1.4 GENERATION OF AM-DSBSC

1. Balanced Modulator Method
2. Ring Modulator Method

BALANCE MODULATOR METHOD

- The same circuit can be used to generate AM with carrier. The main difference between AM with carrier generation and DSB-SC –AM is the feeding points of the carrier and modulating signals are interchanged.
- The transistor is operated in a balanced mode thus heavy filtering is not required to remove the unwanted harmonics.
- It is assumed that the two transistors are identical and the circuit is symmetrical. The operation is confined in the nonlinear region of the active devices employed in this circuit. The carrier voltages across the upper and lower part of the secondary windings of the center tap transformers are equal in magnitude and opposite in phase.

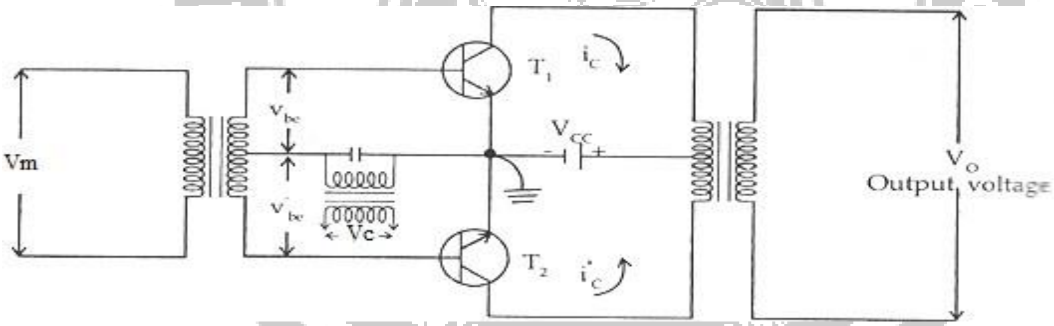

Figure 1.4.1 Balanced Modulator

RING MODULATOR METHOD

- The balanced Ring modulator circuit is widely used in carrier telephony suppresses both unwanted modulating and carrier signal in its output.
- Ring modulator is a type of product modulator which is used to generate DSB-SC Signal.
- The band pass filter is not used at the output hence the harmonic frequencies are automatically controlled.
- In a ring modulator circuit four diode are connected in the form of ring in which all the four diodes are connected in the same manner and are controlled by a square wave carrier signal ec (t).

- The carrier signal acts as a switching signal to alternate the polarity of the modulating signal at the carrier frequency.
- When no modulating signal is present diode D1 and D2 or D3 and D4 will conduct depending upon polarity of the carrier.

POSITIVE HALF CYCLE OF CARRIER:

- Diodes D1 and D3 are forward biased. At this time D2 and D4 are reverse biased and act like open circuits. The current divides equally in the upper and lower portion of the primary winding T2.
- The current in the upper part of the winding produces a magnetic field that is equal and opposite to the magnetic field produced by the current in the lower half of the secondary.
- Therefore the magnetic fields cancel each other out and no output is induced in the secondary. Thus the carrier is effectively suppressed.

NEGATIVE HALF CYCLE OF CARRIER:

- When the polarity of the carrier reverses. Diodes D1 and D2 are reverse biased and the diodes D3 and D4 will conduct. Again the current flows in the secondary winding of T1 and the primary winding of T2.
- The equal and opposite magnetic fields produced in T2 cancel each other and thus result in zero carrier output. The carrier is effectively balanced out.

PRINCIPLE OF OPERATION

- When both the carrier and the modulating signals are present, during positive half cycle of the carrier diodes D1 and D2 conduct, while diodes D3 and D4 does not conduct.
- During negative half cycle of the carrier voltage diodes D3 and D4 conduct and D1 and D2 does not conduct.
- When polarity of the modulating signal changes the result is a 180 phase reversal. At the time D3 and D4 are in forward bias.

<u>DEMODULATION/DETECTION OF AM-DSBSC</u>

- SYNCHRONOUS OR COHERENT DETECTOR
- COSTAS PLL DETECTOR

<u>SYNCHRONOUS OR COHERENT DETECTOR</u>

- The coherent detector uses exact carrier synchronization for retrieving the message signal from modulated signal. These types of detectors are mainly used for detecting DSB&SSB signals.

- It consists of a product modulator with a low pass filter.
- For detecting signal local oscillator at the receiver end is required. The frequency and phase of the locally generated carrier and transmitter carrier must be synchronized that is exactly coherent.
- All types of linear modulation can be detected by using synchronous detector. It consists of a product modulator with LPF.

