# UNIT II ANALOG COMMUNICATION

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# Objective

1. To understand the importance of modulation index .

2. AM Power and Efficiency calculation

3. Types of Am

# Importance of Modulation Index

- Modulation index is known as just the ratio of modulating signal amplitude to the carrier signal amplitude.

$$m = \frac{E_m}{E_c}$$

- Modulation index should be in the range of $0 < m < 1$.

  Based on the values of the AM modulation can be classified into two types. They are: i)Linear modulation and ii) Over modulation.

- *Linear modulation:*
- The type of modulation is linear modulation when $m \leq 1$. For proper signal reception at receiver side, should be maintained.

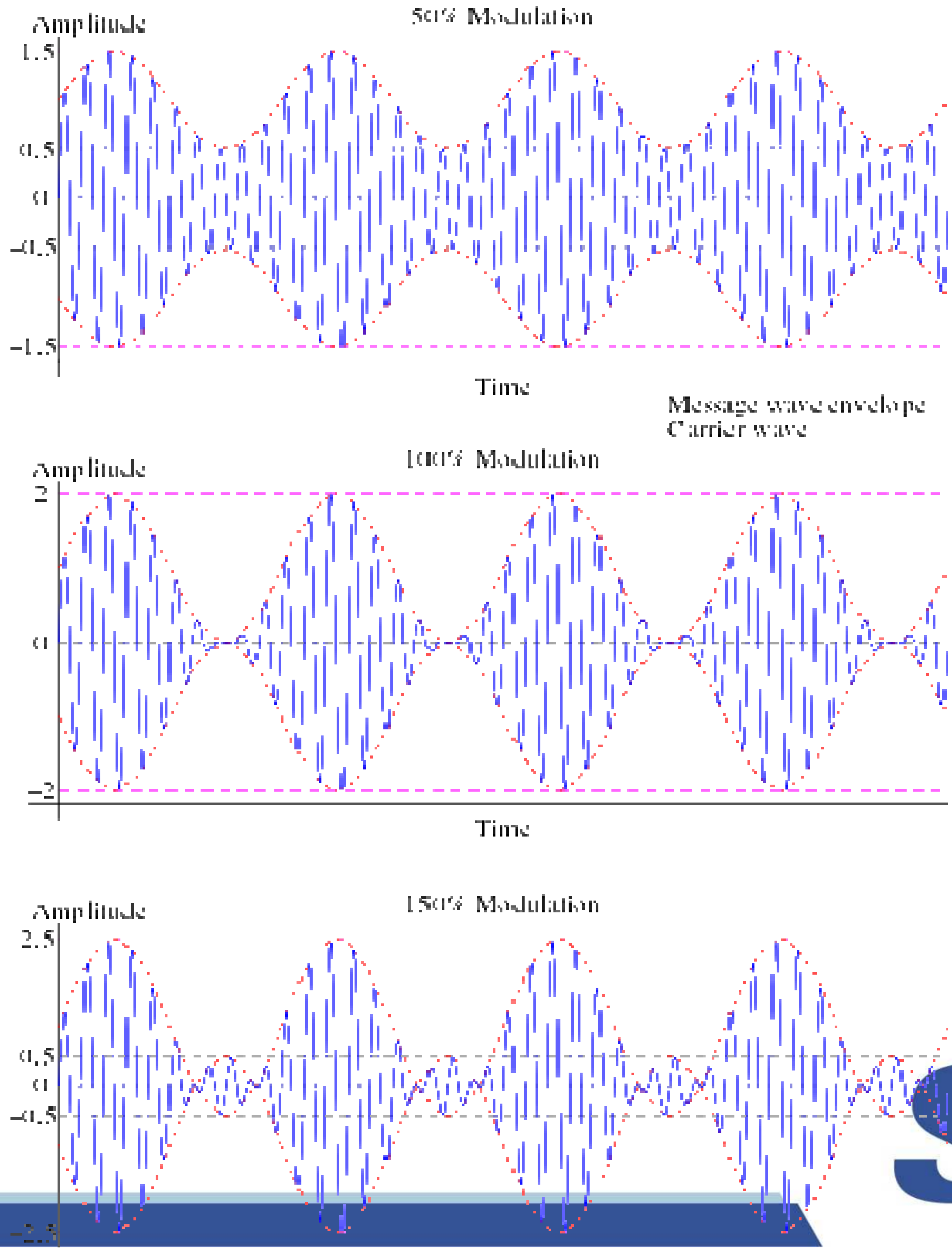
# Depth of modulation or percent modulation

- *Over modulation:*

  The type of modulation is over modulation when $m > 1$. Upper and lower envelopes are combined with each other due to $m > 1$ and so there may be a phase reversal in the modulated signal. Perfect reconstruction is therefore not possible in over modulation.

