PRINCIPLES OF COMMUNICATIONS

UNIT-3

LECTURE-1

Definition of Bandwidth

- *"Bandwidth is defined as a band containing all frequencies between upper cut-off and lower cut-off frequencies."* (see Figure 1)

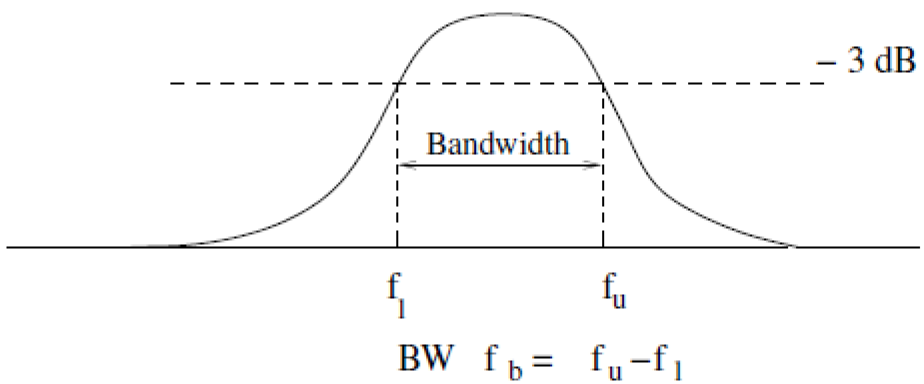

Figure 1: Bandwidth of a signal

Upper and lower cut-off (or $3dB$) frequencies corresponds to the frequencies where the magnitude of signal's Fourier Transform is reduced to half ($3dB$ less than) its maximum value.

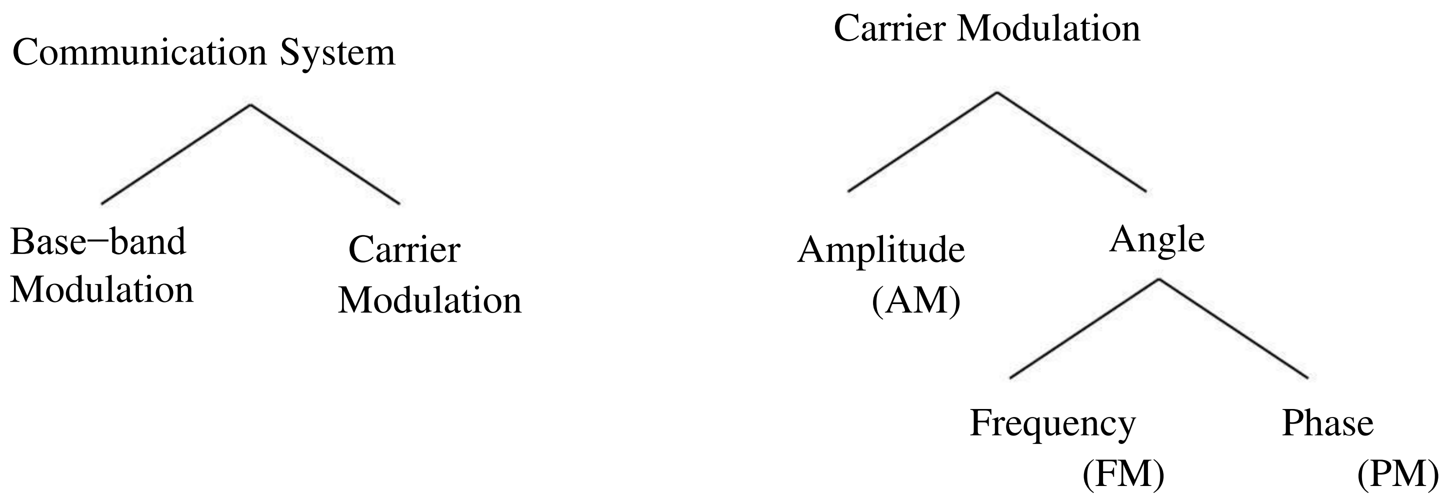

Figure 1: A broad view of communication system

- Amplitude Modulation It is the process where, the amplitude of the carrier is varied proportional to that of the message signal.

  - Amplitude Modulation with carrier

    Let $m(t)$ be the base-band signal, $m(t) \longleftrightarrow M(\omega)$ and $c(t)$ be the carrier, $c(t) = A_c \cos(\omega_c t)$. f_c is chosen such that $f_c >> W$, where W is the maximum frequency component

of m(t).
The amplitude modulated signal is given by

$$s(t) = A_c\,[1 + k_a m(t)]\cos(\omega_c t)$$

$$\begin{aligned} S(\omega) \;&=\; \frac{\pi A_c}{2}\left(\delta(\omega - \omega_c) + \delta(\omega + \omega_c)\right) + \\ &\quad \frac{k_a A_c}{2}\left(M(\omega - \omega_c) + M(\omega + \omega_c)\right) \end{aligned}$$

- From Figure 2 and the concept of the Hilbert Transform,

$$
\begin{aligned}
\Phi_{USB}(\omega) &= M_+(\omega-\omega_c) + M_-(\omega+\omega_c) \\
\phi_{USB}(t) &= m_+(t)e^{j\omega_c t} + m_-(t)e^{-j\omega_c t}
\end{aligned}
$$

But, from complex representation of signals,

$$
\begin{aligned}
m_+(t) &= m(t) + j\hat{m}(t) \\
m_-(t) &= m(t) - j\hat{m}(t)
\end{aligned}
$$

So,

$$\phi_{USB}(t) = m(t)\cos(\omega_c t) - \hat{m}(t)\sin(\omega_c t)$$

Similarly,

$$\phi_{LSB}(t) = m(t)\cos(\omega_c t) + \hat{m}(t)\sin(\omega_c t)$$

- Generation of SSB signals A SSB signal is represented by:

$$\phi_{SSB}(t) = m(t)\cos(\omega_c t) \pm \hat{m}(t)\sin(\omega_c t)$$