BITT POLYTECHNIC, RANCHI

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Question Set-4 Communication Systems

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A. Objectives Questions:

Choose the correct answer:

1. Internal noise occurs in :
2. External noise comes from :
3. Noise temperature is used only in:
4. Application of AM is:
5. Automatic gain control (AGC) is used to :
6. Sampling process is :
7. Nyquist Rate :
8. Pulse Amplitude modulation (PAM) is:

B. Short Answer Types Questions:

1. Explain Pre- emphasis and De-emphasis?
2. Explain Vestigial Sideband modulation (VSB)?
3. Explain Spectrum of Amplitude Modulated Signal.
4. Explain the AM Modulation (DSB-FC).
5. Explain AM Modulation Index.
6. Draw the block diagram of Demodulation of DSB -SC, AM Signal.
7. Explain the Superhetrodyne AM receivers.

Solutions:

A. Objectives Questions:

1) The receiver due to active components, tank circuits etc.
2) Industrial, atmospheric, or extraterrestrial or space sources.
3) Circuits or equipment that operates at VHF, UHF or microwave frequencies.
4) Radio broadcasting and Picture transmission in TV.

5) Ensure that the signal fed to the limited is within its limiting range and also prevents overloading of last IF amplifier.
6) A process of converting a continuous time signal to an equivalent discrete time signal.
7) It is the minimum sampling rate required to represent the continuous signal C(t) in its sampled form. .
8) When the amplitude of the pulsed carrier varies in accordance with instantaneous value of modulating signal, is called PAM, where width and position remains constant.

B. Short Answer Types Questions

1)

- **Pre-emphasis:** The noise suppression ability of FM decreases with the increase in the frequencies. Thus increasing the relative strength or amplitude of the high frequency components of the message signal before modulation is termed as Pre-emphasis. The Fig3 below shows the circuit of pre-emphasis.

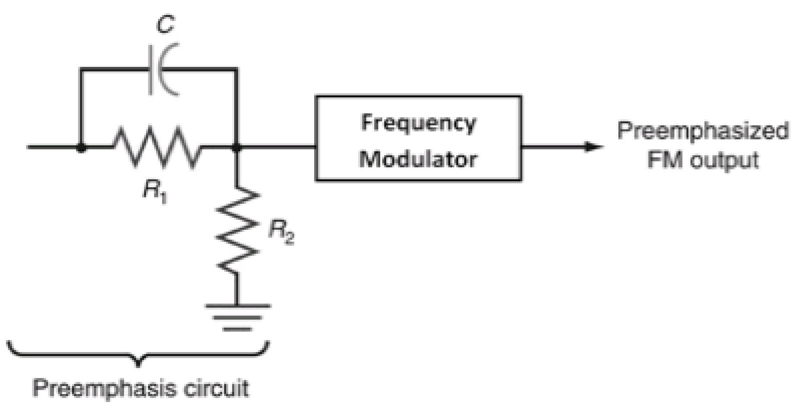


Fig3. Pre-emphasis circuit

- **De-emphasis:** In the de-emphasis circuit, by reducing the amplitude level of the received high frequency signal by the same amount as the increase in pre-emphasis is termed as De-emphasis. The Fig4. below shows the circuit of de-emphasis.

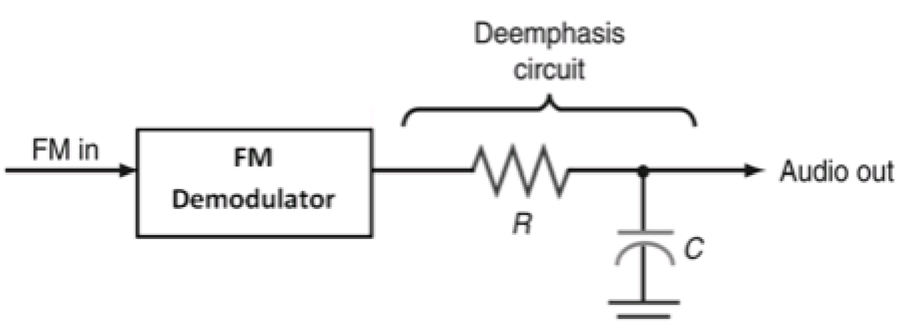
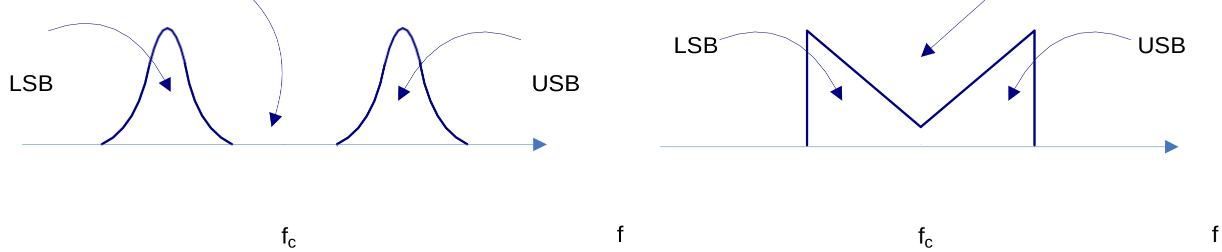


