SNS COLLEGE OF TECHNOLOGY

An Autonomous Institution
Coimbatore-35

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A++' Grade(3rd Cycle)
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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECB301-ANALOG AND DIGITAL COMMUNICATION

III YEAR/ V SEMESTER

UNIT 1 – ANALOG COMMUNICATION

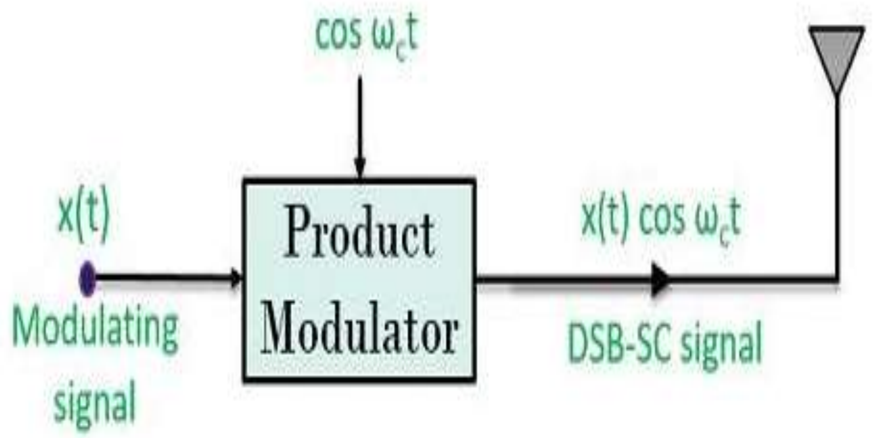
TOPIC – DOUBLE SIDEBAND SUPPRESSED CARRIER

DEFINITION

- **DSB-SC(Double Side band suppressed carrier)** is an amplitude modulated wave transmission scheme in which only **sidebands** are **transmitted** and the **carrier** is not transmitted as it gets **suppressed**.
- The carrier does not contain any information and its transmission results in loss of power. Thus only sidebands are transmitted that contains information. This results in saving of power used in transmission.

Generation of DSB-SC signal

A product modulator generates a DSB-SC signal.The signal is obtained by the multiplication of baseband signal x(t) with carrier signal



By frequency shifting property of Fourier transform-

$$x(t)\cos\omega_c t \longleftrightarrow \frac{1}{2}[\,X(\omega+\omega_c) + (\omega-\omega_c)]$$

From the above equation, it is clear that only 2 components are present in the spectrum. These two are the two sidebands that are placed at $+\boldsymbol{\omega_c}$ and $-\boldsymbol{\omega_c}$.