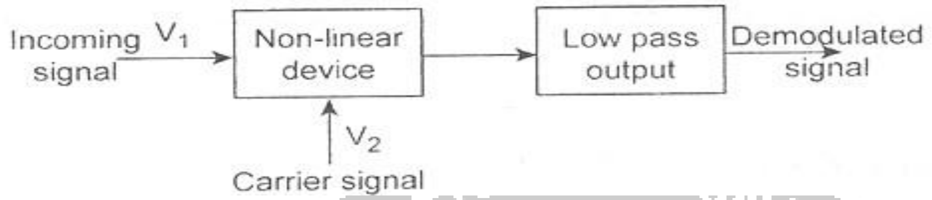

Figure 1.4.2 Coherent Detector

- The incoming signal is first multiplied with locally generated carrier and then passed through low pass filter. The filter bandwidth is same as the message bandwidth ωm
- Tthe local oscillator should be exactly synchronized with carrier signal in both phase and velocity.

COSTAS PLL DETECTOR

- Costas receiver is one of the method for obtaining a practical synchronous receiver suitable for demodulating DSB-SC waves. It consists of two coherent detectors supplied with the same input signal.
- One detector is supplied with the DSB-SC AM and locally generated carrier which is in phase with the transmitted carrier. This detector is known as **"In-phase coherent detector or I channel".**
- The other detector is supplied with the DSB-SC AM and locally generated carrier which is quadrature phase with the transmitted carrier. This detector is known as **"Quadrature coherent detector or Q channel".**
- These two detectors are coupled together to form a negative feedback system designed in such a way as to maintain the local oscillator synchronous with the carrier wave.

<u>Operation of the circuit</u>:

- In this case I channel output contains the desired demodulated signal where as Q channel output is zero due to the quadrature null effect of Q channel.
- Suppose there is some phase shift φ radians between local oscillator carrier and the transmitting carrier then I channel output will remain essentially unchanged. But Q channel output contains some signal which is proportional to sin φ
- This Q channel output will have same polarity as the I channel output

for one direction of local oscillatorwhereas the polarity will be opposite to the I channel for the other direction of phase shift.

- Thus the I and Q channel outputs are combined in phase discriminator
- The phase discriminator provides a d.c. control signal which may be used to correct local oscillator phase error.
- The local oscillator is a voltage controlled oscillator. Its frequency can be adjusted by an error control
  d.c signal.
- The costas receiver ceases phase control when there is no modulation and that phase lock has to be re- established with reappearance of modulation.

1.5 SINGLE SIDEBAND SUPPRESSED CARRIER

In AM with carrier both the transmitting power and bandwidth is wasted. Hence the DSB-SC AM scheme has been introduced in which power is saved by suppressing the carrier component but the bandwidth remains same.

- Increase in the saving of power is possible by eliminating one sideband in addition to the carrier component because the USB and LSB are uniquely related by symmetry about the carrier frequency. So either one sideband is enough for transmitting as well as recovering the useful message. The block diagram of SSB-SC AM is shown in figure.

- As for as transmission information is concerned only one side band is necessary. So if the carrier and one of the two sidebands are suppressed at the transmitter, no information is lost.

- This type of modulation is called as single side band suppressed carrier-AM and the SSB system reduces the band width by half.

Frequency Spectrum Of SSB-SC-AM:

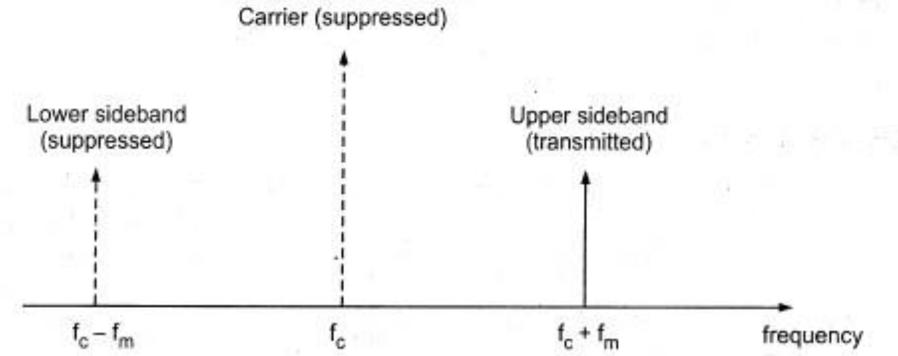

Figure 1.5.1 Frequency Spectrum Of SSB-SC-AM

- The Frequency spectrum shows that only one side band signal is present, the carrier and the other sideband signal are suppressed. Thus the bandwidth required reduces from 2 ω_m to ω_m i.e., bandwidth requirement is reduced to half compared to AM & DSB-SC signals.

