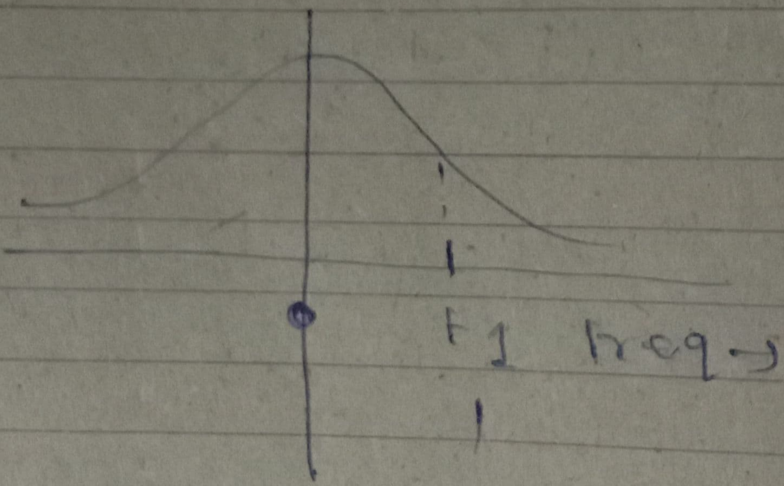
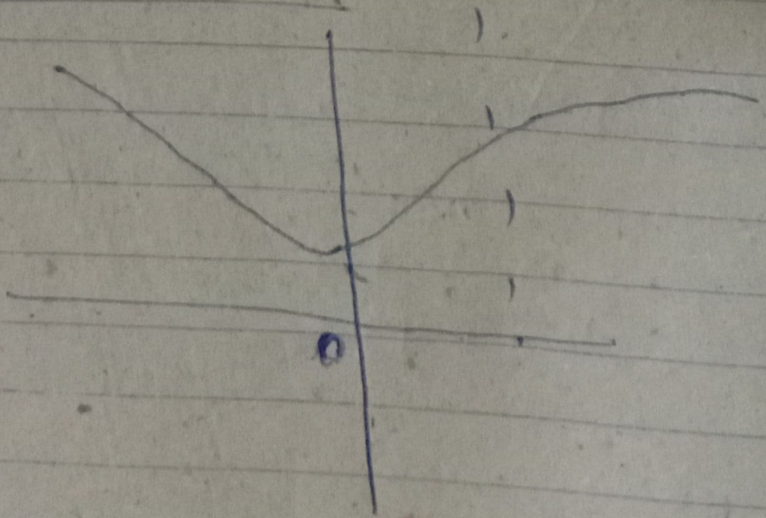
POC-lec 6 (PRE EMPHASIS & DE-EMPHASIS)

→ Power spectral density

PSD of Audio signal



PSD of noise



Upto f_1, $\frac{S}{N} > 1$ (desired)

→ beyond f_1, $\frac{S}{N} < 1$ (not desired)

For high freq

① Either signal power 'S' has to be increased

OR

② decrease the noise power

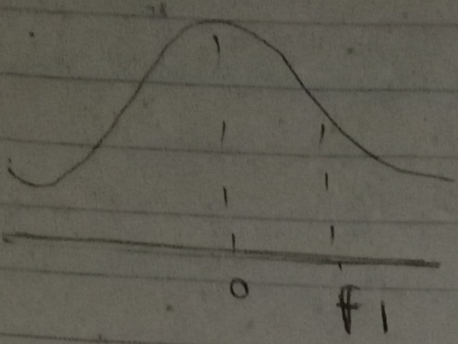
⇒ The signal strength is increased artificially at high frequency
↳ PRE-EMPHASIS

PRE-EMPHASIS

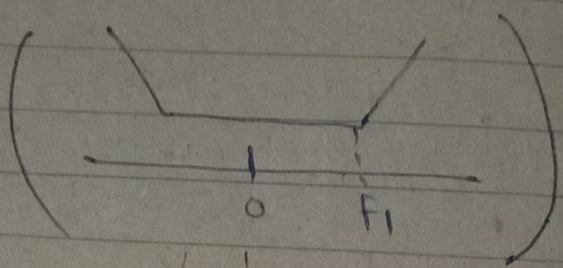
↳ process of increasing the strength of high frequency components of audio signal is called pre-emphasis

