Analog & Digital Communication
B. Tech (CSE) Sem-5.
Assignment

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Ques 1:- Explain the types of communication: Analog, Pulse and Digital.

* Analog Communication → It is a type of communication in which the message / information signal to be transmitted is analog in nature i.e. the modulating signal is an analog signal. The analog communication is from the sender to the receiver in the form of an analog signal. The analog signal is a continuous time varying signal.

* Digital Communication → The communication that occurs in our day-to-day life is in the form of signals. These signals such as sound signals generally are analog in nature. When the communication needs to be established over a distance, then the analog signals are sent through wire, using different techniques for effective transmission.

* Pulse Communication → Modulation of continuous waves is inherently restricted to amplitude and angular variations, but a pulse train also

allows variations in shape of pulse. There are four basic types of modulation, each of which has a number of variations and can be further classified according to the detailed manner in which modulation is effected. These are, pulse-amplitude modulation, pulse-freq. modulation, pulse-length modulation, pulse-phase modulation.

Ques2: Give the Fourier Transformation for various signals and Fourier Spectrum.

I) Signum Function

$$sgn(t) = \begin{cases} -1 : & t < 0 \\ 0 : & t = 0 \\ 1 : & t > 0 \end{cases}$$

$$F(sgn(t)) = X(\omega) = \int_{-\infty}^{\infty} sgn(t)\, e^{-j\omega t}\, dt$$

$$X(\omega) = \int_{\infty}^{0} (-1)\, e^{-j\omega t}\, dt + \int_{0}^{\infty} 1\, e^{-j\omega t}\, dt$$

$$= -\int_{-\infty}^{0} e^{j\omega t}\, dt + \int_{0}^{\infty} e^{-j\omega t}\, dt$$

$$= \left[\frac{e^{-j\omega t}}{-j\omega}\right]_{\infty}^{0} + \left[\frac{e^{-j\omega t}}{-j\omega}\right]_{0}^{\infty}$$

$$= \frac{1}{j\omega}\left[e^{0} - e^{-\infty}\right] - \frac{1}{j\omega}\left[e^{-\infty} - e^{0}\right]$$

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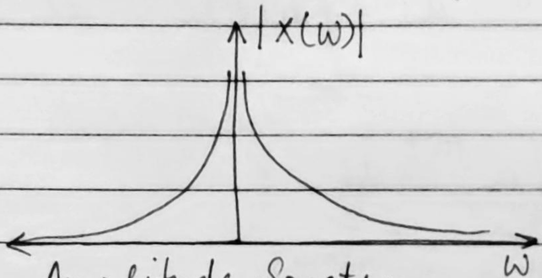
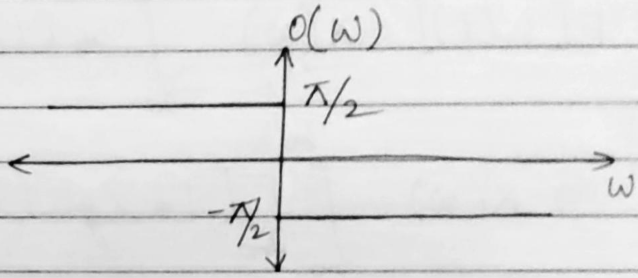
$$= \frac{1}{j\omega}[1-0] - \frac{1}{j\omega}[0-1] = \frac{1}{j\omega} + \frac{1}{j\omega} = \frac{2}{j\omega}$$

$$sgn(t) \xleftrightarrow{F.T.} \frac{2}{j\omega}$$



Amplitude Spectrum



Phase Spectrum.