Phasor representation of SSB-SC-AM:

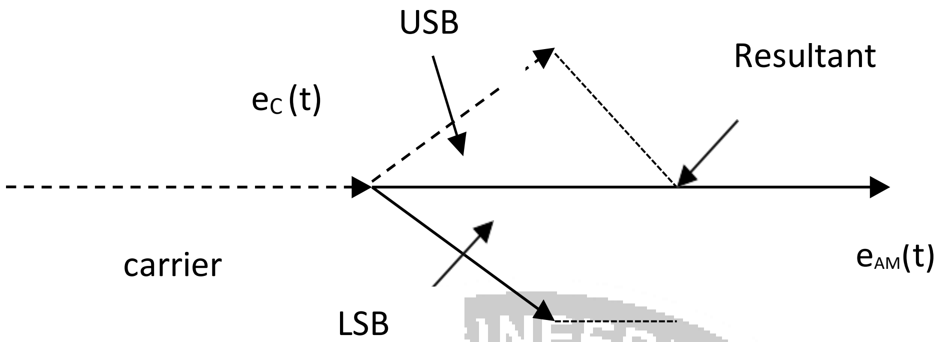

Figure 1.5.2 Phasor representation of SSB-SC-AM

Applications of SSB

1. Used to save applications where such a power saving is warranted, i.e., in mobile system, in which weight and power consumption must naturally be kept low.
2. Single sideband modulation is at a premium. Point-to-Point communication, land, air, maritime mobile communication, TV, Telemetry, Military and Radio navigation are the greatest use of SSB in one formor another.

SSB Advantages

- ***Power conservation***: Much less total transmitted power required to produce the same quality signal.
- ***Bandwidth conservation***: Half of the bandwidth of conventional AM bandwidth.
- ***Selective Fading***: Not present in SSBSC.
- ***Noise Reduction:*** Since SSB uses half the bandwidth, the thermal noise power is reduced to half. Hence immunity to selective fading is improved.

SSB Disadvantages

- ***Complex Receivers***: Required carrier recovery and synchronization circuit adds cost, complexity andsize.
- ***Tuning Difficulties***: Complex and Expensive Tuning Circuits.

GENERATION OF SSB

1. Filter Method
2. Phase Shift Method
3. Modified Phase Shift Method or Weaver Method

FILTER METHOD

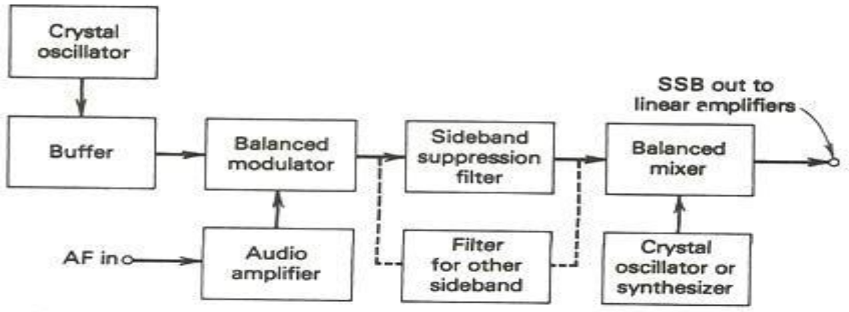

Figure 1.5.3 Filter Method

In this method of SSB generation, after the BM, the unwanted sideband is removed (actually heavilyattenuated) by a filter and hence this name. The filter may be LC, ceramic or mechanical depending upon the carrier frequency and other requirements. Such a filter must have a flat bandpass and extremely high attenuation outside the passband.

In radio communication system, the frequency range used for voice is 300 Hz to about 2800 Hz in mostcases. If it is required to suppress the lower sideband and if the transmitting frequency is f_C , then the lowestfrequency that this filter must pass without attenuation is f_C+300 Hz whereas the highest frequency that must be fully attenuated is f_C-300 Hz. So we need a filter whose transition band is very low. This situation becomes worse if lower modulating frequencies are employed, such as the 50 Hz minimum in AM broadcasting. In order to obtain a filter response curve with skirts as steep the 'Q' of the tuned circuits mustbe very high.

