① 1 ADC-Assignment-II

19BD1A0482
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Q1 Demodulation of DSBSC using synchronous or coherent. and find the expressions for frequency error and phase error.

A DSBSC - Double side band suppressed carrier

→ Demodulation of DSBSC can be done in 2 types.

① synchronous (or) coherent detector.

② COSTAS Loop.

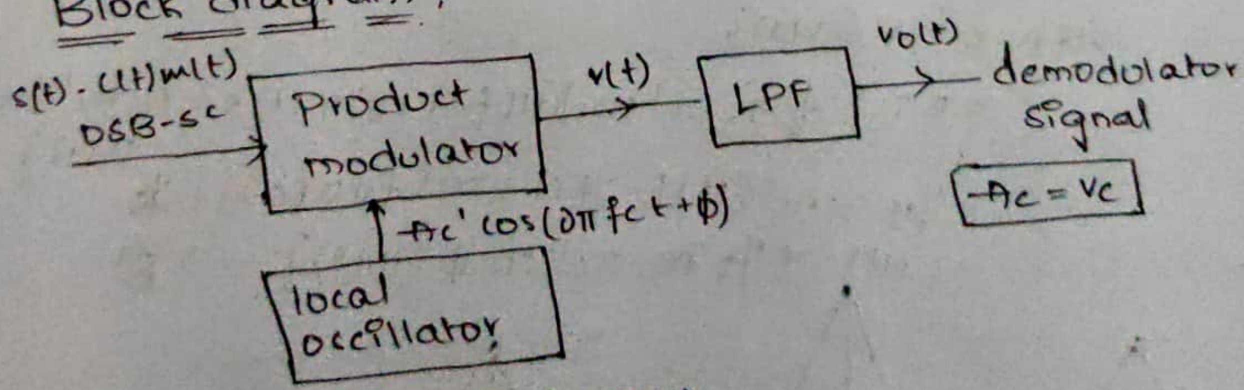
synchronous (or) coherent detector:-

→ we know that, envelope of DSBSC modulated wave form is different than the msg. s/g so we must employ coherent detection at a synchronous detection

→ in this process to multiply the DSBSC modulated w/f with a locally generated sinusoidal waveform & then LPF. then original msg can be obtained.

→ it is assumed that local oscillator used as the detector (demodulation) is of same frequency and phase (i.e coherent w.r.t oscarrier etc) used in Txn and in synchronous to it

Block diagram:-



w.k.t $s(t) = A_c \cos 2\pi f_c t \, m(t)$

Product modulator ⇒ $V(t) = s(t)_{DSB-SC} * Lo(t)$.

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$\rightarrow v(t) = s(t)\, A_c' \cos[2\pi f_c t + \phi]\, m(t)$

$= A_c A_c' \cos 2\pi f_c t \cdot \cos[2\pi f_c t + \phi)\, m(t)$

$= \frac{A_c A_c'}{2}[2\cos 2\pi f_c t \cos[2\pi f_c t + \phi)]\, m(t)$

$= \frac{A_c A_c'}{2}[\cos(4\pi f_c t + \phi) + \cos\phi]\, m(t)$

$v(t) = \frac{m(t)}{2} A_c A_c' \cos(4\pi f_c t + \phi) + \boxed{\frac{1}{2} A_c A_c' \cos\phi\, m(t)} \rightarrow ①$

High frequency   Low frequency

$\rightarrow$ this $v(t)$ from product modulator is sent to a lowpass filter which allow only low frequency signal to pass through it

$\rightarrow$ o/p of LPF

$v_o(t) = s(t)_{\text{demodulator}} = \frac{A_c A_c'}{2} m(t) \cos\phi \rightarrow ②$

$\rightarrow$ it is not compulsary that the oscillator produce the exact synchronous output carries wave (or) signal each time. Hence it may produce 2 types of errors they are :-