II) Unit Impulse Function

$$x(t) = \delta(t) = \begin{cases} 1 & \text{for } t = 0 \\ 0 & \text{for } t \neq 0 \end{cases}$$

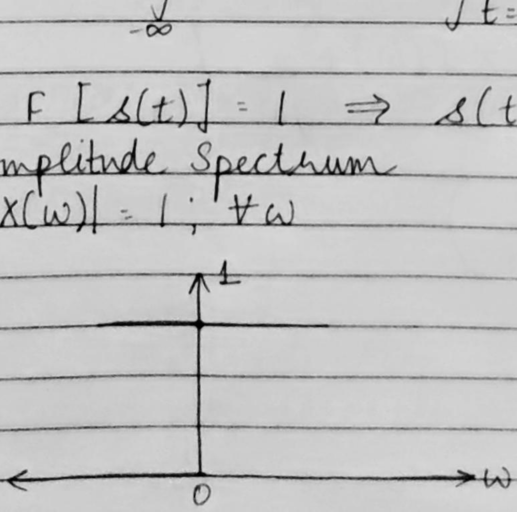
$$X(\omega) = \int_{-\infty}^{\infty} x(t)\, e^{-j\omega t}\, dt = \int_{-\infty}^{\infty} \delta(t)\, e^{-j\omega t}\, dt$$

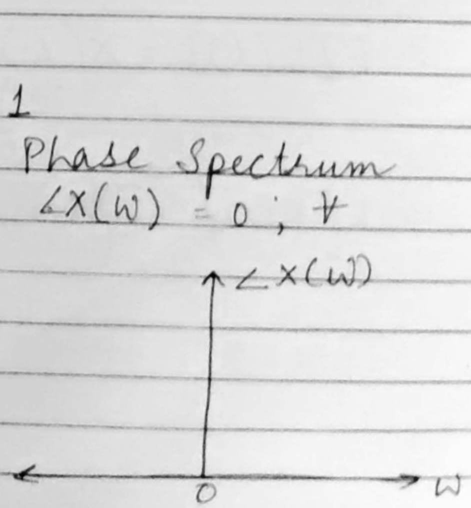
$$* \quad = \left.\int_{-\infty}^{\infty} 1 . e^{j\omega t}\, dt \right\}_{t=0} = 1$$

$$F[\delta(t)] = 1 \Rightarrow \delta(t) \xleftrightarrow{F.T.} 1$$

Amplitude Spectrum
$|X(\omega)| = 1 ; \forall \omega$

Phase Spectrum
$\angle X(\omega) = 0 ; \forall$





III) Unit Step Function

$$u(t) = \begin{cases} 1 & \text{for } t \geq 0 \\ 0 & \text{for } t < 0 \end{cases}$$

we know, $u(t) = \frac{1}{2}[1 + sgn(t)]$

$$F[u(t)] = X(\omega) = \int_{-\infty}^{\infty} x(t) e^{-j\omega t} dt = \int_{-\infty}^{\infty} u(t) e^{-j\omega t} dt$$

$$\Rightarrow X(\omega) = \int_{-\infty}^{\infty} \frac{1}{2}[1 + sgn(t)] e^{-j\omega t} dt$$

$$X(\omega) = \frac{1}{2}\left[\int_{-\infty}^{\infty} e^{-j\omega t} dt + \int_{-\infty}^{\infty} sgn(t) e^{-j\omega t} dt\right]$$

$$X(\omega) = \frac{1}{2}[F[1] + F[sgn(t)]]$$

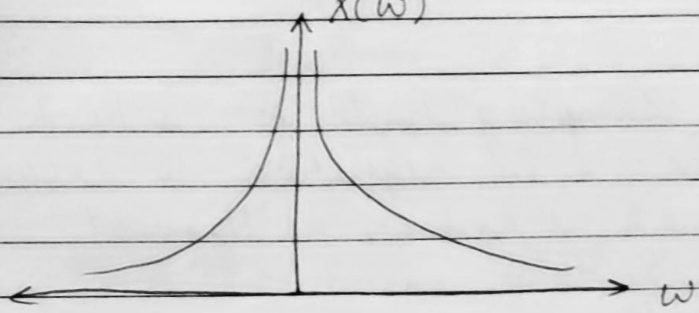
As $F[1] = 2\pi\delta(\omega)$

and

$F[sgn(t)] = \frac{2}{j\omega}$

$$\therefore F[u(t)] = X(\omega) = \frac{1}{2}\left[2\pi\delta(\omega) + \frac{2}{j\omega}\right]$$

$$\Rightarrow F[u(t)] = \left(\pi\delta(\omega) + \frac{1}{j\omega}\right)$$



Amplitude

$$|X(\omega)| = \begin{cases} \infty & \text{at } \omega = 0 \\ 0 & \text{at } \omega = -\infty \\ 0 & \text{at } \omega = \infty \end{cases}$$

