Data Transmission Methodologies .

Communication system
→ Analoge ⇒ sin wave ⇒ continous
→ Digital ⇒ cos wave ⇒ discrete data ⇒ 0 & 1
→ Wired ⇒ coxial cable ⇒, twisted cable, fiber cable
→ wireless ⇒ satellite communication, internet, etc .

Noise :- An unwanted signal that 'interferes with the communication or measurement of another signal.

Types of Noise .
- Acoustic Noise → white Noise.
- Electromagnetic Noise → coloured Noise
- Electrostatic Noise → impulsive Noise
→ channel Noise → Transient noise pulses Noise
→ processing Noise → flicker Noise Noise .
→ narrowband Noise

Distortion :- any change in a signal that alters the basic waveform or the relationship between various frequency components .

• Two types
→ Linear Distortion . → Non-Linear Distortion .

• Regenerative repeaters :- There are placed along the communication path of a digital system at distance short enough that noise and distortion remain within a limit .

*Analog to digital conversion .
Two steps :- 1.) Sampling
2.) Quantization .

Date

Signal Bandwidth :- → rang of frequency that it can transmit with reasonable fidelity (bandwidth).

→ channel bandwidth should be ~~gerate~~ greater than a signal bandwidth.

• Signal power (P_s) :- dual role in transmission of information. $\left[P = \frac{E}{t}\right]$

• related to quality of transmission

$\boxed{\text{quality of transmission} \propto P_s}$

Use of les Bandwidth if we want to increase P_s

$$\boxed{B.W \propto \frac{1}{P_s}}$$

• SNR → Signal to Noise Ratio

$$SNR = \frac{P_{signal}}{P_{noise}}$$

• Modulation :- converts information signal into a form suitable for transmission over a channel.

• Demodulation :- reverse this process recovering original signal at the receiver

modulation :- – superimposing high frequency to low.

– In carrier signal, the signal contains no information but they have phase, amplitude & frequency.

Types –

Amplitude

frequency

phase.

Spiral

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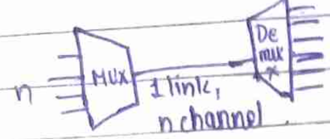
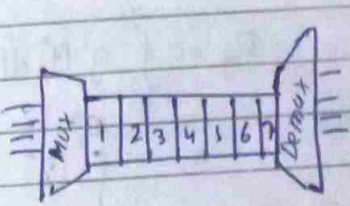
→ Multiplexing (MUX)
→ Demultiplexing (DEMUX)

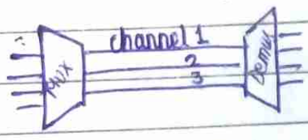


Multiplexing types → time Division multiplexing

↓

frequency division multiplexing





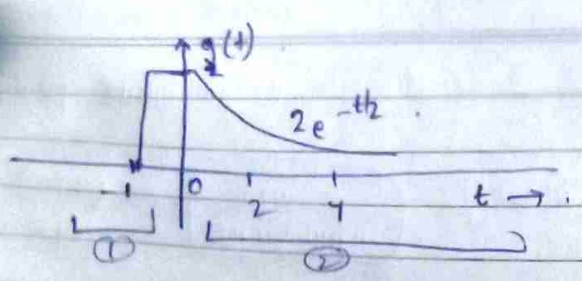
Advantages :- – efficient use of Bandwidth
→ increase Data transmission
→ scalibility
→ flexibility

Disadvantages :- – synchronization issues
– latency
– signal Degradation
– Resource Management .

Extra Signal Basics

- signal :- is a set of information of data .
- system :- signal may be processed further by system
  A system is an entity that processes a set of signals (inputs) to yield another set of signal (output)
- signal Energy :- $\boxed{E_g = \int_{-\infty}^{\infty} g^2(t)\,dt}$
- signal power :- $\boxed{P_g = \lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{T/2} g^2(t)\,dt}$

Date ____



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

$$= \int_{-1}^{0} (2)^2\,dt + \int_{0}^{\infty} (2e^{-t/2})^2\,dt$$

$$\Rightarrow [4t]_{-1}^{0} + \int_{0}^{\infty} 4e^{-t}\,dt$$

$$\Rightarrow \cancel{-4t + (4e^{-t^2/2}}$$

$$\Rightarrow \cancel{4e^{-t^2/2}}$$

$$\Rightarrow 4t + \left[\frac{4e^{-t}}{-1}\right]_{0}^{\infty}$$

$$\Rightarrow -4t + \left[\frac{4e}{-1}\right]_{0}^{\infty}$$

$$\Rightarrow 4t - 4(e^{-\infty} - e^{0}]$$

$$\Rightarrow 4 - 4(-1) \Rightarrow 8$$

⇒ classification of signals

1) continous & discrete time signal..
2) analog & digital signal.
3) periodic & Aperiodic signal.
4) Energy & power signal.
5) Deterministic & Random signal
6) unit impulse signal.

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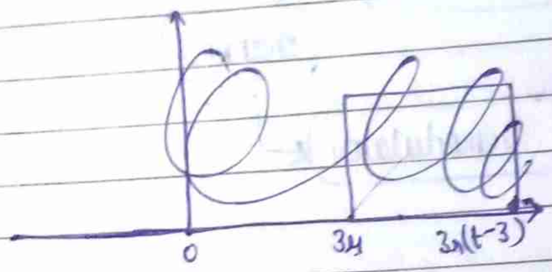
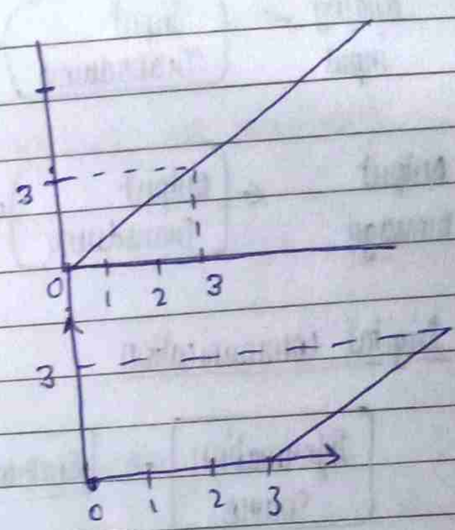
Sketch the following signal

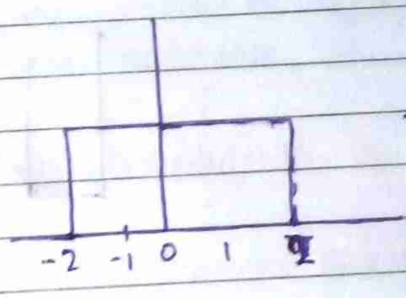
1.) $(t) = 3u(t-3)$

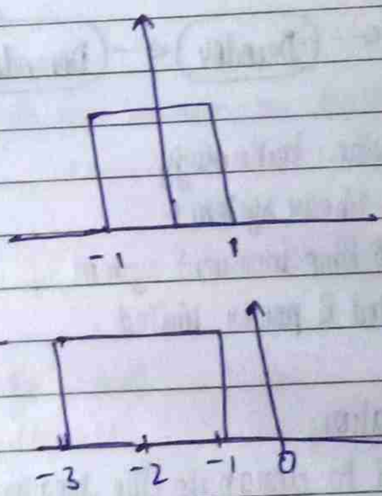
$= 3ut - 9u$





2.) $(t) = \pi(t+2)$





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Analog communication

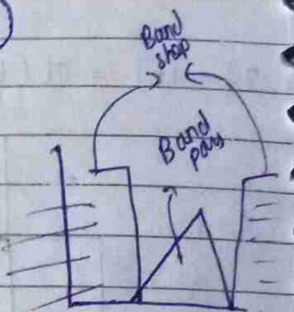
Analog input → Input Transducer → Modulator → channel → Demodulator → Output Transducer → output message

Digital communication

Information Source → Encoder → Modulator → channel → Demodulator → Decoder → Destination

Amplitude transmission technology

1) linear & Non-linear system
2) Time varient & time invarient system
3) bandwidth limited & power limited.



