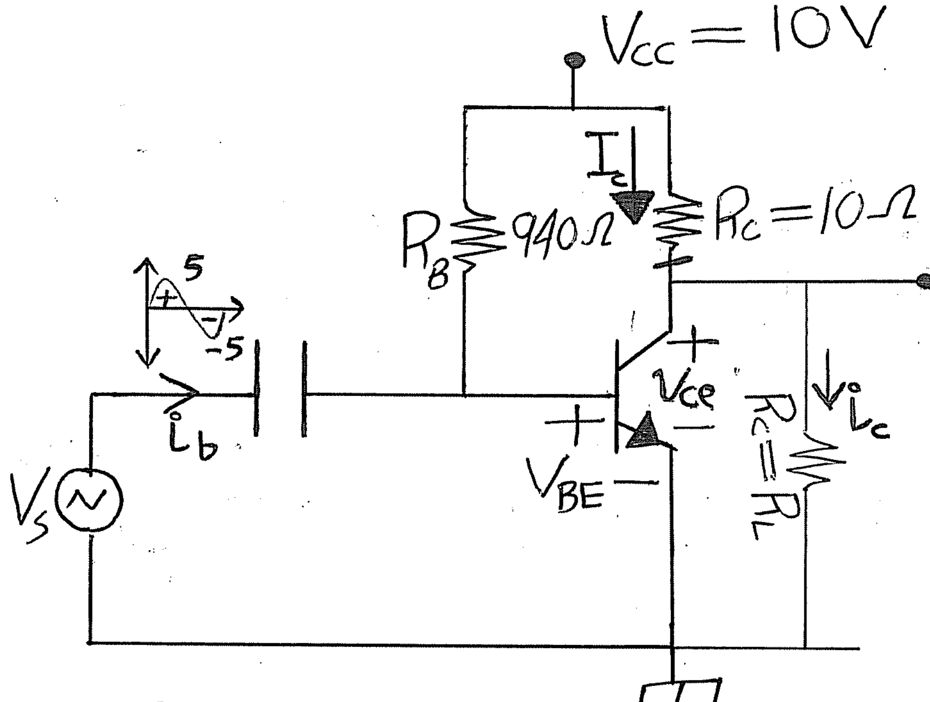


monostable



$$\tau_p = 0.69\, R_x C_x$$

Power Amplifier :-
(Large - Signal Amp.)



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

$V_{BE} = 0.6\,V$

$\beta = 50$

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

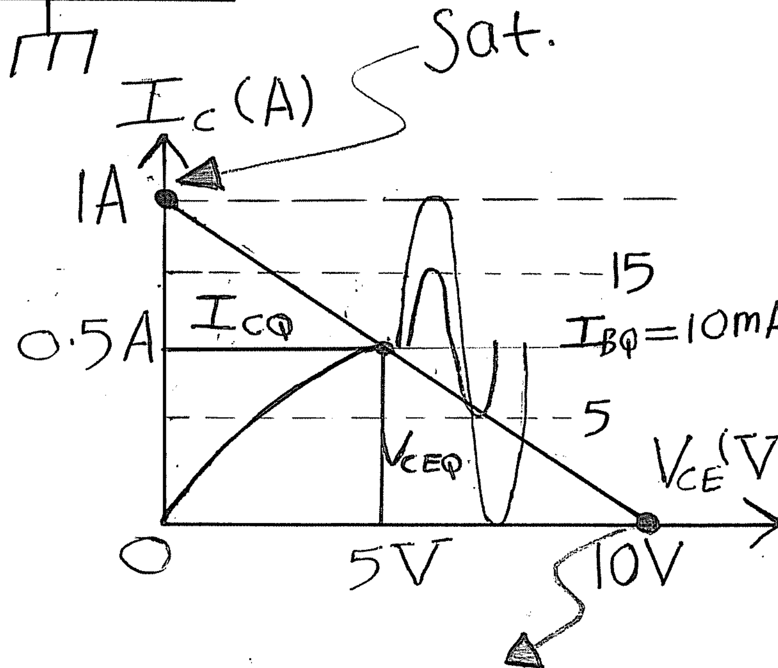
$$= \frac{(10 - 0.6)\,V}{940\,\Omega}$$

$$= \frac{9.4}{940} = 10\,mA.$$

$$I_C = \beta I_B = 0.5\,A.$$

$$V_{CE} = 10 - 0.5 * 10 = 5\,V$$

$$Q_{Pt} = (5V, 0.5A)$$



Power Amp. : dc i/P Power Signal. → ac o/p Power Signal.

$$\eta = \frac{P_{out}}{P_{in}}$$

$$P_{in} = V_{cc} I_{cq}$$

$$P_{out} = V_{ce_{rms}} \, i_{c_{rms}} = i_{c_{rms}}^2 R_c = \frac{V_{ce_{rms}}^2}{R_c}$$

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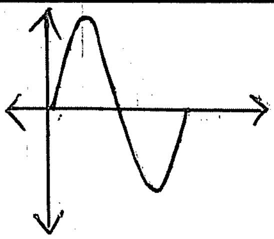
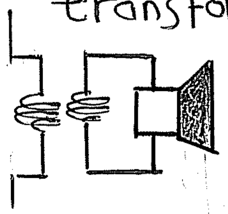
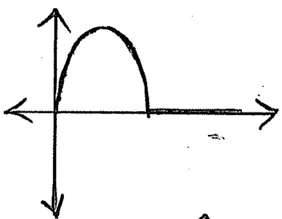
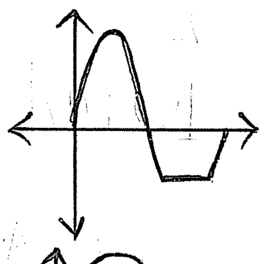
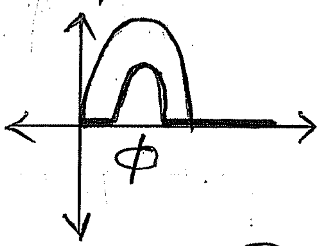
i_c → 360° →  → A
- → $\eta = 25\%$ direct load
- → $\eta = 50\%$ load with transformer



i_c → 180° →  → B → $\eta = 78.5\%$

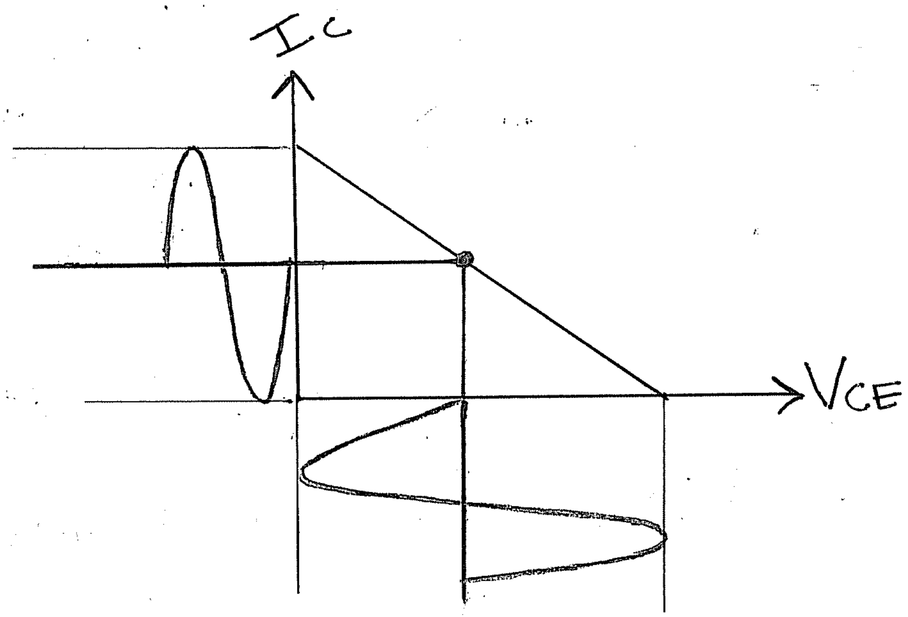
i_c → $180° < \phi < 360°$ →  → AB → $\eta < 78.5\%$

i_c → $\phi < 180°$ →  → C → $\eta > 90\%$

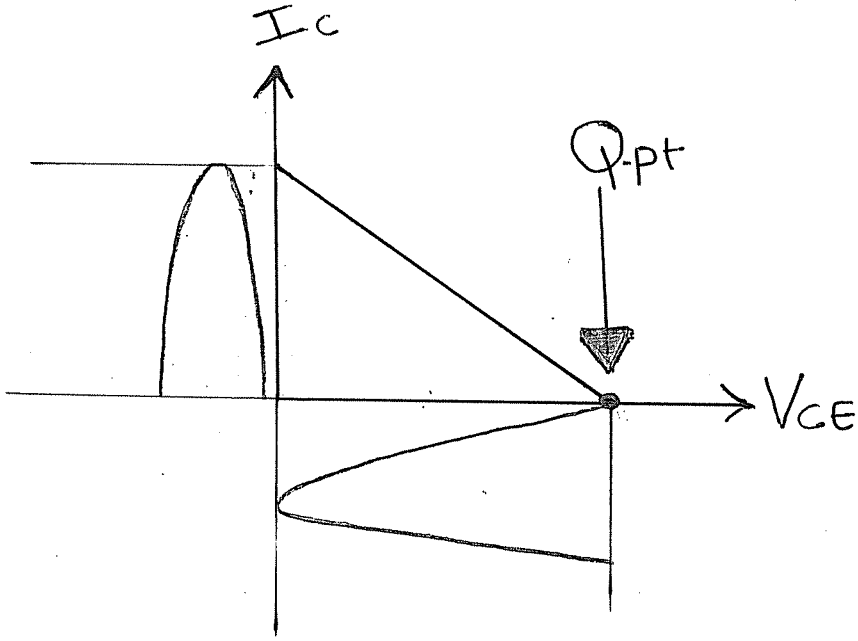
A, B, AB } Audio. freq. Power Amp. → Reciver

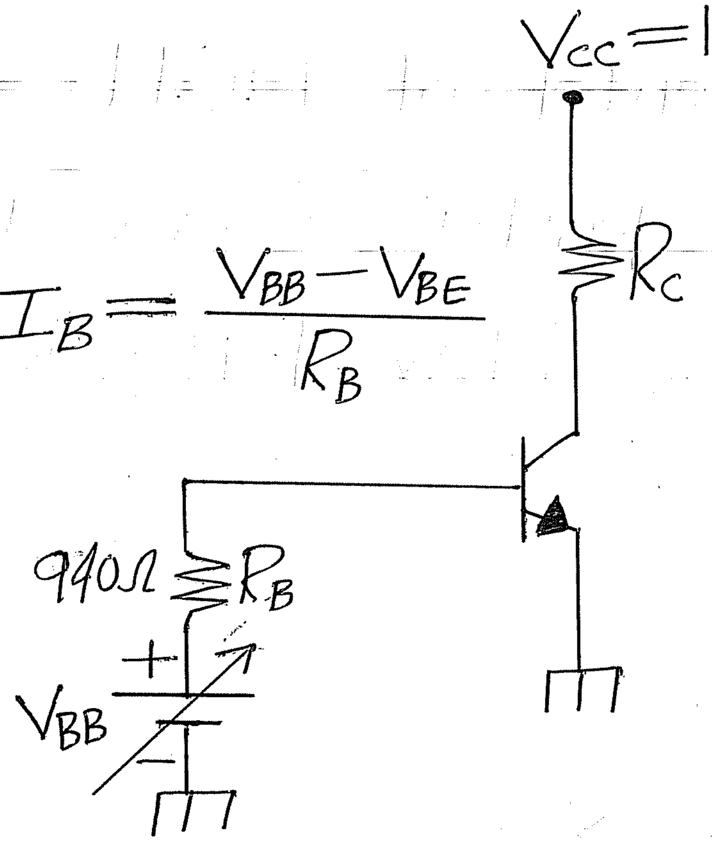
C } Radio Freq. Power Amp. → Trans.

Class-A : Q-pt at Center of D.C.l.l (idealy) . but in general, i_c, V_{ce} are Complete signals i_c flows for 360°.



Class-B : idealy, Qpt at Cut-off I_{CQ}=0 but in general, i_c, V_{ce} are half cycle.

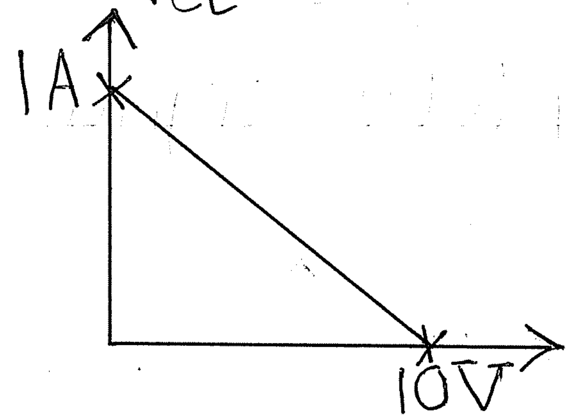




$$I_B = \frac{V_{BB} - V_{BE}}{R_B}$$

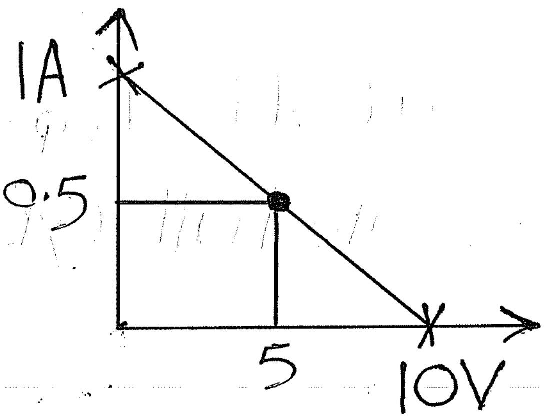
in general:

$V_{CE} = 10 - I_C R_C$



For Class-A : idealy $I_c = \frac{1}{2} I_{c\,max}$.

$= \frac{1}{2}$ A.



$$I_{BQ} = \frac{I_{CQ}}{\beta} = \frac{0.5}{50}$$

$= 10$ mA.

$$I_B = \frac{V_{BB} - 0.6}{R_B}$$

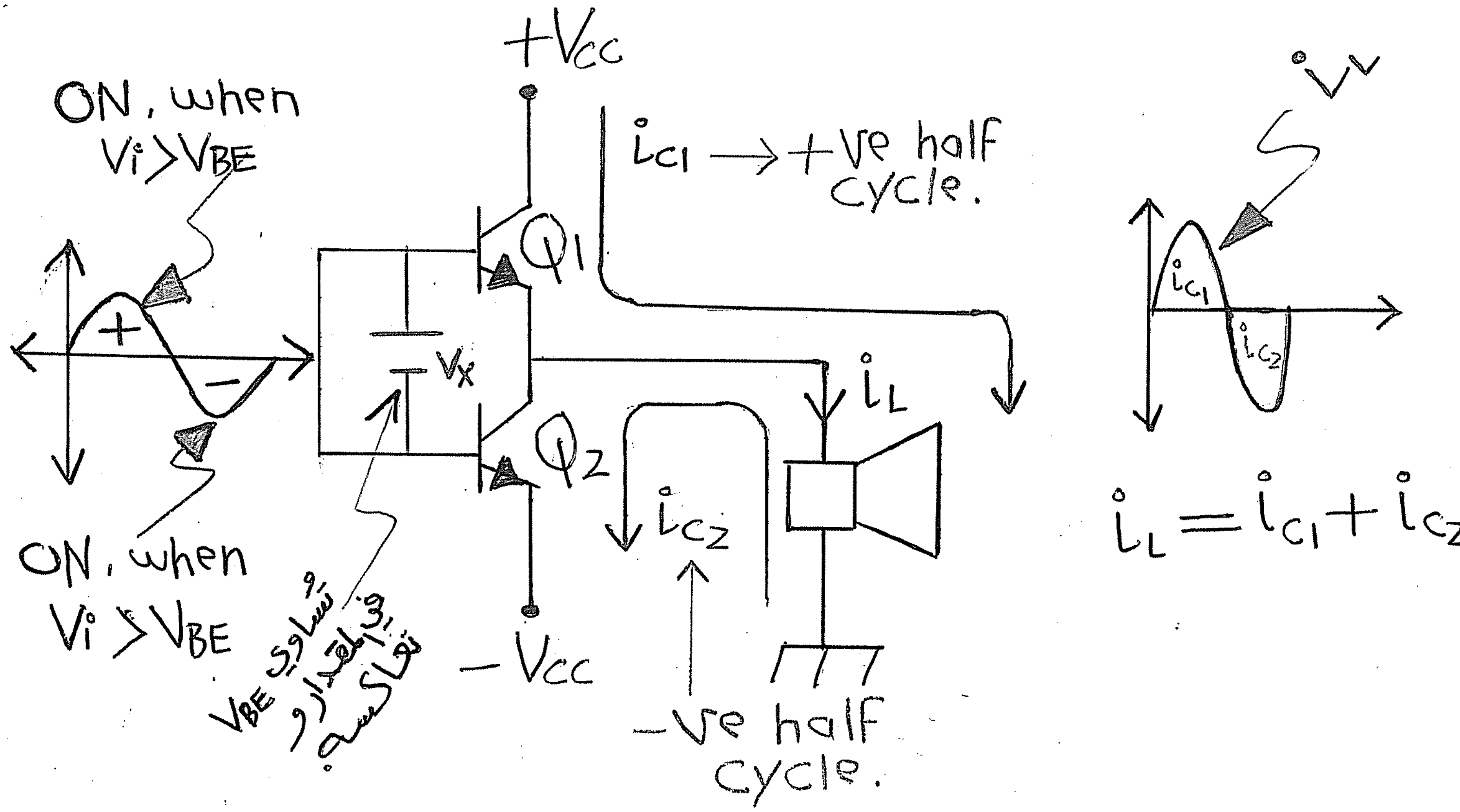
$V_{BB} = I_B R_B + V_{CE}$

$= 10 * 940 + 0.6$

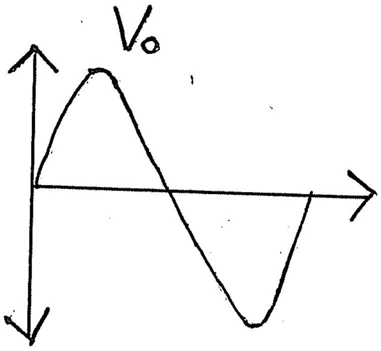
$= 10$ V. #

For Class-B :

$I_{CQ} = 0 \rightarrow I_{BQ} = 0 \rightarrow V_{BB} = V_{BE} = 0.6$ V.



$i_L = i_{C1} + i_{C2}$

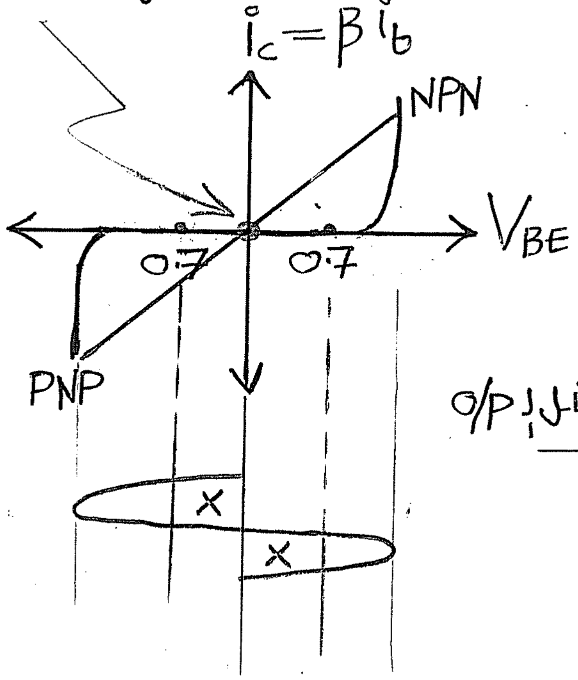


Class-B Push-Pull Power Amp.

[using two Complemently Transistor]

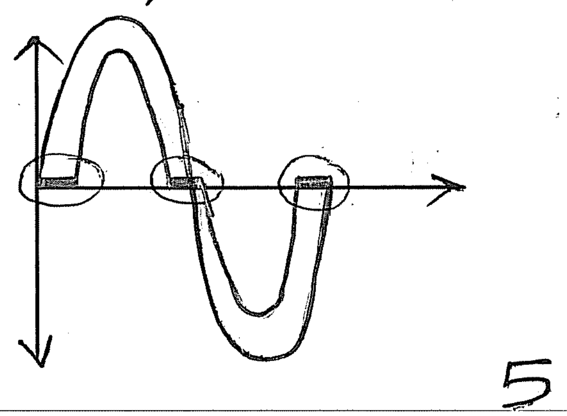
$\eta = 78.5\%$

Qpt in origin



Class-over distortion

يصبح شكل ال o/p →

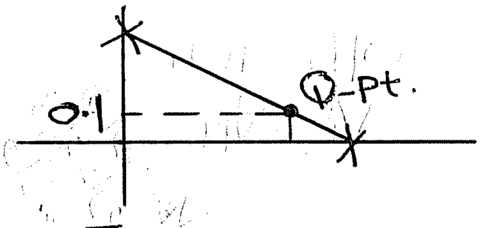


Class-AB :

Q-pt is between A and B ,

→ position Choose $I_{CQ} = 0.1\,A$:

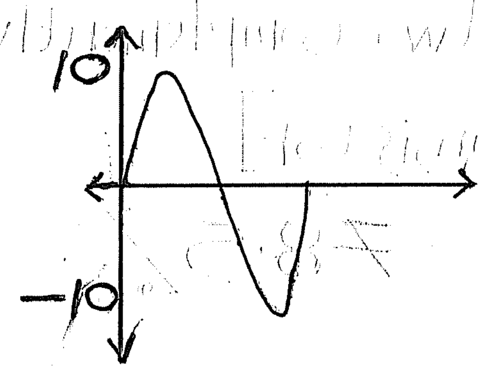
$$I_{BQ} = \frac{0.1}{50} = 2mA$$



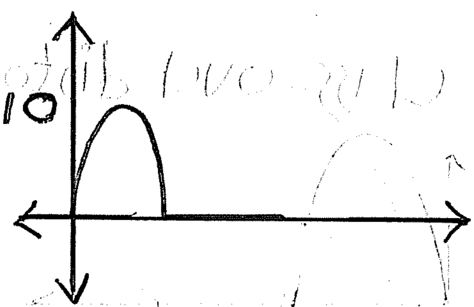
$$V_{BB} = I_B R_B + V_{BE}$$
$$= 2 \times 0.94 + 0.6 = 2.48V.$$

$\eta < 78.5\%$.

note :-



$$Rms = \frac{V_P}{\sqrt{2}} = \frac{10}{\sqrt{2}}$$ ✓



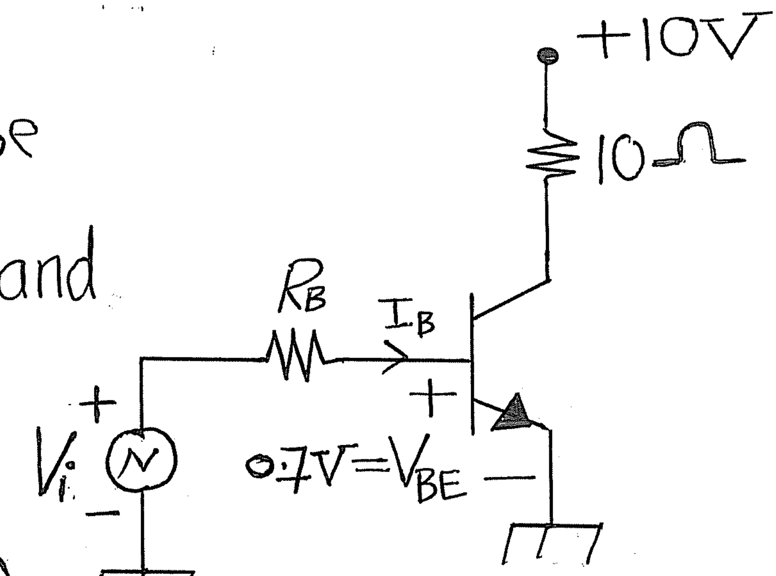
$$Rms = \frac{V_P}{2} = \frac{10}{2}$$ ✓

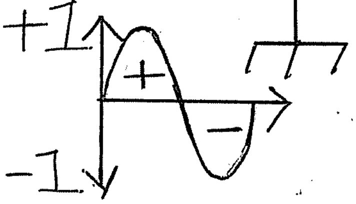
Class-C Power Amp. :-

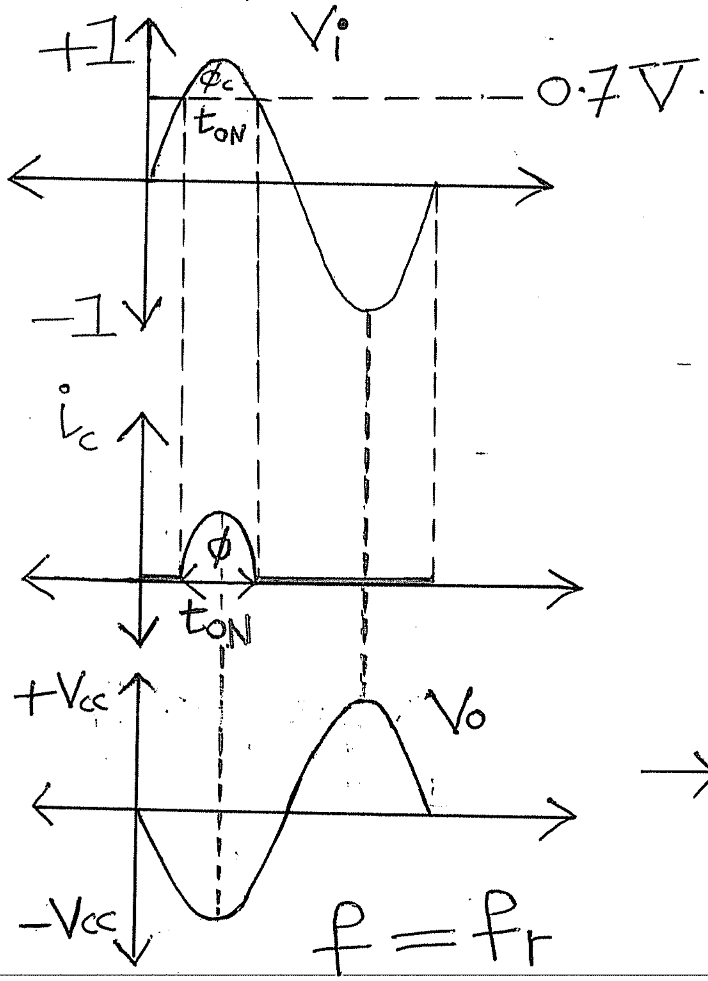
1] Q-Pt is down the cutoff.

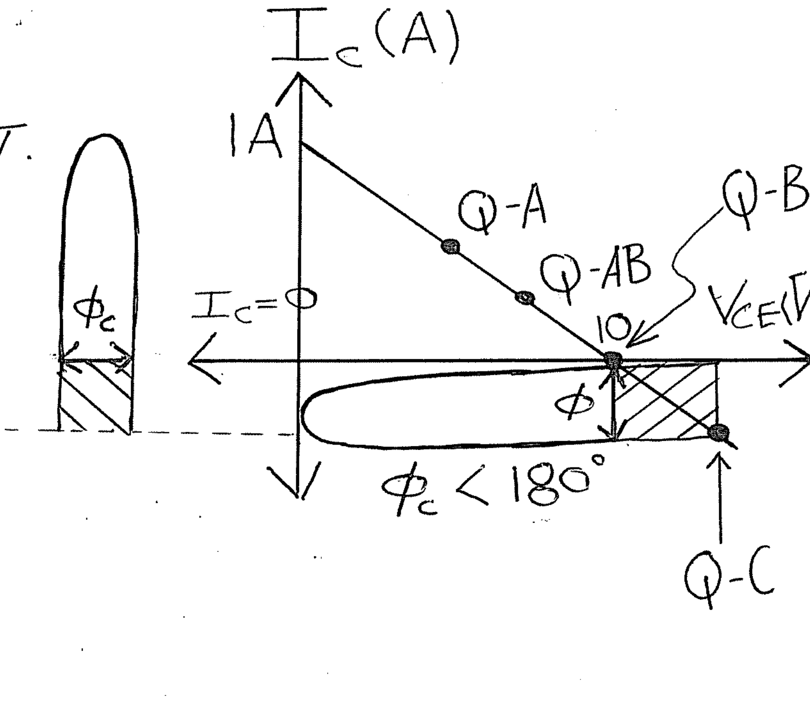
i.e $\phi_c < 180^\circ$ (BJT is ON for $< 180^\circ$).

The BJT will be ON in +ve H.C and only when $V_i > V_{BE}$.





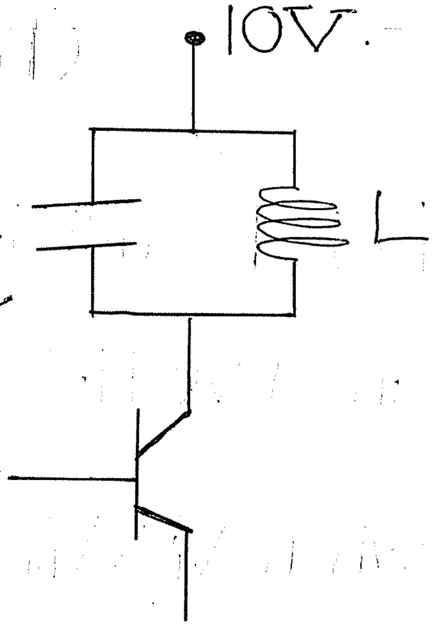




→ fly wheel effect.

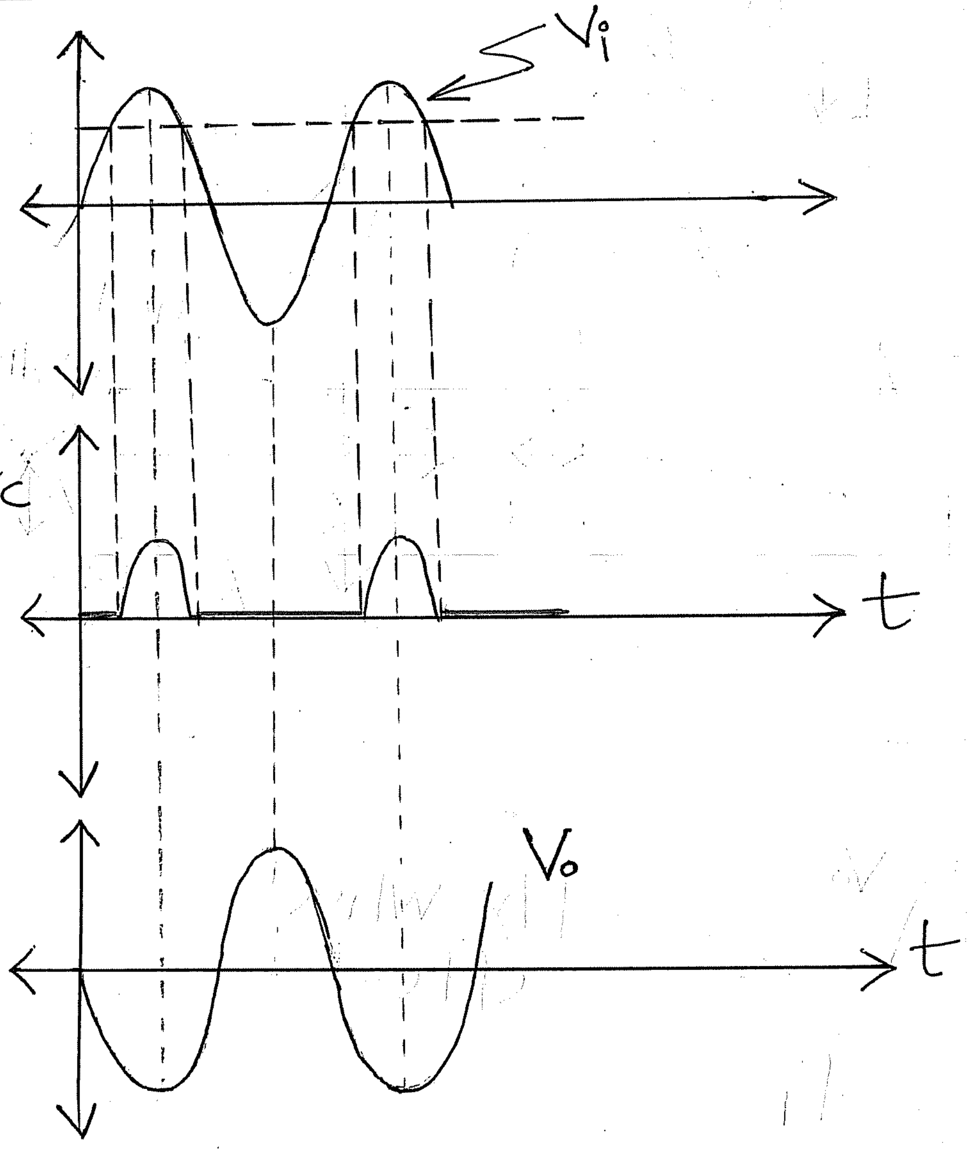
R.F → f↑ → C, L ↓ (قيم معتدلة)

↑ we use class-C in Radio freq.

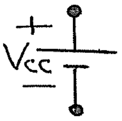


• تكبّر الPower لـ Fund. Sig.

$$f_r = \frac{1}{2\pi\sqrt{LC}} = f_{fund.}$$



2] The Shape of i_c is pulse-Shape, So i_c will Charge the Capacitor with +Vcc $\boxed{V_o = -V_{cc}}$ (When BJT is ON).



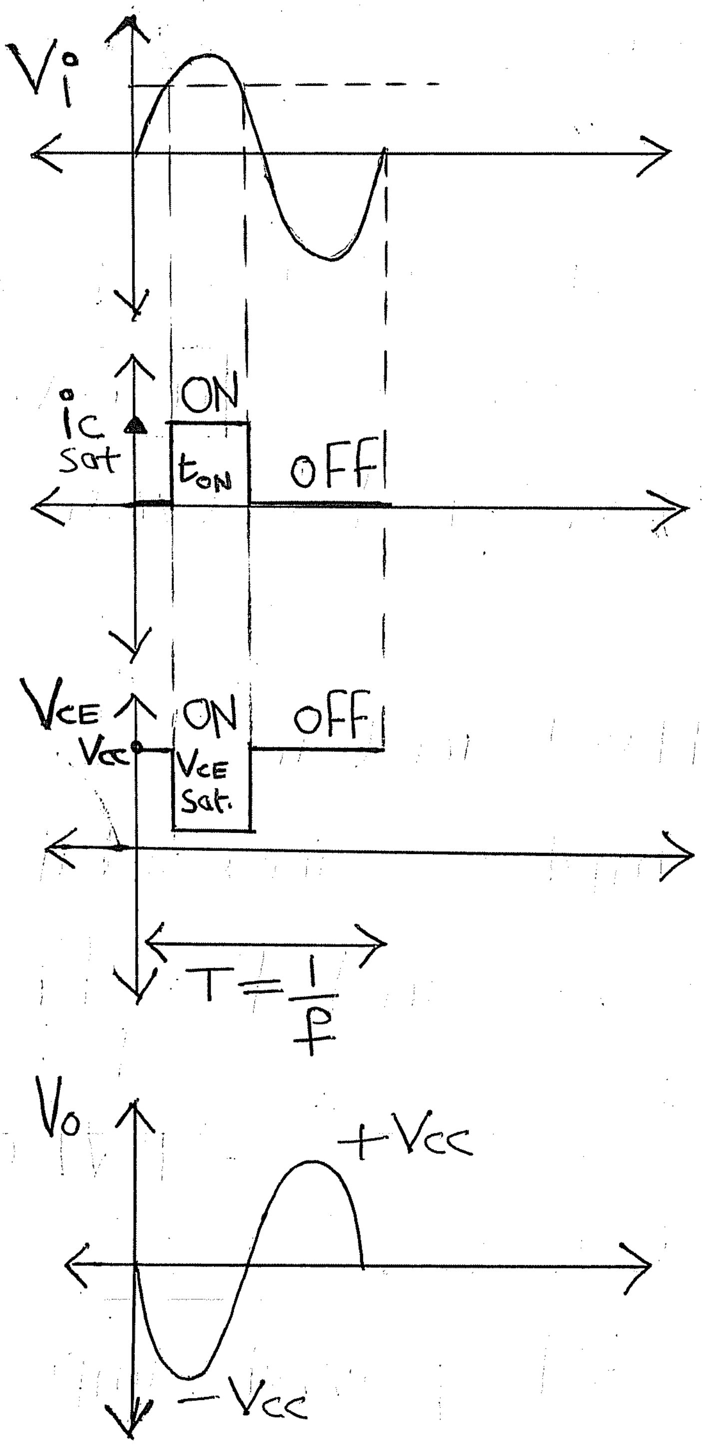
3] When BJT is OFF, the Capacitor will Charge the inductor with +Vcc [Produce $V_o = +V$...]
[The Energy will be transfered between C and L].

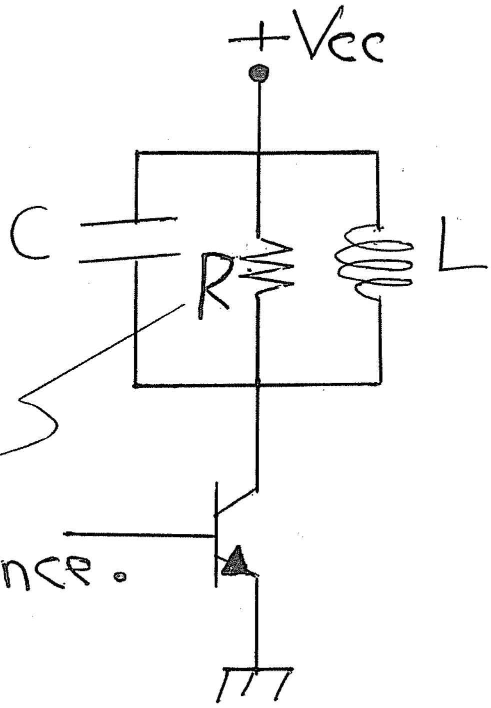
4] Due to Fly wheel effect in tuned LC cct the O/P will be a complete Sinusoidal wave with $V_{Pmax} = \pm V_{cc}$ and $f = f_r = \frac{1}{2\pi\sqrt{LC}}$.

5] In Class-C, the load is parallel tuned LC cct.

6] Class-C is used as R.F power amp. in Transmitter.

Power Calculation :





R: Total effective Resistance.

at Resonant: $X_L = X_C$

← لا يوجد reactance.

* Average - load power:

$$\bar{P}_L = \frac{V_{o\,(rms)}^2}{R} = \frac{\left(\frac{V_{op}}{\sqrt{2}}\right)^2}{R}$$

$$= \boxed{\frac{V_{cc}^2}{2R}} \; \#.$$

* Average DC power dissipated in BJT:

$$\bar{P}_D = P_D(ON) \cdot \frac{t_{ON}}{T}$$

$$= \boxed{I_C(sat) \cdot V_{CE}(sat) \cdot \frac{t_{ON}}{T}} \cdot \#.$$

$$\boxed{\bar{P}_i(DC) = \bar{P}_D + \bar{P}_L}$$

Conversion efficiency:-

$$\eta\% = \frac{\text{Average ac load power}}{\text{DC input power drawn from DC Source}} * 100\%$$

$$\eta\% = \frac{\overline{P_L}}{P_i(DC)} = \frac{\overline{P_L}}{\overline{P_D}+\overline{P_L}} * 100\%.$$

<u>Exa.</u> A Class-C R.F power Amp. is used to process a signal with ($f = 500kHz$). If ($V_{CC} = +20V$), and the total effective resistance of the tuned cct. ($R = 100\,\Omega$), and the BJT has $I_c(sat.) = 1A$) and ($V_{CE}(sat) = 0.3V$). and it is (ON) for ($0.4\,\mu s$). Calculate

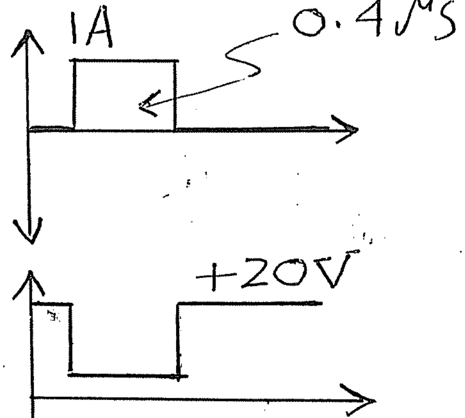
1) $\overline{P_L}$, $\overline{P_{i(DC)}}$, $\eta\%$?

2) Sketch $V_o(t)$.

3) Design the tuned CCt. process the required Signal.

Solution :

1)



$$T = \frac{1}{f} = \frac{1}{500k} = 2\mu s.$$

$$\overline{P}_L = \frac{V_{cc}^2}{2R} = \frac{20^2}{2 \times 100} = 2W.$$

$$\overline{P}_D(ON) = P_D(ON) \cdot \frac{t_{ON}}{T}$$

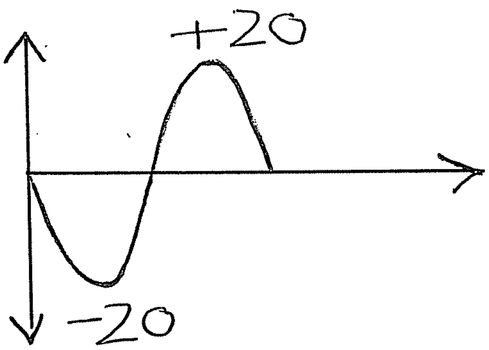
$$= I_c(Sat) \cdot V_{CE}(Sat) \cdot \frac{t_{ON}}{T}$$

$$= 1 * 0.3 * \frac{0.4\mu}{2} = 0.06 W.$$

$$P_i(DC) = 2 + 0.06 = 2.06 W.$$

$$\eta \% = \frac{2}{2.06} * 100\% = 97\%.$$

2)



$f = 500kHZ.$

3) we must Choose $f_r = f = 500\,kHz$

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

let $C = 0.01\,\mu F$

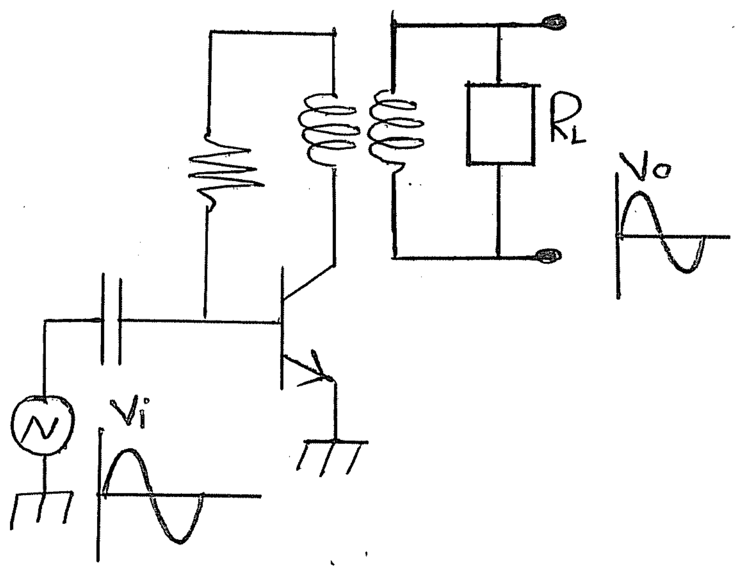
$$f_r^2 = \frac{1}{2\pi^2 LC}$$

$$L = \frac{1}{4\pi^2 \times 0.01\mu \times 25 \times 10^{10}}$$

$$= 10\,\mu H.$$

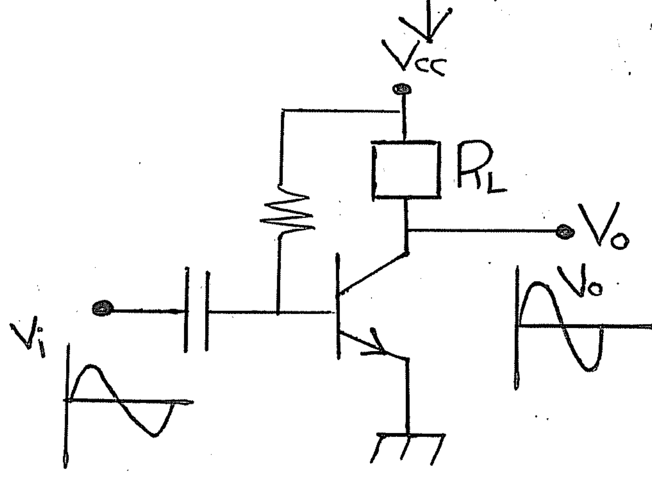
Class-C	Class-A, B, AB
Nonlinear.	linear p. A.
R.F.p.A.	A.F.p.A.
Used in Transmitter	Used in Receiver.

Class-A



Transformer Coupled

$\eta_{max} = 50\%$



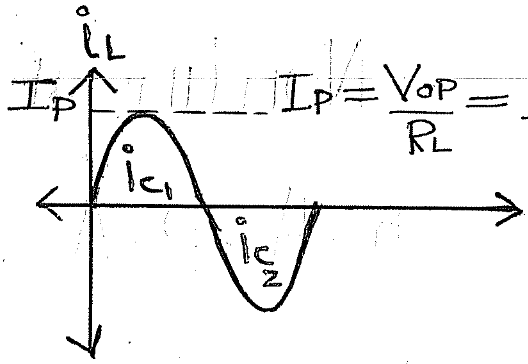
Direct Coupled

$\eta_{max} = 25\%$

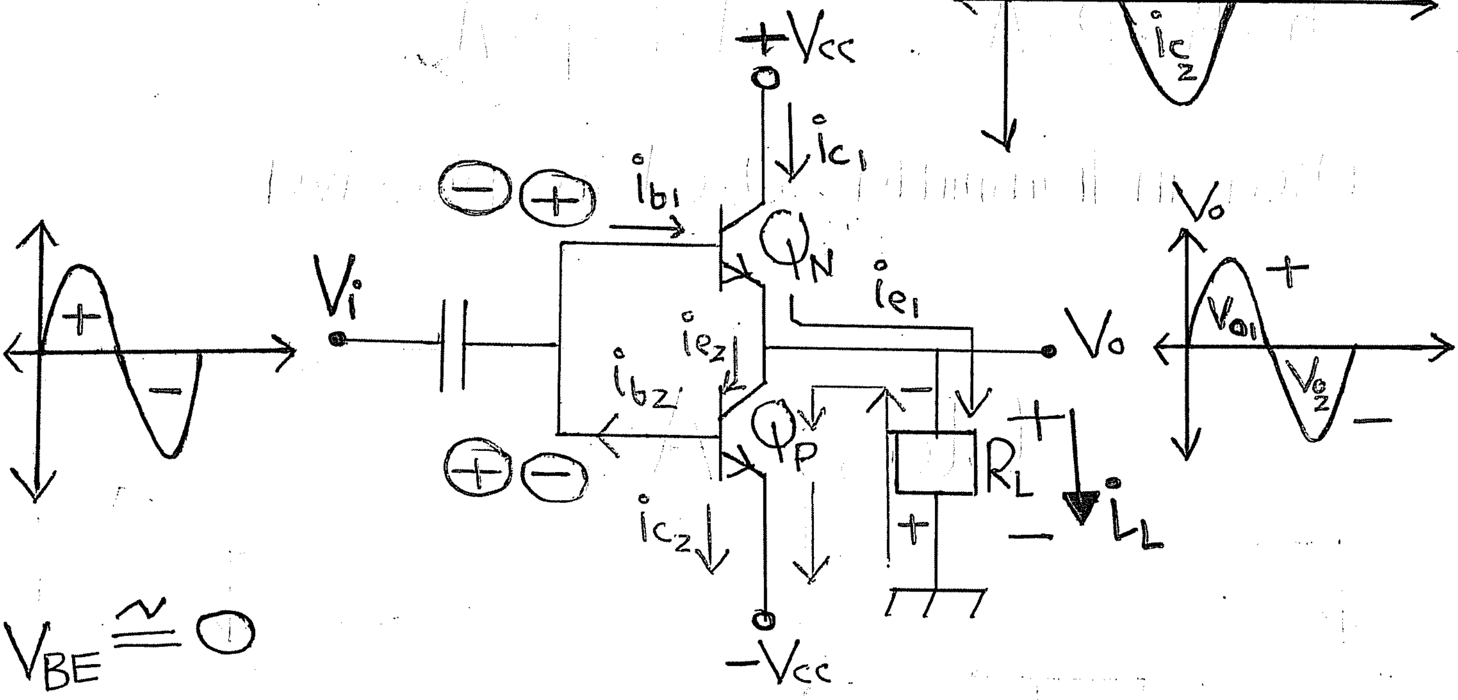
$$\eta = \frac{\bar{P}_L}{P_{i(D.C)}} * 100\%$$

- عند نفس $\bar{P}_L$ ، $P_{i(DC)}$ في الـ direct coupled أعلى من Transformer coupled.

