28 Sept, 2023

Com. Sys

Chap 4 & 5 are important

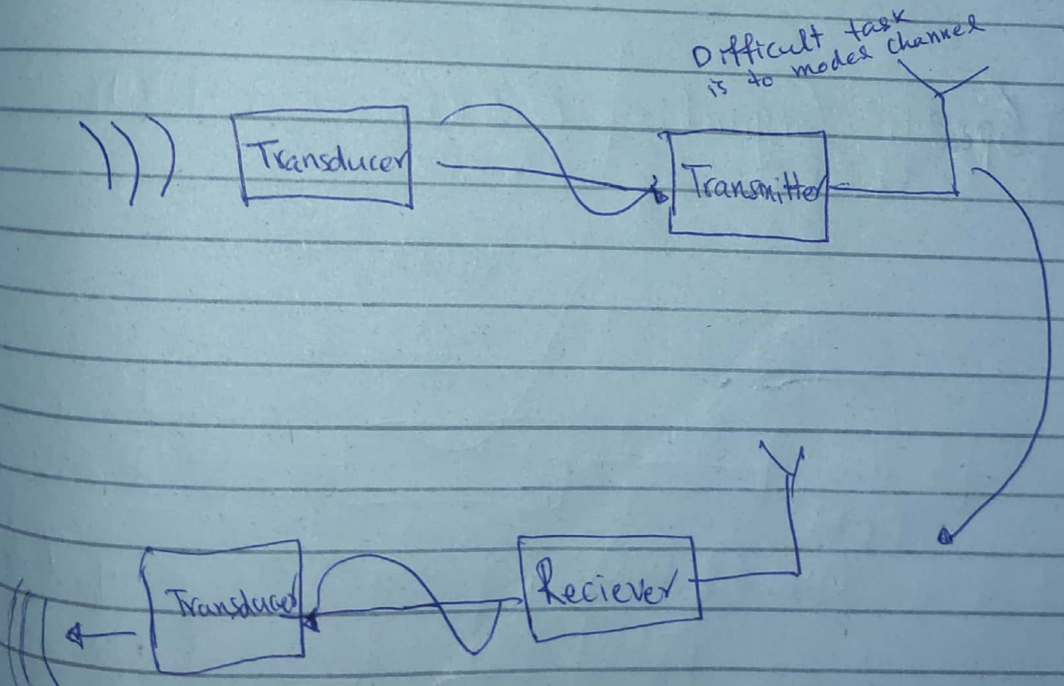
Tele Communication → Exchange of info

→ Exchange of messages over a long distances by using ~~us~~ some electro-technical aid.

Telegraphy
written

Audio
Telephony

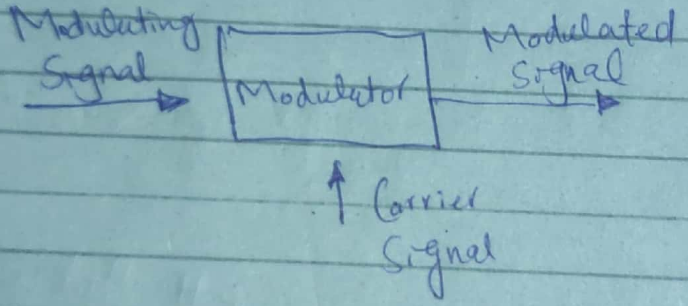
Television
Visual



By ALI ASGHAR

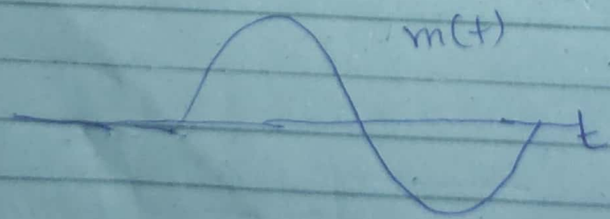
Essential part of Transmitter.

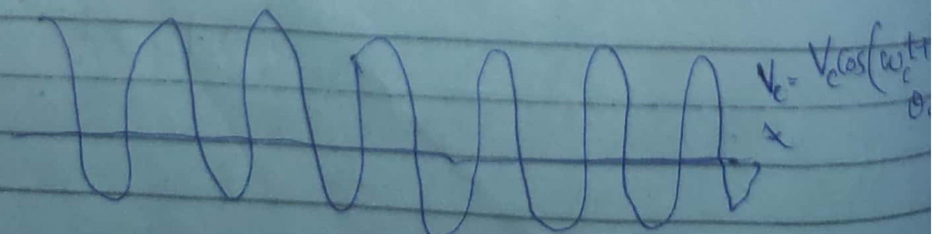
Modulator:- If we vary any attribute of the carrier signal in accordance with the instantenous value of base-band signal, the process is said to be modulation.



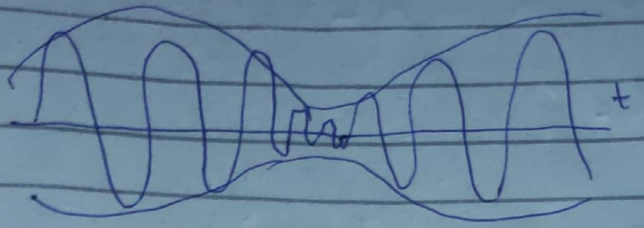
Speech Signal:- 0.3 KHz - 3.4 KHz

300 Hz





A.M chapter 4

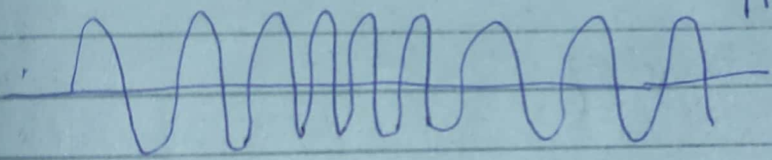


Modulated Signal

Only Ampl changed.

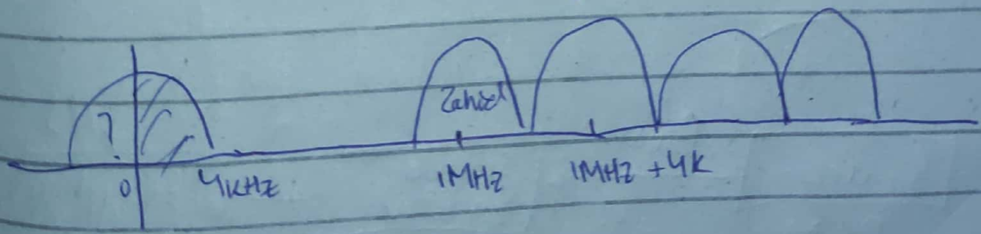
Now if we write amplitude in Modulator definition then it is called Amplitude Modulation.

FM
Angle Modulation



This Analogue Modulation

★ Why Modulation?-
(i) Frequency Translation



(ii) Practicality of Antenna

Antenna Theory: dimensions of antenna should be comparable with wavelength of signal.

Let f is 0 - 4 KHz

$c = f\lambda$

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{4\times10^3} = 75\text{ km}$$

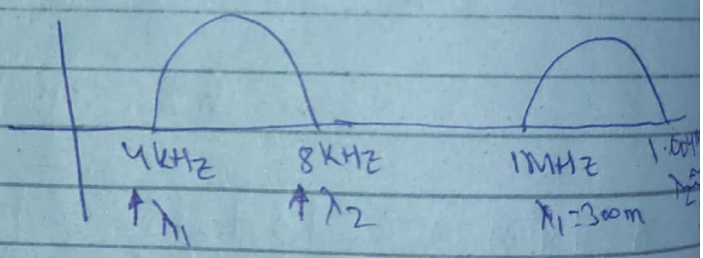
we have to decrease it, increasing f.

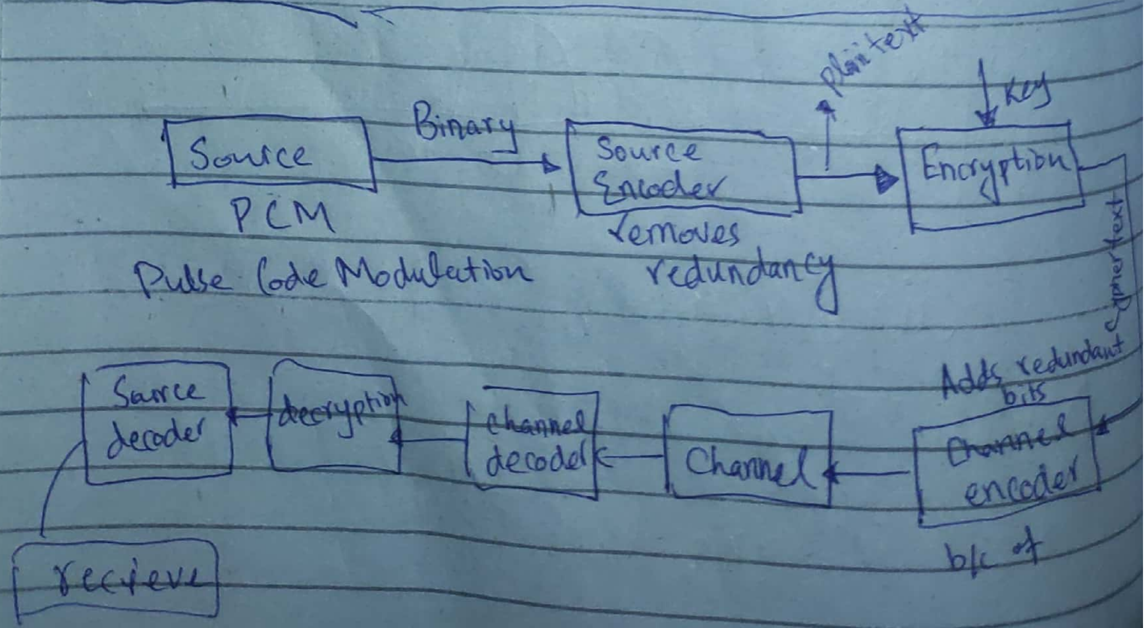
$$\lambda = \frac{3\times10^8 \text{ m/s}}{1\times10^6} = 3\times10^2 = 300\text{m}$$

(iii) Narrowbanding

$\lambda_1 = 75$ Km

$\lambda_2 = 37.5$ Km





Date 04 Oct, 2023

	P.B
0001	1
1110	1
1100	0

Even parity has limitation. Hence, Hamming code came.

