COMMUNICATION
Third stage
Electrical Power & Machines Engineering Department
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Lecture 6

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Analog modulation

Reasons for Analog Modulation

- Modulation of digital signals
  - When only analog transmission facilities are available, digital to analog conversion required
- Modulation of analog signals
  - A higher frequency may be needed for effective transmission
  - Modulation permits frequency division multiplexing

Basic Encoding Techniques

- Analog data to analog signal
  - Amplitude modulation (AM)
  - Angle modulation
    - Frequency modulation (FM)
    - Phase modulation (PM)

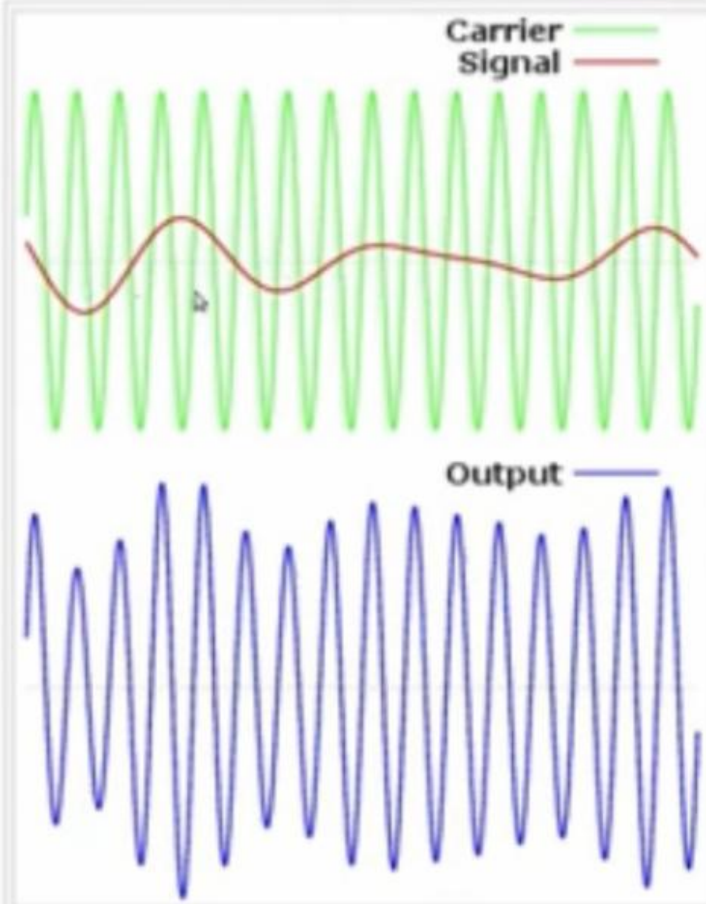
Amplitude Modulation

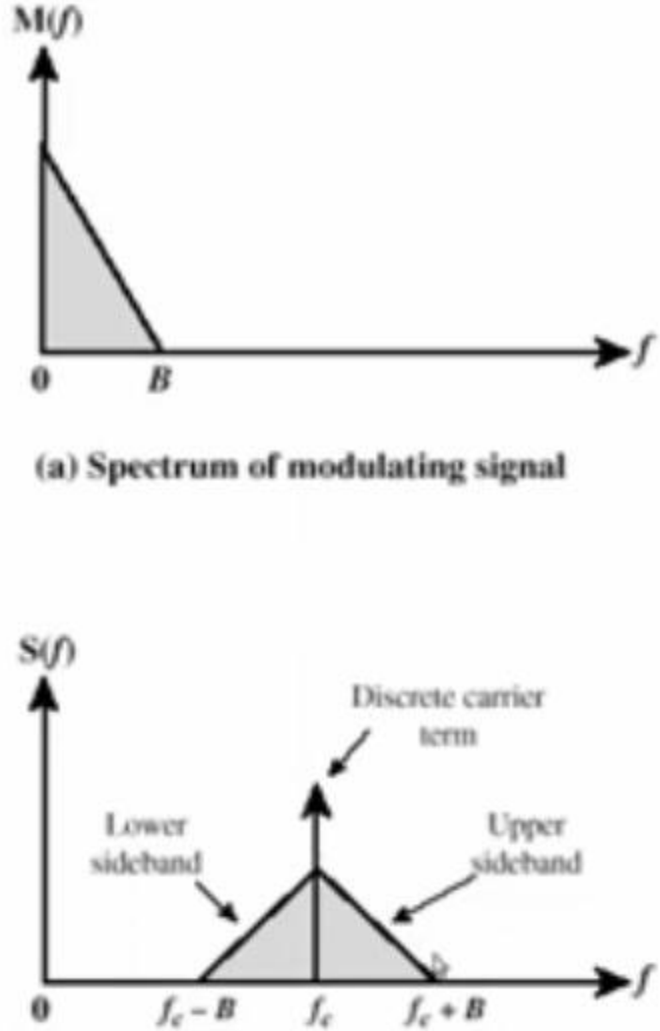
- Amplitude Modulation

$$s(t) = \left[1 + n_a x(t)\right] \cos 2\pi f_c t$$

  - $\cos 2\pi f_c t$ = carrier
  - $x(t)$ = input signal
  - n_a = modulation index
    - Ratio of amplitude of input signal to carrier
- a.k.a double sideband transmitted carrier (DSBTC)

Amplitude modulation





(a) Spectrum of modulating signal

(b) Spectrum of AM signal with carrier at f_c

Figure 6.12 Spectrum of an AM Signal

Amplitude Modulation

- Transmitted power

$$P_t = P_c \left(1 + \frac{n_a^{\,2}}{2} \right)$$

  - P_t = total transmitted power in $s(t)$
  - P_c = transmitted power in carrier

Single Sideband (SSB)

- Variant of AM is single sideband (SSB)
  - Sends only one sideband
  - Eliminates other sideband and carrier
- Advantages
  - Only half the bandwidth is required
  - Less power is required
- Disadvantages
  - Suppressed carrier can't be used for synchronization purposes

Other variants

- Double sideband suppressed carrier (DSBSC): filters out the carrier frequency and sends both sidebands.
- Vestigial sideband (VSB), uses one sideband and reduced-power carrier.

Angle Modulation

- Angle modulation

$$s(t) = A_c \cos\left[2\pi f_c t + \phi(t)\right]$$

- Phase modulation
  - Phase is proportional to modulating signal

$$\phi(t) = n_p m(t)$$

    - n_p = phase modulation index

Angle Modulation

- Frequency modulation
  - Derivative of the phase is proportional to modulating signal

$$\phi'(t) = n_f m(t)$$

  - n_f = frequency modulation index

Angle Modulation

- Compared to AM, FM and PM result in a signal whose bandwidth:
  - is also centered at f_c
  - but has a magnitude that is much different
    - Angle modulation includes $\cos(\oslash(t))$ which produces a wide range of frequencies
- Thus, FM and PM require greater bandwidth than AM

Angle Modulation

- Carson's rule

where
$$B_T = 2(\beta + 1)B$$

$$\beta = \begin{cases} n_p A_m & \text{for PM} \\ \dfrac{\Delta F}{B} = \dfrac{n_f A_m}{2\pi B} & \text{for FM} \end{cases}$$

- The formula for FM becomes

$$B_T = 2\Delta F + 2B$$