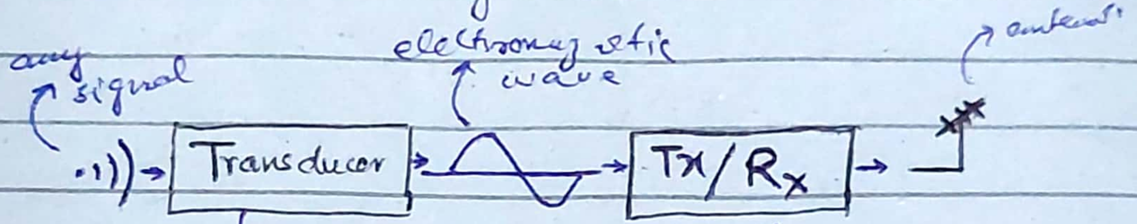
Week 5, Cu#4.

26-09-23/Tu

Communicatio System Lecture

* Communication System:

Exchange of messages over a long distances. (Tele-Communication) {long distance}. by using some electro gates.

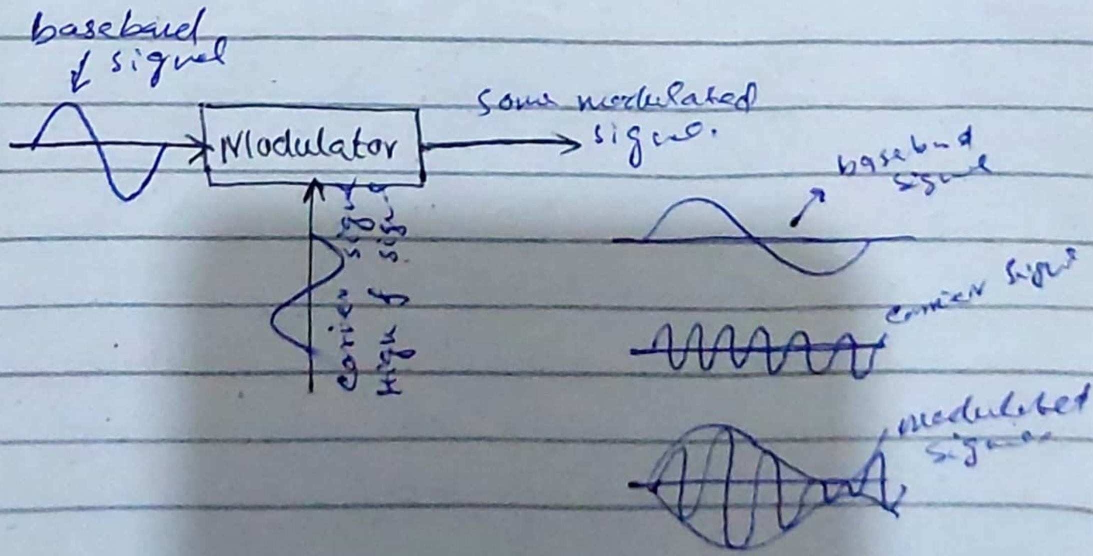


Convert any form of Energy to another.

Transmitter and receiver.

* Modulation:

If we vary any amplitude upto carrier signal an accordance with the instantaneous value of the baseband signal, the process is called modulation.



Modulation?
channels?
Noise?

الله

عمل سلیمان بن ع 27-9-23

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

AWGN
additive white Gaussian Noise

→ Internal Noise is additive in nature.

* SNR: Signal to Noise Ratio

$\frac{P_{signal}}{P_{Noise}}$ ↑↓ ↑ → unit less but represented in dbs.

$$db = 10 \log(\ )$$

Multiplexing:
Sending many ~~channels~~ signals through one channel.

? * FDM (Frequency division multiplexing)
* FDMA (Frequency division multiple Access).
* CDMA (Code division Multiple Access).
* SDMA (Space division multiple Access).

* ALOHA & Slotted Aloha
* Throughput: number of successful packets received per unit time.
* Data rate:

→ Bels (B): $\log \frac{a}{b}$

→ deci bels (DB): $10 \log \frac{a}{b}$

eq: $P = 10\, mW$ = $10^{-2}\, W$

$P = 10 \log 10$ | $= 10 \log 10^{-2}$

$= 10\, dBm$ | $= -20\, dBW$

→ $20\, dBm - 10\, dBm = \cancel{10\, dB}$

$\therefore \frac{20\, dBm}{10\, dBm} = 20\, dB - 10\, dB = 10\, dB.$

→ $20\, dBw + 10 = 30\, dBw.$

Shannon Capacity:

$$C = B \log_2 (1 + SNR).$$

Hamming Code:

K - redundant bits

m - info bits

$$\boxed{2^K \geq m + K + 1}$$

let if we have m = 8

then K = 4 for which

the expression is true.

Ch no 3

* Signal transmission throug LTI System.

* $g(t) \rightarrow \boxed{h(t)} \rightarrow y(t) = g(t) * h(t)$

$Y(\omega) = G(\omega) H(\omega)$

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

$= h(t) \rightarrow$ impulse response.

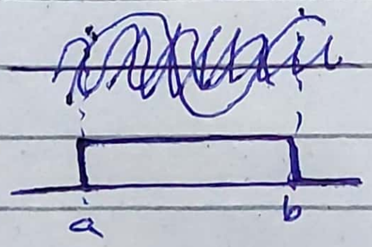
* $|Y(\omega)| e^{j\theta_y(\omega)} = |G(\omega)| e^{j\theta_g(\omega)} \cdot |H(\omega)| e^{j\theta_H(\omega)}$

* $|Y(\omega)| = |G(\omega)| \cdot |H(\omega)|$ → Amplitude respons

* $\theta_y(\omega) = \theta_g(\omega) + \theta_h(\omega)$ → phase respons

* $H(\omega) = |H(\omega)| e^{j\theta_h(\omega)}$ → frequency response of LTI System

* Marvelous Balancig Act:



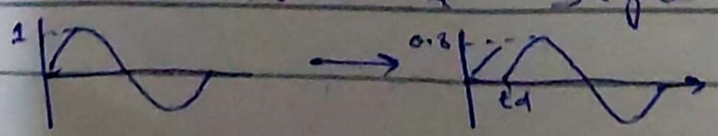
added compone such that between a & b ≠ 0 while outside a & b = 0.

* Distortion less Signal:

* $y(t) = K g(t - t_d)$

→ delaying a signal doesn't distort a signal

→ Changing amplitude doesn't distort a signal



$$g(t-t_d) = G(\omega)e^{j\omega t_d}$$

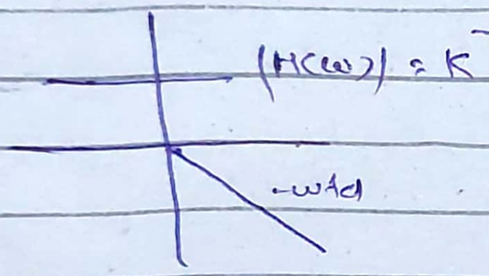
$$Y(\omega) = K\,G(\omega)\,e^{-j\omega t_d}$$

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

$$\therefore \; |H(\omega)| = K, \quad \theta_h(\omega) = -\omega t_d$$

should be constant for all frequency

$$-\frac{d\theta_h(\omega)}{d\omega} = t_d$$ & should be same slope



property of distortionless signal.