Baseband communication

It is used to designate the frequency band of the original message signal from the source or the input transducer.

In baseband communication, message signals are directly transmitted without any modification.

Carrier modulation :-

communication that uses modulation to shift the freq. spectrum of a single signal is known as carrier communication.

$\boxed{h = \frac{\lambda}{4}}$ → wave length

antenna freq.

$\boxed{\lambda = \frac{c}{\nu}}$

c → speed of light (3×10^8)

ν → freq

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voice ⇒ 30 Hz to 3300 Hz.

$\lambda = \frac{c}{\nu} = \frac{3\times10^8}{3\times10^3}$

$\lambda = 10^5 m$.

$h \Rightarrow 25{,}000 m$ or 25 km (practically not possible)

$f \Rightarrow 3 GHz$

$\nu \Rightarrow 3 GHz$.

$\lambda = \frac{3\times10^8}{3\times10^9} \Rightarrow 0.1$

$h \Rightarrow \frac{0.1}{4} \Rightarrow 0.025 m$ (practically possible)

Carrier by modulation types.

Amplitude modulation (linear)

$\left.\begin{array}{l}\text{freq. modulation}\\ \text{phase modulation}\end{array}\right\}$ Both are known as angle modulation. (non-linear).

Amplitude modulation.

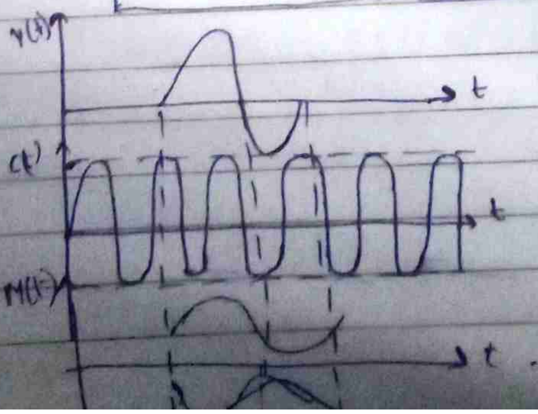
$x(t) \to$ baseband message signal.

$c(t)$ = carrier signal = $V_c \cos\omega_c(t)$

$M(t)$ = modulated signal.

$u(t) \Rightarrow$ unit step function.

$$\boxed{\begin{array}{c} s_1(t) = m(t)\cos 2\pi f_c t \\ S_1(f) = \frac{1}{2}M(f-f_c) + \frac{1}{2}M(f+f_c) \end{array}}$$



$M(t) = x(t)\cos\omega_c t + V_c\cos\omega_c t$

$= \cos\omega_c t\,(x(t) + V_c)$

$\cos\omega_c t \leftrightarrow \pi[\delta(\omega-\omega_c) + \delta(\omega+\omega_c)]$

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Dirichet condition

1) single value → . finite value → maxima & minima

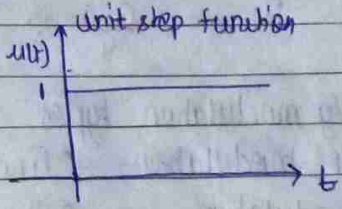
2) freq. is completely . integral .

$$\int_{-\infty}^{\infty} |f(t)|\,dt < 0$$

$$f(\omega) = \int_{-\infty}^{\infty} f(t)\, e^{-j\omega_{c}t}\, dt .$$

$$\boxed{\omega_{ct} = 2\pi f_c t}$$

Que find .a FT of $e^{-at}u(t)$



$$f(\omega) = \int_{-\infty}^{\infty} e^{-at} u(t)\, e^{-j\omega t}\, dt .$$

$$\int_{0}^{\infty} e^{-at}\, e^{-j\omega t}\, dt .$$

$$\int_{0}^{\infty} e^{-at}\, e^{-j2\pi f t}\, dt = \int_{0}^{\infty} e^{-(a+j2\pi f)t}\, dt$$

$$= \frac{-1}{a+j2\pi f}\left[e^{-(a+j2\pi f)}\right]_0^{\infty}$$

$$= \frac{-1}{a+j2\pi f}\ \cancel{[e^{-(a+j2\pi f)}}\ [0-1]$$

$$= \frac{1}{a+j2\pi f}$$

$$e^{-at}u(t) \longleftrightarrow \frac{1}{a+j2\pi f} .$$

Spiral

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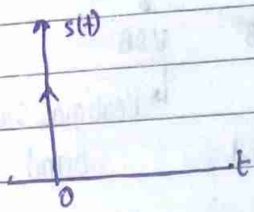
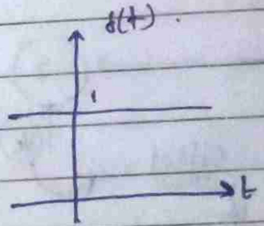
Qu find the F-T of $\delta(t) \rightarrow$ impulse function.



$$F(\delta(t)) = \int_{-\infty}^{\infty} \delta(t)\, e^{-j\omega t}\, dt.$$

$$= \int_{-\infty}^{\infty} \delta(t)\, e^{-j2\pi f t}\, dt.$$



at $t = 0$

$$= \int_{-\infty}^{\infty} \delta(t)\, e^{-j2\pi f(0)}\, dt$$

$$= \int_{\infty}^{\infty} \delta(t)\, dt = 1.$$

Qu find the f-T of $\cos \omega_0 t$.

$$f(f(t)) = \int_{-\infty}^{\infty} \cos \omega_0 t.$$

$$= \int_{-\infty}^{\infty} \cos 2\pi f_0 t$$

$$\left.\cos 2\pi f_0 t \longrightarrow \frac{1}{2}\left[e^{j2\pi f_0 t} + e^{-j2\pi f_0 t}\right]\right\} \text{ Euler formula}$$

$$\delta(f - f_0) \longleftrightarrow e^{j2\pi f_0 t}$$

$$\delta(f + f_0) \longleftrightarrow e^{-j2\pi f_0 t}$$

$$\boxed{\cos(2\pi f_0 t) = \frac{1}{2}\left[\delta(f - f_0) + \delta(f + f_0)\right]}$$

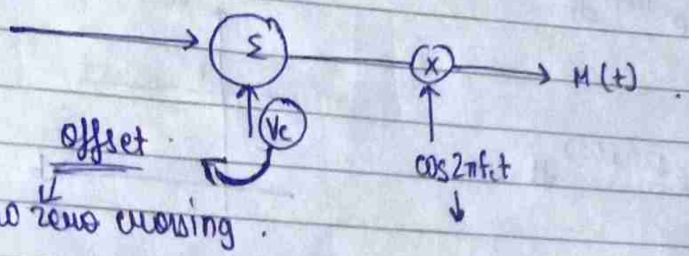
delta function

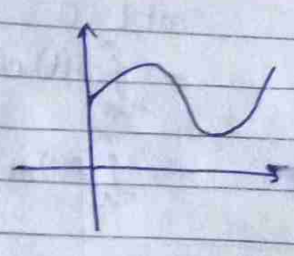
Date

Amplitude modulation.