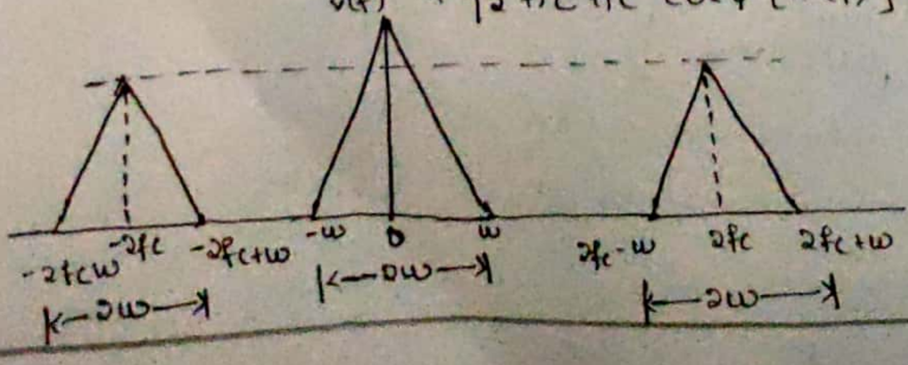
① phase error
② frequency error

<u>from eq ①</u>: $v(f)$ can be obtained as

$v(f) = F.T\{v(t)\}$

$= F.T\{\frac{1}{2} A_c A_c' \cos(4\pi f_c t + \phi) m(t) + \frac{1}{2} A_c A_c' \cos\phi\, m(t)\}$

$= \frac{1}{4} A_c A_c' [M(f - 2f_c) + m(f + 2f_c)] + \frac{1}{2} A_c A_c' \cos\phi\, [m(f)] \rightarrow ②.$



→ Amplitude of demodulated signal is maximum difference iff $\phi = 0$ minimum iff $\phi = \pm\pi/2$

Note: when $\phi = \pm\pi/2$ demodulated signal this is called Quadrature Null effect incoherent detection.

Drawback due to QNE:-

→ the phase error ϕ causes demodulator output to be attenuated by a factor of ϕ

→ when ϕ = constant, there is no distortion in demodulated o/p else if ϕ = randomly varying ⇒ $\cos\phi$ also varies randomly not desired

→ so, a new ckt has to be provided to make sure that L.O in Rx works in perfect synchronisation w.r.t carrier c(t) in Tx w.r.t frequency & phase thus it increases cost at DSBSC demodulator

$$s(t)_{DSBSC} = m(t)c(t) = A_c \cos 2\pi f_c t \, m(t).$$

Phase error:- $s_1(t) = s(t)_{DSBSC} * c(t)$

$$= A_c \cos 2\pi f_c t \, m(t) * \cos(2\pi f_c t + \phi)$$

$$= \frac{A_c^2}{2} m(t) \left[2\cos 2\pi f_c t \cos(2\pi f_c t + \phi)\right]$$

$$= \frac{A_c^2}{2} m(t) \left[\cos(4\pi f_c t) + \phi)\right] + \cos\phi]$$

$$= \frac{A_c^2}{2} m(t) \cos\phi + \frac{A_c^2}{2} m(t) \cos(4\pi f_c t + \phi)$$

output after lpf

$$s_1(t)_{demod} = \frac{A_c^2}{2} m(t) \cos\phi$$

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Frequency Error:-

$s_1(t) = s(t)_{DSBSC} * c(t)$

$= A_c \cos 2\pi f_c t \, m(t) * A_c \cos(2\pi f_c t + \Delta f)$

$= \frac{A_c^2}{2} m(t) \left(2\cos 2\pi f_c t \cos[2\pi f_c t + \Delta f)\right]$

$= \frac{A_c^2}{2} m(t) \left[\cos(4\pi f_c t + \Delta f) + \cos \Delta f)\right]$

$= \frac{A_c^2}{2} m(t) \cos \Delta f + \frac{A_c^2}{2} m(t) \cos(4\pi f_c t + \Delta f)$

output after LPF

$s(t)_{demodulated} = \frac{A_c^2}{2} m(t) \cos \Delta f$.

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Amplitude of demodulated signal is max iff $\phi = 0$ and min iff $\phi = \pm \pi/2$.

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2Q Demodulation of SSBSC using synchronous or coherent detector and also find the expression for frequency error and phase error.

