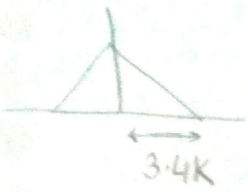
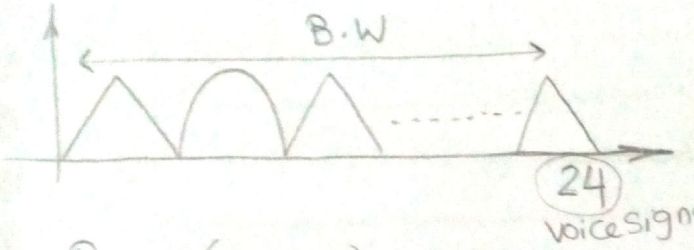
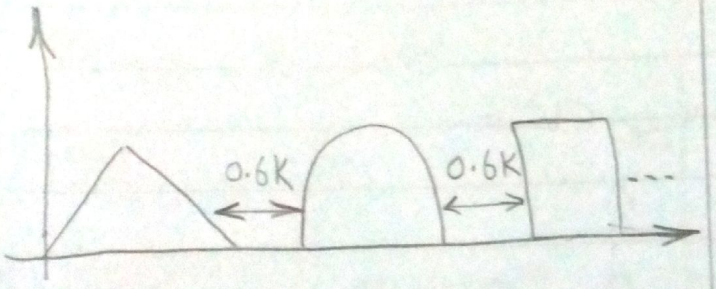
Pb1 Sheet 2





