Principle of Communication (BEC-28)

Amplitude Modulation

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UNIT-1

- Overview of Communication system
- Communication channels
- Need for modulation
- Baseband and Pass band signals
- Comparison of various AM systems
- Amplitude Modulation
  - Double side-band with Carrier (DSB-C)
  - Double side-band without Carrier
  - Single Side-band Modulation
  - SSB Modulators and Demodulators
  - Vestigial Side-band (VSB)
  - Quadrature Amplitude Modulator.

MODULATION

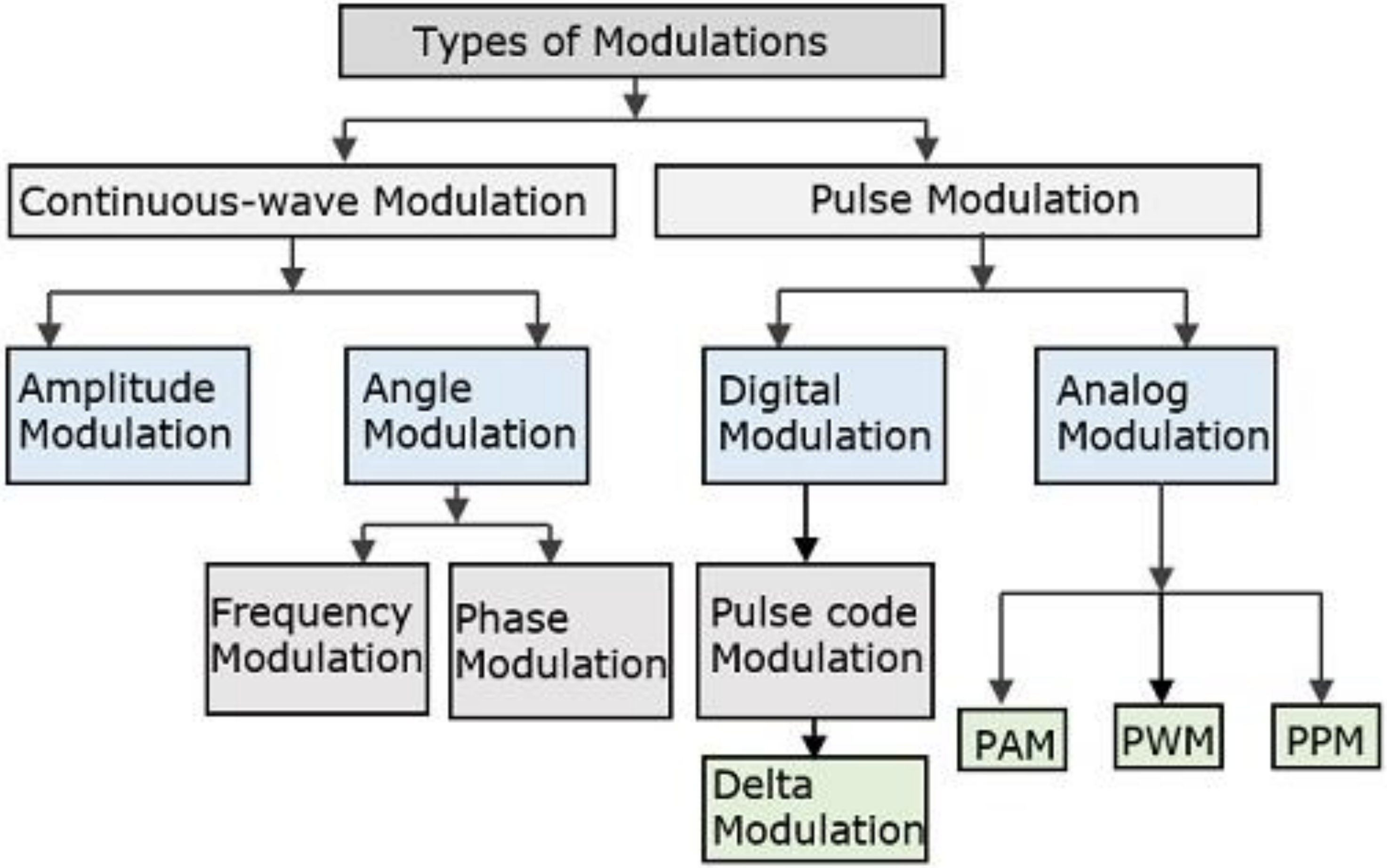
What is Modulation

- **Modulation** is the process of changing the parameters of the carrier signal, in accordance with the instantaneous values of the modulating signal.
- Advantage:
  - Antenna size gets reduced.
  - No signal mixing occurs.
  - Communication range increases.
  - Multiplexing of signals occur.
  - Adjustments in the bandwidth is allowed.
  - Reception quality improves.