A SSBSC - (single side band - suppressed carrier)

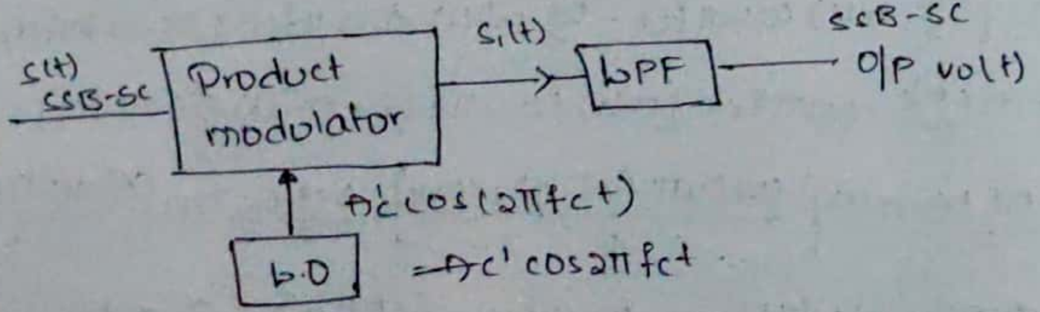
Coherent (or) synchronous detector of - SSB-SC :-

-> Demodulation of SSB is complicated since here carrier as well as one of the sidebands is suppressed when compared to DSB-SC.

-> Coherent detection is used where synchronisation is needed in both frequency & phase hardware locally generated carrier in Rxer w.r.t carrier used in Txes

-> Although carrier is suppressed, yet info is embedded on carrier phase and frequency is present in side bands of modulated wave.

-> The 2 side bands are mirror images of each other



$= A_c' \cos 2\pi f_c t$

w.k.T

$s(t)_{SSB-SC} = \frac{A_c}{2}[m(t) \cos 2\pi f_c t - \hat{m}(t) \sin 2\pi f_c t]$

$c(t) = A_c' \cos(2\pi f_c t)$

$= A_c' \cos 2\pi f_c t$

o/p of product modulator $s_1(t) = s(t)_{SSBSC} * c(t)$.

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$S_1(t) = \left[\frac{A_C}{2} m(t) \cos 2\pi f_c t - \frac{A_C}{2} m^{n}(t) \sin 2\pi f_c t\right] A_c' \cos 2\pi f_c t.$

$= \frac{A_C A_c'}{2} \cos^2 2\pi f_c t \, m(t) - \frac{A_C A_c'}{2} m^{n}(t) \sin 2\pi f_c t \cos 2\pi f_c t$

$= \frac{A_C A_c'}{4} m(t) + \frac{A_C A_c'}{4} \cos 4\pi f_c(t) \, m(t) - \frac{A_C A_c'}{2} m^{n}(t) \sin 2\pi f_c t \cos 2\pi f_c t.$

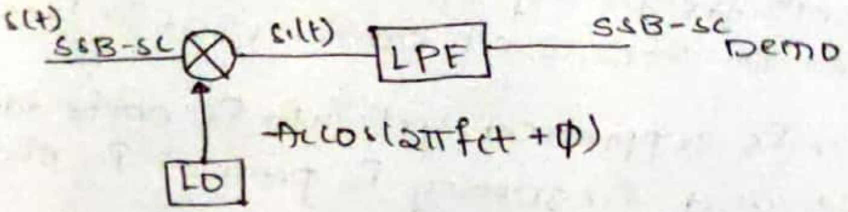
the o/p is sent to low pass filter which allows only low frequency & attenuators high frequency

o/p of LPF is $s(t)_{SSB-SC} = \frac{A_C A_c'}{4} m(t).$

phase error :- $A_c \cos(2\pi f_c t + \phi)$

frequency error :- $A_c \cos(2\pi f_c t + \Delta f)$

a <u>Phase error</u> :-



$s(t)_{SSB-SC} = \frac{A_C}{2} m(t) \cos 2\pi f_c t - \frac{A_C}{2} m^{n}(t) \sin 2\pi f_c t$

$c_L(t) = A_c \cos(2\pi f_c t + \phi)$

$S_1(t) = \left[\frac{A_C}{2} m(t) \cos 2\pi f_c t - \frac{A_C}{2} m^{n}(t) \sin 2\pi f_c t\right] A_c' \cos 2\pi f_c t)$

$= \frac{A_C A_c'}{2} \cos 2\pi f_c t \left[m(t) \cos 2\pi f_c t - m^{n}(t) \sin 2\pi f_c t\right]$