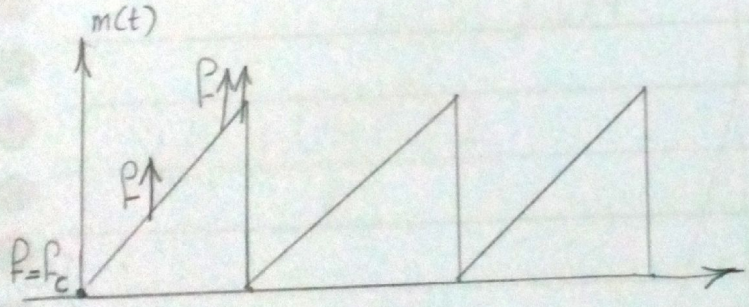
$B.W = (3.4 * 2) * 24$

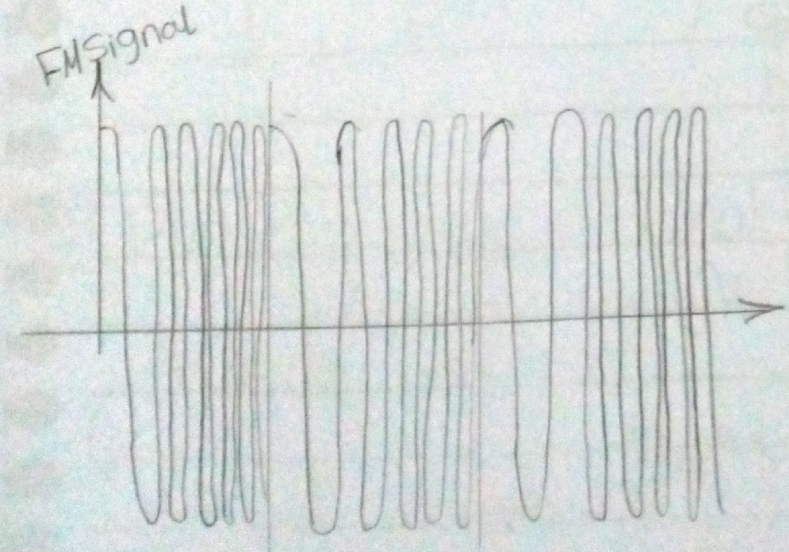


$B.W = (3.4 * 2 * 24) + (0.6 * 23)$

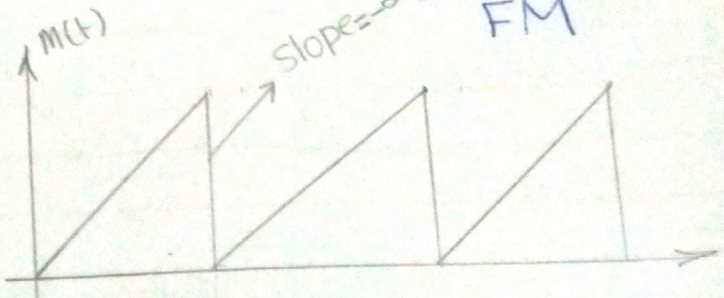
—

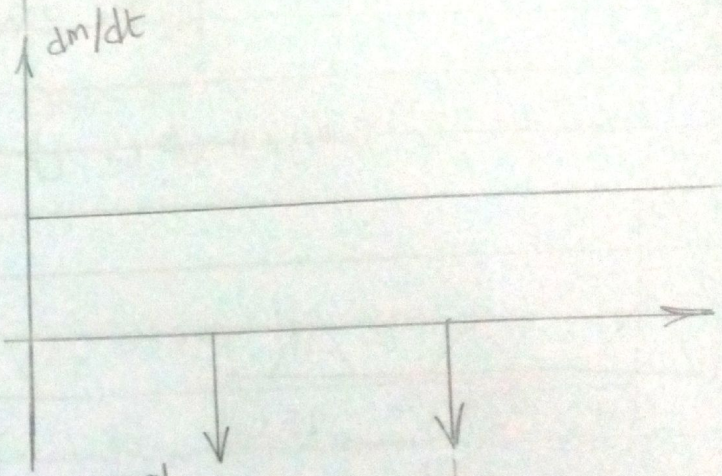
Pb2

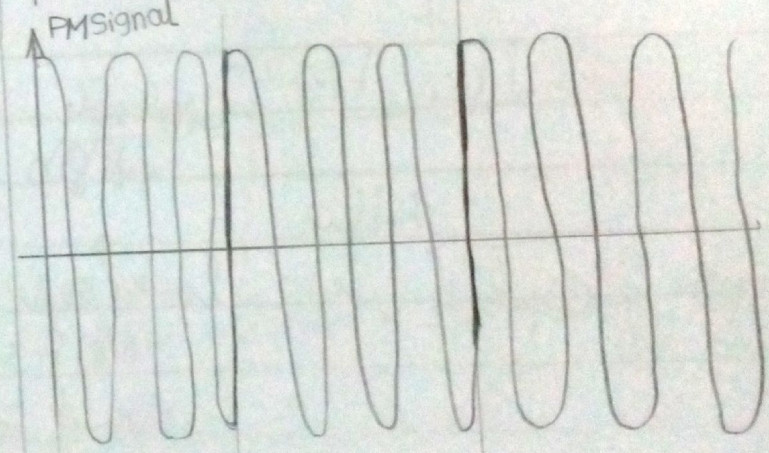




عشان نعمل FM
هنفاضل M(t)
ونعمل التفاضل







Pb3

NBFM Signal

$S(t) = A_c \cos[2\pi f_c t + B \sin w_m t]$

$\simeq A_c \cos 2\pi f_c t - B A_c \sin w_m t \sin w_c t$

① Env. of the Signal

$= \sqrt{A_c^2 + B^2 A_c^2 \sin^2 w_c t}$

$= A_c \sqrt{1 + B^2 \sin^2 w_m t}$

$env_{max} = A_c \sqrt{1 + B^2}$

$env_{min} = A_c$

② $\frac{\text{Power Signal}}{\text{Power unModulated}} =$

$$\frac{(A_c^2/2) + (BA_c/2)^2/2 + (\frac{BA_c}{2})^2/2}{A_c^2/2}$$

$$= \frac{A_c^2 + (A_c^2 B^2)/2}{A_c^2}$$

$$= 1 + B^2/2$$

③ Phase of NBFM Signal

$A \cos wt + B \sin wt$

$\rightarrow \sqrt{A^2 + B^2} \cos(wt - \tan^{-1}\frac{B}{A})$

$A\sqrt{A_c^2 + B^2 A_c^2 \sin^2 w_m t} \cdot \cos[2\pi f_c t + \tan^{-1}\frac{B A_c \sin w_m t}{A_c}]$

$\Phi(t) = 2\pi f_c t + \tan^{-1}(B \sin w_m t)$.