The initial modulation takes place in the balanced modulator at a low frequency (such as 100 kHz) because of the difficulty of making adequate filters at higher frequencies. The filter is a BPF with a sharp cutoff frequency at either side of the bandpass to obtain satisfactory adjacent sideband rejection. The filtered signal is up-converted in a mixer to the final transmitter frequency and then amplified before beingcoupled to the antenna. The integrated ceramic filters are used as sideband filters. The drawback of filter method is that it requires sharp filtering, which requires filters with high Q. Primary modulation cannot bedone at the transmitting frequency which is another drawback of the filter method.

PHASE SHIFT METHOD

- This method avoids the prime disadvantage of filtering method. That is requirement of a sidebandfilter with a narrow transition band and it cannot be used for very low and very high frequencies.
- This method does not have any sideband filters and the primary modulation can be done at the transmitting frequency. The unwanted sideband can be removed by generating the components ofsideband out of phase.
- If the undesired sideband is LSB then the two LSB are generated such that they are 180 out of phasewith each other. So that USB add with each other and LSB cancel each other. When two undesired sideband components are added they cancel each other with only the presence of desired signal.
- Two balanced modulators and two phase shifters are used. One of the modulator BBM1 receives the carrier voltage shifted by 90^0 and the modulating voltage, where as another balanced modulator BBM2 receives the modulating voltage shifted by 90^0 and the carrier voltage.
- The carrier signal is cancelled out by both the balanced modulator and then unwanted sidebands cancel at the output of the summing amplifiers and hence produces SSB signal.

MODIFIED PHASE SHIFT METHOD (OR) WEAVER'S METHOD

- The modified phase shift method overcomes the limitation of phase shift method. That is AF phaseshift network is required to operate over a large range of audio frequencies but also retains the advantage like its ability to generate SSB at any frequency and use of low audio frequency.
- This method provides both RF and AF oscillator phase shift and also used in low frequency and so itcan be used for both audio and radio frequencies.
- Modulators 1 and 2 both have the unshifted modulating signal as inputs. BM1 takes low frequencysubcarrier with a 90 phase shift from the AF oscillator. BM2 receives the subcarrier signal directly from the oscillator.
- This method tries to aEoid the phase shift of audio frequencies and combine the audio frequencycarrier with AF which lies in the middle of audio frequency.
- The low pass filter at the output of BM1 and BM2 with cut off frequency ensures the input to thebalance modulator BM3 and

BM4. The output of BM3 and BM4 gives the desired sideband suppression.

DEMODULATION/DETECTION OF AM-SSBSC

SYNCHRONOUS OR COHERENT DETECTOR

- The coherent detector uses exact carrier synchronization for retrieving the message signal frommodulated signal. These types of detectors are mainly used for detecting DSB&SSB signals.
- It consists of a product modulator with a low pass filter.
- For detecting signal local oscillator at the receiver end is required. The frequency and phase of the locally generated carrier and transmitter carrier must be synchronized that is exactly coherent.
- All types of linear modulation can be detected by using synchronous detector. It consists of a productmodulator with LPF.

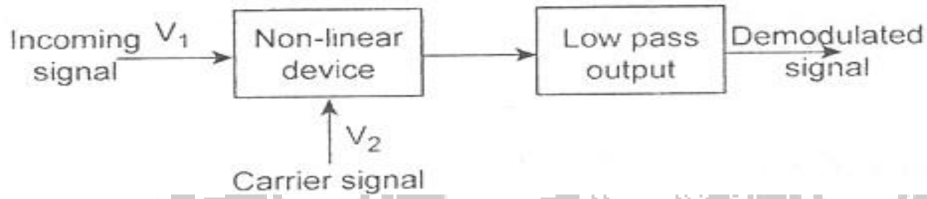

Figure 1.5.4 Coherent Detector

- The incoming signal is first multiplied with locally generated carrier and then passed through low passfilter. The filter bandwidth is same as the message bandwidth ωm
- Tthe local oscillator should be exactly synchronized with carrier signal in both phase and velocity.

VESTIGIAL SIDE BAND MODULATION

Definition : One of the sideband is partially suppressed and vestige (portion) of the other sideband is transmitted, This vestige (portion) compensates the suppression of the sideband. It is called vestigial sideband transmission.

Generation and demodulation of VSB:

A VSB signal is obtained as shown figure below by suppressing one of the sidebands of a DSBSC usinga VSB filter.