$= \frac{A_C A_c'}{2} m(t) \left[\frac{\cos(4\pi f_c t + \phi) + \cos\phi}{2}\right] - \frac{A_C A_c'}{2} m^{n}(t) \left[\frac{\sin 4\pi f_c t] + \sin\phi}{2}\right.$

$S_1(t) = \underbrace{\frac{A_C A_c'}{4} m(t)}_{\text{desired}} + \underbrace{\frac{A_C A_c'}{4} m(t) \cos 4\pi f_c t - \frac{A_C A_c'}{4} m^{n}(t) \sin 4\pi f_c t}_{\text{undesired}}$

o/p of LPF

$s(t) = \frac{A_C A_c'}{4} (m(t) \cos\phi + m^{n}(t) \sin\phi]$

-Applying fourier T/F

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$s(f) = \frac{A_c A_c'}{4} m(f)\cos\phi + \frac{A_c A_c'}{4} \hat{m}(f)\sin\phi$

$s(f) = \frac{A_c A_c'}{4} m(f)\cos\phi + \frac{A_c A_c'}{4} m(t)(j\,\mathrm{sgn}(f)\sin\phi)$

$= \frac{A_c A_c'}{4} m(f)\cos\phi - j\frac{A_c A_c'}{4} m(f)\sin\phi$

$\boxed{s(f) = \frac{A_c A_c'}{4} m(f) e^{-j\phi}} \Rightarrow v_0(t)$

there is no Quadrature Null effect in coherent detection of SSB-SC

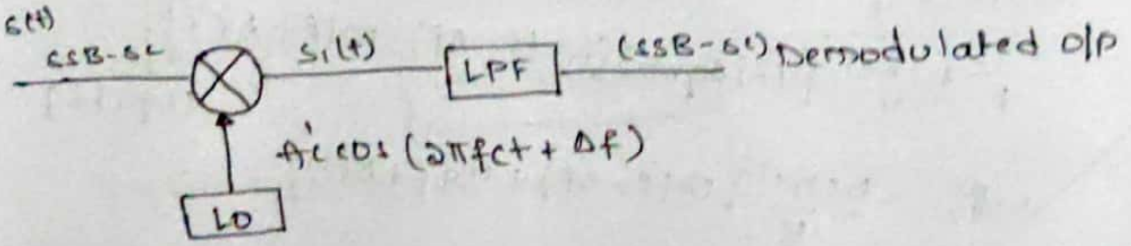
Effects of phase and frequency error in SSB-Demodulation

-> for effective coherent detection Rx should generate coherent frequency and phase of carrier as that of in Txer. this can be done by.

a using stable local oscillator at receiver

b providing pilot carrier along with SSB during Txn.

b frequency error:



-> it produces phase shift of $+\theta$ (or) $+\pi$ for the negative frequencies & $-\theta$ (or) $-\pi$ for the positive frequencies.

-> Let Δf be the frequency error is locally generated carrier $A_c'\cos(2\pi(2f_c+\Delta f)t)$ is used

$s(t)_{SSBSC} = A_c/2\, m(t)\cos 2\pi f_c t - \frac{A_c}{2}\hat{m}(t)\sin 2\pi f_c t$

$c(t) = A_c'\cos 2\pi(f_c + \Delta f)t$.

o/p of product modulator

$s_1(t) = s(t) * c(t)$

$$s_1(t) = \left[\frac{A_c}{2} m(t) \cos 2\pi f_c t - \frac{A_c}{2} \hat{m}(t) \sin 2\pi f_c t\right] A_c' \cos(2\pi f_c t + \Delta f)$$

$$= \frac{A_c A_c'}{2} m(t) \cos 2\pi f_c t \cdot \cos 2\pi (f_c + \Delta f) t - \frac{A_c A_c'}{2} \hat{m}(t) \sin 2\pi f_c t \cos 2\pi (f_c + \Delta f) t .$$

$$s(t)_{SSB-SC} = \frac{A_c A_c'}{4} m(t) \left[\cos(4\pi f_c t + 2\pi \Delta f) t + \cos 2\pi \Delta f t\right]$$

