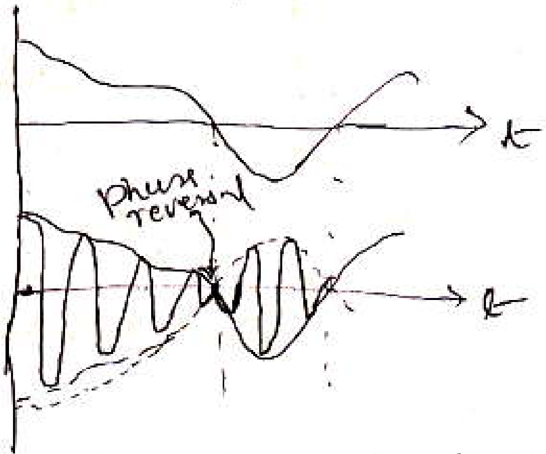
Dr. Vun
PC1- DSB-SC - 1

Module 1 - 2nd bit

Double sideband- Suppressed Carrier Modulation: Consists of the product of the message signal $m(t)$ and the carrier wave $c(t)$, as follows

$$s(t) = c(t)\, m(t) = A_c \cos(2\pi f_c t)\, m(t)$$

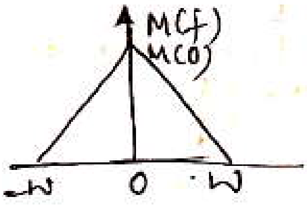
Consequently, the modulated signal $s(t)$ undergoes a "phase reversal" whenever the message signal $m(t)$ crosses zero.

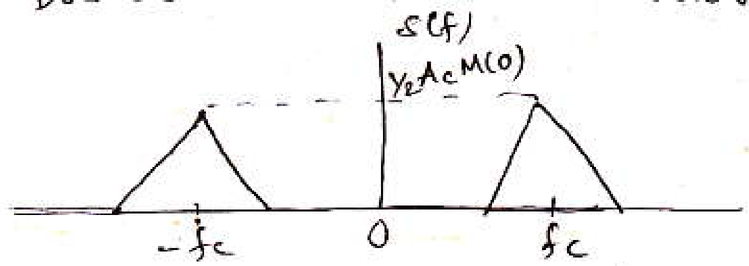


Fourier transform of $s(t)$ is obtained as

$$S(f) = \frac{1}{2} A_c [M(f-f_c) + M(f+f_c)]$$

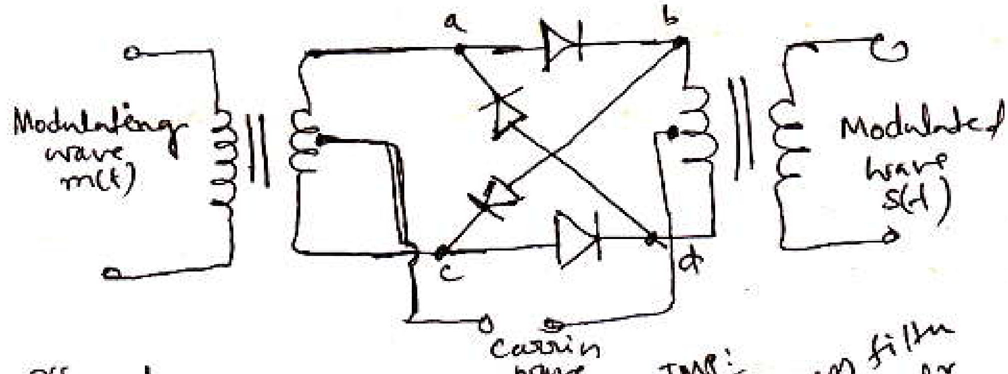
For the case when the baseband signal $m(t)$ is limited to the interval $-W \le f \le W$, as in Figure 3-9(a), we thus find that the spectrum $S(f)$ of the DSB-SC wave $s(t)$ is shown below:

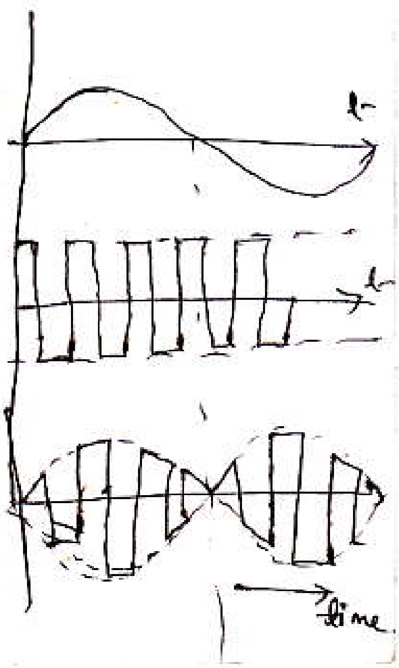


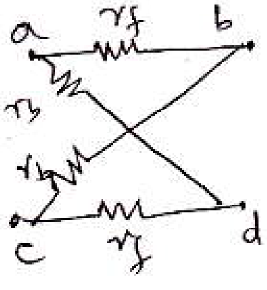


$\Rightarrow$ Bandwidth required for AM & AM DSB-SC is same.