Hamming Code:-

m bits to be transmitted

k bits must be added.

m bits + K bits

$$2^k \geq m + k + 1$$

Let m = 8, if k = 4

$$\boxed{16 \geq 13}$$

So we should add 4 extra bits

1100	1011	1010	1001	1000	0111	0110	0101	0100	0011	0010	0001
12	11	10	9	8	7	6	5	4	3	2	1
D_7	D_6	D_5	D_4	C_8	D_3	D_2	D_1	C_4	D_0	C_2	C_1

$C_1 = D_0 \oplus D_1 \oplus D_3 \oplus D_4 \oplus D_6$

$C_2 = D_0 \oplus D_2 \oplus D_3 \oplus D_5 \oplus D_6$

(Exor of least significant bits)

$C_4 = D_1 \oplus D_2 \oplus D_3 \oplus D_7$

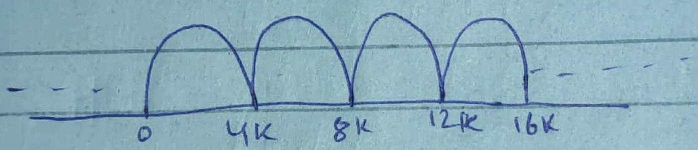
$C_8 =$ [illegible] $\oplus D_7$

Scanned with CamScanner

Let we want to transmit
1 1 1 1 1 1 1 1 → 8 bits

* if one of the bits is containing error, then we will take EXOR of key and measured key whose answer will give us the location of parity bit.

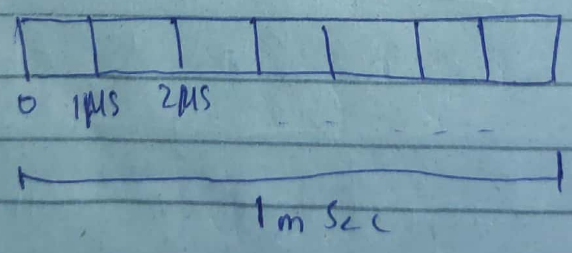
★ FDM (Frequency Division Multiplexing)



Time is compromised by band.

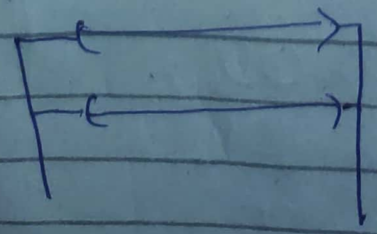
★ TDM

Different time slots



★ SDM

Distribution of space among channels



Space is divided using physical / Non-physical link

Advanced

★ FDM / FDMA → 1G Technology → Analogue Tech

GSM ★ FDM / TDMA → 2G Tech.

→ Digital Tech.

rect ⟷ Sinc

8	7	6	5	4	3	2	1		8	7	6	5	4	3	2	1

Pause for 7 μSec

★ FDM / CDMA → Code division multiple access.

→ 5MHz Bandwidth.

→ Costly

→ data rate increased

→ we give tag to each signal. to avoid confusion.

$$C_1 = \frac{1}{\sqrt{4}}\begin{bmatrix}1 & 1 & 1 & 1\end{bmatrix}, \quad C_2 = \frac{1}{\sqrt{4}}\begin{bmatrix}-1 \\ 1 \\ -1 \\ 1\end{bmatrix}$$

$$\left\{\begin{array}{l} C_1 \cdot C_2^T = 0 \\ C_1 \cdot C_1^T = 1 \end{array}\right.$$

Code Selection Criteria

$$m_1(t) \cdot c_1(t) + m_2(t) \cdot c_2(t)$$

Now we multiply $c_1(t)$ to get $m_1(t)$

21

→ Ext. Noise → Multiplicative Effect
→ Internal Noise → Additive Effect like AWGN

Date 05/10/2023

★ Signal to Noise Ratio:-

$$SNR = \frac{P_s \rightarrow \text{Power of signal}}{P_n \rightarrow \text{'' '' Noise}}$$

$$y(t) = g(t) * h(t) + n(t)$$

★ Shannon Capacity:-

$$C = B \log_2(1 + SNR) \text{ bits/sec}$$

$$C = 1000 \log_2(1+100) \text{ bits/sec}$$

$$10.\log P_s/P_n = 10.\log 100 = 20.\log 10$$
$$= 20.dB$$

if $P = 100mW$

$$10.\log P = 10.\log 100 = 20dBm$$

if $P = 100$ Watts

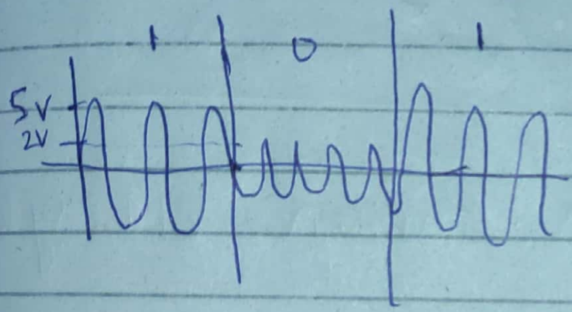
→ 100 dBw − 50 dBw = 50 dB

$10 . \log \frac{10^2}{10^5}$

$20 \log 10 - 50 . \log 10$

→ 10 . dB + 50 dBw = 60 dBw

→ 100 dB~~w~~ + 10 dBw = 60 dBw



ASK

FSK

QPSK

Date 06/10/2023

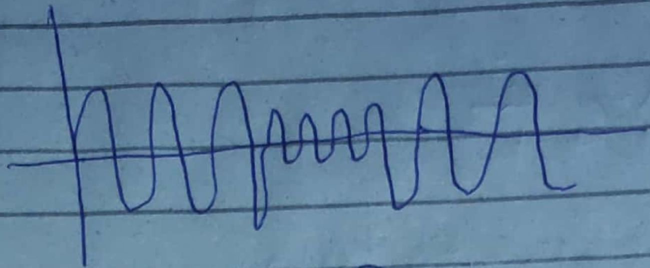
AMPS → 30 KHz

$C = B . \log(1 + SNR)$ bits/sec

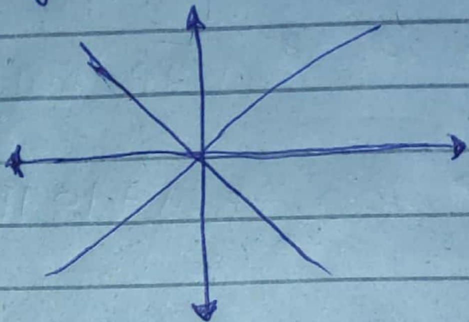
It contributes more

$P_e = 10^{-4} = \frac{1}{10,000}$

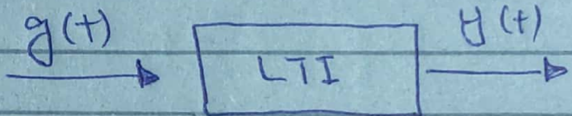
CDMA → 5 MHz



Constellation Diagram



★ Signal Transmission through LTI System:



$$y(t) = g(t) * h(t) + n(t)$$

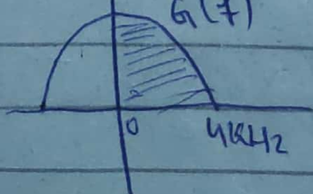
$n(t)$ → AWGN → Internal Noise

$\hat{g}(t)$

$$h(t) = \delta(t)$$

★ Impulse Response

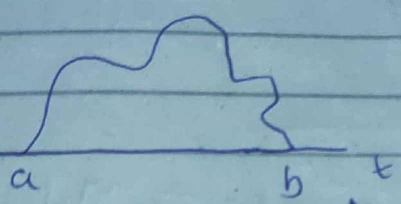
$$Y(\omega) = G(\omega) . H(\omega) \quad \text{—(i)}$$

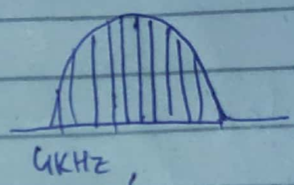


$$|Y(\omega)| \cdot e^{j\theta_y(\omega)} = |G(\omega)| \cdot e^{j\cdot\theta_g(\omega)} \, |H(\omega)| \cdot e^{\theta_h(\omega)}$$

$$|Y(\omega)| = |G(\omega)|\,|H(\omega)| \rightarrow \text{Amplitud Response}$$

$$\theta_{y(\omega)} = \theta_{g(\omega)} + \theta_{h(\omega)} \rightarrow \text{Phase Response}$$

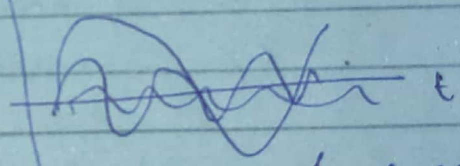




and outside a-b boundary they form zero.

↓

Marvelous Balancing Act.



many f component are added and form

★ Distortion less transmission.

If any of response (Amp or Phase) is not ideal then signal will be distorted.

So we do trade off on it b/G

→ ear is insensitive to phase response of speech signal.

→ In terms of video signal, it is opposite. i.e eye is more sensitive to phase response.

0.01 — 0.1 sec Average speech syllable

→ Digital Comm. is very much sensitive to phase response.

Now Let

$$y(t) = K.\,g(t - t_d)$$

it is distortionless if all the components are delayed by same amount.