Class-B push pull power Amp. :-



$$I_p = \frac{V_{op}}{R_L} = \frac{V_{ip}}{R_L}.$$

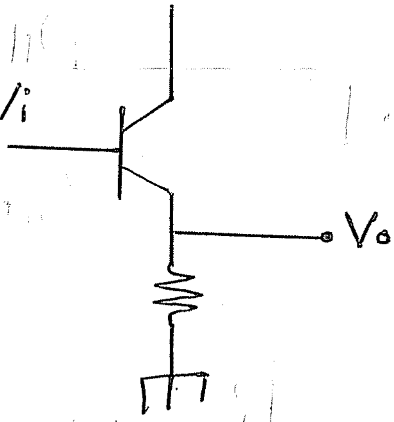


$V_{BE} \cong 0$

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

$V_o = V_i$, assume $i_c = i_e \rightarrow i_e = \frac{V_o}{R_L}$.

it is Common Collector : [C.C]



$$A_v \cong 1 \rightarrow V_o = V_i$$

1] without V_i , Q_N and Q_P are off , $V_o = 0$

2] During +Ve H·C of V_i , Q_N is ON , Q_P is off

$i_{c_1} = i_{e_1} = i_L$ will flow in R_L Causing

$V_o = i_c R_L$.

3] In −Ve H·C of V_i , Q_P is ON , Q_N is off ,

$i_{c_2} = i_{e_2} = i_L$ will flow in R_L Causing

$V_o = -i_{e_2} R_L$.

$$\bar{P}_L = \frac{V_o^2}{R_L} , \; i_L^2 R_L , \; i_L V_L \quad \text{[Rms Value]} .$$

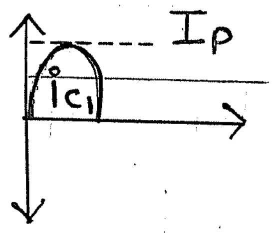
or:

$$\bar{P}_L = \frac{V_{oP}^2}{2R_L} , \; \frac{i_{LP}^2}{2} R_L , \; \frac{i_{LP} V_{LP}}{2} .$$

$$P_{i(DC)} = V_{cc} \cdot I_{DC}$$

$$= P_{DC}^{\oplus} + P_{DC}^{\ominus}$$

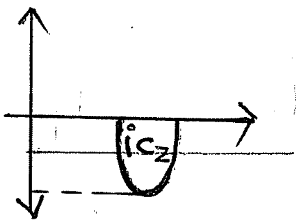
1] For +ve H.C :- $\longrightarrow Q_N$ ✓



$$I_{DC} = \frac{I_P}{\pi}$$

$$P_{DC}^{+} = V_{cc} \cdot \frac{I_P}{\pi}.$$

2] For −ve H.C :- $\longrightarrow Q_P$ ✓



$$I_{DC} = \frac{-I_P}{\pi}$$

$$P_{DC}^{-} = -V_{cc}\left(-\frac{I_P}{\pi}\right)$$

$$= V_{cc} \cdot \frac{I_P}{\pi}$$

$$\Rightarrow \boxed{P_{DC} = 2 V_{cc} \frac{I_P}{\pi}} \quad \#$$

$$I_P = \frac{V_{oP}}{R_L}.$$

Conversion efficency :-

$$\eta\% = \frac{\overline{P_L}}{\overline{P_{D.C}}} * 100\%$$

$$\eta\% = \frac{\frac{V_{LP} \cdot I_{LP}}{2}}{\frac{2V_{cc} I_{LP}}{\pi}} = \frac{\pi V_{LP}}{4 V_{cc}} * 100\%$$

When $V_{LP} = V_{cc} \longrightarrow \eta = \eta_{max}$

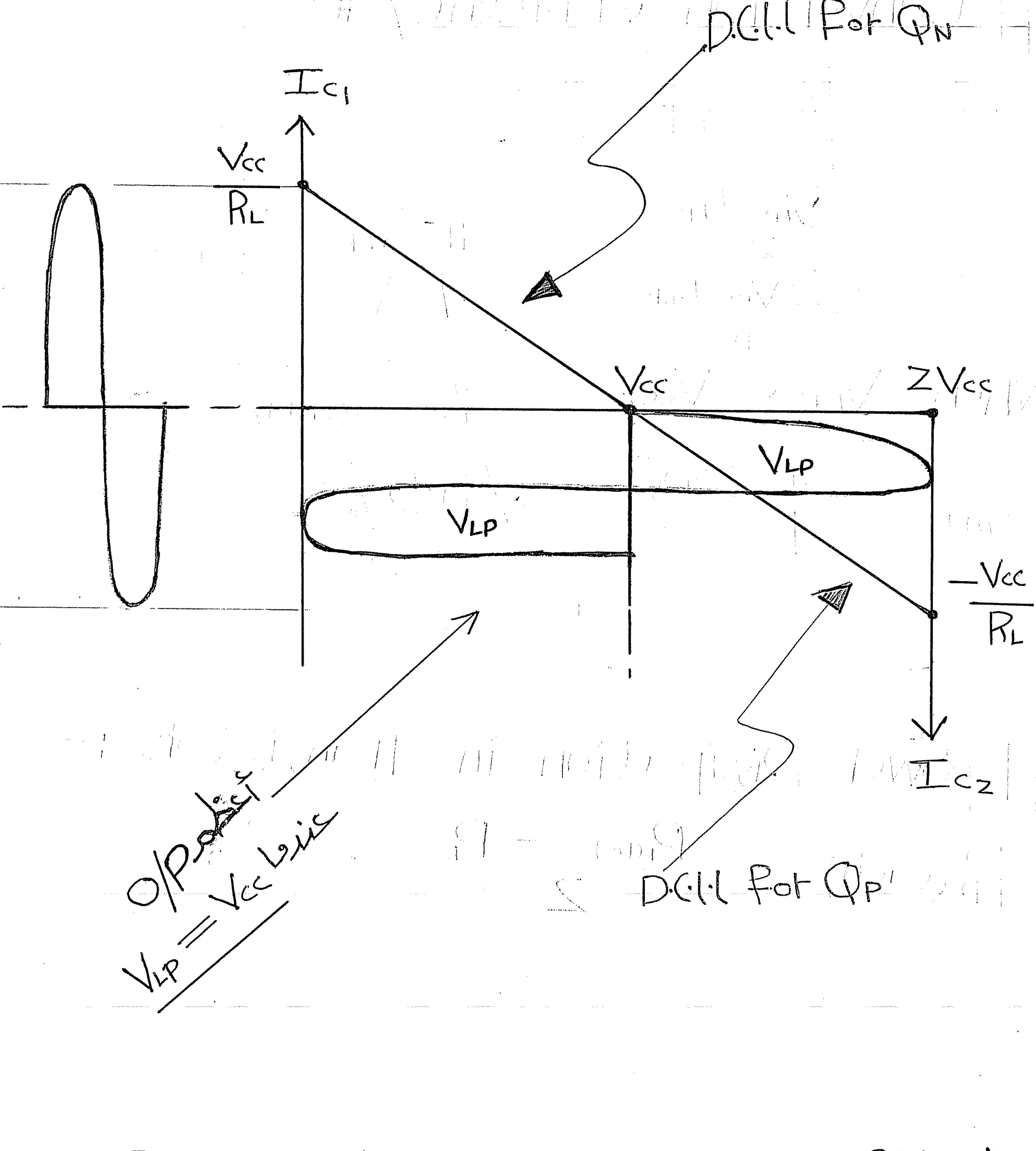
$$\eta_{max} = \frac{\pi}{4} 100\% = 78.5\%$$

↳ 22.5% Power dissipated in Transistors.

Power Dissipation in Transistors :-

$$P_D(\text{each}) = \frac{\overline{P_{i(DC)}} - \overline{P_L}}{2}$$

$$V_{CE_1} = V_{CC} - I_{C_1} R_L$$



الـ ACll والـ DCll مُنطبقان [نفس الخط].

Exa. A Class-B Push Pull power amp. Using Complementary Trans. has $V_{cc} = \pm 25\,V$, is used to feed 8-Ω Speaker. If the i/p Voltage is:

$V_i = 20 \sin \omega t \ V$.

1] Calculate: $\bar{P}_{DC}, \bar{P}_L, \eta\%, P_D$ (each).

2] Sketch D.C.L.L with o/p Voltage and Current Swings.

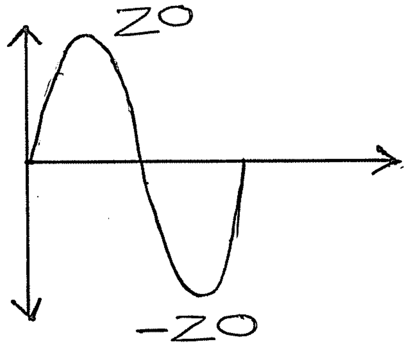
3] What is the peak i/p Voltage required to give max. Conv. efficiency?

[assume $V_{BE} \approx 0$].

Sol. Since the cct. is (C.C):

$V_o = V_i = 20 \sin \omega t\ (V)$.

$V_o = V_L$



$$\bar{P}_L = \frac{V_{LP}^2}{2R_L} = \frac{20^2}{2\times 8} = 25\ W.$$

$$\bar{P}_{i(DC)} = 2V_{cc}\frac{I_P}{\pi}$$

$$I_P = \frac{V_{oP}}{R_L} = \frac{20}{8} = 2.5\ A.$$

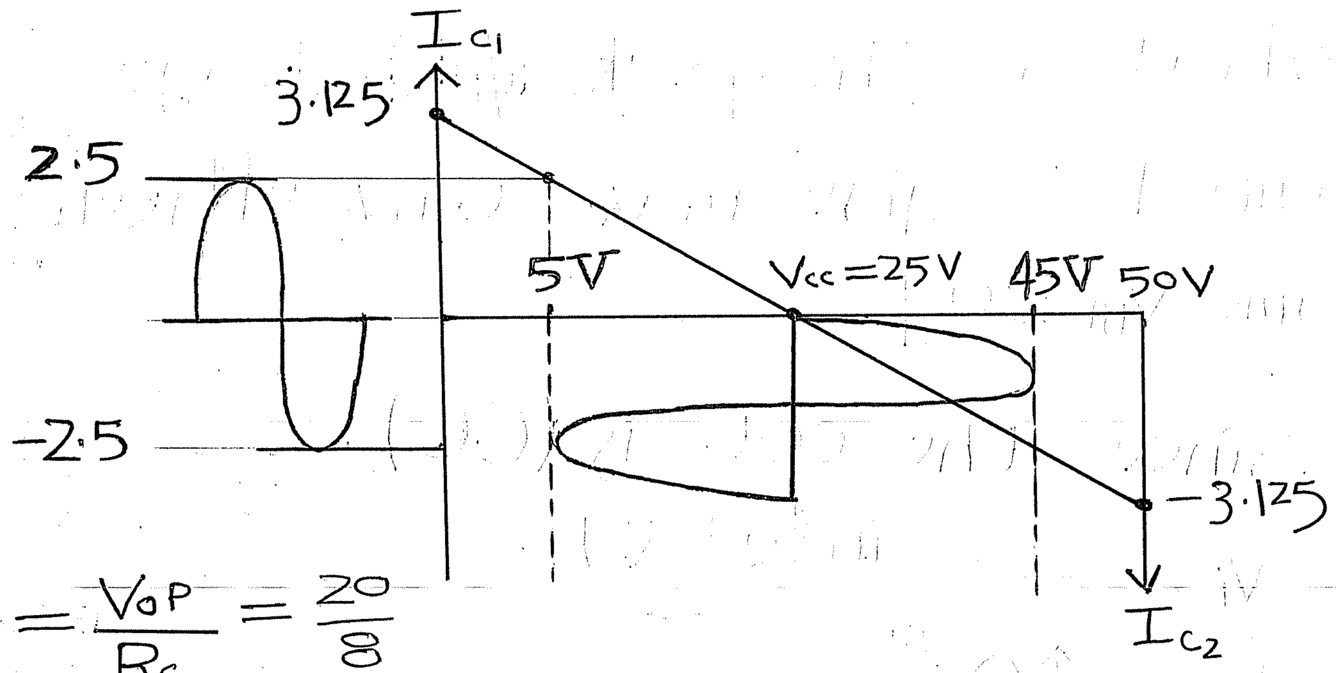
$$\bar{P}_{DC} = \frac{2\times 25\times 2.5}{\pi} \cong 40\ W.$$

$$\eta\% = \frac{\bar{P}_L}{\bar{P}_{DC}} * 100\% = \frac{25}{40} * 100\%$$

$$= 62.5\%.$$

$$P_D(\text{each}) = \frac{40-25}{2} = 7.5\ W.$$

2]



$$i_{LP} = \frac{V_{oP}}{R_c} = \frac{20}{8}$$

$$= 2.5\ A.$$

3] when $V_{oP} = V_{iP} = V_{cc} = 25\ V.$

Communication Electronics Sheet 1

Q1: A crystal oscillator has the following parameters:
$L_s = 0.33H$, $C_s = 0.065 pF$, $C_p = 1 PF$, $R_s = 5 K\Omega$

i) Calculate f_s, f_p and selectivity Q.

ii) Derive an expression for f_p interms of f_s, C_p & C_s.

Q2: Does the oscillator shown work?
If yes calculate f_o.
If No modify the cct. to operate as an oscillator and Calculate f_o.
Sketch $V_o(t)$

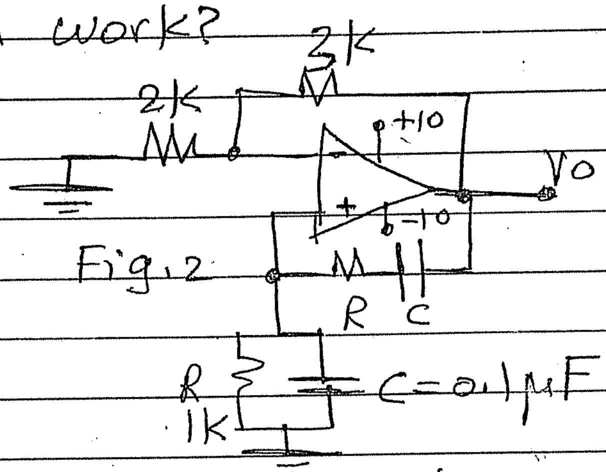


Fig. 2

Q3: Name the oscillator shown in Fig. 3 & Calculate the freq. of oscillation and the minimum value for R_D required for oscillation. Assume the JFET is biased such that $g_m = 2 mA/V$.

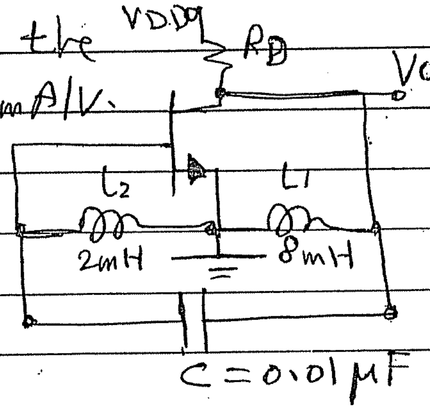


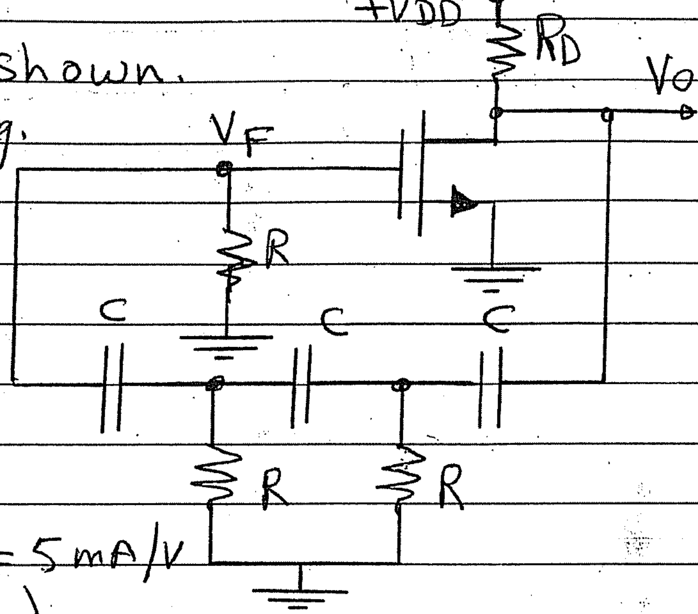
Fig. 3

Q4: Design a Colpitts Oscillator to have $f_o = 50KHz$. Use an op-Amp. with $V_{cc} = \mp 20V$. The gain of the Amplifier must be 10. The available inductor $L = 0.1 mH$. Draw the circuit diagram, Calculate all the required Components value and draw $V_o(t)$.

Q5: For the oscillator cct. shown.

$|B| = \frac{V_F}{V_o} = \frac{1}{29}$ at a freq.

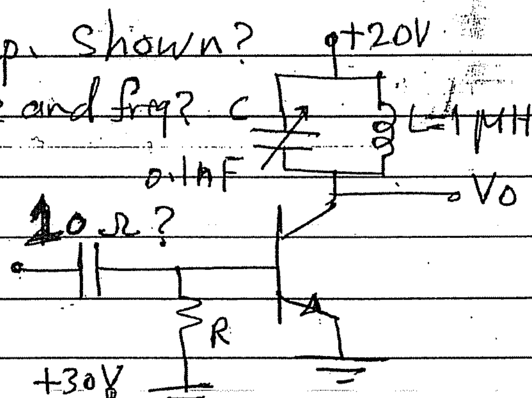
of $f_o = \frac{1}{2\pi\sqrt{6}\,RC}$



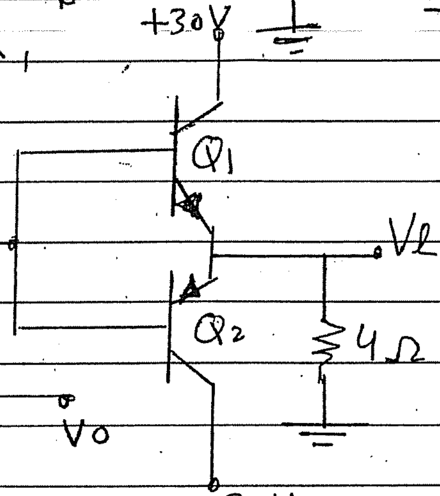
*) Design the cct. to oscillate at 20KHZ (Choose $C = 0.01\,\mu F$) and knowing that $g_m = 5\,mA/V$ (Hence determine R & R_D).

Q6: Name the class of the power Amp. shown?

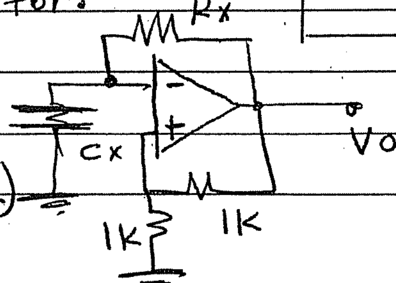
- Draw Vo(t) indicating Amplitude and freq?
- Calculate $P_{o(max)}$ when the total A.C resistance of the tuned cct. is $10\,\Omega$?



Q7: For the Complementary class-B push power Amplifier shown, the input is $V_i = 20\sin\omega t$ (V) Calculate P_L, $P_{i(D.C)}$, $\eta\%$ and power dissipated in each transistor.



Q8) Calculate fo and draw Vo(t) ($C_x = 10\,nF$, $R_x = 1K$)

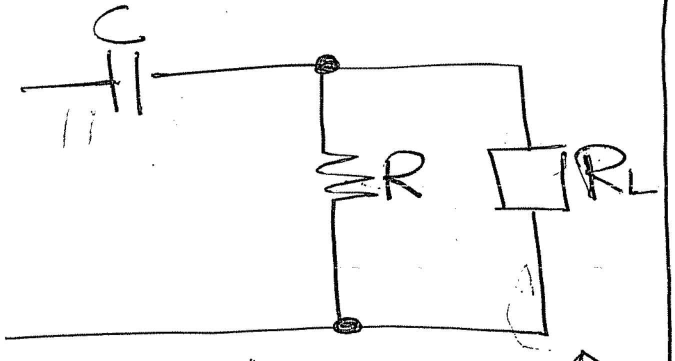


Filters :-

Selective cct.s allow certain bands of freq. to pass and reject other bands. It contain freq. dependant elements (C, L and R). In general filters are classified as: (hard ware)

- Passive filters (R, C, L)
- Active filters (R, C, L) + Active element (BJT, FET, OP-Amp)

Passive filter	Active filter
No gain	Certain gain
No power consumption	DC sources are required (power consumption)
Suffer from loading effect	No loading effect.



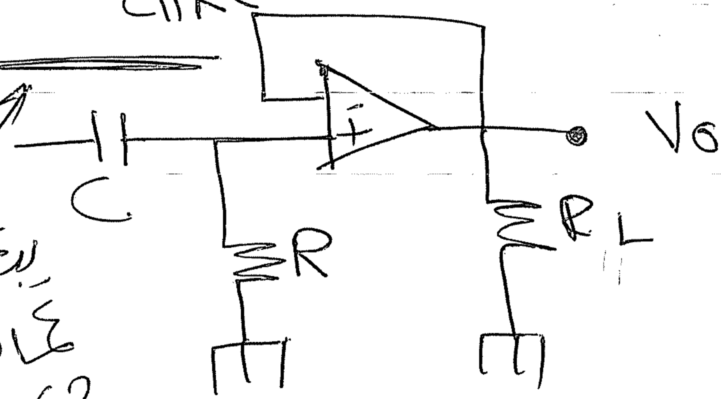
$$f_c = \frac{1}{2\pi RC}$$

بعد اضافة الـ load

$$f_c = \frac{1}{2\pi R_{eq} C} \quad \#$$

$R_{eq} = (R \parallel R_L)$

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



يبقى كأنها هو حتى بعد ما أشيل الـ R_L

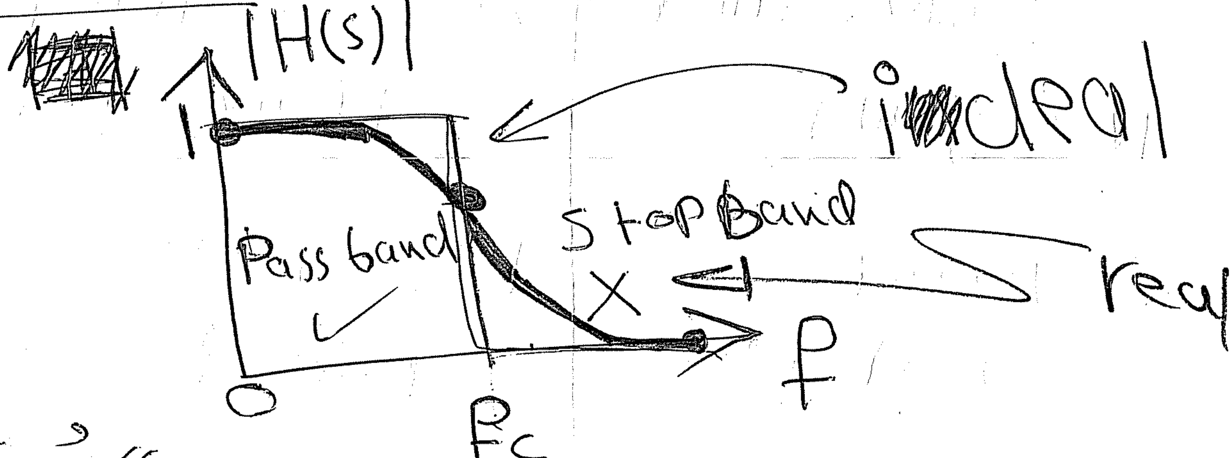
$R_i = \infty$

$R_i \parallel R = R$

يبقى كأنها هو

According to freq. band, Filters are Classified in to :-

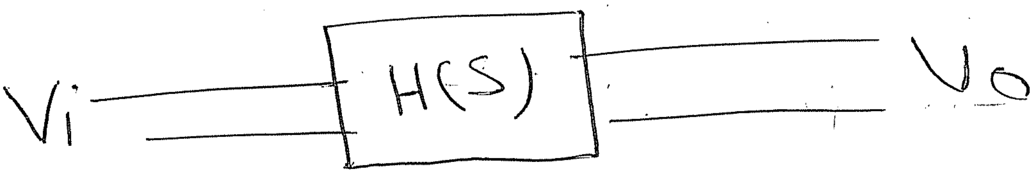
(1) Low pass-filter (LPF) :-



$f_c \Downarrow$ مثلاً 3KHz

عادةً بستخدم

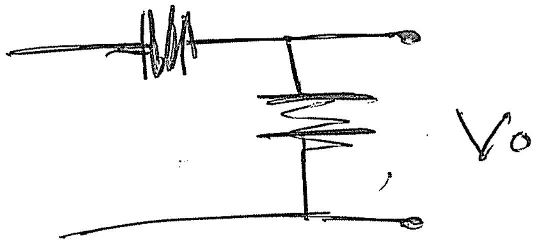
Receiver في الـ detector وما بعد الـ

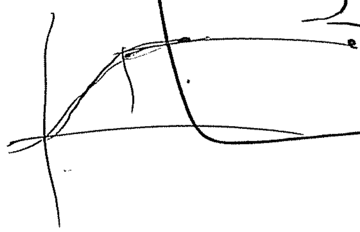


$$H(S) = \frac{V_o}{V_i}$$

قيمة ال inductor عالية
وبالتالي يحتاج size كبير

passive LPF :-





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

$f = 0 \rightarrow X_c = \infty$
$V_o = V_i$
$f = \infty \rightarrow X_c = 0$

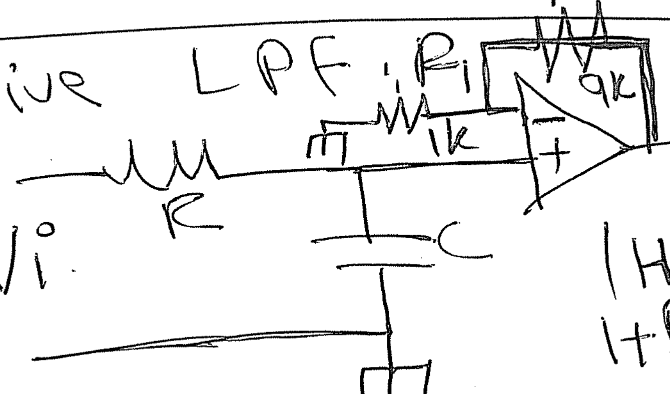
$$\frac{V_o}{V_i} = \frac{X_c}{X_c + R} = \frac{1}{1 + \frac{R}{X_c}}$$

$f = 0 \rightarrow \frac{V_o}{V_i} = 1$

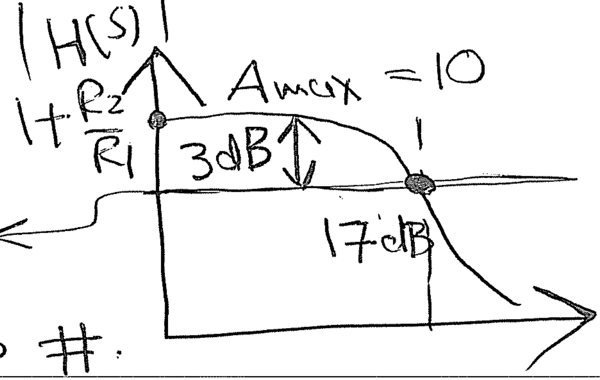
$f = \infty \rightarrow \frac{V_o}{V_i} = 0$

$$X_c = \frac{1}{2\pi f C}$$

Active LPF :



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



$$\frac{10}{\sqrt{2}} = \frac{A_{max}}{\sqrt{2}}$$

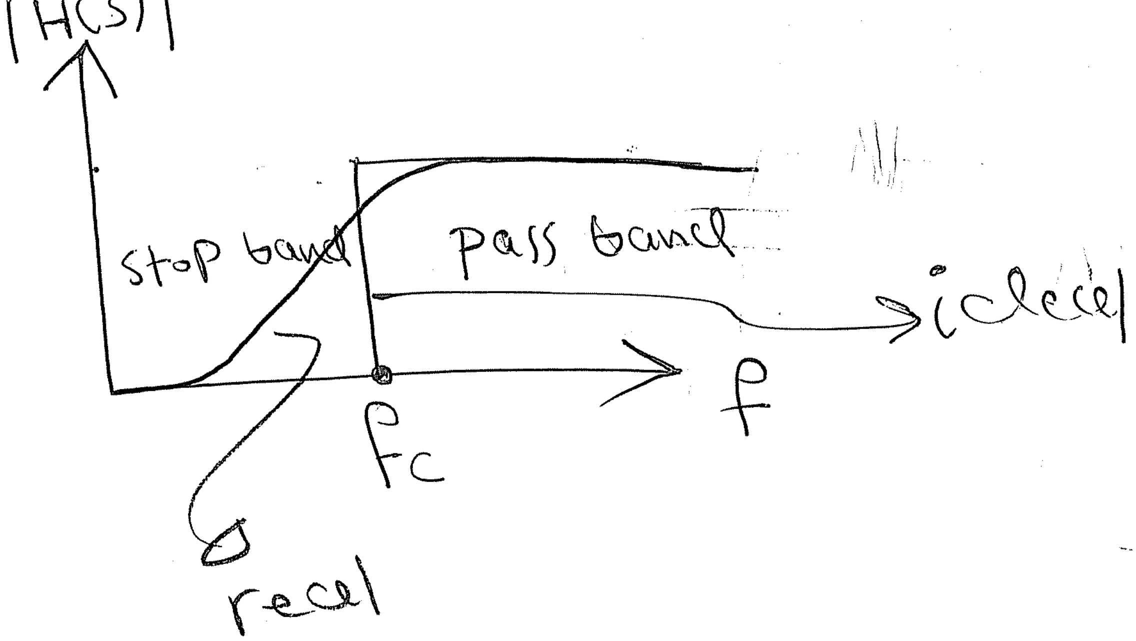
$$A(dB) = 20 \log A \sqrt{2}$$
$$= 20 \log 10 = 20 dB \ \#$$

$R_1 , R_2 \rightarrow$ ليس لها علاقة بـ

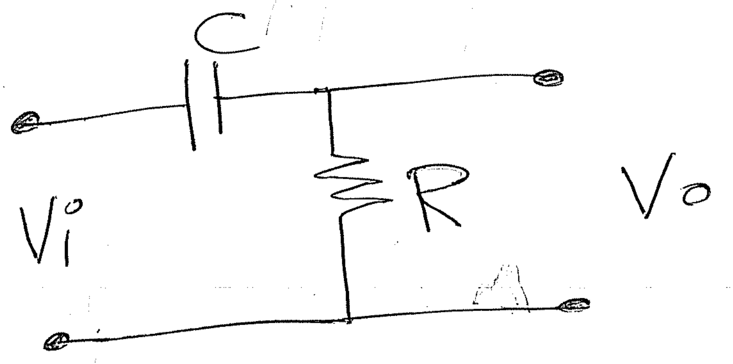
تحديد f_c .

$C , R \rightarrow f_c$ هي اللي تحدد

② High-pass Filter (HPF) :-



Passive:-



$$\frac{V_o}{V_i} = \frac{R}{R + \frac{1}{j\omega C}}$$

$$= \frac{1}{1 + \frac{1}{j\omega CR}}$$

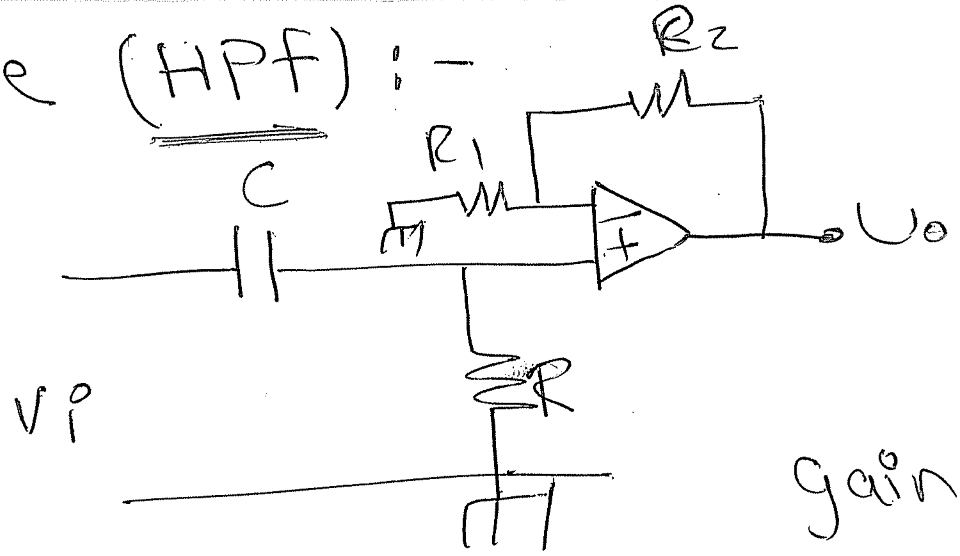
$\omega = 0 \rightarrow \frac{V_o}{V_i} = 0$

$V_o = 0$

$\omega = \infty \rightarrow \frac{V_o}{V_i} = 1 \rightarrow V_o = V_i$

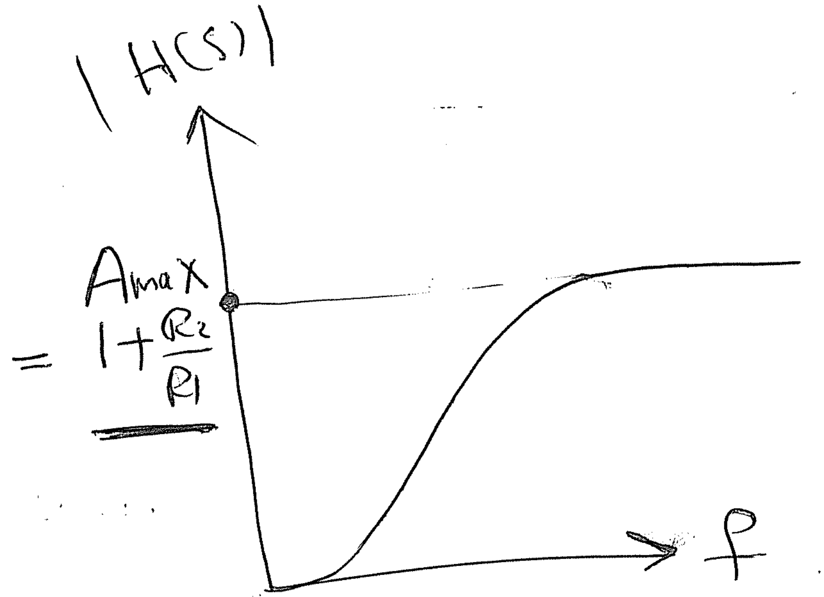
$$f_c = \frac{1}{2\pi RC}$$

active (HPF) :-



$$gain = 1 + \frac{R_2}{R_1}$$

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



Example:- ① Design a HPF to give a gain of 40 dB and cutoff freq. of 100 KHz.

② Sketch Bode Plote of this filter.

$$A(dB) = 20 \log \frac{V_o}{V_i}$$

$$40 = 20 \log \frac{V_o}{V_i}$$

$$\frac{V_o}{V_i} = 10^{40/20} = 100 \ \#$$

$$A = 1 + \frac{R_2}{R_1} = 100$$

$$\frac{R_2}{R_1} = 99$$

let $R_1 = 1k\Omega$, $\therefore R_2 = 99k\Omega$

$$f_c = \frac{1}{2\pi RC}$$ let $C = 1$[illegible] nF.

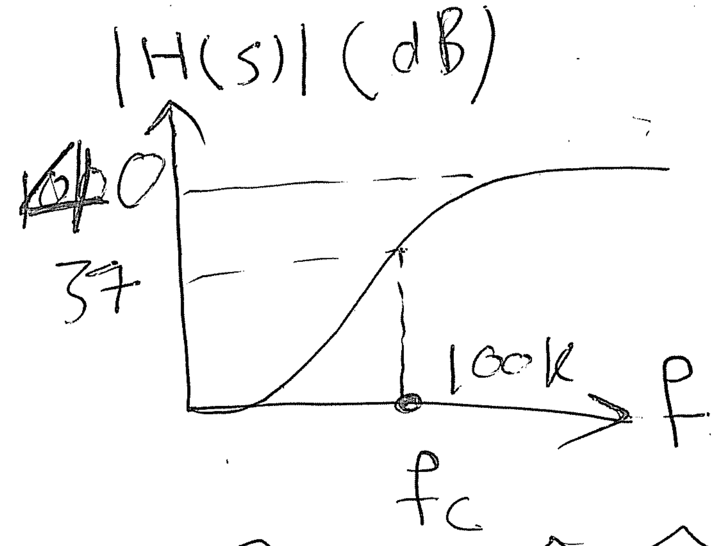
$$R = \frac{1}{2\pi * 10 * 10^{-9} * 10^5} = \frac{10^3}{2\pi}$$

$$\simeq 1.7 k\Omega.$$

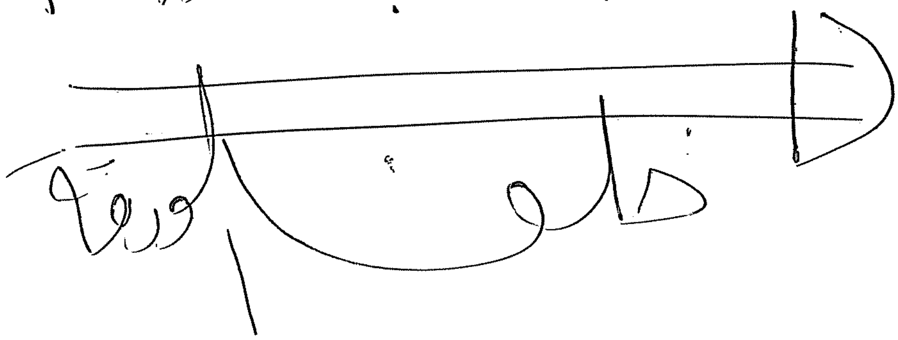
من الأفضل R تكون معدلة

بالـ design ← ($k\Omega$) #

6



③ Band pass filter (BPF):-



filter order:-

① C ضرب C تجي مثل 1

$$H(S) = \frac{N(S)}{D(S)} = \frac{3}{s+1} \quad \text{, } 1^{st} \text{ order LPF}$$

$$= \frac{s^2}{s^2+s+1} \quad \text{, } 2^{nd} \text{ order HPF}$$

(2C)

$$= \frac{2s}{s^3+s^2+s+1} \quad \text{, } 3^{rd} \text{ order BPF}$$

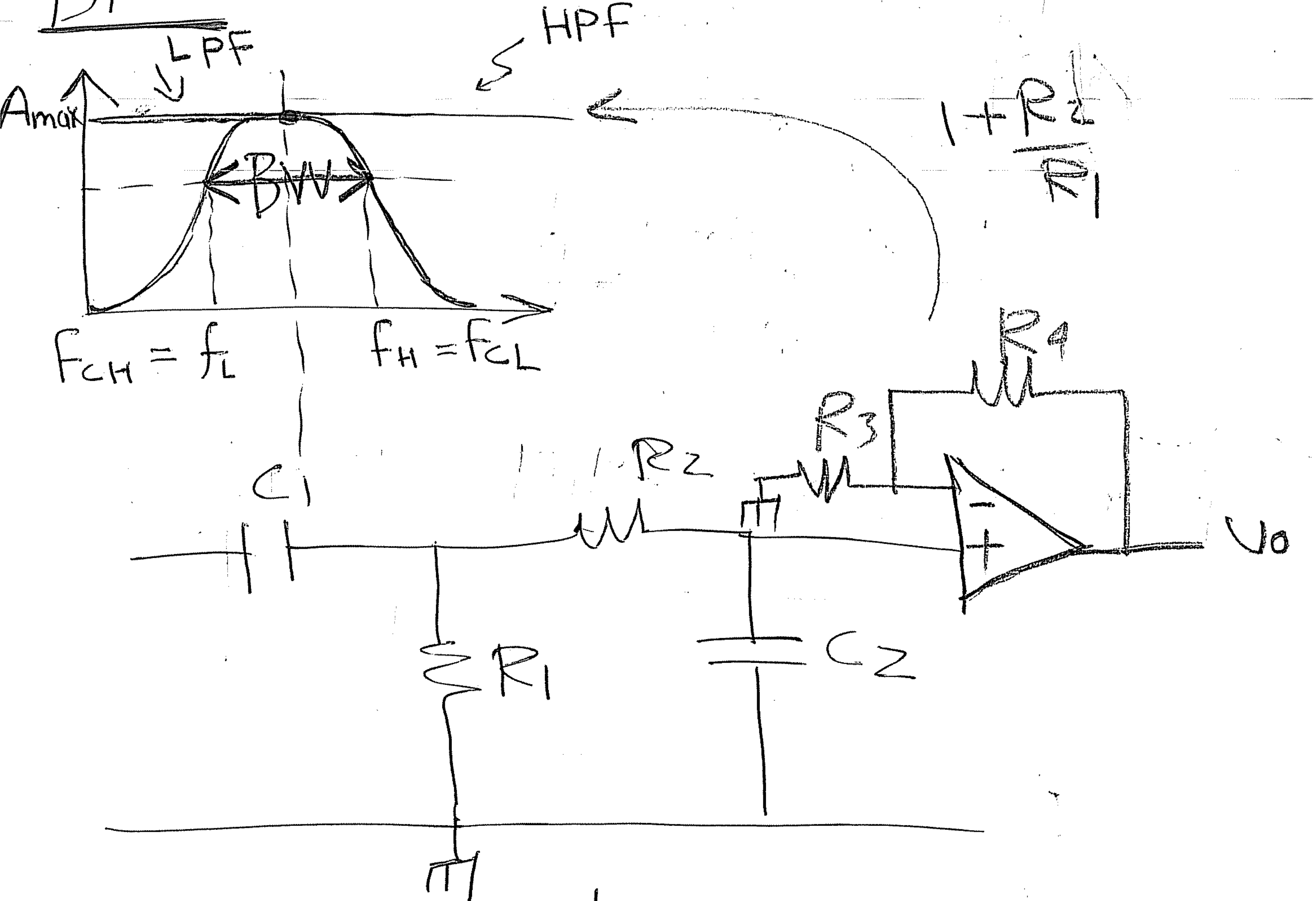
(3C)

$N(S)$ → Type of filter. (LPF, HPF, BPF, BS)

$D(S)$ → order of filter. (عدد C)

$N(S)$ → constant : LPF (No s)
→ s : BPF
→ s^2 : HPF

BPF :-



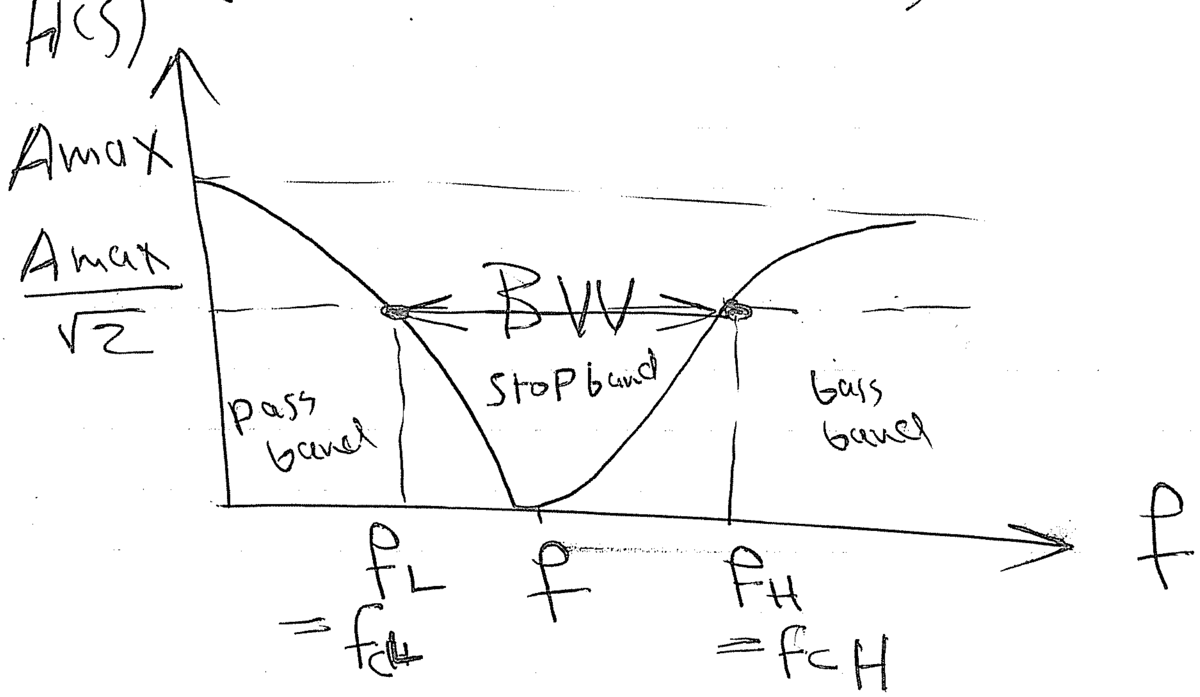
$$f_{CL} = \frac{1}{2\pi R_2 C_2}$$

$$f_{CH} = \frac{1}{2\pi R_1 C_1}$$

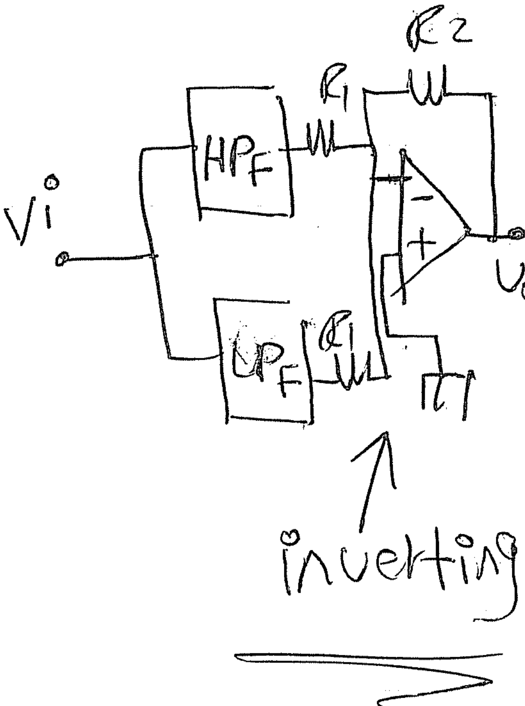
$f_{CL} > f_{CH}$ ⟸ to obtain band pass filter.

#.

