



Medical Communication System

نظم اتصالات طبية

Amplitude Modulation (AM) system

Third Stage

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Communication System



A communication system is a framework that facilitates the transmission of information (messages, data, signals, etc.) between two or more entities, often over a distance.

The system typically consists of several key components:

Transmitter: Converts the information into a signal suitable for transmission.

Channel: The medium through which the signal travels (e.g., air, cable, fiber optics).

Receiver: Converts the received signal back into the original information.

Noise: Unwanted signals or disturbances that can affect the quality of the transmission.

Communication Process



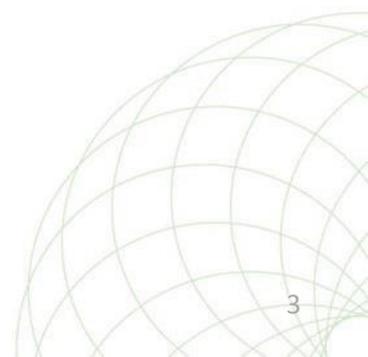
Source: Generates the message or data to be sent.

Encoding: The message is converted into a signal by the transmitter.

Transmission: The signal is transmitted over the channel.

Decoding: The receiver decodes the signal back into the original message.

Destination: The final recipient of the message.



Examples of Communication Systems



Telephony: Both traditional landlines and mobile phones.

Radio and Television Broadcasting: Transmitting audio and visual content.

Internet Networks: Email, instant messaging, and voice-over-IP services like Zoom.



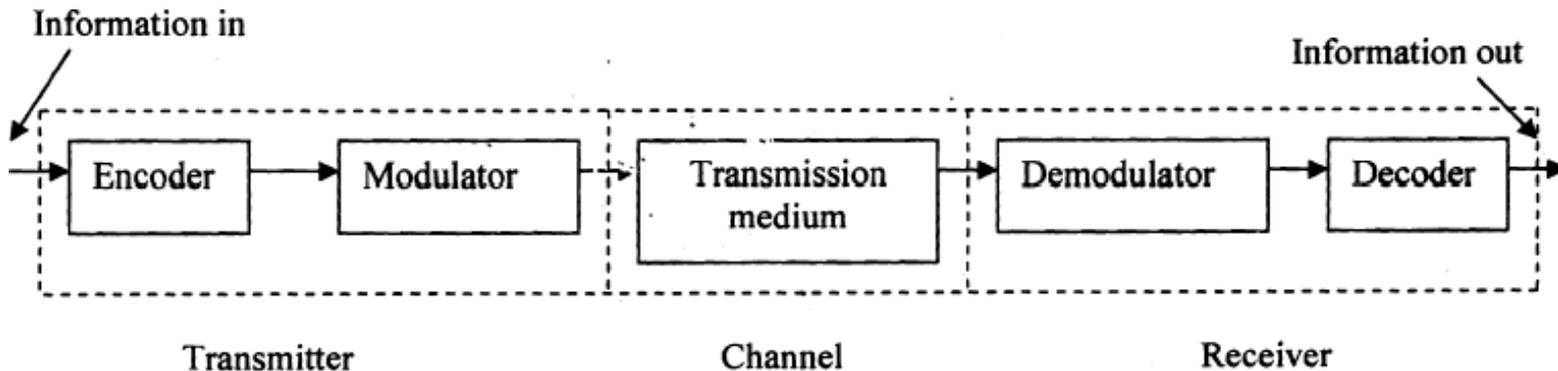
Communication System



There are three types of Communication systems according to the direction of transmission:-

A. Simplex (SX) communication system

The simplex (SX) communication system is capable of transmit information in one- way ,for example of this system (Radio channel, TV channel, satellite receiver). shows the block diagram of this system.