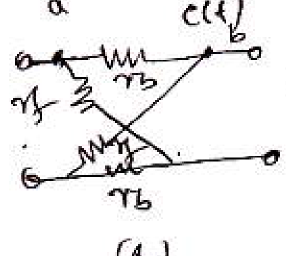
Generation: Ring Modulator:







(A)



(B)

IMP:
$\Rightarrow$ Bandpass filter after ring mod^r
i) to prevent SBs overlap
ii) $f_c > W$.

$$c(t) = \frac{4}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{2n-1} \cos(2\pi f_c t(2n-1))$$
(Fourier series)

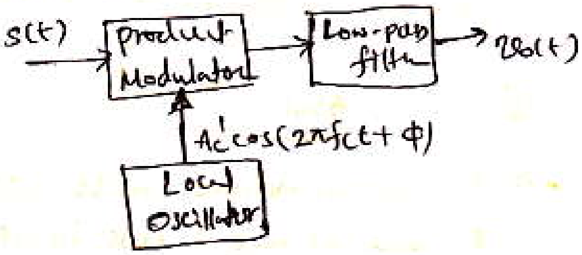
The ring modulator o/p is therefore

$$s(t) = c(t)\, m(t)$$
$$= \frac{4}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{2n-1} \cos(2\pi f_c t(2n-1))\, m(t)$$

Coherent Detection: The baseband signal m(t) can be uniquely recovered from a DSB-SC wave s(t) by first multiplying s(t) with a locally generated sinusoidal wave & then low-pass filtering the product.

⇒ It is assumed that the local oscillator signal is exactly coherent or synchronized in both frequency & phase, with the carrier wave c(t) used in the product modulator to generate s(t).

⇒ This method of demodulation is known as coherent detection or synchronous demodulation.



⇒ But in general local oscillator freq has some phase shift ϕ.

i.e., $v(t) = A_c' \cos(2\pi f_c t + \phi)\, s(t)$

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

Neglecting higher freq terms (after filtering)

$$v_0(t) = \frac{1}{2} A_c A_c' \cos\phi(\phi) . m(t)$$

⇒ o/p is min ~~max~~ for $\phi = \pm\pi/2$ as $\cos\phi = 0$

& o/p is max for $\phi = 0$.

when $\phi = \pm\pi/2$ $\cos\phi = 0 \Rightarrow v_0 = 0$ ⇒ Quadrature Null

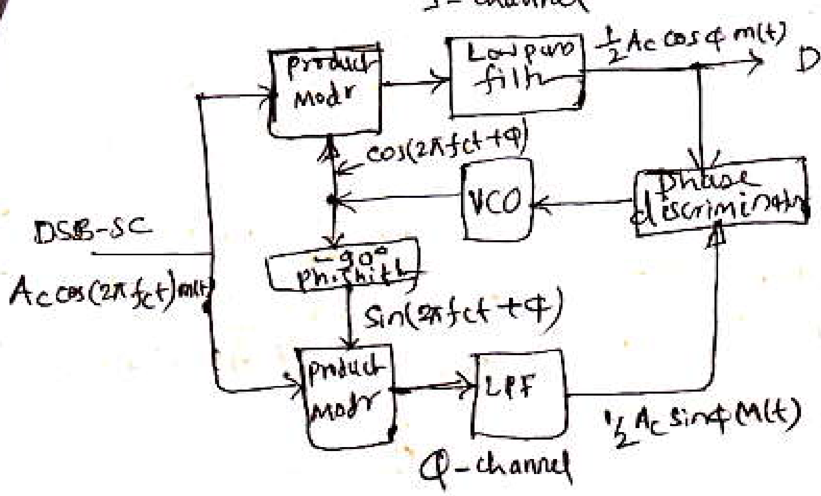
⇒ As long as ~~cos φ~~ phase error 'ϕ' is const, the detector o/p is undistorted.

⇒ However, practically ϕ varies w.r.t. 't' (randomly) (due to nonlinear behavior comm^n channel properties)

VGK PCS-DSB-SC-2

COSTAS RECEIVER

⇒ practical synchronous receiver, suitable for demodulating DSB-SC waves



⇒ If LO phase is same as f_c ⇒ I channel o/p is max & Q-channel o/p is zero (quadrature null effect)

⇒ As the phase shift of VCO changes Q-channel o/p starts appearing.