$$- \frac{A_c A_c'}{4} \hat{m}(t) \left[\sin(4\pi f_c t + 2\pi \Delta f) t - \sin 2\pi \Delta f t\right]$$

$$= \frac{A_c A_c'}{4} \underbrace{m(t) \cos(4\pi f_c t + 2\pi \Delta f) t}_{\text{unwanted}} + \underbrace{\frac{A_c A_c'}{4} m(t) \cos 2\pi \Delta f t}_{\text{Desired}}$$

$$- \frac{A_c A_c'}{4} \underbrace{\hat{m}(t) \sin\left[4\pi f_c t + 2\pi \Delta f t\right]}_{\text{unwanted}} + \underbrace{\frac{A_c A_c'}{4} \sin 2\pi \Delta f t \, \hat{m}(t)}_{\text{Desired}} .$$

o/p of low pass filter.

$$v_o(t) = \frac{A_c A_c'}{4} m(t) \cos 2\pi \Delta f t + \frac{A_c A_c'}{4} \sin 2\pi \Delta f \, \hat{m}(t)$$

$$= \frac{A_c A_c'}{4} \left[m(t) \cos 2\pi \Delta f t + \hat{m}(t) \sin 2\pi \Delta f t\right]$$

Apply F.T

$$v_o(f) = \frac{A_c A_c'}{4} \left[\frac{m(f - \Delta f) + m(f + \Delta f)}{2}\right]$$

$$+ \frac{A_c A_c'}{4} \left[(-j \operatorname{sgn} f)\left[m(f - \Delta f) - m(f + \Delta f)\right]\right]$$

$j \operatorname{sgn} f = 1$

$$v_o(f) = \frac{A_c A_c'}{8} \left[m(f - \Delta f) + m(f + \Delta f)\right]$$

$$- \frac{A_c A_c'}{8} \left[m(f - \Delta f) - m(f + \Delta f)\right]$$

$$- \frac{A_c A_c'}{8} m(f - \Delta f) + \frac{A_c A_c'}{8} m(f + \Delta f) - \frac{A_c A_c'}{8} m(f - \Delta f) + \frac{A_c A_c'}{8} m(f + \Delta f)$$

$$\boxed{v_o(f) = \frac{A_c A_c'}{4} m(f + \Delta f)} \rightarrow \text{demodulated o/p.}$$

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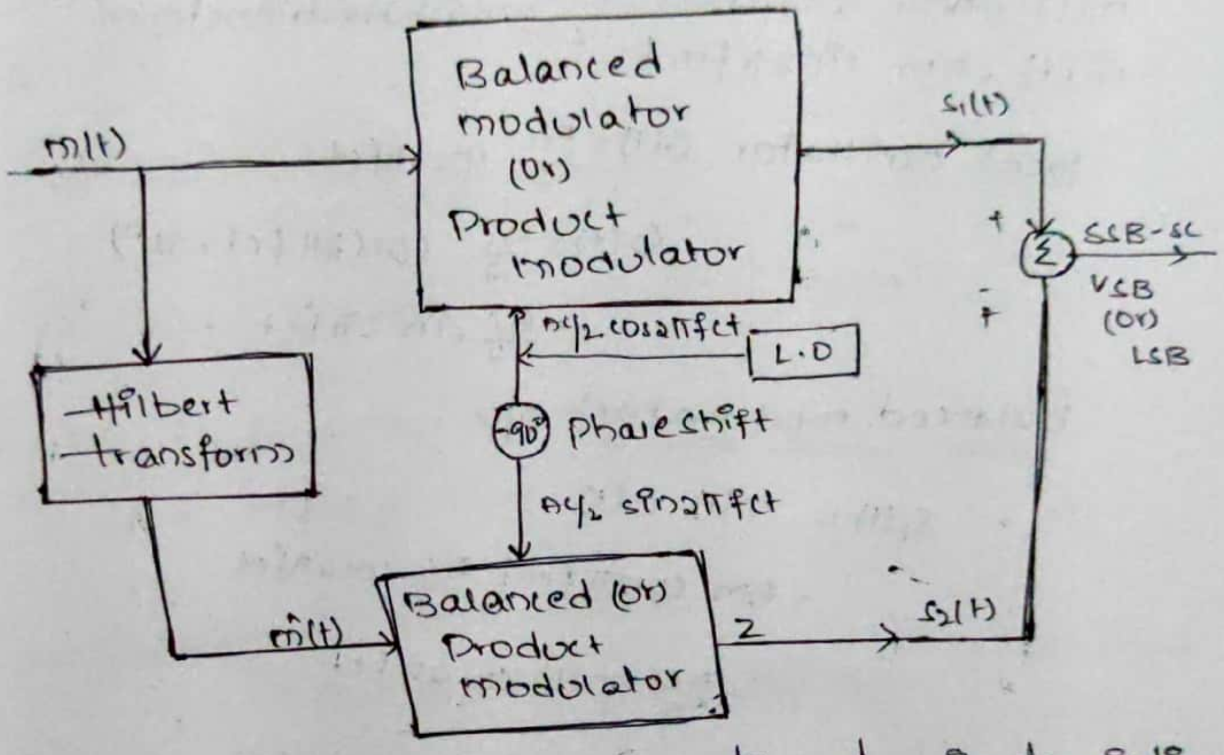
3Q Generate SSB-SC waves Using 2nd and 3rd method.