Fig4. De-emphasis circuit

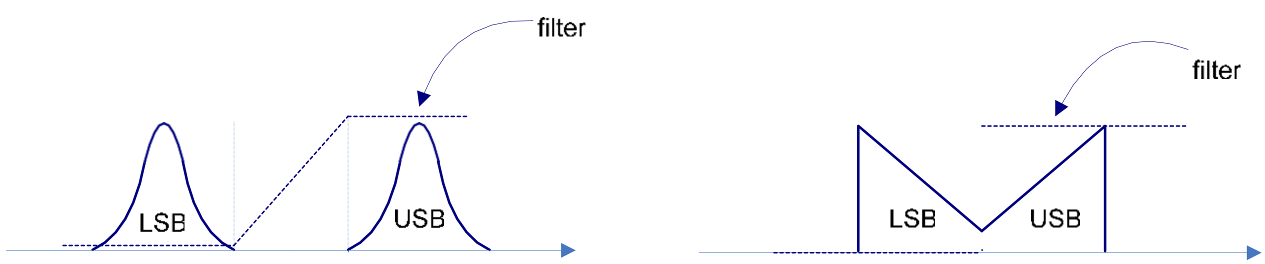
- The pre-emphasis process is done at the transmitter side, while the de-emphasis process is done at the receiver side.
- Thus a high frequency modulating signal is emphasized or boosted in amplitude in transmitter before modulation. To compensate for this boost, the high frequencies are attenuated or de-emphasized in the receiver after the demodulation has been performed. Due to pre-emphasis and de-emphasis, the S/N ratio at the output of receiver is maintained constant.
- The de-emphasis process ensures that the high frequencies are returned to their original relative level before amplification.
- Pre-emphasis circuit is a high pass filter or differentiator which allows high frequencies to pass, whereas de-emphasis circuit is a low pass filter or integrator which allows only low frequencies to pass.

2) **Vestigial Sideband Modulation (VSB):**

Single sideband modulation is well suited for the transmission of speech because of the **energy gap** that exists in the spectrum of speech signals between zero and a few hundred hertz. When the message signal contains significant components at extremely low frequencies (as in the case of television signals), the upper and lower sidebands **meet** at the carrier frequency.



This means that the use of SSB modulation is in appropriate for the transmission of such message signals owing to the **practical difficulty of building a filter** to isolate one sideband completely.