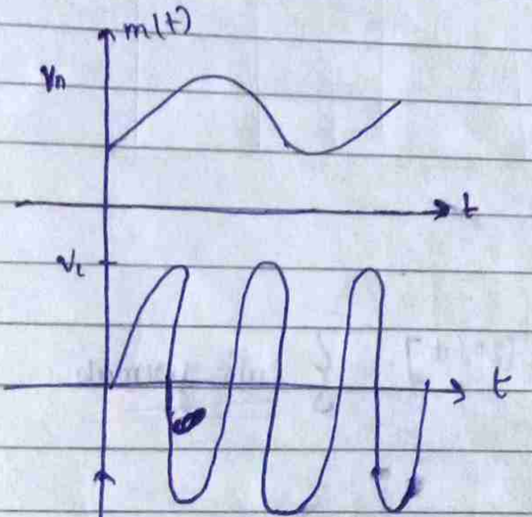
- DSB-FC → Double side Band full carrier.
- DSB-SC → Double side Band suppressed carrier
- SSB → Side Band
- VSB → Vestigial side band.

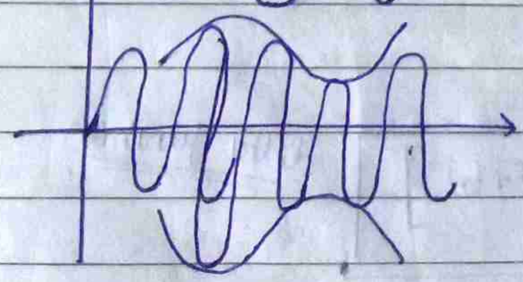
DSB-Fc





$$M(t) = (m(t) + V_c)\cos 2\pi f_c t.$$





$$M(t) = (\underbrace{x(t)}_{\text{message signal}} + \underbrace{V_c}_{\text{offset}}) \underbrace{\cos \omega_c t}_{\text{carrier}}.$$

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$$M(t) = \underbrace{x(t)\cos\omega_c t}_{①} + \underbrace{V_c \cos\omega_c t}_{②}$$

① $x(t)\cos\omega_c t = x(t)\left[\frac{e^{j\omega_c t} + e^{-j\omega_c t}}{2}\right]$

$$= \frac{1}{2}x(t)\left[e^{j\omega_c t} + e^{-j\omega_c t}\right] \longleftrightarrow \frac{1}{2}\left[X(\omega-\omega_c) + X(\omega+\omega_c)\right]$$

② $V_c \cos\omega_c t = V_c\left[\delta(\omega-\omega_c) + \delta(\omega+\omega_c)\right]$.

adding ① + ②

$$\boxed{M(t) = \frac{1}{2}\left[X(\omega-\omega_c) + X(\omega+\omega_c)\right] + V_c\left[\delta(\omega-\omega_c) + \delta(\omega+\omega_c)\right]}$$

↳ modulated eqⁿ for DSB-fc/Amplitude modulation signal.
↳ single tone modulation.

Modulation index (m/μ)

$x(t) = V_m \cos\omega_m t$

message signal

$\omega_m = 2\pi f_m$

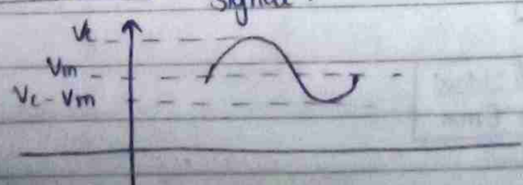
$= V_m \cos 2\pi f_m t$.

$M(t) = [V_m \cos\omega_m t + V_c]\cos\omega_c t$

$= \cos\omega_c t\,[V_m \cos\omega_m t + V_c]$

$$= \boxed{V_c \cos\omega_c t\left[\underbrace{\frac{V_m}{V_c}}_{\text{modulation index}}\cos\omega_m t + 1\right]}$$

$\Rightarrow \boxed{m = \frac{V_m}{V_c}}$ → It define how much carrier is modulated by message signal.



$E_{max} = V_c + V_m$

$E_{min} = V_c - V_m$

$$\boxed{m = \frac{V_m}{V_c} = \frac{E_{max} - E_{min}}{E_{max} + E_{min}}}$$

modulation idex

$\boxed{\text{Bandwidth} = 2 f_m}$

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$$M(t) = V_c \cos \omega_c t \left[1 + \frac{V_m}{V_c} \cos \omega_m t\right]$$

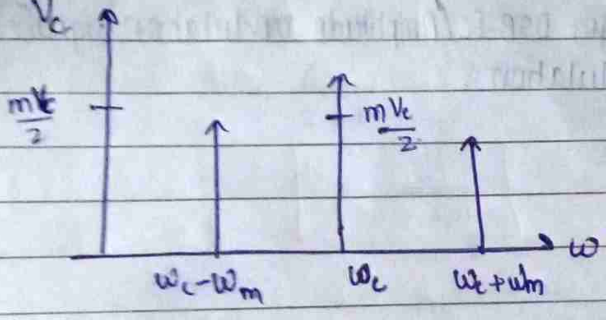
$$m = \frac{V_m}{V_c}$$

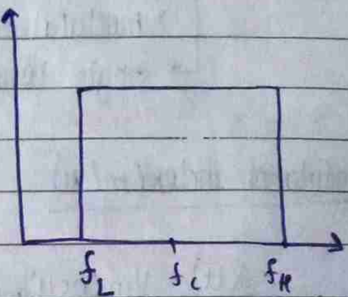
$$= V_c \cos \omega_c t \, [1 + m \cos \omega_m t]$$

$$= \underbrace{V_c \cos \omega_c t}_{\text{carrier}} + \underbrace{\frac{mV_c}{2} \cos \omega_m t \cdot \cos \omega_c t}_{\text{message signal + carrier}}$$

$$= V_c \cos \omega_c t + \frac{mV_c}{2} [\cos(\omega_c - \omega_m) + \cos(\omega_c + \omega_m)]$$

$$[\because 2 \cos \omega_c t \cdot \cos \omega_m t = \cos(\omega_c - \omega_m) + \cos(\omega_c + \omega_m)]$$





$$B.W = f_H - f_L$$

$$B\omega = \omega_c + \omega_m - (\omega_c - \omega_m)$$

$$= \omega_c + \omega_m - \omega_c + \omega_m$$

$$\boxed{B\omega = 2\omega_m}$$

Summary

$$\boxed{m = \frac{V_{m,max} - V_{m,min}}{2V_c + V_{m,max} + V_{m,min}}}$$

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

$$\boxed{m = \frac{E_{max} - E_{min}}{E_{max} + E_{min}}}$$

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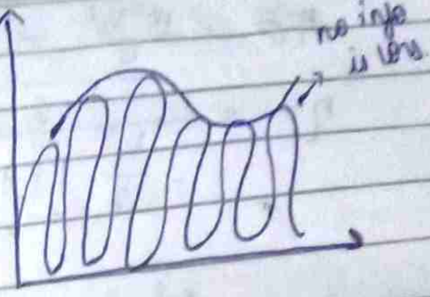
① $m < 1$