A Generating SSB-SC wave by using 2nd and 3rd method

-> second method :-

second method is also known as phase discrimination (or) Hartley modulator.



its implementation follows from time domain description of SSB waves.

-> it has got 2 paths -> inphase path
-> Quadrature path.

Each path has got product modulator they receive inphase carrier $\cos 2\pi f_c t$ and out of phase carrier by 90° i.e $\sin 2\pi f_c t$ respectively.

-> wide band phase shifter is designed to produce $\hat{m}(t)$ ie H.T of m(t).

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→ the quadrature path integeres with inphase path and eliminates the power in one of the 2-side bands, depend on whether upper SSB (or) lower SSB is request

→ in this method wideband phase shifter requires special attention whereas in frequency discrimination method only BPF is required.

mathematical analysis:-

$m(t) = A_m \cos 2\pi f_m t$ → Hilbert transform.

$\hat{m}(t) = A_m \sin 2\pi f_m t$

local oscillator $c_1(t) = \frac{A_c}{2} \cos 2\pi f_c t$

$c_2(t) = \frac{A_c}{2} \cos(2\pi f_c t - 90^0)$

$- \frac{A_c}{2} \sin 2\pi f_c t$

Balanced modulator:- o/p.

$s_1(t) = m(t)\, c_1(t)$

$= A_m \cos 2\pi f_m t \frac{A_c}{2} \cos 2\pi f_c t$

$= \frac{A_c}{2} m(t) \cos 2\pi f_c t$

$s_2(t) = \hat{m}(t)\, c_2(t)$

$= \frac{A_c}{2} \hat{m}(t) \sin 2\pi f_c t$

$s(t)_{SSB\,SC} = s_1(t) - s_2(t)$ for USB

$= \frac{A_c}{2} m(t) \cos 2\pi f_c t - \frac{A_c}{2} \hat{m}(t) \sin 2\pi f_c t$

$s(t)_{SSB-SC} = s_1(t) + s_2(t)$ for LSB

$= \frac{A_c}{2} m(t) \cos 2\pi f_c t + \frac{A_c}{2} \hat{m}(t) \sin 2\pi f_c t$