Ques 3:- Define a) Power Spectral Density
b) Sampling, Nyquist Rate for Sampling, Sampling Theorem for band limited signals.

a) Power Spectral Density $S(\omega) \rightarrow$

The distribution of average power of signal $x(t)$ in the frequency domain is called power spectral density (PSD) or power density Spectrum.

$$S(\omega) = \lim_{Z \to \infty} \frac{|X(\omega)|^2}{Z}$$

b).

* Sampling →

The reduction of a continuous time signal to discrete time signal.

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* Nyquest Rate →
The minimum sampling rate for which $W_s = 2 W_m$ or $f_s = 2 f_m$ required to recover the message signal is known as Nyquest Rate.

* Sampling Theorem of band limited Signal →

Any base band signal $f(t)$ which is band limited (such that its highest frequency spectral component is 'w') can be periodically sampled every T_s, second such that $T_s \leq \frac{1}{2\omega}$, so that these samples $f(nT_s)$ uniquely determines the signal and may be reconstructed from these samples of by means of a low pass filter with no distortion.

Ques 4: Explain types of AM methods (AM, DSBSC, SSBSC), Power and Bandwidth Requirements.

① AM:-

Amplitude modulation is a process by which the wave signal is transmitted by modulating the amplitude of the signal. It is often called AM and is commonly used in transmitting a piece of information through a radio carrier wave. Amplitude modulation is mostly used in the form of electronic communication. In general, amplitude modulation definition is ~~as~~ given as a type of modulation where the amplitude of the carrier wave is varied in some proportion with respect to the modulating data on the signal.

Mathematically,

modulating signal,

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

carrier signal

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

where,

A_m - Amplitude of modulating signal

f_m - Frequency of modulating signal

A_c - Amplitude of carrier signal

f_c - Frequency of carrier signal.

Amplitude modulated wave,

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

Mathematically,

modulating signal

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

carrier signal,

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

equation of DSBSC wave,

$$s(t) = m(t)\, c(t)$$

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

- Power →

DSBSC modulated wave,

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

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

$$P = \frac{V_{rms}^2}{R}$$

Upper sideband power,

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

Lower sideband power,

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

$$P_t = \frac{A_m^2 A_c^2}{8R} + \frac{A_m^2 A_c^2}{8R}$$

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

Bandwidth →

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

amplitude modulated wave,

$$s(t) = A_c[1 + \mu \cos(2\pi f_m t)] \cos(2\pi f_c t)$$

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

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

where f_c - carrier frequency

$(f_c + f_m)$ - upper sideband frequency

$(f_c - f_m)$ - lower sideband frequency.

$$BW = (f_c + f_m) - (f_c - f_m)$$
$$= f_c + f_m - f_c + f_m$$
$$= 2f_m$$

* DSBSC :-

In process of Amplitude Modulation, the modulated wave consists of the carrier wave and two sidebands. The modulated wave has the information only in the sidebands. Sidebands is nothing but a band of frequencies, containing power, which are the lower and higher frequencies of the carrier frequency If this carrier is suppressed and the saved power is distributed to the two sidebands, then such a process is called as Double Sideband Suppressed Carrier system or simply DSBSC.