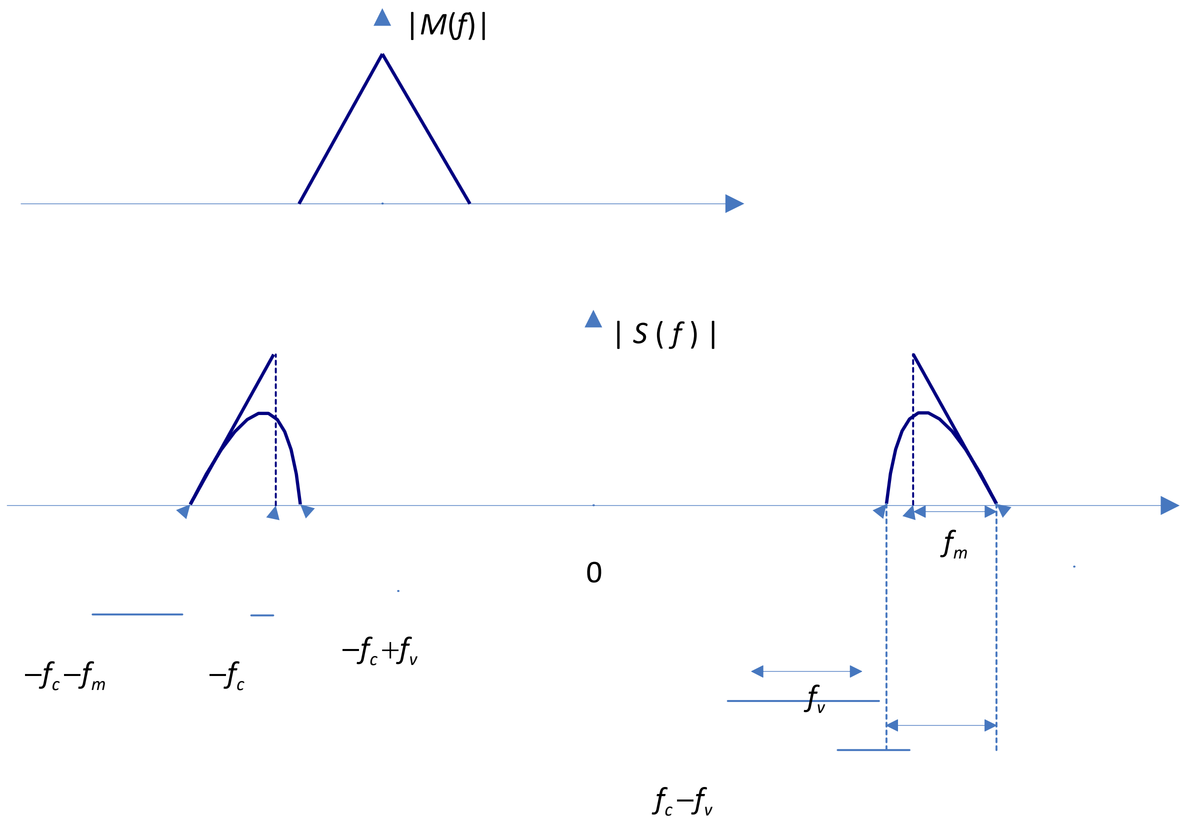


f_c f f_c f

This difficulty suggests an other scheme known as vestigial side band modulation (VSB), which is a compromise between SSB and DSB-SC forms of modulation.

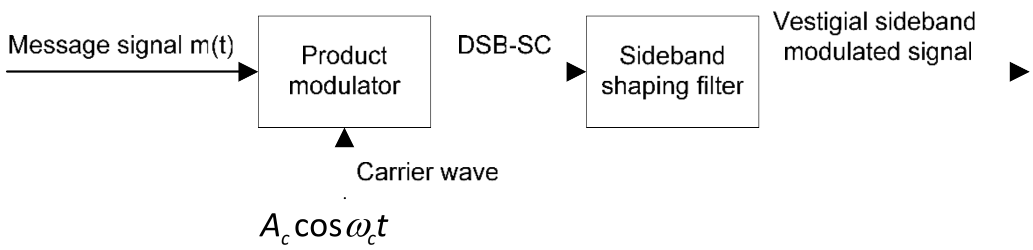
In VSB modulation, one side band is passed almost completely whereas just a **trace** or vestige, of the other sideband is retained.

Figure: illustrates the spectrum of a VSB modulated wave s(t) in relation to that of the message signal m(t) assuming that the lower sideband is modified into the vestigial sideband.



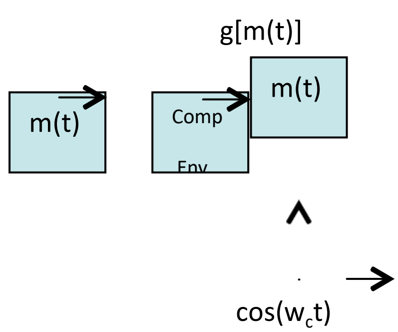
Specifically, the transmitted vestige of the lower sideband compensates for the amount removed from the upper sideband.
The transmission bandwidth (f_T) required by the VSB modulated wave is therefore
$f_T = f_m + f_v$

To generate a VSB modulated wave, we pass a DSB SC modulated wave through a side band shaping filter as in Fig:



3) **Spectrum of Amplitude Modulated (AM) SignaL:**

Assume the complex envelop g[m(t)] $=A_o[1+m(t)]$
Thus, s(t) $=A_o[1+m(t)]\cos(w_c t)$



Find the mathematical expression for S(f) and |S(f)| for all f using the givenM(f):

- FindS(f)
- Find|S(f)|

- Normalized power $P_S=P_V$

Evaluate the magnitude spectrum for an AM signal with the complex envelope $g[m(t)]=A_c[1+m(t)]$.