MATHEMATICAL EXPRESSION

The baseband or modulating signal,

$$x(t) = A_x \cos(2\pi f_x t)$$

and the carrier signal,

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

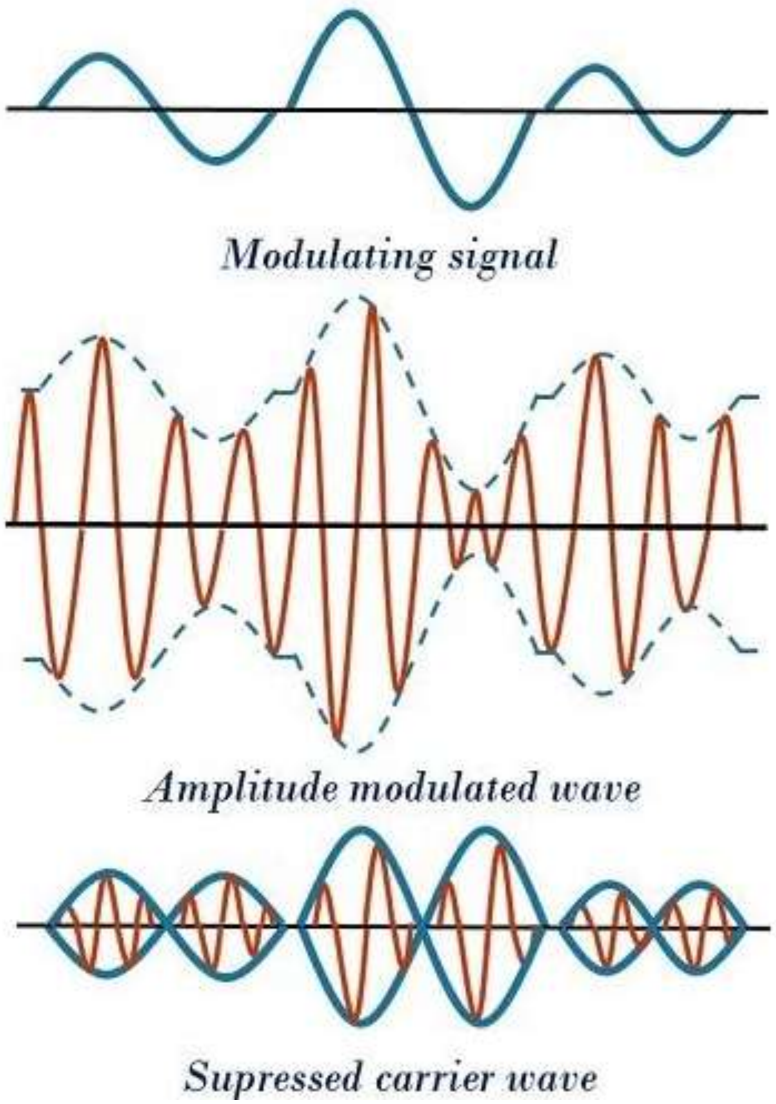
The mathematical representation of the signal at the output of the product modulator is given as,

$$s(t) = x(t).c(t)$$

Further,

$$s(t) = A_x A_c \cos(2\pi f_x t) \cos(2\pi f_c t)$$

$$s(t) = \frac{Ax\,Ac}{2} \cos[2\pi(f_c + f_x)t] + \frac{Ax\,Ac}{2} \cos[2\pi(f_c - f_x)t]$$



BANDWIDTH

The maximum frequency is $\mathbf{f_c + f_x}$
The minimum frequency is $\mathbf{f_c – f_x}$
As we know,
Bandwidth is given as

$$\mathbf{BW = f_{max} – f_{min}}$$
$$\mathbf{BW = f_c + f_x – (f_c – f_x)}$$
$$\mathbf{BW = 2f_x}$$

Thus, at the output, the DSB-SC wave contains a signal whose frequency is twice the frequency of the baseband signal.

The following two modulators generate DSBSC wave.