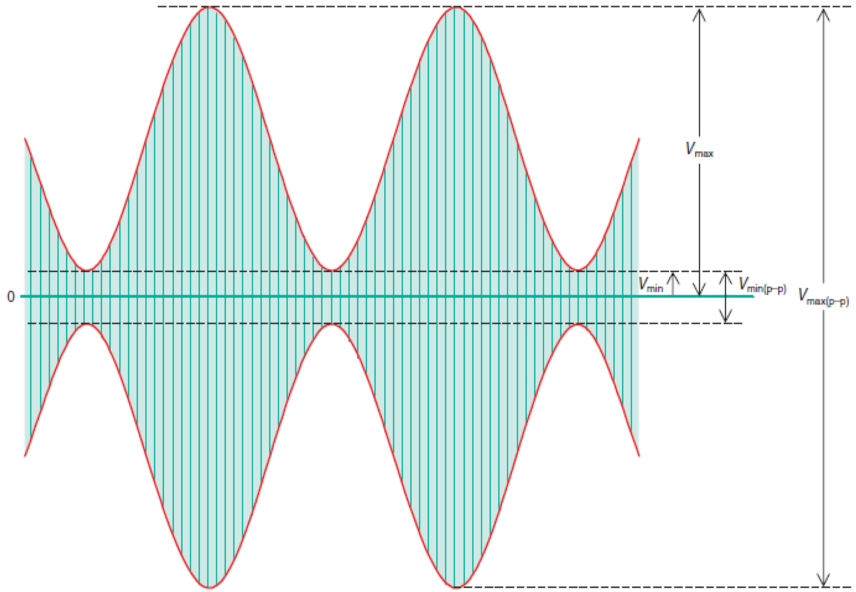
- *Depth of modulation or percent modulation*

  It is modulation index $m$ multiplied by 100.


50% Modulation
Amplitude
1.5
0.5
0
-0.5
-1.5
Time
Message wave envelope
Carrier wave
100% Modulation
Amplitude
2
0
-2
Time
150% Modulation
Amplitude
2.5
0.5
0
-0.5
-2.5

# Modulation index calculation

$$m = \frac{E_m}{E_c} \qquad m = \frac{V_{\max} - V_{\min}}{V_{\max} + V_{\min}}$$




Where $E_m$ or $=V_m$ ; $V_m = V_{\max} - V_{\min}$

and $E_c$ or $=V_c$ ; $V_c = V_{\max} + V_{\min}$ and are shown in figure

# AM Power calculation

- Total transmitted power $(P_T)$ is the sum of carrier power $(P_C)$, the power in the upper side band $(P_{USB})$ and the power in the lower side band $(P_{LSB})$.

$$P_T = P_C + P_{USB} + P_{LSB}$$

$$P_T = \frac{E_{CARR}^2}{R} + \frac{E_{USB}^2}{R} + \frac{E_{LSB}^2}{R}$$

- Where are $E_{CARR}, E_{USB}, E_{LSB}$ RMS values of the carrier and sideband amplitude and R is the characteristic impedance of antenna in which the total power is dissipated.

- The carrier power is given by $P_C = \frac{E_{CARR}^2}{R} = \frac{\left[E_C / \sqrt{2}\right]^2}{R} = \frac{E_C^2}{2R}$

Where $E_C$ is peak carrier amplitude.