Solution: The spectrum of complex envelope is $G(f)=A_c\delta(f)+A_cM(f)$

$$s(t)=\mathrm{Re}\{g(t)e^{jw_ct}\}=A_c[1+m(t)]\cos\omega_c t$$

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

where because m(t) is real, *M*(f)=M(-f)* & *δ(f)= δ(-f)* is even.

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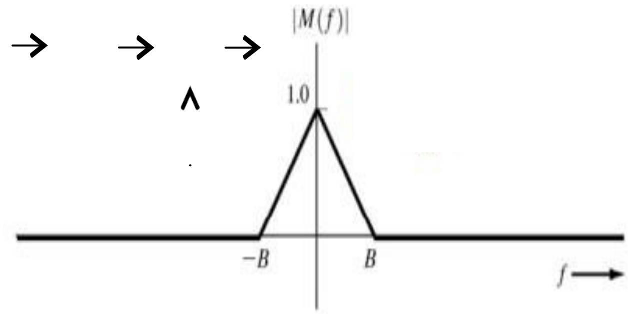
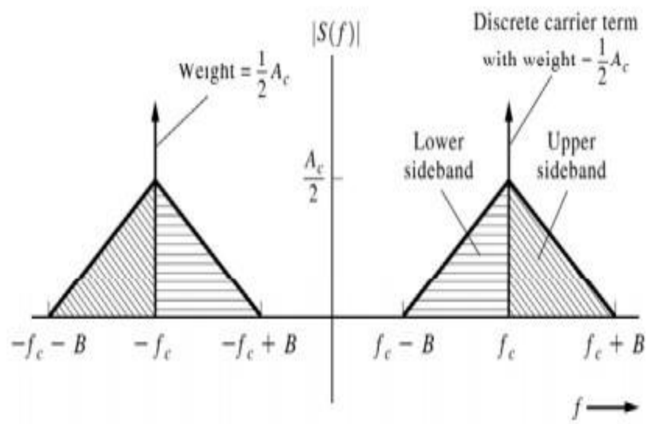


(a) Magnitude Spectrum of Modulation



(b) Magnitude Spectrum of AM Signal

$$|S(f)|=\begin{cases}\frac{A_c}{2}\delta(f-f_c)+\frac{A_c}{2}|M(f-f_c)|, f>0\\ \frac{A_c}{2}\delta(f+f_c)+\frac{A_c}{2}|M(-f-f_c)|, f<0\end{cases}$$

- The 1 in $g(t)=A_c[1+m(t)]$ causes extra delta functions to occur in spectrum at $f=\pm f_c$.

- Total average signal power

$$P_v = \frac{1}{2}A_c^2\left\langle |1+m(t)|^2 \right\rangle = \frac{1}{2}A_c^2\left\langle 1+2m(t)+m^2(t) \right\rangle$$

$$= \frac{1}{2}A_c^2\left[1+2\langle m(t)\rangle + \langle m^2(t)\rangle\right]$$

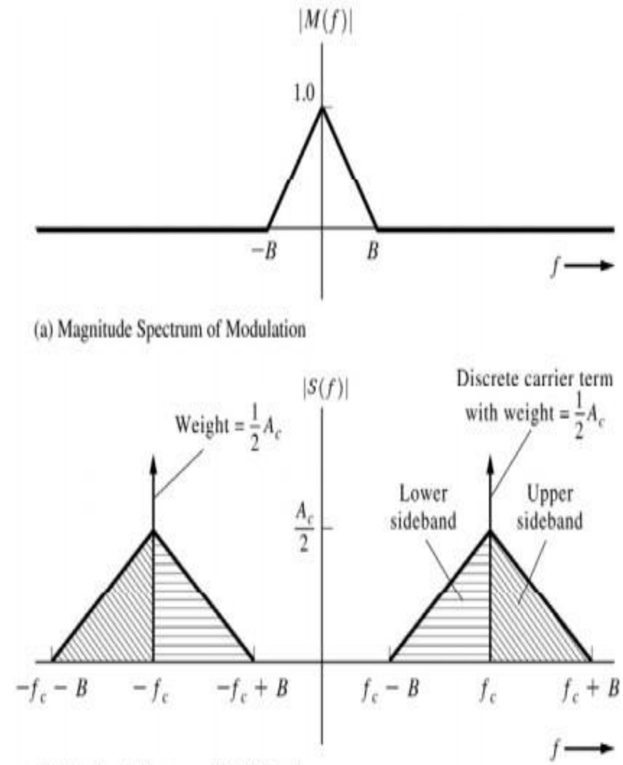
- If we assume that DC value of modulation is zero, then <m(t)>=0.