Now $g(t-t_d) \Longleftrightarrow G(\omega).\,e^{-j\omega t_d}$

$$Y(\omega) = K.\,G(\omega).\,e^{-j\omega t_d} \quad \text{—(ii)}$$

Compare with (i)

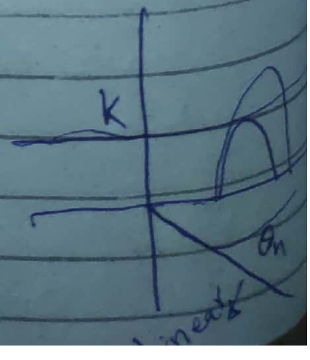
$$\cancel{G(\omega)}.\,H(\omega) = K.\,\cancel{G(\omega)}.\,e^{-j\omega t_d}$$

$$H(\omega) = K.\,e^{-j\omega t_d}$$

$$|H(\omega)| = K$$

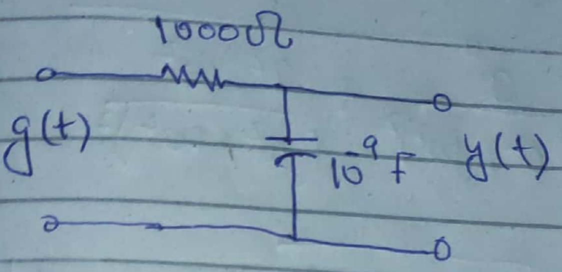
$$\theta_h(\omega) = -\omega.t_d$$

$$y = mx + c$$



Now $\dfrac{d.\,\theta_h(\omega)}{d\omega} = -t_d$

'td' is constant for all $\phi\,\omega$.



$$Y(\omega) = \frac{1/j\omega c}{R + 1/j\omega c} \times G(\omega)$$

$$\frac{Y(\omega)}{G(\omega)} = \left[\frac{1/j\omega c}{R + 1/j\omega c}\right] = H(\omega)$$

$$H(\omega) = \frac{1/j\omega RC}{1 + 1/j\omega RC}$$

$$= \frac{1}{1 + j\omega RC} = \frac{1/RC}{1/RC + j\omega}$$

Let $a = RC$

$$H(\omega) = \frac{a}{a+j\omega} \times \frac{a-j\omega}{a-j\omega} = \frac{a^2}{a^2+\omega^2} - j\frac{a\omega}{a^2+\omega^2}$$

$$|H(\omega)| = \sqrt{\left(\frac{a^2}{a^2+\omega^2}\right)^2 + \left(-\frac{a\omega}{a^2+\omega^2}\right)^2}$$

$$'' = \sqrt{\frac{a^4}{(a^2+\omega^2)^2} + \frac{a^2.\omega^2}{(a^2+\omega^2)^2}}$$

$$'' = \sqrt{\frac{a^4+a^2\omega^2}{(a^2+\omega^2)^2}} = \frac{a\left(\sqrt{a^2+\omega^2}\right)}{(a^2+\omega^2)}$$

$$'' = \cancel{\frac{\sqrt{a^2(a^2+\omega^2)}}{a^2+\omega^2}}$$

$$'' = \frac{a}{\sqrt{a^2+\omega^2}}$$

$$\theta_n(\omega) = \tan^{-1}\left(\qquad\qquad\right) = \omega/a$$

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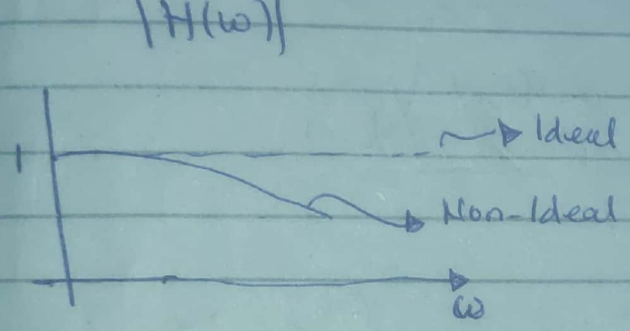
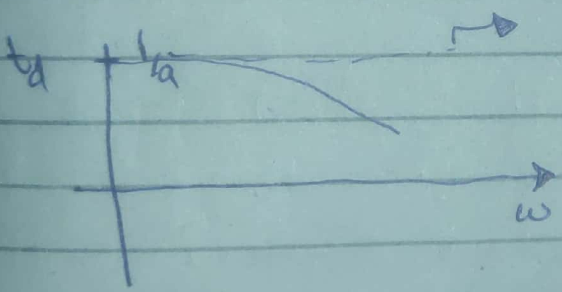
$$|H(0)| = 1$$

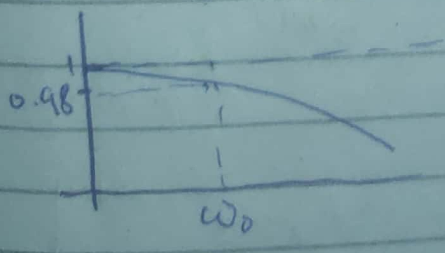
$$t_d = \frac{d\theta_n(\omega)}{d\omega} = \frac{a}{a^2+\omega^2}$$

$$t_d(0) = \frac{a}{a^2} = \frac{1}{a}$$





Higher frequency comp. will reach destination ~~by~~ fast. will less delay.



$$|H(\omega)| \geq 0.98$$

$$\frac{a}{\sqrt{a^2+\omega^2}} \geq 0.98$$

$$a \geq 0.98\sqrt{a^2+\omega^2}$$

$$a^2 \geq 0.96a^2 + 0.96\omega_0^2$$

$$0.96\omega_0^2 \leq a^2 - 0.96a^2$$

$$\omega_0 \le \sqrt{\frac{a^2 - 0.96a^2}{0.96}}$$

$$\omega_0 \le \sqrt{\frac{0.04}{0.96}}\, a$$

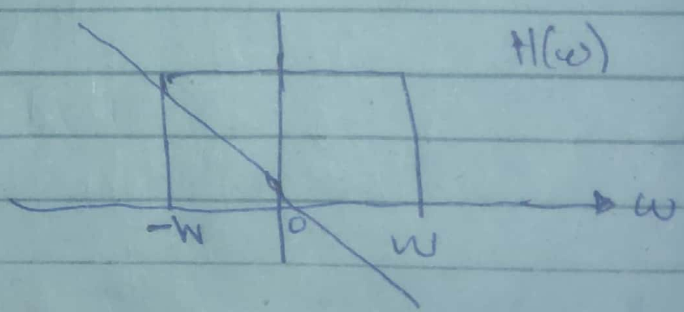
$$a = 1/_{RC} = 10^6$$

$$\boxed{\omega_0 \le 203{,}000}$$

For td:-

$$\frac{a}{a^2 + \omega_0^2} \le 0.95 \times 1/a$$

★ Ideal and Practical filters:-



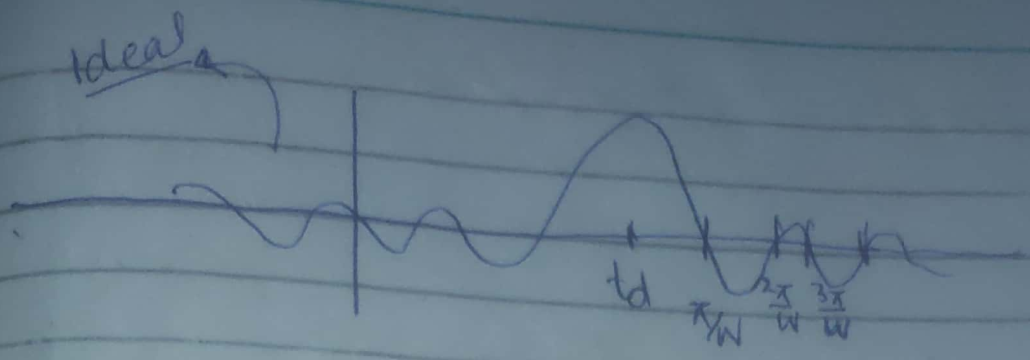
$$H(\omega) = \text{rect}\left(\frac{\omega}{2W}\right) \cdot e^{-j\omega t_d}$$

Impulse Response:-

$$F^{-1}\left[\text{rect}\left(\frac{\omega}{2W}\right) \cdot e^{-j\omega t_d}\right]$$

$$\frac{W}{\pi} \cdot \text{Sinc}\,W(t - t_d) \Leftrightarrow \text{rect}\left(\frac{\omega}{2W}\right) \cdot e^{-j}$$

Ideal



$$\frac{\sin(x(t - t_d))}{x - t_d} = 0$$

$x - \cancel{t_d} = 0$ $W(t - t_d) = \pm n\pi$

$$t - t_d = \pm \frac{n\pi}{W}$$

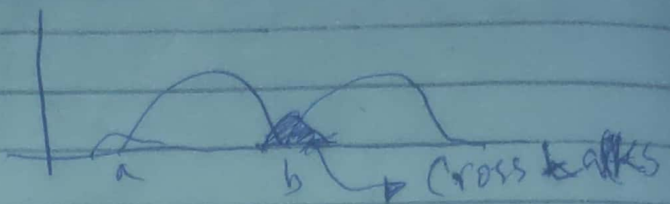
h(t) exist at t<0 : Ideal case
Paley-Weiner Criteria for making signal realizable.

$$\int_{-\infty}^{\infty} \frac{\ln |H(\omega)|}{1+\omega^2} d\omega < \infty$$

* If we truncate sinc then it will no longer remain ~~ideal~~. ~~sinc~~ sinc.
* By increasing td, bitrate will decrease but signal will be good.

$\hat{h}(t) = h(t).u(t)$

★ Linear Distortion :-



When pulse spread up in time domain it is called linear distortion.

★ It has severe effect in TDM system, doesn't effect FDM.