→ Pre-emphasis is done at the transmitter before modulation

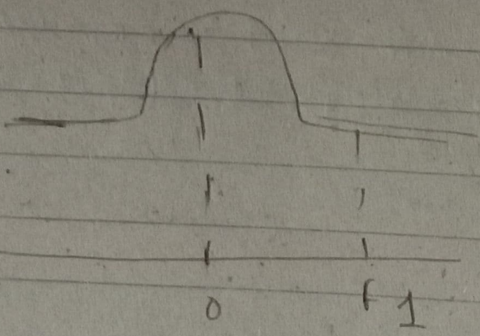
CIRCUIT FOR PRE-EMPHASIS :



Pre-emphasis circuit

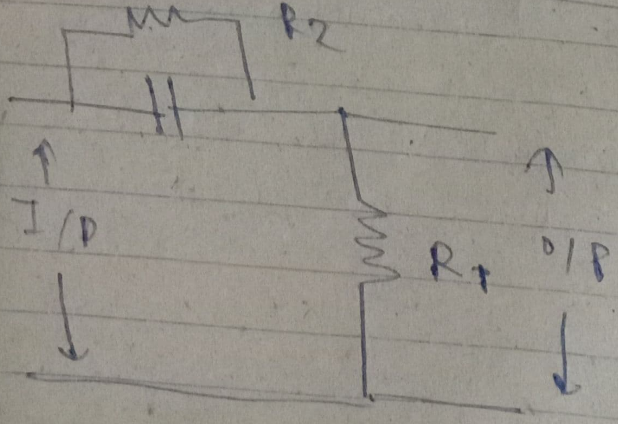


Transfer function of circuit



Lead compensator circuit

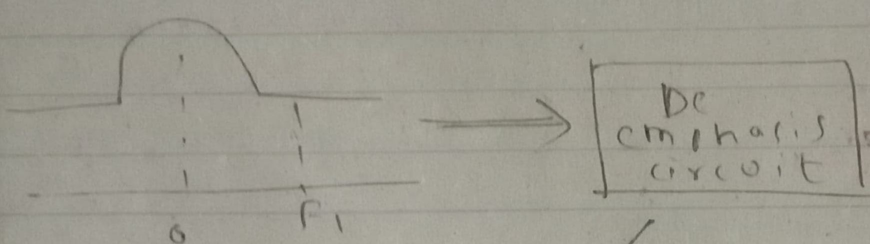
Lead compensator circuit



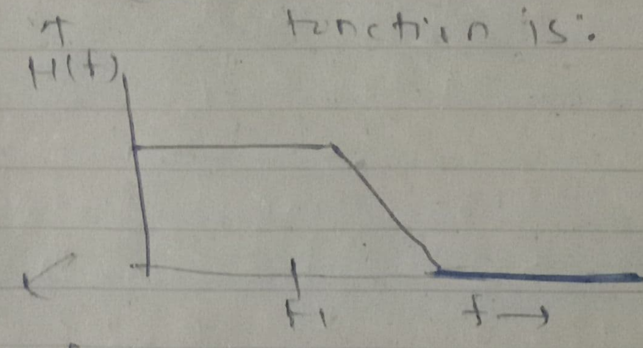
DE-EMPHASIS

At the receiver end after demodulation

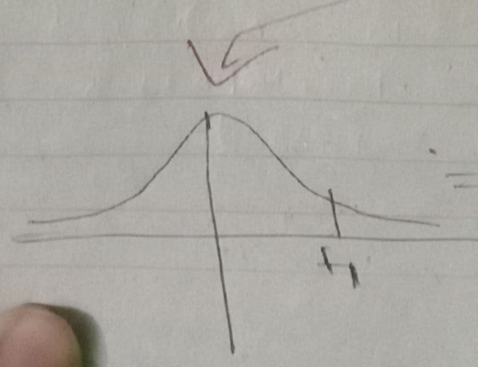
→ Decreasing the strength of the signal of high frequency components of Audio signal