Average signal Power = $P_v = \frac{1}{2}A_c^2[1+P_m]$

Power in the modulation $m(t) = P_m = \langle m^2(t) \rangle$

Carrier Power $= \frac{1}{2}A_c^2$

Power in the sidebands of $s(t) = \frac{1}{2}A_c^2 P_m$

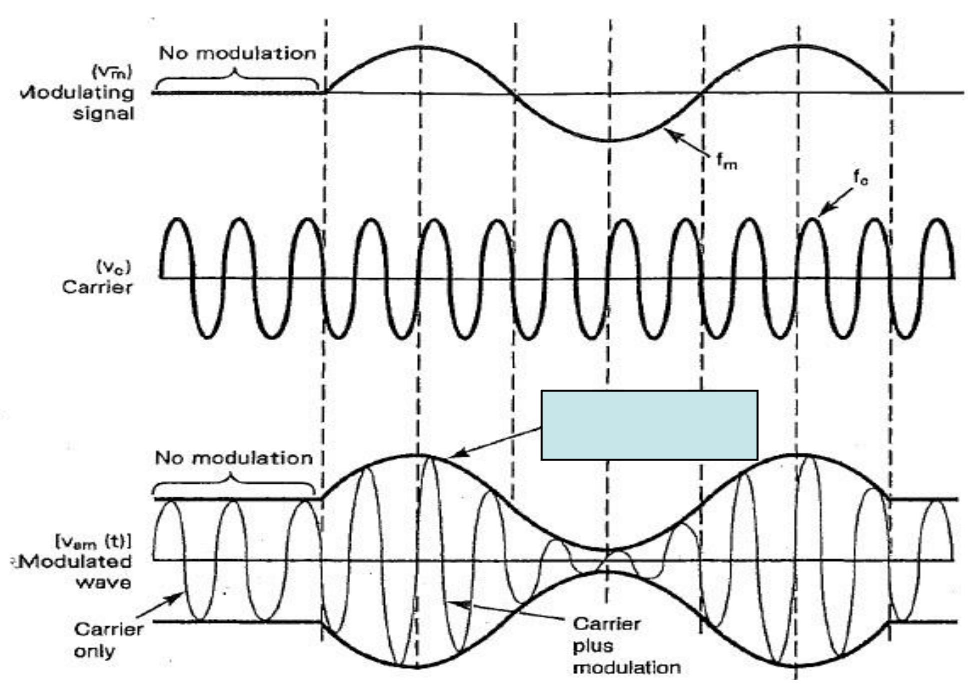


(a) Magnitude Spectrum of Modulation

(b) Magnitude Spectrum of AM Signal

4) AM Modulation DSB-FC :

Waveforms:



- Remember for bandpass waveform wehave

$$s(t) = \mathrm{Re}\{g(t)e^{j\omega_c t}\}$$

- The voltage (or current) spectrum of the bandpass signalis

$$S(f) = \frac{1}{2}[G(f-f_c) + G^*(-f-f_c)]$$

- The PSD willbe

$$\mathcal{P}_s(f) = \frac{1}{4}[\mathcal{P}_g(f-f_c) + \mathcal{P}_g(-f-f_c)]$$

- In case of Ordinary AM (DSB – FC)modulation:

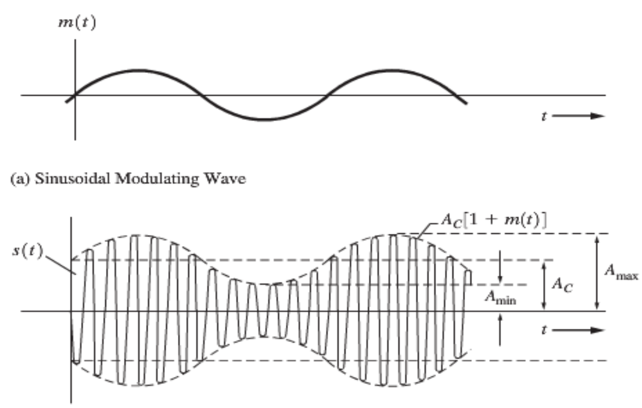
$$g(t) = A_c[1 + m(t)]$$

In this case Ac is the power level of the carrier signal with no modulation;