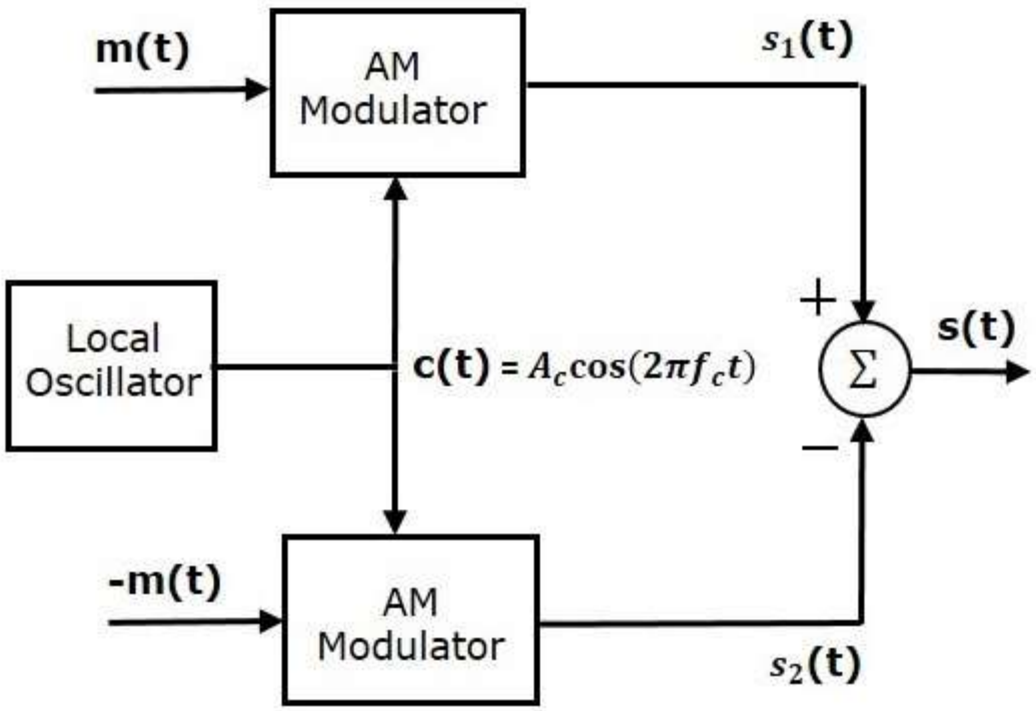
- Balanced modulator
- Ring modulator

BALANCED MODULATOR

Balanced modulator consists of two identical AM modulators. These two modulators are arranged in a balanced configuration in order to suppress the carrier signal. Hence, it is called as Balanced modulator.

The carrier without any information content is suppressed by a balanced modulator.

Its principle of operation is such that, when two signals of the different frequency are passed through a non-linear resistance then an amplitude modulated signal with the suppressed carrier is achieved at the output.

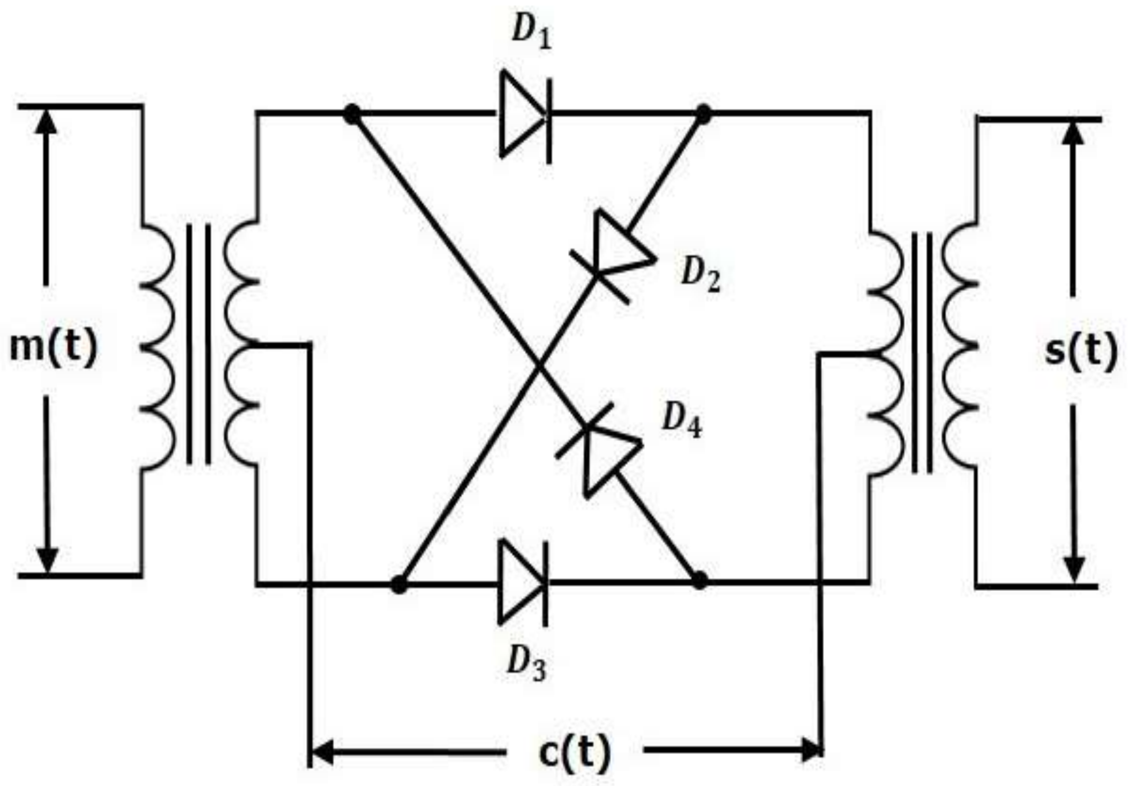


RING MODULATR

In this diagram, the four diodes D1,D2,D3 and D4 are connected in the ring structure. Hence, this modulator is called as the **ring modulator**.