$\frac{V_m}{V_c} < 1$

$V_m < V_c$

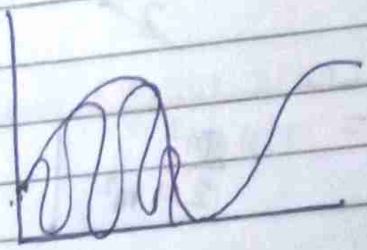
$V_c - V_m = +ve$ {under modulation}



② $m = 1 \rightarrow$ critical modulation

$V_m = V_c$

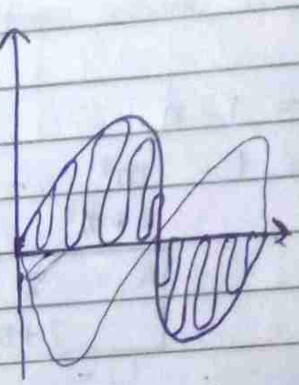
$V_c - V_m = V_c - V_c = 0$



③ $m > 1$ over modulation

$\frac{V_m}{V_c} > 1$

$V_c - V_m = -ve$



$P_c \rightarrow V_c \cos \omega_c$

$P_c = \frac{V_c^2}{2}$ ∵ $P_c \rightarrow$ Power

$P_T = P_c + P_{am}$

$$P_T = \frac{V_c^2}{2} + \frac{\left(\frac{mV_c}{2}\right)^2}{2} + \frac{\left(\frac{mV_c}{2}\right)^2}{2}$$

$$= \frac{V_c^2}{2} + \left(\frac{mV_c}{2}\right)^2$$

$$= \frac{V_c^2}{2} + \frac{m^2V_c^2}{4} = \frac{V_c^2}{2}\left(1 + \frac{m^2}{2}\right)$$

$$\boxed{P_T = P_c\left[1 + \frac{m^2}{2}\right]}$$

efficiency $\boxed{\eta = \frac{P_{SB}}{P_T}}$

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$$\eta = \frac{\dfrac{\dfrac{m^2 V_c^2}{4} + \dfrac{m^2 V_c^2}{4}}{2}}{\dfrac{V_c^2}{2}\left[1 + \dfrac{m^2}{2}\right]}$$

$$\frac{\dfrac{m^2 V_c^2}{4} + \dfrac{m^2 V_c^2}{4}}{\cancel{2}} \times \frac{\cancel{2}}{V_c^2\left[1 + \dfrac{m^2}{2}\right]}$$

$$\boxed{\eta = \frac{m^2}{2 + m^2}}$$

Redundancy

$$R = 1 - \eta$$

$$= 1 - \frac{m^2}{2 + m^2} = \frac{2 + m^2 - m^2}{2 + m^2} = \frac{2}{2 + m^2}$$

$$\boxed{R = \frac{2}{2 + m^2}}$$

$$I_T^2 \cancel{R} = I_c^2 \cancel{R}\left[1 + \frac{m^2}{2}\right]$$

→ Radiation Resistance of Antena.

$$I_T = \sqrt{I_c^2\left[1 + \frac{m^2}{2}\right]}$$

$$\boxed{I_T = I_c\sqrt{1 + \frac{m^2}{2}}}$$ → Total current of modulated signal.

Qu Determine η & % of total power carried $\left[\because \% P_T = \eta \times 100\,\%\right]$ by the side band of the AM wave for single tone modulation when $\mu = 0.5$ and when $\mu = 0.3$

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$m_1 = 0.5$

$\eta = \frac{(0.5)^2}{2+(0.5)^2}$

$= \frac{0.25}{2.25} = 0.111$

~~$\eta \times 100$~~

% power $\Rightarrow 0.111 \times 100$

$\Rightarrow 11$

$m_2 = 0.3$

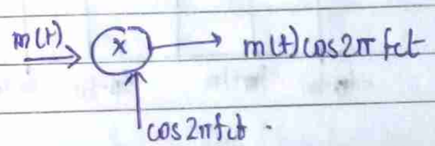
$\eta = \frac{(0.3)^2}{2+(0.3)^2}$

$\eta = \frac{0.09}{2.09} = 0.043$

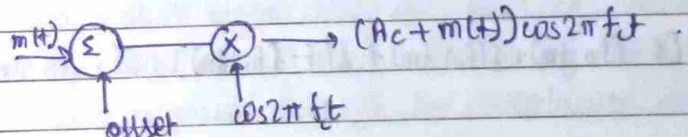
% power $\Rightarrow 0.043 \times 100$

4.3

DSB-SC $\rightarrow$ Double slide ~~Boun~~ Band suppress carrier.

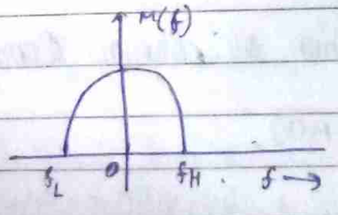


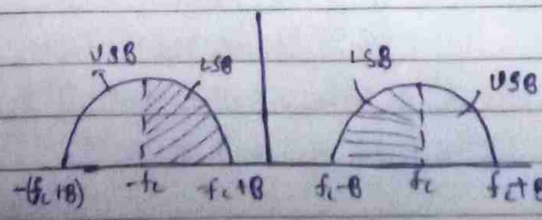
DSB-FC / AM



$m(t) \longleftrightarrow M(f)$

$m(t)\cos 2\pi f_c t \longleftrightarrow \frac{1}{2}[M(f+f_c) + M(f \mp f_c)]$





Spiral

Tone modulation

$\cos(2\pi f_m(t)) \rightarrow \otimes \rightarrow \frac{1}{2}[2\cos 2\pi f_m t \cdot \cos 2\pi f_c t]$

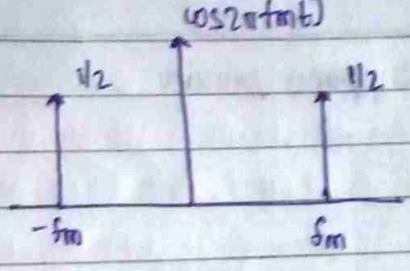
$\uparrow \cos$

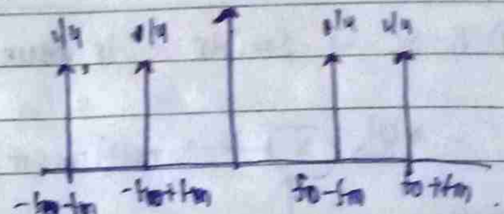
$= \frac{1}{2}[\cos 2\pi(f_m - f_c) + \cos 2\pi(f_m + f_c)]$

Eulers form:-

$\cos(2\pi f_m(t)) = \frac{1}{2}(e^{j2\pi f_m t} + e^{-j2\pi f_m t}]$

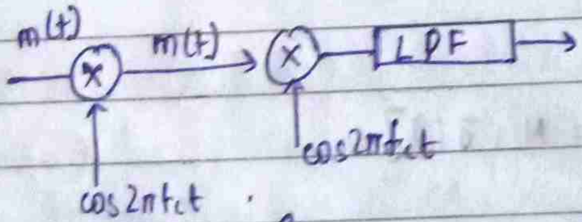
$= \frac{1}{2}[\delta(f - f_m) + \delta(f + f_m)]$





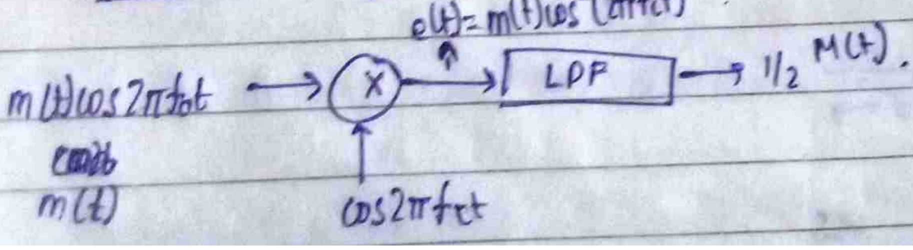
$= \frac{1}{2}\cancel{[\cos 2\pi(f_m}\ = \frac{1}{2}[\cos 2\pi(f_0 - f_m) + \cos 2\pi(f_0 + f_m)]$