Signals involved in modulation

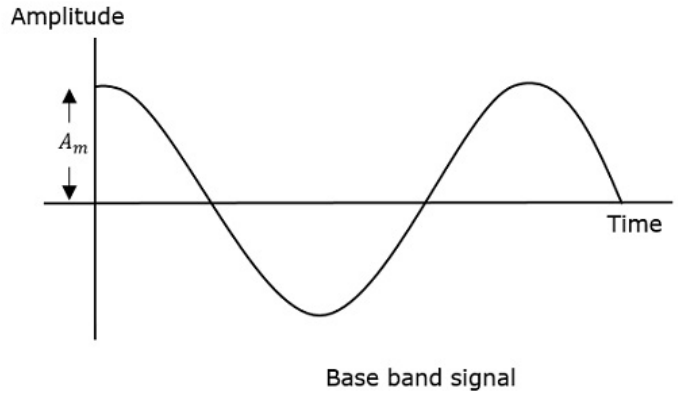
- Message or Modulating Signal:
  - message to be transmitted
  - baseband signal to undergo the process of modulation
  - Low frequency signal
- Carrier Signal:
  - High frequency signal
  - Contains Phase, frequency, amplitude
  - No information
  - Carry the signal after modulation
- Modulated Signal:
  - Resultant signal after modulation
  - Combination of modulating signal and carrier signal.

Types of modulation

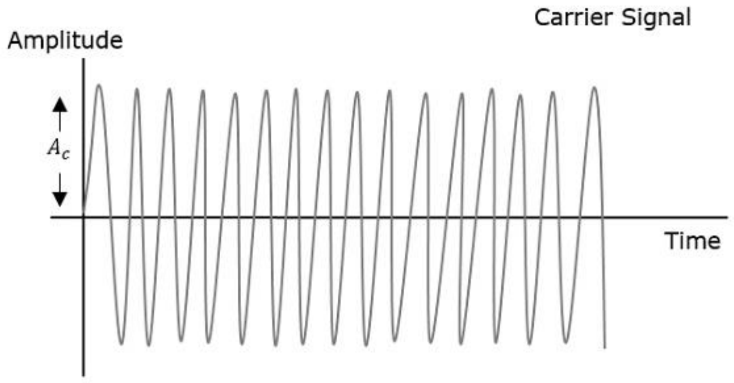


Amplitude Modulation (AM)

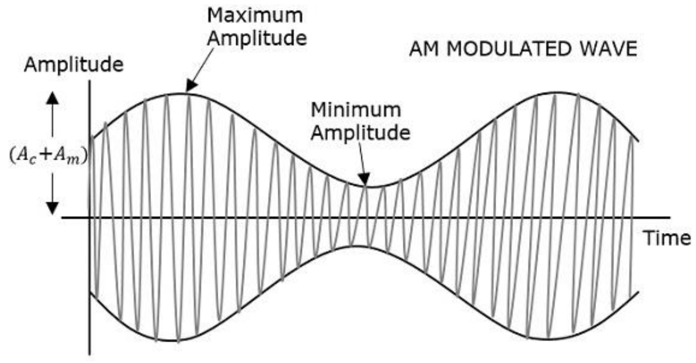
- Definition: The amplitude of the carrier signal varies in accordance with the instantaneous amplitude of the modulating signal.



$$m(t) = A_m \cos(2\pi f_m t)$$



$$c(t) = A_c \cos(2\pi f_c t)$$



$$S_{AM}(t) = A_c[1 + K_a m(t)]\cos(2\pi f_c t)$$

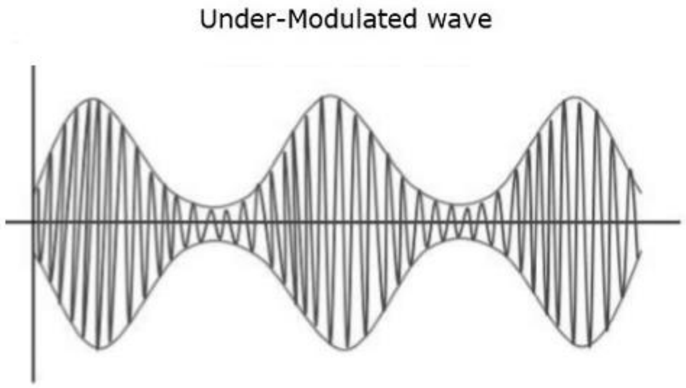
K_a: Amplitude Sensitivity of AM modulator