~~circuit~~ Transfer function is:



(Low Pass Filter)



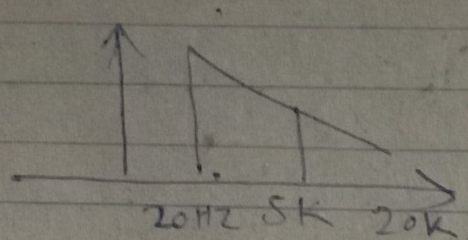
= original Audio signal

Q)
Why Preemphasis & deemphasis are only needed in FM & not in AM ?

Soln:

for AM:

BW = 10kHz
fm = 5kHz



~~signal~~

* Signal strength decreasing with frequency

* message signal lies in vicinity of 5kHz, the signal strength is appropriate in case of AM,
Signal strength $\frac{S}{N} > 1$

* So in AM, only the low frequency of Audio signal is considered for transmission, so preemphasis & deemphasis not required

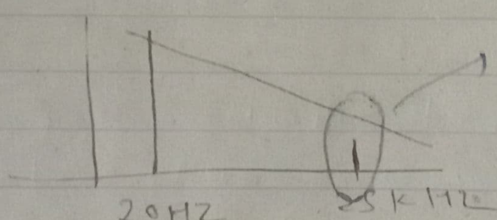
For fm:

BW = 200 KHZ

$2(\Delta f + f_m) = 200$ KHZ

$\Delta f = 70$ KHZ

$f_m = 25$ KHZ



$\frac{S}{N} <\uparrow$, signal strength less

therefore preemphasis & demphasis required in case of FM.

→ (FDM)

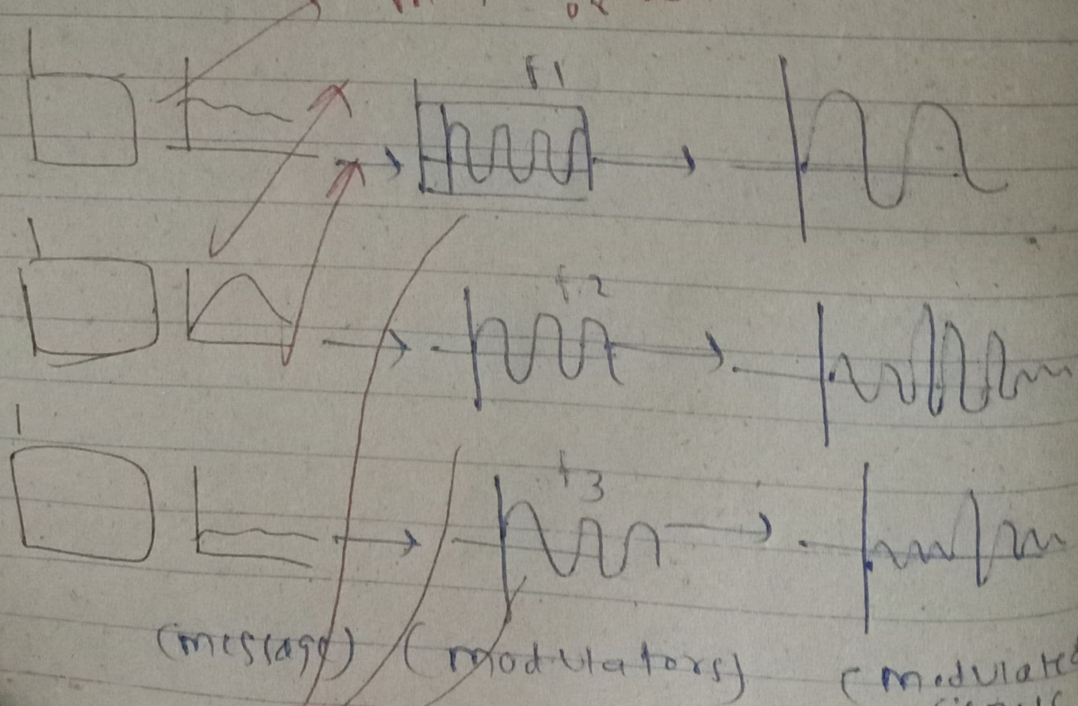
FREQUENCY DIVISION (MULTIPLEXING)