$= \frac{1}{4}[\delta(f - (f_0 - f_m)) + \delta(f_0 + f_m) + \delta(f - (f_0 + f_m)) + \delta(f - (f_0 - f_m))]$



{LPF → Low pass filter}

Demodulation (Synchronous demodulation or coherent Demodulation)



Date

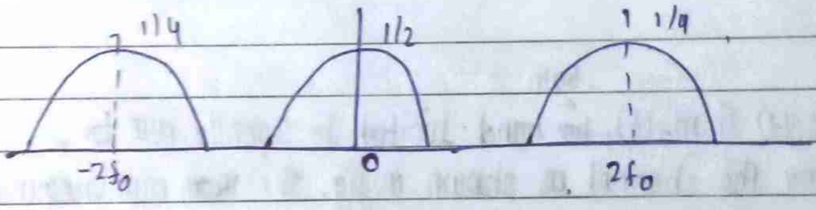
$m(t)\cos^2 2\pi f_0 t$

$e(t) = m(t)\left[\frac{1+\cos 2\pi \times 2f_0 t}{2}\right]$

$\Rightarrow \underbrace{\frac{m(t)}{2}}_{\text{message signal}} + \frac{m(t)\cos(2\pi \times 2f_0 t)}{2}$

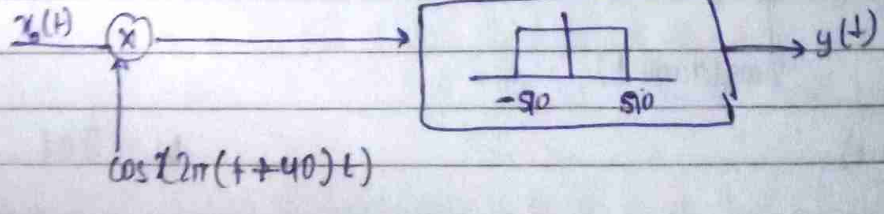
↳ nedgible because of very high frequency

$\frac{M(f)}{2} + \frac{1}{2}\left[\frac{1}{2}M(f-f_0) + M(f+f_0)\right]$



$m(t)\cos 2\pi f_0 t = Am\,(t - t_d)\cos(2\pi f_c t + \Delta f(t - t_d))$

Q. The modulation signal $x(t) = m(t)\cos 2\pi f_c t$, with carrier freq. of 1MHz and $m(t) = 4\cos(1000\pi t)$ is transmited by the transmitter at the R_x. the signal $x(t)$ is passed through the demodulator as shown the o/p of demodulation is :-



$e(t) = x(t)\cos(2\pi(f+40)t)$

$x(t) = m(t)\cos 2\pi f_c t$

$m(t) = 4\cos(1000\pi t)$

$e(t) = m(t)\cos 2\pi f_c t . \cos(2\pi(f_c+40)t)$

$= \frac{m(t)}{2}$ [illegible] $-40-f_c)t]$

If $m=1$, $\eta = 33\%$ efficiency is very less. } drawbacks of DSB-SC
modulation signal is 2B is not much efficient. DSB-FC/AM

Date

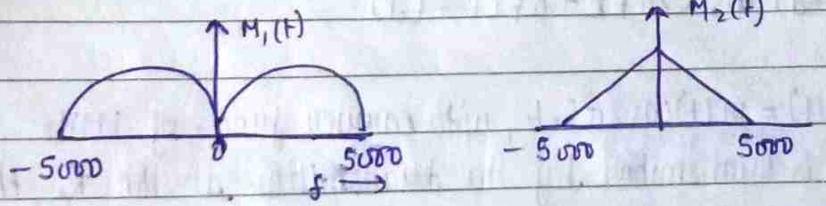
$= \cancel{2}\,4 \cos(1000\pi t)\,[\cos 2\pi(2f_c + 40)t] + \cos(2\pi(40t))]$

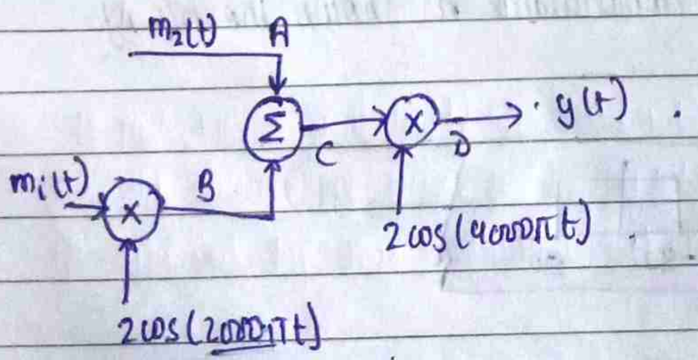
$\Rightarrow 2\cos 1000\pi t \cdot \cos(2\pi(2f_c + 40t)) + 2\cos 1000\pi t \cdot \cos(2\pi(40)t)$

$\Rightarrow \cos(1000\pi t - (4\pi f_c + 80\pi)t) + \cos(1000\pi t + (4\pi f_c + 80\pi t))$

$\Rightarrow \cos(1000\pi t) + \cos(920\pi t) + \cos(2\pi(2f_c + 940)t) + \cos(2\pi(f_0 - 460))$

Qu. Two signals $m_1(t)$ & $m_2(t)$, both band limited to 5000Hz are tx. simultaneously over the channel as shown in fig. The min requirements B.W. of the channel

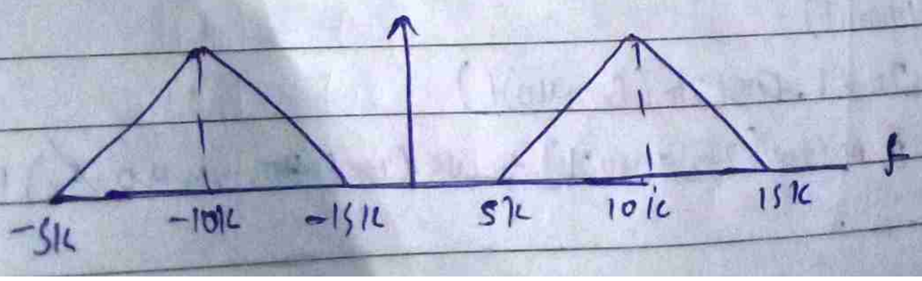




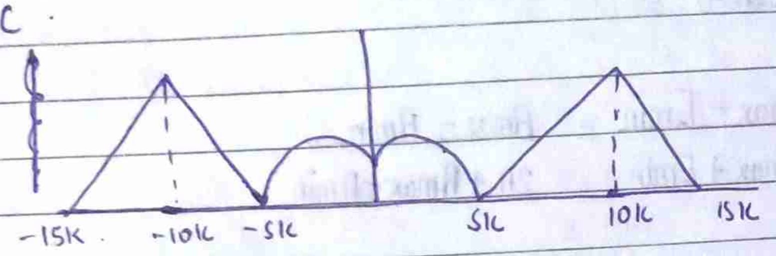
$\omega \Rightarrow 2\pi f$

At pt B

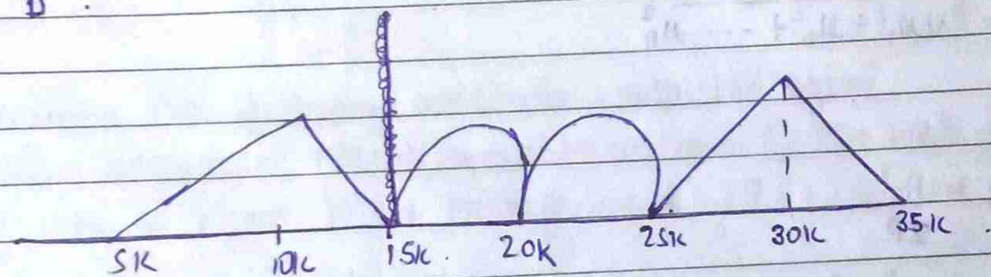
$f_c = 1000 = 10kH_2$



At pt C .