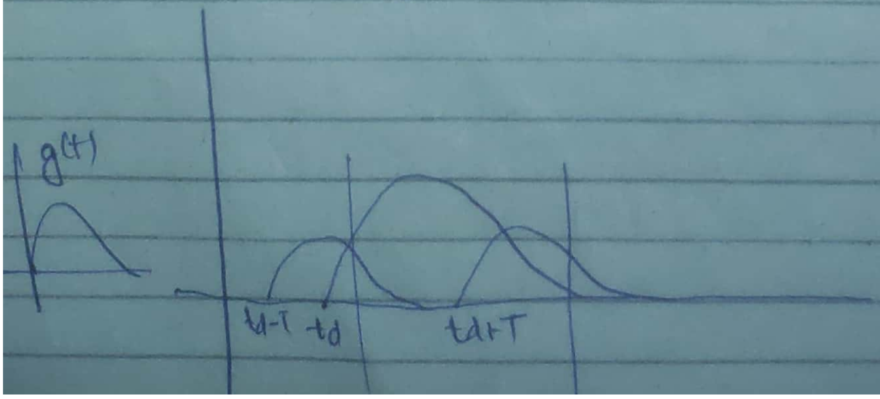
$$H(\omega) = (1 + K.\cos T\omega) . e^{-j\omega t_d} \qquad |\omega| < 2\pi B$$

$$\cos\theta = \frac{e^{j\theta} + e^{-j\theta}}{2}$$

$$H(\omega) = e^{-j\omega t_d} + \frac{K}{2} . e^{-j\omega(t_d - T)} + \frac{K}{2} . e^{-j\omega(t_d+T)}$$

Multiply $G(\omega)$ to get $Y(\omega)$

$$Y(\omega) = G.(\omega) . e^{-j\omega t_d} + \frac{K}{2} . g(t - (t_d - T)) + \frac{K}{2} . g[t - (t_d + T)]$$



★ Linear distortion will spread the signal in time domain.

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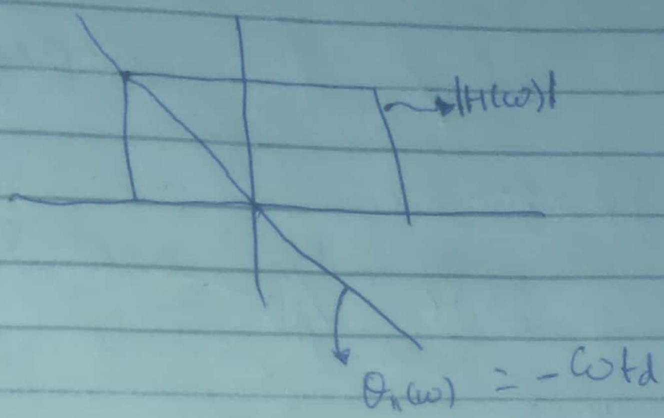
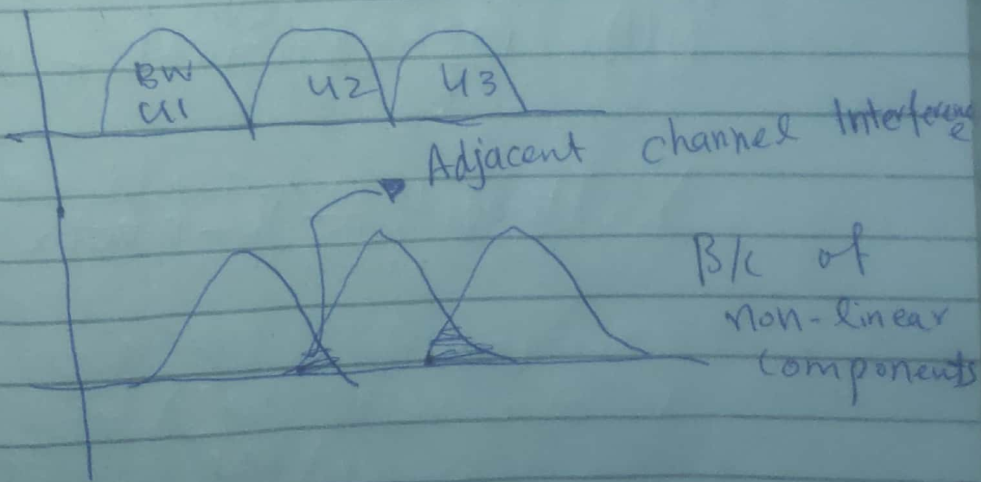


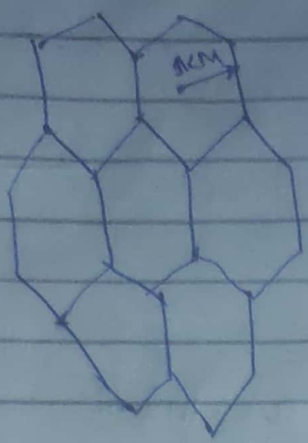
★ Non-Linear Distortion:-

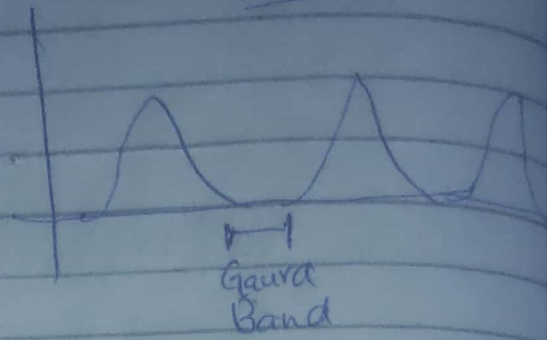
$$y(t) = \overbrace{a_0 + a_1 x(t)}^{\text{Linear}} + a_2 \cdot x^2(t) + a_3 \cdot x^3(t) + \cdots$$
$$\cdots + a_n \cdot x^n(t) \cdots$$

→ Non-linear will affect frequency domain.



Solution





wattage of band.

Power Law :-

$P_r \propto 1/d^{(n)} \rightarrow$ path loss Exponent

★ $y(t) = x(t) + 0.001\, x^2(t)$

$x(t) = \frac{1000}{\pi} \operatorname{sinc} 1000t$

18. $\frac{W}{\pi} \operatorname{Sinc} Wt \Longleftrightarrow \operatorname{rect} \frac{\omega}{2W}$

20. $\frac{W}{2\pi} . \operatorname{Sinc}^2 \frac{Wt}{2} \Longleftrightarrow \Delta\left(\frac{\omega}{2W}\right)$

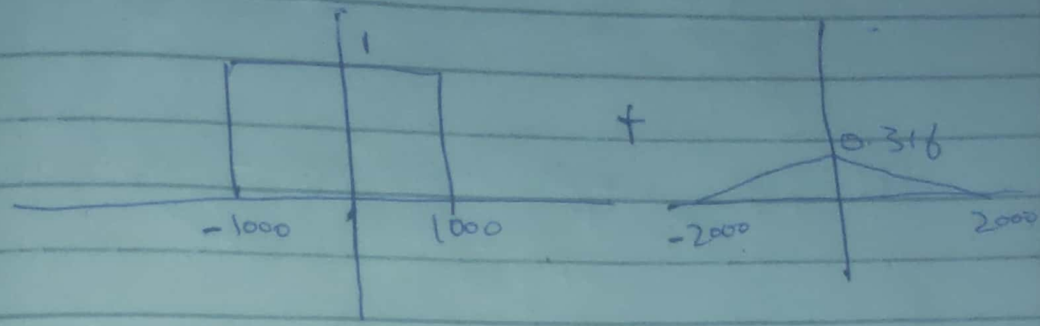
$y(t) = \frac{1000}{\pi} . \operatorname{Sinc}. 1000t + 0.001 \times \frac{10^6}{\pi^2} . \operatorname{Sinc}^2 1000t$

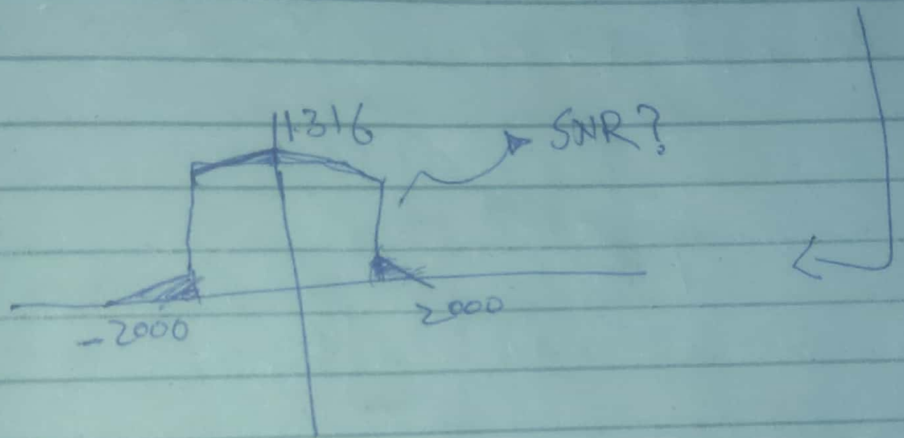
$Y(\omega) = \operatorname{rect}\left(\frac{\omega}{2000}\right) + 0.001 \times \frac{1000}{\pi} . \Delta\left(\frac{\omega}{4000}\right)$

unwanted

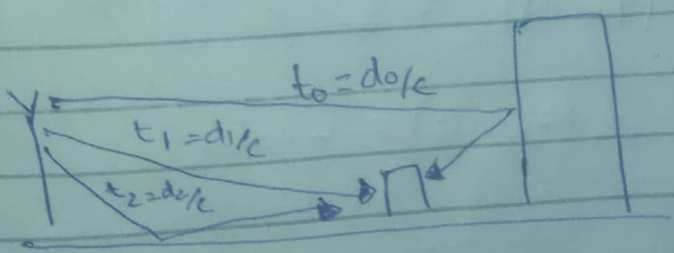
$Y(\omega) = \operatorname{rect}\left(\frac{\omega}{2000}\right) + \frac{1}{\pi} \Delta\left(\frac{\omega}{4000}\right)$