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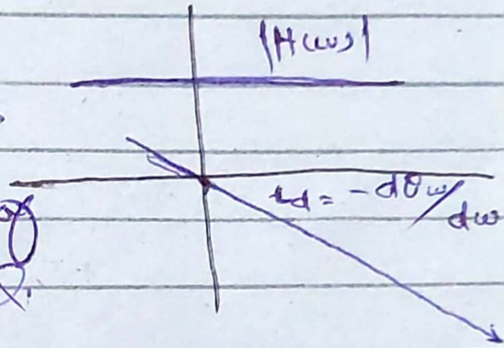
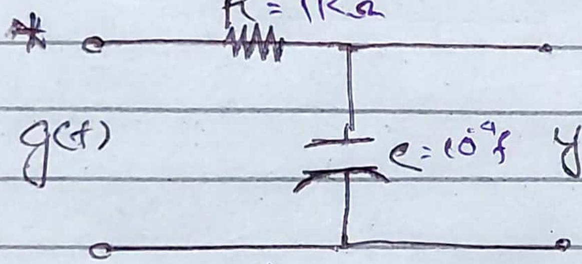
$$g(t) \xrightarrow{\text{channel}} K\,g(t-t_d)$$

$$G(\omega) \longrightarrow K\,G(\omega)\,e^{-j\omega t_d}$$



Ideal representation of distortionless Signal



$$* Z_c = \frac{1}{j\omega C}$$

→ It is a low-pass filter

$$\rightarrow Y(\omega) = \frac{1/j\omega C}{R + 1/j\omega C}\, G(\omega)$$

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

$$|H(\omega)| = \frac{a}{\sqrt{a^2+\omega^2}} \qquad a = 1/RC$$

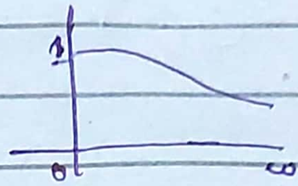
$$\theta_h(\omega) = -\tan^{-1}\frac{\omega}{a}$$

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

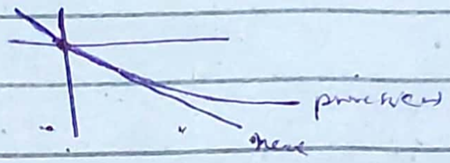
If $\omega << a$:

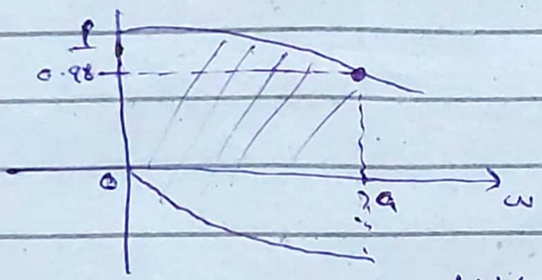
$$|H(\omega)| \approx 1$$

If $t_d \approx 1/a$



$$\theta_H(\omega) = -\tan^{-1}\omega/a$$





$$|H(\omega)| = \frac{a}{\sqrt{a^2+\omega^2}} \geq 0.98$$

$$a \geq 0.96a^2 + 0.98\omega^2$$

$$\omega_0 \geq \sqrt{\frac{0.04\omega^2}{0.96}}$$

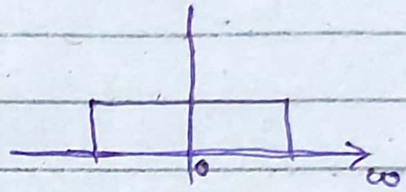
$$\omega_0 \geq 203000 \text{ rad/sec}$$

follow same procedure for t_d.

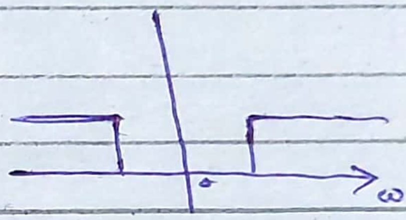
* Amplitude response is remain constant for some band of frequencies.
* Phase response should be linear function.

Ideal vs Practical filter:

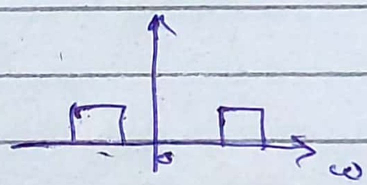
→ Low-pass filter.

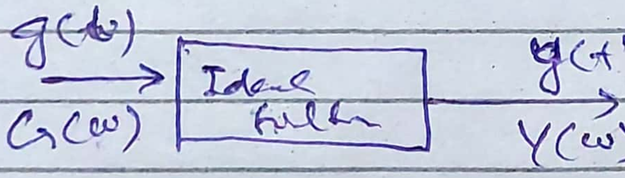


→ High-pass filter



→ Band-pass filter

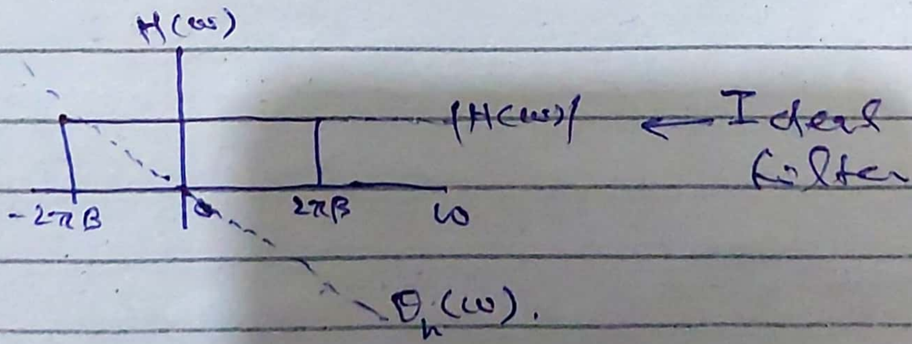




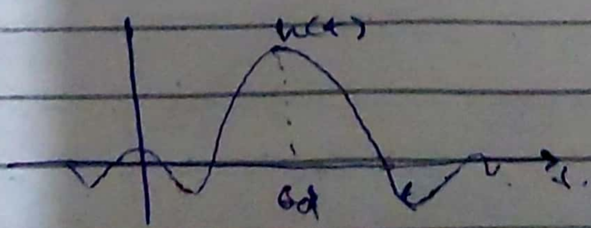
$y(t) = 1 \cdot g(t-td)$

$Y(\omega) = G(\omega) e^{-j\omega td}$.

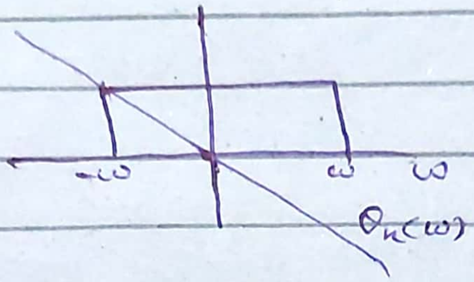
* $H(\omega) = e^{j\omega td}$.



→ In time

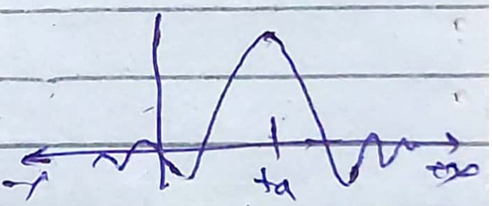


$\hat{h}(t) = h(t)\,u(t)$ → practical signal by removing before 0.



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

$$F^{-1}\left\{\text{rect}\,\frac{\omega}{2W}\, e^{-j\omega t_d}\right\} = \frac{W}{\pi}\,\text{Sinc}\,W(t-t_d).$$



passes zero when $Wt = \pm n\pi$

so $W(t-t_d) = \pm n\pi$

→ It should be delayed only 3 or 4 times of π/W.

* Paley-weiner criterea:

→ Show us when a signal is ideal or practical.

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

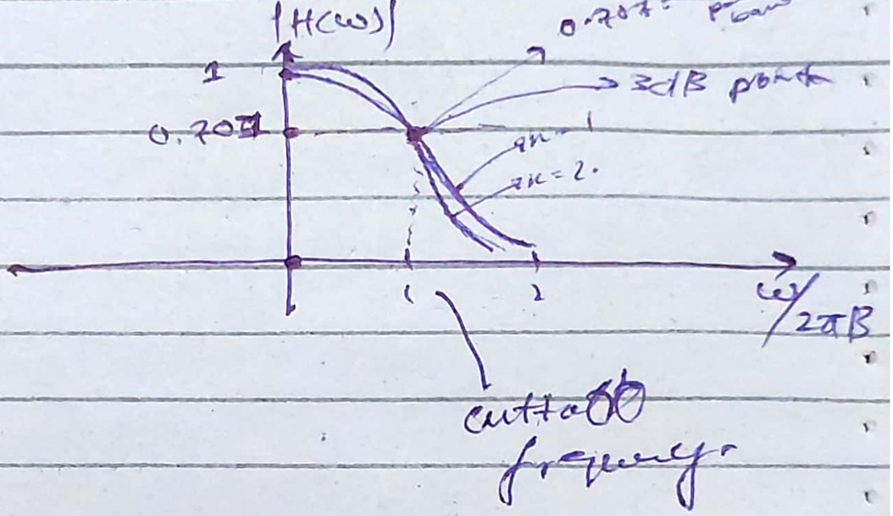
finite.

