Lecture 06: DSBSC

DOUBLE SIDE BAND SUPPRESSED CARRIER MODULATION (DSB-SC)

To overcome the drawback of power wastage in standard AM wave (DSBFC), a DSBSC method is used.

Definition: The method of transmission where only two sidebands are transmitted without the carrier (Suppressing the carrier) is known as ***Double sideband suppressed carrier modulation (DSB-SC)***.

(OR)

The conventional AM wave in which the carrier is suppressed/removed before the transmission is known as ***Double sideband suppressed carrier modulation (DSB-SC)***.

This form of linear modulation is generated by using a product modulator that simply multiplies the message signal $\mathrm{m(t)}$ by the carrier wave $\mathrm{A_c cos(\omega_c t)}$ as in fig.1.

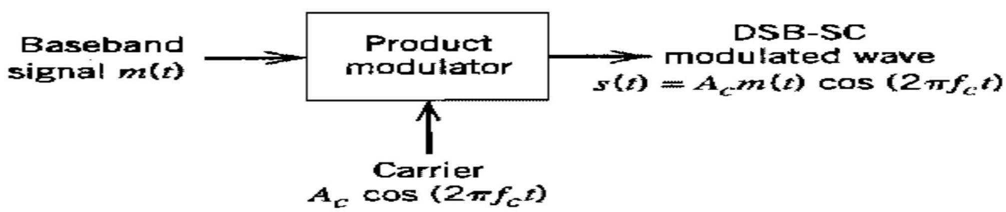

Fig.1. Block diagram of DSB-SC modulator

Time-domain description:

Let $\mathrm{m(t)}$ be the message signal having a bandwidth equal to $'W'$ Hz and $\mathrm{c(t) = A_c cos(\omega_c t)}$ be the carrier signal. Then the DSB-SC modulated wave time-domain expression is

$$\mathbf{s(t) = m(t).\,c(t) = A_c m(t)\cos(\omega_c t) \rightarrow (1)}$$

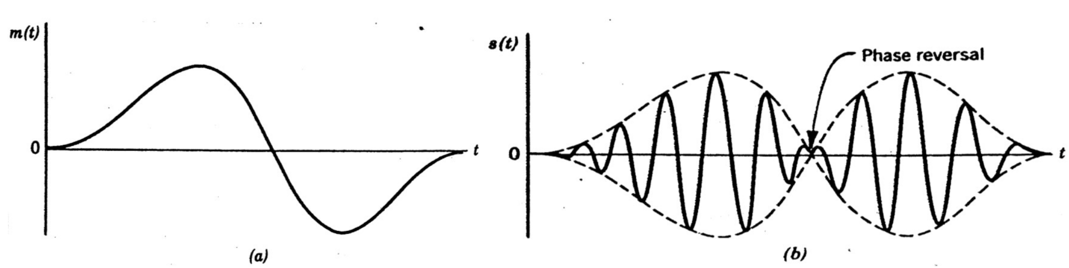

Fig.2. (a) message signal (b) DSB-SC modulated signal time-domain waveforms

The DSB-SC waveform undergoes a phase reversal at the zero crossing points of the message signal and thus the envelope of DSB-SC is completely different from that of DSB-FC as shown in fig.2 above.

Frequency domain description:

DSB-SC modulated wave $\mathbf{s(t) = A_c m(t) \cos(\omega_c t)}$

Taking Fourier transform on both sides, we get

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

Here S(f) is the Fourier transform of DSB-SC modulated signal $s(t)$ and $M(f)$ is the Fourier transform of the message signal $\mathrm{m(t)}$.

The frequency spectrums of message signal and DSB-SC signal are shown in fig.3 below:

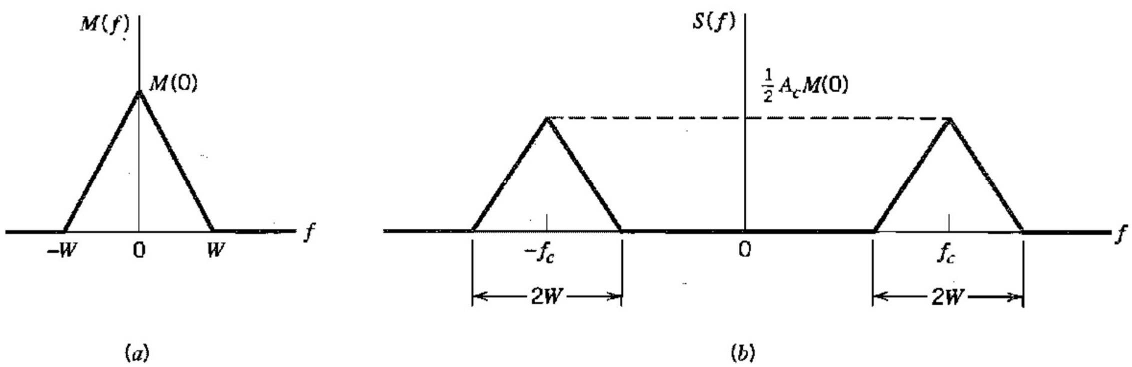

Fig.3. (a) Spectrum of message signalm$(\mathbf{t})$ (b) Spectrum of DSB-SC signal s$(\mathbf{t})$

The amplitude spectrum of DSB-SC drawn in fig.3 (b) exhibits the following factors:

i) On either sides of $\pm \mathrm{f_c}$, we have two sidebands designated as Lower and Upper sidebands.
ii) The upper sideband is from $\mathrm{f_c}$ to $(\mathrm{f_c + W})$ and from $-(\mathrm{f_c + W})$ to $-\mathrm{f_c}$. The lower sideband is from $(\mathrm{f_c - W})$ to $\mathrm{f_c}$ and from $-\mathrm{f_c}$ to $-(\mathrm{f_c - W})$.
iii) The impulses are absent at $\pm \mathrm{f_c}$ in the spectrum signifying the fact that the carrier term is suppressed in the transmitted wave.
iv) The highest frequency component is $\mathrm{f_{USB} = (f_c + W)}$
& the lowest frequency component is $\mathrm{f_{LSB} = (f_c - W)}$.