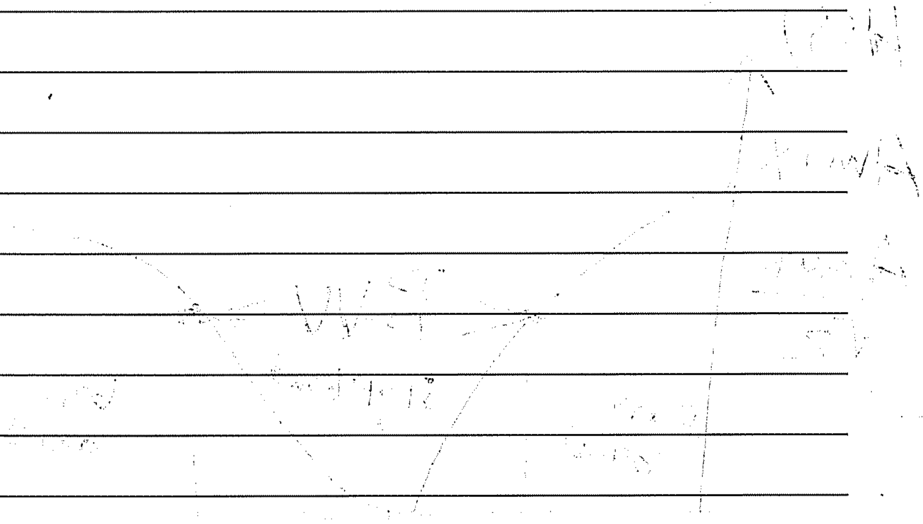
④ Band stop filter :- (BSF)
(Band Reject) (BRF)
(notch filter) (NOTCh).

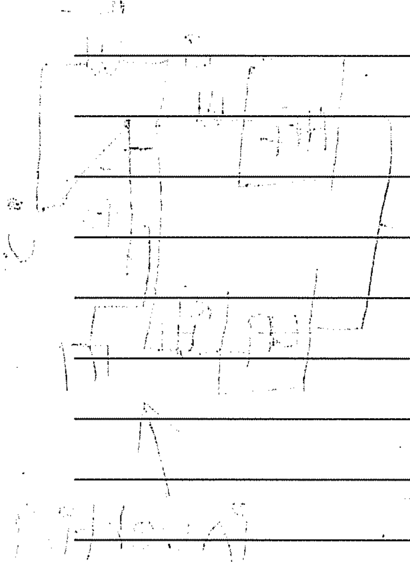


$f_{cLP} < f_{cHP}$



#





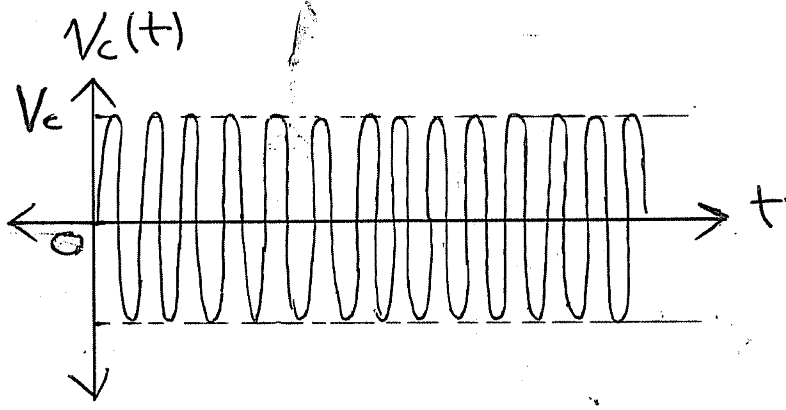
<u>Modulation</u> : Changing Certain Characteristics of Carrier Signal according to amplitude of modulating Signal.

FM mod. : Changing freq. carrier according to Amp. of modulating Signal.

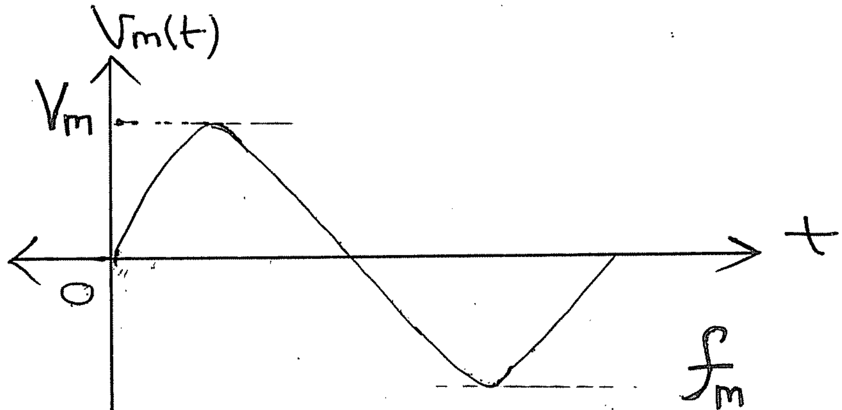
PM mod. : Changing the phase of carrier according to Amp. of modulating Signal.

<u>AM</u> :-

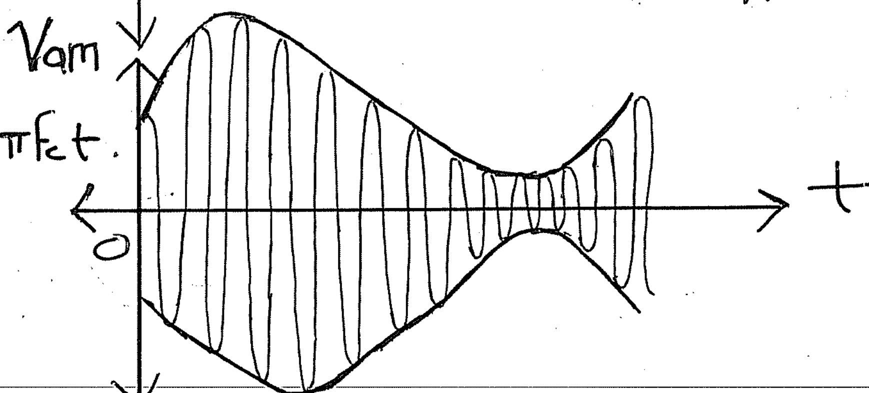
$V_c(t) = V_c \sin 2\pi f_c t$



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



$V_{am} =$
$(V_c + V_m \sin 2\pi f_m t) \sin 2\pi f_c t.$



$$m = \frac{V_m}{V_c} \longrightarrow V_m = m V_c$$

m : is mod. index.

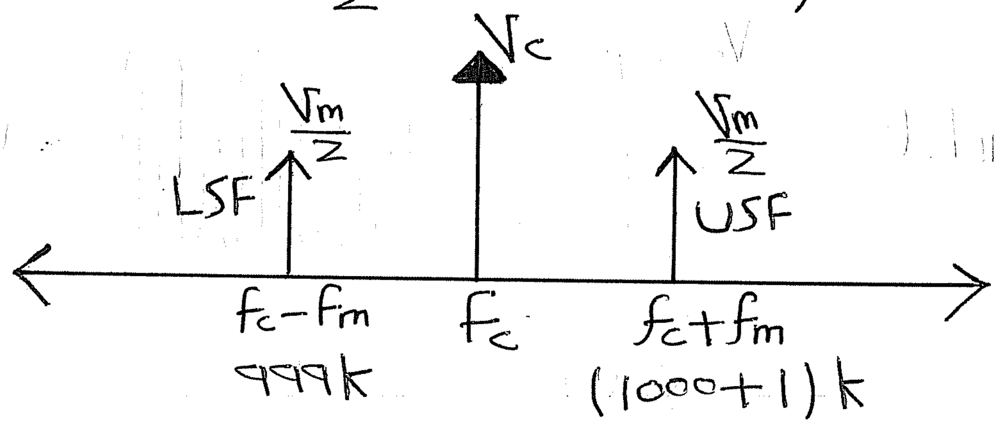
$$V_{am}(t) = V_c(1 + m \sin 2\pi f_m t) \sin 2\pi f_c t$$

$$V_{am}(t) = 5(1 + 0.8 \sin 2\pi * 10^3 t) \sin 2\pi * 10^6 t$$

$V_c = 5V$, $m = 0.8$, $V_m = 4V$, $F_m = 10^3 Hz$, $F_c = 10^6 Hz$

In Freq. domain:

$$V_{am}(f) = V_c \sin 2\pi f_c t + \frac{V_m}{2} \cos(f_c - f_m) - \frac{V_m}{2} \cos(f_c + f_m).$$

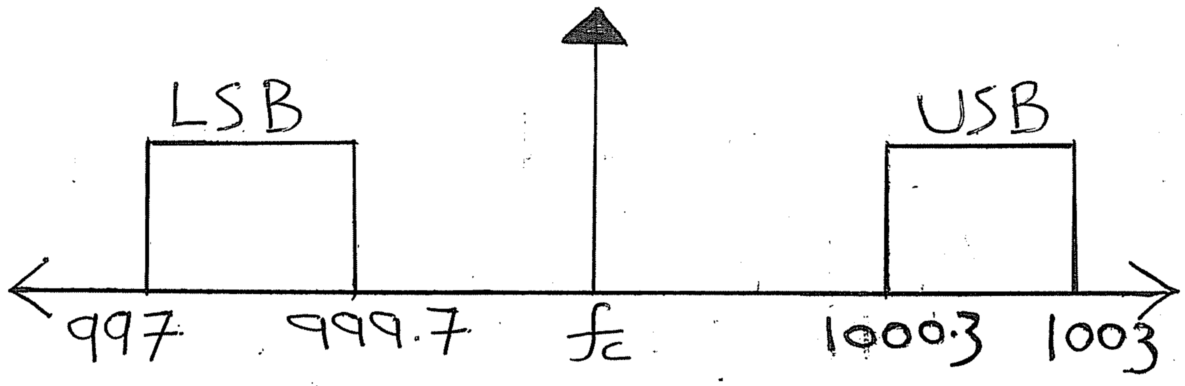


When $m = 1 \rightarrow V_c = V_m \rightarrow 100\%$ AM modulation.

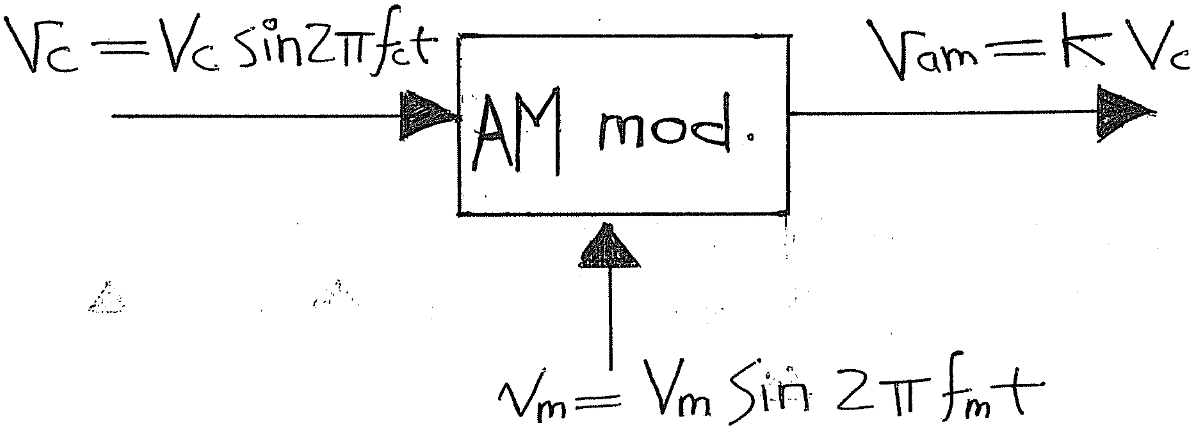
note: if the modulating Signal (V_m) has a Single freq. : (upper side freq., Lower side freq.)

$$(BW)_{am} = USF - LSF = F_c + f_m - (f_c - f_m)$$
$$= 2f_m$$
$$= 2K$$

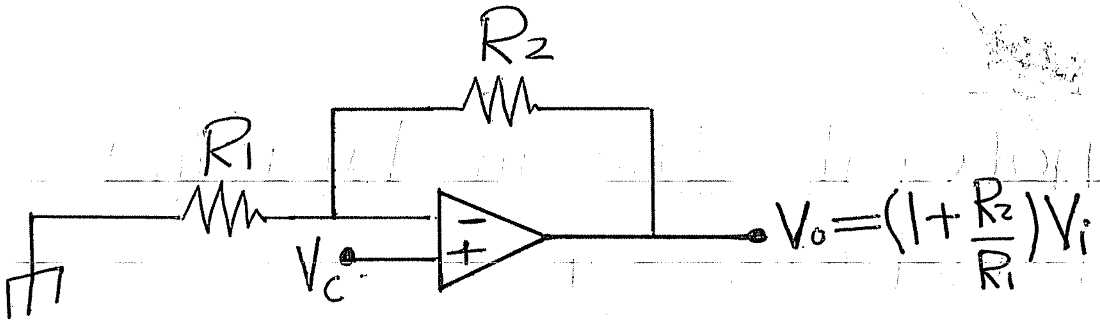
note: if the modulating Signal (V_m) has band (0.3−3)k
Voice

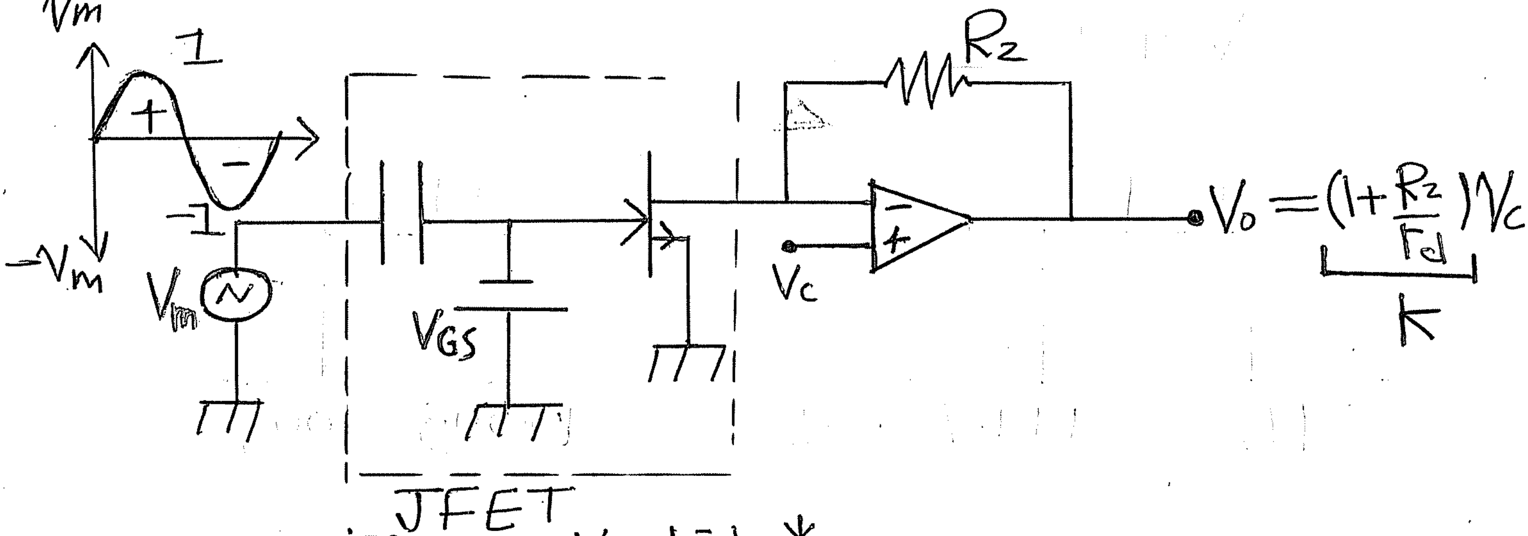


f_m: max. freq. of modulating Signal.



K : must be a factor depends on Amp. of V_m.





* يحتاج V_{GS} حتى يشتغل.

$$r_d = \frac{1}{1 - \frac{V_{GS}}{V_P}} \quad , \quad V_{GS} = V_{GS} + v_{gs}$$

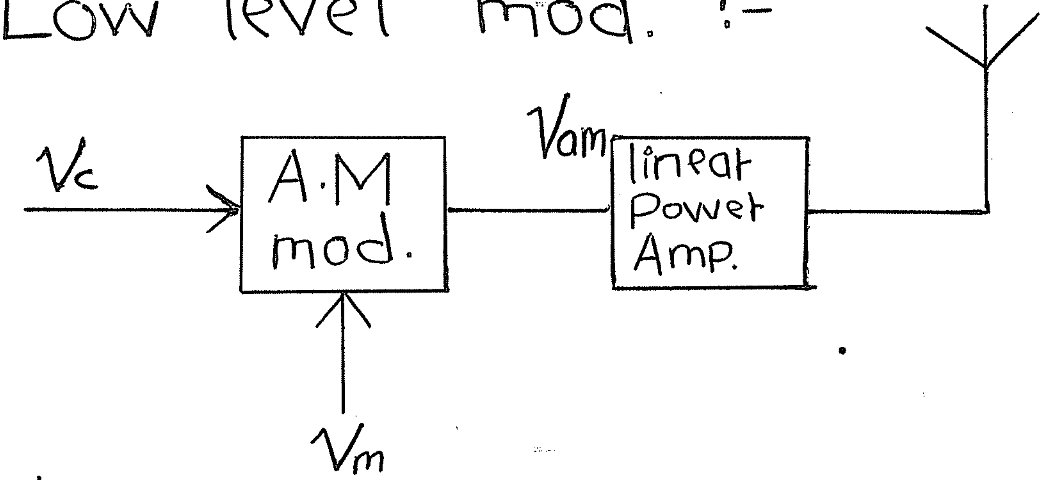
1) When V_m increase (During +ve H.C of V_m), $V_{GS} = V_{GS}^{DC} + v_{gs}^{AC}$, $r_d \downarrow$, So $K \uparrow$, $V_o \uparrow$, i.e Amp. of $V_c \uparrow$.

2) When V_m decrease (During -ve H.C), $r_d \uparrow$, So $K \downarrow$, $V_o \downarrow$, i.e Amp of $V_c \downarrow$.

In General, the Amp. of Carrier will be $\downarrow$ or $\uparrow$ according to Amp. of mod. signal. This process is AM generation.

AM modulators :-

1) Low level mod. :-



2) High level mod. :-

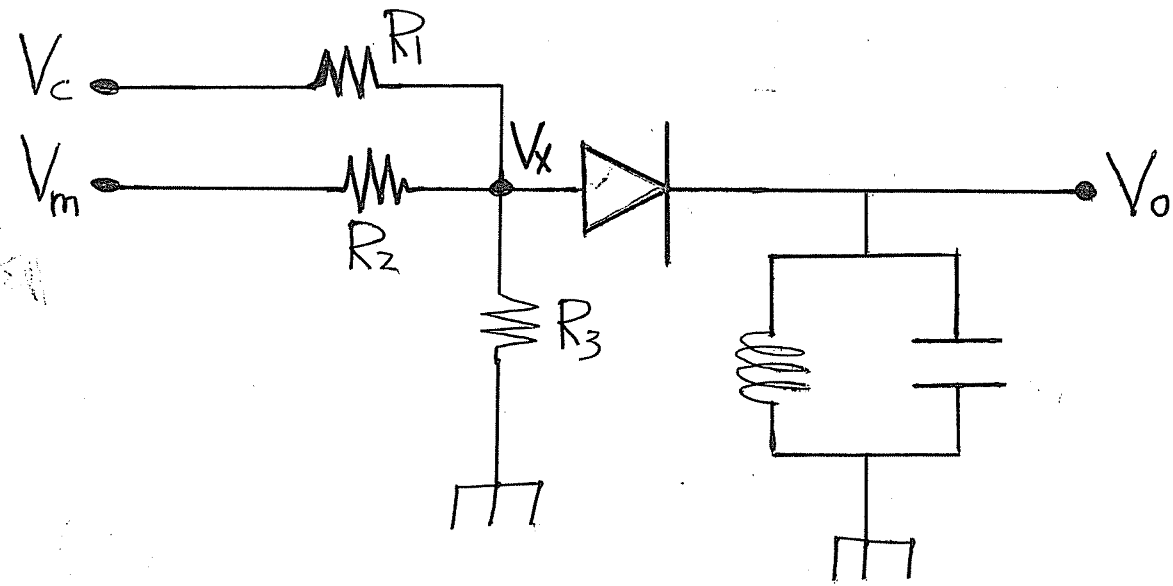
No Need for linear Power Amp. (The mod is achived Amp. at Class-C R.F Power Amp.).

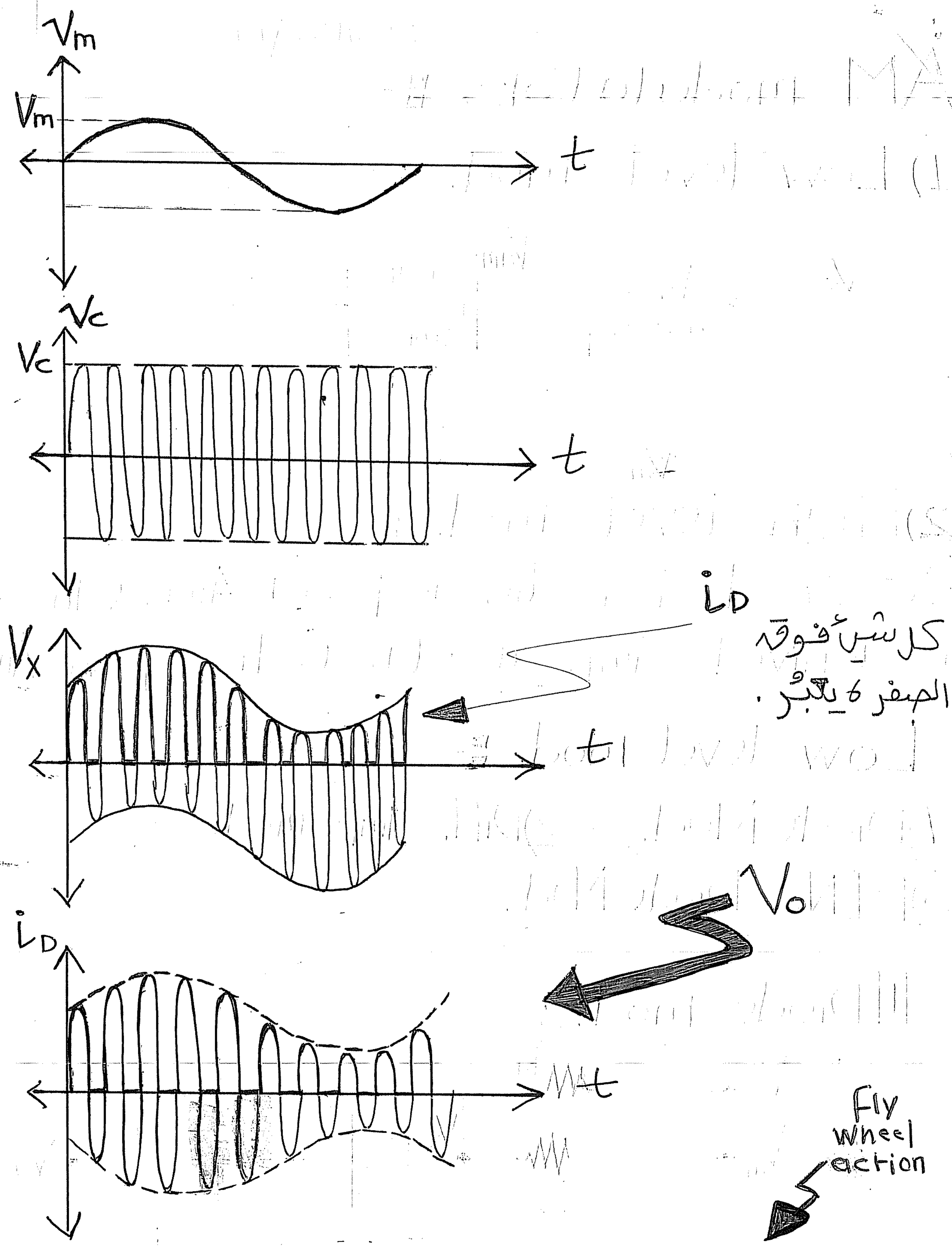
Low level mod. :-

1) Diode Mod. 2) Diff. -Amp. mod.

3) PIN -Diode Mod.

1 Diode mod. :-





إذا مرّ تيار بـ Parallel tuned cct. فإنها ستردّ عليه بـ V مساوية لها في المقدار وبعكس الاتجاه.

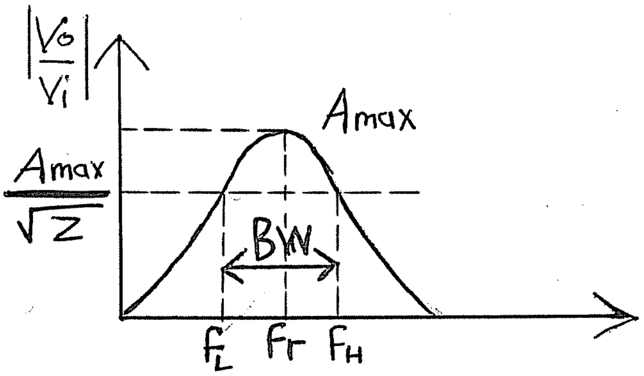
(كل pulse يرد على pulse)

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

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

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

Response of LC CCt. :-



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

$$B.W = \frac{f_r}{Q}$$ → بحيث تشمل ال lower و ال upper .

نختار Q بحيث $(BW > 2F_m)$.

1) The Composit signal $V_x = V_c + V_m$ will be applied to diode, i_D will be a Half-Cycle pulse which excited the tuned CCt..

2) Due to fly wheel effect in LC CCt. each pulse of i_D will produce a −Ve pulse of amplitude proportional to Amp. of i_D.

3) The o/p will be an AM Signal.

4) The tuned CCt. must be designed such that $f_r = f_c$ and a Selectivity $Q = \frac{f_r}{B.W}$ such that B.W ≥ B.W of AM Signal ($2f_m$).

← هنه الدارة لاتعطي (gain) [diodes لا يعطي gain].

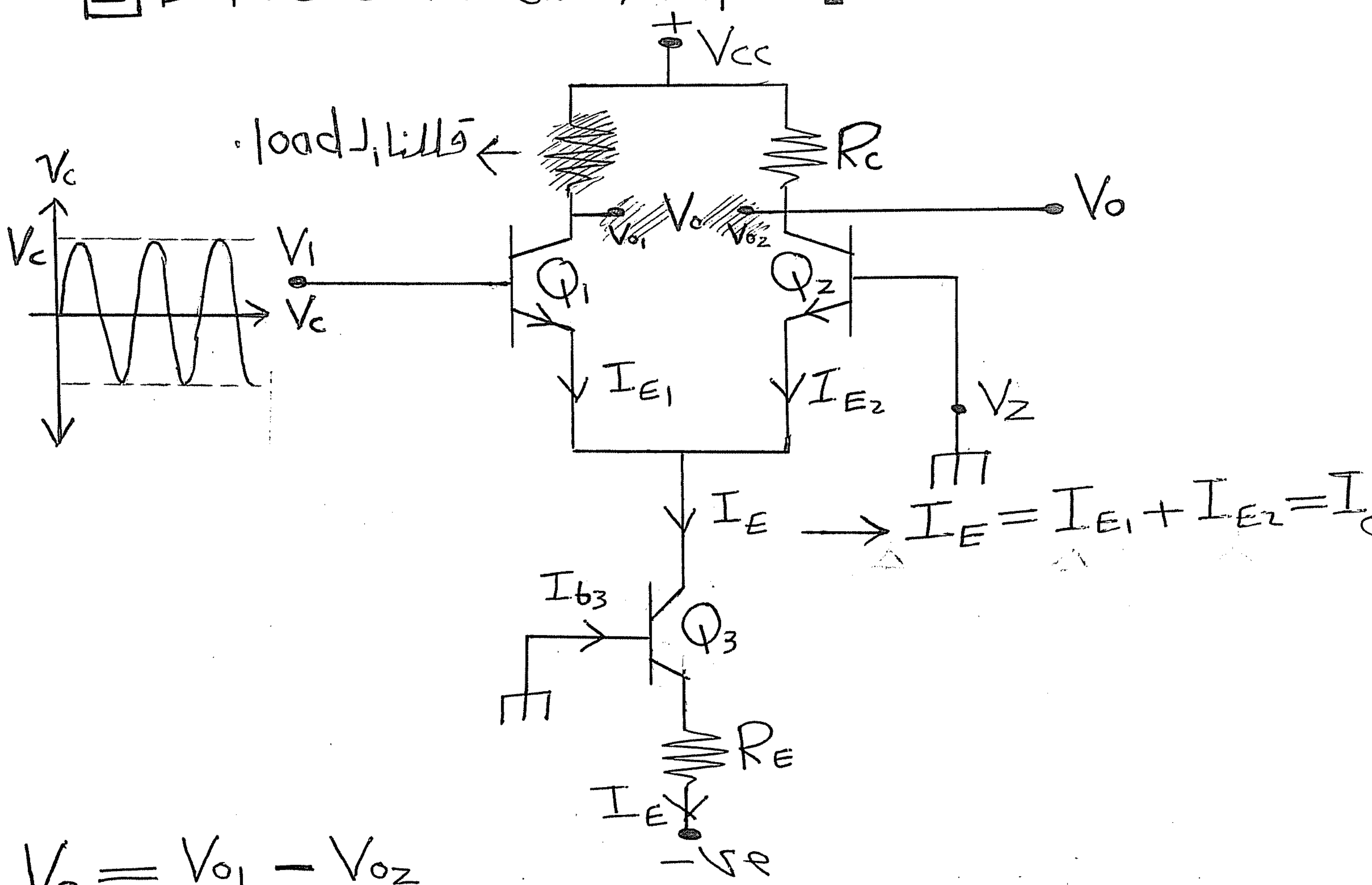
* in generation of AM using Diode mod.:

−Ve cycle المسؤول عنها هي

Parallel tuned CCt.

وبخاصية fly wheel effect.

[2] Differential Amp. :-



$V_o = V_{o1} - V_{o2}$

$= A \cdot (V_2 - V_1)$, A = diff gain.

Q_1, Q_2 : diff. pair. Q_3 : Const. Current Source.

$V_{o2} = -V_{o1}$

for $V_2 = 0$:

$V_o = -AV_1$: * إذا أخذنا ال o/p من V_{o1} .

So, $V_o = V_{o2} = AV_1$: * إذا أخذنا ال o/p من V_{o2} .

$A = \frac{I_E \cdot R_c}{K}$, $0 < K < 300$.

When $V_1 = V_c$:-

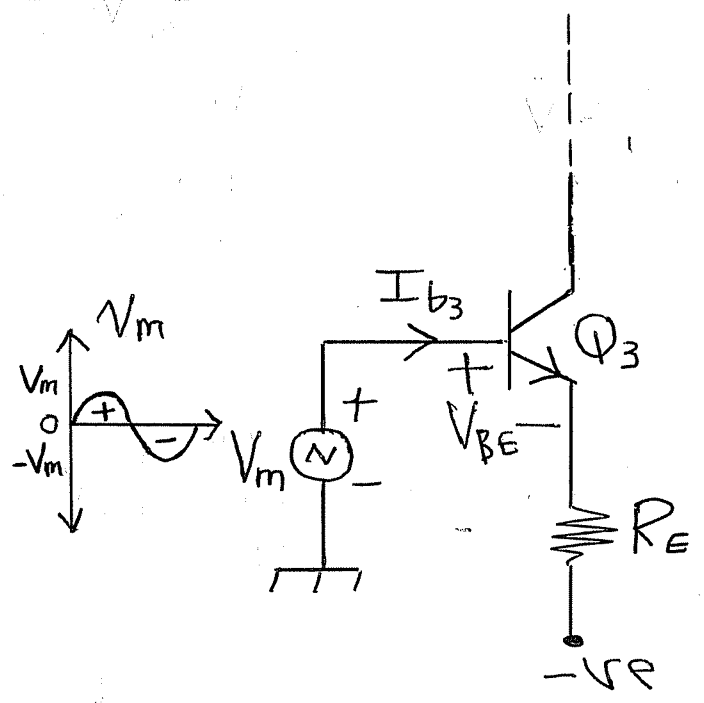
$V_o = A \cdot V_c$

↑ بدي أخليه يعتمد على ال modulating signal

$$I_E = \frac{V - V_{BE}}{R_E}$$ ... من الرسمة الأصلية

+ve H.C :

$$I_E = \frac{V_m + V - V_{BE}}{R_E}$$



$I_E \uparrow$, $A \uparrow$, $V_o \uparrow$.

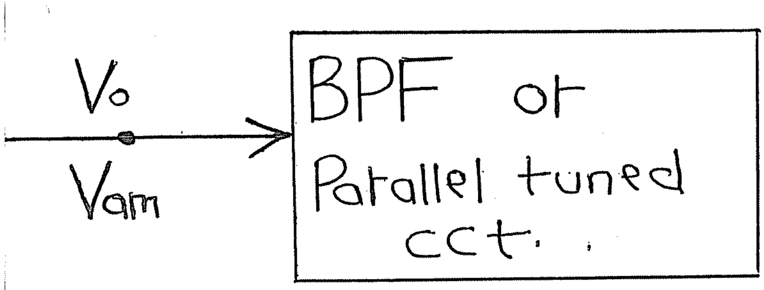
-ve H.C :

$$I_E = \frac{V - V_m - V_{BE}}{R_E}$$

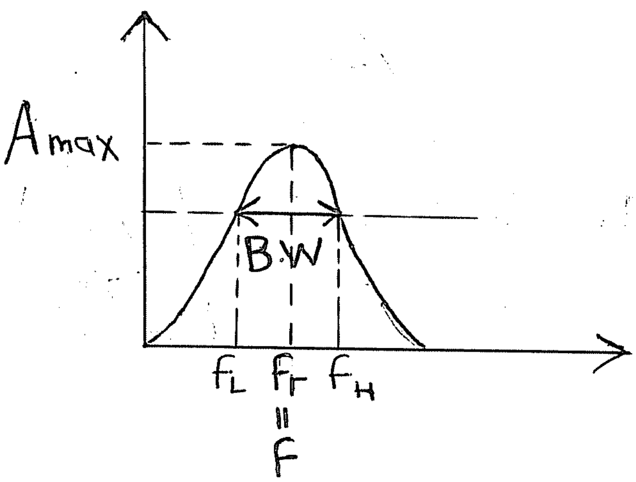
$I_E \downarrow$, $A \downarrow$, $V_o \downarrow$.

1) When V_m increase , I_E increase , A increase , V_o increase . (Amp. of Carrier $\uparrow$).
2) when V_m decrease , I_E decrease , A decrease , V_o decrease . (Amp. of Carrier $\downarrow$).

i.e : Amp. of Carrier will increase and decrease according to Amp. of modulating Signal. i.e AM signal is generated.



Response for BPF, PTC :-



$$Q = \frac{f_r}{B \cdot W} = \frac{f_{center}}{B \cdot W}.$$

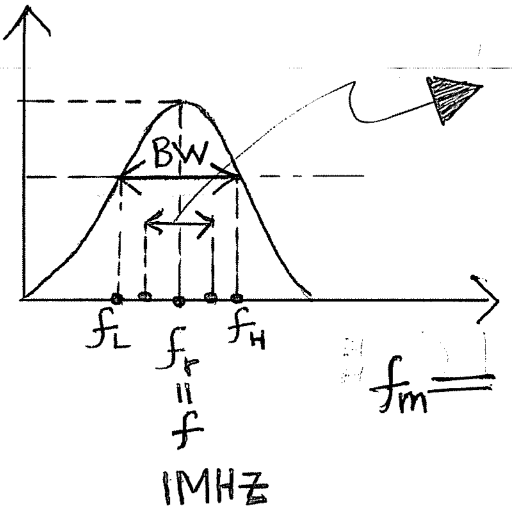
$\underbrace{\frac{f_r}{B \cdot W}}_{PTC}$ $\quad$ $\underbrace{\frac{f_{center}}{B \cdot W}}_{BPF}$

$$B \cdot W = \frac{f_r}{Q} \geq (B \cdot W)_{am}.$$

→ To be sure that Vam Contain USB and LSB and f_c then either a parallel LC cct. is used or BPF , and designed such that : $f_r = f_c$ (LC cct.).
$f_{cen} = f_c$ (BPF).

and Q such that :

$$\frac{f_c}{Q} \geq (BW)_{am}.$$



$$\frac{f_c}{Q} < (B.W)_{am}$$

$$O/P < BW$$

$$f_m = 1kHz$$

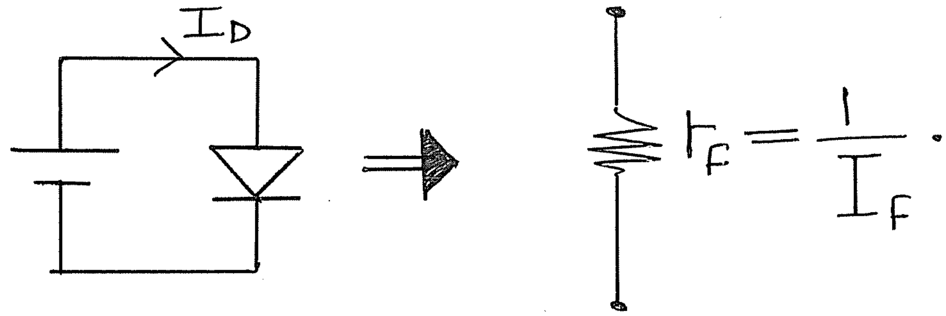
distortion of Sig.:
band Cutting / band Limitting

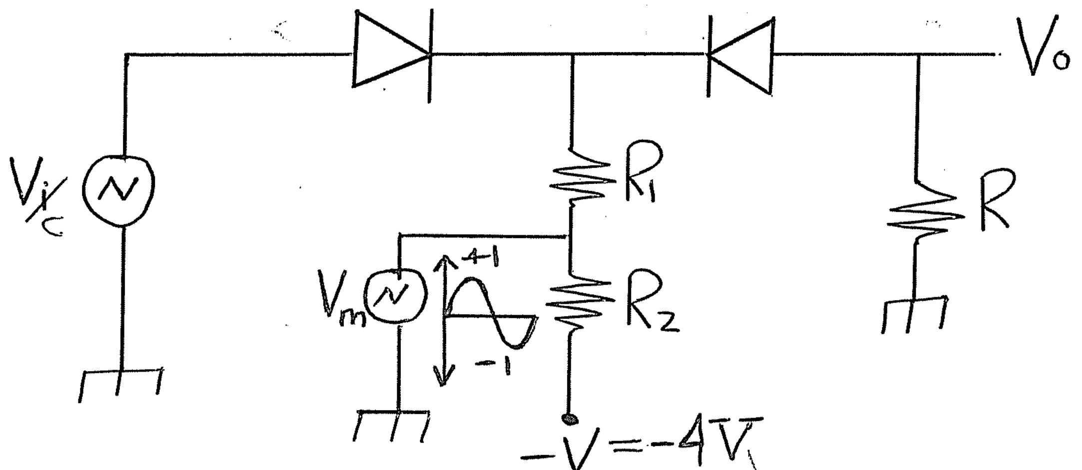
3 PIN-Diode mod. :-

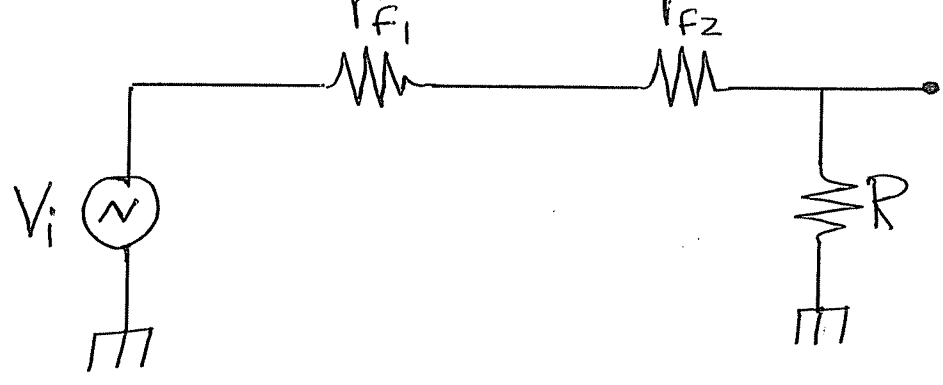
PIN diode : a special diode used at microwave freq. > 100 MHz.

It works as a resistanc in F.w biasing,

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







$$V_o = \frac{V_i R}{r_{F_1} + r_{F_2} + R} = \frac{V_c R}{r_{F_1} + r_{F_2} + R}$$

↑ without modulating Signal

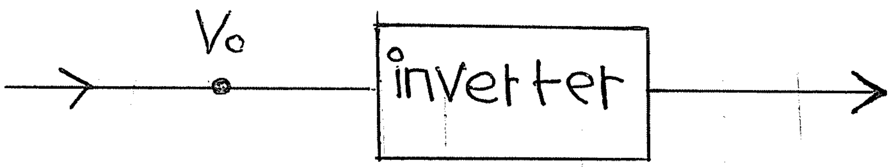
This modulator works based ON using PIN diode as variable resistance.

1) When V_m increase, $I_D \downarrow$, $r_f \uparrow$, and $V_o \downarrow$.

2) When V_m decrease, $I_D \uparrow$, $r_f \downarrow$, and $V_o \uparrow$.

i.e V_o increase and decrease according to modulating Signal.

note



* متى يصبح :

$V_m \uparrow$, $V_o \uparrow$

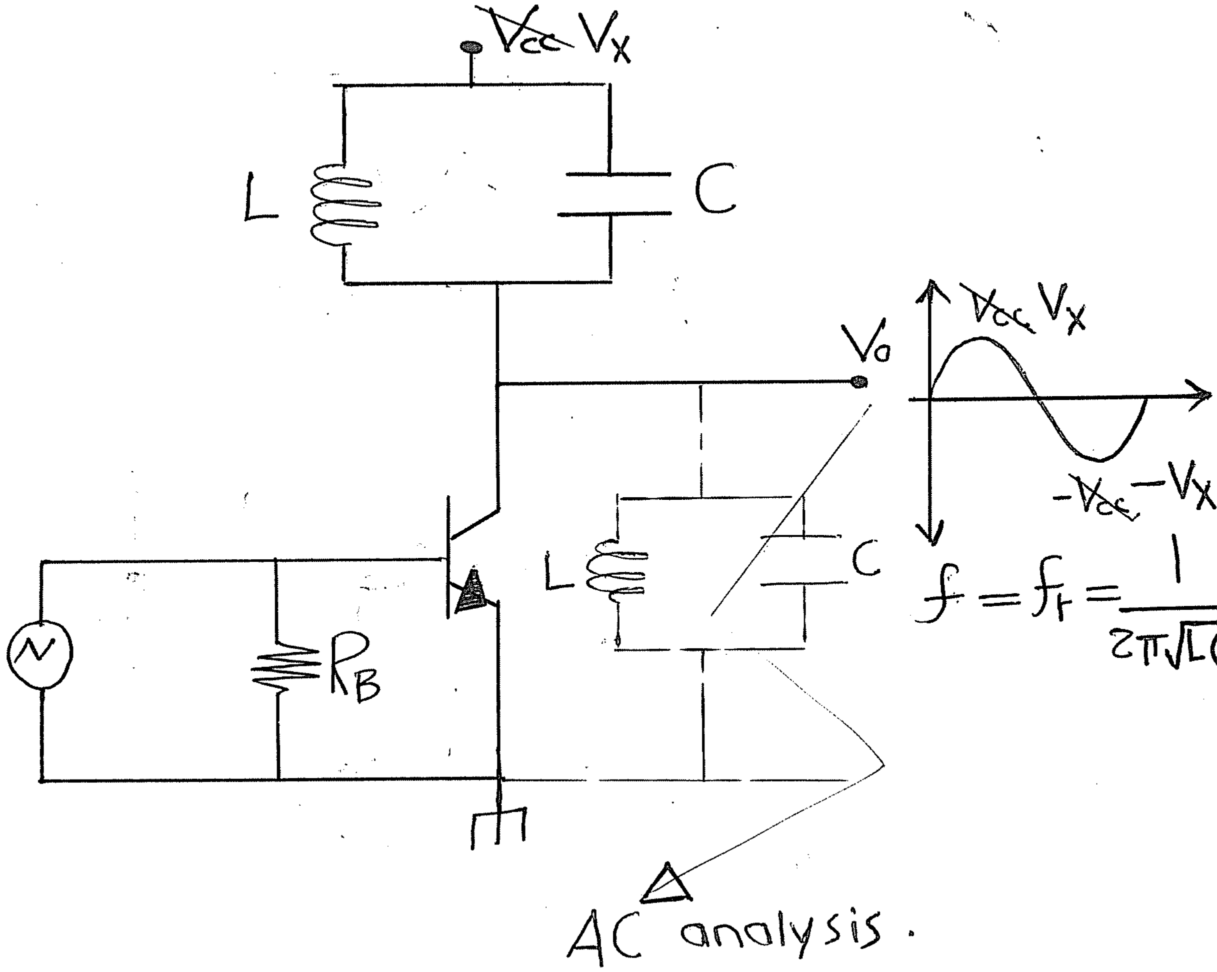
أو

$V_m \downarrow$, $V_o \downarrow$ # .

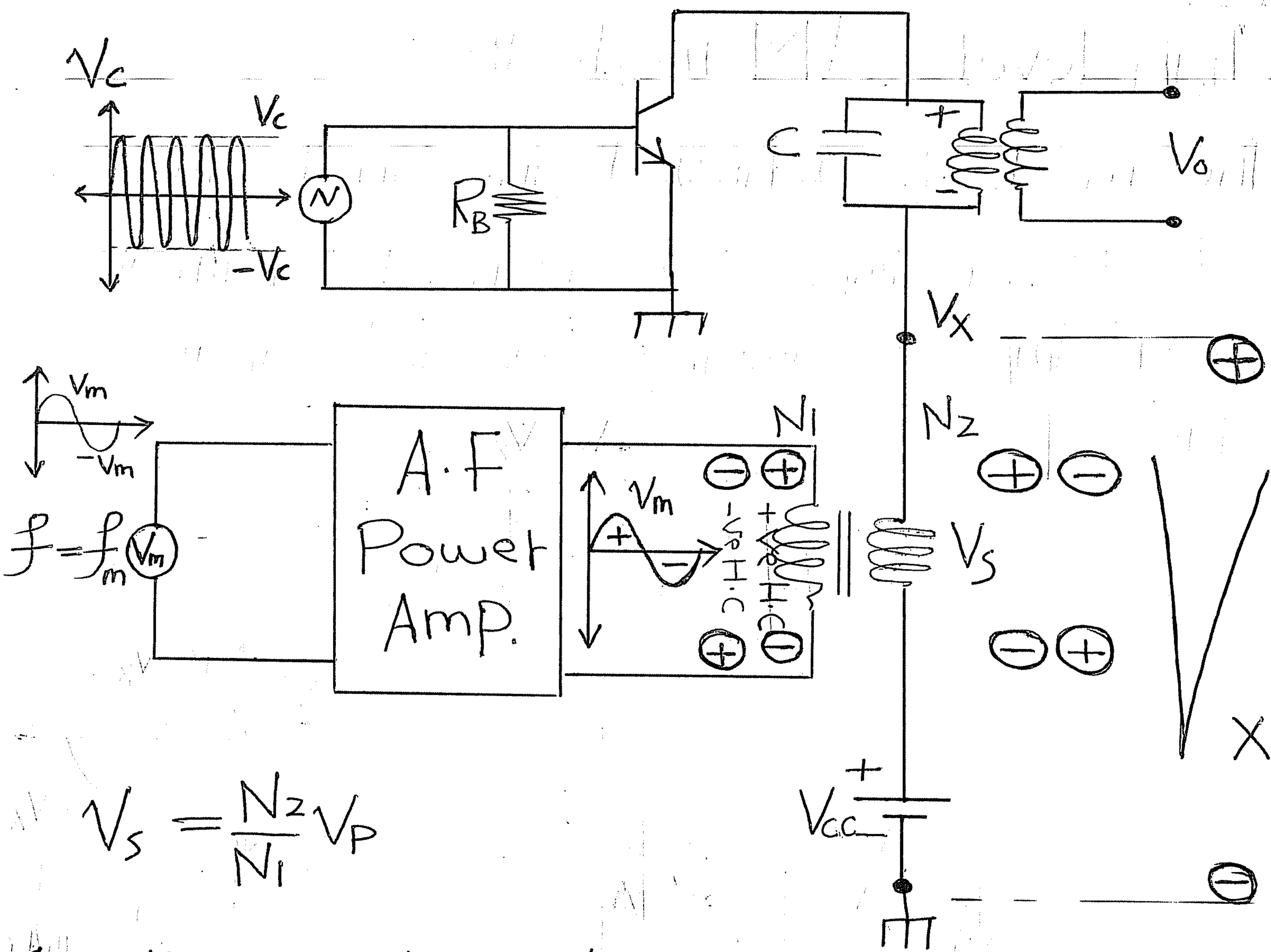
High level - AM mod. :-

The mod. is achieved in final Class-C R.F Power Amp. So no need for linear Power Amp. to amplify the AM Signal.