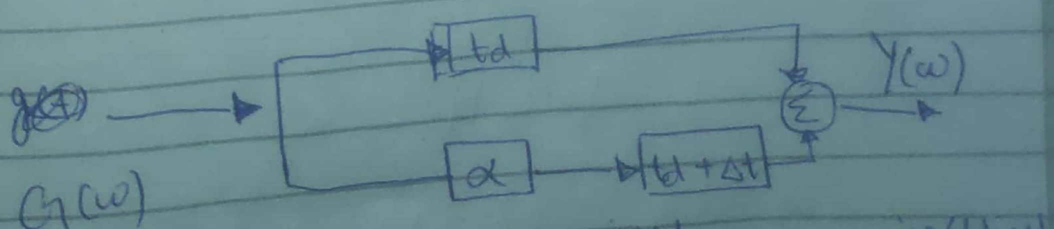
$$\frac{1000}{\pi} \times \frac{2000}{\pi} \cdot \sin^2 1000t \Longleftrightarrow \frac{1000}{\pi} \Delta\left(\frac{\omega}{4000}\right)$$





★ Distortions Caused by Multipath effect:-





$$H(\omega) = 1 \cdot e^{-j\omega t_d} + \alpha \cdot e^{-j\omega(t_d + \Delta t)}$$

$$e^{j\theta} = \cos\theta + j\sin\theta$$

$$H(\omega) = \left[1 + \alpha . e^{-j\omega\Delta t}\right] . e^{-j\omega t_d}$$

$$H(\omega) = \left[1 + \alpha . \cos\omega.\Delta t - j.\alpha.\sin\omega.\Delta t\right] . e^{-j\omega t_d}$$

$$H(\omega) = \left\{\sqrt{(1+\alpha\cos\omega\Delta t)^2 + \alpha^2 . \sin^2\omega\Delta t}\right) . e^{-j\tan^{-1}}$$

$$\times e^{-j\omega t_d}$$

Date 18/10/2023

$$\boxed{H(\omega) = 1 e^{-j\omega t_d}}$$

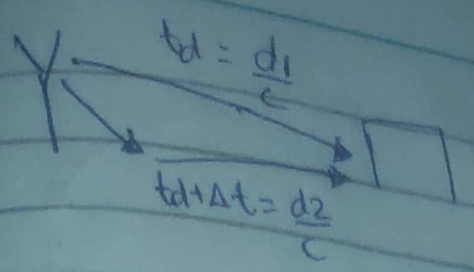
$$|H(\omega)| = 1$$

$$\theta_h(\omega) = -\omega t_d$$

$$H(\omega) = \alpha . e^{-j\omega(t_d + \Delta t)}$$

$$|H(\omega)| = \alpha$$

$$\theta_h(\omega) = -\omega(t_d + \Delta t)$$



at reciever's end:

$$H(\omega) = e^{-j\omega t_d} + \alpha e^{-j\omega(t_d+\Delta t)}$$

$$\text{"} = \left(1 + \alpha . e^{-j\omega\Delta t}\right) . e^{-j\omega t_d}$$

If $\alpha \approx 1$

Max value of $\boxed{|H(\omega)| = 2}$

→ For $\cos\omega\Delta t = 1$ (Constructive interference)

$\cos\omega\Delta t = -1$ (Destructive ")

This phenomenon is called freq. Selective Fading.

Hence, $\omega . \Delta t = n\pi$ $n = 0, 2, 4, \ldots$ (Const. interf.)

$$\omega = \frac{n\pi}{\Delta t}$$

(Destructive inter.) for $n = 1, 3, 5, 7 \ldots$

★ **Energy:-**

$g(t)$

$$E_g = \int_{-\infty}^{\infty} |g(t)|^2 dt = \int_{-\infty}^{\infty} g(t) \cdot g^*(t)\, dt$$

$$\int_{-\infty}^{\infty} g(t).\, e^{-j\omega t}$$

$$g(t) \qquad\qquad G(\omega)$$

$$\frac{1}{2\pi}\int_{-\infty}^{\infty} G(\omega).\, e^{j\omega t}$$

Now $\int_{-\infty}^{\infty} g(t).\, g^*(t)\, dt$

$$= \int_{-\infty}^{\infty} g(t)\left[\frac{1}{2\pi}\int_{-\infty}^{\infty} G^*(\omega).\, e^{-j\omega t}.\, d\omega\right] dt$$

$$E_g = \frac{1}{2\pi}\int_{-\infty}^{\infty} G^*(\omega)\left[\int_{-\infty}^{\infty} g(t).\, e^{-j\omega t} dt\right] d\omega$$

$$E_g = \frac{1}{2\pi}\int_{-\infty}^{\infty} G^*(\omega).\, G(\omega)\, d\omega$$

$$E_g = \frac{1}{2\pi}\int_{-\infty}^{\infty} |G(\omega)|^2\, d\omega \longrightarrow \text{Parseval's Theorem}$$

$g(t) = e^{-at}.\, u(t) \qquad a > 0$

$E_g = 1/2a \qquad |G(\omega)|^2$:

Do it yourself

using Parseval's theorem,

$$E_g = \frac{1}{2\pi}\int_{-\infty}^{\infty} \frac{1}{a^2+\omega^2}\, d\omega$$

$$E_g = \frac{1}{2\pi . a} \cdot \tan^{-1}(\omega/a)\Big|_{-\infty}^{\infty}$$

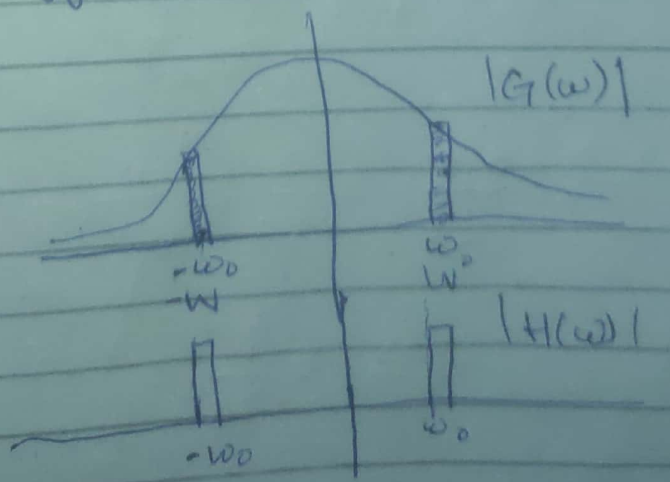
$$E_g = \frac{1}{2\pi a}\left[\tan^{-1}(\infty) - \tan^{-1}(-\infty)\right]$$

$$E_g = \frac{1}{2\pi a}\left[\frac{\pi}{2} + \pi/2\right] = \frac{1}{2\pi a}(\pi)$$

$$\boxed{E_g = \frac{1}{2a}}$$

★ **Energy Spectral Density:-**

↳ Energy per unit of frequency.



$$E_g = \frac{1}{2\pi}\int_{-\infty}^{\infty} |Y(\omega)|^2 d\omega$$

$$E_g = \frac{1}{2\pi} \cdot |G(\omega)|^2 d\omega$$

$$E_g = \frac{1}{\cancel{2\pi}} \cdot |G(\omega)|^2 . \cancel{2\pi} . df$$

$$ESD = \frac{E_g}{df} = \boxed{|G(\omega)|^2}$$

$$g(t) \Longleftrightarrow G(\omega)$$

$$|G(\omega)|^2$$

★ $g(t) = e^{-at} . u(t)$ $\quad a > 0$

95% needed B

$$0.95 \times E_g = \frac{1}{2\pi}\int_{-W}^{W} \frac{1}{a^2+\omega^2} d\omega$$

The band used for our own requirement is called essential bandwidth.

Replace W by B to avoid confusion

$$\frac{0.95}{2a} = \frac{1}{2\pi}\int_{-W}^{W} \frac{1}{a^2+\omega^2} d\omega$$

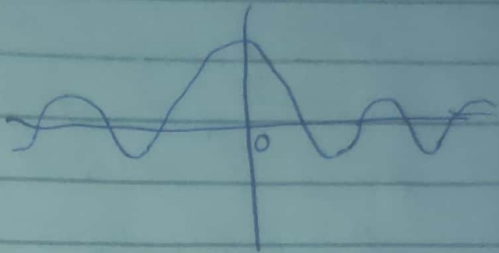
$$\frac{0.95}{2a} = \frac{1}{2\pi a} \cdot \tan^{-1}\left(\frac{\omega}{a}\right)\Big|_{-B}^{B}$$

$$\frac{0.95}{2\cdots} = \frac{1}{2\pi a}\left[2 . \tan^{-1}\frac{B}{a}\right]$$

$\tan^{-1} B/a = \frac{0.95\pi}{2}$

$$B = a.\tan\left(\frac{0.95\pi}{2}\right)$$

★ $g(t) = rect\ t/\tau$



$$G(\omega) = \tau.\ Sinc \frac{\omega\tau}{2}$$

$$\frac{\omega\tau}{2} = \pm n\pi$$

$$\omega = \frac{\pm 2n\pi}{\tau}$$

$$E_g(\omega) = \frac{1}{2\pi}\int_{-\infty}^{\infty} \tau^2.\ Sinc^2\left(\frac{\omega\tau}{2}\right) d\omega$$

$$E_g(\omega) = \tau$$

$$2\pi . x\ \frac{0.9\tau}{\tau} = \frac{1}{2\pi}\int_{-B}^{B} \tau^2.\ Sinc^2\left(\frac{\omega\tau}{2}\right) d\omega$$