Modulation Index

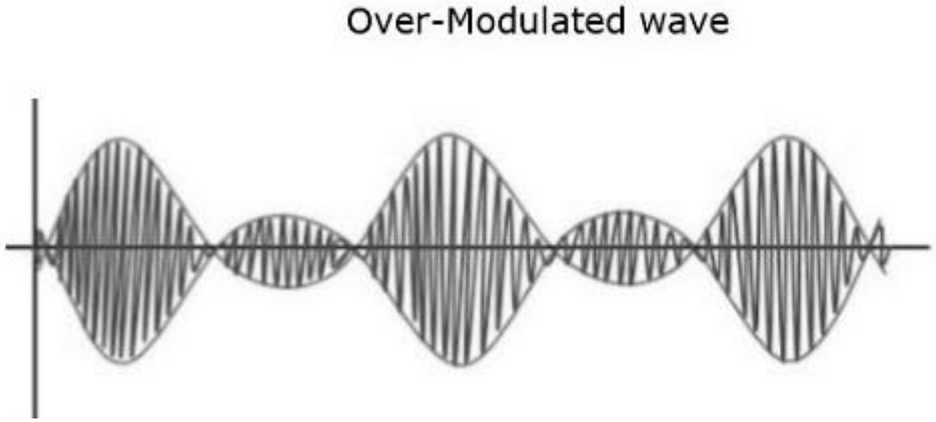
- Measurement of modulated level of carrier signal.
- Modulation depth.
- $S_{AM}(t) = A_c[1 + \mu\cos(2\pi f_m t)]\mu\cos(2\pi f_c t)$
- μ: Modulation index.
- $\mu = \frac{A_m}{A_c}$
- A_{max}: Maximum amplitude of modulated signal: $A_c + A_m$
  A_{min}: Minimum amplitude of modulated signal: $A_c - A_m$
  $\mu = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$
- Percentage modulation: Multiply μ by 100.

Modulation Index….

- μ=1 : Perfect Modulation/Critical Modulation ($A_c = A_m$)
- μ <1 : Under Modulation



- μ >1 : Over Modulation



Bandwidth

- Bandwidth: Highest positive frequency – Lowest Positive frequency

$$BW = f_{max} - f_{min}$$

- For AM signal: $s(t) = A_c [1 + \mu \cos(2\pi f_m t)] \cos(2\pi f_c t)$

$$\Rightarrow s(t) = A_c \cos(2\pi f_c t) + \frac{A_c \mu}{2} \cos[2\pi (f_c + f_m) t] + \frac{A_c \mu}{2} \cos[2\pi (f_c - f_m) t]$$

f_c: Carrier frequency
$f_c + f_m$: Upper sideband frequency
$f_c - f_m$: Lower sideband frequency

f_{max}= $f_c + f_m$; f_{min}= $f_c - f_m$
$BW = 2f_m$

- Bandwidth required for AM signal is twice of message signal frequency.

Power Calculation

- AM Signal: $\Rightarrow s(t) = A_c \cos(2\pi f_c t) + \frac{A_c \mu}{2} \cos[2\pi (f_c + f_m) t] + \frac{A_c \mu}{2} \cos[2\pi (f_c - f_m) t]$
- Power of AM signal:

P_t: *Total power of AM signal*
P_c: *Carrier Power*
P_{USB}: *Upper sideband power*
P_{LSB}: *Lower sideband power*

$$P_t = P_c + P_{USB} + P_{LSB}$$

$$P = \frac{{v_{rms}}^2}{R} = \frac{\left(v_m/\sqrt{2}\right)^2}{2}$$

$$P_c = \frac{\left(A_c/\sqrt{2}\right)^2}{R} = \frac{{A_c}^2}{2R}$$

$$P_{USB} = \frac{\left(A_c\mu/2\sqrt{2}\right)^2}{R} = \frac{{A_c}^2{\mu}^2}{8R} \qquad P_{LSB} = \frac{{A_c}^2{\mu}^2}{8R}$$

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

Modulation Efficiency

- Share of sideband power in total power.
- $\eta = \frac{P_{SB}}{P_t}$
- $\eta = \frac{P_c\frac{\mu^2}{2}}{P_c\left(1+\frac{\mu^2}{2}\right)}$
- $\eta = \frac{\mu^2}{2+\mu^2}$
- When, $\mu = 0; \eta = 0$, i.e. P_{SB} is 0% of P_t.
- When, $\mu = 0.5; \eta = 0.11$, i.e. P_{SB} is 11% of P_t.
- When, $\mu = 0.707; \eta = 0.2$, i.e. P_{SB} is 20% of P_t.
- When, $\mu = 1; \eta = 0.33$, i.e. P_{SB} is 33.3% of P_t.

Thank You