Class-C



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

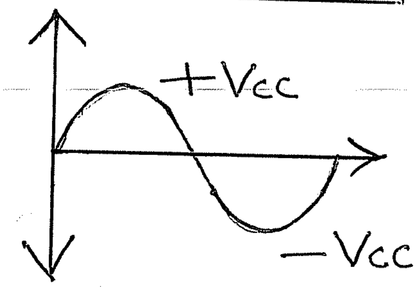


$$V_s = \frac{N_2}{N_1} V_P$$

1) without V_m ; $V_P = 0 \rightarrow V_s = 0$.

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

for $V_m = 0$, $V_s = 0$:- $\boxed{V_X = V_{CC}}$



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

2) During +ve H.C of V_m :

$$-V_{cc} - V_s + V_x = 0$$

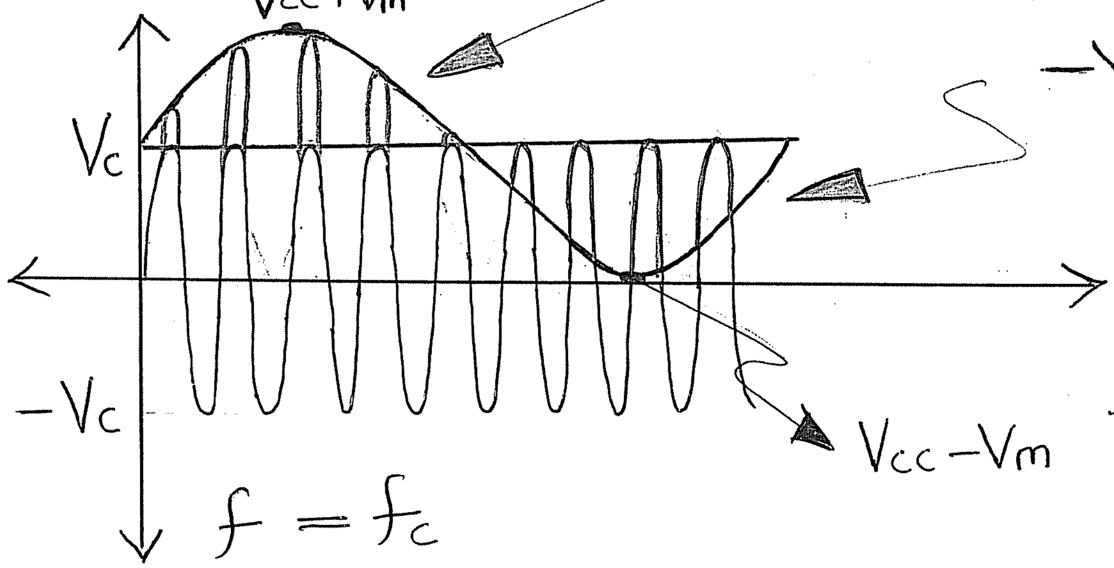
$$V_x = V_{cc} + V_s$$

$$V_s = \frac{N_2}{N_1} V_m \quad , \quad \text{for } \frac{N_2}{N_1} = 1 \; : \; V_s = V_m$$

$$\therefore V_x = V_{cc} + V_m \quad , \quad V_o \uparrow , V_m \uparrow$$

(V_{cc}: ثابت)

(V_x ↑: تزداد بزيادة V_m)



3) During -ve H.C of V_m ,

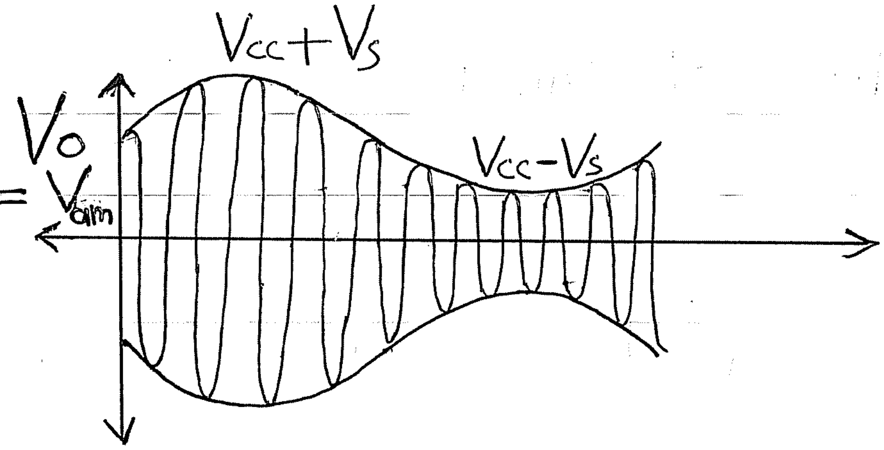
$$-V_{cc} + V_s + V_x = 0$$

$$V_x = V_{cc} - V_s \quad ,$$

$$V_s = \frac{N_2}{N_1} V_m \quad , \quad \frac{N_2}{N_1} = 1 \; : \; V_s = V_m$$

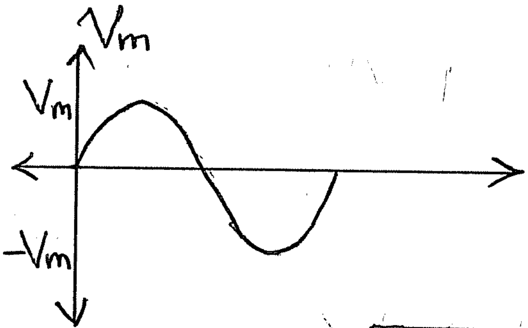
$$\therefore V_x = V_{cc} - V_m \quad , V_o \downarrow , V_m \downarrow$$

(V_x ↑: تقل بنقصان V_m)

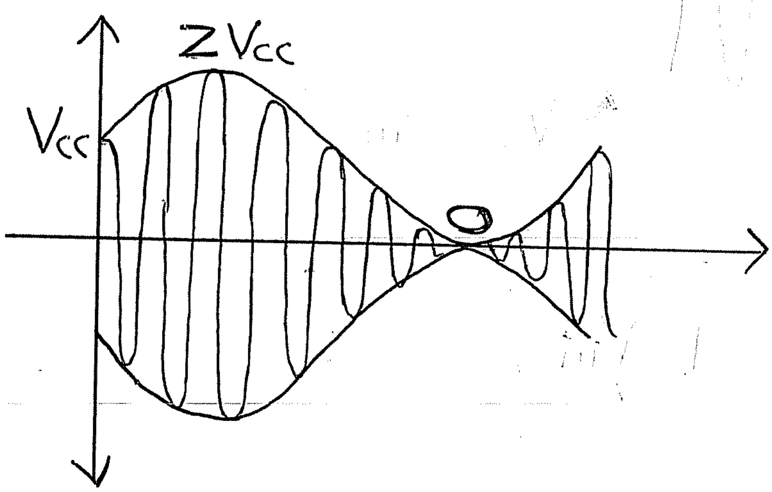


Where $V_s = \frac{N_2}{N_1} V_m$, for $\frac{N_2}{N_1} = 1$:

$V_s = V_m$



for 100% mod :- $\boxed{V_s = V_s = V_{cc}}$



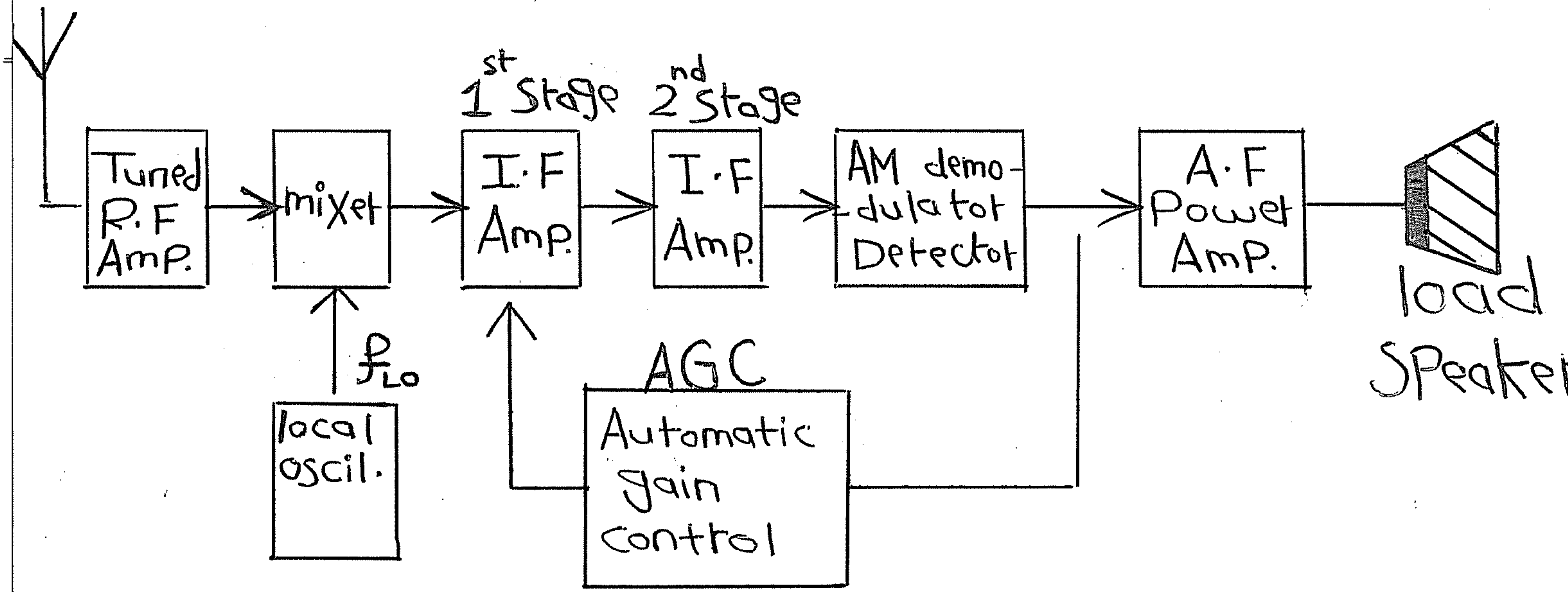
$V_m = 2V$, $V_{cc} = 10$, mod 100% , $\frac{N_2}{N_1} = ?$

$V_{cc} = V_s$

$V_s = \frac{N_2}{N_1} V_m \rightarrow \frac{N_2}{N_1} = \frac{10}{2} = 5$ ※.

AM Receiver Circuits :-

Super hettrodyne Rec. CCt.s :-



Two important factors in R_x :

:(Reciver Parameters):

1) Selectivity : ability of Reciver to Select a Certain freq. among different frequencies.

depends on Selectivity of Tuned R.F Amp and I.F. (mainly from T.R.F Amp.)

. T.R.F Amp. : يُحددها بالدرجة الأولى

2) Sensitivity : The minimum power level for the input signal which Can the R_X process.

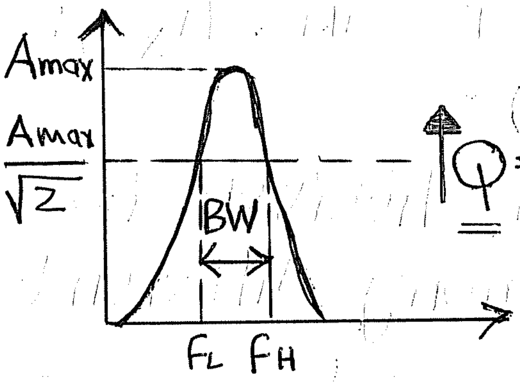
يحددها الـ gain of the Reciver •

gain=200 أفضل من

gain = 100 ($P_{in} \downarrow$)

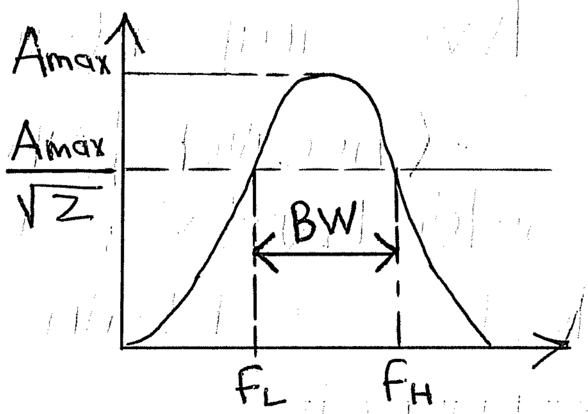
depends on I.F and T.R.F amp. gain (mainly in I.F Amp.).

T.R.F Amp.



$$\uparrow Q = \frac{f_o}{BW}$$

I.F Amp.



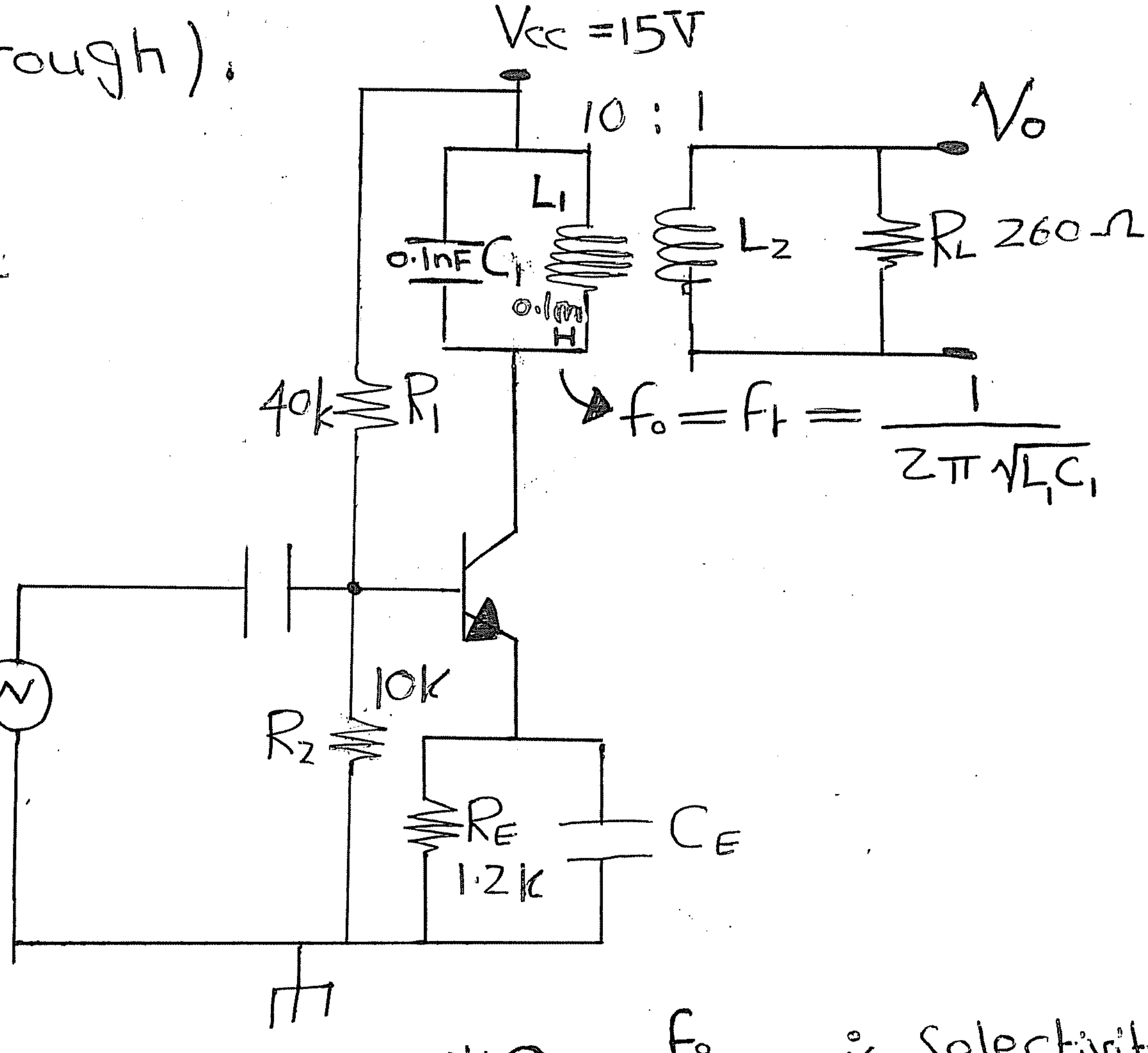
Tuned R.F Amp. :

1) Determine and improve R_x Selectivity.

2) prevent Reradiation of Lo. Signal (Leak through).

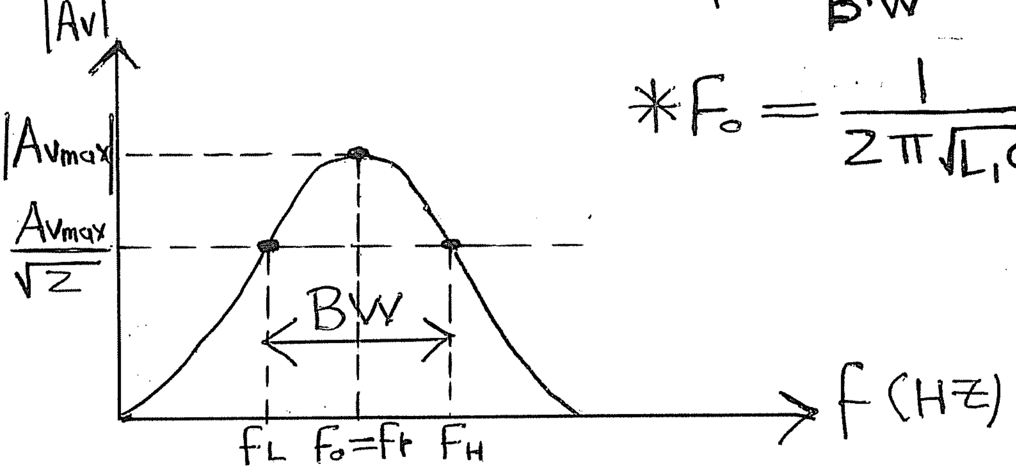
$V_{BE} = 0.6V$

$\beta = 100$



$$*Q = \frac{f_o}{B.W}$$, is Selectivity

$$*F_o = \frac{1}{2\pi\sqrt{L_1C_1}}$$



freq. Response.

for the design :

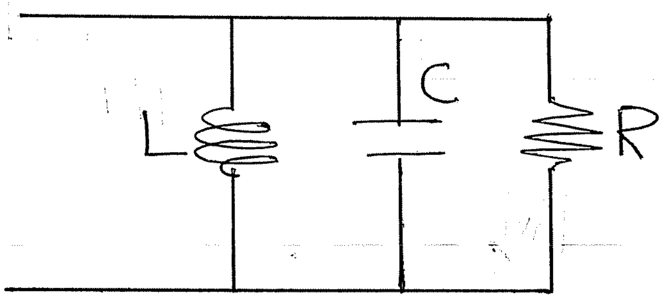
1) $f_o = f_r = f_c = \frac{1}{2\pi\sqrt{L_1 C_1}}$

2) The Selectivity Q must be Choosen Such that $B.W = \frac{F_o}{Q}$, must inculde USB and LSB of the AM signal, to avoide bandwidth cutting which causes distortion in AM Signal.

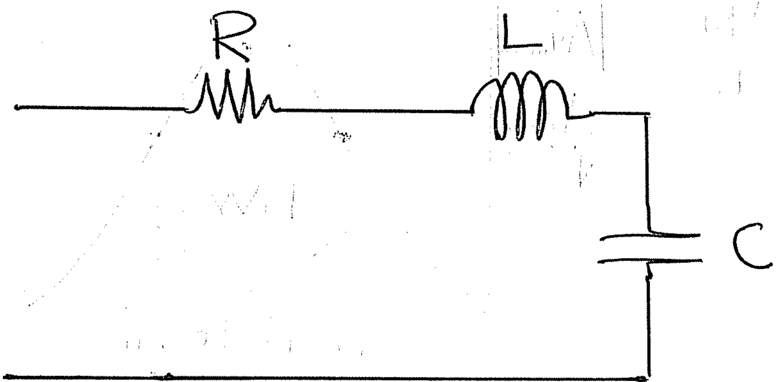
$\boxed{Q = \omega_o . \overline{R_L} . C}$ or $\boxed{Q = \frac{\overline{R_L}}{\omega_o L}}$

note:- in General, at Resonance;

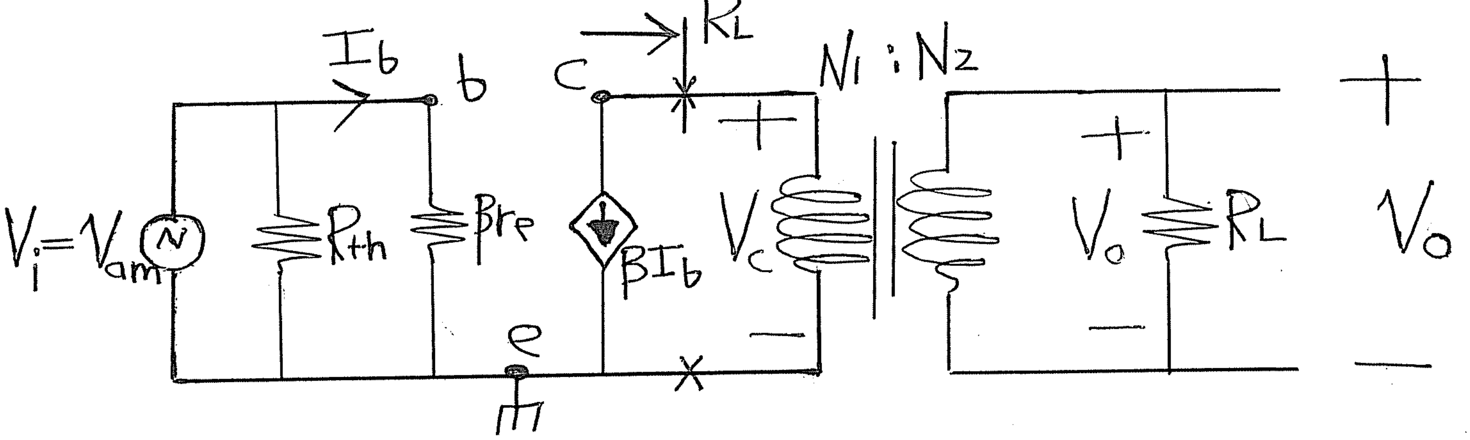
$\rightarrow Q = \omega_o R C$
$= \frac{R}{\omega_o . L}$



$\rightarrow Q = \frac{\omega_o . L}{R}$



At Resonance :



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

$$V_c = -\beta I_b \overline{R_L} \quad , \quad \overline{R_L} = a^2 R_L \quad , \quad a = \frac{N_1}{N_2}$$

$\overline{R_L}$: AC reflected impedance.

$$\frac{V_c}{V_i} = \frac{-\beta I_b \overline{R_L}}{I_b \cdot \beta r_e} = -\frac{\overline{R_L}}{r_e} = \frac{-a^2 \cdot R_L}{r_e}$$

$$\boxed{r_e = \frac{V_T}{I_E} \quad , \quad V_T = 26\,mV.}$$

$$\frac{V_o}{V_c} = \frac{N_2}{N_1} = \frac{1}{a} \longrightarrow A_V = \frac{\overline{R_L}}{r_e} \cdot \frac{1}{a} .$$

$$= -\frac{a^2 R_L}{r_e} \cdot \frac{1}{a}$$

$$\therefore \boxed{A_V = \frac{-a R_L}{r_e}}$$

$$f_o = f_c = \frac{1}{2\pi\sqrt{L_1 C_1}} \quad , \quad Q = \omega_o \overline{R_L} C .$$

Example: ① Calculate $|A_{V_{max}}|$, Q, B.W ?

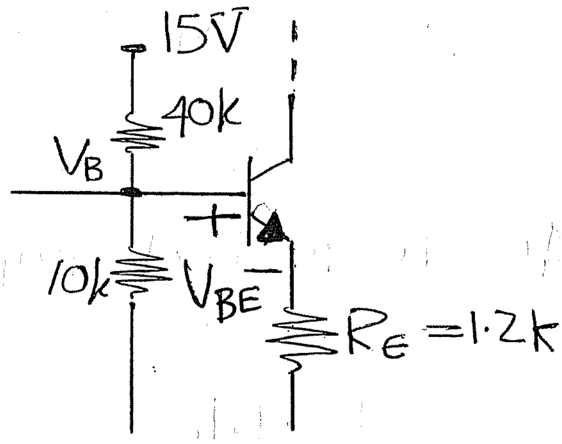
② Sketch freq. Resp. ?

③ Can This T.R.F Process an amod Signal of max. freq. of 10 kHz ?

Solution;

① $|A_{V_{max}}| = \frac{a R_L}{r_e}$, $r_e = \frac{V_T}{I_E}$

$I_E \rightarrow$ D.C analysis:



$V_B = \frac{15 * 10}{50} = 3V$

$V_E = V_B - V_{BE} = 3 - 0.6$
$= 2.4V.$

$I_E = \frac{V_E}{R_E} = \frac{2.4V}{1.2k} = 2mA.$

$r_e = \frac{26mV}{2mA} = 13\Omega.$

→ $|A_{V_{max}}| = \frac{10 * 260}{13} = 200.$

$f_o = \frac{1}{2\pi\sqrt{L_1 C_1}} = \frac{1}{2\pi\sqrt{10^{-4} * 10^{-10}}}$

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

$Q = \omega_o \overline{R_L} C$

$\overline{R_L} = a^2 * R_L = 100 * 260 = 26k\Omega$.

$\rightarrow Q = 2\pi * 10^6 * 1.6 * 26 * 10^3 * 0.1 * 10^{-9}$

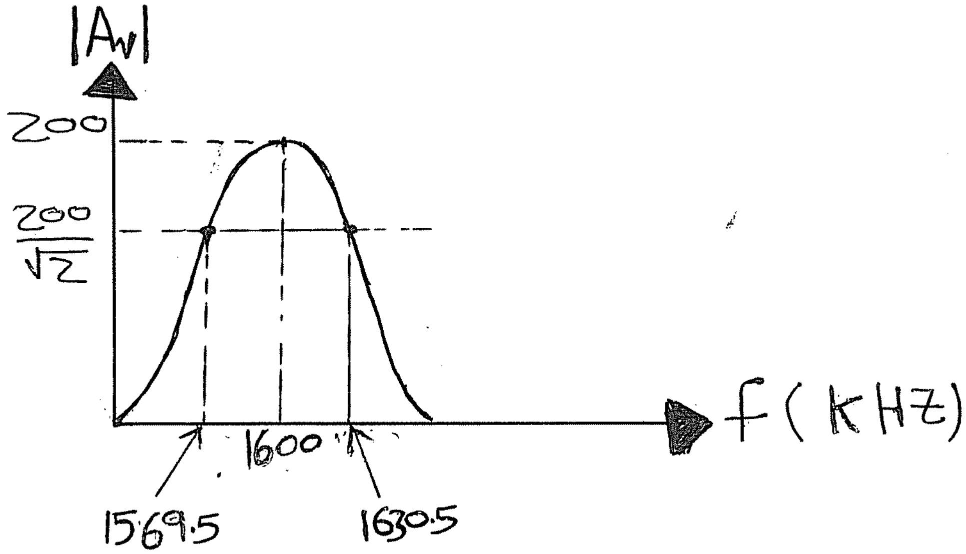
$= 26.13$.

$B.W = \frac{f_o}{Q} = \frac{1.6 * 10^6}{26.13} = 61.2\,k$

②

$f_L = f_o - \frac{B.W}{2} = 1.6 * 10^6 - \frac{61.2 * 10^3}{2} \cong 1.57\,MHz$

$f_H = f_o + \frac{B.W}{2} = 1.6 * 10^6 + \frac{61.2 * 10^3}{2} \cong 1.63\,MHz$

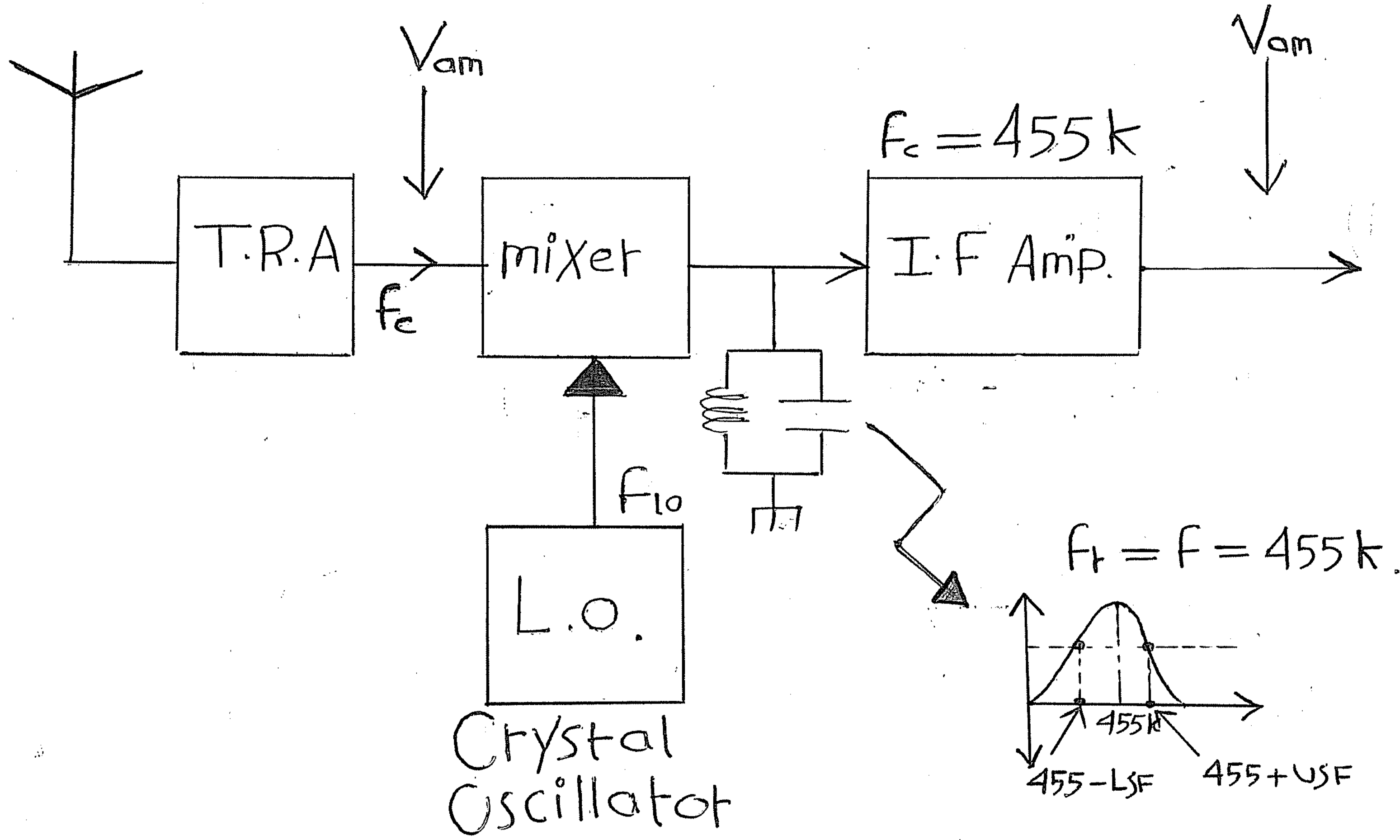


③ $1600k + 10k = 1610k < 1630.5$

$1600k - 10k = 1590k > 1569.5$

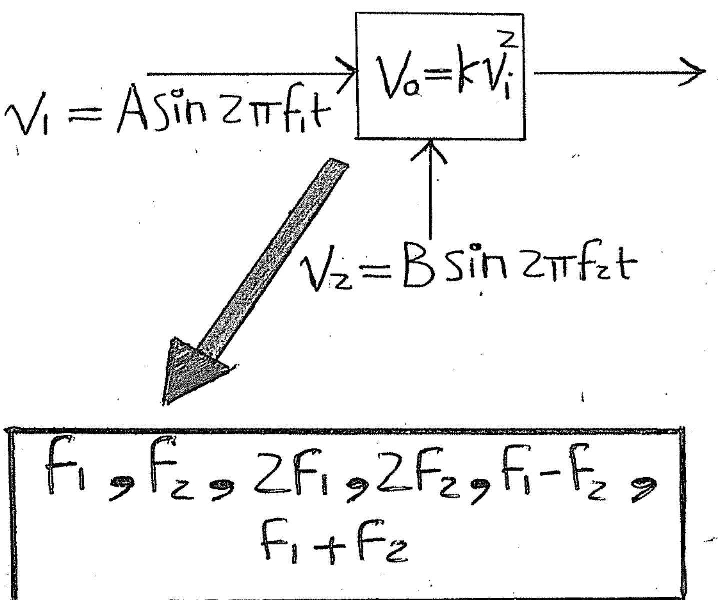
∴ Yes ... T.R.F Can process a mod. Signal of max. Freq. 10 kHZ.

Mixer :



down Freq. Converter → كلّما قللنا الـ Freq أكثر، كلما كنا قادرين على زيادة الـ gain of R_x .

mixer → non linear cct. (diode/BJT/MOSFET).



$$V_o = k(V_1 + V_2)^2$$
$$= k(A\sin 2\pi f_1 t + B\sin 2\pi f_2 t)^2$$
$$= k[A^2\sin^2 2\pi f_1 t + 2AB\sin 2\pi f_1 t\sin 2\pi f_2 t + B^2\sin^2 2\pi f_2 t].$$

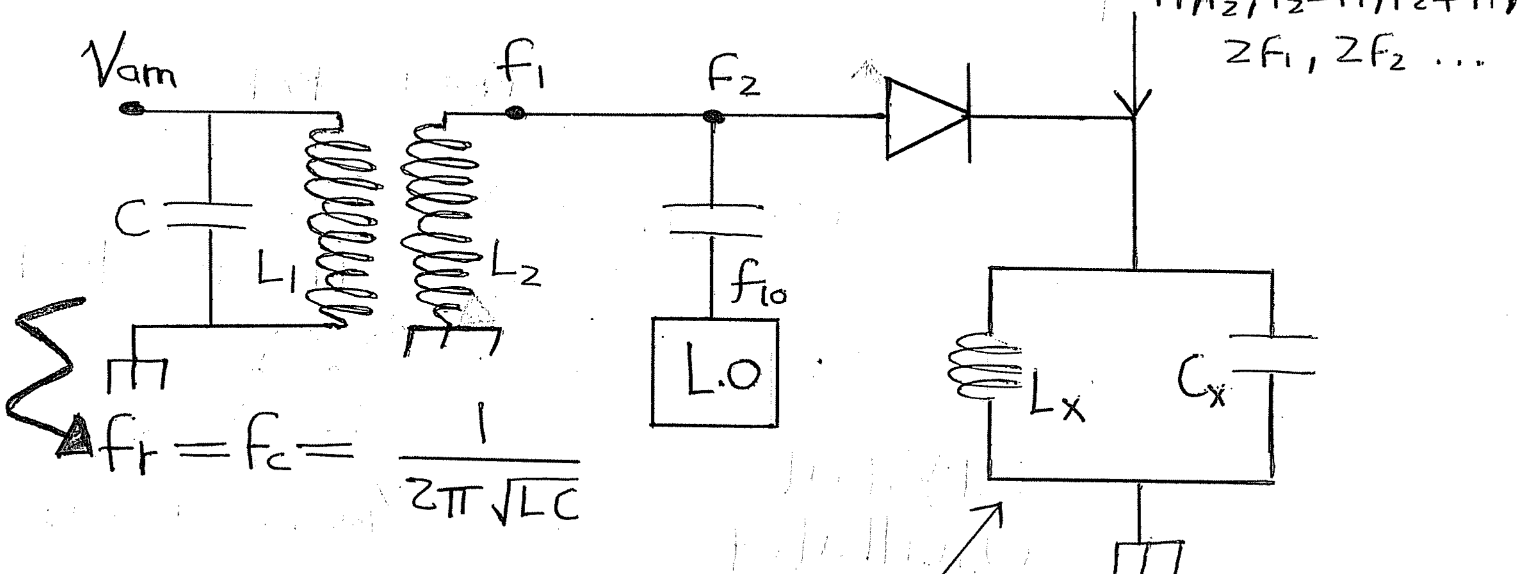
$1 - \cos 2(\ )$

if $V_o = ke$ → infinite # of frequnces.
(many harmonics)

Mixer : is non-linear CCt. used for freq. Conversion. (Mixing → multiplication process).

* The following devices can be used as mixer:

1) Diode mixer :-

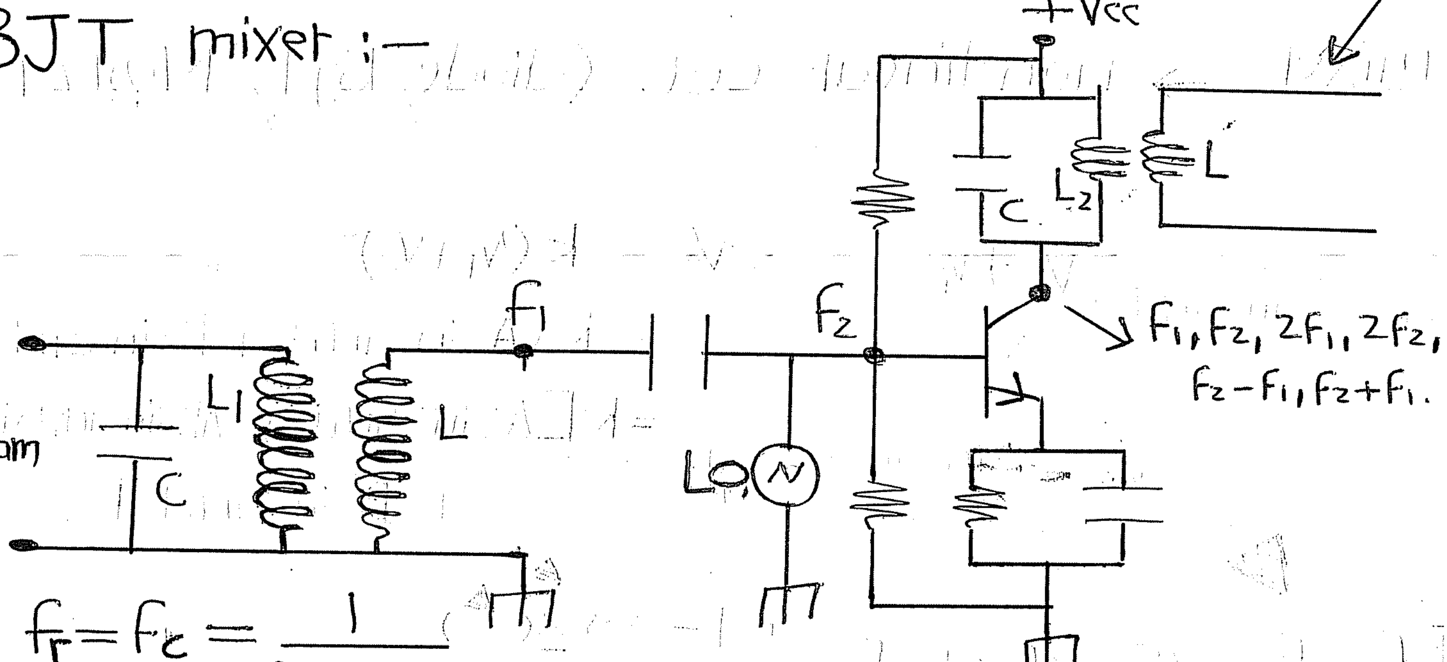


$$f_r = f_c = \frac{1}{2\pi\sqrt{LC}}$$

$$f_{IF} = \frac{1}{2\pi\sqrt{L_x C_x}}$$

Noisy , No gain , Exponential device.

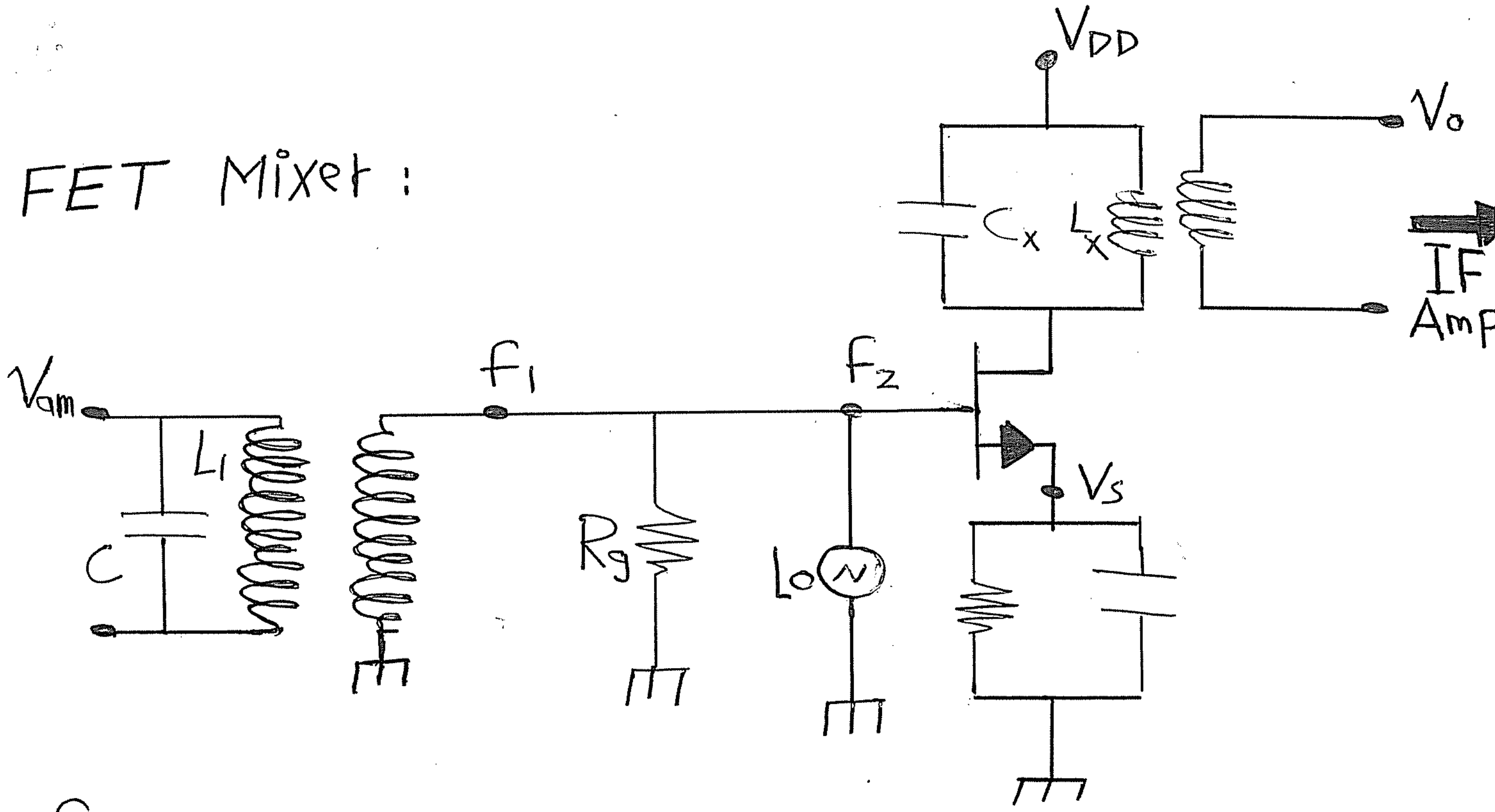
2) BJT mixer :-



$$f_r = f_c = \frac{1}{2\pi\sqrt{CL_1}}$$

Noisy , gain , Exponential device.

3) FET Mixer :



1. Gain.
2. No Noise.
3. maximum Freq. is Second harmonic. (Square Law device).

يمكن استبدال الـ LC.Cct ب BPF .

note:

$$f_{IF} = f_{LO} - f_s = f_s - f_{LO}$$

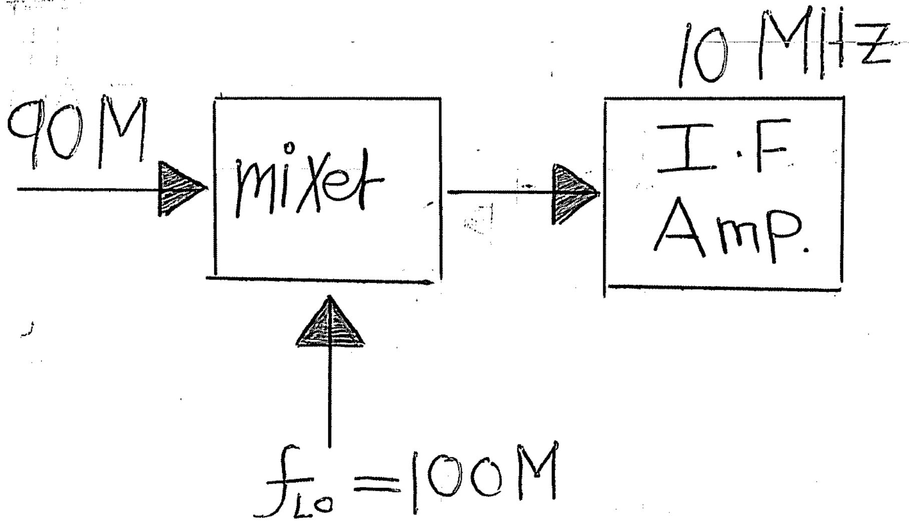
for high-Side injection : $f_{IF} = f_{LO} - f_s$

$f_{LO} > f_s$

For low-Side injection : $f_{IF} = f_s - f_{LO}$

$f_s > f_{LO}$

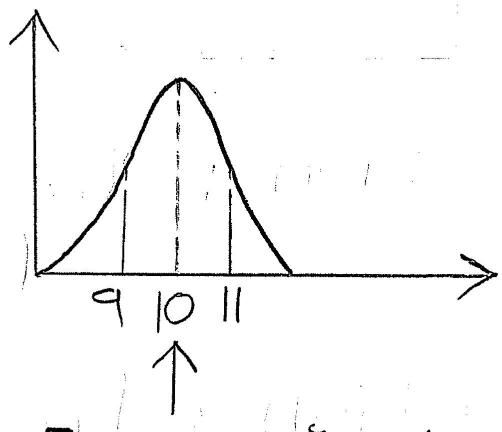
IF Amp. :



$$f_{image} = f_s + 2f_{IF}$$

mixer لايميز بين 90M و ال 110M (image) ، مما يؤدي الى
حدوث interferance بين ال Signals .