In similar manner, power in side band is given by,

$$P_{USB} = P_{LSB} = \frac{E_{SB}^2}{R}$$

As we know the peak amplitude of each sideband is $\frac{mE_C}{2}$

$$P_{USB} = P_{LSB} = \frac{E_{SB}^2}{R} = \frac{\left[mE_C / 2\sqrt{2}\right]^2}{R} = \frac{m^2 E_C^2}{8R}$$

$$P_{USB} = P_{LSB} = \frac{m^2}{4} \times \frac{E_C^2}{2R}$$

$$P_{USB} = P_{LSB} = \frac{m^2}{4} \times P_C$$

- Total power is, $P_T = P_C + P_{USB} + P_{LSB}$

$$P_T = P_C + \frac{m^2}{4} \times P_C + \frac{m^2}{4} \times P_C$$

$$P_T = P_C + \frac{m^2}{2} \times P_C$$

The total power in terms of modulation index can be expressed by,

$$P_T = P_C \left(1 + \frac{m^2}{2}\right)$$

***Current Equation of AM:***

$$I_T^2 = I_C^2 \left(1 + \frac{m^2}{2}\right)$$

$$I_T = I_C \sqrt{\left(1 + \frac{m^2}{2}\right)}$$

# Transmission Efficiency$(\eta)$

- It is the ratio of power in sidebands to total power.

=[Power in sidebands/Total power] X 100

$$\eta = \frac{P_{USB} + P_{LSB}}{P_T} \times 100$$

- Transmission efficiency $\eta$ can relate with modulation index by,

$$\eta = \frac{m^2}{2 + m^2} \times 100$$

- When the carrier power of AM broadcast station is 1000W and the modulation index is 1 or percent modulation is 100, then find the total power

$$P_T = 1000\left(1 + \frac{1}{2}\right)$$

$$P_T = 1500$$

W

- It implies, carrier power is 1000 W and side band power is 500 W. (1000 W+500 W=1500 W). Hence power in the individual sideband is 250 W.
- Hence, total sideband power is half of carrier power for 100% modulation.
- *When the modulation index is less than one, power consumed by the side bands are not half of the carrier power, but only a small volume of power consumed in sidebands.*
- Assume, m=0.7 and carrier power is 1000 W, then find the total power.

$$P_T = 1000\left(1 + {(0.7)^2}\big/{2}\right)$$

=1245 W.

- It informs carrier power as 1000 W and the remaining 245 W is the sideband power. The sideband powers, it may be noted, are not half of the carrier power. This shows the importance of modulation index.
- The spectrum of AM signal leads to the conclusion that in the conventional AM or Double sideband full carrier (DSB-FC) technique, the total power transmitted from the radio station is mostly wasted in carrier. Since the carrier does not convey any useful information. Also, both the sidebands carry the same information. So power in one sideband is also wasted. Power inefficiency is the major problem for DSB-FC requiring introduction of various AM techniques.