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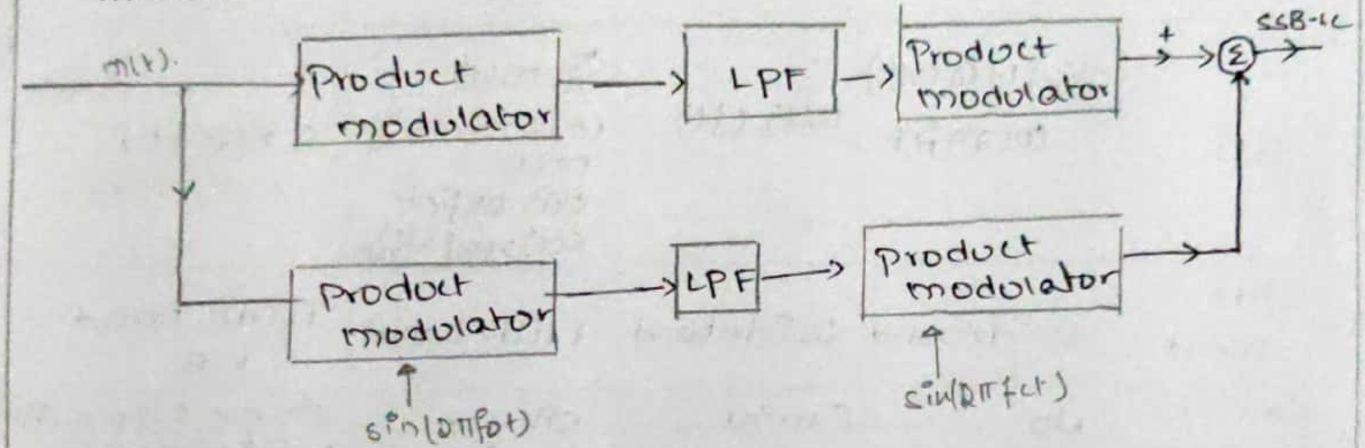
Advantages:-

1) there is no need of any filters to select a band of frequencies

2) it is applicable for all frequencies.

iii Third method is also known as [1&2 method] or weaver's method



→ m(t) ⇒ frequency $f_a \le |F| \le f_b$.

→ $f_0 = \frac{(f_a+f_b)}{2}$

→ LPF < in phase channel / quadrative phase channel } - identical

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4 write a table comparing the following parameters for Am, DSBSC, SSBSC, & VSB
i) s(t) ii) sidebands iii) carrier suppression iv) bandwidth v) power vi) complexity vii) modulation type viii) efficiency
IX application.

	Parameter	AM	DSB-SC	SSBSC	VSB.
i)	s(t)	$V_c[1+k_a m(t)] \cos 2\pi f_c t$.	$m(t)\,c(t)$	$\frac{V_c}{2} m(t) \cos 2\pi f_c t - \frac{V_c}{2} \hat{m}(t) \sin 2\pi f_c t$ s(t)VSB | s(t)VSB	$S_{VSB}(t)$
ii)	side band	2sideband	2sideband	1sideband	1side band VSB
iii)	Carrier suppression	No suppression	Carrier suppression	single suppression	single suppression & side band Partially
iv)	band width	$2f_m$	$2f_m$	f_m	f_m+f_v
v)	power	high	medium	low	low but higher than SSBSC
vi)	complexity	simple.	complex	complex	simple
vii)	Application	Radio communi-cation	point to point communic-ation	for voice transmission	Tv (or) video broadcasting
viii)	modulation type	non-linear	linear	linear	linear
IX	Efficiency	minimum	moderate	maximum	moderate

Scanned with CamScanner

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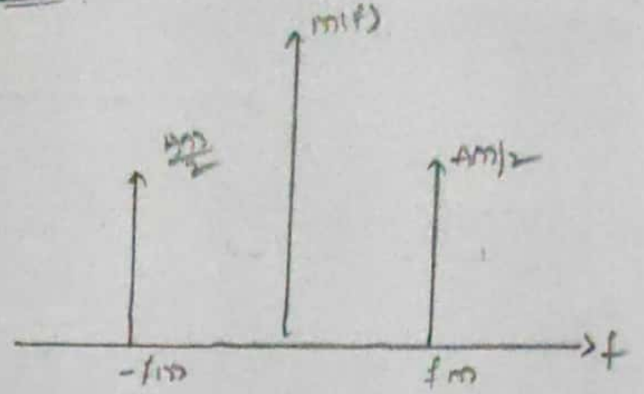
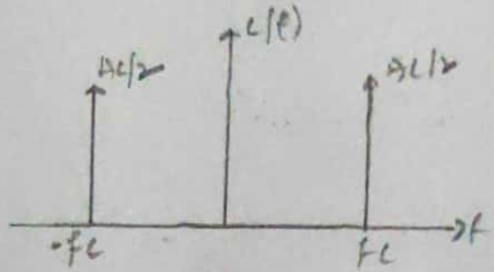
5Q Draw frequency spectrum from Am to VSB in neat diagram.