At pt D .



$BW = F_H - F_L$

$= 35K - 5K = 30KHz$

Date

Important formulas (AM).

1) $\mu = \frac{A_c}{A_m} = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} = \frac{A_{max} - A_{min}}{2A + A_{max} + A_{min}}$

2) for Multitone modulation.

$$\mu_T = \sqrt{\mu_1^2 + \mu_2^2 + \cdots \mu_n^2}$$

3) power

$$P_c = \frac{A_c^2}{2R}$$

$$P_s = \frac{\mu^2 A_c^2}{4R}$$

$$P_T = P_c\left[1 + \frac{\mu^2}{2}\right]$$

4) efficiency

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

Que A message signal $m(t) = 0.5\cos(\omega_1 t) - 0.5\sin(\omega_2 t)$ is amplitude modulation with the carrier of freq. ω_c to generate $s(t) = [1 + m(t)]\cos\omega_c t$. The power η achieved by this modulation scheme is?

Sol $s(t) = [1 + m(t)]\cos\omega_c t$

$A_c = 1$

$m(t) = 0.5\cos(\omega_1 t) - 0.5\sin(\omega_2 t)$

$|A_{m_1}| = 0.5$

$|A_{m_2}| = 0.5$

$\mu_1 = \frac{0.5}{1} = 0.5, \quad \mu_2 = \frac{0.5}{1} = 0.5$

Spiral

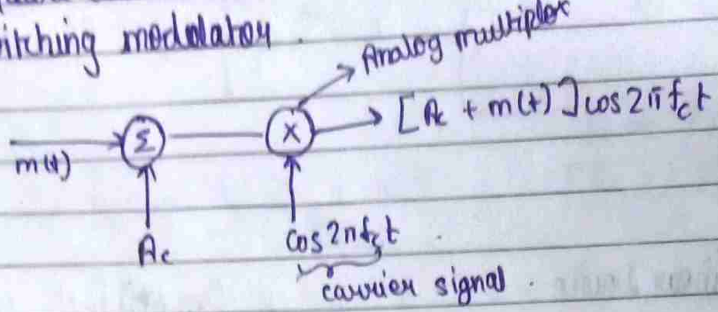
Date ________

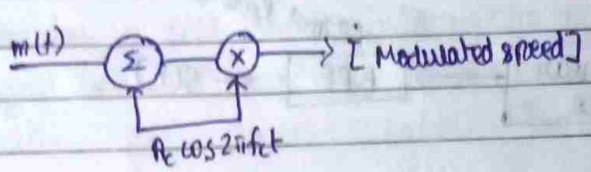
AM Generation

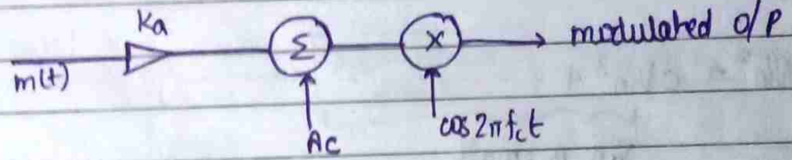
1.) Analog multiplier

2) Square law detector

3) Switching modulator.



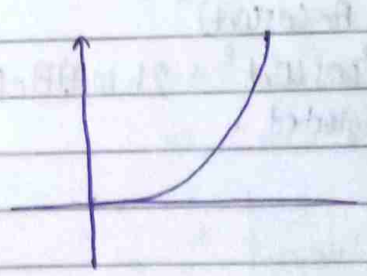


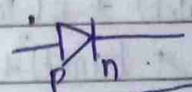


$\Rightarrow$ $\underbrace{A_c k_a}_{\text{amplitude sensitivity}} m(t) \cos 2\pi f_c t + A_c \cos 2\pi f_c t$.

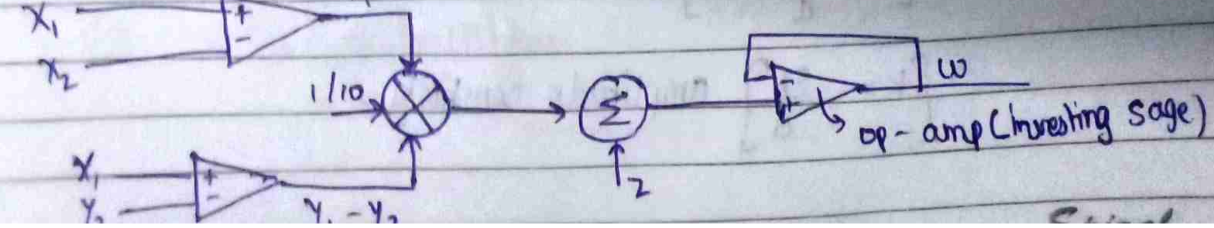
$= \boxed{A_c [1 + k_a m(t)] \cos 2\pi f_c t}$ — (1)

$$\boxed{k_a = \frac{1}{A_c}}$$





$\boxed{I_D = I_s \left(e^{\frac{V_p}{nV}} - 1\right)}$ → non linear eq.



Date

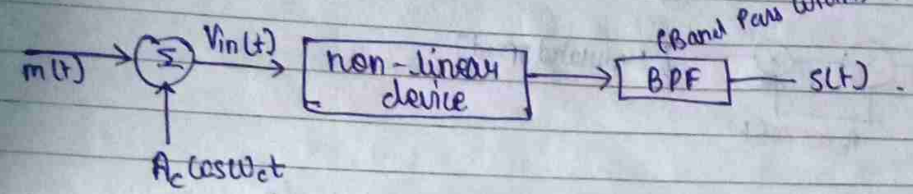
$$\omega = \frac{(x_1 - x_2)(y_1 - y_2)}{10} + 2$$

let, x = m signal, y is carrier z is also

$S(t) = m(t)$,

Square law modulator

↳ Non-Linear Device.



