Principle of Communication (BEC-28)

Amplitude Modulation

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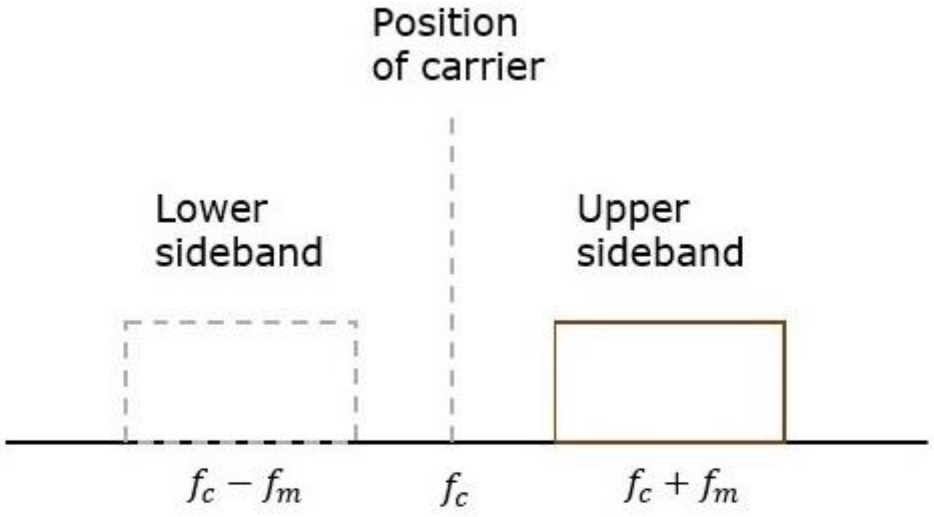
UNIT-1

- 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.

SSBSC

Single Sideband Suppressed Carrier

- Carrier and one sideband are suppressed.
- One sideband is used for transmission.
- SSBSC system: Transmits a single sideband has high power



Single Sideband Suppressed Carrier…

- Modulating signal : $m\,(t) = A_m \cos(2\pi f_m t)$
- Carrier signal: $c\,(t) = A_c \cos(2\pi f_c t)$
- For the Upper sideband SSBSC signal: $s\,(t) = \frac{A_m A_c}{2} \cos[2\pi\,(f_c + f_m)\,t]$
- For the Lower sideband SSBSC signal: $s\,(t) = \frac{A_m A_c}{2} \cos[2\pi\,(f_c - f_m)\,t]$
- BW: f_m

Single Sideband Suppressed Carrier…

- Power calculation:

Upper sideband-

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

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

$$P_{USB} = \frac{(A_m A_c/2\sqrt{2})^2}{R} = \frac{{A_m}^2 {A_c}^2}{8R}$$

Lower sideband-

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

$$P_{LSB} = \frac{{A_m}^2 {A_c}^2}{8R}$$

$$P_t = P_{USB} = P_{LSB} = \frac{{A_m}^2 {A_c}^2}{8R}$$

Single Sideband Suppressed Carrier…

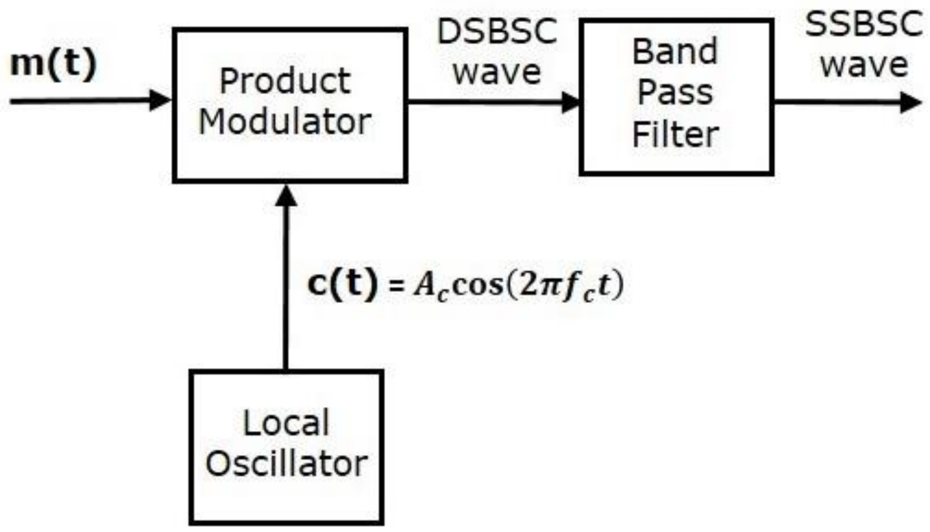
- Advantages:
  - Bandwidth or spectrum space occupied is lesser than AM and DSBSC waves.
  - Transmission of more number of signals is allowed.
  - Power is saved.
  - High power signal can be transmitted.
  - Less amount of noise is present.
  - Signal fading is less likely to occur.
- Disadvantages:
  - The generation and detection of SSBSC wave is a complex process.
  - The quality of the signal gets affected unless the SSB transmitter and receiver have an excellent frequency stability.