- Therefore: $$s(t) = A_c[1 + m(t)] \cos \omega_c t$$

5) AM Modulation Index:

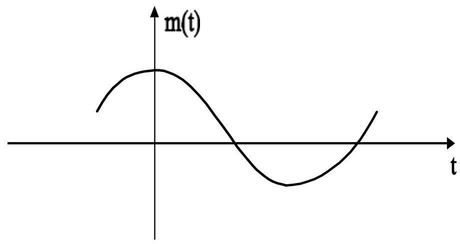
$$\% \text{ modulation} = \frac{A_{\max} - A_{\min}}{2A_c} \times 100 = \frac{\max[m(t)] - \min[m(t)]}{2} \times 100$$

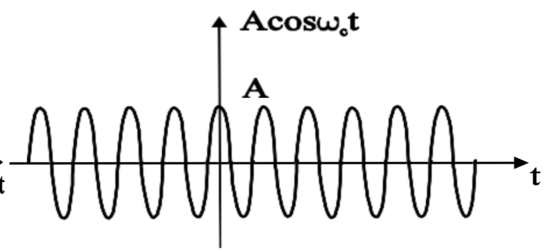


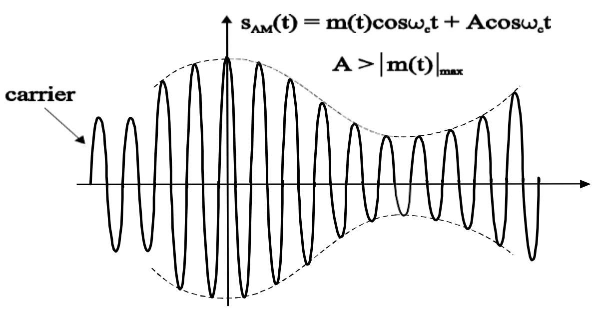
(a) Sinusoidal Modulating Wave

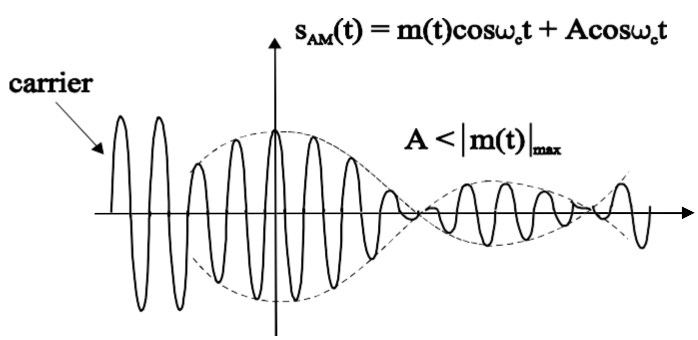
(b) Resulting AM Signal

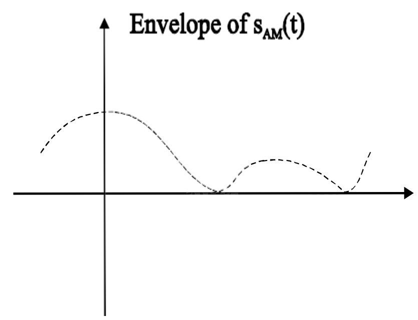
$$s(t) = \begin{cases} A_c[1 + m(t)] \cos w_c t, & \text{if } m(t) \geq -1 \\ 0, & \text{if } m(t) < -1 \end{cases}$$