* $\frac{W}{\pi}\,\text{sinc}\,Wt \Leftrightarrow \text{rect}\,\frac{\omega}{2W}$

* $\frac{W}{2\pi}\,\text{Sinc}^2\,\frac{Wt}{2} \Leftrightarrow \Delta\left(\frac{\omega}{2W}\right)$

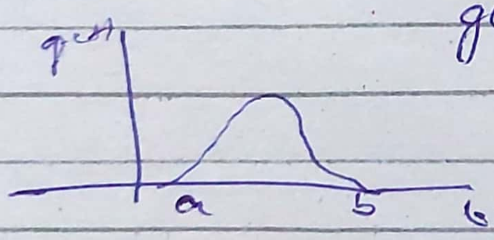
* Butterworth filter:

$$|H(\omega)| = \frac{1}{\sqrt{1+\left(\frac{\omega}{2\pi B}\right)^{2n}}}$$



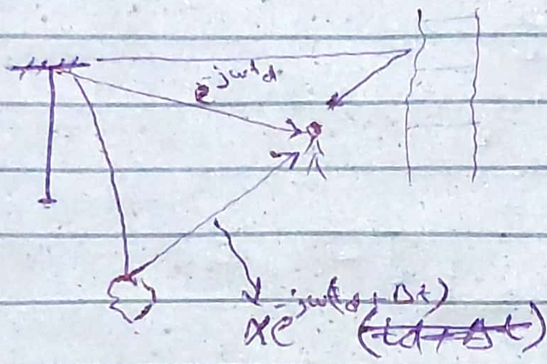
* Linear Distortion:

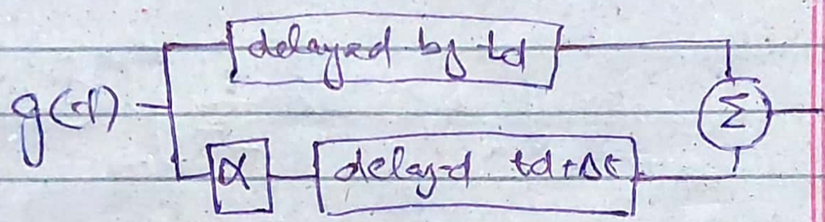
$g(t) \longrightarrow \boxed{\text{Channel}} \longrightarrow y(t).$



CS Lec 17/10/23 / Tu

Multipaths:





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

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

amplitude and phase

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

$$= \sqrt{1+\alpha^2 + 2\cos\omega\Delta t}$$

* frequency Selective fading

$$* \; g(t) \xrightarrow{\int_{-\infty} g(t) e^{-j\omega t} dt} G(\omega)$$

$$G(\omega) \xrightarrow{\frac{1}{2\pi}\int_{-\infty}^{\infty} G(\omega) e^{j\omega t} d\omega} g(t)$$

$* \; G^*(\omega) = G(\omega)$

Energy of Signal

$g(t)$

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

$\updownarrow$ signal

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

$(a+bi)(a-bi)$

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

from negative of ω.

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

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

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

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

parcevals Theorm in which energy is represented in freq domain.

Example: $g(t) = e^{-at} u(t)$ $a>0$

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

$$G(\omega) = \frac{1}{a+j\omega}$$

$$|G(\omega)| = \frac{1}{\sqrt{a^2+\omega^2}}$$

$$|G(\omega)|^2 = \frac{1}{a^2+\omega^2}$$

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

$$= \frac{1}{2\pi a} \tan^{-1}\frac{\omega}{a}\Big|_{-\infty}^{\infty}$$

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

$$= \frac{1}{2\cancel{\pi}a} * \cancel{\pi} = \frac{1}{2a}$$

* Energy Spectral Density:

$$\frac{E_g(\omega)}{dt} = |G(\omega)|^2$$

100%-

CS-Lec 24-Oct-23/Tu.

Amplitude modulation:

→ without doing modulation is called baseband communication.

→ Signal has frequency, amplitude, phase - amp, fre, phase.

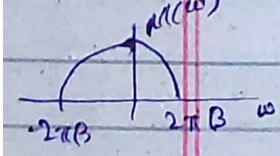
→ let $m(t)$ be a baseband signal. multiply it with a carrier signal.

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

$$= \phi_{AM}(t) = m(t)\cos\omega_c t.$$

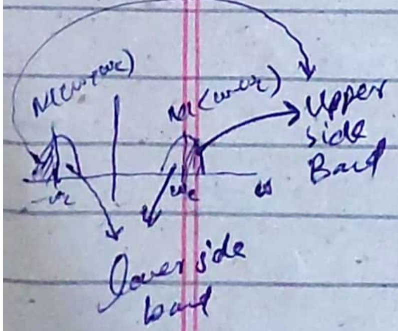
$$= m(t)\left[\frac{e^{j\omega_c t} + e^{-j\omega_c t}}{2}\right]$$

$$= \frac{m(t)e^{j\omega_c t}}{2} + \frac{m(t)e^{-j\omega_c t}}{2}$$



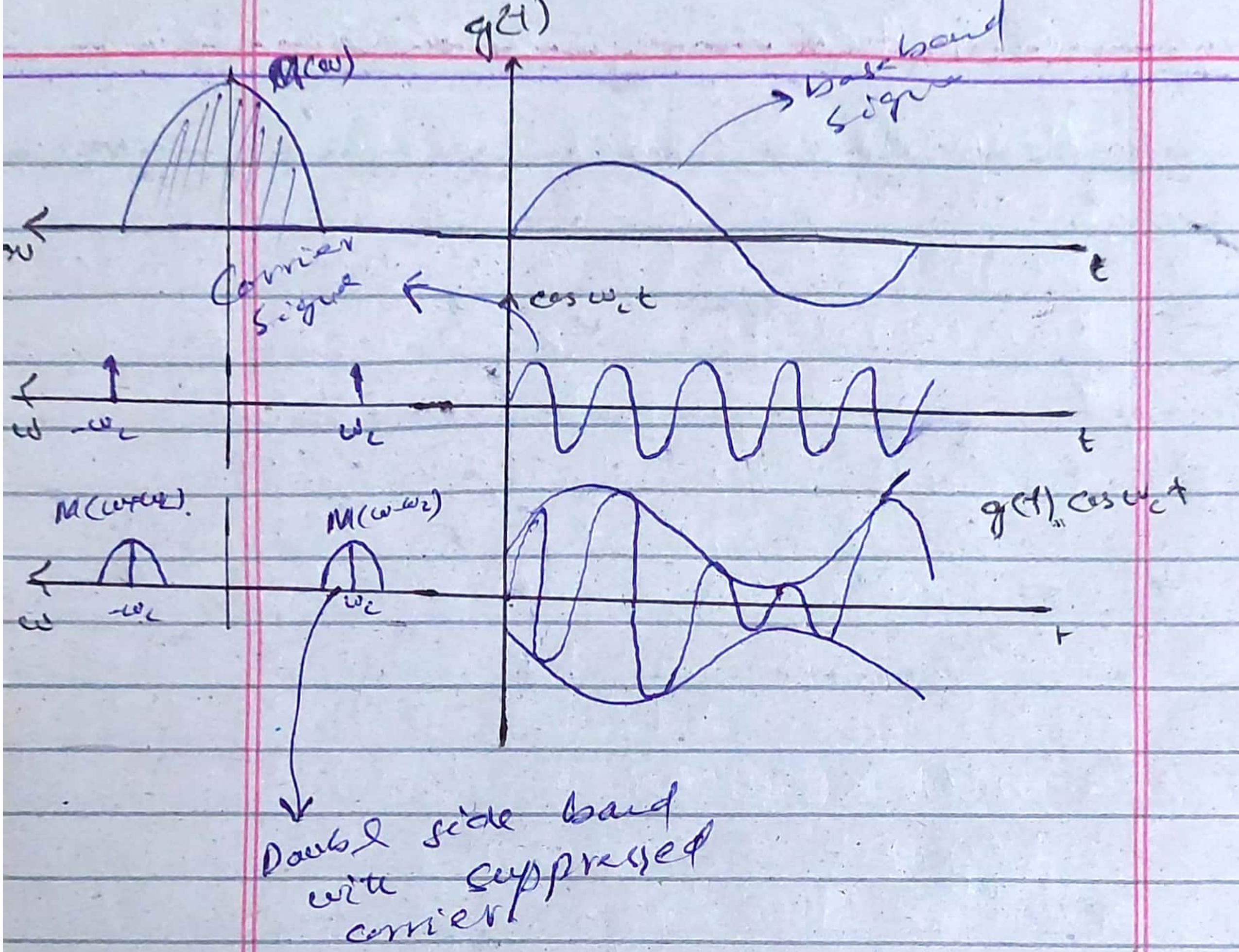
$$\because g(t)e^{j\omega_0 t} = G(\omega+\omega_0),\ g(t)e^{-j\omega_0 t} = G(\omega-\omega_0$$