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Mathematically,

modulating signal

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carrier signal,

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

equation of DSBSC wave,

$$s(t) = m(t)\, c(t)$$

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

• Power →

DSBSC modulated wave,

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

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

$$P = \frac{v_{rms}^2}{R}$$

Upper sideband power,

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

Lower sideband power,

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

$$P_t = \frac{A_m^2 A_c^2}{8R} + \frac{A_m^2 A_c^2}{8R}$$

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

· Bandwidth →

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

DSBSC modulated wave,

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

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

$BW = (f_c + f_m) - (f_c - f_m)$

$= f_c + f_m - f_c + f_m$

$= 2 f_m$

* SSBSC:-

The DSBSC modulated signal has two sidebands. Since the two sidebands carry the same information, there is no need to transmit both sidebands. We can eliminate one sideband. The process of suppressing one of the sidebands along with the carrier and transmitting a single sideband is called as Single Sideband Suppressed Carrier system (SSBSC).

modulating signal

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

carrier signal

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

SSBSC wave,

for upper sideband,

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

or

for lower sideband

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

- Power →

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

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

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

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

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

- Bandwidth →

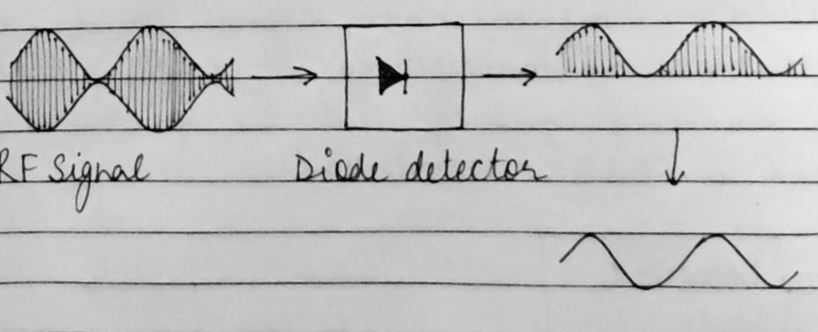
Since the SSBSC modulated wave contains only one sideband, its bandwidth is half of the bandwidth of DSBSC modulated wave,

Bandwidth of SSBSC modulated wave $= \frac{2f_m}{2} = f_m$

Ques 5: Explain generation and demodulation of AM: Diode detector, product detector, product demodulation for DSBSC and SSBSC.

* Diode Detector →

The diode detector is the simplest and most basic form of amplitude modulation, AM signal detector and it detects the envelope of the AM signal. The AM diode detector can be built from just a diode and a few other components and as a result it is a very low cost circuit block within an overall receiver. The AM diode detector is an evelope detector - it provides an output of the envelope of the signal. As such the diode detector or demodulator is able to provide an output proportional to the amplitude of the enevelope of the amplitude modulated signal. The signal diode detector consists of two main elements to the circuit. diode / rectifier and low pass filter.



* Product Detector →

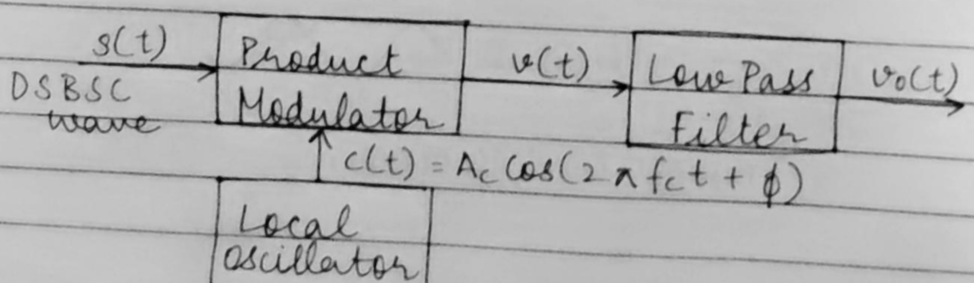
A detector for suppressed carrier AM signals that works by multiplying the signal with a regenerated carrier. A diode detector used alone not works of SSB or DSBSC because the envelope is different from that of AM. A locally generated carrier can be injected along with the SSB signal into a diode detector, but it is better to use an arrangement similar to the one used to generate suppressed carrier signals. When used in receivers, such a device is called a product detector.

* Product demodulation for DSBSC →

The process of extracting an original message signal from DSBSC wave is known as detection or demodulation of DSBSC. The following demodulators are used for demodulating DSBSC wave.