Single Sideband Suppressed Carrier…

- Applications:
  - For power saving requirements and low bandwidth requirements.
  - In land, air, and maritime mobile communications.
  - In point-to-point communications.
  - In radio communications.
  - In television, telemetry, and radar communications.
  - In military communications, such as amateur radio, etc.

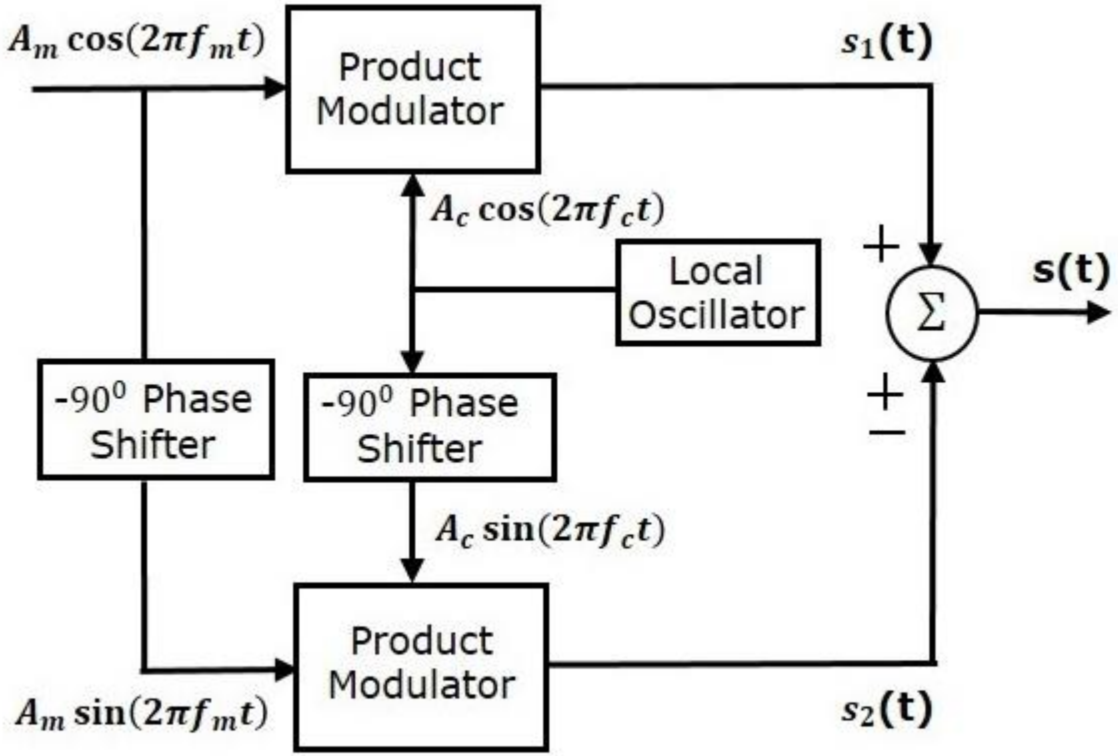
SSBSC MODULATORS

- Generation of SSBSC
  - Frequency discrimination method
  - Phase discrimination method
- Frequency Discrimination Method:



SSBSC MODULATORS...

- Phase Discrimination Method



SSBSC MODULATORS...