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



frequency domain

time domain



* ω_c should be greater or equal to $2\pi B$. so that the component should not interfere with each other.

$$\omega_c \geq 2\pi B.$$

* Now performing demodulation.

$$\{m(t)\cos\omega_c t\}\cos\omega_c t$$

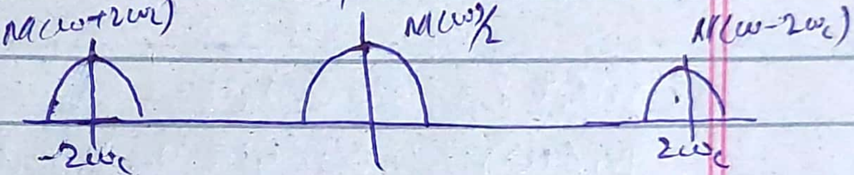
$$= m(t)\cos^2\omega_c t$$

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

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

$$= \frac{m(t)}{2} + \frac{m(t)e^{j2\omega_c t}}{4} + \frac{m(t)e^{-j2\omega_c t}}{4}$$

$$= \frac{M(\omega)}{2} + \frac{M(\omega-2\omega_c)}{4} + \frac{M(\omega+2\omega_c)}{4}$$



$$\text{DSB-SC} \longrightarrow \bigotimes \longrightarrow \boxed{\text{LPF}} \longrightarrow \frac{M(\omega)}{2}$$

$$\uparrow \cos\omega_c t$$

Synchronous or coherent detection.

→ In above communication we are not transmitting carrier signal but we are just using it.

→ If we transmit a carrier signal too with baseband signal it will consume 66.67% of total power

Assignment:
* $m(t) = \cos \omega_c t$
modulate it and then
demodulate it.

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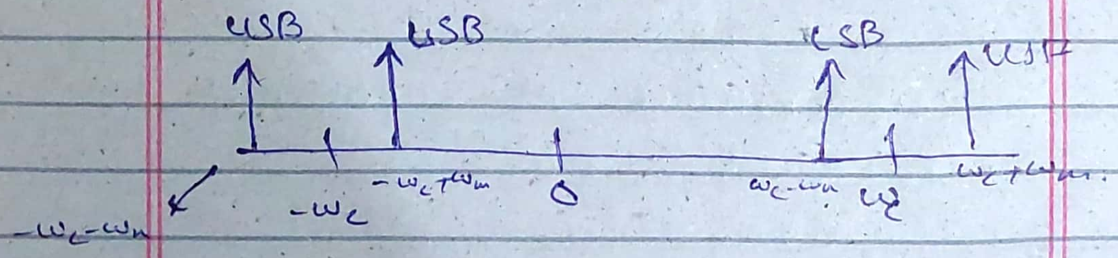
$m(t) = \cos \omega_m t$

$M(\omega) = M(\omega+\omega_m) + M(\omega-\omega_m)$.

$\phi_{AM}(\omega) = m(t)\cos\omega_c t = \cos\omega_m t \cdot \cos\omega_c t$

$= \cos(\omega_c+\omega_m)t + \cos(\omega_c-\omega_m)t$



Modulators:

→ Electronic devices to perform modulation

(a) → Multiplier

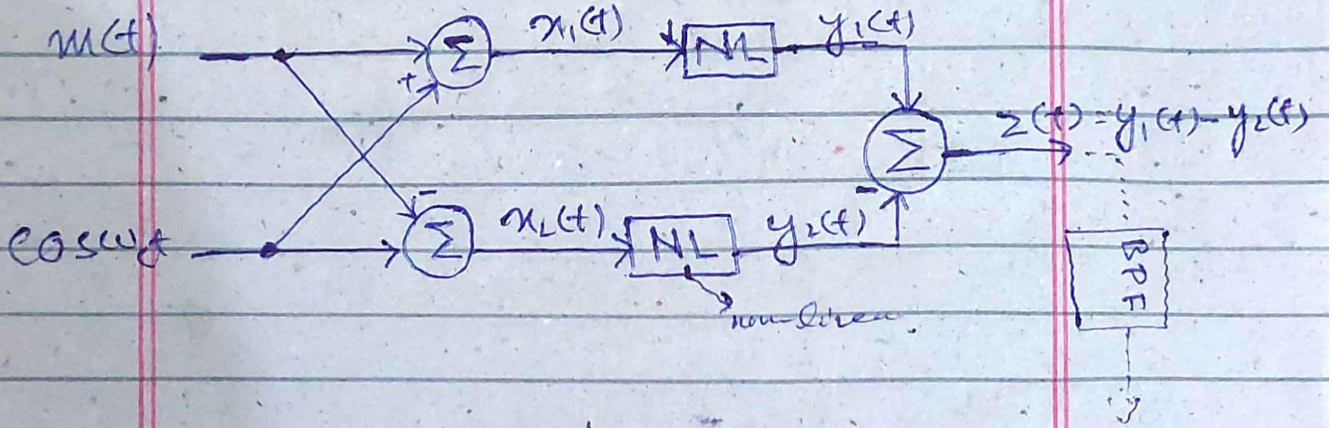
(b) Non-linear Modulator:
having higher order inputs