transmission of several signals simultaneously using/sharing the same resource

* In FDM, several signals are transmitted simultaneously by sharing a band of channel.

FDM Process (At transmitter end)

may be digital or analog



subcarriers ~~for~~ for individual modulation

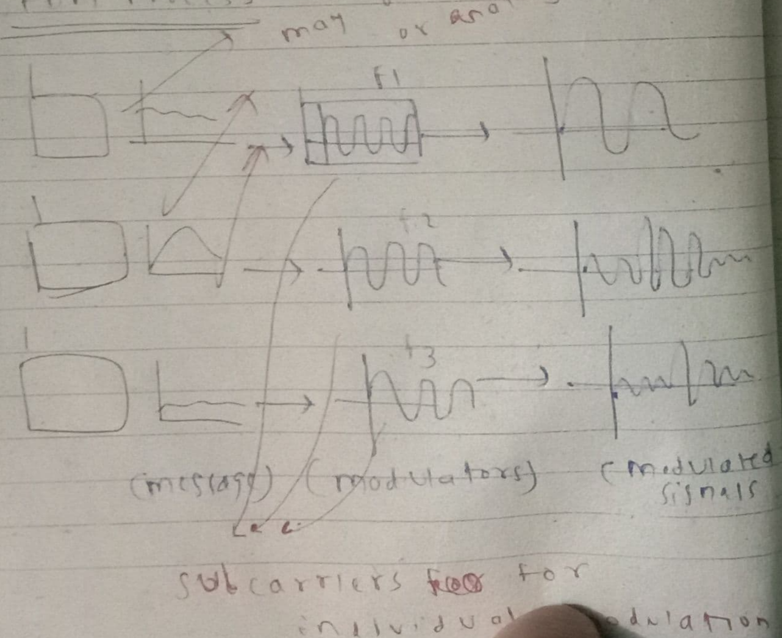
→ (FDM)

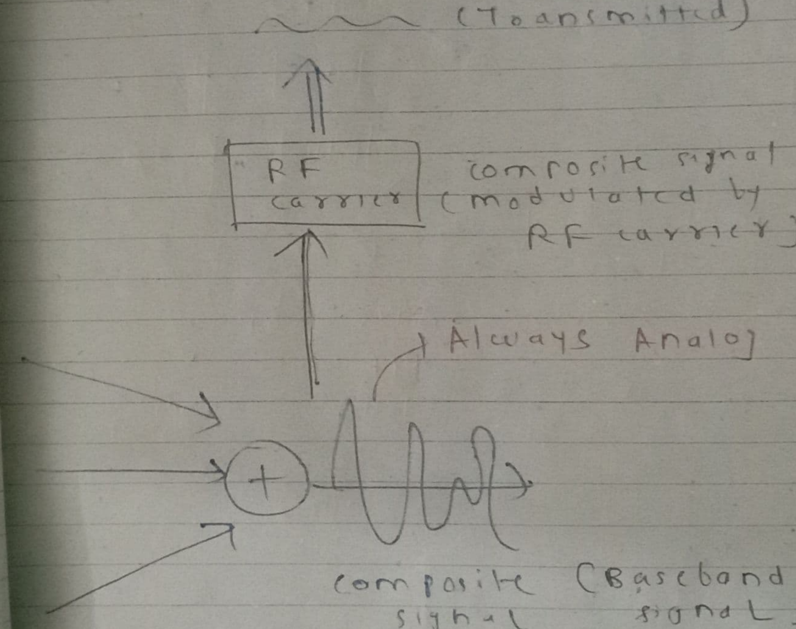
FREQUENCY DIVISION (MULTIPLEXING)

transmission of several signals simultaneously using/sharing the same resource

* In FDM, several signals are transmitted simultaneously by sharing a band of channel.