Q: Implement your own pwd command in C language.
Ans: we don't know about it

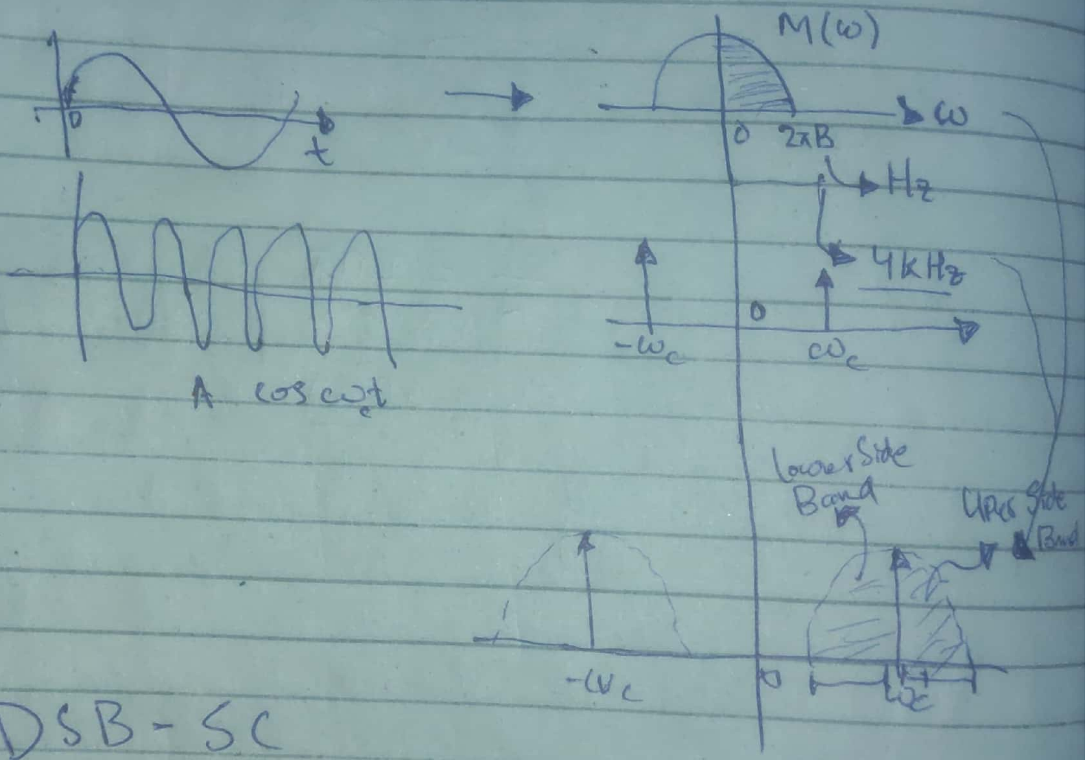
Date 25/oct/2023

Chapter 01

1 Amplitude Modulation:-

Baseband Communication → No Modulation
Carrier // (Wireless Communication)

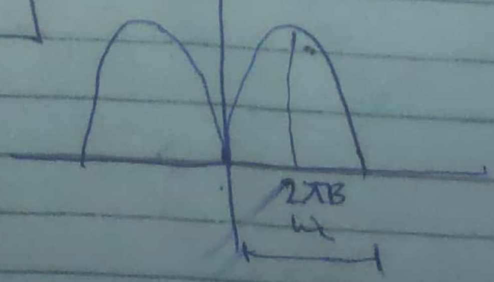
$m(t)$



DSB-SC

↳ Supress Carrier Band is increase

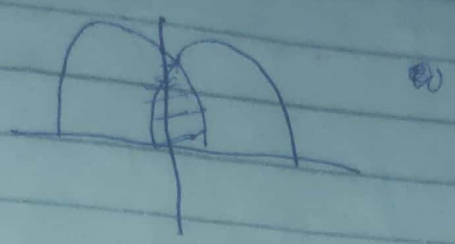
$\boxed{\omega_c \geq 2\pi B}$



B = 4πB

ω_c 2B Hz

How for $\omega_c < 2\pi B$



* At reciever's end:

$m(t) \cdot \cos(\omega_c t)$

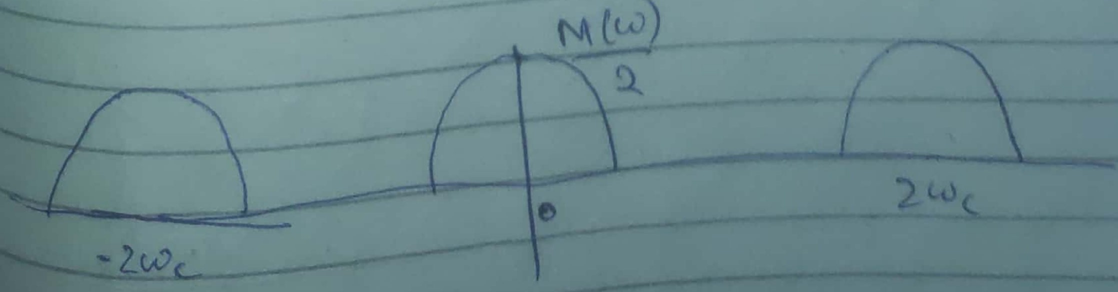
Again multiply it with $\cos(\omega_c t)$.

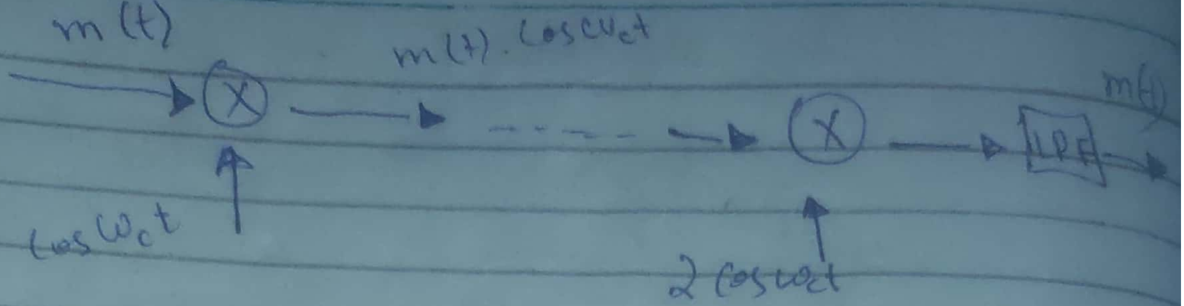
i.e $\{m(t) \cdot \cos(\omega_c t)\} \cos(\omega_c t)$

$= m(t) \cdot \cos^2(\omega_c t)$

$= m(t) \left\{ \frac{1 + \cos 2\omega_c t}{2} \right\}$

$= \frac{m(t)}{2} + \frac{m(t) \cos 2\omega_c t}{2}$



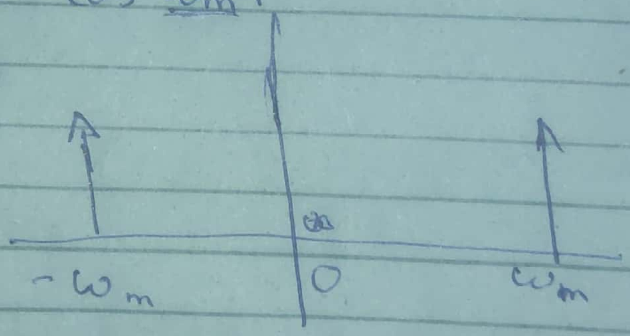


★ Synchronous / Coherent Detection

DSB-SC → need synchronous detection
- it becomes difficult in high frequencies. Like Synchronizing clocks.

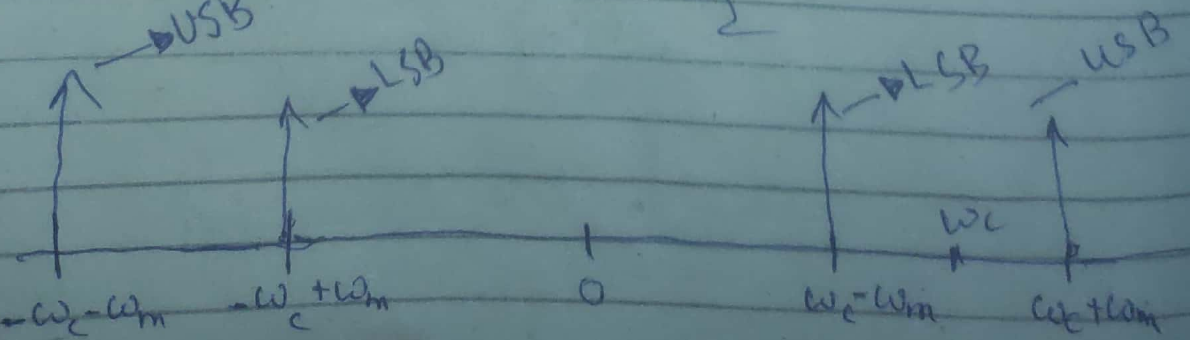
★ $m(t) = \cos \omega_m t$

Baseband



$m(t) = \cos \omega_m t \cdot \cos \omega_c t$ ← Modulation

$$\phi_{AM}(t) = \frac{\cos((\omega_m + \omega_c)t) + \cos((\omega_c - \omega_m)t)}{2}$$