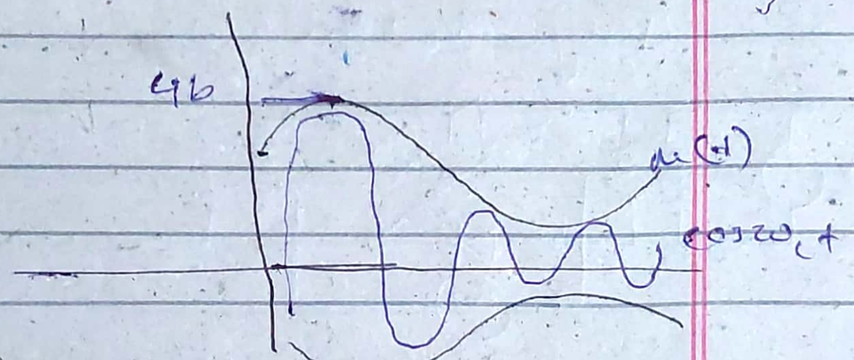
$y(t) = a x(t) + b x^2(t)$

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

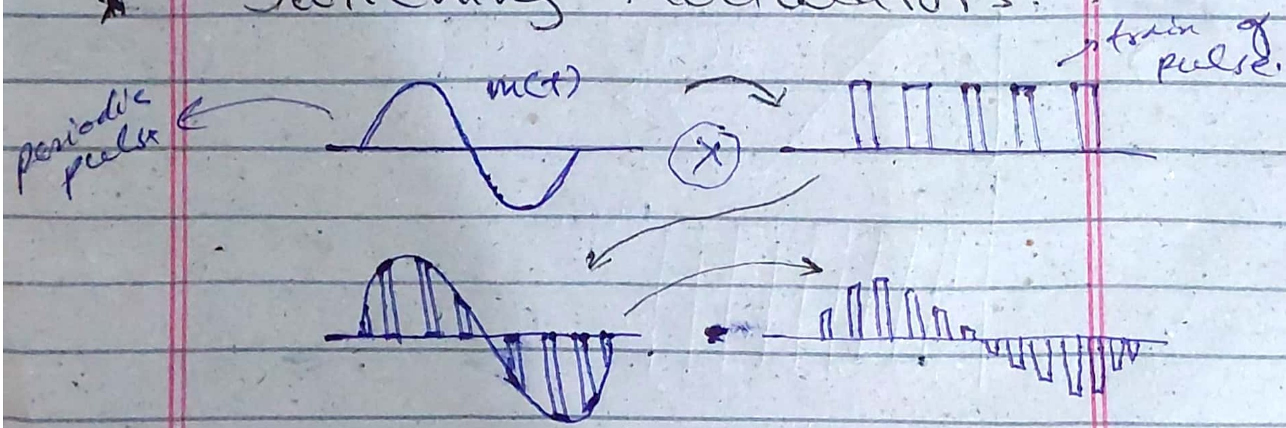
$x_1(t) = \cos \omega_c t + m(t)$

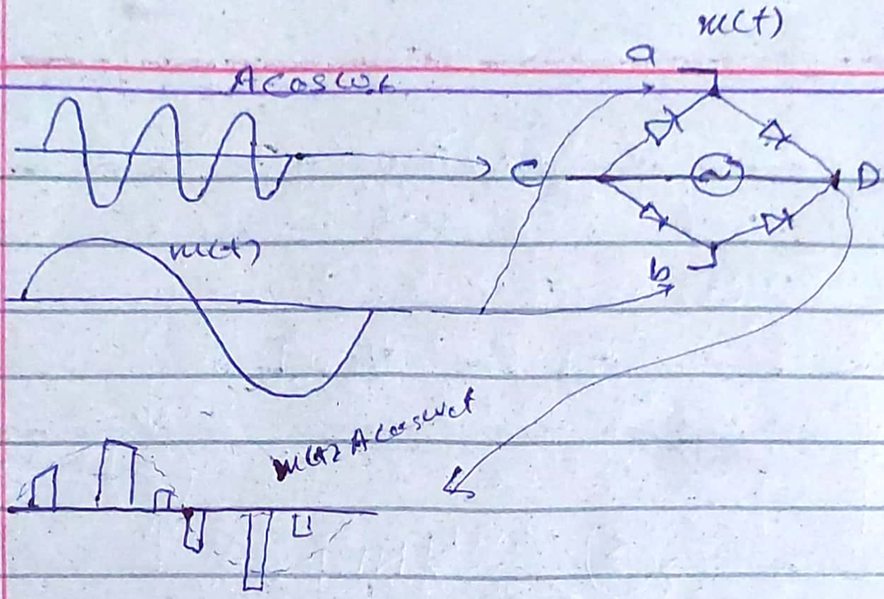
$x_2(t) = \cos \omega_c t - m(t)$



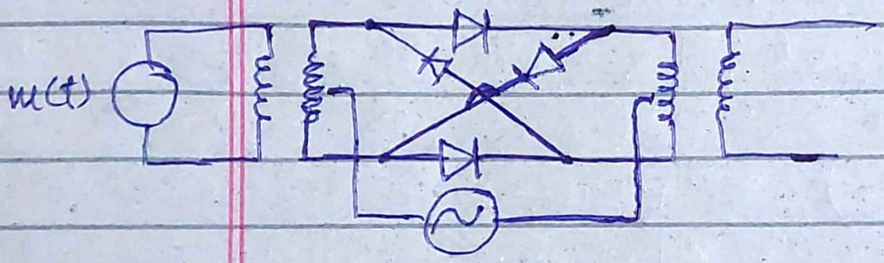


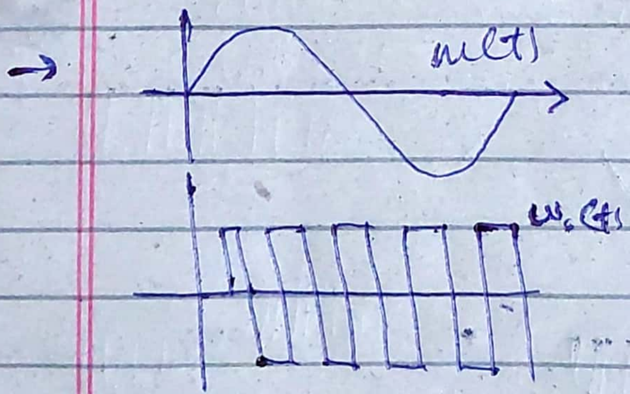
* Switching Modulators:





Ring Modulator:





$\phi_{Am}(t) = A\cos w_c t + m(t)\cos w_c t$

$\phi_{Am}(w) = \pi \{ \delta(w - w_c) + \delta(w + w_c) \}$

$+ \dfrac{m(w+w_c) + m(w-w_c)}{2}$

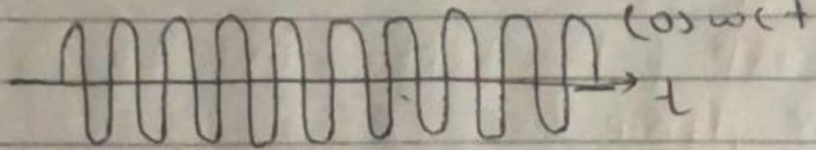
$e^{jw_ct} \Leftrightarrow 2\pi\delta(w-w_c)$

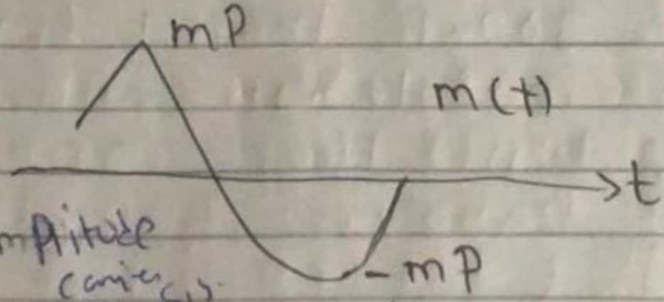
$e^{-jw_ct} \Leftrightarrow 2\pi\delta(w+w_c)$

So impulses will also be transformed.

$\phi_{Am}(t) = A\cos w_c t + m(t)\cos w_c t$

$= (A + m(t))\cos w_c t$





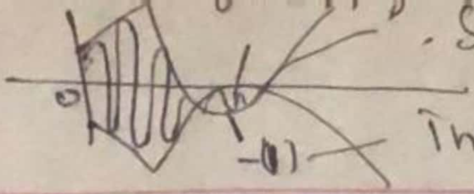
Peak Amplitude carrier sig.

$A + m(t) \geq 0$ "for all error detection"

$A - mP \geq 0$ Peak Amplitude modulated sig.

if $-mP$ is greater than A then some of envelop will come to -ve

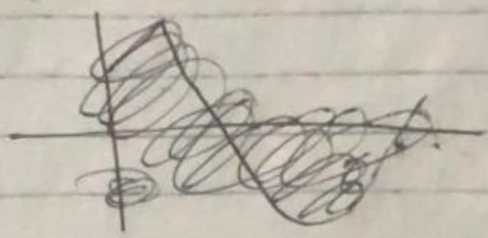
e.g. $A = 5$, $mP = \pm 6$, $5 + (-6)$
$= -1$

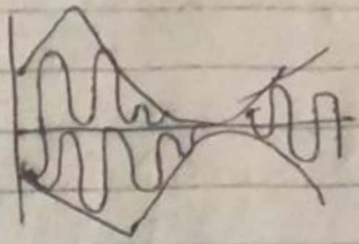


. So Detection tough.

This is over modulation.

· So this is the case of over modulation. (Some part in -ve side.





· MODULATION INDEX :-

$$u = \frac{mP}{A} \qquad 0 \le u \le 1$$

if ~~mP~~ $u = 1$ it is touching zero line

· if ~~mP~~ u = greater than 1 (1.5) So over modulation will come

· if u = less than one it will be above zero line.

$m(t) = B\cos\omega_m t$ $\qquad\qquad \mu = 0.5$

$\qquad\qquad\qquad\qquad\qquad\qquad \mu = 1$

we know that

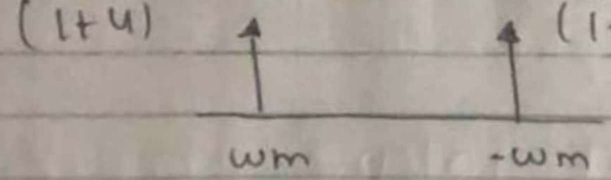
$$\varphi_{AM} = \{A + m(t)\}\cos\omega_c t$$

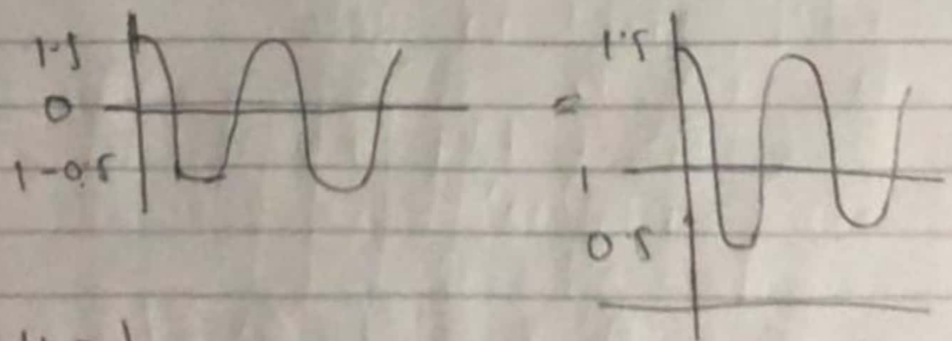
$$= \{A + B\cos\omega_m t\}\cos\omega_c t$$

$$= \{A + \mu A\cos\omega_m t\}\cos\omega_c t$$

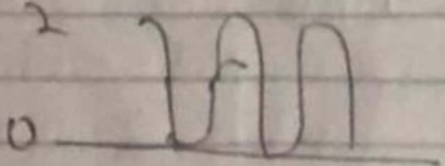
$$= A\{1 + \mu\cos m(t)\}\cos\omega_c t$$

$1 + \mu\cos\omega_m t$ Dom.





fo $u = 1$



$(1+\mu) = 1+1 = 2$

$(1-\mu) = (1-1) = 0$

· if carrier is going (transmitt so excessive power is used.