Two center tapped transformers are used in this diagram. The message signal m(t) is applied to the input transformer. Whereas, the carrier signals c(t) is applied between the two center tapped transformers.

For positive half cycle of the carrier signal, the diodes D1 and D3 are switched ON and the other two diodes D2 and D4 are switched OFF. In this case, the message signal is multiplied by +1.



RING MODULATOR

For negative half cycle of the carrier signal, the diodes D2 and D4 are switched ON and the other two diodes D1 and D3 are switched OFF.

In this case, the message signal is multiplied by -1. This results in 18001800 phase shift in the resulting DSBSC wave.

From the above analysis, we can say that the four diodes D1, D2, D3 and D4 are controlled by the carrier signal.

DSBSC modulators are also called as **product modulators** as they produce the output, which is the product of two input signals.

DSBSC DEMODULATORS

The process of extracting an original message signal from DSBSC wave is known as detection or demodulation of DSBSC. The following demodulators (detectors) are used for demodulating DSBSC wave.

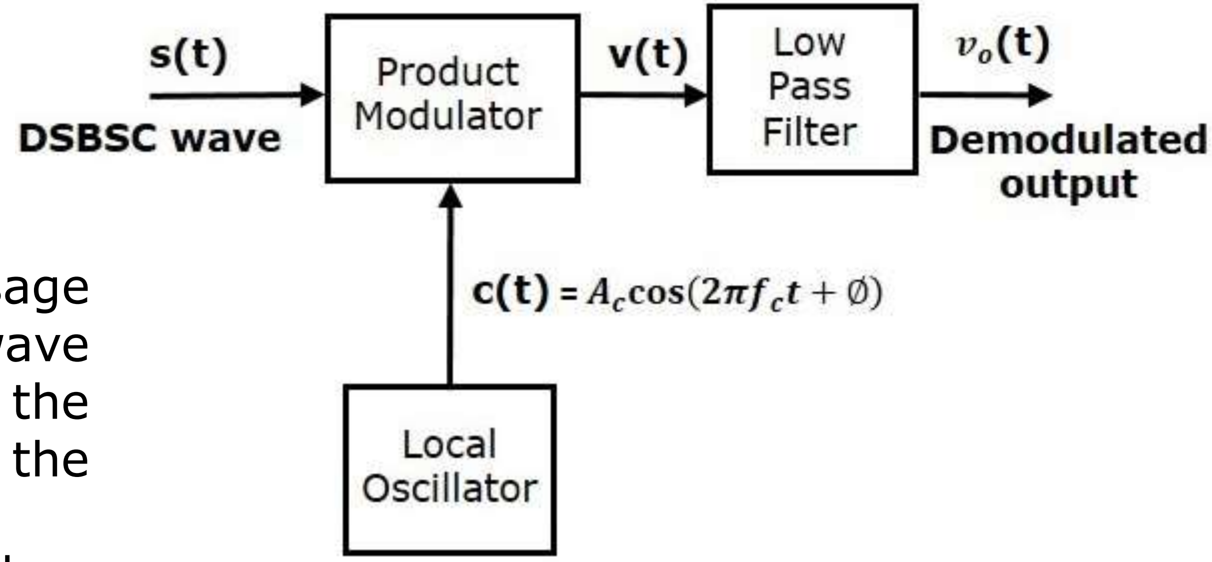
- Coherent Detector
- Costas Loop

Coherent Detector

Here, the same carrier signal (which is used for generating DSBSC signal) is used to detect the message signal. Hence, this process of detection is called as **coherent** or **synchronous detection**.

In this process, the message signal can be extracted from DSBSC wave by multiplying it with a carrier, having the same frequency and the phase of the carrier used in DSBSC modulation.

The resulting signal is then passed through a Low Pass Filter. Output of this filter is the desired message signal.



Where, ϕ is the phase difference between the local oscillator signal and the carrier signal, which is used for DSBSC modulation.