نتخلص من ال image بزيادة ال f_{IF} :



$$Q = \frac{f_o}{B.W} = \frac{10}{2} = 5$$ ✓

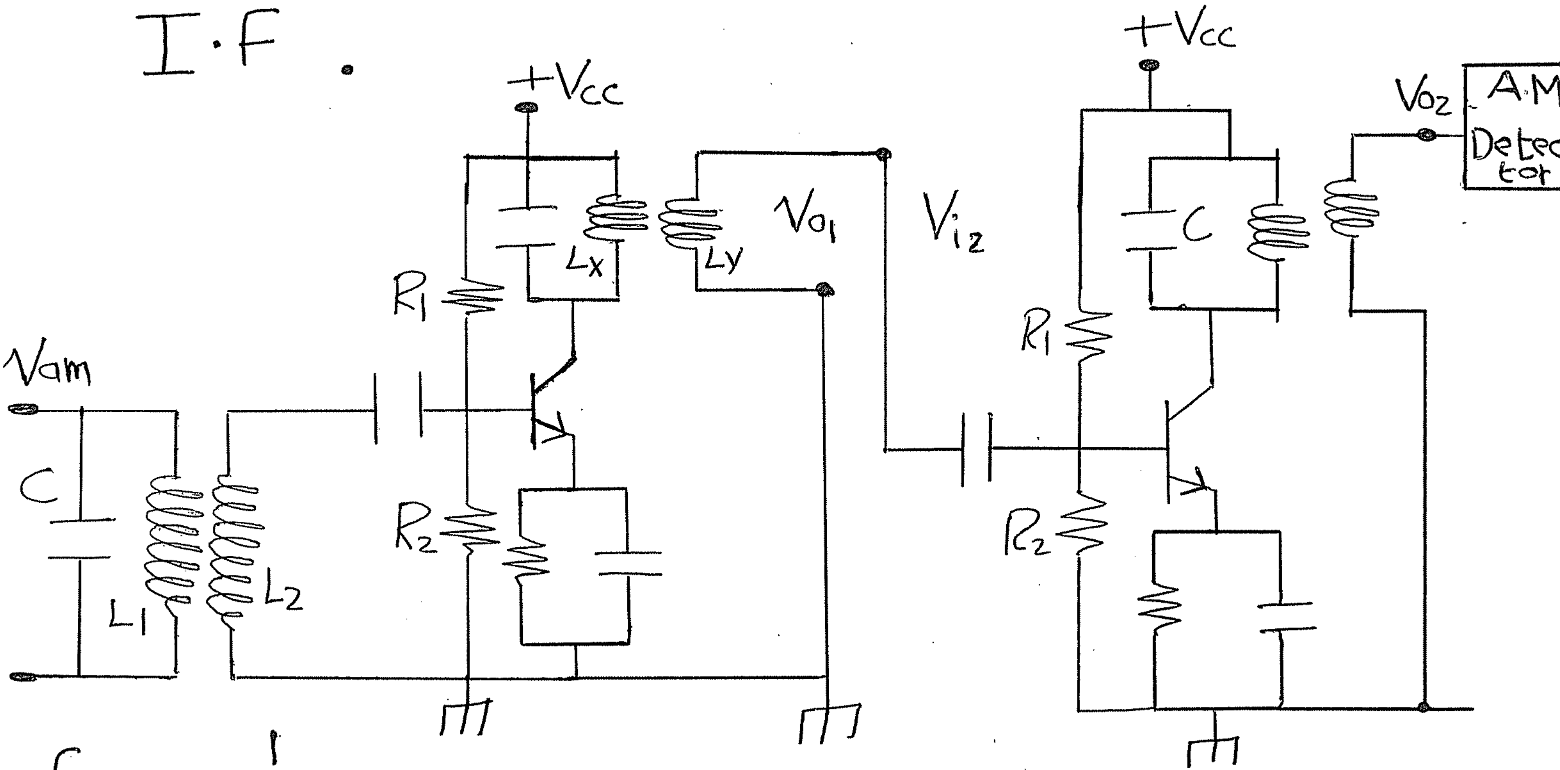
* لو أخترناها 50M ،
تصبح ال image خارج ال B.W . #

* The Bulk size of R_x gain is achieved in I.F Amp.

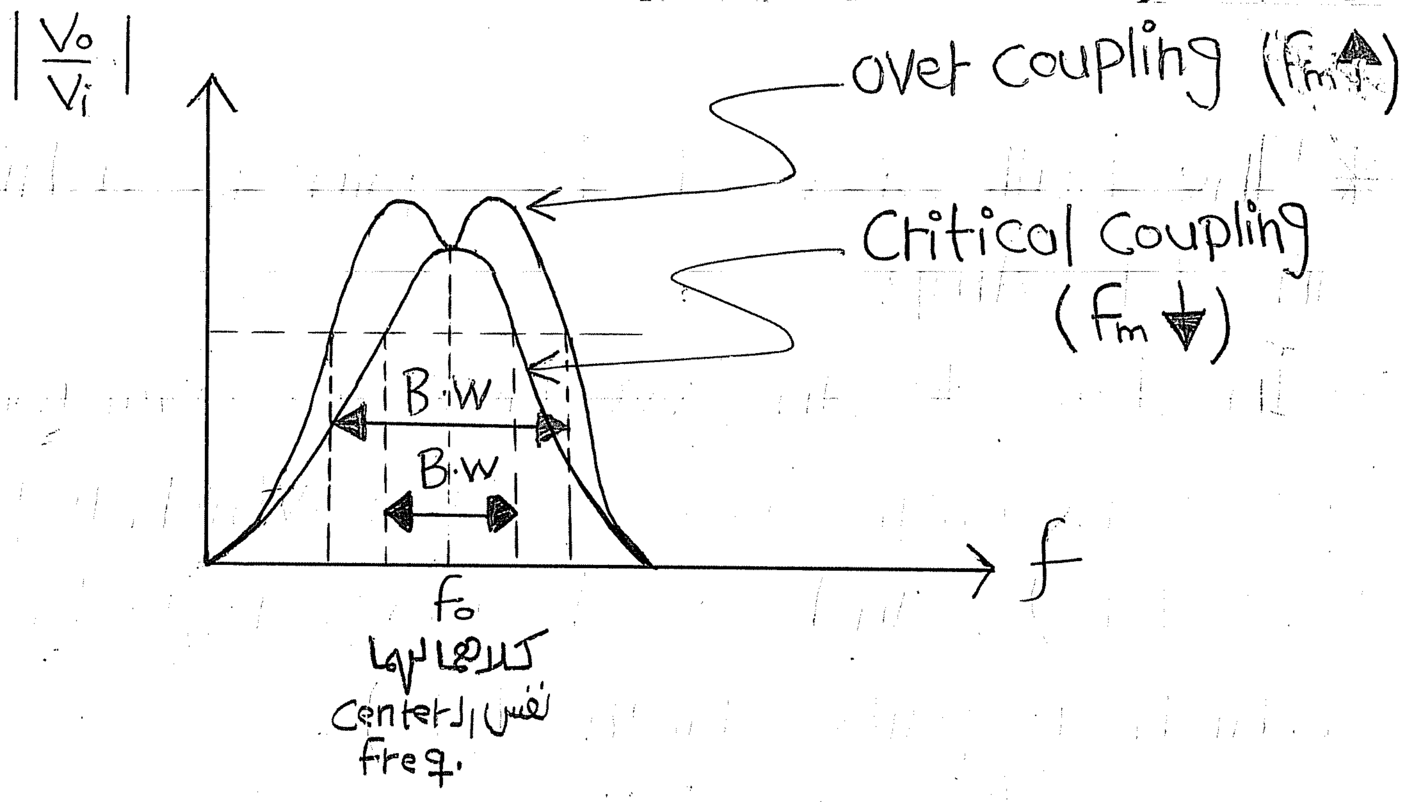
* In I.F design, we have to Compromise between high and Stable (Which requires low I.F), and good image rejection (Which requires high I.F).

For AM, 455 kHz was Choosen to give the required gain and image rejection.

For FM, 10.7 MHz was Choosen for I.F.

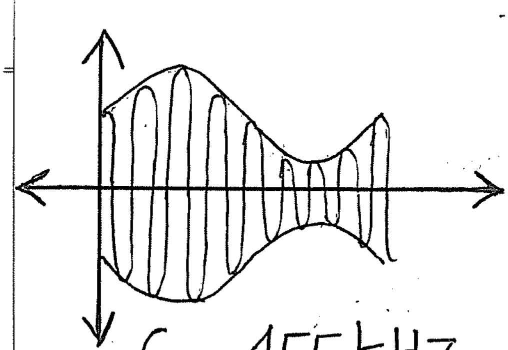


$$f_r = \frac{1}{2\pi\sqrt{L_1 C}} = 455 \text{ kHz}$$

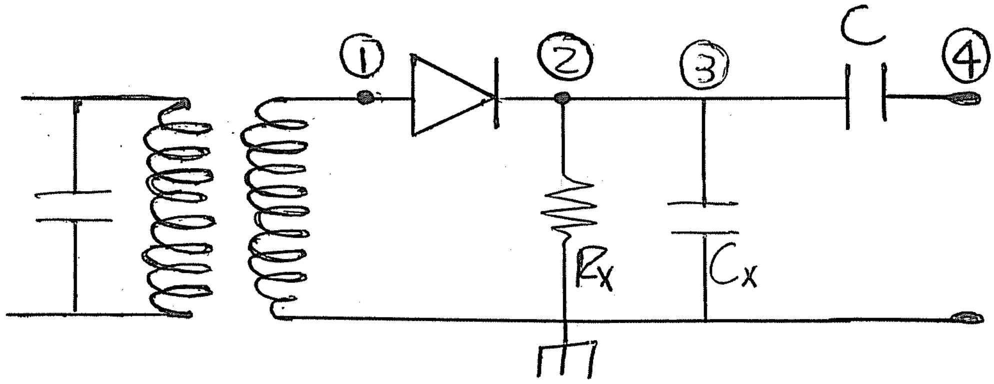


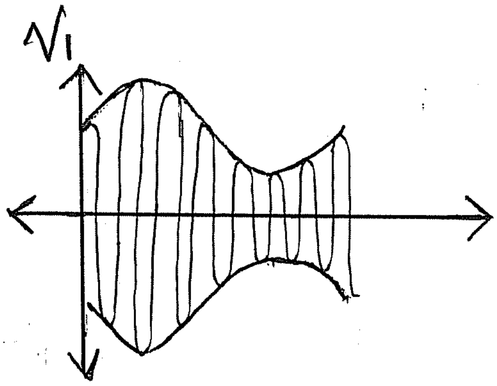
for high freq. modulating Signal, a wide band Amp. must be used.
(using over coupling double I.F stage).

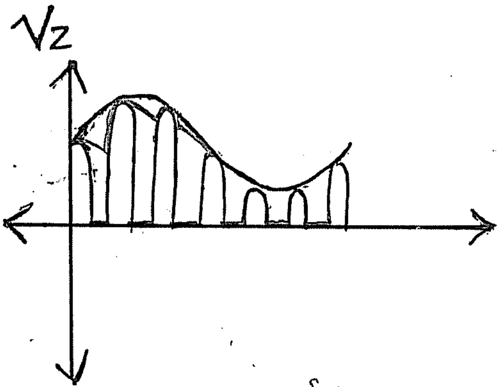
AM Demodulator [Diode Detector]:



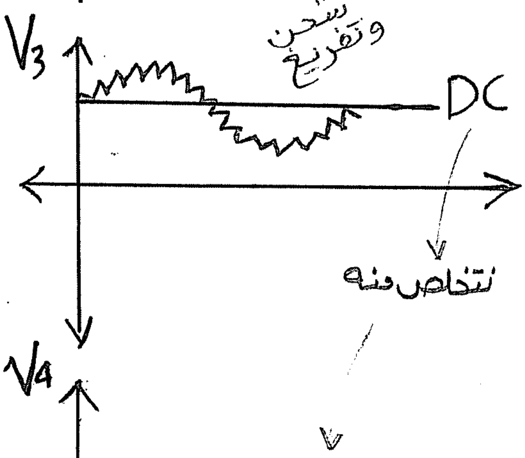
f = 455 kHz.







$$V_r = \frac{V_m}{f \cdot C \cdot R}$$



$$X_c = \frac{1}{2\pi f_c}$$

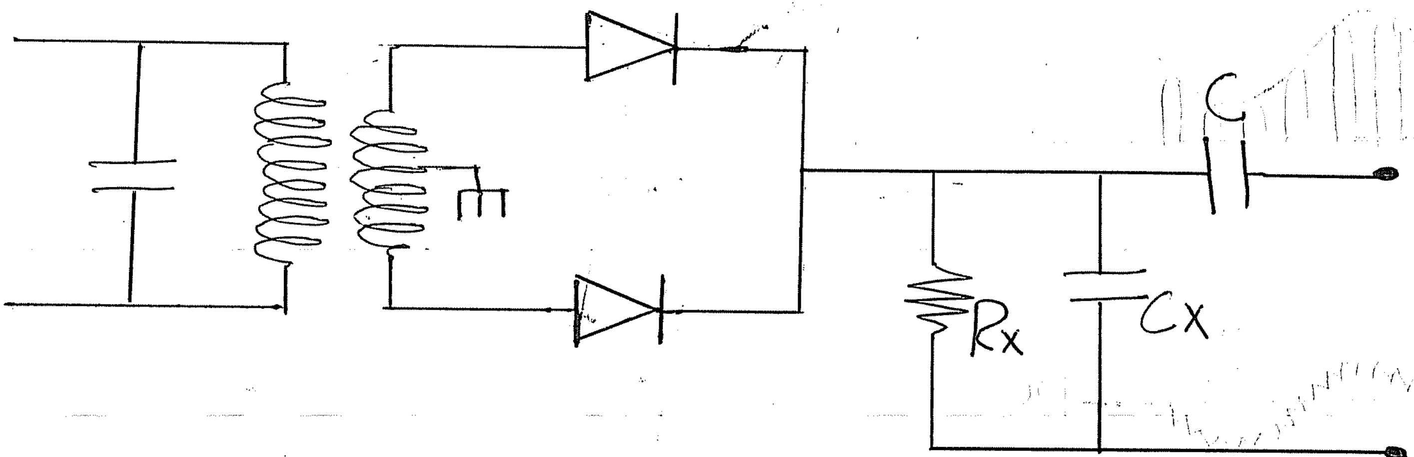
$f = f_m$ (mod. freq. → Signal freq.).

1] The Diode is Used as Rectifier.

2] R_X and C_X used as high pass filter, C_X is Choosen Such that it gives very low X_c for Carrier (455k).

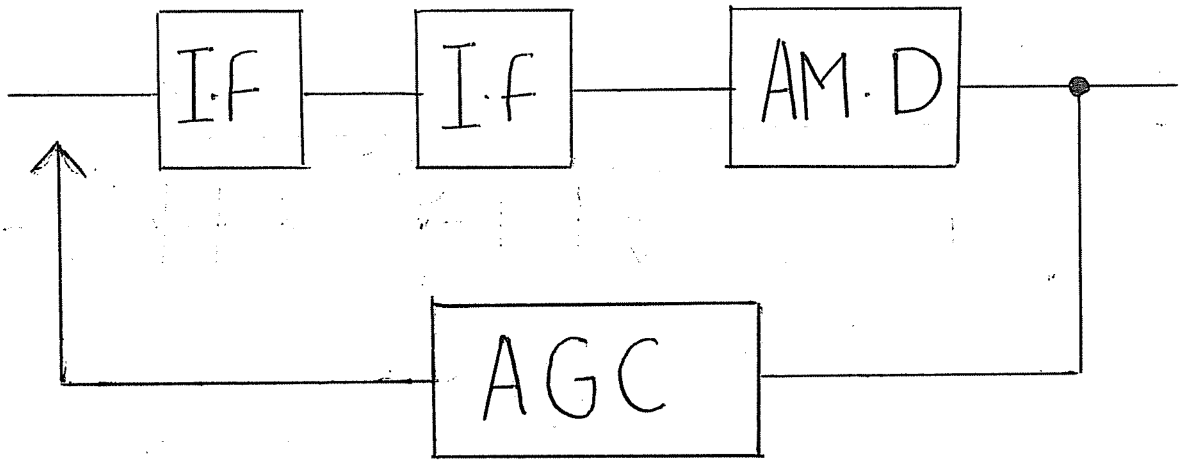
3] C is used as a blocking Capacitor to remove DC Component from V_3.

4] we Can improve the Performance of this modulator (reduce ripple) by using F.W.R with Center tap. Transformer.



$$V_r = \frac{V_m}{2f \cdot C \cdot R}$$

#AGC : Automatic Gain Control :-

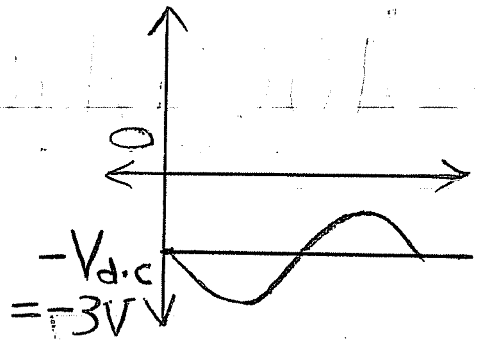


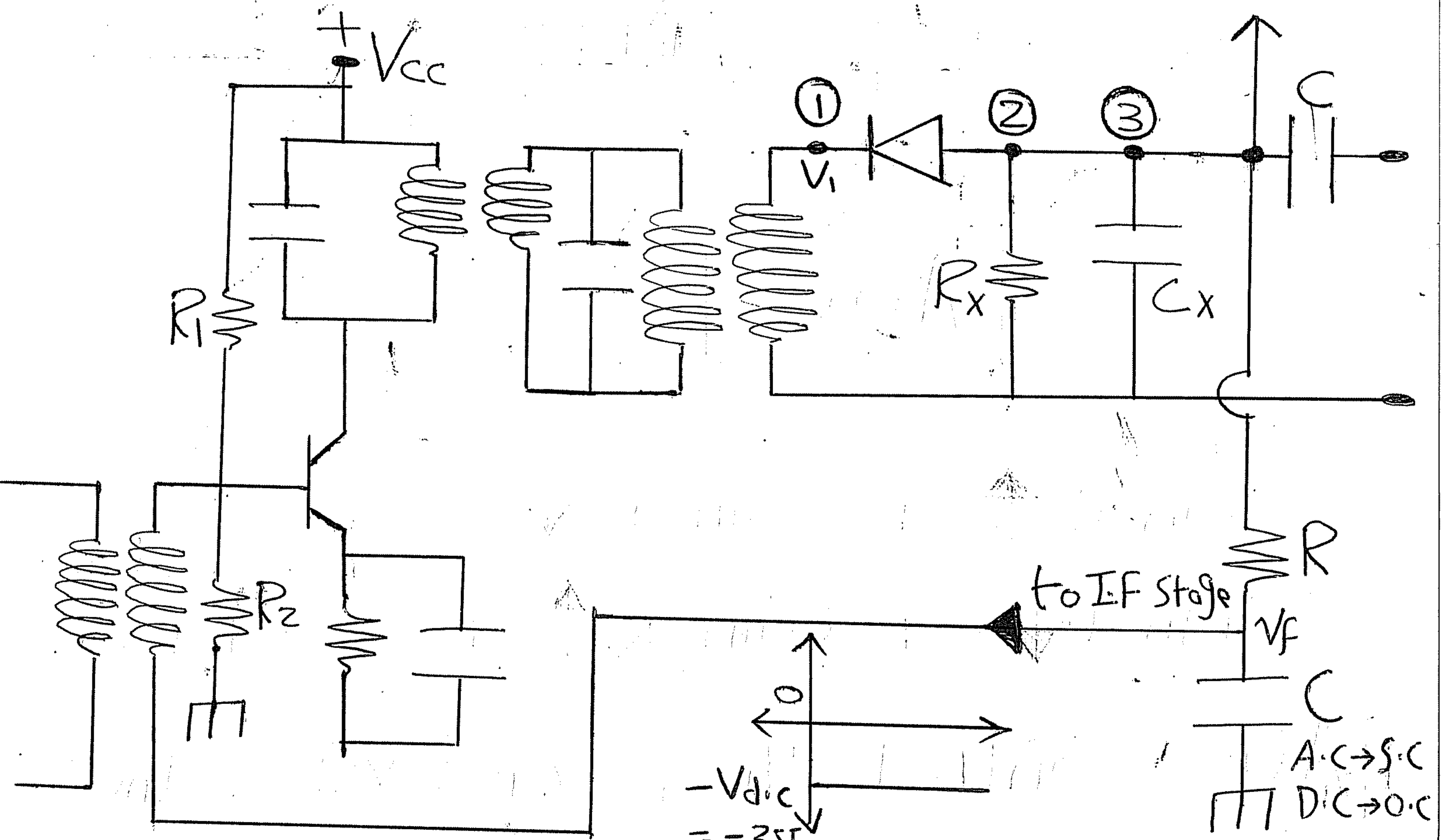
Signal ↑ : Gain R_x ↓
Signal ↓ : Gain R_x ↑
→ at constant power level.

1] AGC control the power level of the output signal.

2] It is a feedback controlled sys. taking output of AM demodulator and feed it back to I.F stage.

من النقطة ③ (فقط بآخذ DC)





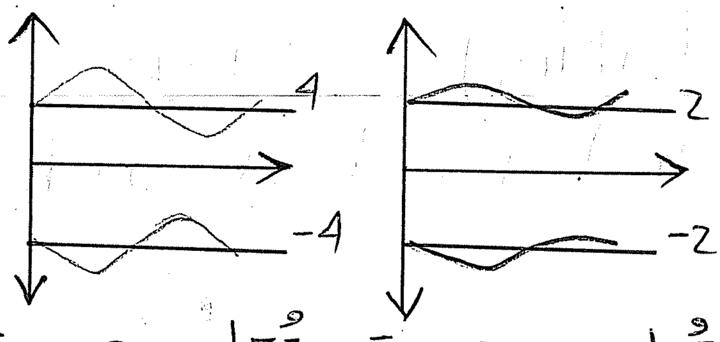
اشارة قوية

→DC Voltage ↑ , I_B ↓ , I_C ↓ , gain ↓ , amplitude V_o ↓ .

اشارة ضعيفة

→DC Voltage ↓ , I_B ↑ , I_C ↑ , gain ↑ , amplitude V_o ↑ .

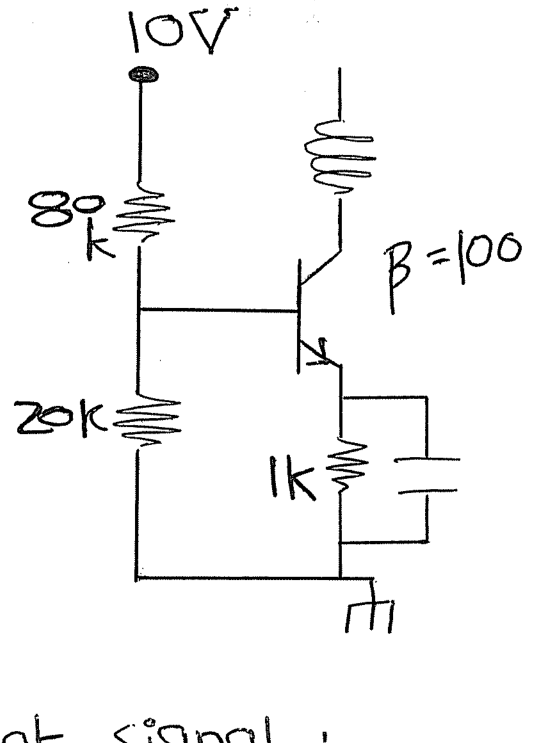
*note :-



تُعطي DC عالية تُعطي DC قليلة

1] For Stronge Signal, Large −Ve DC Voltage is produced which will reduce I_B ↓, I_C ↓, g_m ↓, and Reduce Amp. gain ($A_v = g_m R$) ($g_m = \frac{I_{CQ}}{V_T}$), and Reduce V_o level.

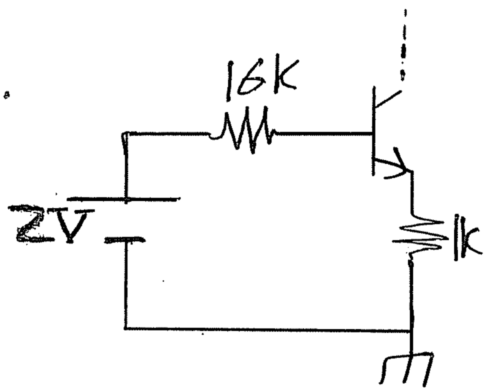
2] The weak Signal produces Small DC Voltage I_B ↑, I_C ↑, g_m ↑, A ↑, V_o ↑.



→ without −Ve F.B :

$$I_B = \frac{2-0.6}{16+101*1} = \frac{1.4}{117k} = 0.012m.$$

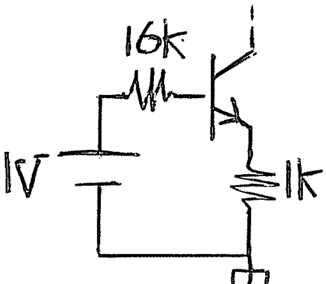
$I_C = 1.2\,mA$.



for −Ve DC of −1V :
(Stronge Signal)

$$I_B = \frac{1-0.6}{117k}$$

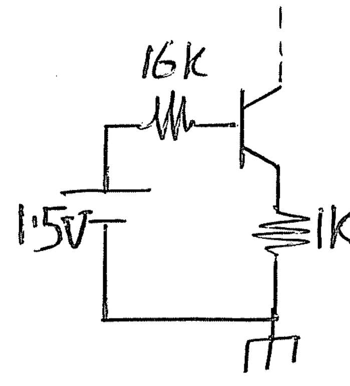
$I_C = 0.3\,mA$.



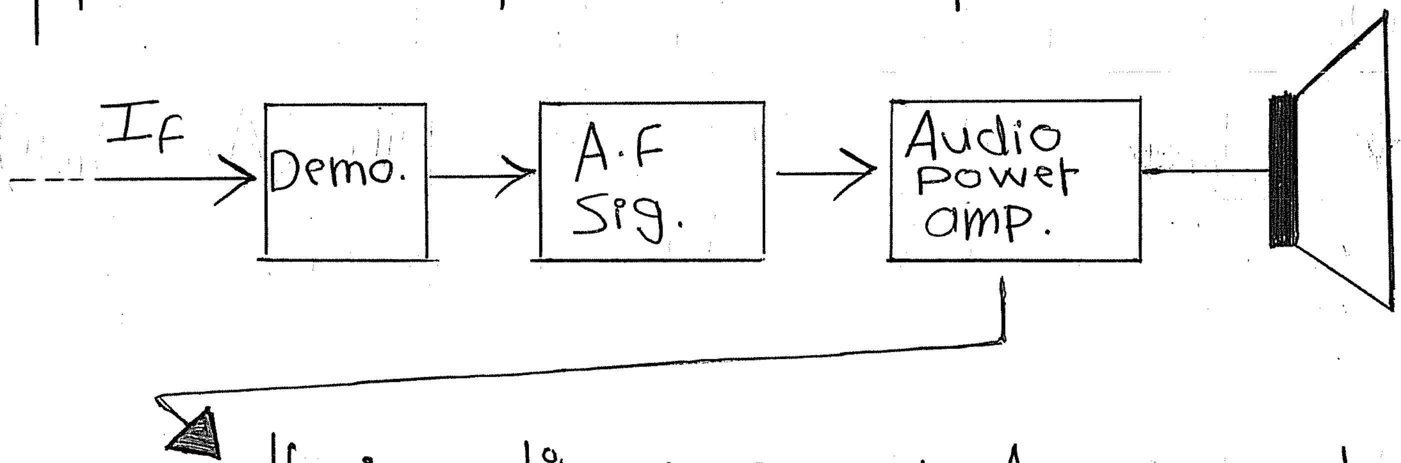
for weak signal :
(Small −Ve DC Voltage −0.5V)

$$I_B = \frac{1.5-0.6}{117k}$$

$I_C = 0.7\,mA$.



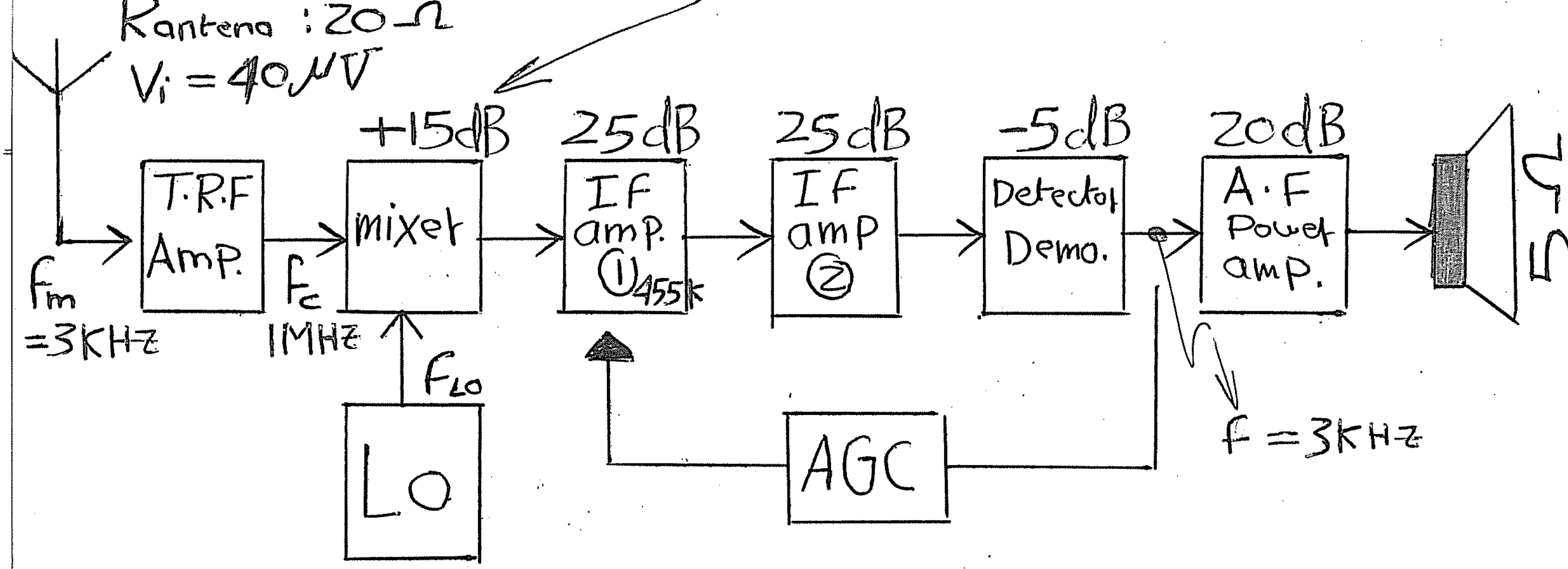
Audio Power Amp. :-



* It is a linear Power Amp. used to increase power level of message Signal.

* It can be Class-A, Class-AB, or Class-B push-pull P.A. #

Example



① Calculate R_x power gain.

② Peak output Voltage.

③ f_{LO} for HSI.

Solution:

① Power gain = 20+15+25+25 −5 +20

= 100 dB.

② $A_P(dB) = 10 \log \frac{P_o}{P_i}$

$100 = 10 \log \frac{P_o}{P_i} \rightarrow \log \frac{P_o}{P_i} = \frac{100}{10}$

$$\boxed{P_o = 10^{10} \cdot P_i}$$

$$P_i = \frac{V_{i(rms)}^2}{R} = \frac{(40*10^{-6})^2}{20} = 80*10^{-12}\ W.$$

$$P_o = 10^{10} \cdot 80*10^{-12} = 0.8\ W$$

$$P_o = P_L = \frac{V_{o(rms)}^2}{R_L} \rightarrow V_{o(rms)} = \sqrt{0.8 * 5} = 2V.$$

$$V_{o(peak)} = 2 * \sqrt{2} = 2.8 V.$$

③ HSI :

$$f_{LO} - f_c = f_{IF}$$

$$f_{LO} = 1M + 0.455 = 1.455 \text{ MHz}.$$

$$f_{Image} = f_s + 2 f_{IF} = 1000 + 910$$

$$= 1.910 \text{ MHZ}.$$

Frequency Modulation :-

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

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

$V_{FM} = V_c \sin(2\pi f_c t + m_f \sin 2\pi f_m t)$

where m_f : mod. index $= \frac{f_d}{f_m}$,

f_d : Frequency deviation.

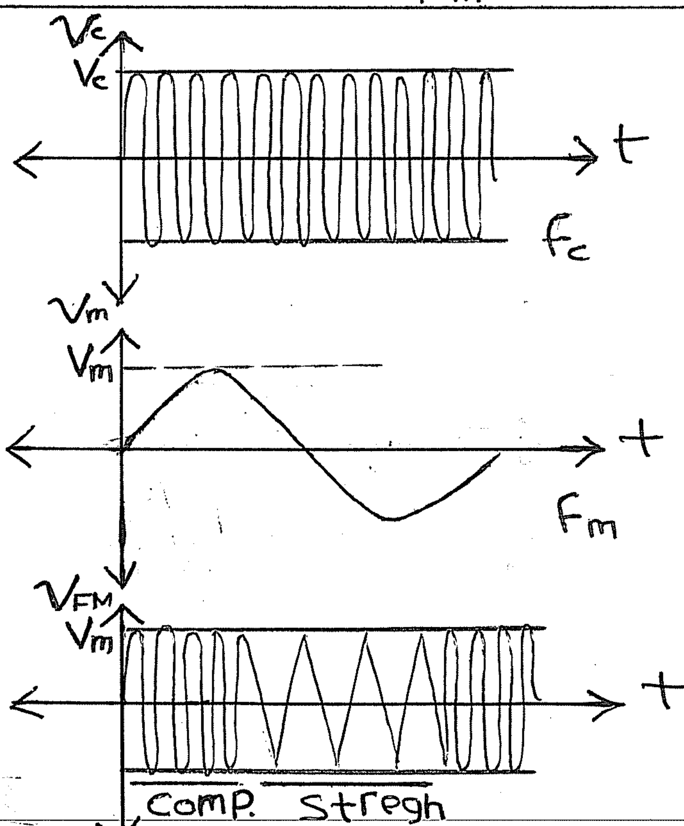
f_m : message frequency.

Example: $V_{FM} = 5 \sin(2\pi * 10^6 t + 8 \sin 2\pi * 10^3 t)$:

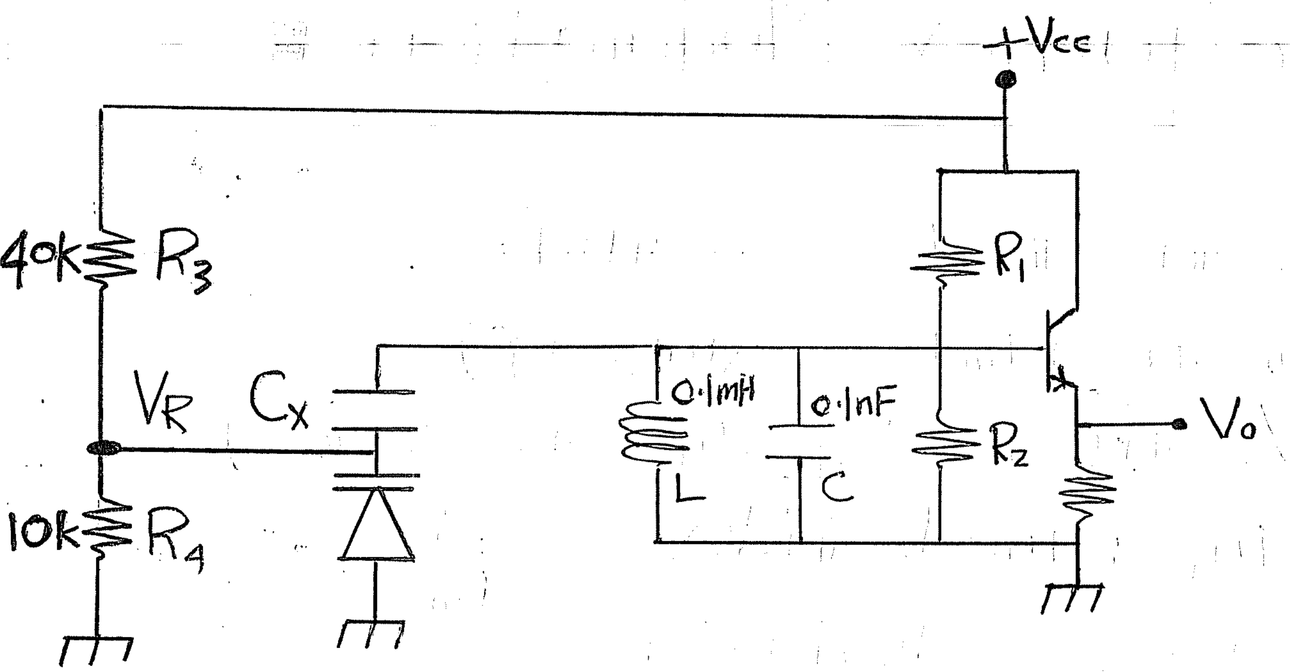
find: V_c , f_c , f_m , m_f , f_d ?

$V_c = 5$, $f_c = 10^6 = 1MHz$, $f_m = 10^3 = 1kHz$,

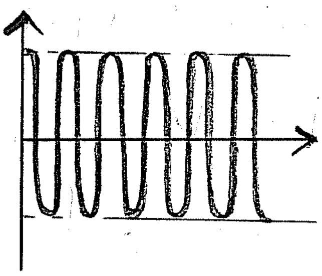
$m_f = 8 = \frac{f_d}{f_m}$, $f_d = 8 f_m = 8kHz$.



FM: Changing freq of carrier according to amplitude of modulating signal.

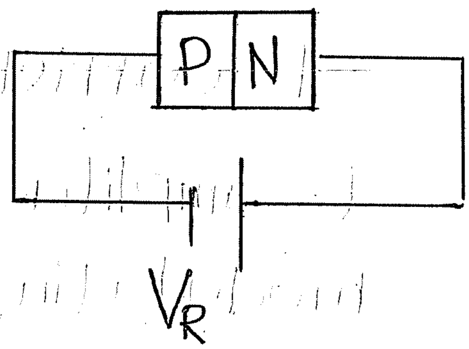


$$f_c = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{10^{-4} * 10^{-10}}} = \frac{10^7}{2\pi} = 1.6\,\text{MHz}.$$



→ C_x is Choosen to be very large.

* Varactor diode can be used as a Variable Cap



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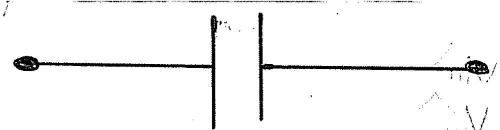
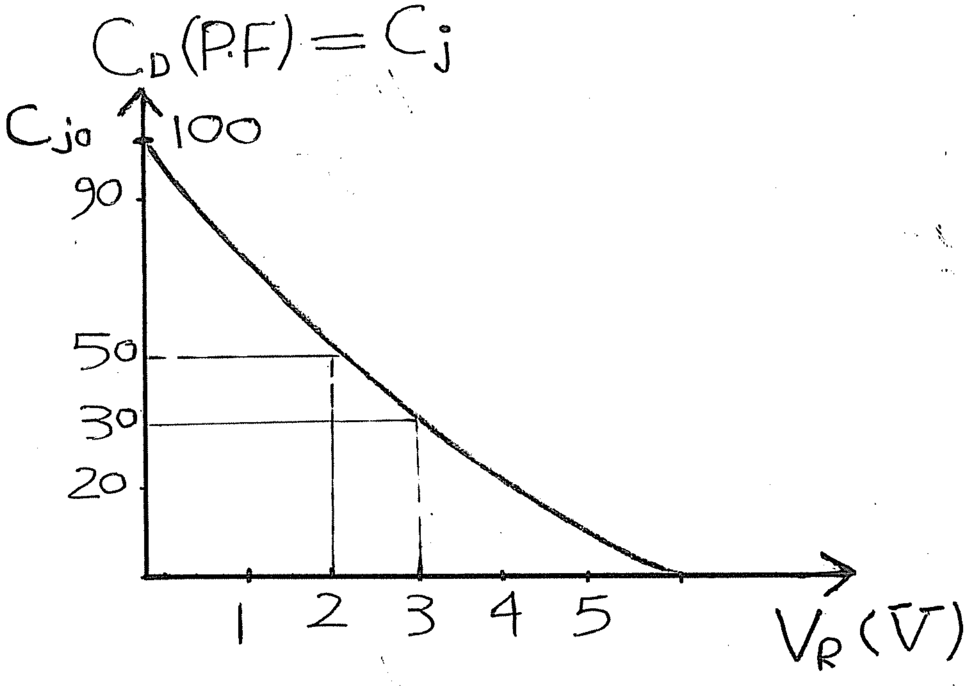


$$C_j = \frac{C_{jo}}{\sqrt{1 + \frac{V_R}{V_{bi}}}}$$

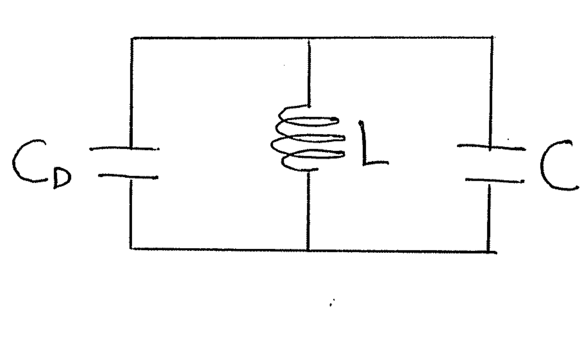


1] without Varactor: $f_{co} = \frac{1}{2\pi\sqrt{LC}} = 1.6 MHz$

2] with Varactor:

$$f_c = \frac{1}{2\pi\sqrt{LC_{eq}}} \quad , \quad \boxed{C_{eq} = C + C_D}$$

Since C_D in Series with C_X, and C_X is very large, So $C_D + C_X \approx C_D$.



$\therefore C_{eq} = C_D + C$.

$$V_R = \frac{10 * 10}{50} = 2V.$$

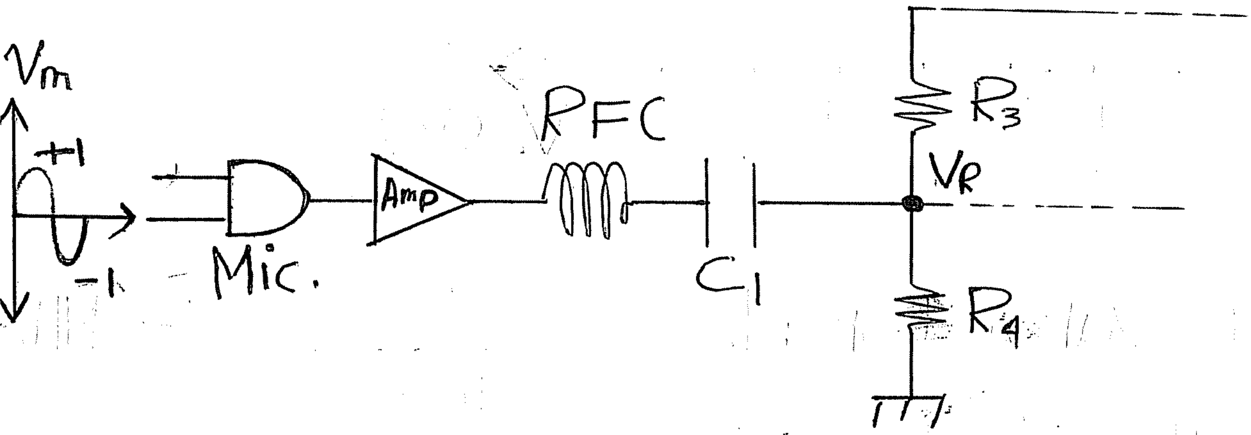
from graph: for $V_R = 2V$. $C_D = 50 P.F.$

$C_{eq} = (50 + 100) P.F.$

$$f_c = \frac{1}{2\pi\sqrt{10^{-4} * 1.5 * 10^{-10}}} = \frac{10^7}{2\pi\sqrt{1.5}} \triangleq \frac{10^7}{2\pi * 1.2}$$

$$= 1.3\ MHz.$$

without V_m.



] During +ve HC of V_m :

$V_R = 2V + V_m = 2 + 1 = 3V.$

$C_D = 30\ P.F$ (From graph)

$C_{eq.} = 100 + 30 = 130\ P.F.$

$$f_c^+ = \frac{1}{2\pi\sqrt{10^{-4} * 1.3 * 10^{-10}}} = \frac{10^7}{2\pi\sqrt{1.3}} = 1.4\ MHz.$$

+ve HC of V_m

↓

f_c ↑

2] During −ve HC of V_m :

$V_R = 2 - 1 = 1V$

$C_D = 80\ pF$ → (from graph)

$C_{eq} = 80 + 100 = 180\ pF$.

$$f_c^- = \frac{1}{2\pi\sqrt{10^{-4} * 1.8 * 10^{-10}}} = \frac{10^7}{2\pi\sqrt{1.8}} = \underline{\underline{1.18\ MHz}}.$$

−ve HC of V_m
↓
f_c ↓

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

$f_d^+ = f_c^+ - f_c = 1.4 - 1.3 = 100\ kHz$.

↑ with varactor and without V_m .

$\rightarrow m_f = \frac{100}{5} = 20$ ✓

$f_d^- = f_c^- - f_c = 1.18 - 1.3 = -0.12\ MHz$

$\rightarrow |\ | = 120\ kHz$.

$\rightarrow m_f = \frac{120}{5} = 24$ ✓

* $f_d^+ \neq f_d^-$: because non linear relation between (V_R) and (C_j) .

LC-FM Modulator :-

(R_1) and (R_2) ⟶ BJT biasing.

(R_3) and (R_4) ⟶ Varactor biasing.

C_1 ⟶ blocking and Coupling Cap.

RFC : Radio freq. Chock.

$X_L = 2\pi f L$: → D.C → S.C. / → A.C → O.C.

↳ O.C : For Radio freq.
S.C : Audio Freq.

يمنع الـ Carrier من الرجوع الى V_R عشان الـ V_m يدخل ويتجمع مع V_R.
↳ because high Impedance.

In This FM mod. :-

1] Varactor is used as Variable Cap. (C_D).

2] As $V_m \uparrow$, $V_R \uparrow$, $C_D \downarrow$, $C_{eq} \downarrow$, $f_c \uparrow$.