# Pictorial Representation (Frequency domain) of AM

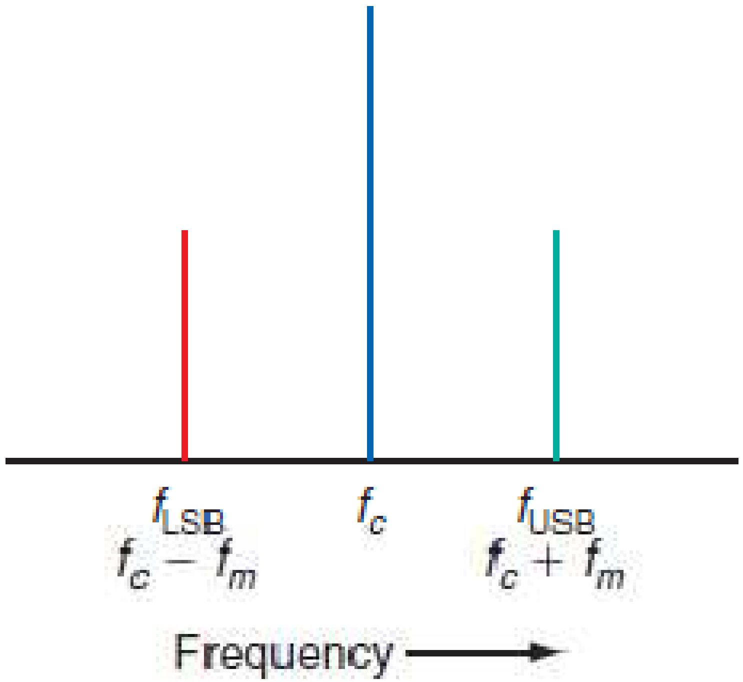



Fig: Frequency domain representation of AM

# Types of AM

1. DSB-SC-Double sideband suppressed carrier modulation

2. SSB-Single sideband modulation

3. VSB-Vestigial sideband modulation

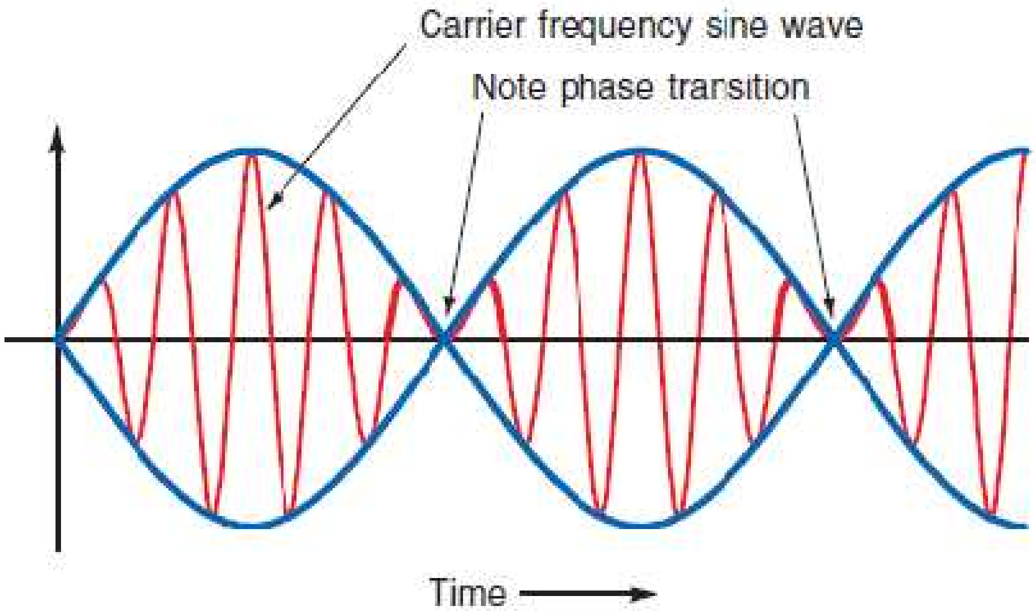
# DSB-SC-Double sideband suppressed carrier modulation

- Carrier is known occupy most of the transmission power also not conveying any useful information. Hence the idea is to suppress the carrier and transmit only the side bands. Since sidebands alone convey the information signal $f_m$.
- **Total power in DSB-SC:**

$$P_{T(DSB-SC)} = P_C \, {m^2}/{2}$$

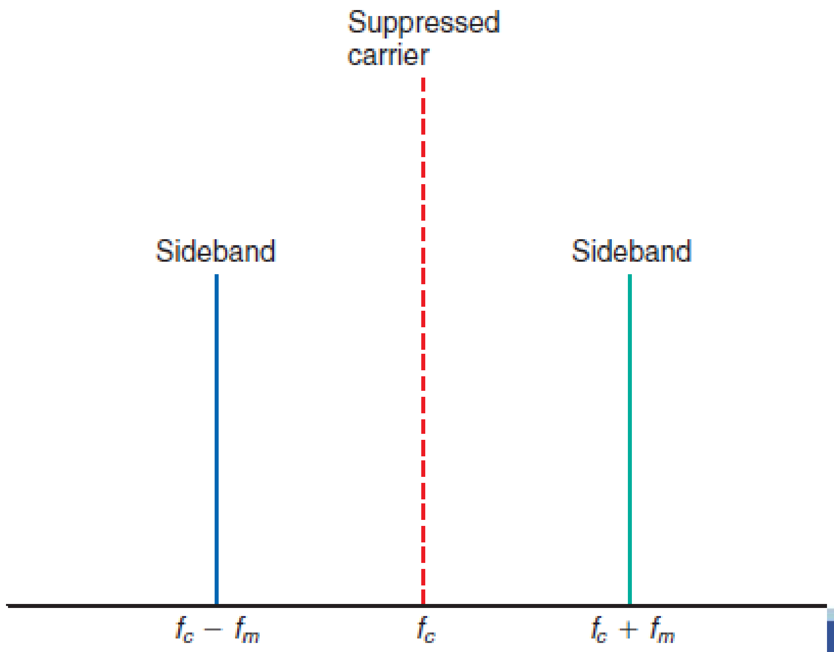
# Time domain representation of DSB-SC signals

- The envelope of the signal is not the same as that of the modulation signal. The unique characteristic of DSB-SC signal is phase transition that occurs at the lower amplitude portion of the wave.