④ $= 2\pi f_c t + B \sin w_m t - \frac{B^3}{3}\sin^3 w_m t + \dots$

فككي دول $\sin w_m t \sin^2 w_m t$ → t

وتفكي دول كمان عشان (تطلع) الـ 3rd harmo.

Pb4

$f_c = 100\ MHz$, $A_m = 20V$

$f_m = 100\ KHz$, $K_f = 25\ KHz/V$

a) Carson's law (rule): D

$BW = 2(f_m + \Delta f) = 2(100K + (25K * 20))$

($\Delta f \rightarrow K_f A_m$)

$= 1200\ KHz$

b) using the universal Curve

$B = \frac{\Delta f}{f_m} = \frac{25 * 20}{100} = 5$

$\frac{BW}{\Delta f} = 3.7 \rightarrow BW = 3.7 * 25 * 20$

$= 1850\ KHz$

c) $A_m' = 2A_m$, $\Delta f' = 2\Delta f$ ← (لأنها زادت مرتين كأنك $\Delta f = K_f A_m$)

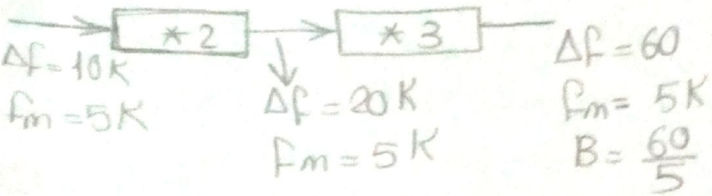
$BW = 2(f_m + \Delta f') = \checkmark$

$B' = \frac{\Delta f'}{f_m} = \checkmark$

$\frac{BW}{\Delta f'} = \longrightarrow BW = \checkmark\checkmark$

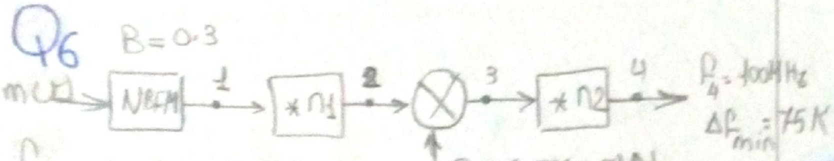
D) نفس الكلام بس خذ بالك أن modulation freq f_m نقصيها

Q5



Separation = f_m = 5K

Q6



$f_m = 100Hz - 15KHz$

$\Delta f = 30 \rightarrow 4.5KHz$

مستقطب

$$B = \frac{\Delta f}{f_m}$$

$f_2 = f_1 * n_1$

الـ f اللى بأرقام دى f_c

$$A_c \cos(2\pi f_2 t + \beta \sin w_m t) \rightarrow \otimes \rightarrow out$$

$\uparrow \cos(2\pi(9.5M)t)$

$$out = \frac{A_c}{2}\cos(2\pi(f_2 - 9.5M)t + \beta_2 \sin w_m t)$$

$$+ \frac{A_c}{2}\cos(2\pi(f_2 + 9.5M)t + \beta_2 \sin w_m t)$$

هوهناك الكل معتبر الـ Mixer
بيعدي الـ low freq عشان كده
أحتزره

$$f_3 = |9.5 - f_2|$$

$$f_4 = n_2 f_3$$

$$f_4 = n_2 |9.5 - n_1 f_1| \rightarrow (1)$$

$$\Delta f_2 = n_1 \Delta f_1$$

$$\Delta f_3 = \Delta f_2$$ مش هتتأثر بالـ Mixer

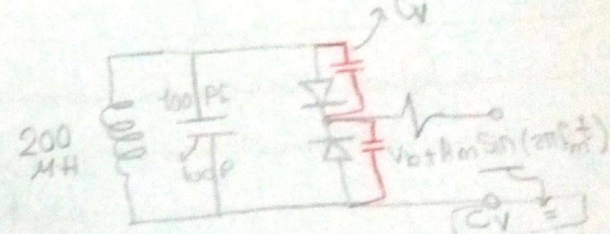
$$\Delta f_4 = n_2 \Delta f_3$$

$$\Delta f_{4_{min}} = n_1 n_2 \Delta f_{1_{min}} \rightarrow (2)$$

Solve (1) & (2)