- The output of upper product modulator is

$$s_1(t) = A_m A_c \cos(2\pi f_m t)\cos(2\pi f_c t)$$

$$\Rightarrow s_1(t) = \frac{A_m A_c}{2}\{\cos[2\pi(f_c + f_m)t] + \cos[2\pi(f_c - f_m)t]\}$$

- The modulating signal and the carrier signal are phase shifted by -90^0.
- The output of lower product modulator is

$$s_2(t) = A_m A_c \cos(2\pi f_m t - 90^0)\cos(2\pi f_c t - 90^0)$$

$$\Rightarrow s_2(t) = \frac{A_m A_c}{2}\{\cos[2\pi(f_c - f_m)t] - \cos[2\pi(f_c + f_m)t]\}$$

- SSBSC modulated wave having lower sideband: (Performing addition)

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

$$\frac{A_m A_c}{2}\{\cos[2\pi(f_c - f_m)t] - \cos[2\pi(f_c + f_m)t]\}$$

$$\Rightarrow s(t) = A_m A_c \cos[2\pi(f_c - f_m)t]$$

- SSBSC modulated wave having upper sideband: (Performing subtraction)

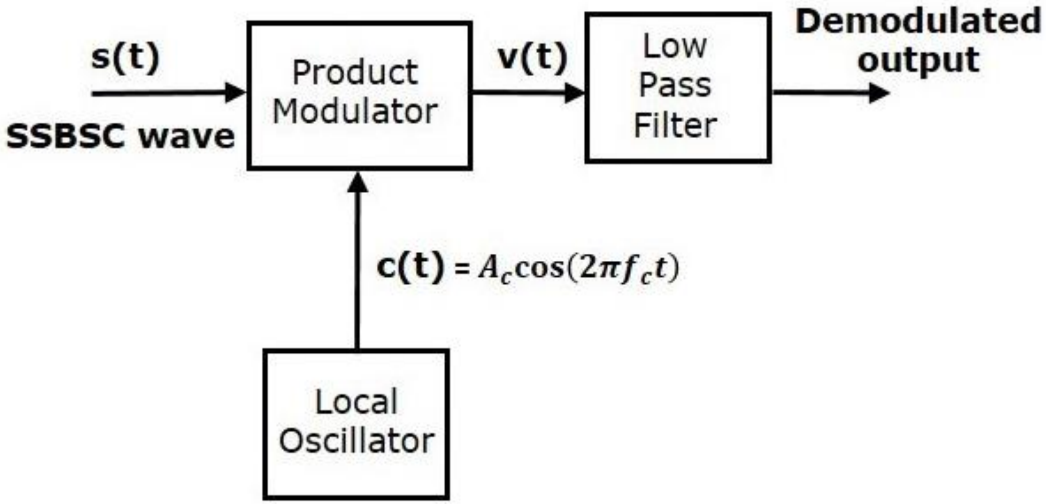
$$\Rightarrow s(t) = A_m A_c \cos[2\pi(f_c + f_m)t]$$

SSBSC DEMODULATOR..

- Coherent Detector:

The same carrier signal (which is used for generating SSBSC wave) is used to detect the message signal. Hence, this process of detection is called as **coherent** or **synchronous detection**.

Block Diagram:



SSBSC DEMODULATOR..

- Consider the following **SSBSC** wave having a **lower sideband**

$$s\left(t\right)=\frac{A_mA_c}{2}\cos[2\pi\left(f_c-f_m\right)t]$$

The output of the local oscillator: $c\left(t\right)=A_c\cos(2\pi f_ct)$

Output of product modulator: $v\left(t\right)=s\left(t\right)c\left(t\right)$

$$v\left(t\right)=\frac{A_mA_c}{2}\cos[2\pi\left(f_c-f_m\right)t]A_c\cos(2\pi f_ct)$$

$$v\left(t\right)=\frac{A_m{A_c}^2}{4}\cos(2\pi f_mt)+\frac{A_m{A_c}^2}{4}\cos[2\pi\left(2f_c-f_m\right)t]$$

Output of low pass filter: $v_0\left(t\right)=\frac{A_m{A_c}^2}{4}\cos(2\pi f_mt)$

SSBSC DEMODULATOR..

- Consider the following **SSBSC** wave having **upper sideband**

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

The output of the local oscillator: $c(t) = A_c \cos(2\pi f_c t)$

Output of product modulator: $v(t) = s(t)\, c(t)$

$$\Rightarrow v(t) = \frac{A_m A_c}{2} \cos[2\pi (f_c + f_m) t] A_c \cos(2\pi f_c t)$$

$$v(t) = \frac{A_m {A_c}^2}{4} \cos(2\pi f_m t) + \frac{A_m {A_c}^2}{4} \cos[2\pi (2f_c + f_m) t]$$

Output of low pass filter: $v_0(t) = \frac{A_m {A_c}^2}{4} \cos(2\pi f_m t)$

Thank You