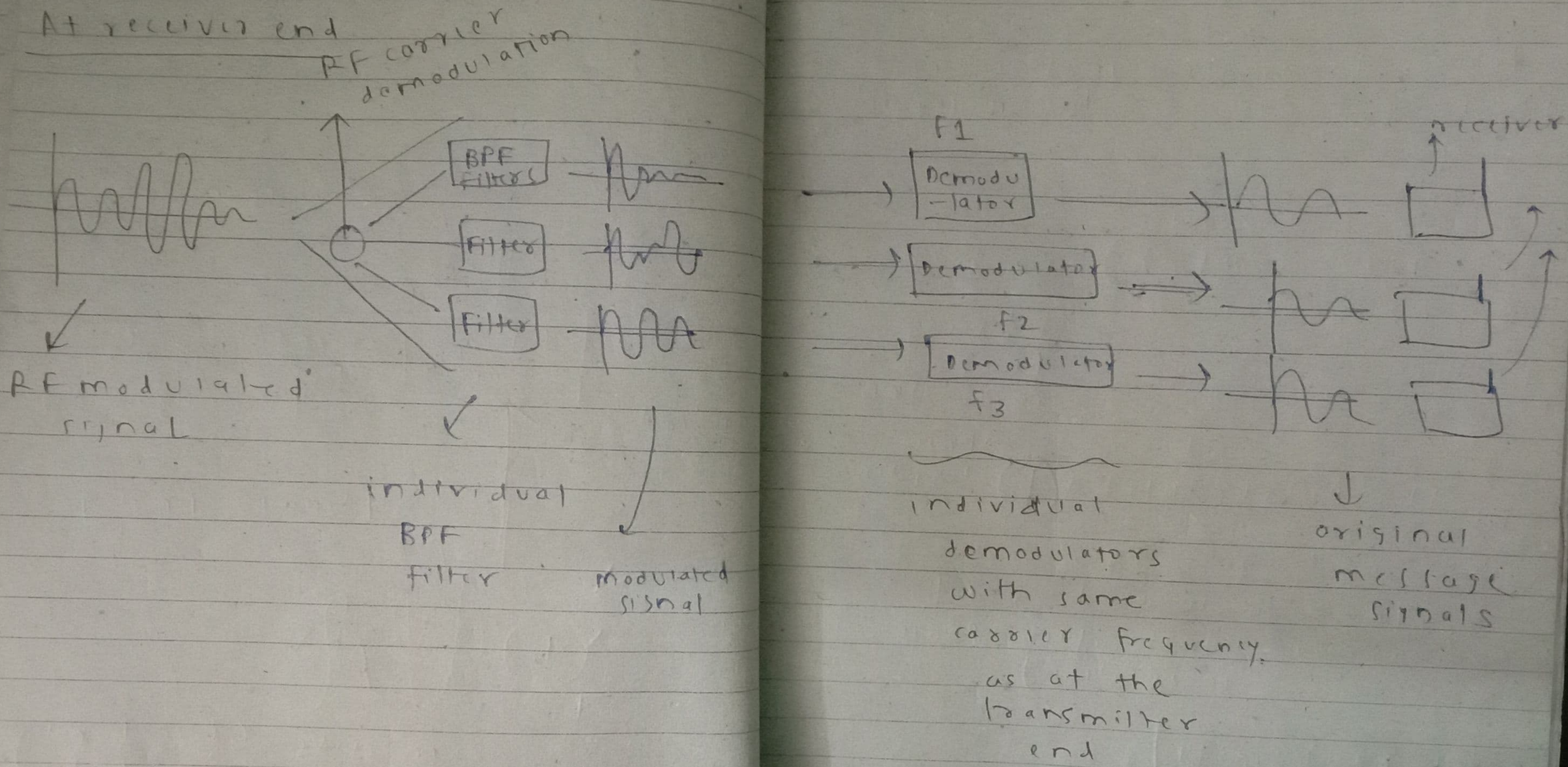
FDM Process (At transmitter end)