3] As $V_m \downarrow$, $V_R \downarrow$, $C_D \uparrow$, $C_{eq} \uparrow$, $f_c \downarrow$.

i.e the freq. of Carrier (f_c) increase and decrease with increasing and decreasing of amplitude of message signal. (FM signal is produced)

- The advantage of this FM mod. is:

Large freq. deviation. ✓

- The disadvantage :

Poor freq. Stability. ✓

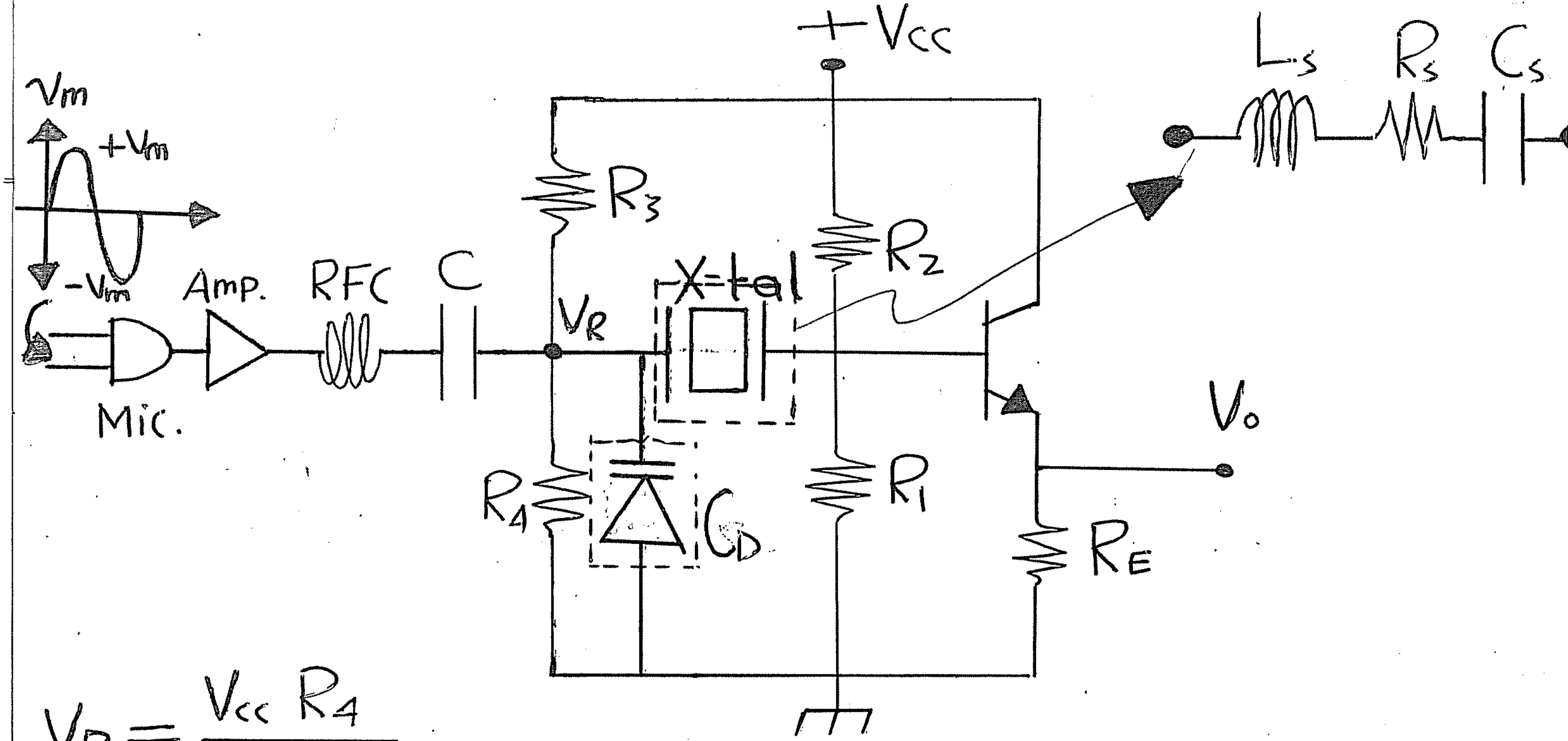
freq. depends on R, L, C → which are affected by Temp., Voltage Variation, aging. → low Stability

Solution : Using Crystal Osci.. (high freq Stability)

→ problem : Small freq. deviation.

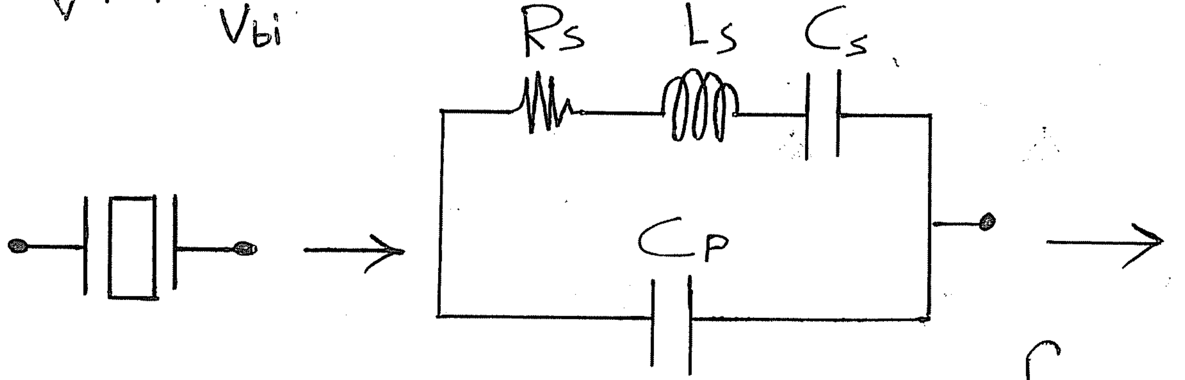
→ Solution: V_o → [Freq. multiplier *2, *3, ...]

Crystal-FM mod. :-



$$V_R = \frac{V_{cc} R_4}{R_3 + R_4}$$

$$C_D = \frac{C_{jo}}{\sqrt{1 + \frac{V_R}{V_{bi}}}}$$



$$f = \frac{1}{2\pi\sqrt{L_s \cdot C_{eq}}}$$

$$C_{eq} = C_s // C_p$$

Since $C_p \gg C_s$,

$$C_{eq} \approx C_s$$

i without V_m :-

1] without Varactor :-

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

2] with Varactor :-

$$f_c = \frac{1}{2\pi\sqrt{L_s \cdot C_{eq}}} \quad , \quad C_{eq} = C_D // C_s .$$

ii when V_m is applied :-

1] During +ve H.C of V_m :

$V_R \uparrow$, $C_D \downarrow$, $C_{eq} \downarrow$, $f_c \uparrow$.

2] During −ve H.C of V_m :

$V_R \downarrow$, $C_D \uparrow$, $C_{eq} \uparrow$, $f_c \downarrow$.

i.e : The freq. of Carrier f_c increase with increasing of V_m , and decrease with decreasing of V_m.

[FM is Produced.] .

Advantage : Superior freq. Stability.
Disadvantage : Small freq. deviation (hundred of Hz). (f_d in range of hundre of Hz).

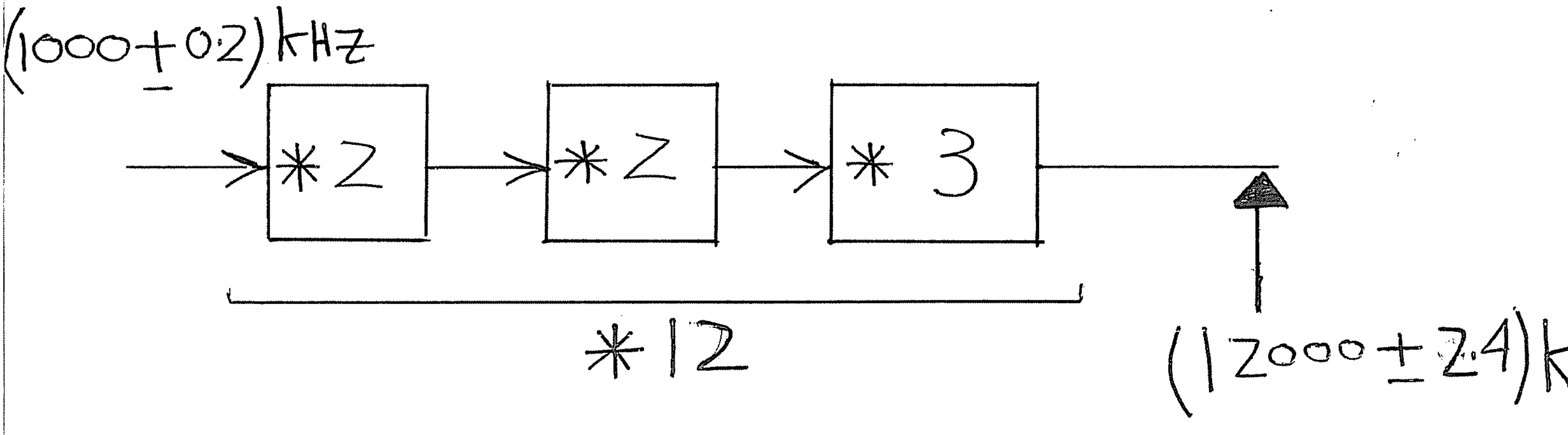
We can increase the freq. deviation by using freq. multiplier.

- for example : if the o/p of Crystal FM mod. is : $f_c = 1MHz$, $f_d = 0.2kHz$.

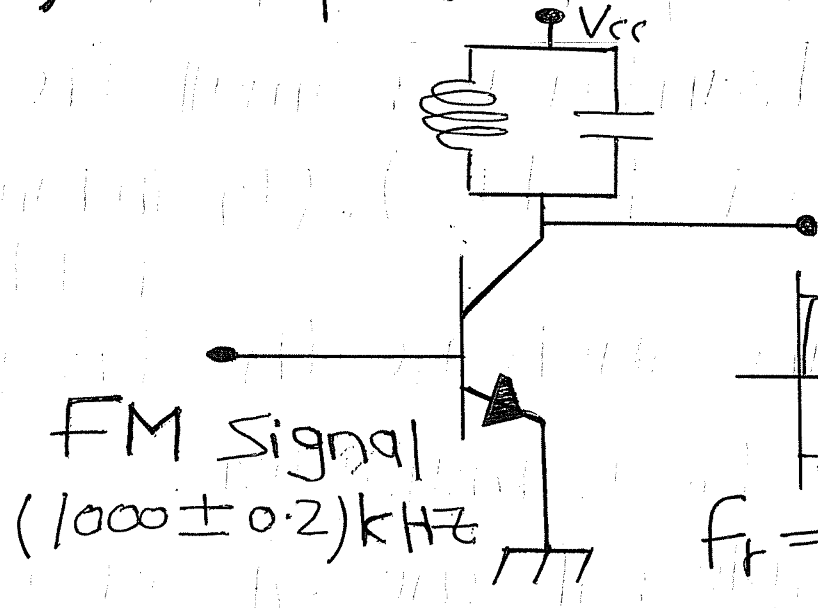
→ to make $f_d = 2.4$ kHz , we have to multiply the o/p by 12.

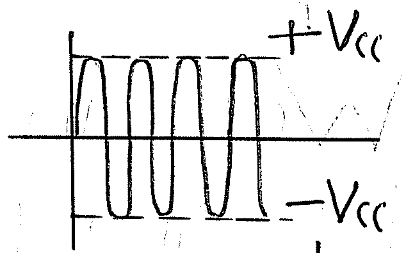
* The available freq. multipliers are

  $*2$ and $*3$
  doupler Trippler



practically, multipiers are Class-C amp.





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

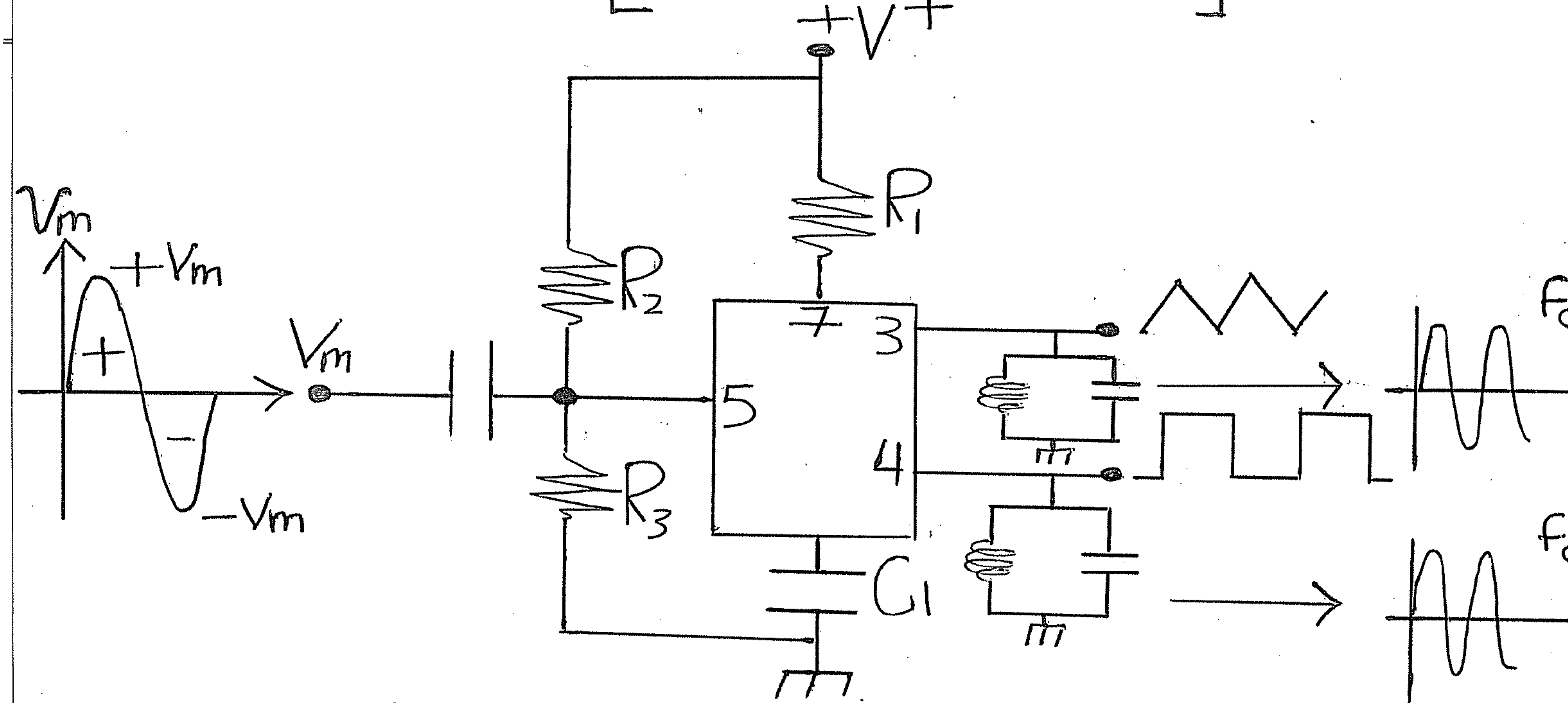
→ To be used as doupler: $f_r = 2 f_m$.

$$2000 = \frac{1}{2\pi\sqrt{LC}}$$

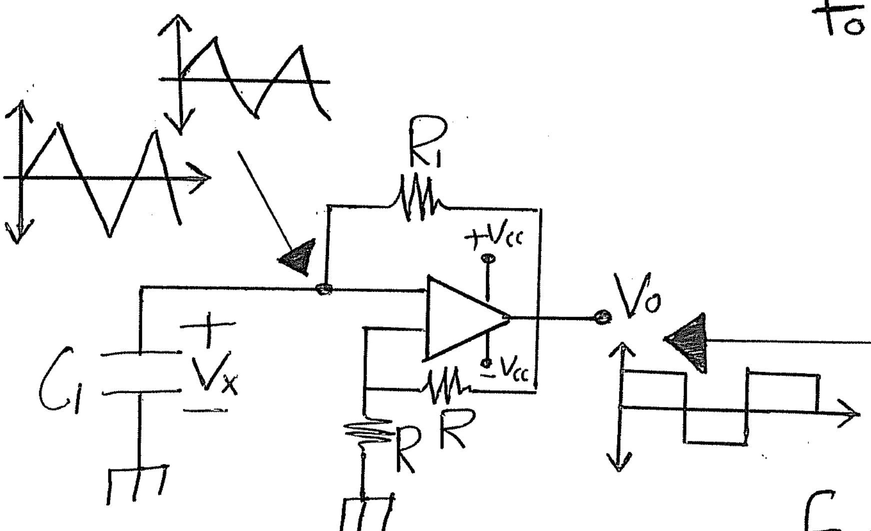
→ To be used as Trippler: $f_r = 3 f_m$.

$$3000 = \frac{1}{2\pi\sqrt{LC}}$$

Voltage - Controlled Oscillator FM mod. [VCO FM mod.] :-



$$f_o = \frac{2}{R_1 C_1}$$ (free running freq.)



[without V_c]

[Astable MTV]

$$f_o = \frac{2(V^+ - V_c)}{R_1 C_1 V^+}$$

[with V_c]

[Voltage Controlled osci].

1] Without V_c, the CCt. will oscillate at free running Mode, with: $f_o = f_c = \frac{2}{R_1 C_1}$

2] With V_c (When R_2 and R_3) are used:

$$f_o = f_c = \frac{2(V^+ - V_c)}{R_1 C_1 V^+}.$$

3] When V_m is applied:

i) when $V_m \uparrow$, $V_c \uparrow$, $f \downarrow$.

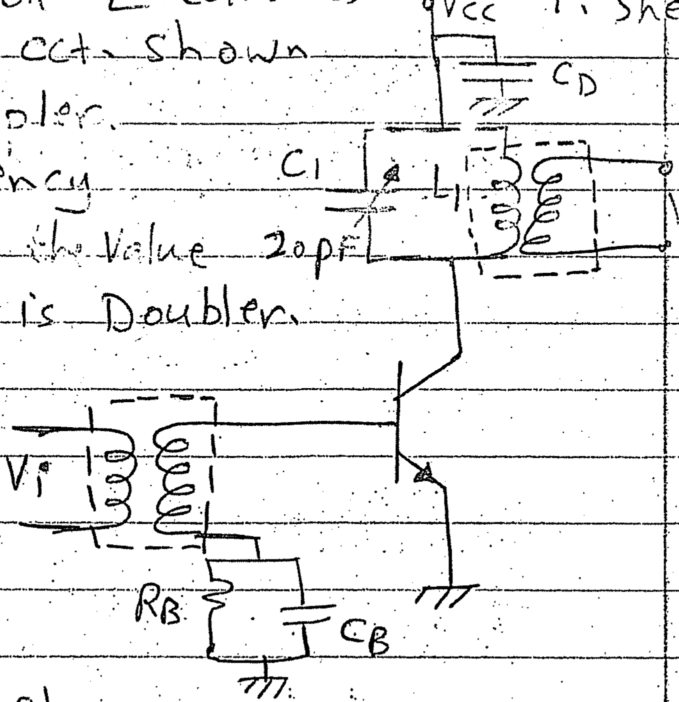
ii) when $V_m \downarrow$, $V_c \downarrow$, $f \uparrow$.

i.e The freq. of O/P is Changed accor-ding to Amp. of mod. Signal.

4] To Obtain a Sinusoidal wave (From Squate or Tringular), aparallel Tuned CCt. is used.

Communication Electronics T. sheet. No. 2

Q1: The freq. multiplier cct. shown operates as a tripler. IF the input frequency is 10 MHZ calculate the value of L_1. Repeate if it is Doubler.

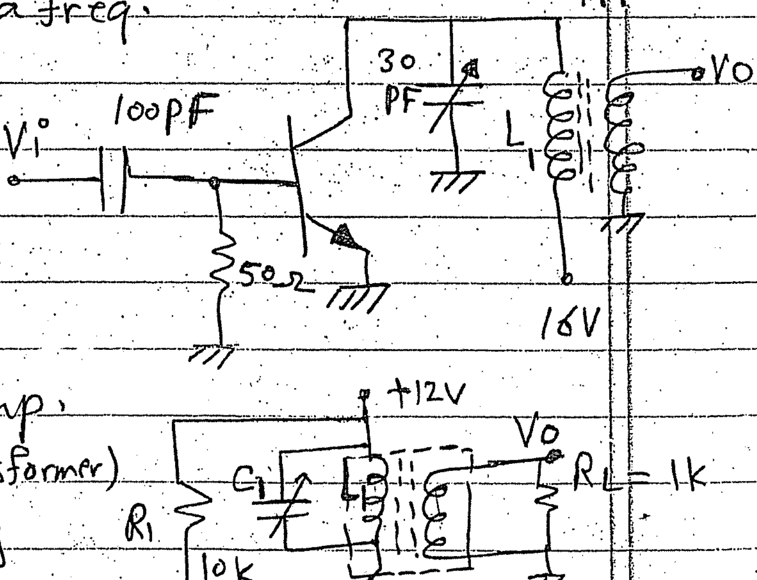


Q2: For the power Amp. shown.

(a) Indicate the class of operation and why?

(b) Assume ideal Transformer what is the Max Load voltage.

(c) IF the input voltage has a freq. of 15 MHZ. Calculate L_1 required to tune the cct. for fundemental.

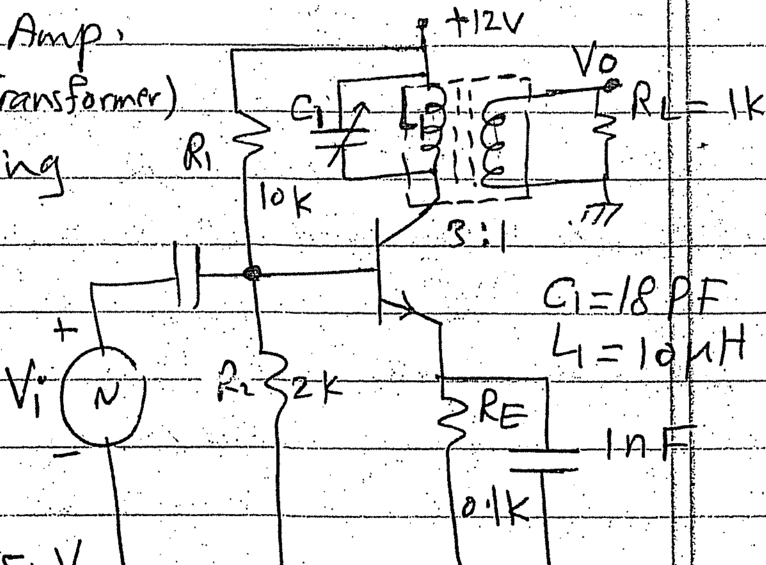


Q3: For the tuned RF Amp. shown (Assume ideal Transformer)

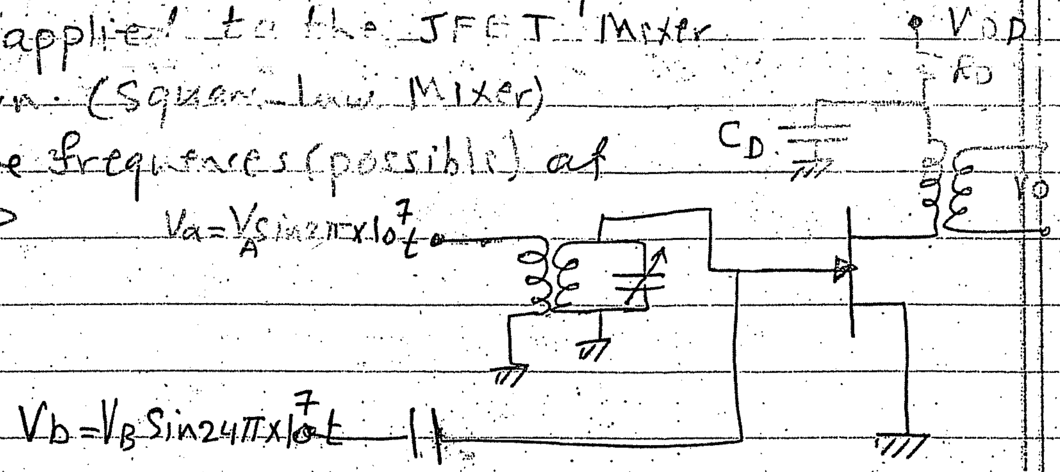
1) Calculate the operating frequency.

2) Calculate the Max. gain and selectivity and B.W?

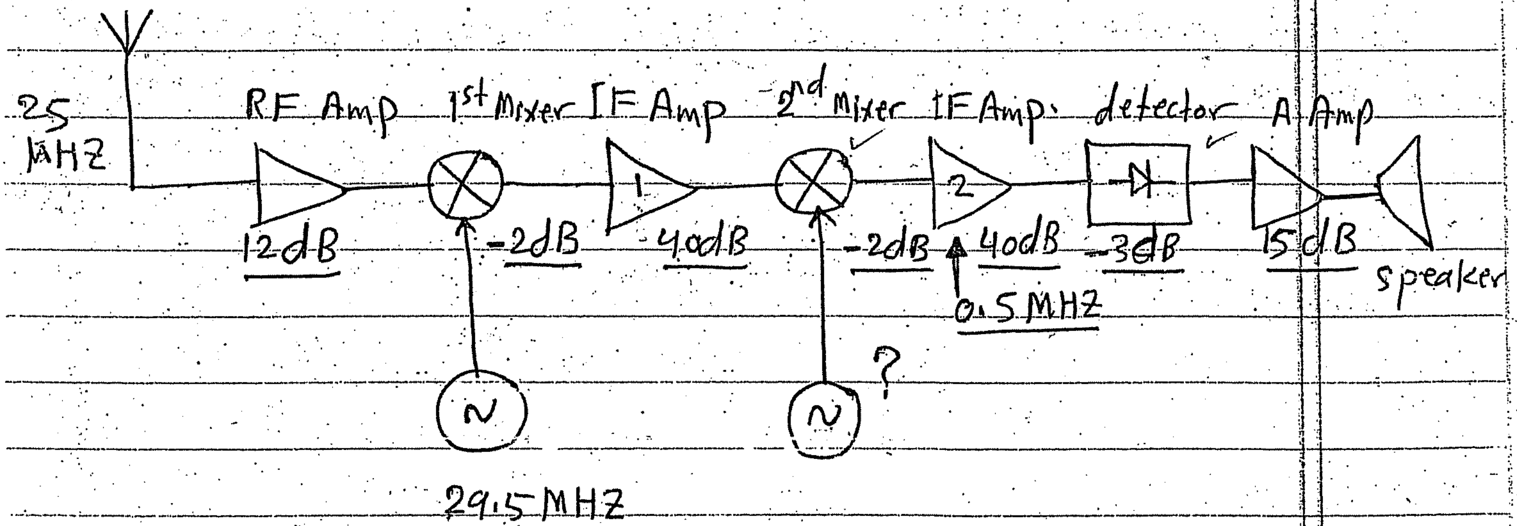
3) The peak o/p Load voltage for Vi = 2.5mV (RMS).



Q4: Sine-wave Signals with frequencies 10 MHZ (f_1) and 12 MHZ (F_2) are applied to the JFET Mixer shown. (Square-law Mixer)
Find the frequencies (possible) at the o/p?

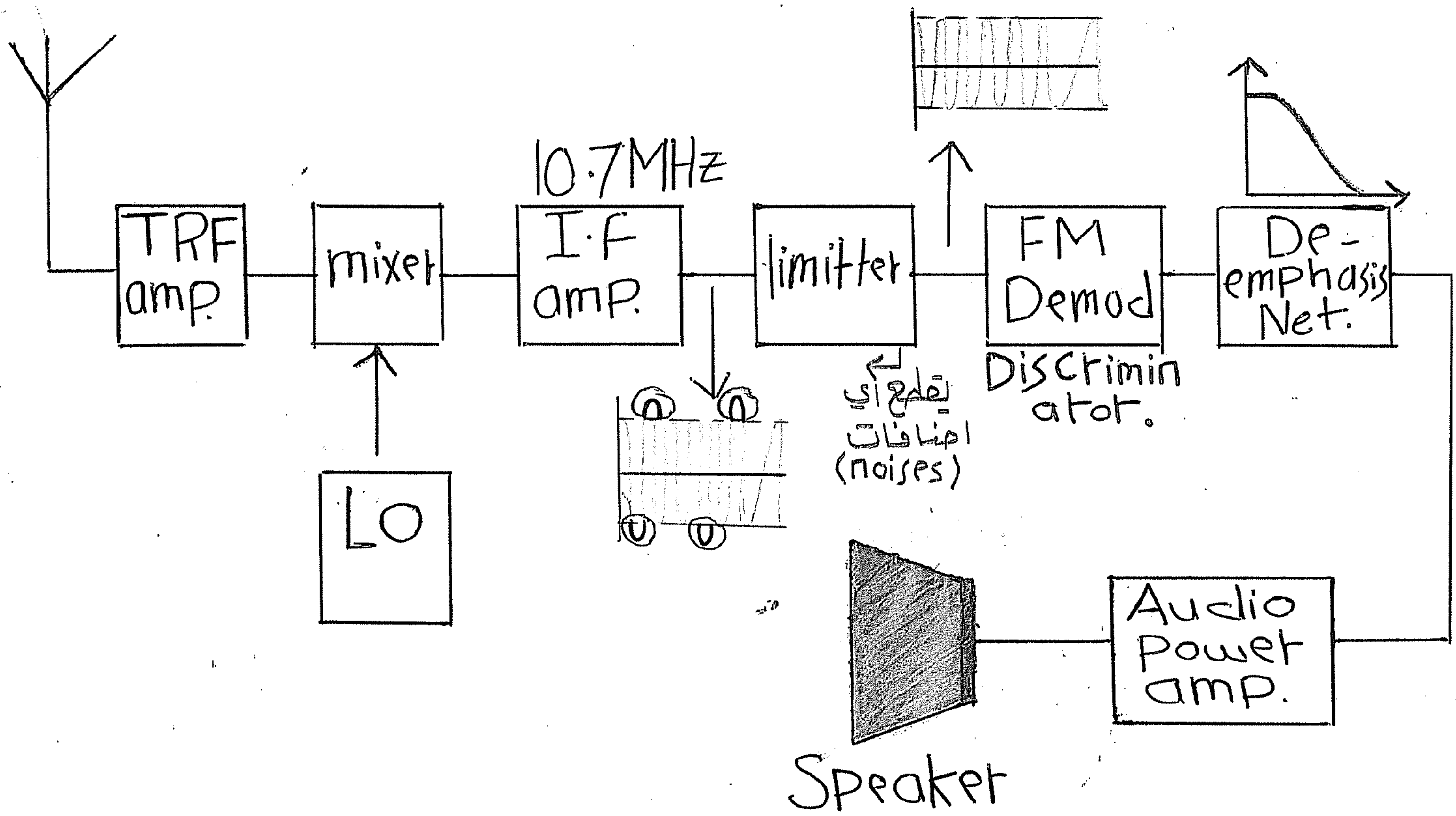


Q5: Fig. 5 shows a block diagram for double conversion AM receiver, with max. gain for each stage.



① what is the total power gain of the receiver from antenna to speaker.
② Calculate the freq of 1st IF Amp & 2nd Local oscillator (4.5; 5 HSI or 4 LSI)
③ what is the Min. Signal required at antenna in order to get 0.5W power at speaker. (in µV) assume 50Ω impedance antenna.
④ Calculate Po for $V_i = 30\mu V$ at the antenna.

FM - Receiver :



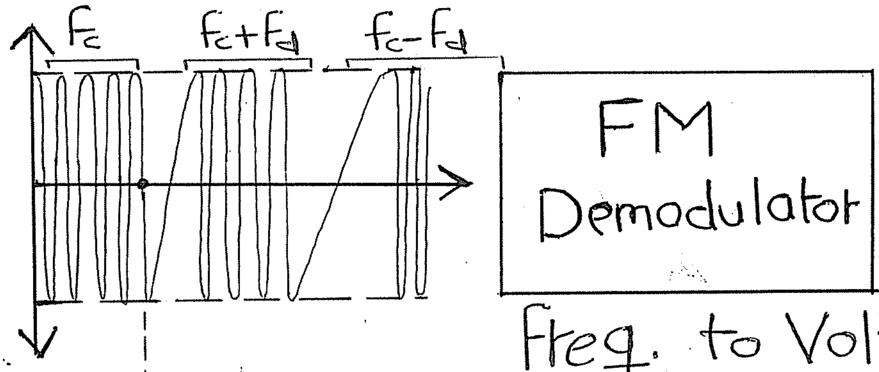
→ @ Transmitter :→ pre-emphasis Net. (HPF)

→ @ Recevier :→ De-emphasis Net. (LPF)

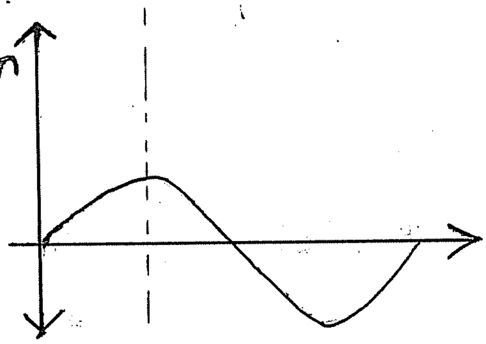
FM-Demodulator :-

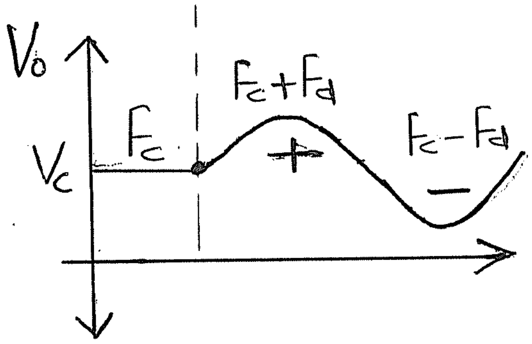
1) Slope Detector :-

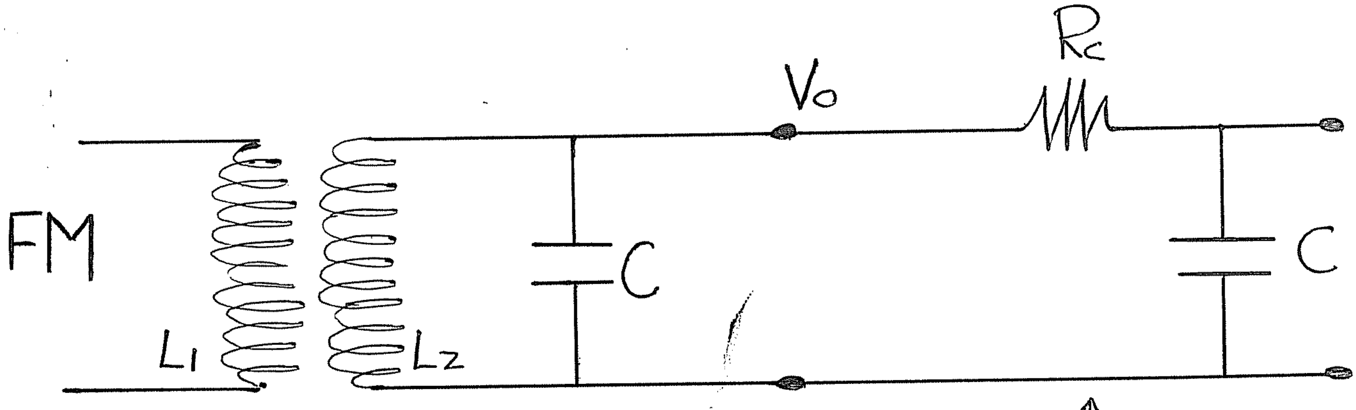
FM mod:
Voltage to Freq
Conversion



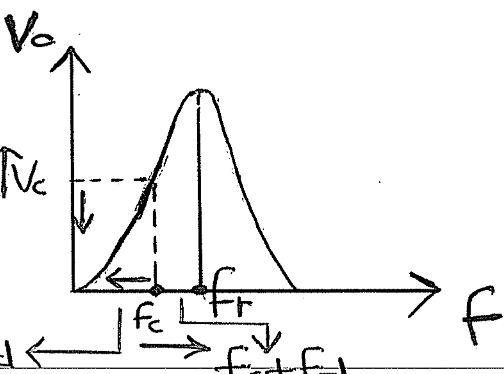
Freq. to Voltage
Conversion.







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



low pass filter
S.C for carrier Sig.
O.C for modulating Sig.

فنحصل على ال mod. Sig.

1) f_r of the tuned cct. must be Choosen such that $f_r > f_c$.

2) f_c must be in the Center of linear part of the response.

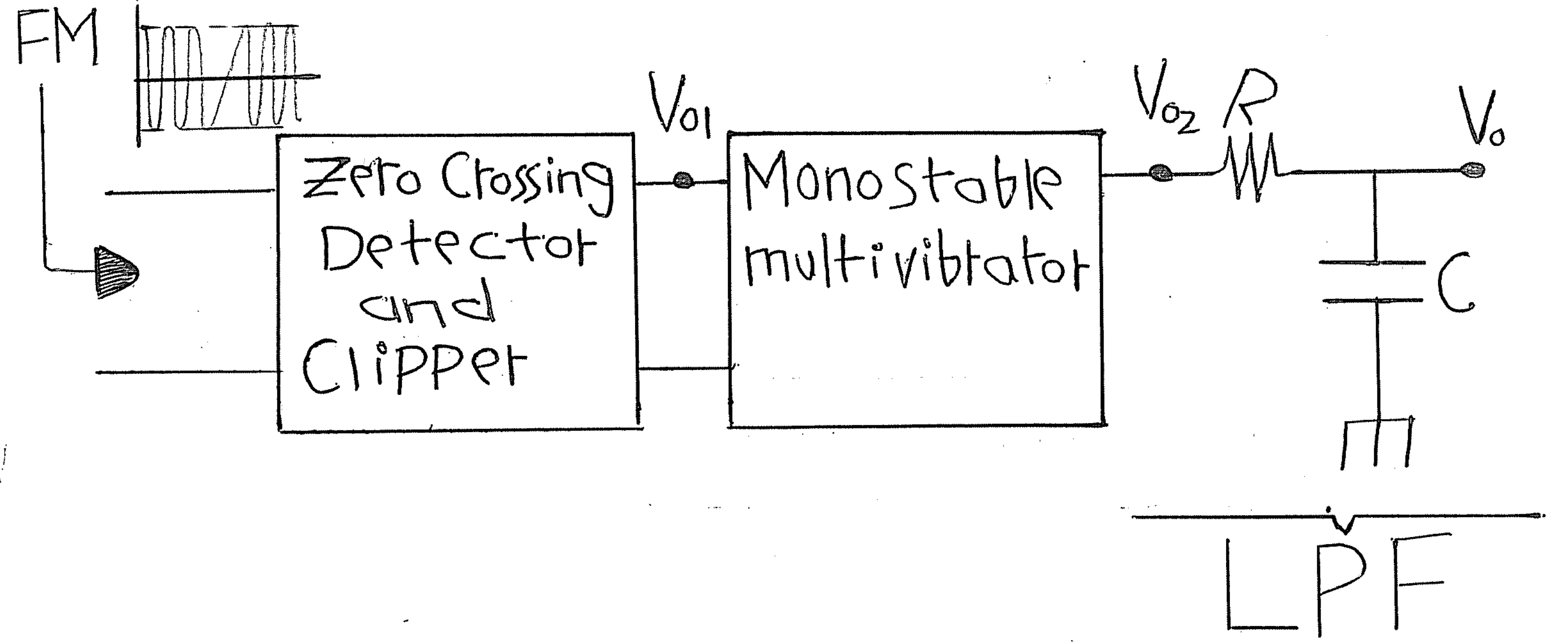
3) i) When $f = f_c$, $V_o = V_c$.

ii) for $f > f_c$, $V_o \uparrow$.

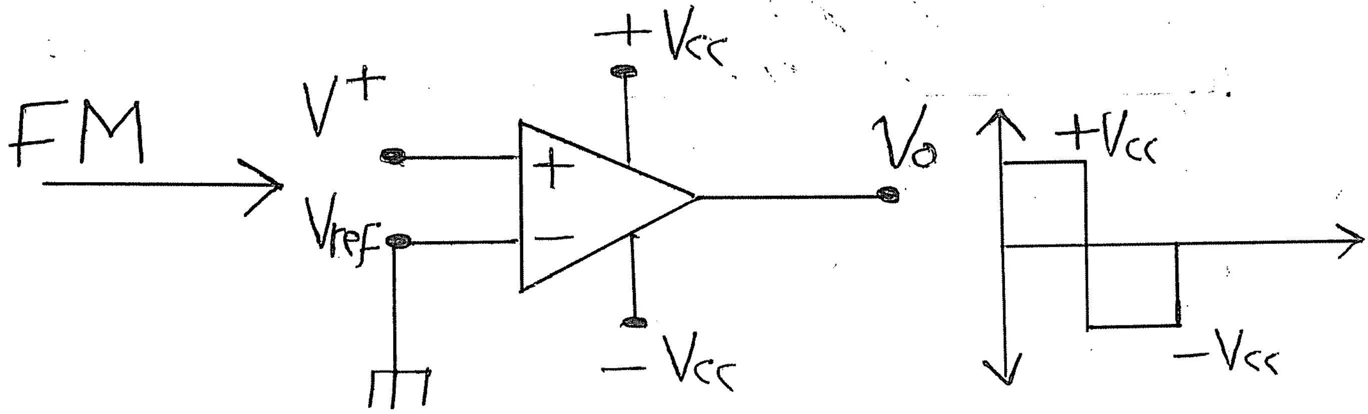
iii) For $f < f_c$, $V_o \downarrow$.

4) This means that o/p of the tuned cct. will be proportinal to freq. of the FM input Signal.

2) Pulse - averaging FM Demod. :-



Zero-Crossing Detector :
(Voltage Comparator with $V_{ref} = 0$)



$V_o \triangleq A_{OL} (V^+ - V^-)$

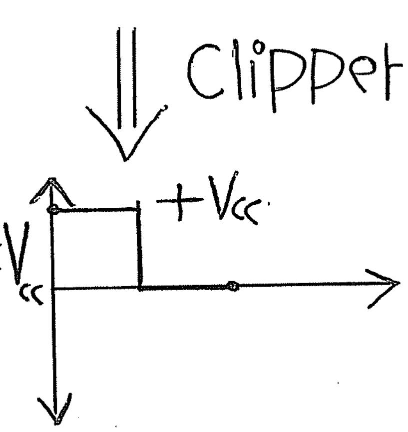
A_{OL} : open-loop gain.

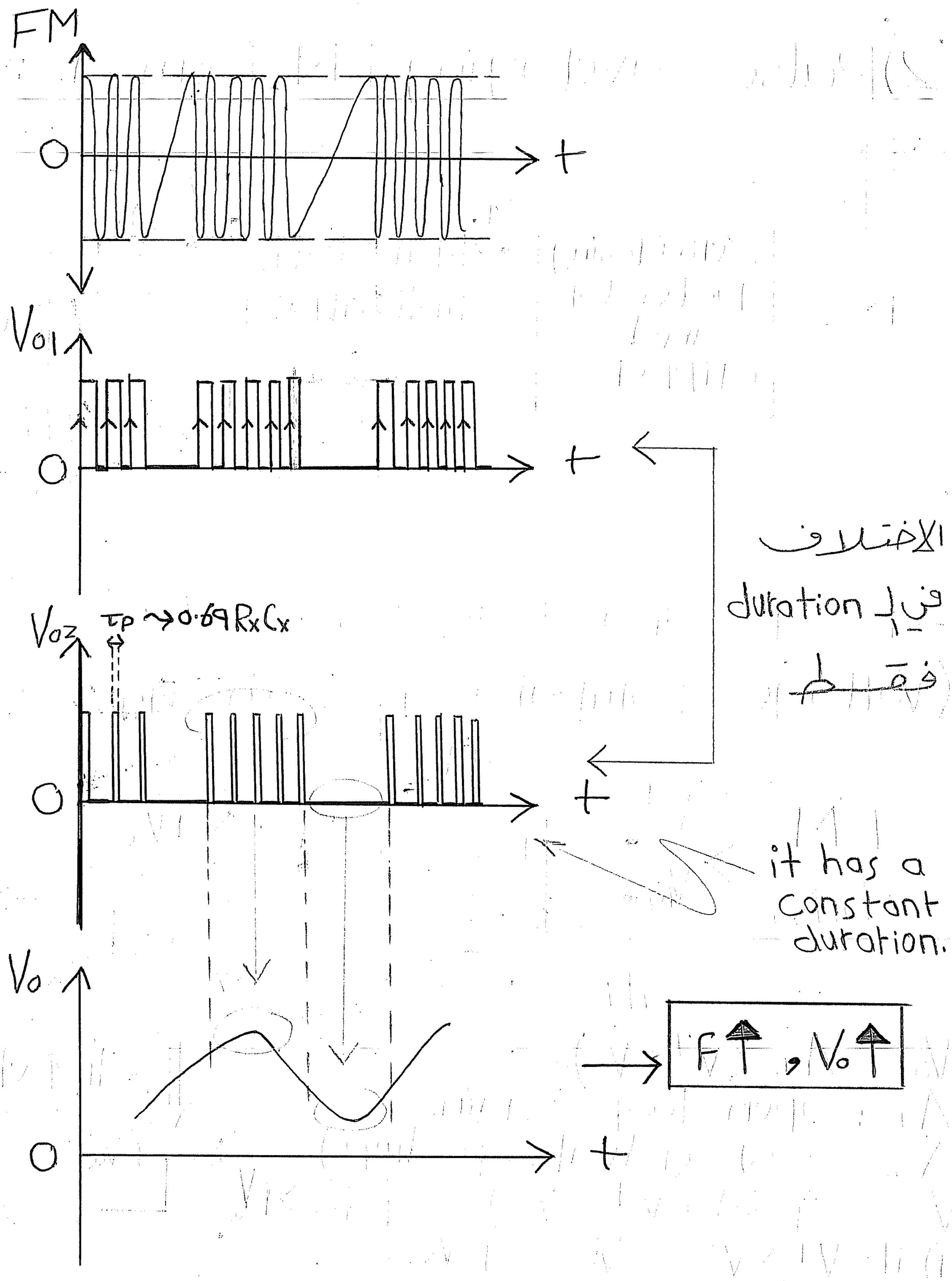
$A_{OL} = \infty$ (ideal op-Amp.)

$V_o = \mp \infty (V^+ - V^-) = \mp \infty \Rightarrow \mp V_{cc}$

① if $V^+ > V^-$, $V_o = +V_{cc}$.

② if $V^+ < V^-$, $V_o = -V_{cc}$.




FM
O
t
V_{o1}
O
t
V_{o2}
$\tau_p \rightarrow 0.69 R_x C_x$
O
t
الاختلاف
في ال duration
فقط
it has a constant duration.
V_o
O
t
F↑ , V_o↑

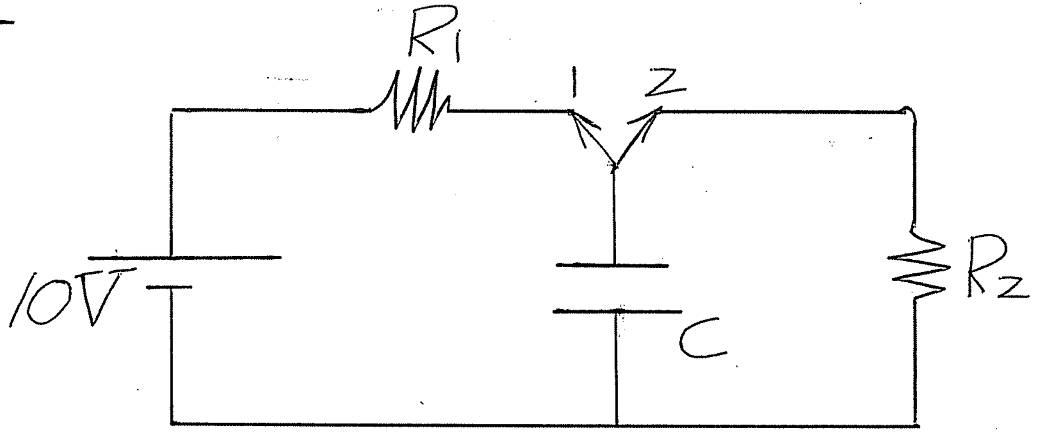
RC must be Choosen (design) to have avery large time constant.

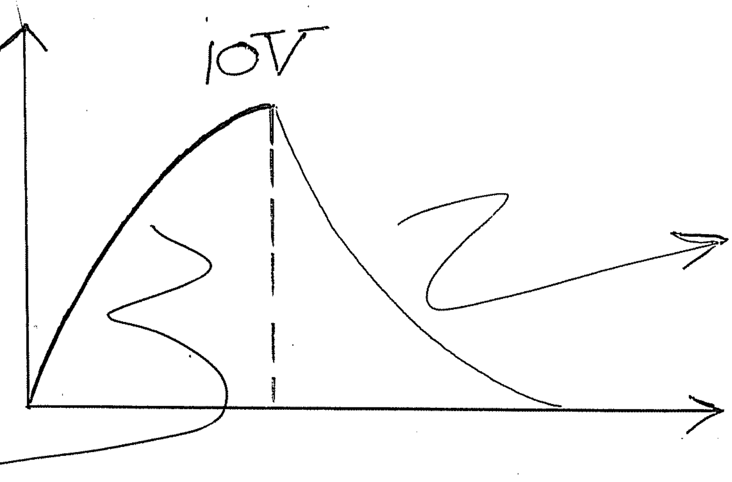
$$T = R \cdot C \gg T_{max}$$

$$T_{max} = \frac{1}{f_{max}}$$, f_{max} : max Freq. in FM Sig.