Date 26/10/2023

$m(t) . \cos^2 \omega_c t$

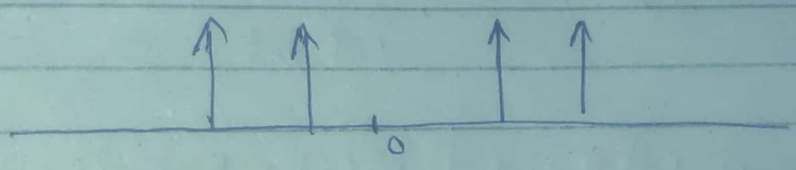
DSB-SC

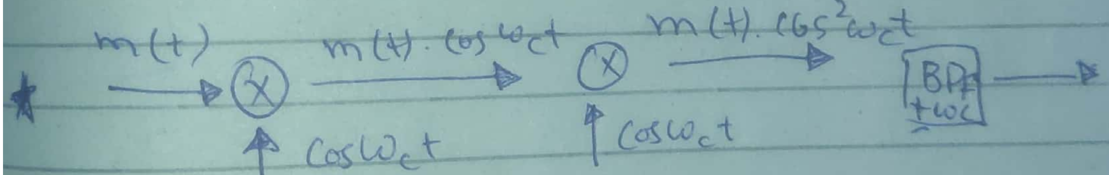
$4\pi B \rightarrow$

$2\pi B + 2\pi B$

$f_{c_{Tx}} = f_{c_{Rx}}$

If $m(t) = \cos \omega_m t$





★ Modulator: (i) Multiplier

↳ A circuit for multiplication

(ii) Non-Linear Modulators :-

$y(t) = a\, x(t) + b\, x^2(t)$

$z(t) = y_1(t) - y_2(t)$

$x_1(t) = \cos \omega_c t + m(t)$

$x_2(t) = \cos \omega_c t - m(t)$

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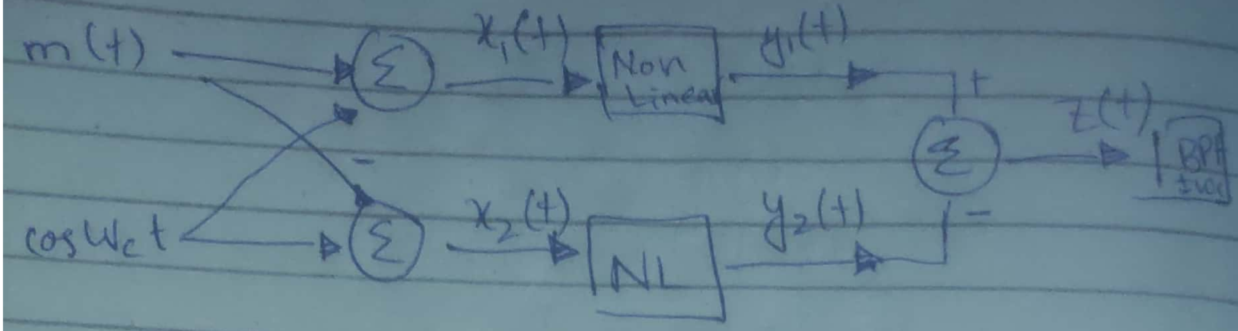


$b\,x_1^2(t) = b\cos^2\omega_c t + b\,m^2(t) + 2b\,m(t)\cos\omega_c t$

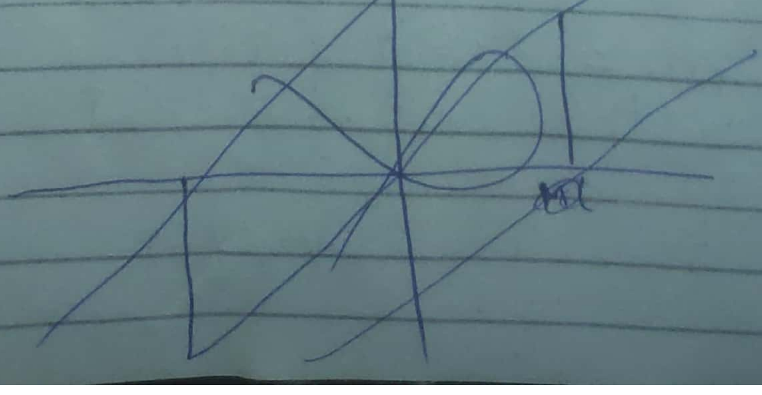
$b\,x_2^2(t) = b\cos^2\omega_c t + b\,m^2(t) - 2b\,m(t)\cos\omega_c t$

$y_1(t) = a\cos\omega_c t + a\cdot m(t) + b\cos^2\omega_c t + b\,m^2(t)$

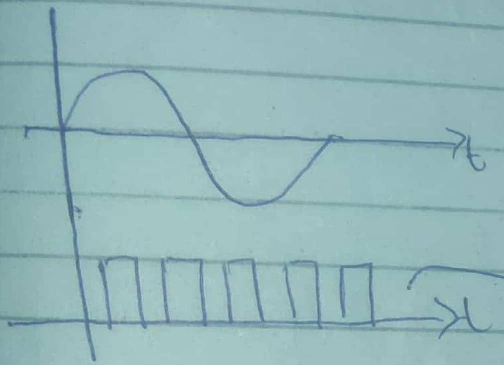
$y_2(t) =$

$z(t) = 2a\,m(t) + 4b\,m(t)\cdot\cos\omega_c t$

$z(\omega) = 2a\,\cancel{M}M(\omega) + 4b\,\dfrac{M(\omega+\omega_c)}{2} + 4b\,\dfrac{M(\omega-\omega_c)}{2}$



Switching Modulator :-



Can be represented using Fourier Series

Assignment

$$\sum_{n=0}^{\infty} C_n \cos(n\omega_0 t + \theta_n)$$

Fourier Series of Train of Pulses :

$$w(t) = \frac{1}{2} + \frac{2}{\pi}\left\{\cos\omega_c t - \frac{1}{3}\cos 3\omega_c t + \frac{1}{5}\cos 5\omega_c t + \cdots\right\}$$

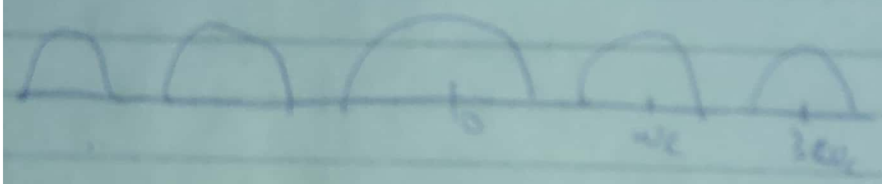
Multiply $m(t)$ with it.

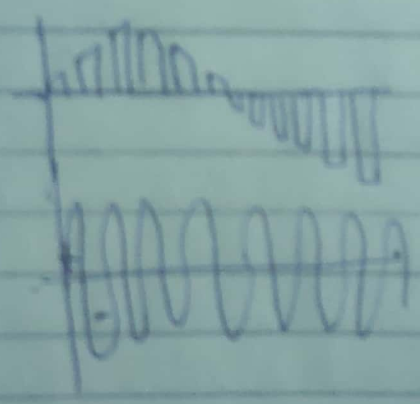
$$= \int_{-\infty}^{\infty} e^{j\omega_c t} \cdot e^{-j\omega t} \, dt$$

$$= \left. \frac{e^{j(\omega_c - \omega)t}}{j(\omega_c - \omega)} \right|_{-\infty}^{\infty}$$

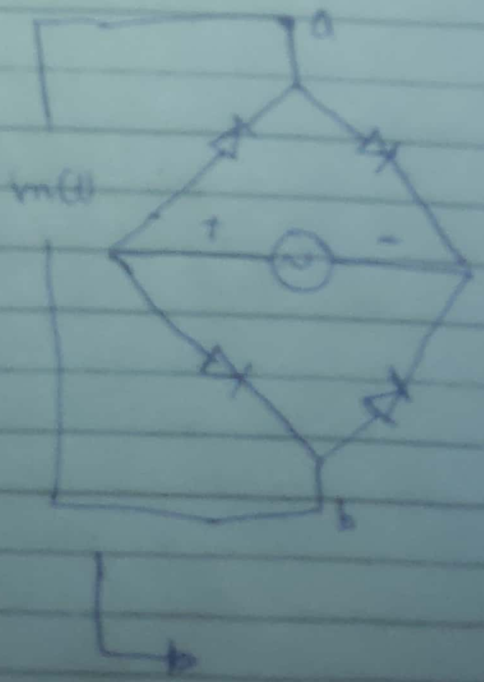
$$= \frac{e^{\infty}}{j(\omega_c - \omega)} - \frac{e^{-\infty}}{j(\omega_c - \omega)}$$