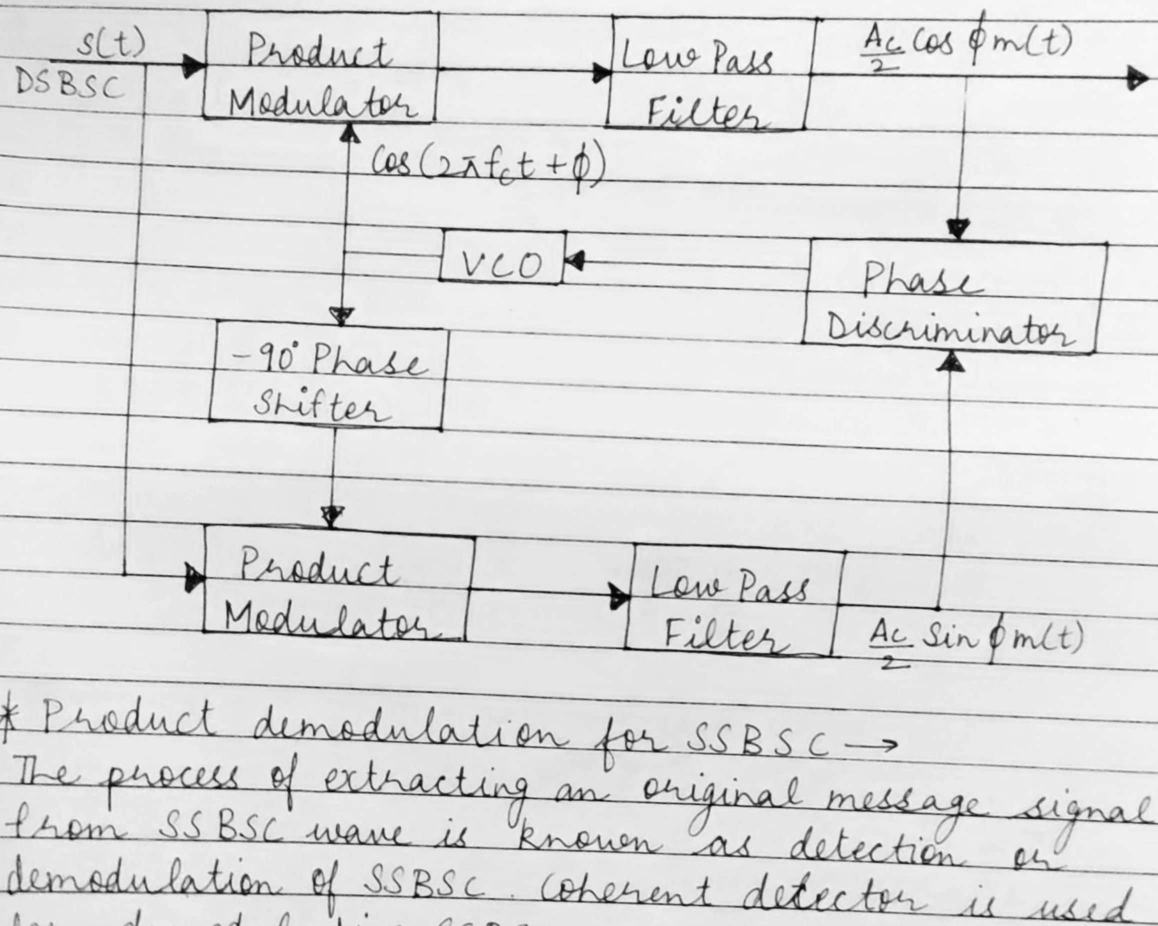
- Coherent Detector
- Costas Loop.

· Coherent Detector - The message signal can be extracted from DSBSC wave by multiplying it with a carrier, having the same fregnency and the phase of the carrier used in DSBSC modulation.



· Costas Loop -

Costas Loop is used to make both the signal (carrier) and the locally generated signal in phase.



* Product demodulation for SSBSC →

The process of extracting an original message signal from SSBSC wave is known as detection or demodulation of SSBSC. Coherent detector is used for demodulating SSBSC wave. The message signal can be extracted from SSBSC wave by multiplying it with a carrier, having the same frequency and the phase of the carrier used in SSBSC modulation. The resulting signal is then passed through a low pass filter. The output of this filter is the desired message signal.