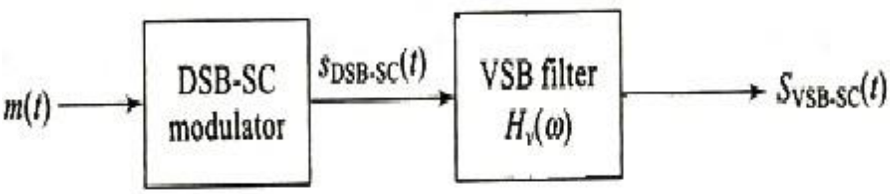

Figure 1.5.5 Vestigial Side Band Modulation

VSB filter is a BPF having an asymmetric frequency response in the transition band, positioned in such a way that the carrier frequency corresponds to the middle of the transition band. From the figure,

$$S_{DSB-SC}(t) = A_c m(t) cos(\omega_c t)$$

The transfer function of the VSB filter is $H_v(\omega)$.

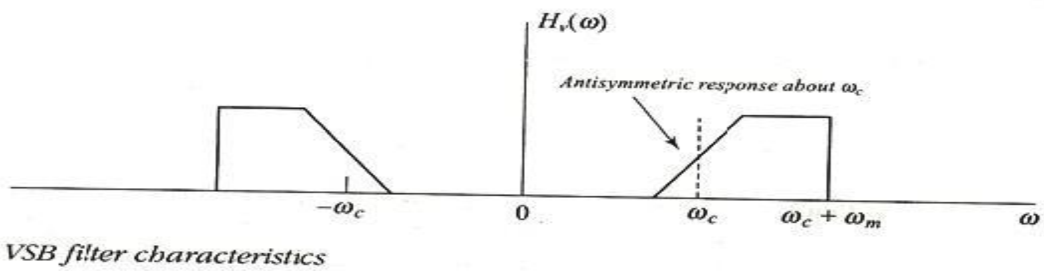

Figure 1.5.6 Transfer Function of the VSB Filter

The coherent detector is a sort of universal detector of AM signals in the sense that DSBSC, conventional AM and SSBSC can all be detected successfully by using it. It would be natural to expect that coherent detectionto work for the VSB-SC signal too.

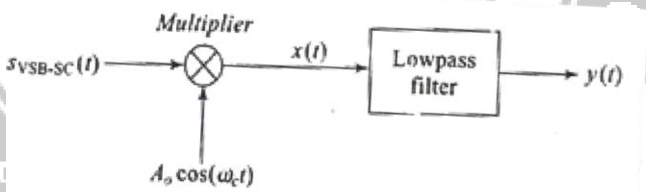

Figure 1.5.7 Coherent Detector

Magnitude Response of VSB Filter

Fig. shows the magnitude response of VSB filter.

- Here observe that fc to fc+W is USB. It's portion from fc to fc +fv is suppressed partially. *fc* to fc - W is LSB. It's portion from fc -fv to fc istransmitted as vestige.
- Observe that H(fc)=1/2. And the frequency response fc-fv ≤ H(f)≤ fc+fv exhibits odd symmetry. The sum of any two frequency components in the range is

fc-fv≤ f ≤fc+fv

equal to unity. i.e H(f-fc) + H(f+fc) = 1

Phase response is linear

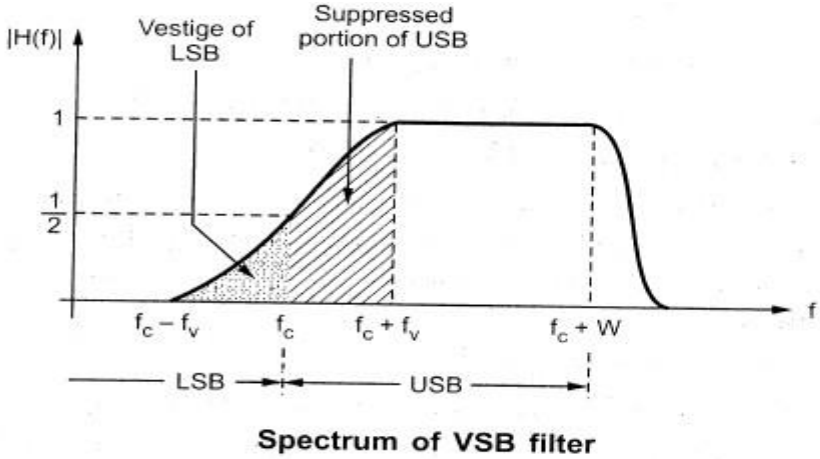

Figure 1.5.8 Spectrum of VSB Filter

Advantages:

1. Low frequencies, near *fc* are, transmitted without any attenuation.
2. Bandwidth is reduced compared to DSB.

Applications:

VSB is mainly used for TV transmission, since low frequencies near *fc* represent significant picture details. They are unaffected due toVSB.