* Subcarriers are adequately separated to avoid overlap / interference

At receiver end



POC lec 7

PHASE MODULATION

Phase of carrier signal is varied in accordance to the message signal

$c(t) = A_c \cos(2\pi F_c t)$ carrier

before Phase modulation

$S_{pm}(t) = A_c \cos(2\pi F_c t + \phi)$ Phase deviation

Phase modulated signal (carrier signal after Phase modulation)

$\boxed{\phi(t) = K_p m(t)}$

Phase sensitivity constant

$$S_{pm}(t) = A_c \cos(2\pi f_c t + K_p m(t))$$

Let $m(t) = A_m \cos(2\pi f_m t)$

Maximum Phase deviation

$$\Delta\phi = \max(K_p m(t))$$

$$= \max(K_p A_m \cos(2\pi f_m t))$$

$$\boxed{\Delta\phi = K_p A_m}$$

Standard expression of PM

$$S_{PM}(t) = A_c \cos(2\pi f_c t + K_p A_m \cos(2\pi f_m t))$$

$$\boxed{K_p A_m = \text{modulation index } (\beta)}$$

also called "muximum phase deviation ~~[illegible]~~"

$$\beta = K_p A_m = \Delta\phi$$

modulation index — max. phase deviation

For FM:

$$\beta = \frac{K_f A_m}{f_m} = \frac{\Delta f}{f_m}$$

↳ dependent on message signal frequency

For PM:

$$\beta = K_p A_m = \Delta\phi$$

independent of ~~m(t)~~ message signal frequency

In PM,

"β & $\Delta\phi$ are independent of the message signal frequency variations"

$$S_{PM}(t) = A_c \cos(2\pi f_c t + \beta \cos(2\pi f_m t))$$

$$S_{FM}(t) = A_c \cos(2\pi f_c t + \beta \sin(2\pi f_m t))$$

" general expression of FM & PM same, except 90° phase shift at message frequency component

" Bandwidth & power requirement in FM & PM are exactly same "

$$\boxed{BW_{PM} = 2(\beta+1) f_m = 2(\Delta\phi + 1) f_m}$$

$$\boxed{Power_{PM} = \frac{A_c^2}{2}}$$

$\Longrightarrow$

Q1) $S_{PM}(t) = 10\cos(2\pi\times10^6 t + 6\sin 6\pi\times10^3 t)$

① Find all the parameters of PM

② repeat above after doubling the message signal frequency

Soln:

$S_{PM}(t) = 10\cos(2\pi\times10^6 t + 6\sin(6\pi\times10^3 t))$

$S_{PM}(t) = A_c\cos(2\pi f_c t + \beta\sin(2\pi f_m t))$

①

$A_c = 10$

$f_c = 1\,MHz = 1000\,kHz$

$f_m = 3\,kHz$

$\beta = 6$

$BW = 2(\beta+1)f_m$

$= 42\,kHz$

$P_t = \frac{A_c^2}{2} = 50\,W$

② If

β

P_t

~~m(t~~

m(t)