# Frequency domain view of DSB-SC

- The DSB-SC does not find extensive use despite the suppression of the carrier in the technique. This is because demodulation requires a very complex circuit. One important application of DSB-SC technique is in the conveying of color information TV broadcasting.

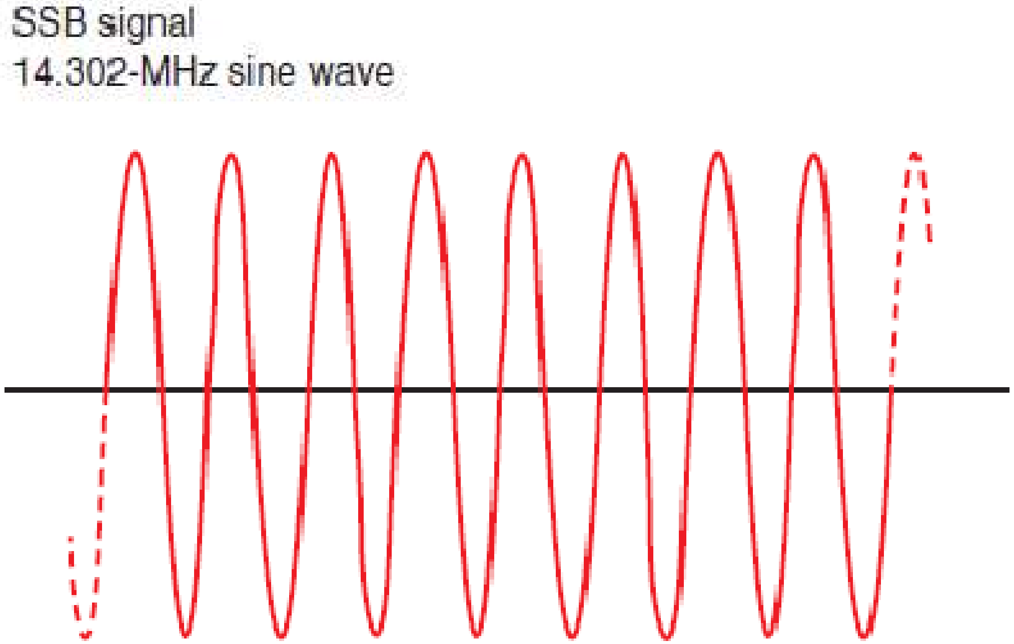


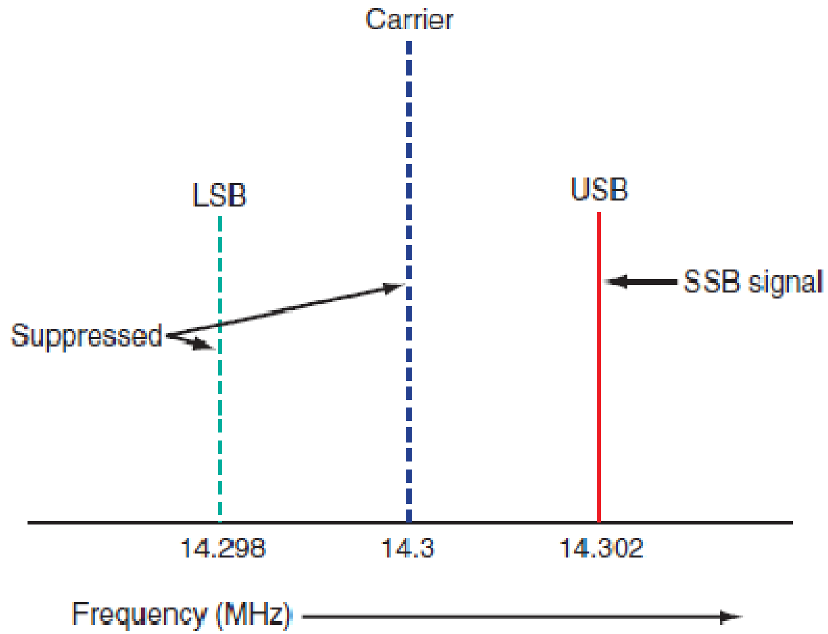
# SSB-Single sideband modulation

- In DSB-SC, both the side bands covey the same information. Hence the next possible idea is to eliminate one of the sidebands, with the resulting technique being a single sideband modulation (SSB).
- The carrier and one of the sidebands are suppressed in SSB, only one sideband is transmitted from radio station.
- Total power in SSB technique:

$$P_{T(SSB)} = P_C \, {m^2}/{4}$$

# Time domain and frequency domain of SSB

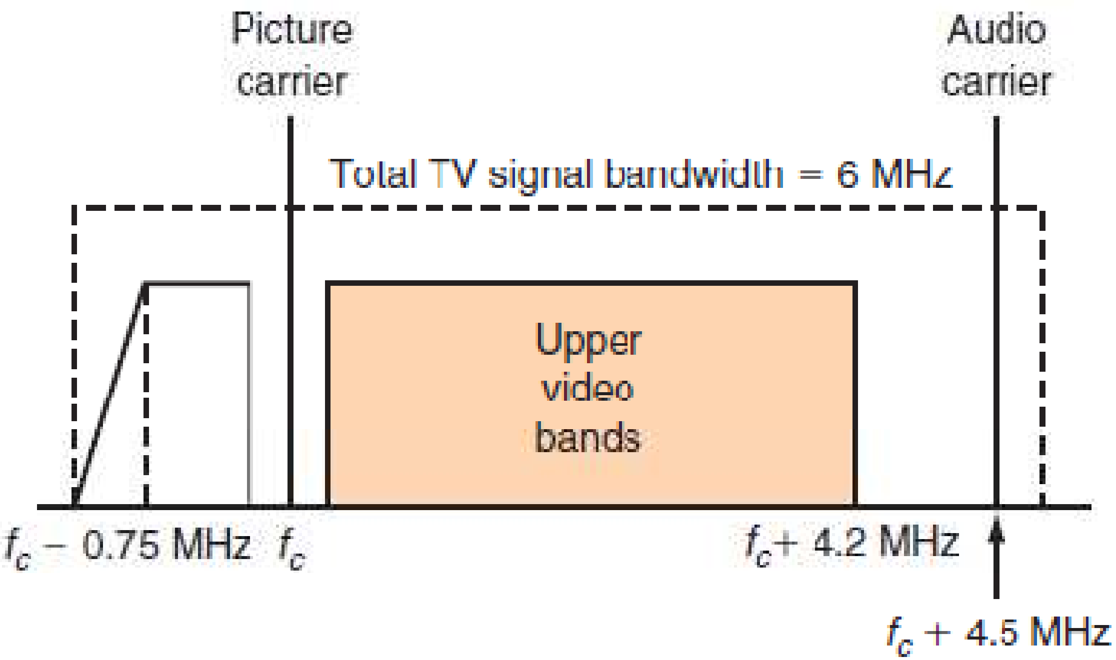


# VSB-Vestigial sideband modulation

- VSB modulation technique is normally used in TV Broadcasting. The TV signal consists of a picture and an audio signal. Both occupy at different frequency regions. i.e. audio carriers are frequency modulated and video information is amplitude modulated.
- Video information is typically available in the region 4.2 MHz. Hence the total bandwidth is 8.4 MHz. But, according to the FCC standard, TV bandwidth is 6 MHz Hence to make 8.4 MHz bandwidth in to 6 MHz, some of the video carriers are suppressed (or small portions or vestige), the resulting modulation is VSB. Normally video signals above 0.75 MHz (750 kHz) are suppressed in the lower sideband and upper sidebands are completely transmitted.

# VSB Spectrum



$f_m$

# Comparison of various AM modulation technique

| S.No. | Parameter | DSB-FC | DSB-SC | SSB |
|---|---|---|---|---|
| 1 | Carrier suppression | Not available | Fully | Fully |
| 2 | Sideband suppression | Not available | Not available | One sideband completely suppressed |
| 3 | Bandwidth | 2 $f_m$ | 2 $f_m$ | $f_m$ |
| 4 | Transmission Efficiency | Minimum | Moderate | Maximum |
| 5 | Number of modulating input | 1 | 1 | 1 |
| 6 | Application | Radio broadcasting | Radio broadcasting | Point to point mobile communication |
| 7 | Power requirement | High | Medium | Very small |
| 8 | Power saving for sinusoidal | 33.33% | 66.66% | 83.3% |
| 9 | Power saving for non-sinusoidal | 33.33% | 50% | 75% |
| 10 | Complexity | Simple | Simple | Complex |