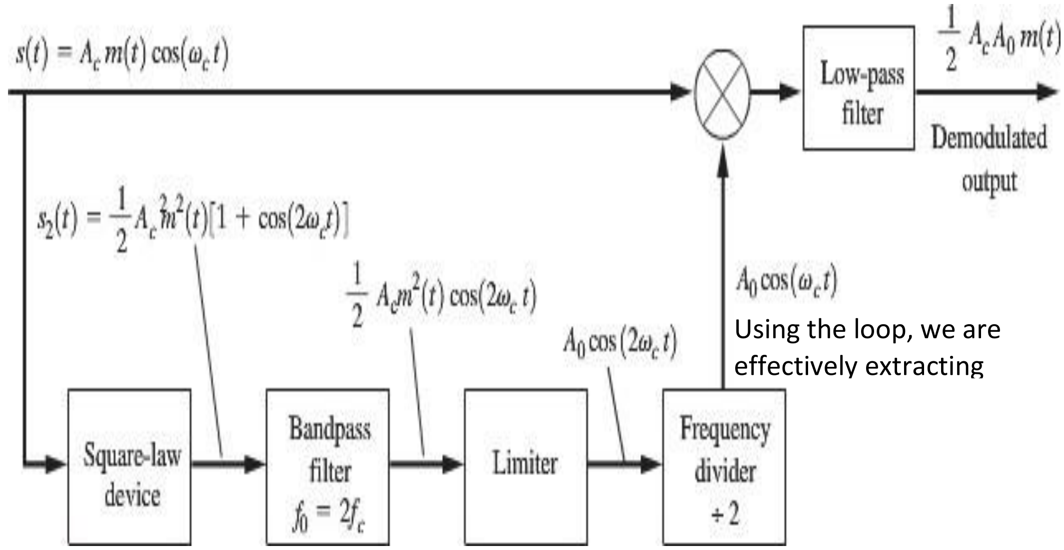






If modulation index >100%

6) Block diagram of Demodulation of DSB-SC ,AM Signal.



One common approach to eliminate phase error impact is using Squaring loop in DSB-SC Demodulation circuit.

7) Superheterodyne AM Receiver:

The block diagram of the superheterodyne receiver is as shown in the figure below.

RF Tuning and Amplification: The modulated RF waves travel through space and reach the antenna of the superheterodyne receiver in situated in a remote location. The receiver is attached to a tuning amplifier circuit which receives and amplifies the modulated RF carrier.

Heterodyning using Mixer : The output of the tuning circuit is fed to the mixer which combines modulated RF with a high frequency RF signals generated by a local oscillator (BFO - Beat Frequency Oscillator) to produce modulated IF signals. To maintain the constant frequency of IF signals output by the mixer at 455kHz, principle of ganged tuning is used. The ganged tuning is a process in which the tuning circuit and the local oscillator are connected to ganged capacitor circuit. The change in the capacitance of the ganged capacitor will keep the tuned frequency and the local oscillator frequency such that the output of the mixer is of frequency 455kHz.

IF amplification : The output of the mixer is fed to the IF amplifier which amplifies the modulated IF signal and increases its amplitude without modifying its waveform.

Demodulation : The amplified IF signal from the IF amplifier is input to the demodulator (Detector). The demodulator consists of a diode circuit which will eliminate the negative portion of the signal. Thus only positive portion of the modulated IF signal is output and fed to the next stage of AF amplification. Thus the demodulator converts the modulated IF into AF signal.

AF amplification : The output of the demodulator is fed to AF amplification stage. In this stage the AF signal is amplified.

Transduction : The amplified AF signal is input to the transducer which is a speaker. Speaker converts the AF signal into speech or intelligence. The process of conversion is called transduction.

Waveforms : The output waveform at the each stage of the superheterodyne receiver is as shown in the figure 6. Thus the reception of modulated RF carrier by superheterodyne receiver and converting the same into speech or intelligence is explained.

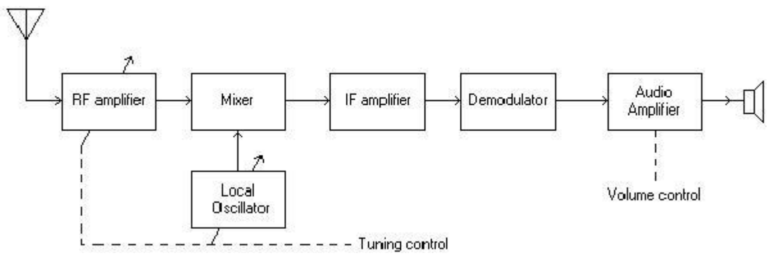


Figure : Super-Heterodyne Receiver

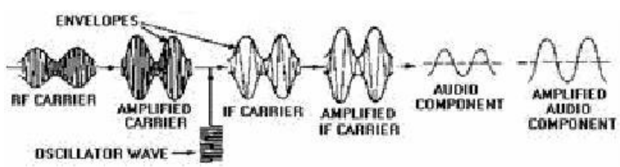


Figure : Super-Heterodyne Receiver Waveforms