The output of low pass filter is,

$$v_0 t = \frac{{A_c}^2}{2} \cos \phi m(t)$$

The demodulated signal amplitude will be maximum, when $\phi = 0^0$. That's why the local oscillator signal and the carrier signal should be in phase, i.e., there should not be any phase difference between these two signals.

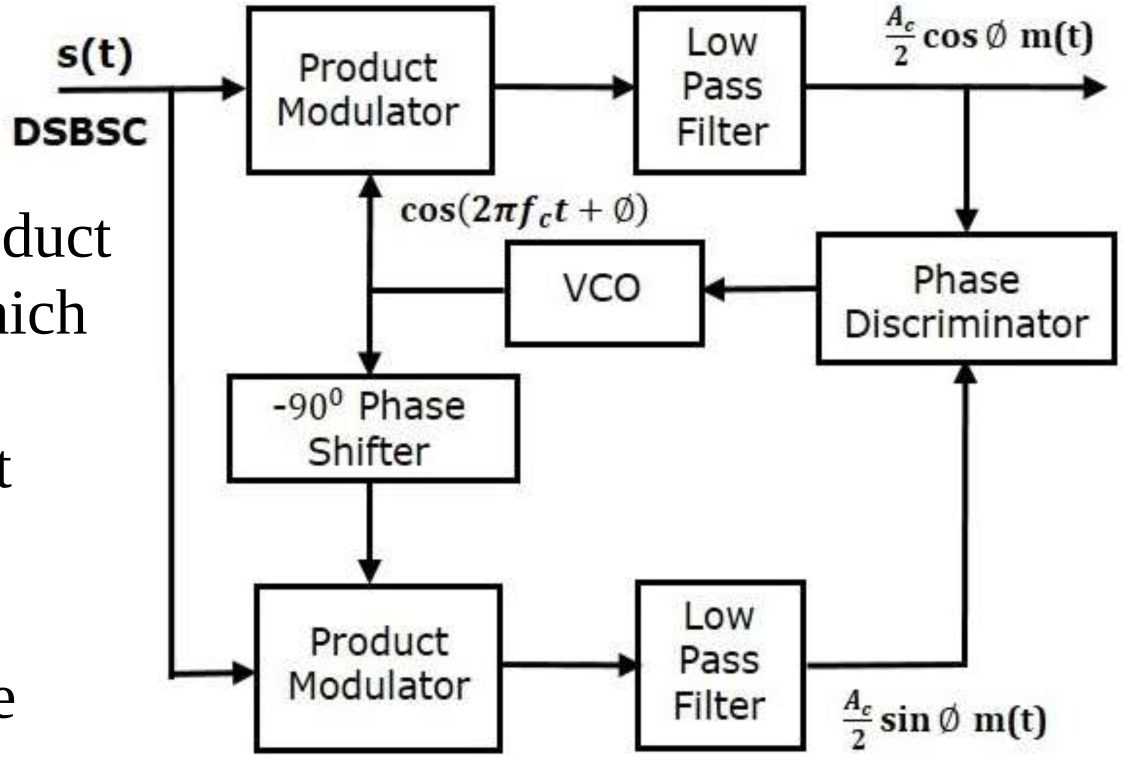
The demodulated signal amplitude will be zero, when $\phi = \pm 90^0$. This effect is called as **quadrature null effect**.

Costas loop

Costas loop is used to make both the carrier signal (used for DSBSC modulation) and the locally generated signal in phase.

Costas loop consists of two product modulators with common input s(t), which is DSBSC wave.

The other input for both product modulators is taken from **Voltage Controlled Oscillator** (VCO) with −900−900 phase shift to one of the product modulator as shown in figure.



COSTAS LOOP

- The outputs of these two low pass filters are applied as inputs of the phase discriminator.
- Based on the phase difference between these two signals, the phase discriminator produces a DC control signal.
- This signal is applied as an input of VCO to correct the phase error in VCO output.
- Therefore, the carrier signal (used for DSBSC modulation) and the locally generated signal (VCO output) are in phase.

ASSESSMENT

1.What is meant by product modulator?

2.Define Quadrature Null Effect.

3.Mention the use of Voltage Controlled Oscillator.

THANK YOU