· Carrier Power & Side Bands:-

$\phi_m(t) = A\cos w_c t$

To find Power $= \frac{1}{T}\int_{-T/2}^{T/2} \phi_m^2$

$$P(t) = \frac{1}{T}\int_{-T/2}^{T/2} A^2 \cos^2 w_c t \, dt$$

$$= \frac{A^2}{T}\int_{-T/2}^{T/2} \int \frac{1 + \cos 2w_c t}{2} dt$$

· we will not integrate because it will give us zero.

$$= \frac{A^2}{2T}\int_{T/2}^{T/2} 1 dt + 0$$

$$= \frac{A^2}{2T} \times T = \boxed{\frac{A^2}{2}}$$

So $m(t)\cos\omega_c t + A\cos\omega_c t$

mean (becose variable)

$P_{(m)} = \frac{\widetilde{m(t)^2}}{2}$, $P_c = \frac{A^2}{2}$

So

$m(t) = B\cos\omega_m(t)$ (tone signal).

$\therefore B = \mu A$

$B\cos\omega_m(t)$

$m(t) = \boxed{\frac{B^2}{2}}$

$m(t) = \boxed{B^2 = \frac{\mu^2 A^2}{2}}$ (Power of tone signal).

• Power Efficiency:-

$$\frac{P_m}{P_c + P_m} = \frac{\widetilde{m^2(t)}/2}{A^2/2 + \widetilde{m^2(t)}/2} \times 100$$

(carrier also transmitting).

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

$$= \frac{\mu^2 A^2/\cancel{2}}{\frac{2A^2 + \mu^2 A^2}{\cancel{2}}} \times 100 = \frac{\mu^2 \cancel{A^2}}{(2+\mu^2)\cancel{A^2}} \times 100$$

$$\% \eta = \frac{\mu^2}{2+\mu^2} \times 100$$

CamScanner

$u = \frac{B}{A}$ if $u = 1$

then

$\boxed{\sqrt{B = A}}$

$$\% \eta = \frac{u^2}{2+u^2} \times 100$$

if $u = 1$

$$= \frac{1 \times 100}{2+1} = \frac{1}{3} \times 100 = 33.33\%$$

66 % ~~P~~ cons. Power consumed by carrier

if $u = 0.5$

$$= \frac{(0.5)^2}{2+(0.5)^2} \times 100 = 11.11\%$$

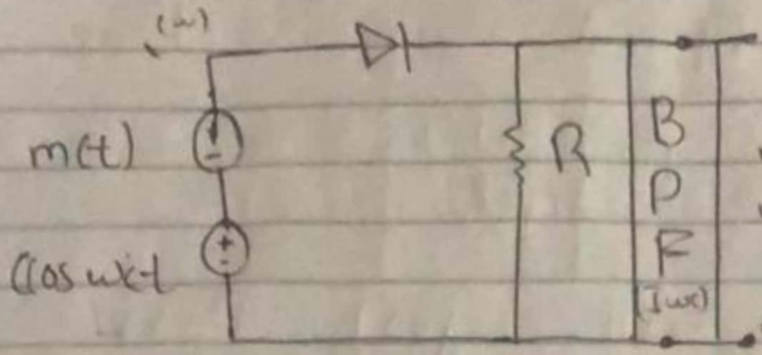
more Degraded.

$u = 1.5$

$$= \frac{(1.5)^2}{2+(1.5)} \times 100 =$$

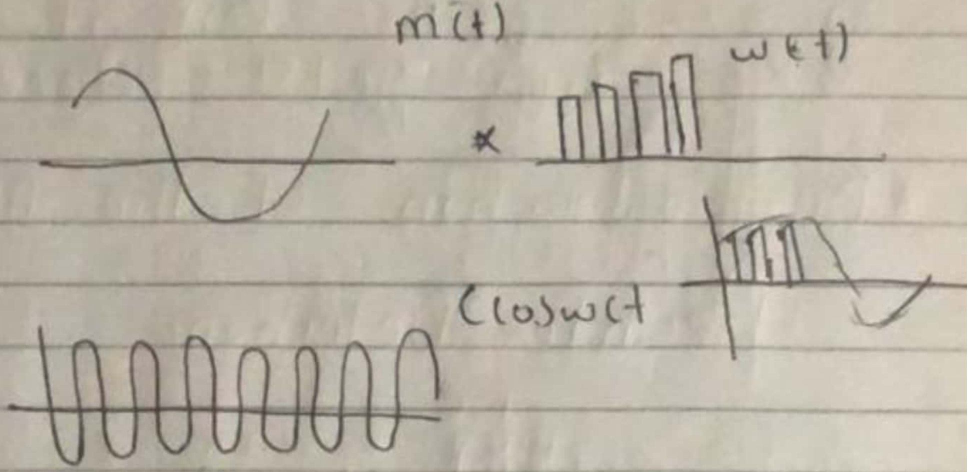
- Sir by inc u value less value / Power is consumed by carrier signal.
- and more only signal is transferring.
- But we ~~hea~~ learned previously in is more over modulation. info is lost?

• Generation of A.M Signal:-



• xw because when m(t) xply with (w) it make train of Pulses.
• So definitly this circuit xplied with w(t)

$C\cos w_c t + m(t)$ "$c >> m(t)$"

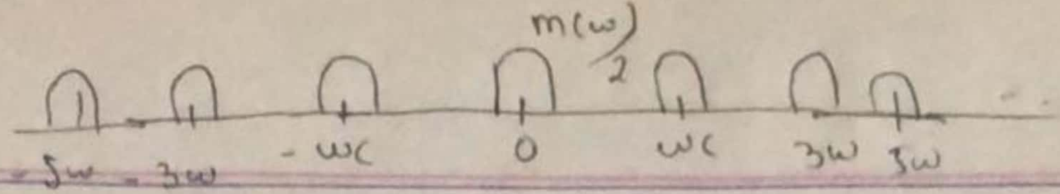


• if Ccoswct So Diode will conduct F.B. value is transmitted.
• if Coswct is -ve Diode will not conduct R.B.

$\{C\cos w_c t + m(t)\}\, w(t)$ — impulse periodic train pulse.

$\left[C\cos w_c t + m(t)\right] \left\{ \frac{1}{2} + \frac{2}{\pi} \left\{ C\cos w_c t - \frac{1}{3}\cos 3 w_c t + \frac{1}{5}\cos 5 w_c t \ldots \right\} \right.$

carrier ...



$= \frac{1}{2} \cos \omega_c t + \frac{2m(t)}{\pi} \cos \omega_c t + \text{other terms.}$

carrier signal generated.

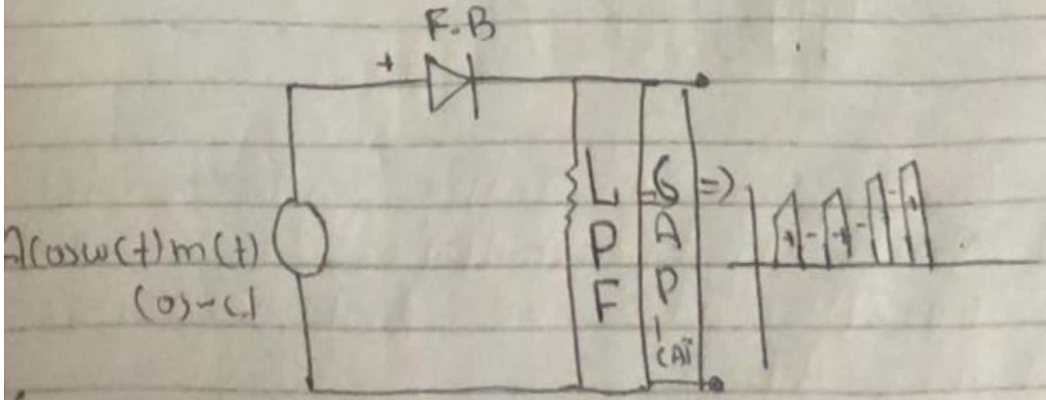
modulated signal

· So we will just Pass $\frac{m(t)}{\pi}$ other will be suppressed

· So we will Pass it through B.P.F to get desired output.