$\rightarrow f_{max} = f_c + f_d$.

<u>note:-</u>

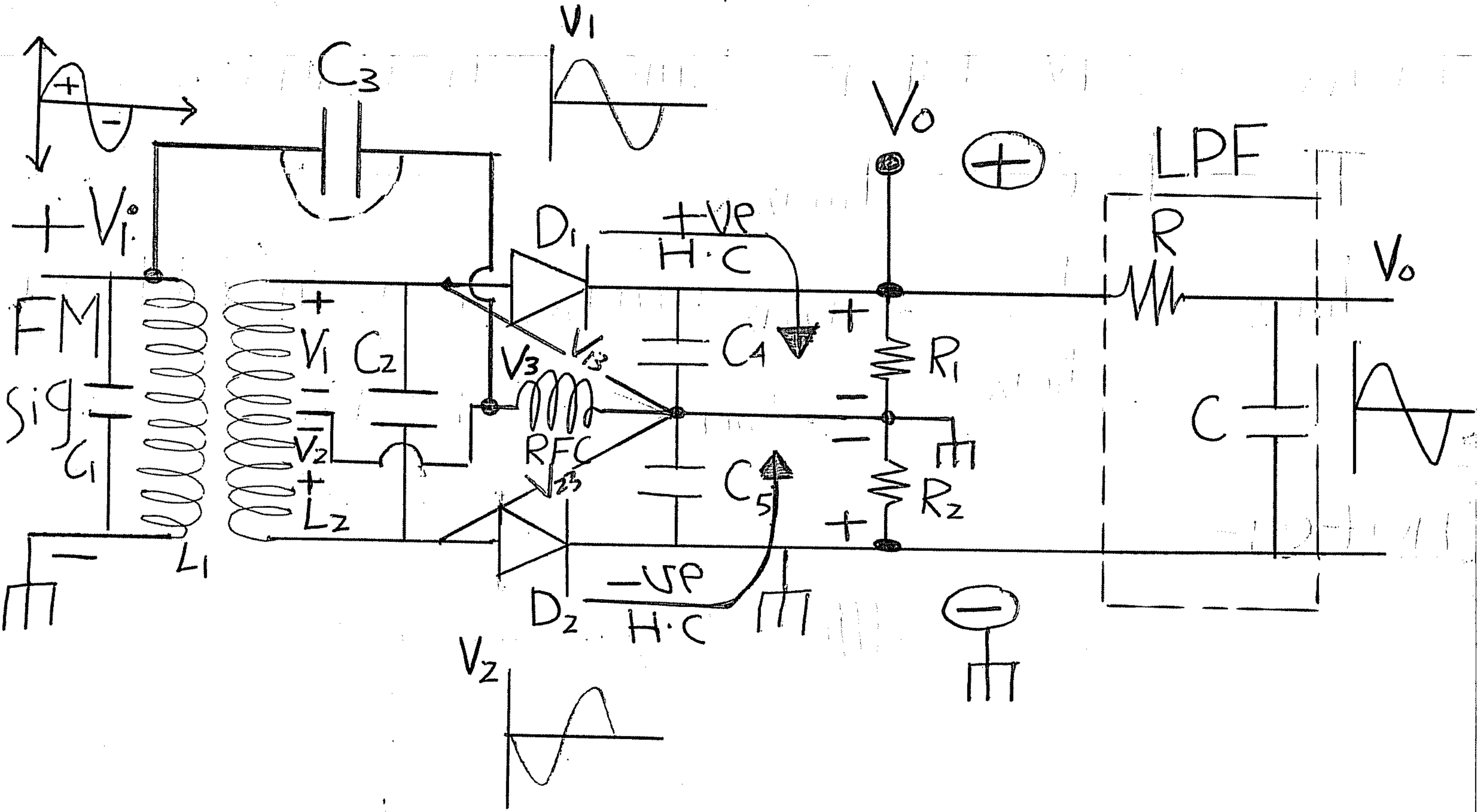




$\tau = 5R_2C$
وقت التفريغ

$\tau = 5R_1C$
وقت الشحن

3) Foster - Seely Discriminator :-



→ C_3 and C_5 are very large. So $V_i = V_3$.

1) For Center Tap Transformer :

V_1 and V_2 are 180° phase Shift.

2) For air-Core Trans. with Tuned CCt. at primary and Secondary, The phase Shift between V_i and (V_1 and V_2) is 90°

$$f_c = \frac{1}{2\pi\sqrt{L_1C_1}} = \frac{1}{2\pi\sqrt{L_2C_2}}.$$

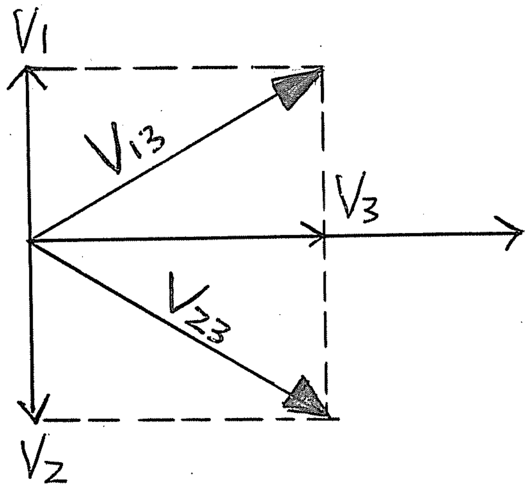
at Resonance :

$(V_i = V_3)$ is 90° phase shift with (V_1) and (V_2).

1) at $f = f_c$:

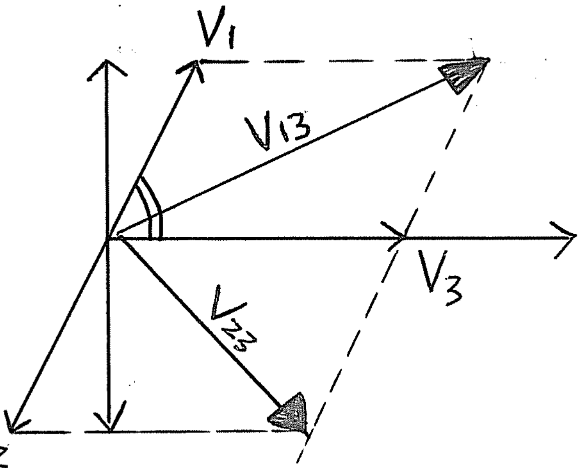
$V_{13} = V_{23}$

$\rightarrow V_o = 0$.



2) for $f = f_c + f_d$:

$X_L > X_c$: inductive cct.



V_1 will lead V_3 by less than 90°. (because the Secondary tuned cct. will be inductive)

$V_{13} > V_{23}$

So V_o will be +Ve.

$X_L = 2\pi f L$

$X_c = \frac{1}{2\pi f C}$

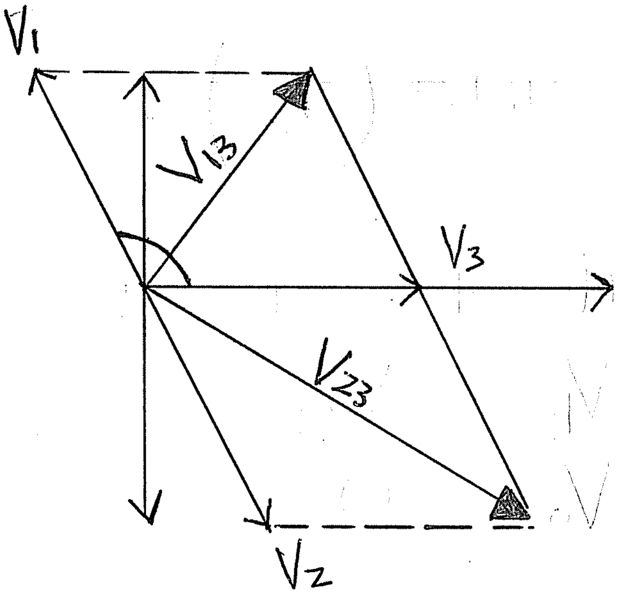
for $f = f_c - f_d$:

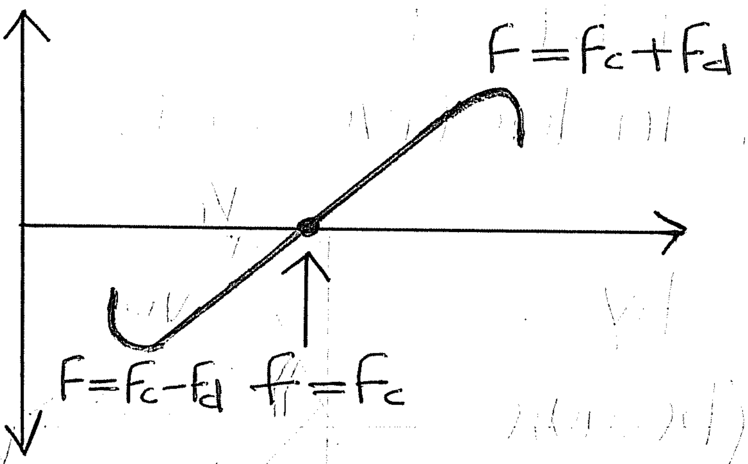
$X_c > X_L$: Capacitive cct.

V_i will lead V_3 by more than 90°.

$V_{23} > V_{13}$

So V_o will be −ve.





LPF permitts only the modulating signal to pass through it	• LPF تمرر فقط modulating Signal

* Foster − Seely Requires limitter cct. after I.F amp.

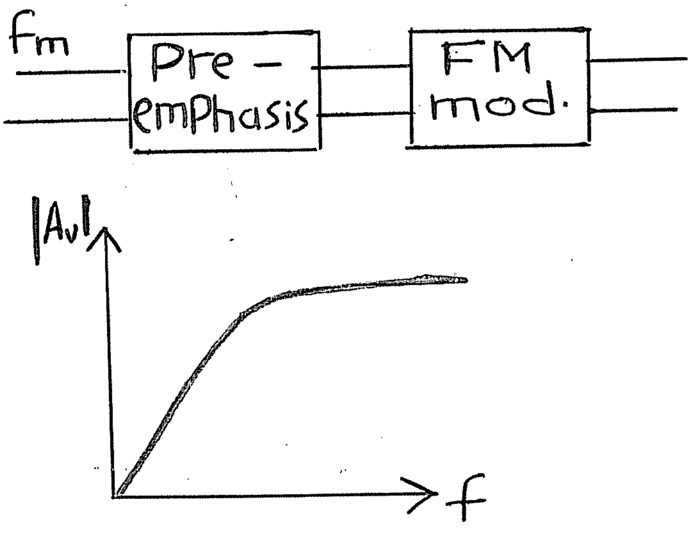
* disadvantages : bulky size. − affected by noise.

* not exact o/p ↲ Preproduced modulatig sig.

FM ← تتأثر بال noise ، ولأنه V_o يعتمد على V_m ، فلا يكون exact

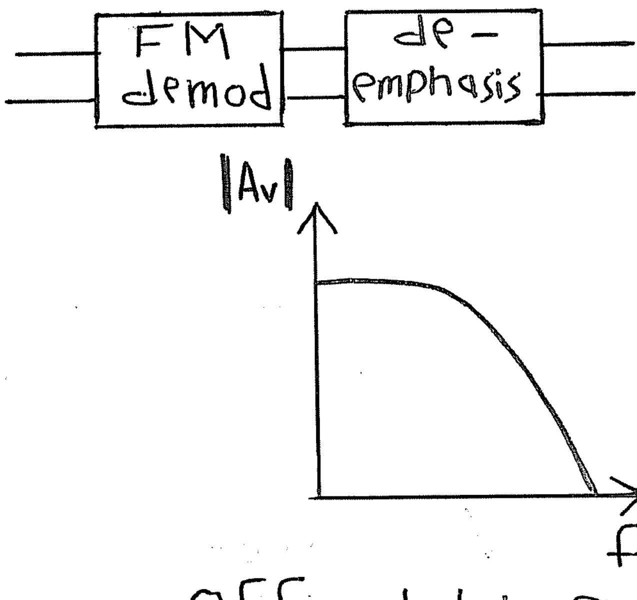
noise : high freq. Component.
↳ interference between noise and high freq. Component of message Signal.
↳ Freq. destortion.

Tx



enhancement

Rx

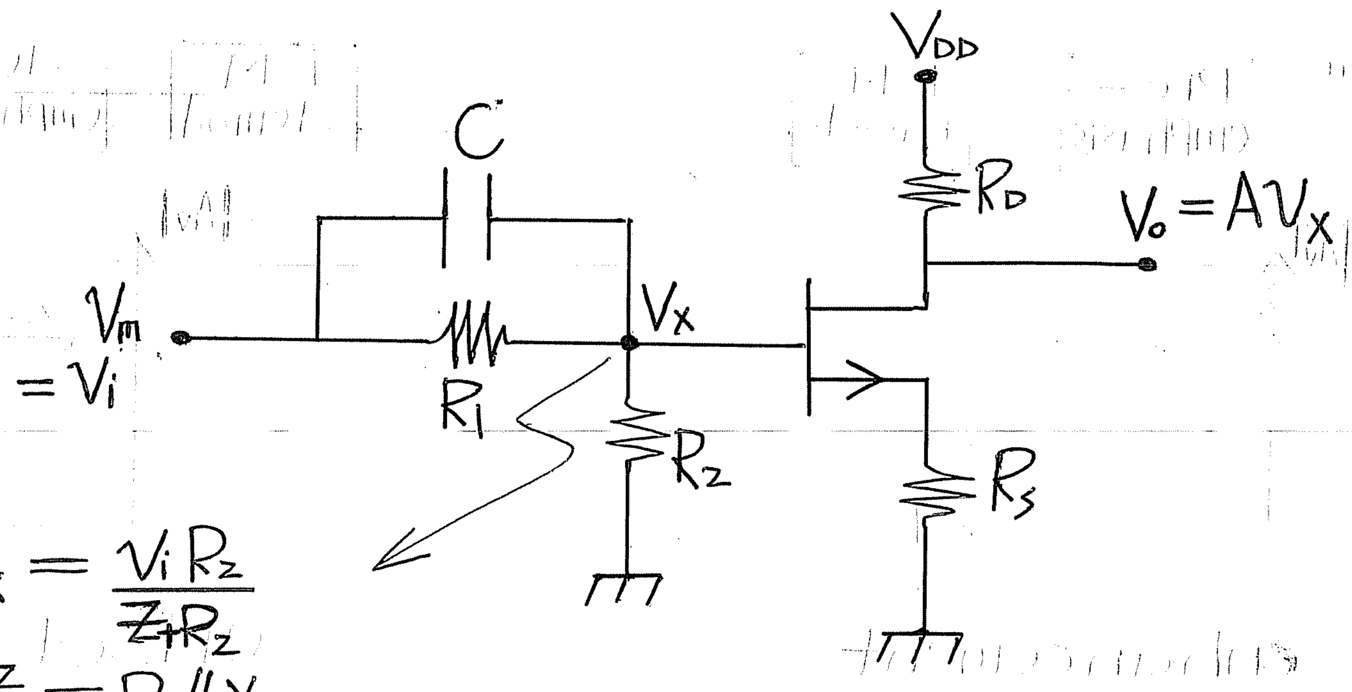


Offsetting.

Pre-emphasis :-

To avoid the effect of Noise (high-freq.) on high freq. Component of message Signal and improve (S/N) ratio, (Signal / noise) we use pre-emphasis cct. (Normally HPF) inserted befor FM mod. used to enhance high-freq. component and improve (S/N) ratio.

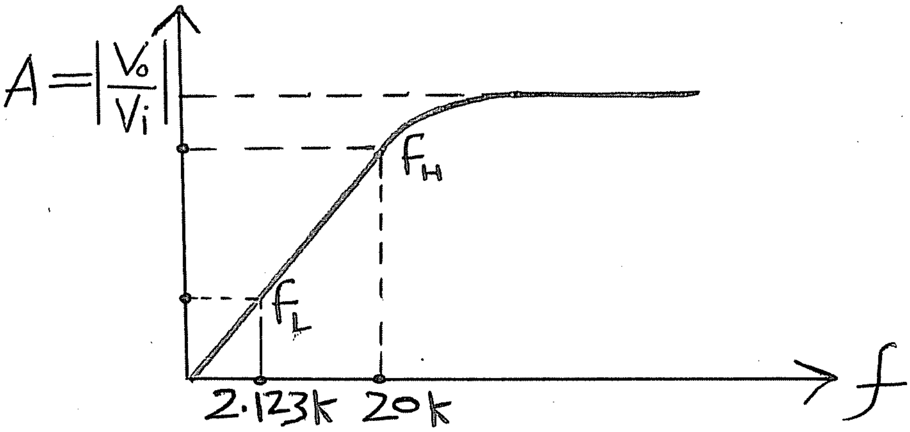
The Standered cct :-



* $V_x = \frac{V_i R_2}{Z + R_2}$

→ $Z = R_1 // X_c$

* $V_o = A V_x$



$$f = \infty \longrightarrow C \to \infty \longrightarrow \boxed{V_x = V_i}$$

$$\boxed{\frac{V_o}{V_i} = A}.$$

$$f_L = \frac{1}{2\pi R_1 C} = 2.123\ \text{kHz}. \quad \boxed{R_1 C = \tau = 75\,\mu s}$$

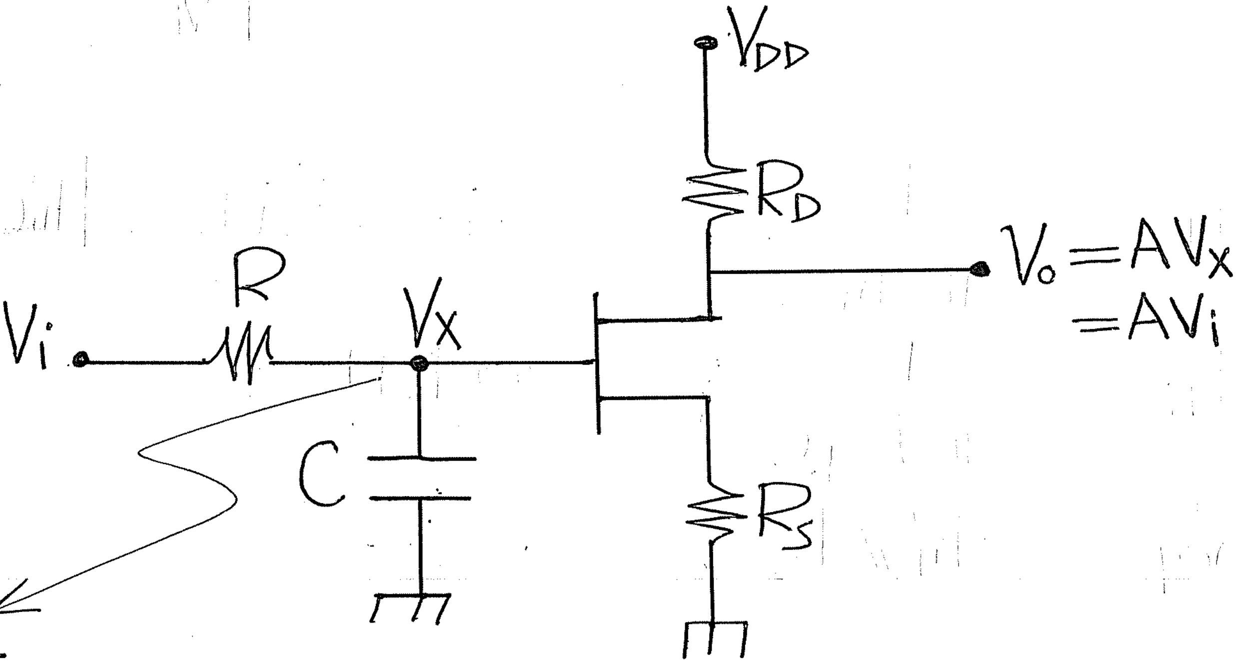
$$f_H = \frac{1}{2\pi R_{eq} C} = 20\ \text{kHz}.$$

$$R_{eq} = R_1 \parallel R_2.$$

De-emphassis :

To offset the effect of pre-emphassis cct. on message Signal and return message - Signal to its Normal level.

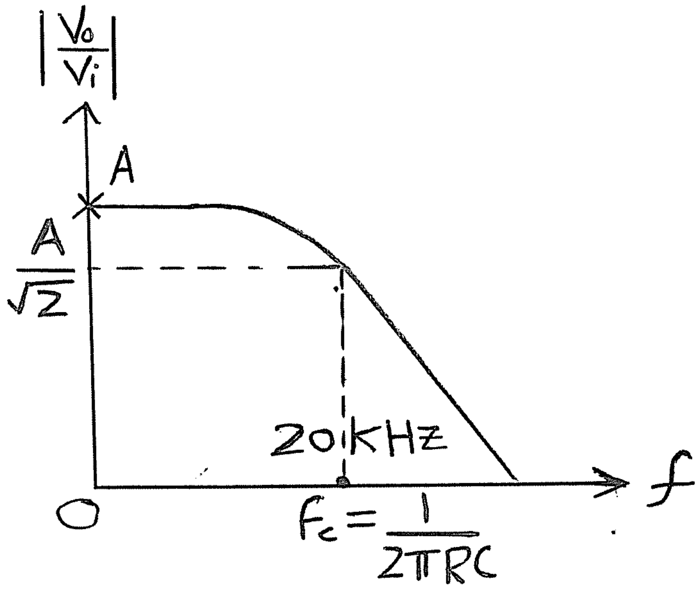
* We use De-emphassis cct. in the R_x and it is a (LPF) Connected in R_x.



$$V_x = \frac{V_i X_c}{R + X_c}$$

$$X_c = \frac{1}{2\pi f C}$$

$$V_x = \frac{V_i}{1 + \frac{R}{X_c}}$$



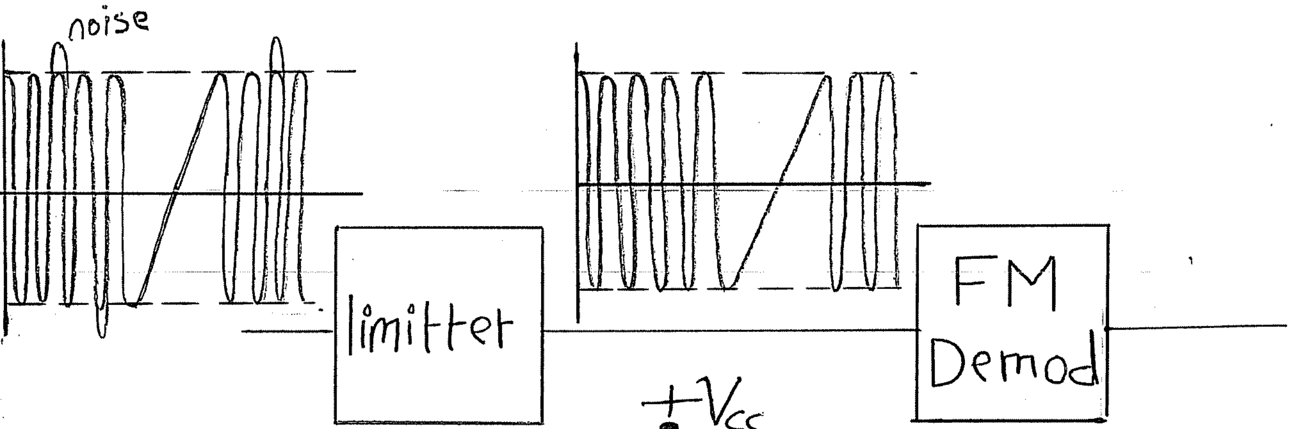
$$\frac{V_o}{V_i} = A V_x = \frac{\frac{A V_i X_c}{X_c + R}}{V_i}$$

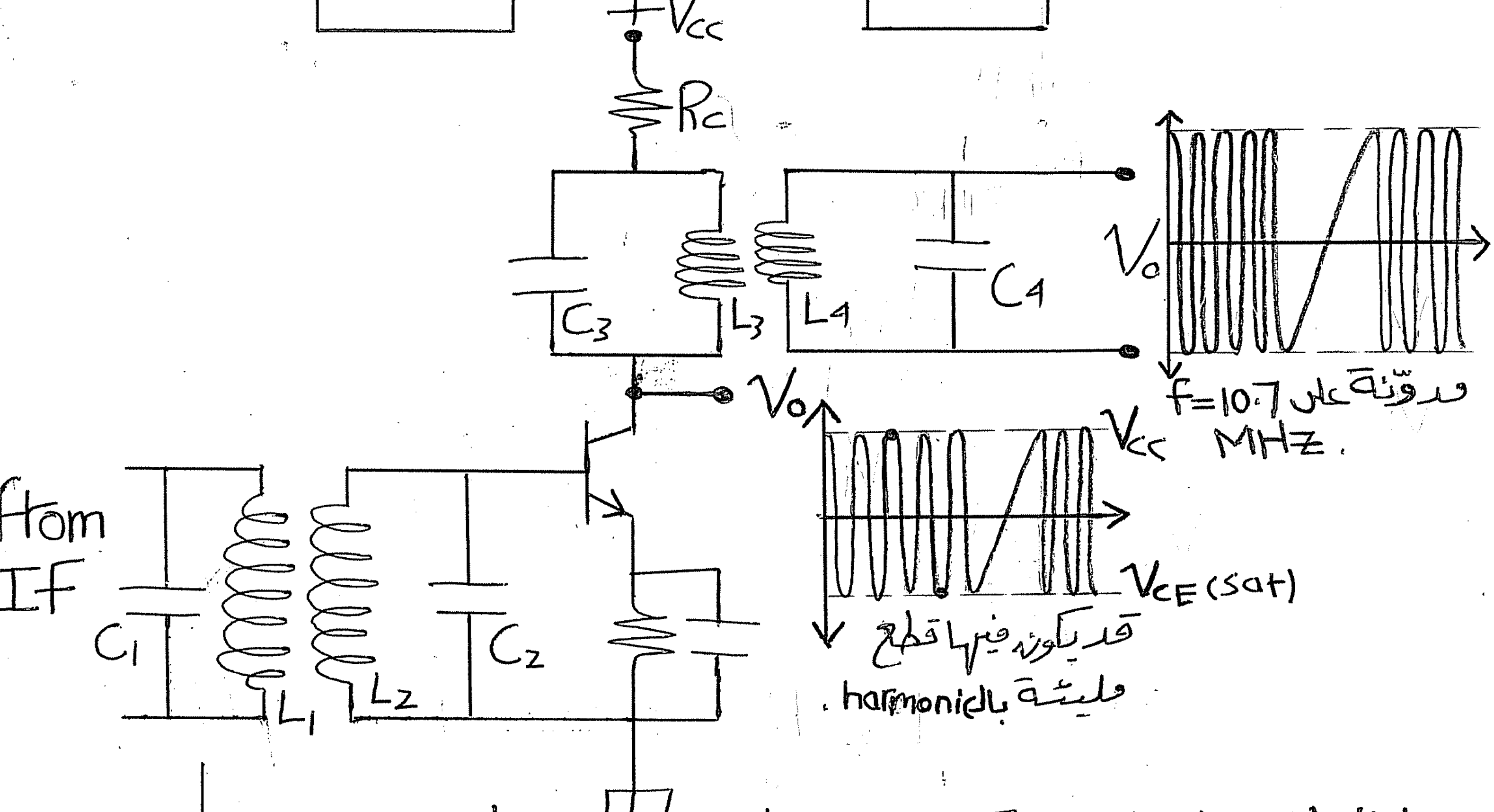
$$V_x = \frac{A}{\sqrt{1 + \left(\frac{R}{X_c}\right)^2}}$$

$$\hookrightarrow \frac{R}{X_c} = 1 \rightarrow 1 = 2\pi f R C$$

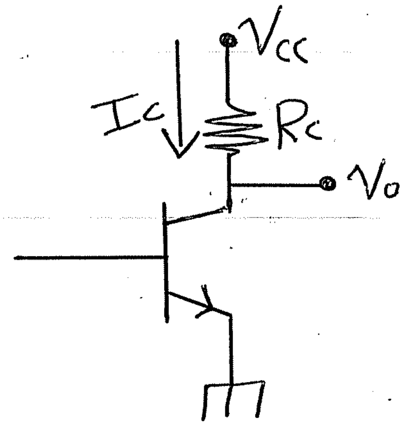
$$f = \frac{1}{2\pi R C}$$

EICoM
ELECTRICAL COMPUTER MECHATRONICS





$$f_r = \frac{1}{2\pi\sqrt{L_1C_1}} = \frac{1}{2\pi\sqrt{L_2C_2}} = f_{IF} = 10.7\,MHZ$$



$$V_o = V_{cc} - I_cR_c$$

→ off : $V_o = +V_{cc}$

→ Sat. : $V_o = V_{CE(sat.)}$

Limiter : a CCt. which gives a Constant amplitude output, Normally it is a Transistor CCt. biased to work a Switch giving $V_o \rightarrow \boxed{V_{CE(sat)} \rightarrow V_{cc}}$. The Output is Taken from parallel Tuned CCt. resonant at :

$$f_r = \frac{1}{2\pi\sqrt{L_3 C_3}} = \frac{1}{2\pi\sqrt{L_4 C_4}} = f_{IF} = 10.7 MHz$$

→ Transmitter :

AM → pre-emp. لايوجد *

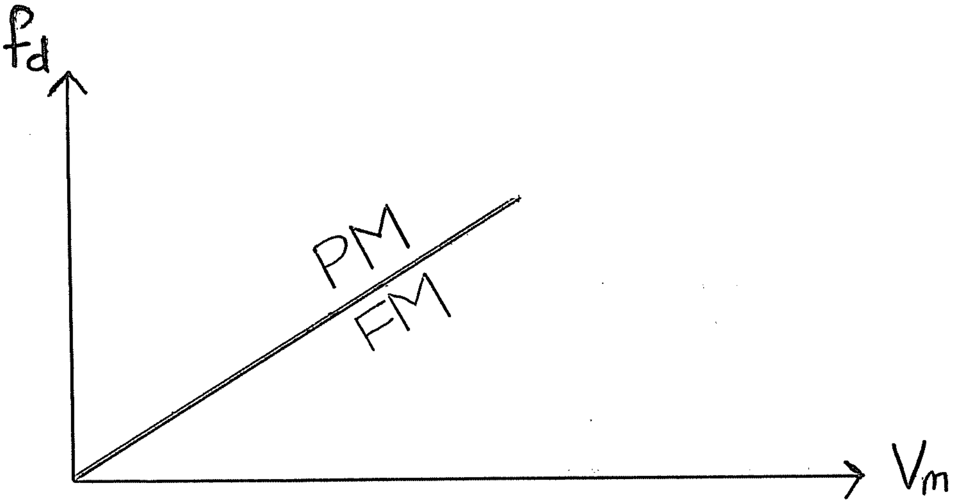
FM → pre-emp. يوجد *

→ Recevier :

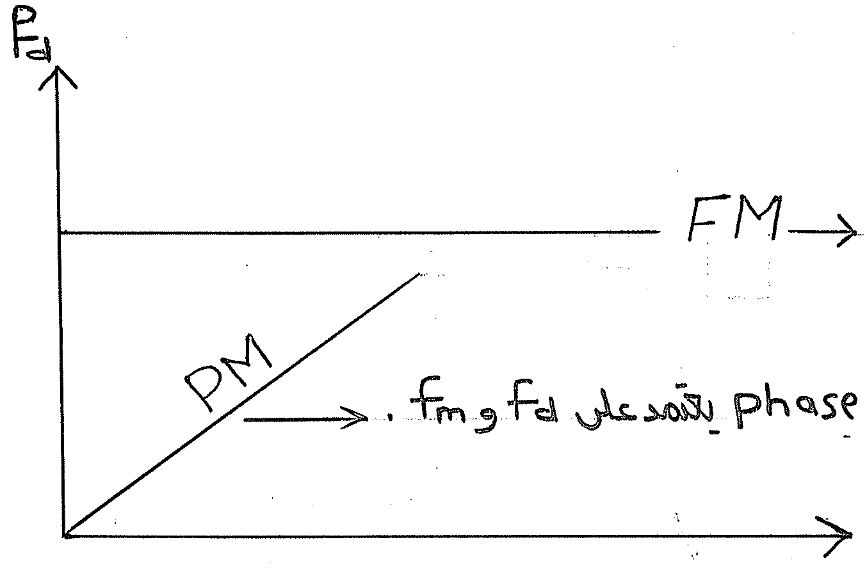
AM → limiter لايوجد / De-emp. لايوجد *

FM → limiter يوجد / De-emp. يوجد *

Phase Modulator :-



↳ amplitude of message signal.

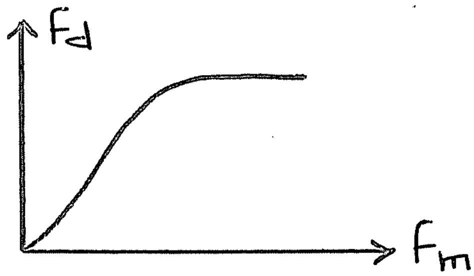


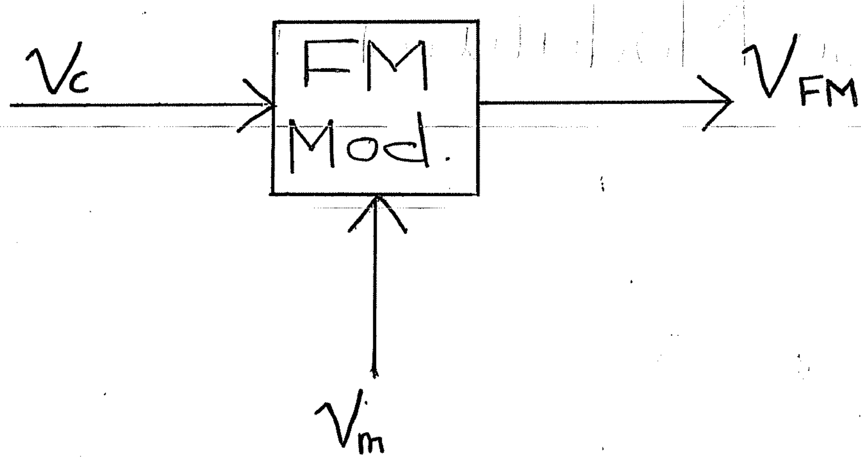
FM → لايوجد علاقة : f_d لا يعتمد على f_m

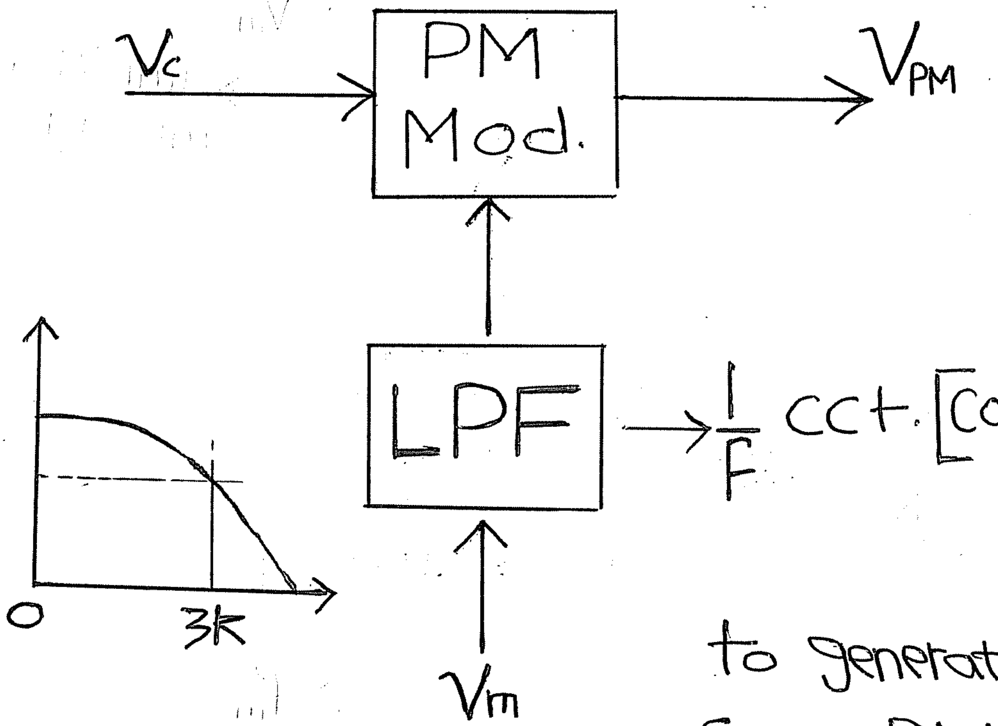
PM → phase of carrier يعتمد على f_d و f_m .

↳ Freq. of message.

high freq. component of modulating signal ; gives f_d ↑







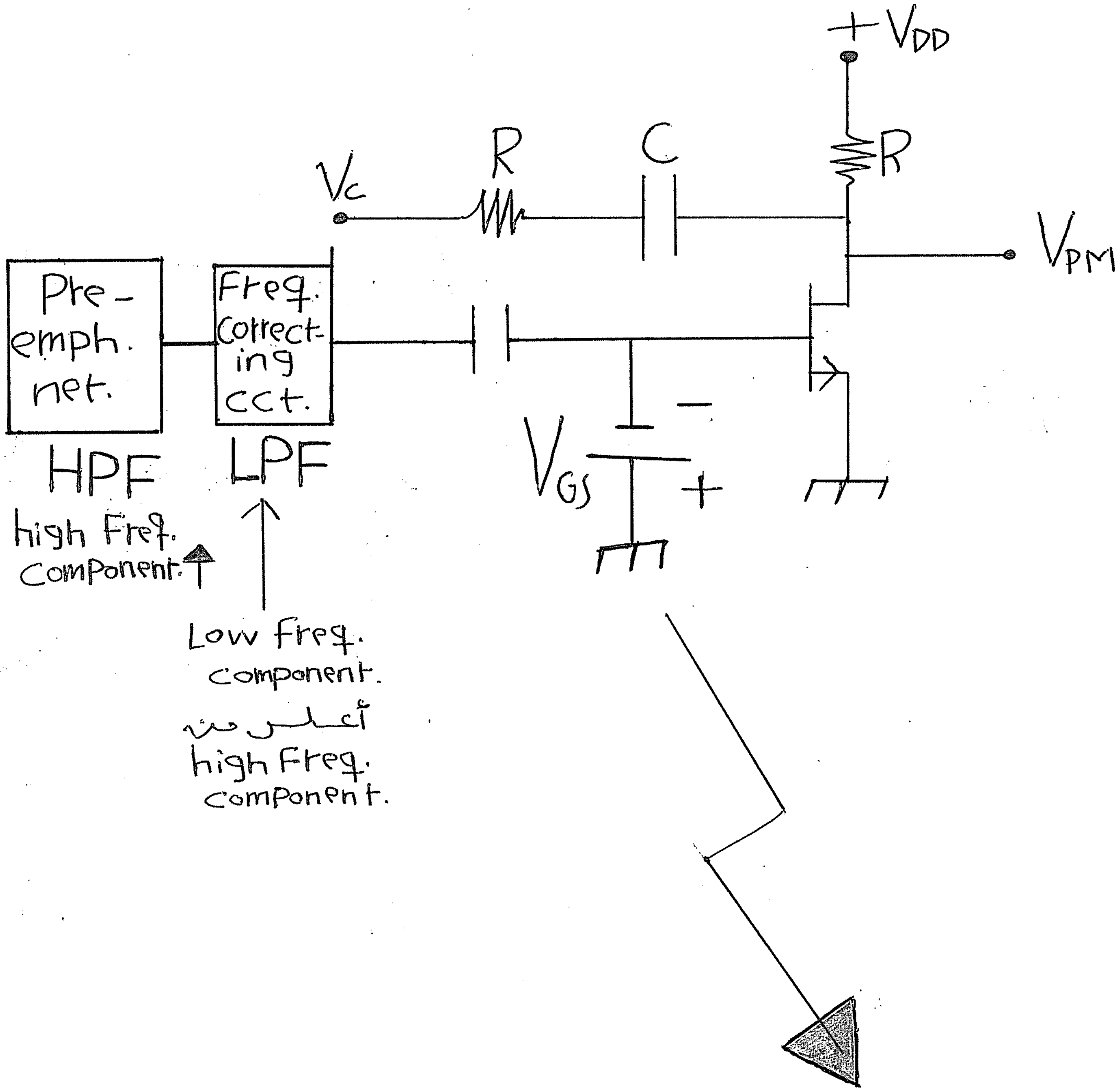
→ $\frac{1}{F}$ cct. [correcter cct.].

↑

to generate FM from PM, we use freq. correcting net. #

it is simply a LPF connected between message signal and phase modulator. (indirect generation).

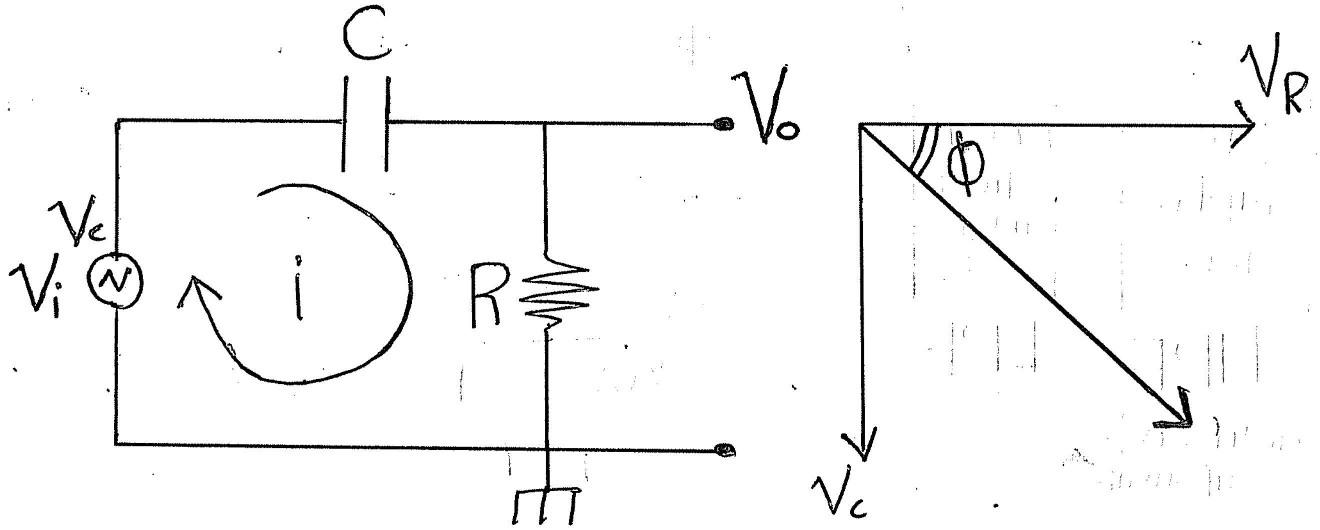
Indirect generation of FM Signal:



Armstronge FM generator.

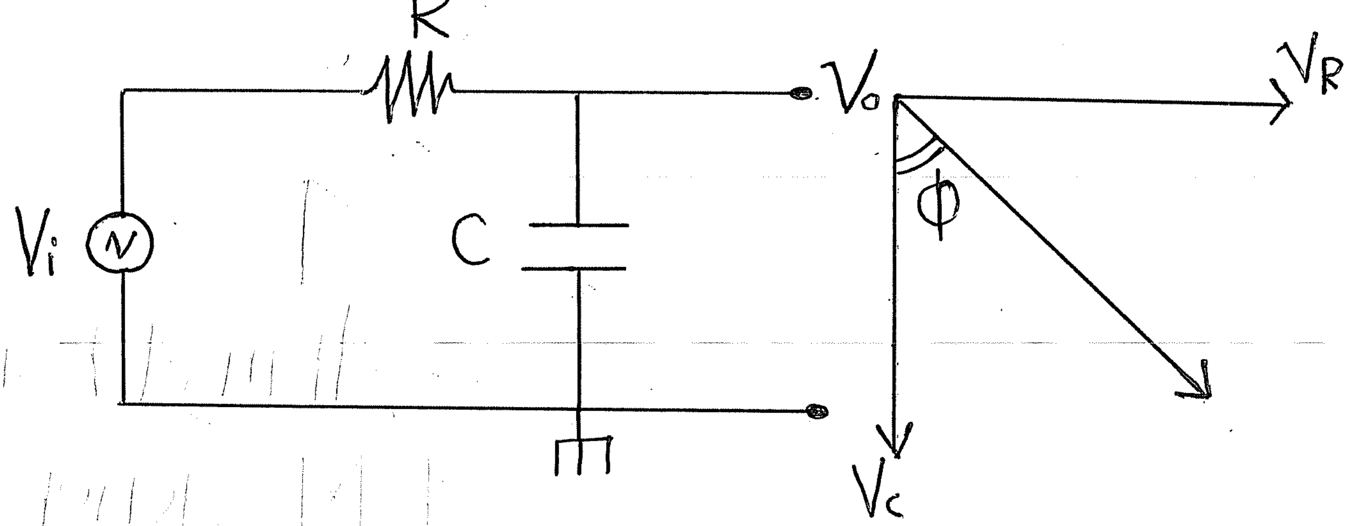
Phase Mod :- Changing the Phase of Carrier according to amp. of modulating Signal.