⇒ VCO phase is in the direction of 'f_c' ($\sin\phi = \phi$) phase ⇒ I & Q have same polarity

⇒ For opposite direction of phase shift Q-o/p is opp. pol w.r.t. I.

• It is apparent that phase control in the Costas receiver ceases with the modulation and that phase-lock has to be reestablished with the reappearance of Modn

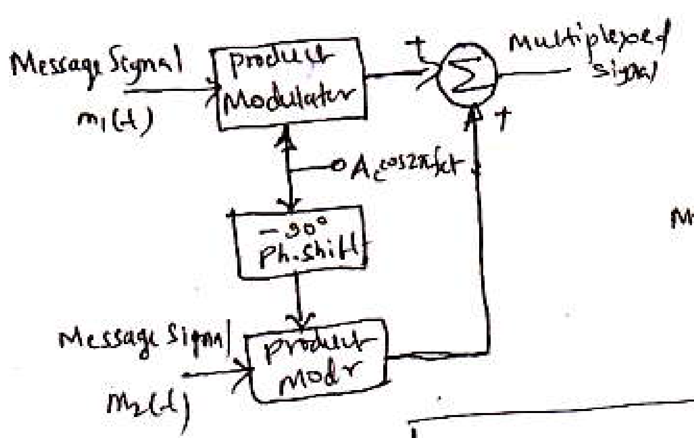
⇒ However, it is not a serious issue as phase lock happens very quickly.

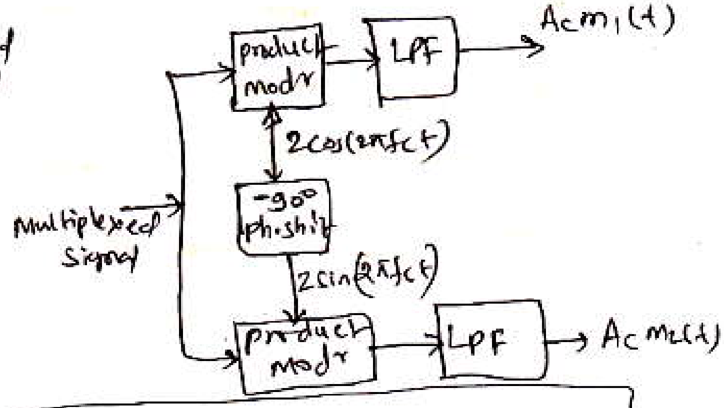
Quadrature Carrier Multiplexing:

⇒ The quadrature null effect of the coherent detector may also be put to good use in the construction of the so-called "quadrature carrier multiplexing" or QAM.

⇒ This scheme enables two DSB-SC modulated waves (resulting from the application of two physically independent message signals) to occupy the same channel bandwidth, and yet it allows for the separation of the two message signals at the receiver o/p.

⇒ Therefore, it is a bandwidth conservation scheme.





$$\boxed{s(t) = A_c m_1(t)\cos(2\pi f_c t) + A_c m_2 \sin(2\pi f_c t)}$$

$$\cos^2\theta = \frac{1}{2} + \frac{1}{2}\cos 2\theta$$

Eg: Consider a square-law detector using a nonlinear device whose transfer characteristic is defined by

$$v_2(t) = a_1 v_1(t) + a_2 v_1^2(t)$$

where a_1 & a_2 are constants, $v_1(t)$ is the i/p & $v_2(t)$ is the o/p. The i/p consists of the AM wave

$$v_1(t) = A_c[(1 + k_a m(t))] \cos 2\pi f_c t$$

(a) Evaluate the o/p $v_2(t)$

(b) Find the condition for which message signal $m(t)$ may be recovered from $v_2(t)$.

$\cos 2\theta = \cos^2\theta - \sin^2\theta$

$\sin 2\theta = 2\sin\theta\cos\theta$

$\sin(-\theta) = -\sin\theta$

$\cos(-\theta) = \cos\theta$

$\sin A \sin B = \frac{1}{2}(\cos(A-B) - \cos(A+B))$

$\sin A \cos B = \frac{1}{2}(\sin(A+B) + \sin(A-B))$

$\cos A \sin B = \frac{1}{2}(\sin(A+B) - \sin(A-B))$

$\cos A \cos B = \frac{1}{2}(\cos(A-B) + \cos(A+B))$

$\lim_{\theta \to 0} \frac{\sin\theta}{\theta} = 1$ $\quad \sqrt{1} = 1$

$\sin^2\theta + \cos^2\theta = 1$

$0! = 1! = 1$

$x^0 = 1$