$7500 = n_1 n_2 * 30$	$7500 = n_1 n_2 * 30$
$100M = n_2(9.5 - 0.1 n_1)$	$100M = -n_2(9.5 - 0.1 n_1)$
$n_1 = \checkmark$	$n_1 = \checkmark$
$n_2 = \checkmark$	$n_2 = \checkmark$

Q7



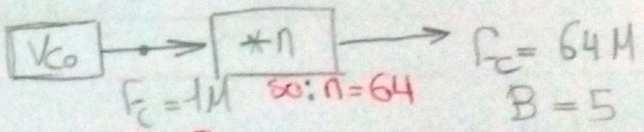
Note

$(1+x)^n \simeq (1 + nx)$ n is real

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

$$f = \frac{1}{2\pi\sqrt{LC_{eq}}} = \frac{1}{2\pi\sqrt{L(100p + \frac{C_v}{2})}}$$

$$= \frac{1}{2\pi\sqrt{L(100P + \frac{100}{2}(V_b + m(t))^{-1/2}}}$$



$$B_{VCO} = \frac{5}{64} = \frac{K_f A_m}{f_m} ?$$

$$f = \frac{1}{2\pi\sqrt{L(100P + \frac{100P}{2}(V_b + m(t))^{-1/2})}}$$

$$= \frac{1}{2\pi\sqrt{L}}\left[100p + \frac{100p}{2}(V_b + m(t))^{-1/2}\right]^{-1/2}$$

هستخدم الـ Note

$$= \frac{(100p)^{-1/2}}{2\pi\sqrt{L}}\left(1 + \frac{1}{2}(V_b + m(t))^{-1/2}\right)^{-1/2}$$

$$f = \frac{(100p)^{-1/2}}{2\pi\sqrt{L}}\left(1 - \tfrac{1}{2}\times\tfrac{1}{2}(V_b + m(t))^{-1/2}\right)$$

$$f = \frac{(100p)^{-1/2}}{2\pi\sqrt{L}}\left(1 - \tfrac{1}{4}V_b^{-1/2}\left(1 + \frac{m(t)}{V_b}\right)^{-1/2}\right)$$

$$f = \underbrace{\frac{(100p)^{-1/2}}{2\pi\sqrt{L}}}_{=x}\left(1 - \tfrac{1}{4}V_b^{-1/2}\left(1 - \frac{m(t)}{2V_b}\right)\right)$$

$$f = x - \tfrac{1}{4}xV_b^{-1/2} + \tfrac{1}{8}xV_b^{-3/2}m(t) \quad \textcircled{1}$$

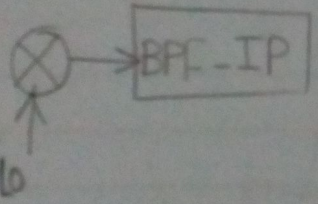
Compare ① with $f = f_c + K_f m(t)$

$\therefore f_c = x - \frac{1}{4}xV_b^{-1/2}$, $K_f = \frac{1}{8}xV_b^{-3/2}$

$f_c = 1\,MHz$ → $V_b = ✓$

$K_f = ✓$

Pb8



$f = 0.535 \longrightarrow 1.605\,MHz$

IF $= 0.455\,MHz$
intermediate freq

$f_{LO} = ? \longrightarrow ?$

Note that $f_{IF} = |f_c - f_{LO}|$

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

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

$= 0.535 - 0.45$

$= 0.085$

$= 1.605 - 0.45$

$= 1.155$

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

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

$f_{LO} = 0.455 + 0.535$

$= 0.99$

$f_{LO} = 0.455 + 1.605$

$= 2.06$

1st case $f_{LO} = 0.085 \rightarrow 1.155$

2nd case $f_{LO} = 0.99 \longrightarrow 2.06$