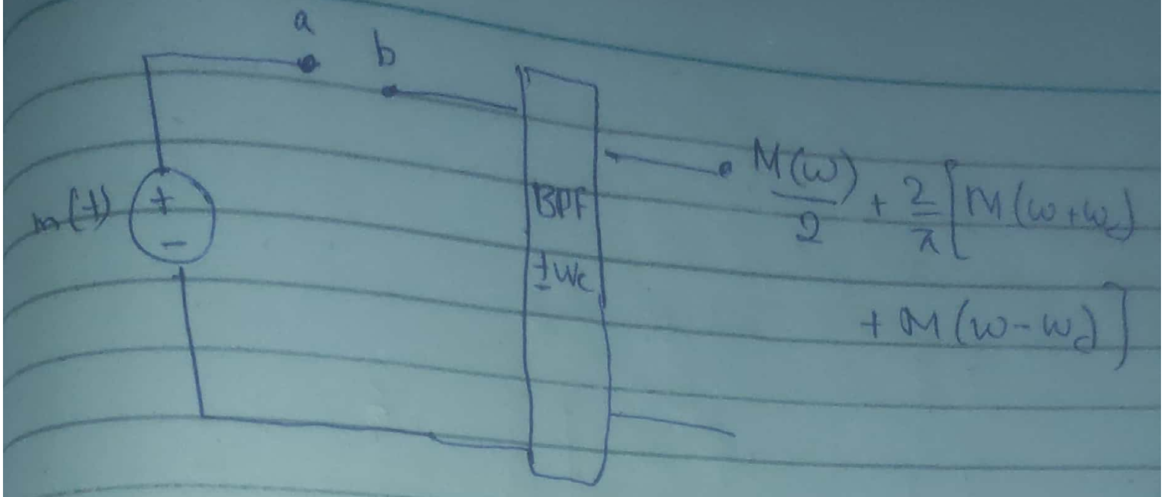
$=$



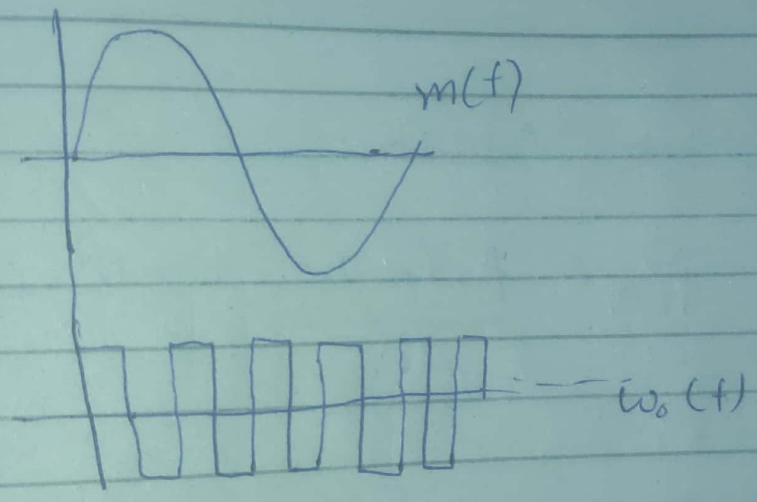


★ Bridge Circuit :-



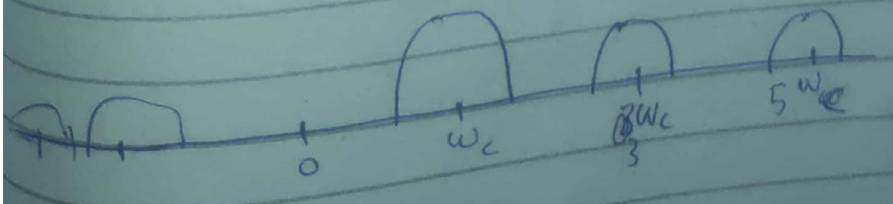


* RING MODULATOR :-

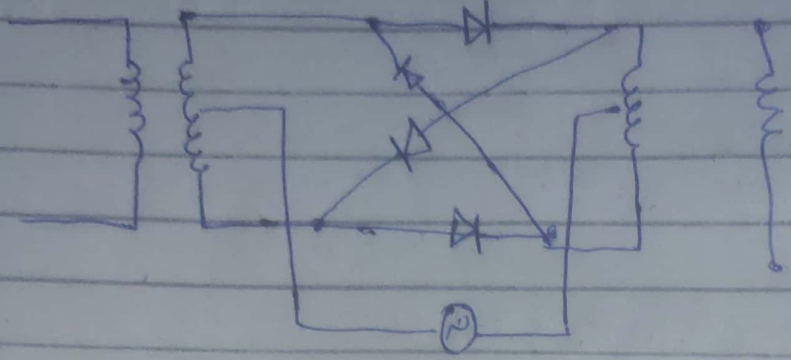


As carrier is periodic, we write it's Fourier series.

$$\omega_o(t) = \frac{4}{\pi}\left(\cos\omega_c t - \frac{1}{3}\cos 3\omega_c t + \frac{1}{5}\cos 5\omega_c t \ldots\right)$$



Now it's circuit B:

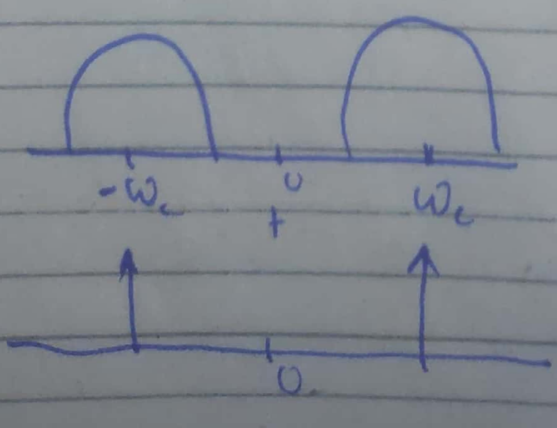


Amplitude Modulation:-

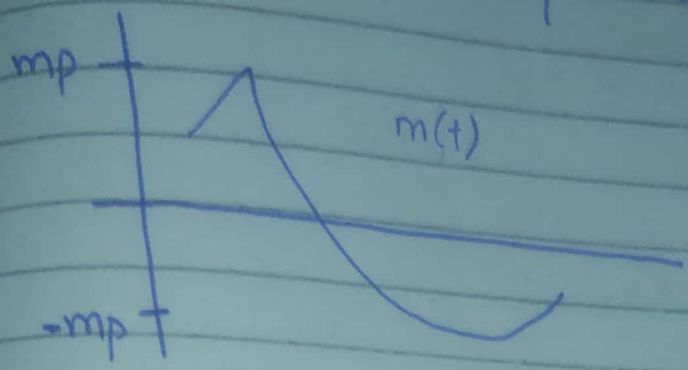
$$\varphi_{AM} = \underbrace{A \cdot \cos\omega_c t}_{\text{Carrier}} + m(t) \cdot \cos\omega_c t$$

$$\Phi_{AM}(\omega) = \pi\left\{\delta(\omega+\omega_c) + \delta(\omega-\omega_c)\right\}$$

$$+ \frac{M(\omega+\omega_c) + M(\omega-\omega_c)}{2}$$



$$\varphi_{AM} = \{A + m(t)\} \cos \omega_c t$$



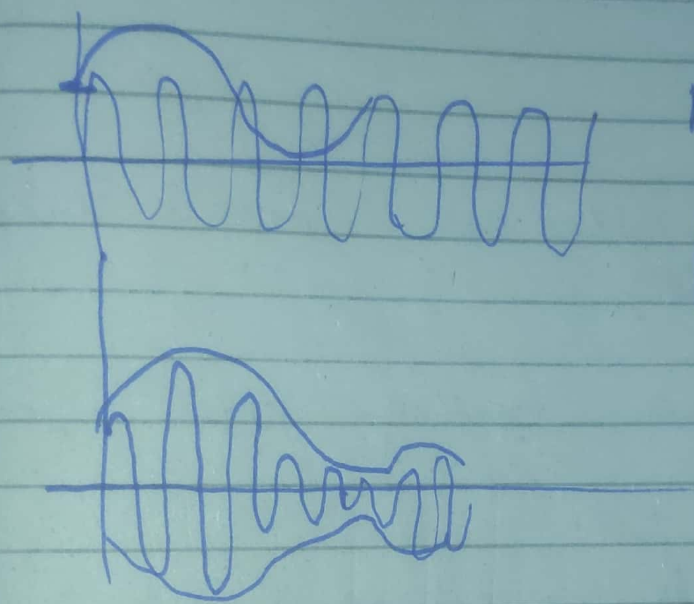
$A + m(t) \geq 0$

for all t

$A \geq m_p$

Modulation Index

$$\boxed{\mu = \frac{m_p}{A}}$$



$A \cdot \sin \omega_c t$

$B \cdot \cos(\omega_c t + \theta_c)$

$$\mu = \frac{m_p}{A}$$

$$0 \leq \mu \leq 1$$

$\mu > 1$ Over Modulation

$$m(t) = B \cos \omega_m t$$

$$\varphi_{AM}(t) = [A + B \cos \omega_m t] \cdot \cos \omega_c t$$

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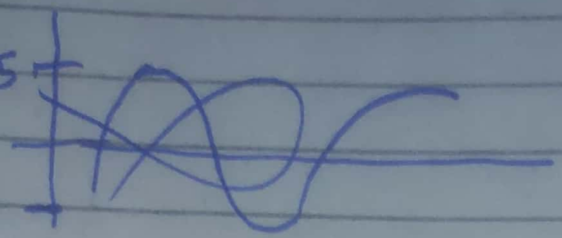
$\mu = B/A$, $B = \mu A$

$\varphi_{AM}(t) = A\left[1 + \mu \cos\omega_m t\right].\cos\omega_c t$



★ Side Bands and Carrier Power:-
(Price Band)
we pay

We are spending extra power.

$$\varphi_{AM}(t) = \underbrace{A\cos\omega_c t}_{P_c} + \underbrace{m(t).\cos\omega_c t}_{P_m}$$

$$P_c = \frac{1}{T}\int_{-T/2}^{T/2} A^2.\cos^2\omega_c t\, dt$$

$$P_c = \frac{A^2}{T}\int_{-T/2}^{T/2}\left(\frac{1 + \overbrace{(\cos 2\omega_c t)}^{0}}{2}\right) dt$$

$$P_c = \frac{A^2}{2\cancel{T}}.\cancel{T} = \boxed{\frac{A^2}{2}}$$

$$P_m = \frac{\overline{m^2(t)}}{2} \rightarrow \text{Mean}$$

Power Efficiency

$$\eta = \frac{\text{Useful Power}}{\text{Total Power}}$$

$$\eta = \frac{\overline{m^2(t)}/2}{A^2/2 + \overline{m^2(t)}/2} \times 100$$

$$\text{"} = \frac{\overline{m^2(t)}}{A^2 + \overline{m^2(t)}} \times 100$$

if $m(t) = B.\cos\omega_m t$

~~If~~

then $B = \mu A.$

~~Now $P_m =$~~

$$\overline{m^2(t)} = \frac{(\mu A)^2}{2}$$

$$\eta = \frac{\mu^2 A^2/2}{A^2 + \mu^2 A^2/2}$$

If $\mu = 1$

$\eta \% = \frac{1}{3} \times 100 = 33.33\%$

If $\mu = 0.5$

then $\eta = 11.01\%$