1]



$$\phi = \tan^{-1} \frac{V_c}{V_R}$$
$$= \tan^{-1} \frac{X_c}{R}.$$

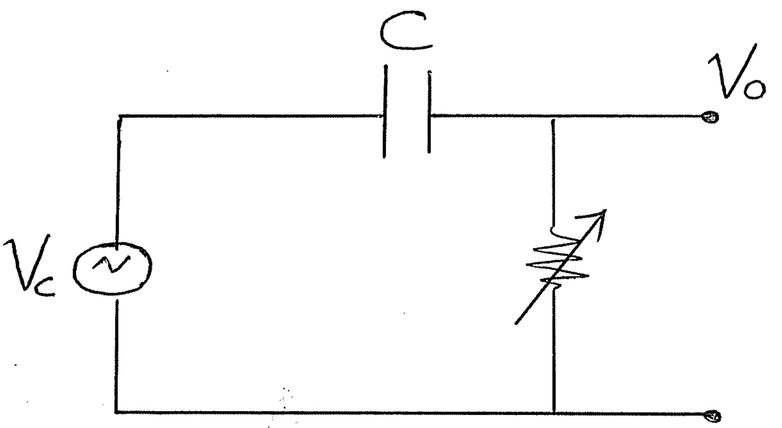
2]

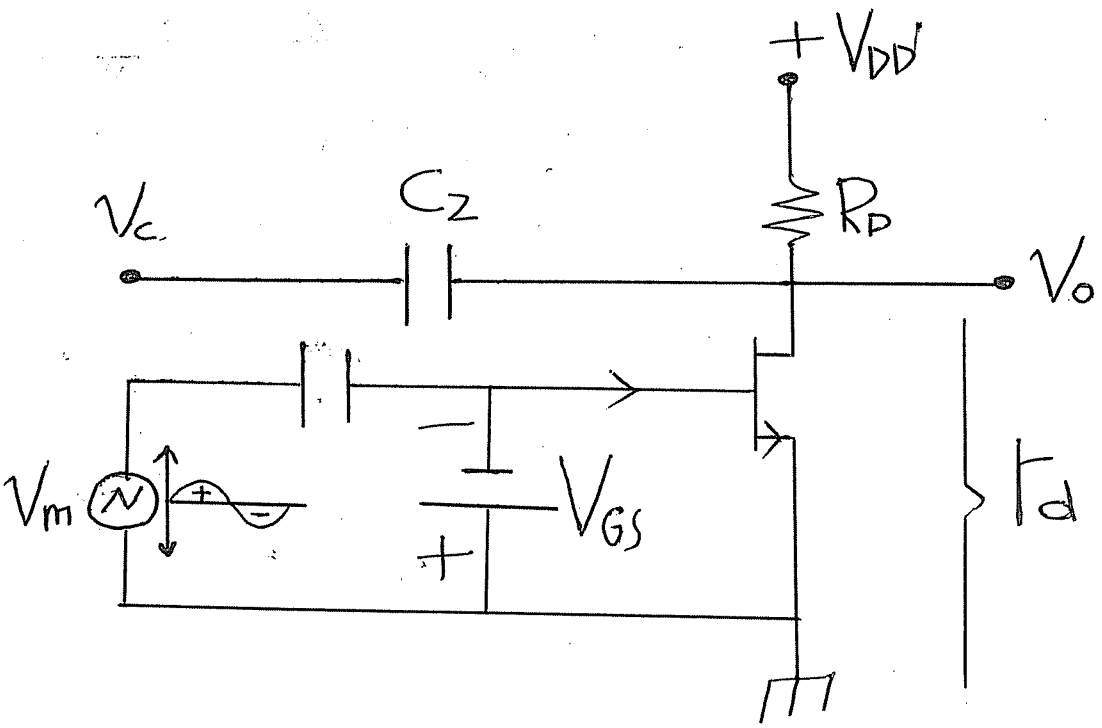


$$\phi = \tan^{-1} \frac{R}{X_c}$$

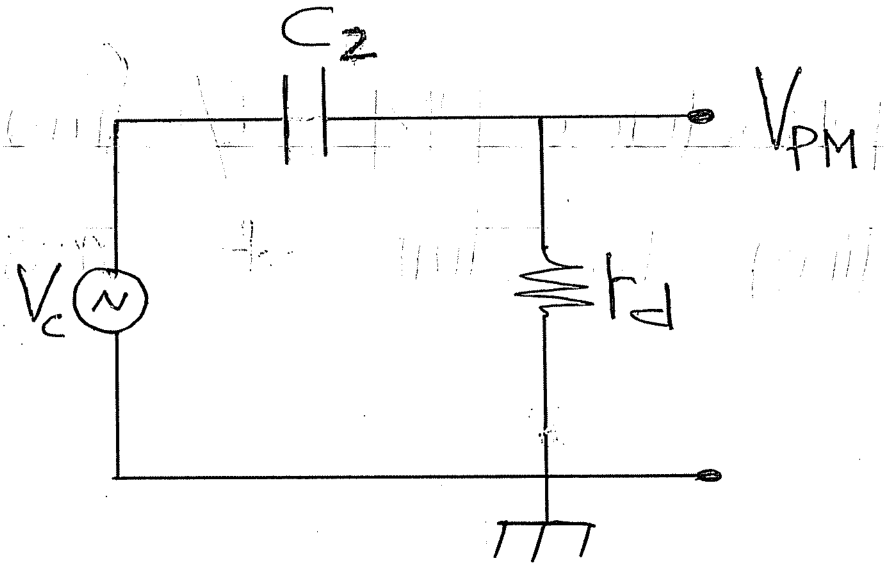
To produce PM, ϕ must be Changed according to Amp. of message Signal.

1]





The J-FET will be biased at linear Regn. $r_d \propto \frac{1}{V_{GS}}$.

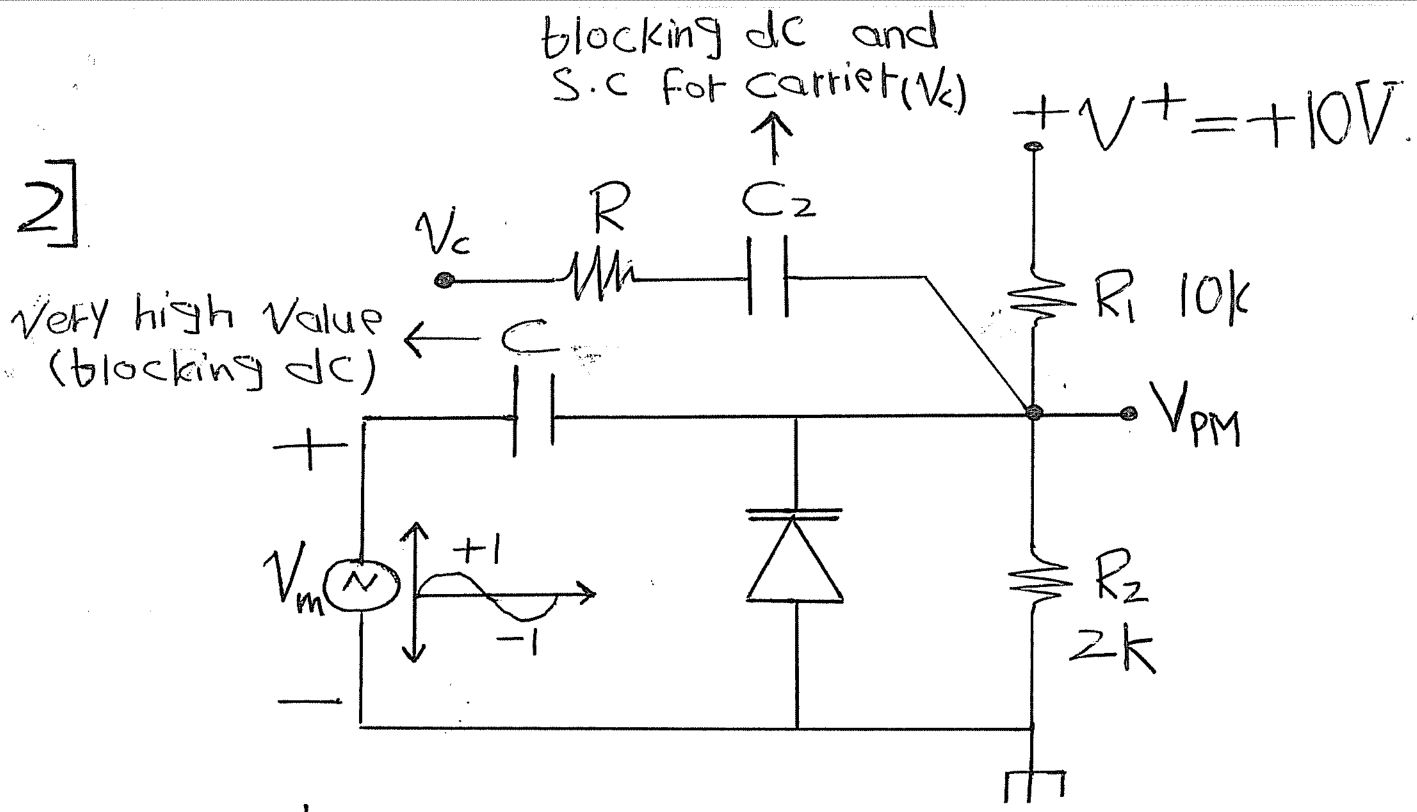


$$\tan^{-1} \frac{X_{C_2}}{r_d}$$

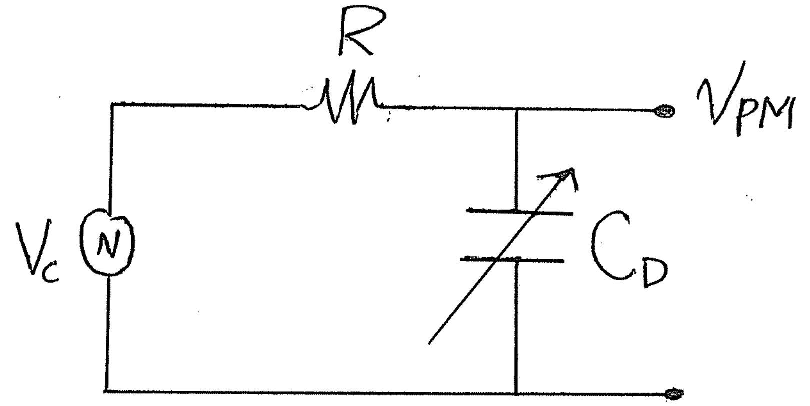
i. when V_m increase ; $V_{GS}\uparrow$, $r_d\downarrow$, $\phi\uparrow$.
ii. when V_m decrease ; $V_{GS}\downarrow$, $r_d\uparrow$, $\phi\downarrow$.
i.e the phase of carrier increase and decrease according to Amp. of modulating signal. (producing phase - modulation).

$C_1 \rightarrow$ Coupling and blocking for dc.
$\rightarrow$ Short cct. for Carrier.
$C_2 \rightarrow$ blocking for dc.
$\rightarrow$ Short cct. for modulating signal.

2]



$$C_D = \frac{1}{R}$$



$$\phi = \tan^{-1} \frac{R}{X_{CD}}.$$

i) when V_m increase, $V_R \uparrow$, $C_D \downarrow$, $X_{CD} \uparrow$, $\phi \downarrow$.

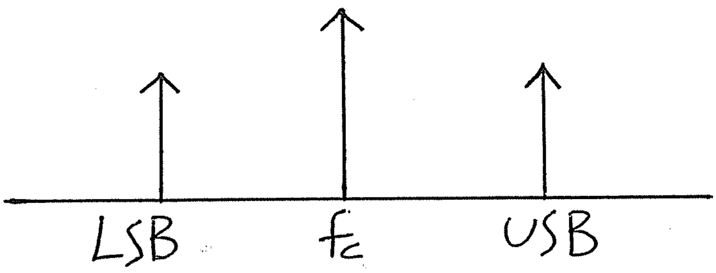
ii) when V_m decrease, $V_R \downarrow$, $C_D \uparrow$, $X_{CD} \downarrow$, $\phi \uparrow$.

iii) i.e the phase of carrier is changing according to Amp. of message signal such that $V_m \uparrow$, $\phi \downarrow$, and $V_m \downarrow$, $\phi \uparrow$.

To Solve this Problem and make $\phi\uparrow$ with $V_m\uparrow$ and $\phi\downarrow$ with $V_m\downarrow$, We have to use inverting Amp. with V_m.

Single Side Band Mod. (SSB) :

* Conventional AM :



for max. mod. index $m = 1$,

$P_c = \frac{2}{3}$, $P_{USB} = P_{LSB} = \frac{1}{6}$.

$\therefore P_T = 6W \rightarrow P_c = 4W$, $P_{USB} = P_{LSB} = 1W$.

$(BW) = 2f_m$.

Double Side band Sub. Carrier

↓

1) filter method.

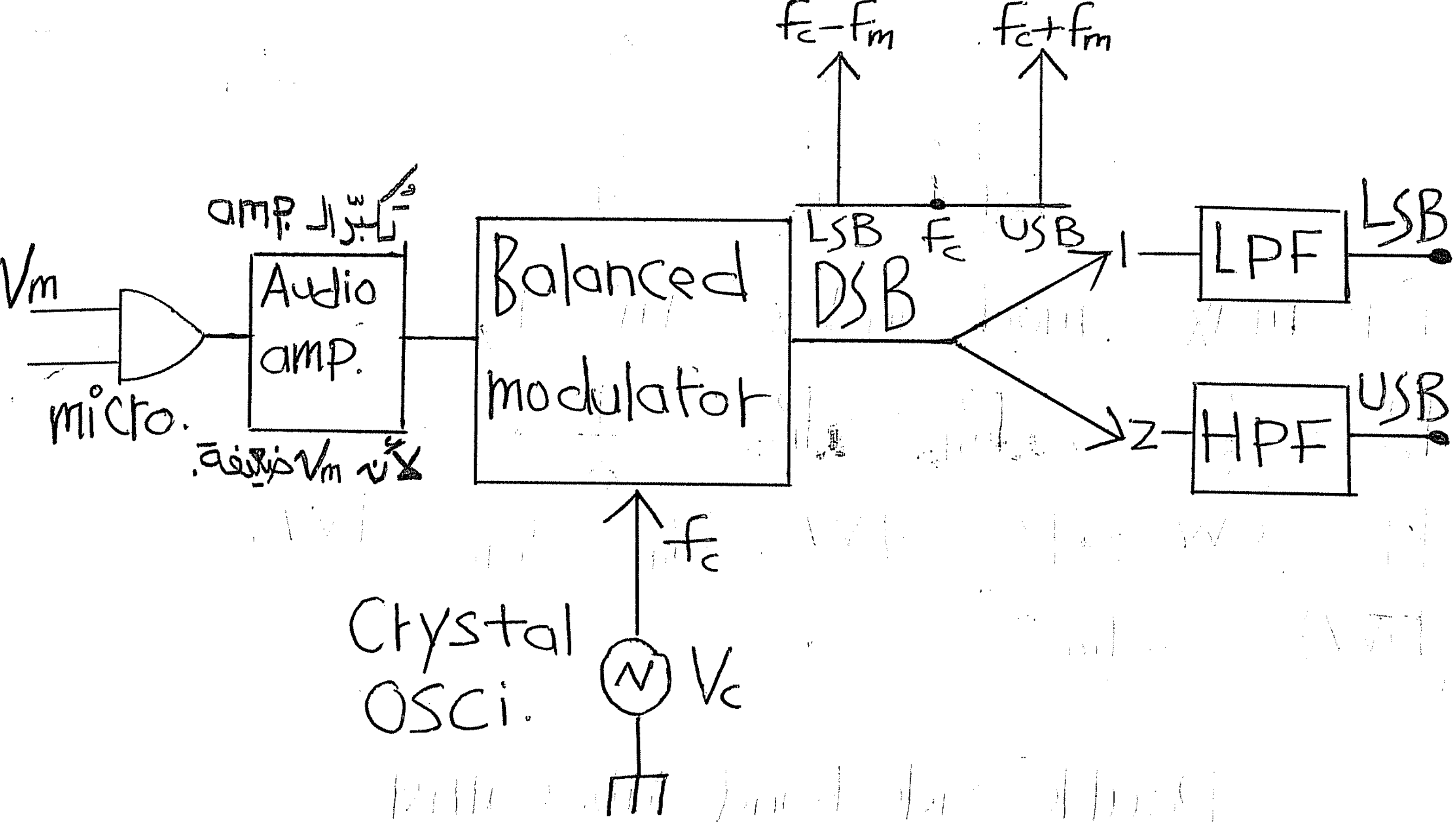
2) Phasing method. (Phase Shifter 90°).

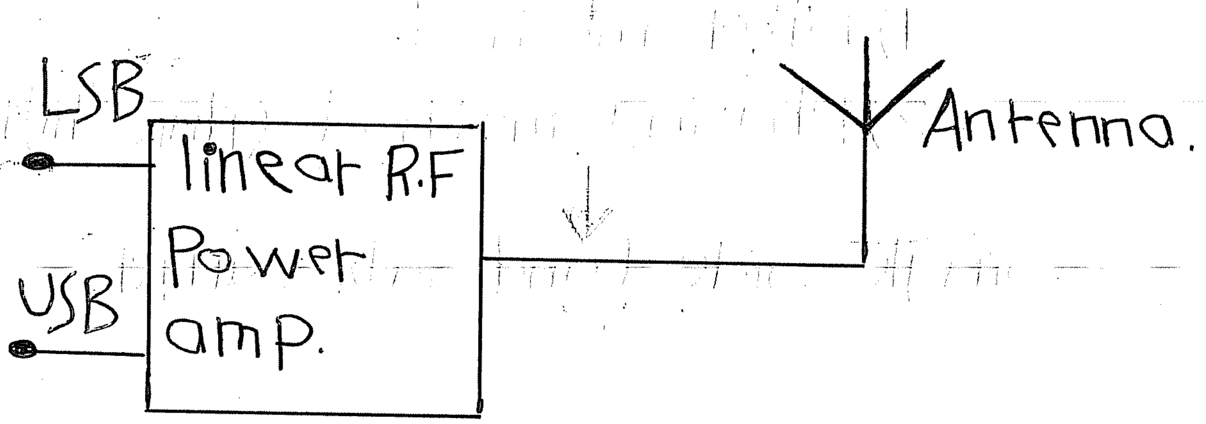
↓

Single Side band Sub. Carrier.

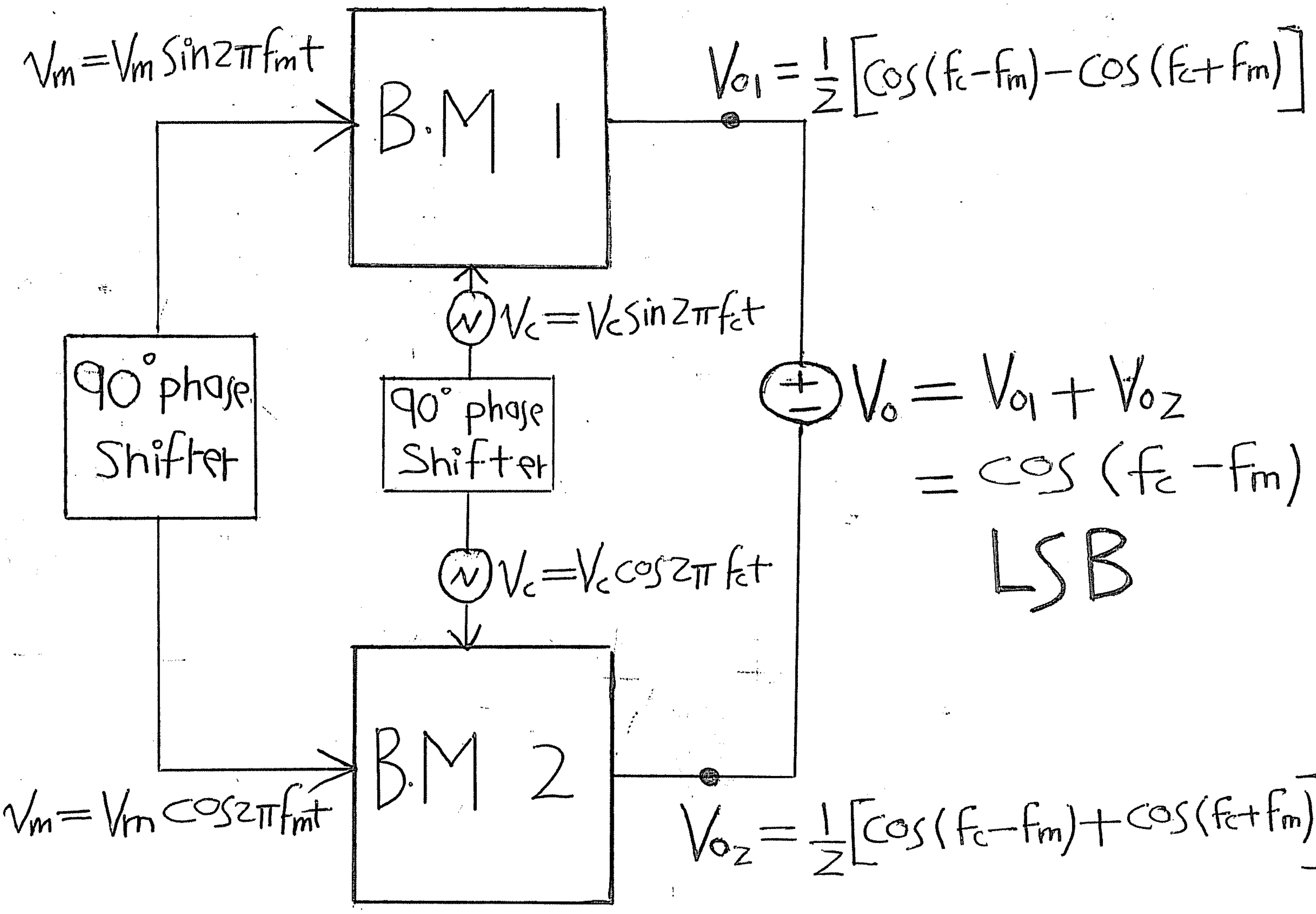
SSB Generation :-

1) Filter Method :-





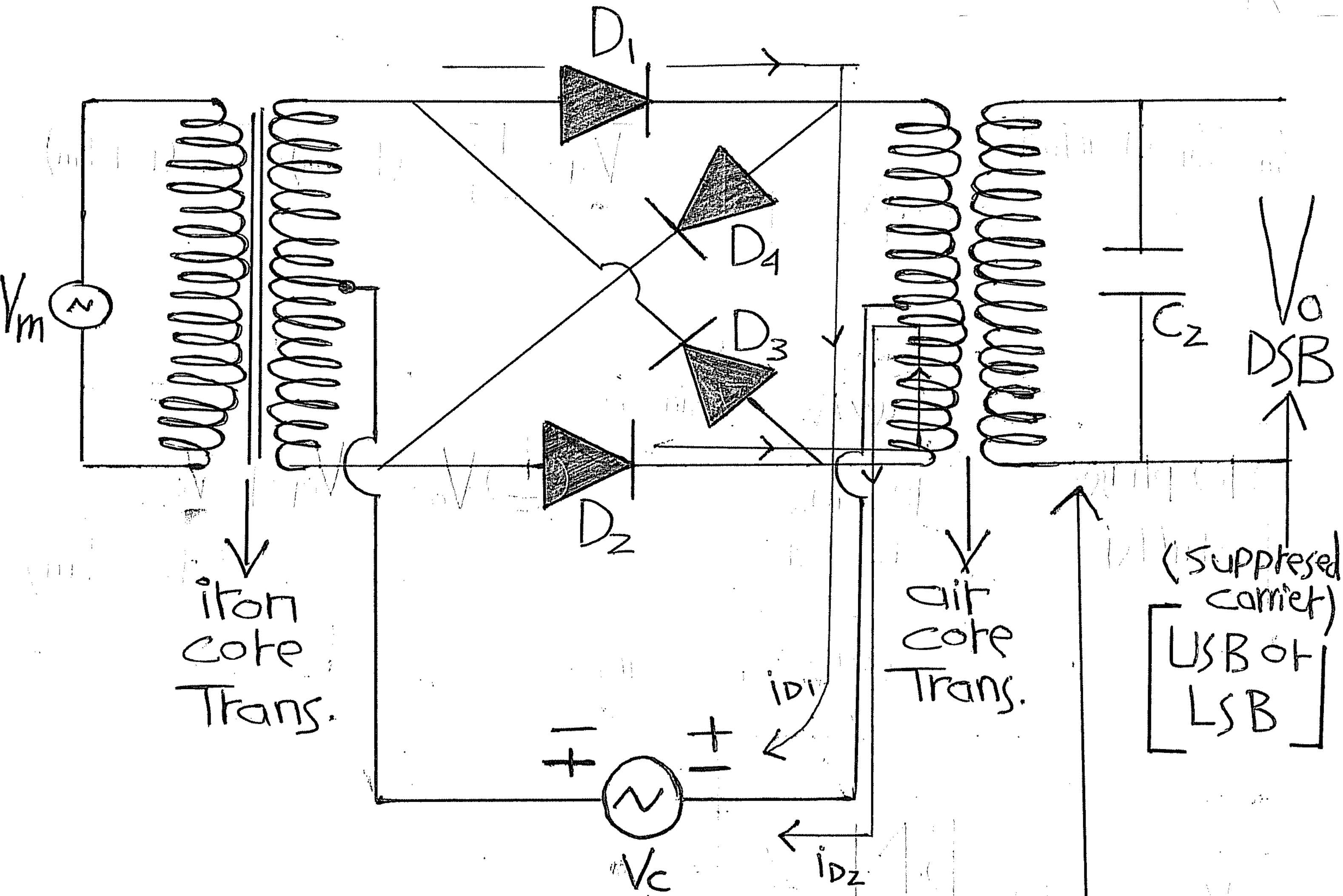
2) Phase - Shift method :-



$$V_o = V_{o1} + V_{o2}$$
$$= \cos(f_c - f_m)$$

LSB

Balanced Mod. :-



tuned cct.
(USB or LSB)

$$f_r = \frac{1}{2\pi\sqrt{L_2 C_2}} = USF \text{ or } LSF.$$

تونيها :

i) For $V_m = 0$, only V_c is applied.

a) for +ve H.C of V_c :

D_1 and $D_2 \longrightarrow$ ON.

D_3 and $D_4 \longrightarrow$ OFF.

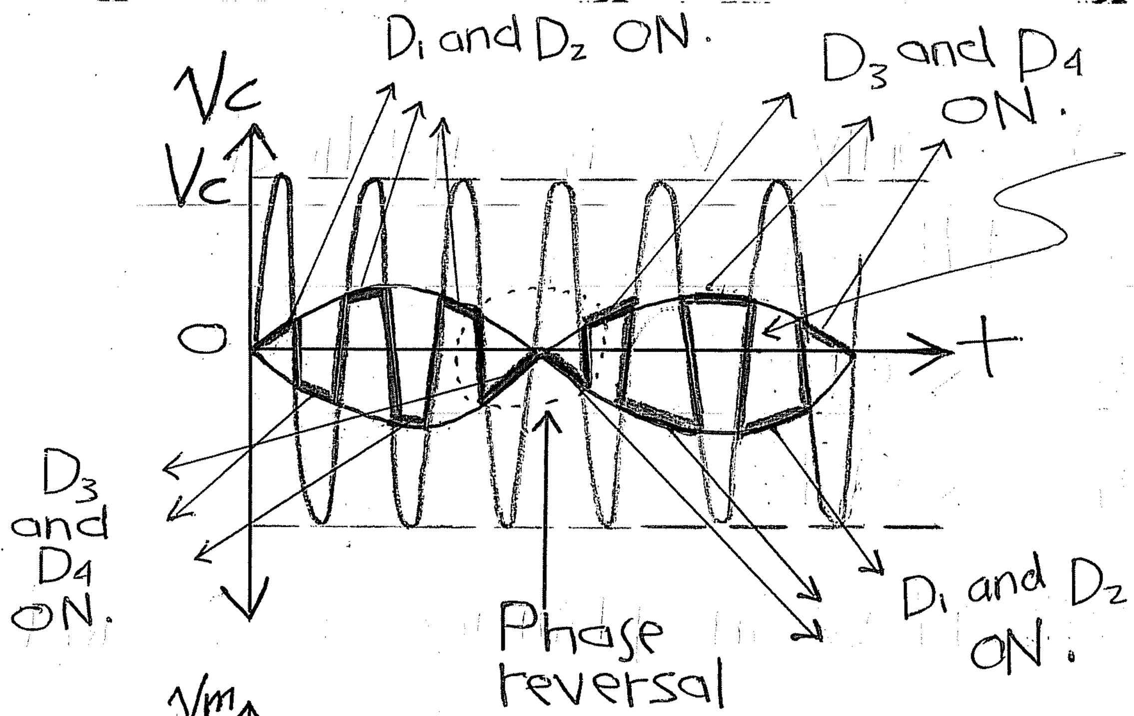
$i_{D_1} = -i_{D_2}$ will flow in primary of T_2 and since i_{D_1} opposes i_{D_2} , So they will produce equal and opposite flux, and the resultant Flux $= 0$, There for the O/P voltage will be zero. (No carrier).

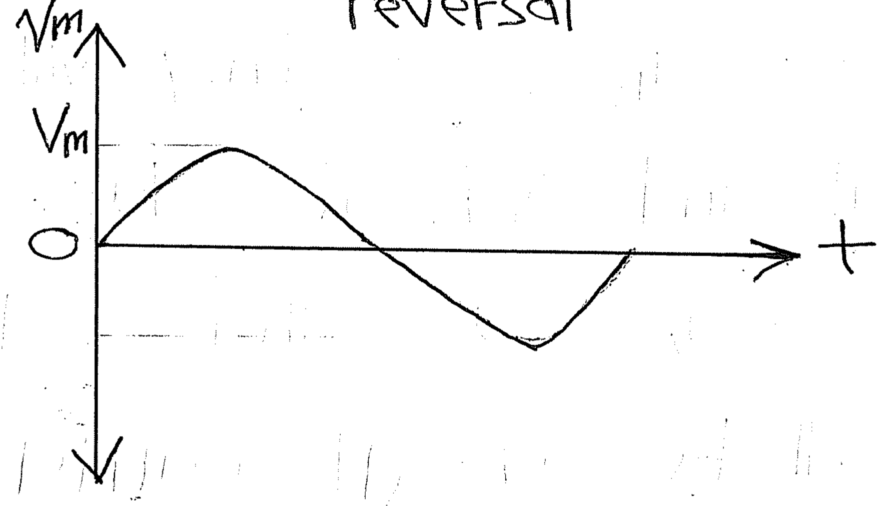
b) for -ve H.C of V_c :

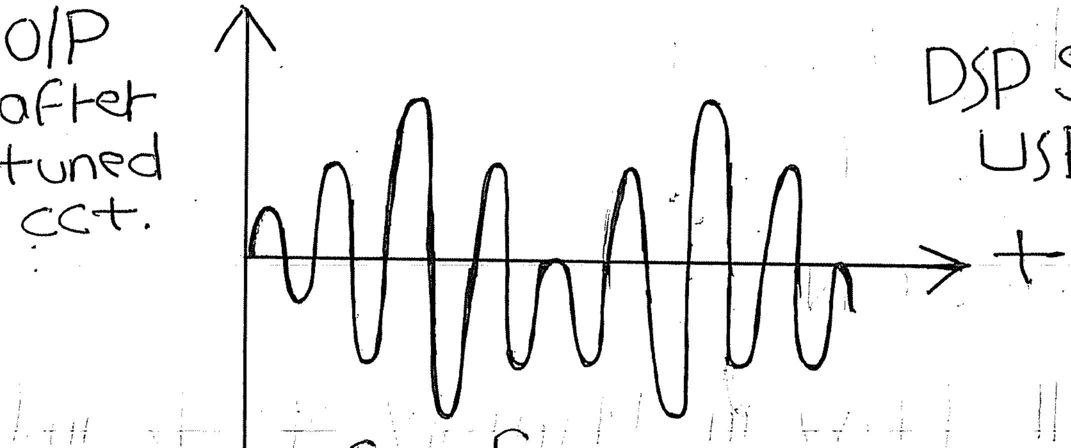
D_1 and $D_2 \longrightarrow$ OFF.

D_3 and $D_4 \longrightarrow$ ON .

$i_{D_3} = -i_{D_4}$ will flow in primary of T_2 and since i_{D_3} opposes i_{D_4} , So they will produce equal and opposite flux, and the resultant flux $= 0$, There for the O/P voltage will be zero. (No carrier).







DSP Signal contains USB and LSB with T.C.

* $f = f_c$ → carrier controls the speed of diodes. (make diodes <u>ON</u> or <u>off</u>)

* amplitude = amplitude of modulating signal.

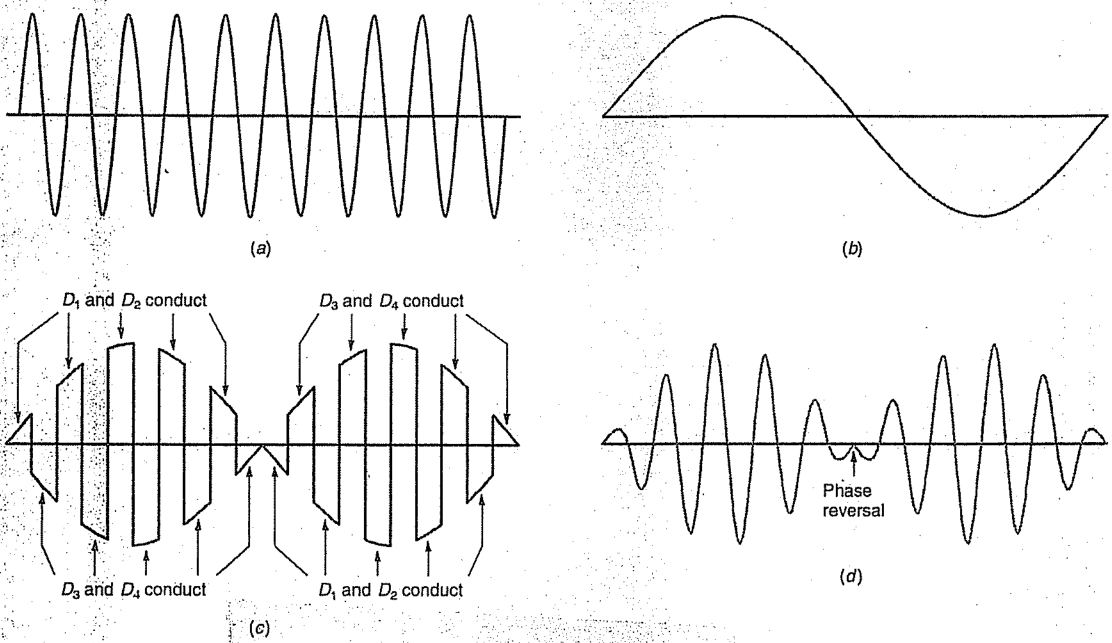
T_1 → bulk size (iron core) large inductors.

V_m → Small Value.

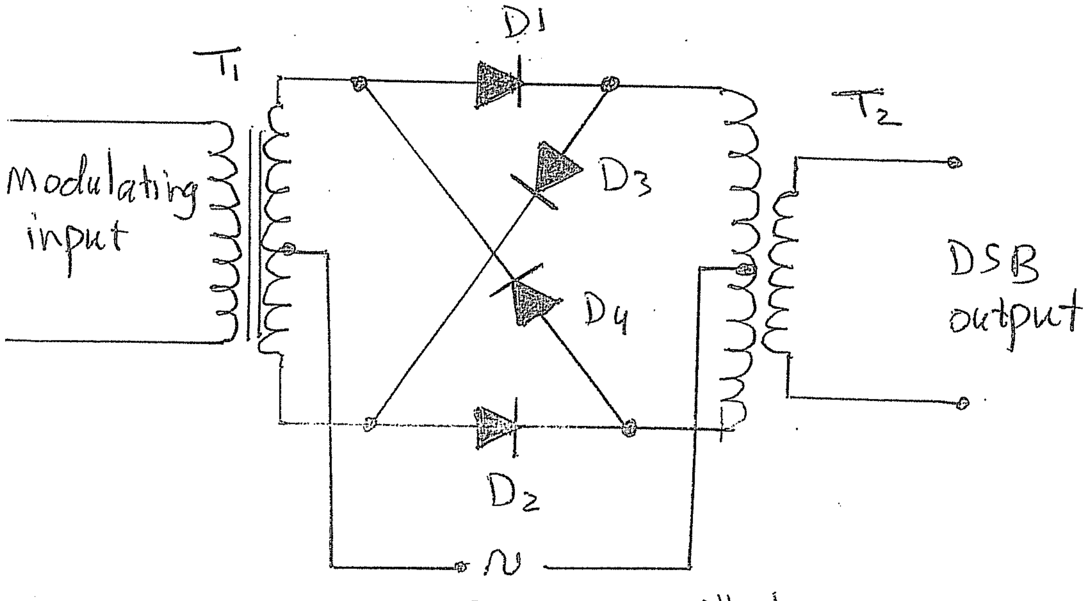
To improve the performance of this modulator, we can replace the i/P iron core Trans. (T_1) by air core Trans.

and interchange the position of V_m and V_c.

Figure 4-25 Waveforms in the lattice-type balanced modulator. (*a*) Carrier. (*b*) Modulating signal. (*c*) DSB signal—primary T_2. (*d*) DSB output.



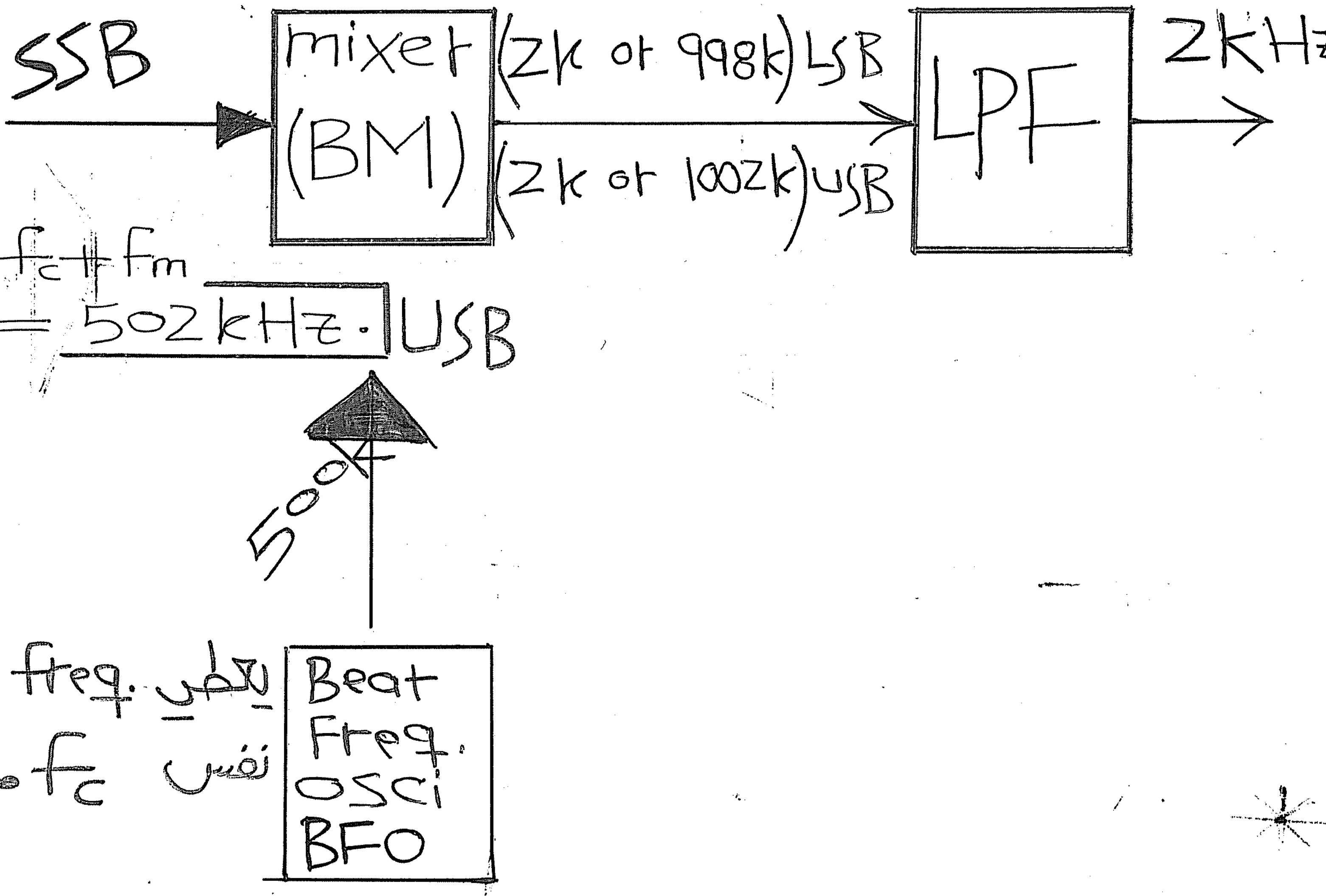
Lattice Balanced modulator



SSB Reception :-

$f_c = 500\,kHz$, $f_m = 2\,kHz$.

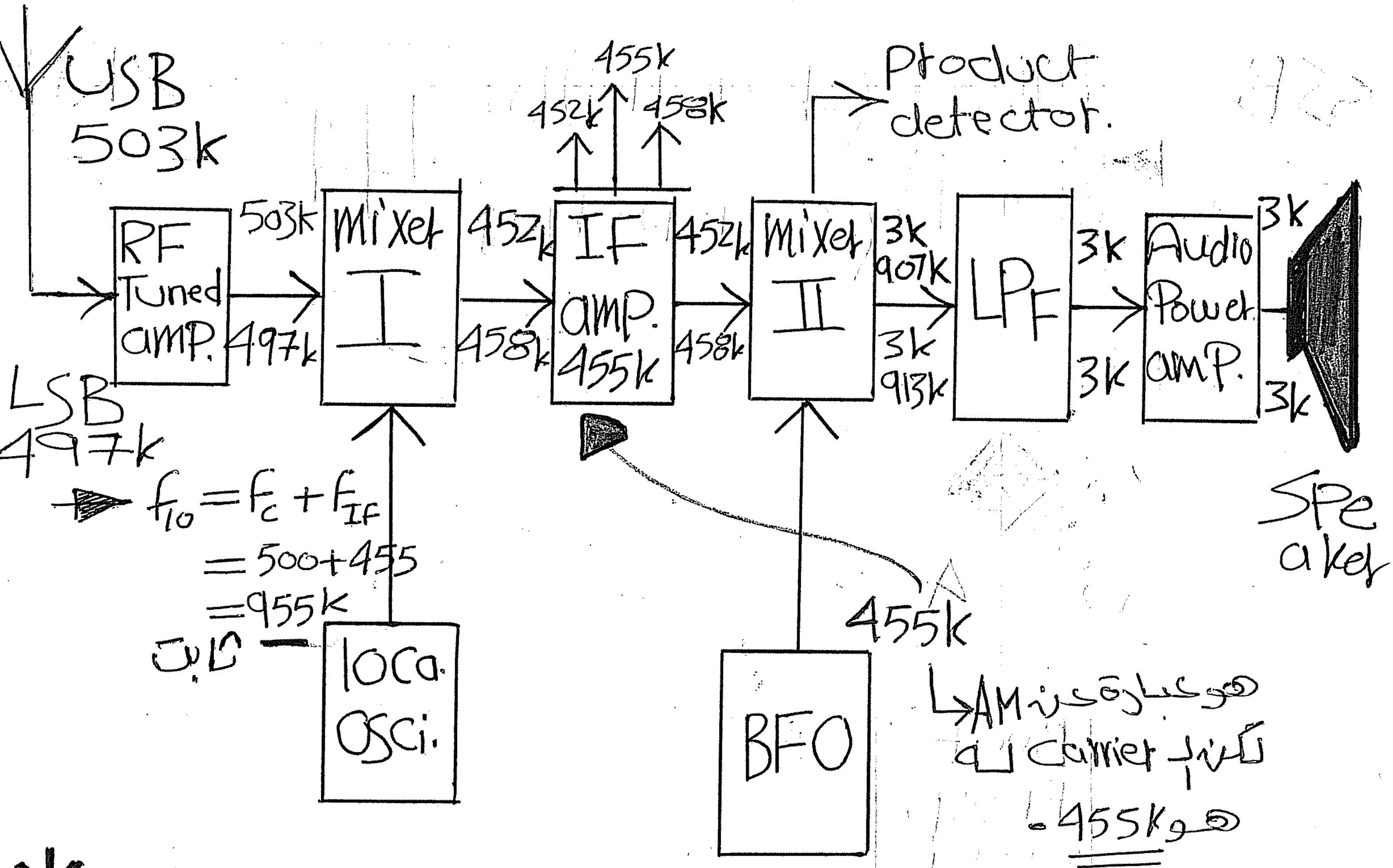
$f_c - f_m = 498\,kHz$. LSB



$f_c + f_m = 502\,kHz$. USB

SSB Receviet :-

$f_c = 500k$, $F_m = 3kHz$.



* determine frequencies at the i/P of each Stage :-

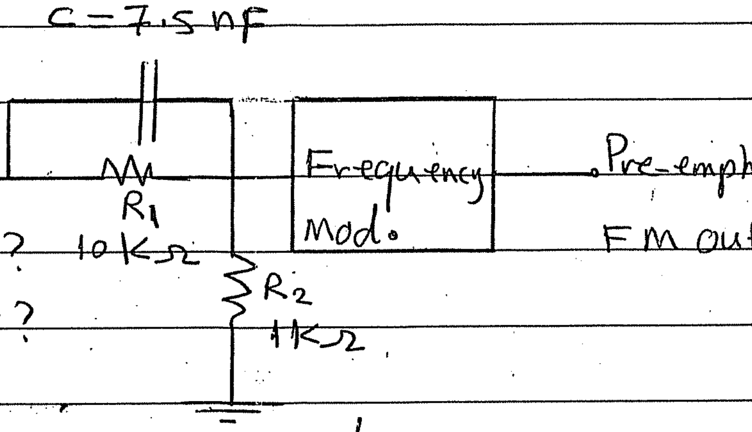
(i) when we receive LSB.

(ii) when we receive HSB.

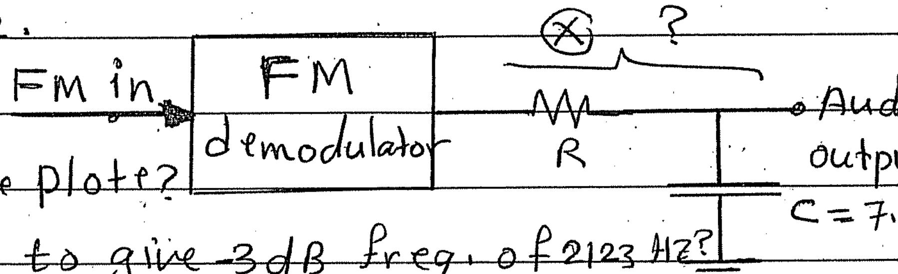
Comm. Electronics Tutorial Sheet. No. 4.

Dr. Hadi AL-Ithawi

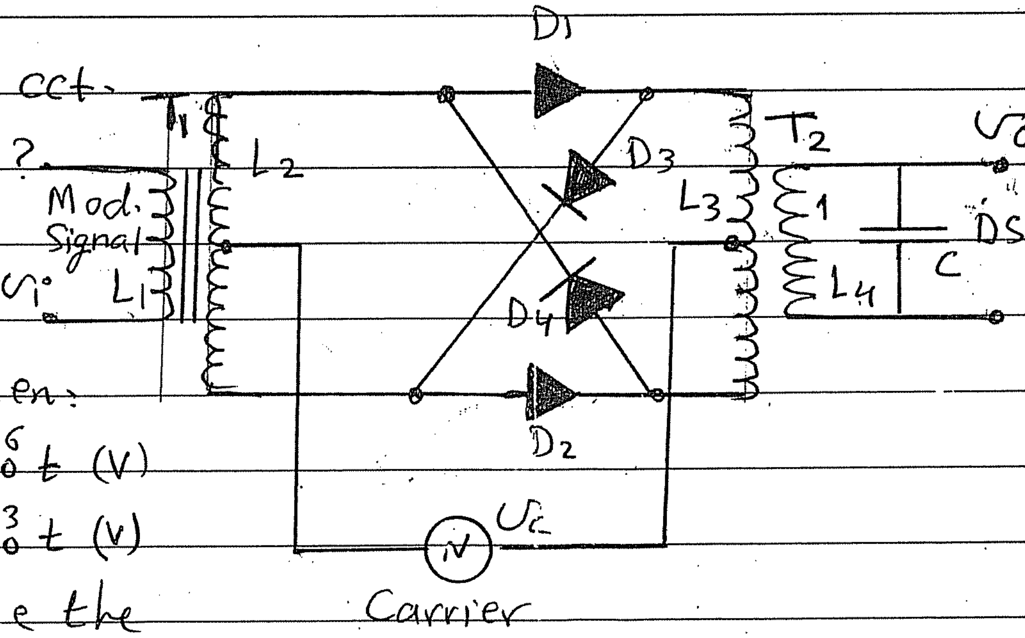
Q1) Name the circuit ⊗ shown in Fig. 1?
explain its function.
and sketch its freq. Resp?
Calculate its Cutoff freq?



Q2) Name the circuit ⊗ shown in Fig. 2.
explain its function
and Sketch its Bode plote?
Calculat R required to give -3dB freq. of 2123 Hz?



Q3) Name the cct. Shown in Fig. 3?
then sketch $V_i(t)$, $V_c(t)$
and $V_o(t)$ when:
$V_c = 10 \sin 2\pi \times 10^6 t$ (V)
$V_m = 4 \sin 6\pi \times 10^3 t$ (V)



- what will be the output when $V_i(t)$ only is applied or when $V_c(t)$ is applied?
- For $L_4 = 1\,\mu H$, what is the value of C required to pass the LSB frequency?
- Redraw the cct. when both transformers are aircore?