* De-modulation of the AM Signal.

· Rectifier Detector



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

$\{\{A + m(t)\} \cos \omega_c t\} \times w(t)$

· we xply with the 2nD because it will give us the Square of cos.

$$\{A+m(t)\}\cos\omega_c t\}\left\{\frac{1}{2}+\frac{2}{\pi}\left(\cos\omega_c t - \frac{1}{3}\cos 3\omega_c t\right.\right.$$

$$\left.+ \text{- other terms}\right)$$

$$\{A+m(t)\cos\omega_c t\}\left\{\frac{2}{\pi}(\cos\omega_c t\right\}$$

$$\frac{2}{\pi}\left\{A+m(t)\cos\omega_c t^2\right\}$$

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

$$\frac{2}{\pi}\left\{\underbrace{\frac{A+m(t)}{2}}_{(1)}+\underbrace{\frac{A+m(t)\cos 2\omega_c}{2}}_{(2)}\right.$$

Pass it through L.P.F 2 will be Removed

$$\frac{\cancel{2}}{\pi}\left\{\frac{A+m(t)}{\cancel{2}}\right.$$

$$:\frac{A}{\pi}+\frac{1}{\pi}m(t)$$

DC

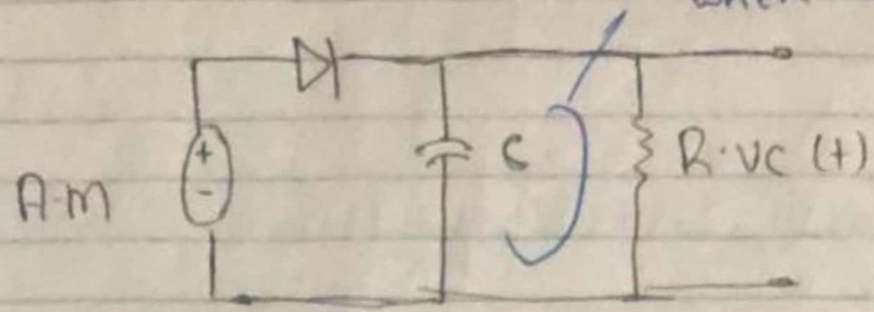
Now add capicitor to Remove DC

$$=\frac{1}{\pi}m(t)$$

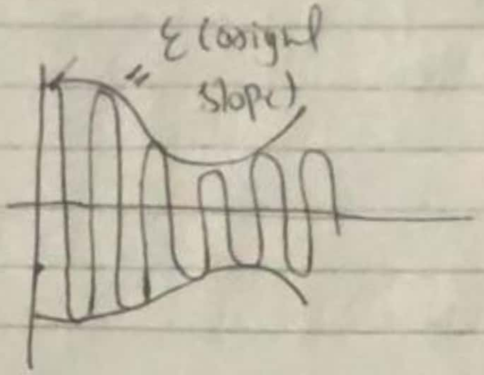
De modulated

· Envelop Detection:-

Discharge when -ve cycle

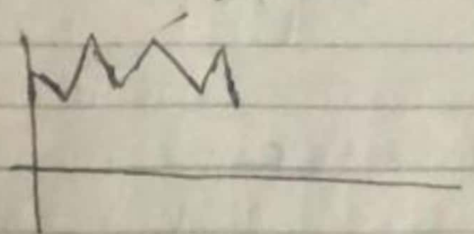


for Envelop detection it is must A ≥ mp



u = 0.7

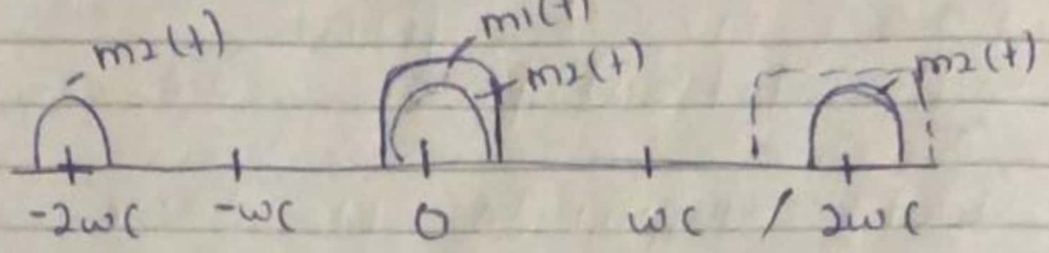
capicitive slope.



· when +ve will occur so F.B & capicitor will charge.
· when -ve will occur so R.B & capicitor will discharge still give value.
So Both +ve & -ve Envelop will be made & Envelop detection will occur.

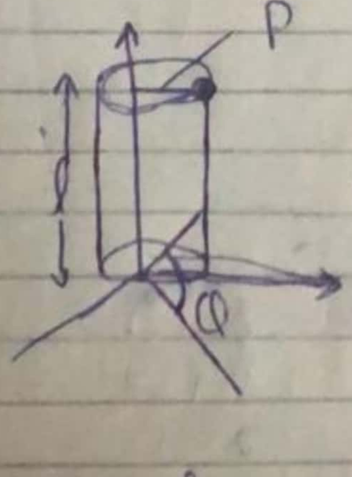
Now to get $m_2(t)$ we will xply it with $\sin(t)$.

$\varphi_{AM} \sin w_c t = m_1(t) \cos w_c t \sin w_c t + m_2(t) \sin^2 w_c t$



Pass it through LPF we will obtain $m_2(t)$.

- Cylindrical co-ordinate System.



(P, l, Q)

By these points we can find the fixed point.

3. Coordinate System.
- Cartesian
- Cylindrical
- Spherical

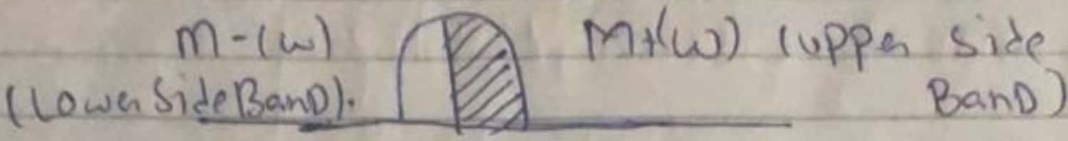
- with carrier transmission two losses
  - Power
  - Band.

Assignment

$\varphi_{Am}(t) = \{m_1(t)\cos\omega_c t + m_2(t)\sin\omega_c t\}$
$\times(\cos\omega_c t + \theta)$

- Single Side Band A.M.

$m(t) \Longleftrightarrow M(\omega)$ F.T



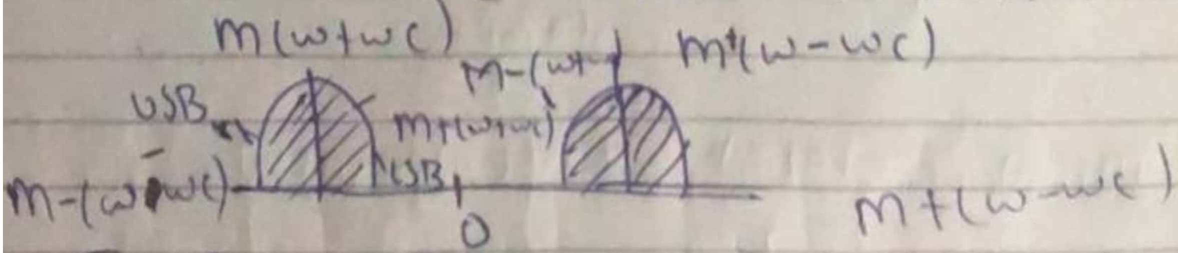
To send half of the Band.