$$V_o(t) = aV_{in} + bV_{in}^2 + \underbrace{cV_{in}^3 + \cdots}_{\substack{V_{in} \text{ is small} \\ \text{all higher order are neglected}}}$$

$$V_o(t) = aV_{in} + bV_{in}^2 \quad \text{— (2)}$$

$$\boxed{V_{in}(t) = m(t) + A_c \cos\omega_c t} \quad \text{— (1)}$$

put (1) in (2)

$$V_o(t) = a(m(t) + A_c\cos\omega_c t) + b(m(t) + A_c\cos\omega_c t)^2$$

$$= am(t) + aA_c\cos\omega_c t + \underbrace{bm(t)^2 + bA_c^2\cos\omega_c t^2}_{\text{neglected}} + 2b\,m(t)A_c\cos\omega_c t$$

$$= aA_c\cos\omega_c t + 2bm(t)A_c\cos\omega_c t$$

$$= A_c[a + 2bm(t)]\cos\omega_c t =$$

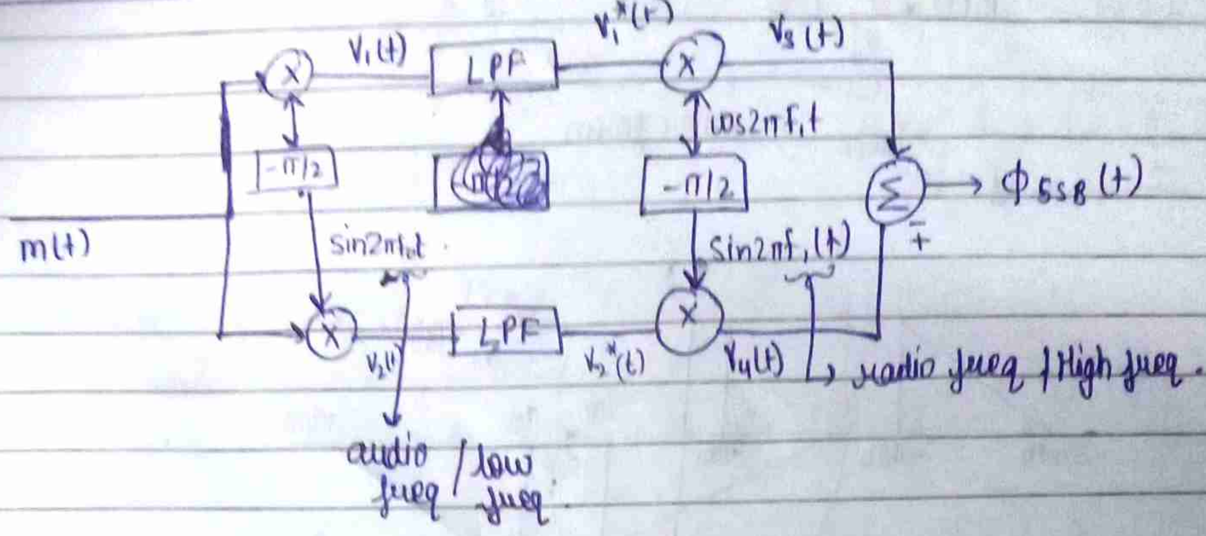
$$= aA_c\left[1 + \frac{2b}{a}m(t)\right]\cos\omega_c t$$

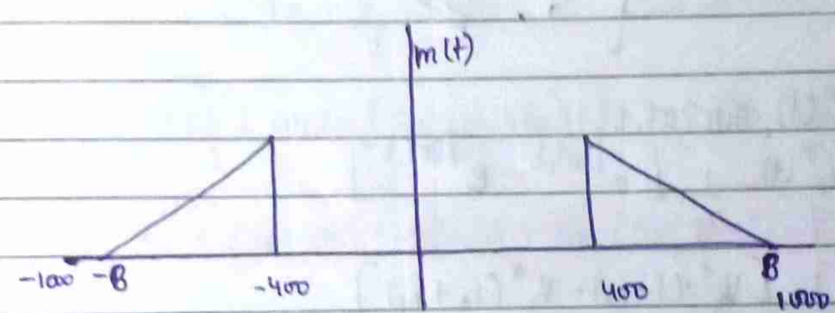
$$\left[k = \frac{2b}{a}\right] \text{ amplitude sensitivity.}$$

Spiral

shift Date

weaver method : extention of ~~pd~~ phase shift method

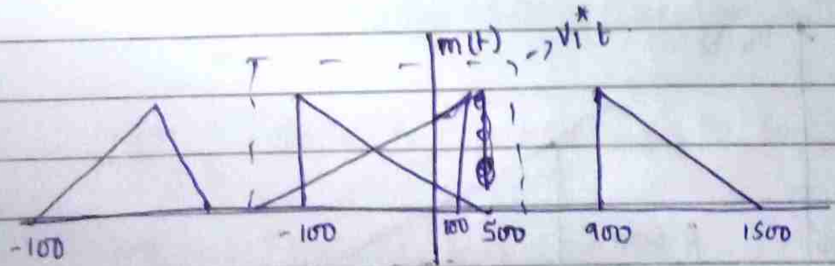


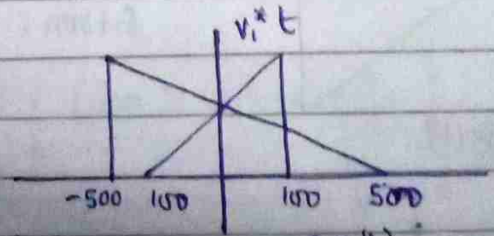


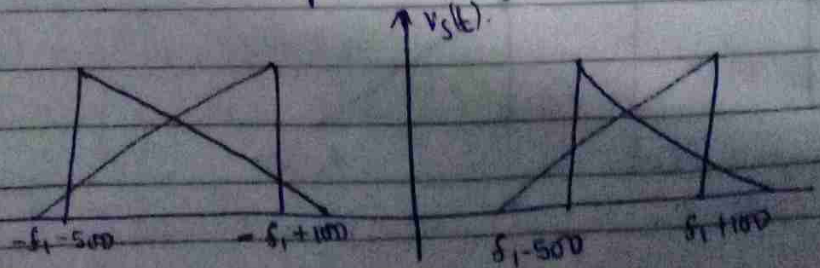
maximum freq. = B

LPF cutoff = B/2

f_0 = B/2







$\frac{800}{2}$

100

Spiral

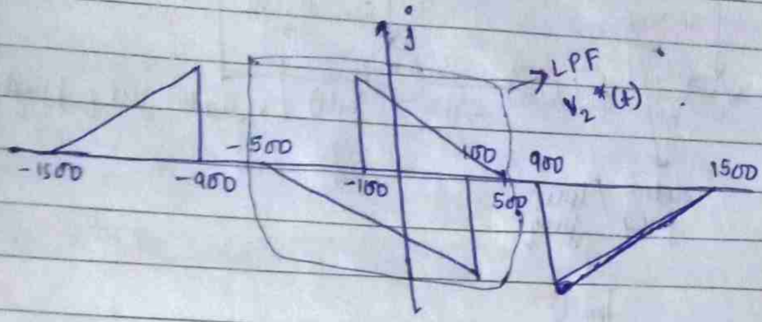
Date

$$V_2(t) = m(t).\sin 2\pi f_0 t$$

$$= m(t) \cdot \frac{1}{2j}\left[e^{j2\pi f_0 t} - e^{-j2\pi f_0 t}\right]$$

Euler form.