Thus the transmission bandwidth $\mathbf{B_T = 2W}$ **Hz** i.e. twice the message bandwidth.

∴ The transmission bandwidth required for DSB-SC wave is same as the standard AM wave.

Single-tone DSB-SC modulation:

Let us consider a single-tone message signal as

$$\mathrm{m(t) = A_m \cos(\omega_m t)} \rightarrow (1)$$

And the carrier signal

$$c(t) = A_c \cos(\omega_c t) \rightarrow (2)$$

Then the time-domain description of DSB-SC wave is $s(t) = m(t).\, c(t)$

$$\Rightarrow s(t) = A_m \cos(\omega_m t)\,.\, A_c \cos(\omega_c t)$$

From the trigonometry relation, $\boxed{\cos A\,.\,cos B = \frac{1}{2}\cos(A+B) + \frac{1}{2}\cos(A-B)}$

$$s(t) = A_m A_c.\,[\frac{1}{2}\cos((\omega_c + \omega_m)t) + \frac{1}{2}\cos((\omega_c - \omega_m)t)]$$

$$\therefore s(t) = \frac{A_m A_c}{2}\cos((\omega_c + \omega_m)t) + \frac{A_m A_c}{2}\cos((\omega_c - \omega_m)t)$$

$$= \frac{A_m A_c}{2}\cos(2\pi(f_c + f_m)t) + \frac{A_m A_c}{2}\cos(2\pi(f_c - f_m)t) \quad \rightarrow (3)$$

Taking Fourier transform on both sides, we get,

$$S(f) = \frac{A_m A_c}{4}\left[\delta(f + (f_c + f_m)\right) + \delta(f - (f_c + f_m)) + \frac{A_m A_c}{4}\left[\delta(f + (f_c - f_m)\right)$$
$$+ \delta(f - (f_c - f_m)) \rightarrow (4)$$

Below fig.4 shows the amplitude spectrum of DSB-SC wave and from this we can observe that on either sides of $\pm f_c$, we have lower and upper sidebands. We can also observe that there are no impulses located at $\pm f_c$ which indicates carrier is suppressed and the ransmission bandwidth is $2f_m$.

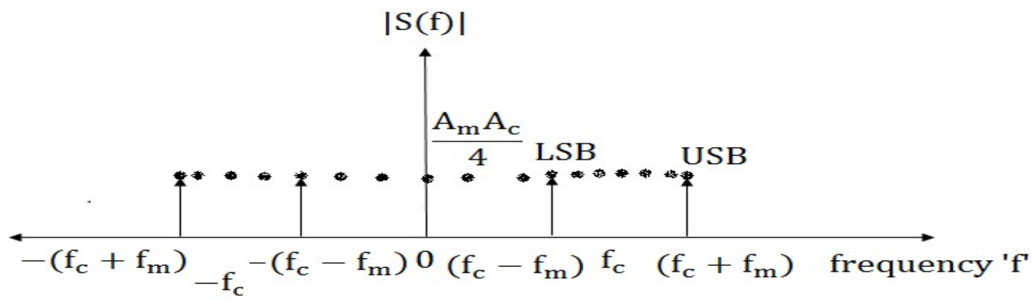

Fig.4.Amplitude spectrum of single-tone DSB-SC wave

The total power transmitted by DSB-SC is $P_t = P_{USB} + P_{LSB}$

$$\Rightarrow P_t = \frac{\left(\frac{A_m A_c}{2\sqrt{2}}\right)^2}{R} + \frac{\left(\frac{A_m A_c}{2\sqrt{2}}\right)^2}{R} = \frac{(A_m A_c)^2}{8R} + \frac{(A_m A_c)^2}{8R}$$

$$\Rightarrow P_t = \frac{(A_m A_c)^2}{4R}$$

The transmission efficiency $'\eta' = \frac{P_{USB}+P_{LSB}}{P_t} = \frac{\frac{(A_m A_c)^2}{8R} + \frac{(A_m A_c)^2}{8R}}{\frac{(A_m A_c)^2}{4R}}$

$$\eta = \frac{\frac{(A_m A_c)^2}{4R}}{\frac{(A_m A_c)^2}{4R}}$$

$$\therefore \eta = 1 \text{ or } \%\eta = 100\%$$

The power saving in DSB-SC compared to standard AM wave (DSB-FC) is

$$\text{The power saving} = \frac{P_{DS} \quad - P_{DSB-S}}{P_{DSB-FC}} = \frac{P_c\left(1+\frac{\mu^2}{2}\right) - P_c.\frac{\mu^2}{2}}{P_c(1+\frac{\mu^2}{2})}$$

$$\text{The power saving} = \frac{1}{(1+\frac{\mu^2}{2})} = \frac{2}{(2+\mu^2)}$$

$$\therefore \% \textbf{ power saving in DSB} - \textbf{SC} = \frac{\mathbf{2}}{(\mathbf{2}+\boldsymbol{\mu}^{\mathbf{2}})} \times \mathbf{100}\%$$

If $\mu = 1$, the %power saving in DSB − SC is = 66.67% .

If $\mu = 0.5$, the %power saving in DSB − SC is = 88.89%