$M(\omega) = M_+(\omega) + M_-(\omega)$

$M_+(t) \Longleftrightarrow M_+(\omega)$ (upper side)
$M_-(t) \Longleftrightarrow M_-(\omega)$ (lower side).

lets say:

$m(t)\cos\omega_c t \Longleftrightarrow M(\omega+\omega_c) + M(\omega-\omega_c)$



To find upper side one

$\varphi_{USB}(\omega) = M_+(\omega-\omega_c) + M_-(\omega+\omega_c)$

$\varphi_{LSB}(\omega) = M_-(\omega-\omega_c) + M_+(\omega+\omega_c)$

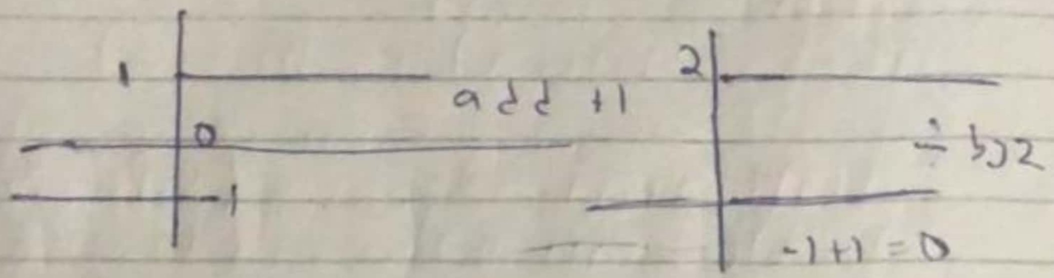
* $m_+(t) = \frac{1}{2}\left\{m(t) + j m_h(t)\right\}$ —(i)

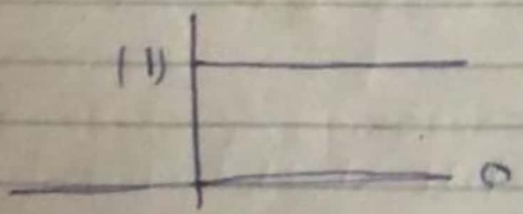
* $m_-(t) = \frac{1}{2}\left\{m(t) - j m_h(t)\right\}$ —(ii)

Pee jao

$M_+(\omega) = M(\omega)\, u(\omega)$

$M_+(\omega) = M(\omega)\left\{\frac{1+\mathrm{sgn}(\omega)}{2}\right\}$





$\frac{1+\mathrm{sgn}(\omega)}{2} = u(\omega)$

Compare

$M_+(\omega) = \frac{M(\omega)}{2} + \frac{M(\omega)\,\mathrm{sgn}(\omega)}{2}$ — iii

So

Compare (i) & (iii)

$j m_h(t) \Longleftrightarrow M(\omega)\,\mathrm{sgn}(\omega)$

$\varphi_{USB}(\omega) = M_+(\omega-\omega_c) + M_-(\omega+\omega_c)$

in TP.

$$= \frac{m_+(t)e^{j\omega_c t}}{2} + \frac{m_-(t)e^{-j\omega_c t}}{2} \to (i)$$

we know that

$m_+(t) = \frac{1}{2}\{m(t) + jm_h(t)\}$

$$\boxed{m(t)e^{j\omega_c t} \Longleftrightarrow M(\omega-\omega_c)}$$

$m_-(t) = \frac{1}{2}\{m(t) - jm_h(t)\}$ Put in eq (i)

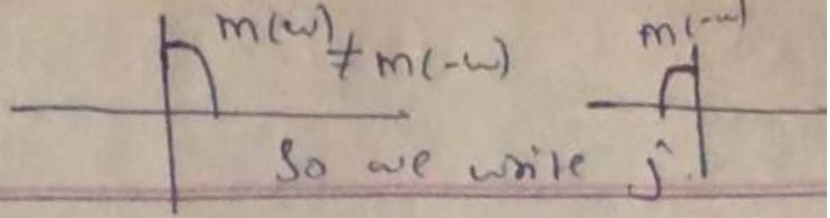
$$= \frac{1}{2}\{m(t) + jm_h(t)\}e^{j\omega_c t} + \frac{1}{2}\{m(t) - jm_h(t)\}e^{-j\omega_c t}$$

$$= \frac{m(t)e^{j\omega_c t} + jm_h(t)e^{j\omega_c t}}{2} + \frac{m(t)e^{-j\omega_c t} - jm_h(t)e^{-j\omega_c t}}{2}$$

$\cos\omega_c t$ $\sin\omega_c t$

$$= m(t)\left\{\frac{e^{j\omega_c t} + e^{-j\omega_c t}}{2}\right\} - jm_h(t)\left\{\frac{e^{j\omega_c t} - e^{-j\omega_c t}}{2}\right\}$$

$\varphi_{USB}(t) = m(t)\cos\omega_c t - m_h(t)\sin\omega_c t.$



j because it is not even after flip.

$m_h(t) \Longleftrightarrow -j\,M(\omega)\,Sgn(\omega)$

$M(\omega) \rightarrow \boxed{H(\omega)}$ $\quad Y(\omega) = M(\omega)\,H(\omega)$

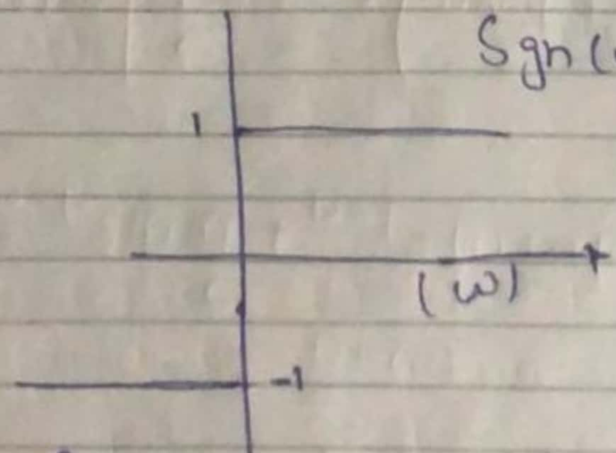
So $H(\omega) = -j\,Sgn(\omega)$ $\quad H(\omega) = |H(\omega)|\,e^{j\theta_h(\omega)}$

constant amplitude

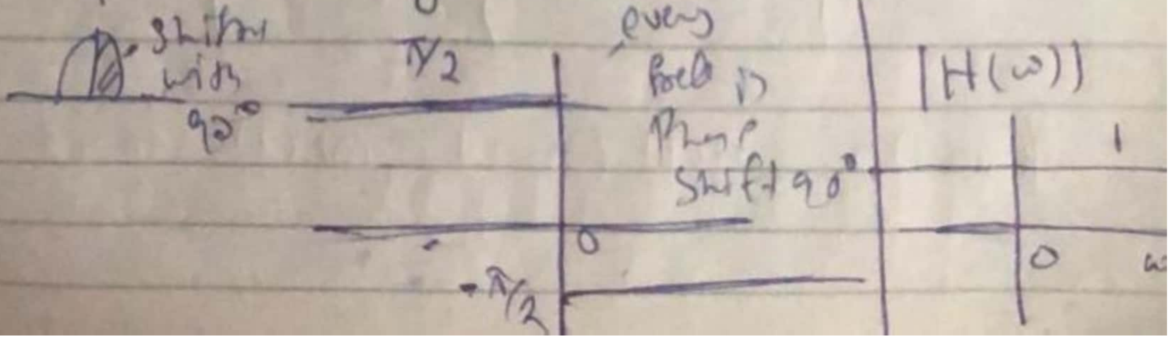
$H(\omega) = 1\,e^{-j\pi/2}$ $\quad \omega > 0$

Phase shift with 90°

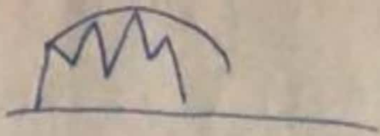
$H(\omega) = 1\,e^{j\pi/2}$ $\quad \omega < 0$



for frequency $\theta_h(\omega)$



$\frac{\varepsilon}{Rc}$



$V_c = \varepsilon e^{-t/Rc}$ > exponential decay.

$Rc \gg \frac{1}{w_c}$

$$\left|\frac{dv_c(t)}{dt}\right| \geq \left|\frac{d\varepsilon(t)}{dt}\right|$$ (slope should be more, more stepe so it could be detected).

let

$v_c(t) = \varepsilon e^{-t/Rc}$ in power

let in Taylor Series

$$v_c(t) \cong \varepsilon\left(1 - \frac{t}{Rc}\right)$$

$$\left|\frac{dv_c(t)}{d(t)}\right| = \frac{\varepsilon(t)}{Rc}$$

Find value of Rc condition.

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

$\varepsilon(t) = uA\cos w_m t$

$\boxed{\begin{aligned}\varepsilon(t) &= A + m(t) \\ &= A + uA\cos w_m t\end{aligned}}$

$$\frac{d\varepsilon(t)}{dt} = uA\, w_m \sin w_m t$$

$$\frac{A(1 + u\cos w_m(t))}{Rc} > uA\, w_m \sin w_m t$$