$$j = e^{j\pi/2}$$

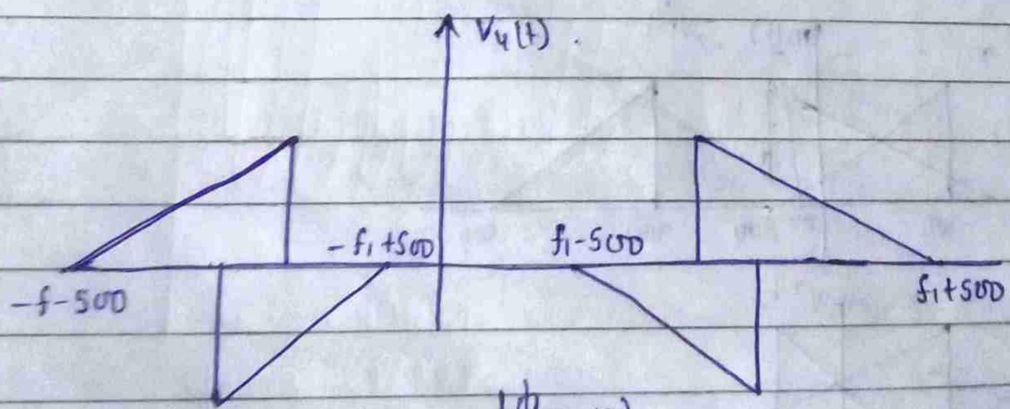


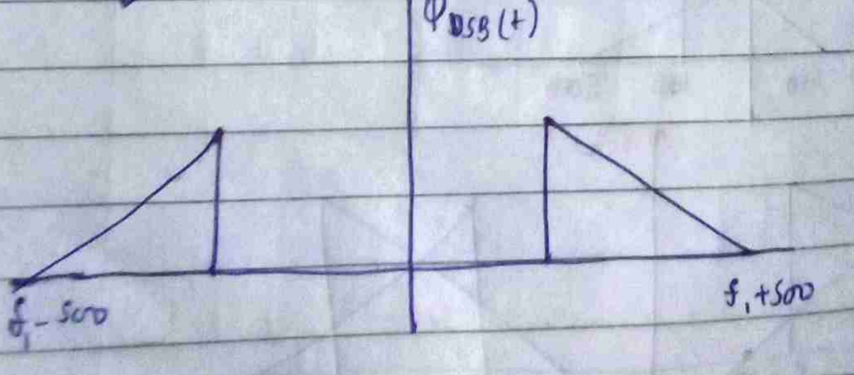
$$V_4(t) = V_2^*(t).\sin 2\pi f_1 t$$

$$= V_2^*(t) \cdot \frac{1}{2j}\left[e^{j2\pi f_1 t} - e^{-j2\pi f_1 t}\right]$$

$$= \frac{1}{2j}\left[V_2^*(f-f_1) - V_2^*(f_0+f_1)\right]$$

$$= \frac{1}{2}\left[V_2^*(f-f_1) - V_2^*(f+f_1)\right]$$





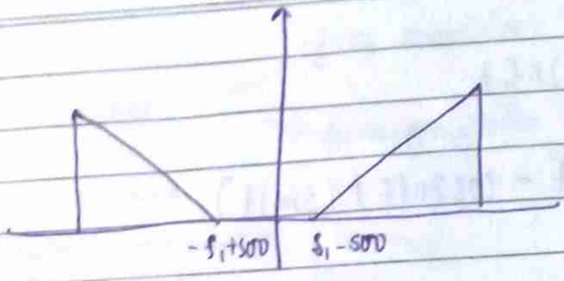
Spiral

Date

$B = 1000\ Hz$

$f_1 + \frac{B}{2} = f_c + B$

$\boxed{f_1 = f_0 + \frac{B}{2}}$



let $m(t) = \cancel{8}\cos 2\pi f m t$

$V_1(t) = \cos 2\pi f m t \cdot \cos 2\pi f_0 t$

$= \frac{1}{2}[\cos 2\pi(f_m + f_0)t - \cos 2\pi(f_m - f_0)t]$

$f_0 = \frac{B}{2} = \frac{f_m}{2}$

$\Rightarrow \frac{1}{2}[\cos 2\pi(f_m + 0.5 f_m)t + \cos(2\pi(f_m - 0.5 f_m)t]$

$= \frac{1}{2}[\cos 2\pi(1.5 f_m)t + \cos(2\pi(0.5) f_m t]$

$\boxed{V_1^*(t) = \frac{1}{2}[\cos 2\pi(0.5 f_m)t]}$

$V_2(t) = \cos 2\pi f m t \cdot \sin 2\pi f_0 t$

$= \frac{1}{2}[\sin(2\pi(f_m + f_0)t - \sin 2\pi(f_m - f_0)t]$

$= \frac{1}{2}[\sin 2\pi(f_m + 0.5 f_m)t - \sin 2\pi(f_m - 0.5 f_m)t]$

$= \frac{1}{2}[\sin 2\pi(1.5 f_m t) - \sin 2\pi(0.5 f_m)t]$

$\boxed{V_2^*(t) = -\frac{1}{2}[\sin 2\pi(0.5 f_m)t]}$

$V_3(t) = V_1^*(t) \cdot \cos 2\pi f_1(t)$

$= \left(\frac{1}{2}[\cos 2\pi(0.5 f_m)t]\right) \cdot \cos 2\pi f_1 t$

$V_3(t) = \frac{1}{4}\cos 2\pi(\cancel{f_1} f_m + 0.5 f_m) + \cos 2\pi(f_1 - 0.5 f_m))$

Spiral

Date

$V_4(t) = V_2^*(t) \cdot \sin 2\pi f_1 t$

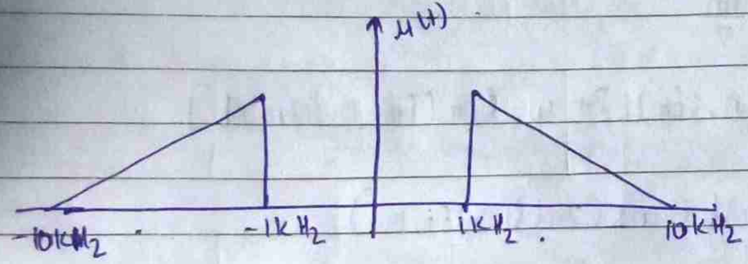
$= \left(-\frac{1}{2} \sin 2\pi(0.5 f_m)t\right) \cdot \sin 2\pi f_1 t$

$= -\frac{1}{4}\left[\cos(2\pi(f_1 - 0.5 f_m)t - \cos 2\pi(f_1 + 0.5 f_m)t\right]$

$\phi_{USB}(t) = \frac{1}{4}\left[\cos 2\pi(f + 0.5 f_m)t\right] + \frac{1}{4}\left[\cos 2\pi(f_1 + 0.5 f_m)t\right]$

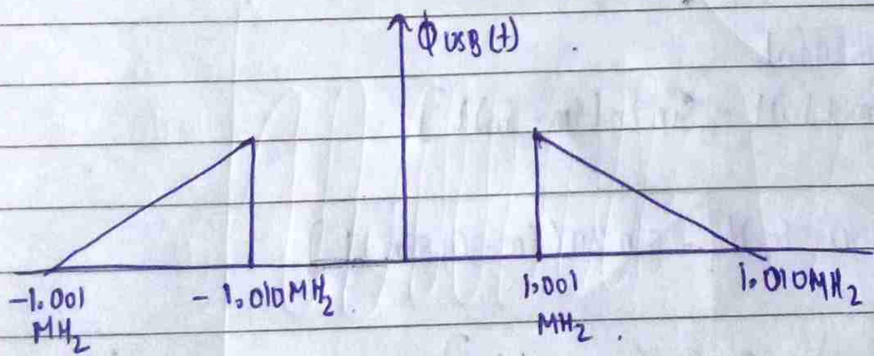
$$\boxed{\phi_{USB}(t) = \frac{1}{2} \cos 2\pi(f + 0.5 f_m)t}$$

Q4



10^6

$f_0 = \frac{B}{2} = 5kHz$



$f_1 + 5k = 1.010 MHz$

$f_1 + 5k = 1010 kHz$

$f_1 = 1010k - 5k = 1005 kHz$