(2) If $f_m = 6$ kHz

$BW = 2(\beta+1) f_m$

$= 84$ KHz

$\beta = K_p A_m = 6$

$P_t = \frac{A_c^2}{2} = 50W$

~~m(t) freq~~

$\boxed{m(t) \text{ frequency} \uparrow = BW \uparrow}$

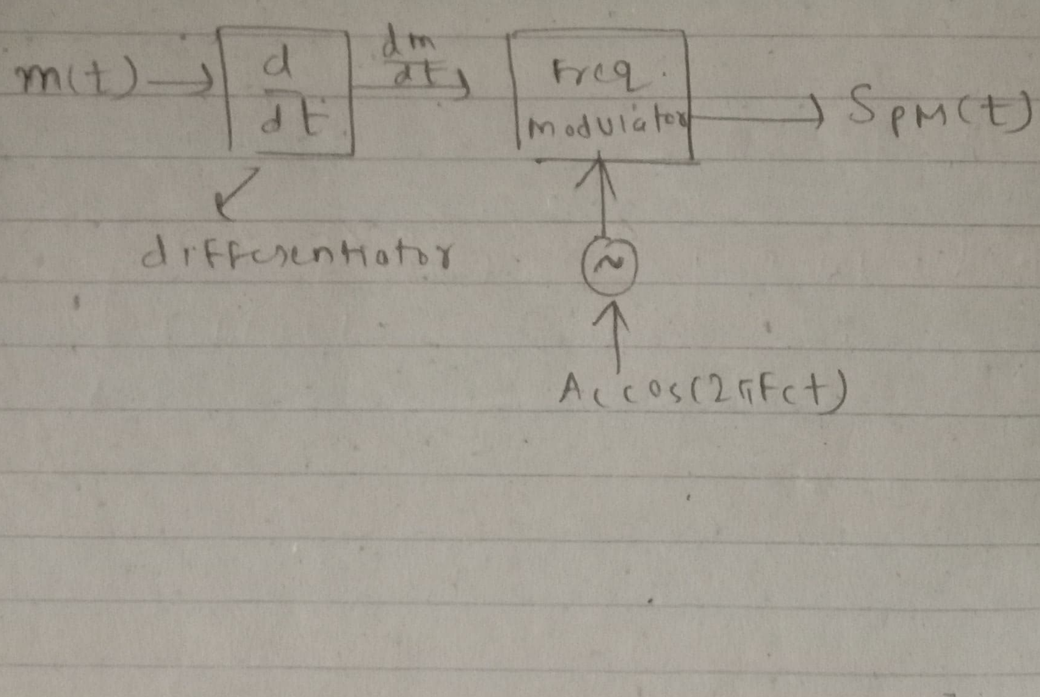
doubles — doubled

GENERATION OF PM

$S_{PM}(t) = A_c\cos(2\pi f_c t + k_p m(t))$

$S_{FM}(t) = A_c\cos(2\pi f_c t + 2\pi k_f \int m(t)\,dt)$

we can generate from FM



Q2) An angle modulated signal is given as:

$$S(t) = \cos(2\pi(10^6 \times 2t + 30\sin 150t + 40\cos 150t))$$

Find max freq deviation & max phase deviation

Soln:

$$s(t) = \cos(2\pi\{\quad\})$$

$$\phi_i(t) = 2\pi[2\times10^6 t + 30\sin 150t + 40\cos 150t]$$

↳ modulated angle

For FM: FM modulated

$$f_i = \frac{1}{2\pi}\frac{d}{dt}\phi_i(t) = f_c + K_f m(t)$$

$$= \frac{1}{2\pi}\frac{d}{dt}[2\pi(2\times10^6 t + 30\sin 150t + 40\cos 150t]]$$

$$f_i = 2\times10^6 + 4500\cos 150t - 6000\sin 150t$$

$$f_i = f_c + \underline{K_f m(t)}$$

↳ freq deviation

freq deviation

$= 4500\cos(150t) - 6000\sin(150t)$

max freq deviation

$= \max(A\cos(2\pi f_1 t) + B\sin(2\pi f_1 t))$

$\hookrightarrow \sqrt{A^2+B^2}$

$= \sqrt{4500^2 + 6000^2} = 7500\,Hz$

$\boxed{= 7.5\,kHz}$

For PM

$S_{PM}(t) = A_c\cos(2\pi f_c t + k_p m(t))$

phase deviation

$s(t) = A_c\cos 2\pi(2\times10^6 t + 30\sin(150t + 40\cos 150t))$

$K_p m(t) = 60\pi\sin 150t + 80\pi\cos 150t$

$\Delta\phi = \max(k_p m(t))$

$= ((60\pi)^2 + (80\pi)^2)^{1/2}$

$\boxed{\Delta\phi = 100\pi}$