A Frequency spectrums:-

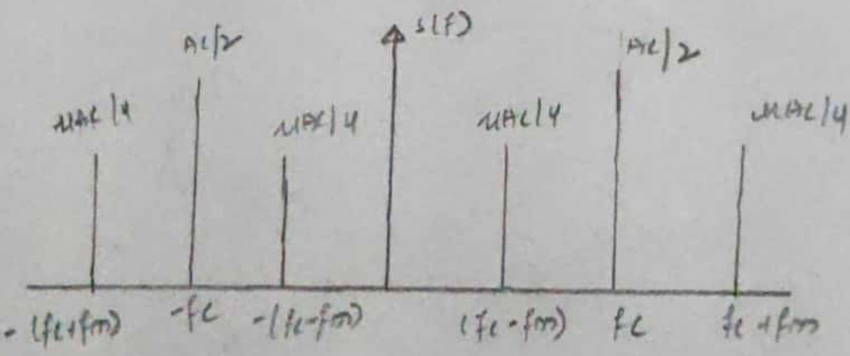
message signal



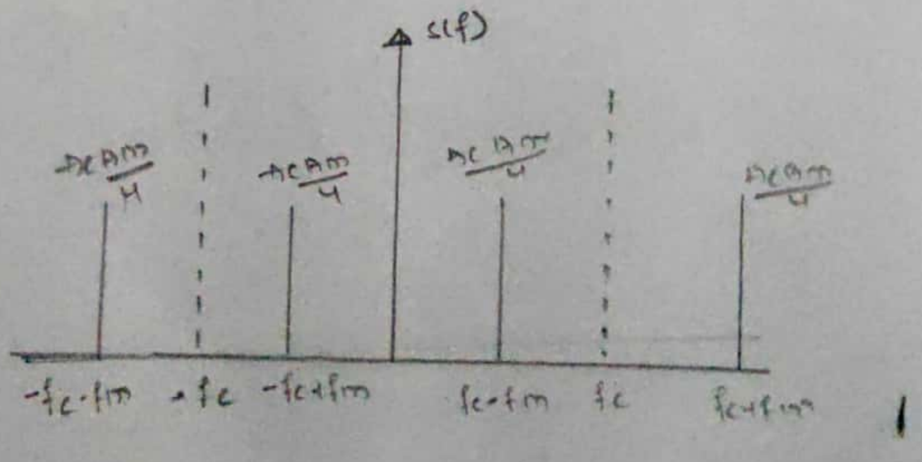
carrier signal



Am



DSB-SC .



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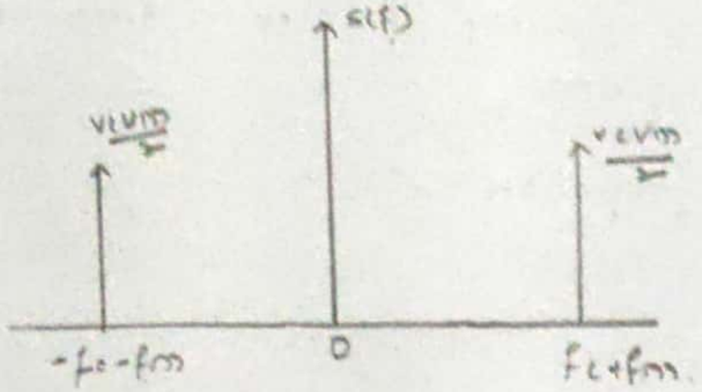
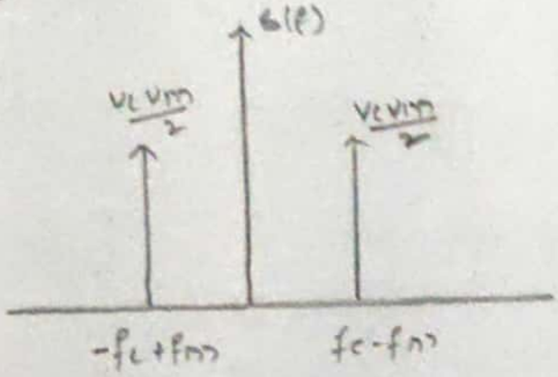
SSB-SC (USB)



SSB-SC (LSB)



VSB