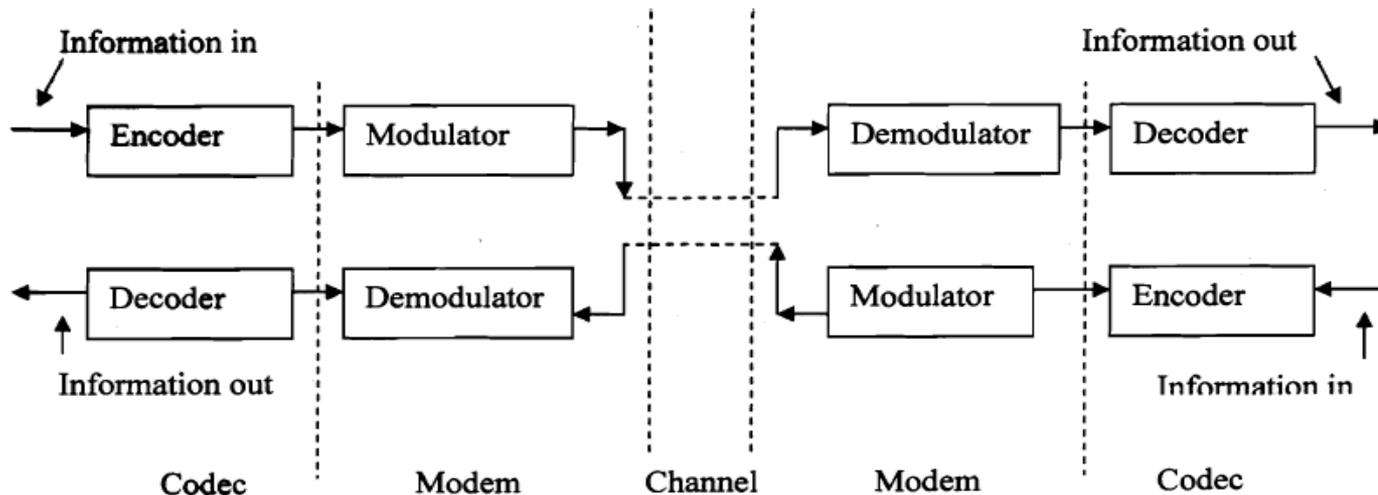


Communication System



B. Half-duplex (HDX) communication system

The half-duplex (HDX) communication system is capable of transmit information in two-way alternately. Although communication flows in both directions in half-duplex transmission, the flow of information is only one-way at any given time. In many cases it is desirable to maintain two-way communication, or at least to be able to send a message back to its origin for possible verification, comparison, or control. Shows the block diagram of this system. For example of this system (walky-talky of the police men).

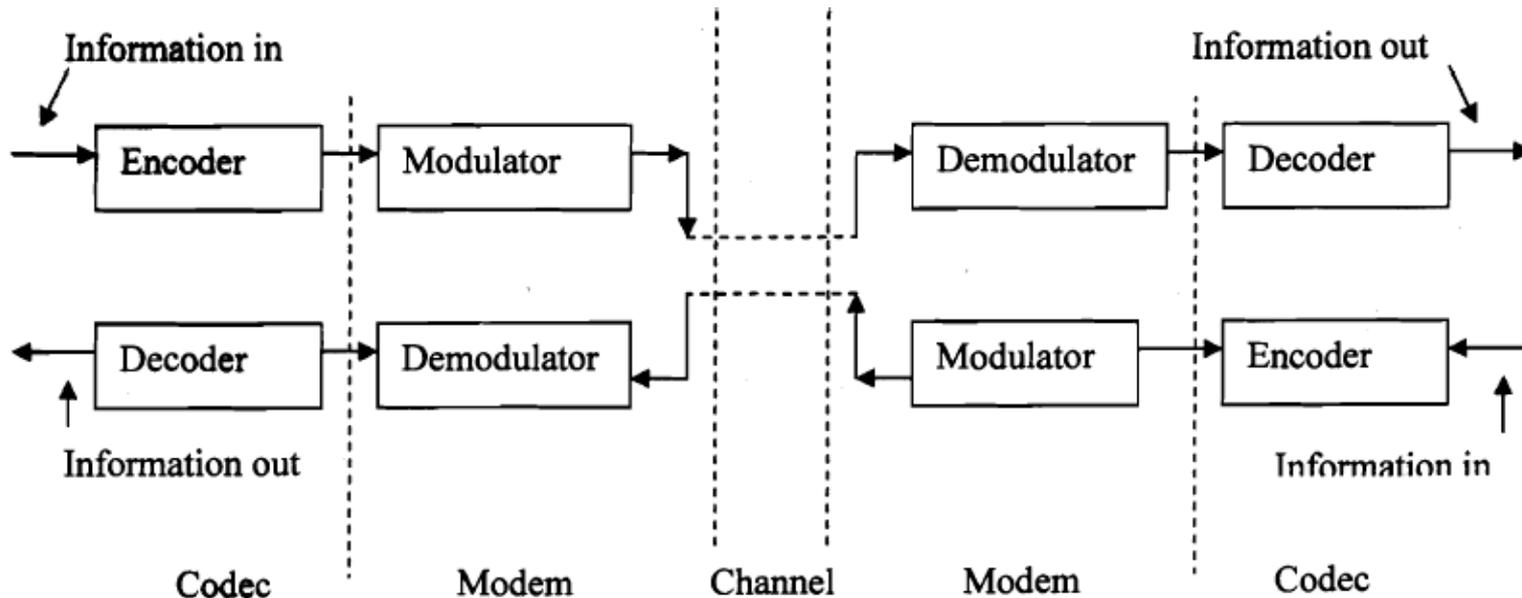


units of period and frequency



C. Full-duplex (FDX) communication system

In full-duplex transmission, simultaneous communication is accomplished in both direction . Shows the block diagram of this system. For example of this system (computer networks, mobile phones).



Main Parts of Communication Systems



A. The encoder

The encoder unit converted the information from one shape to another in order to optimize its detection at the output. The decoder performs the inverse operation to make the best decision, based on the available signal, that a given message was indeed sent. The design of the encoder and decoder must rely on a detailed mathematical description of information transmission.

B. The modulator

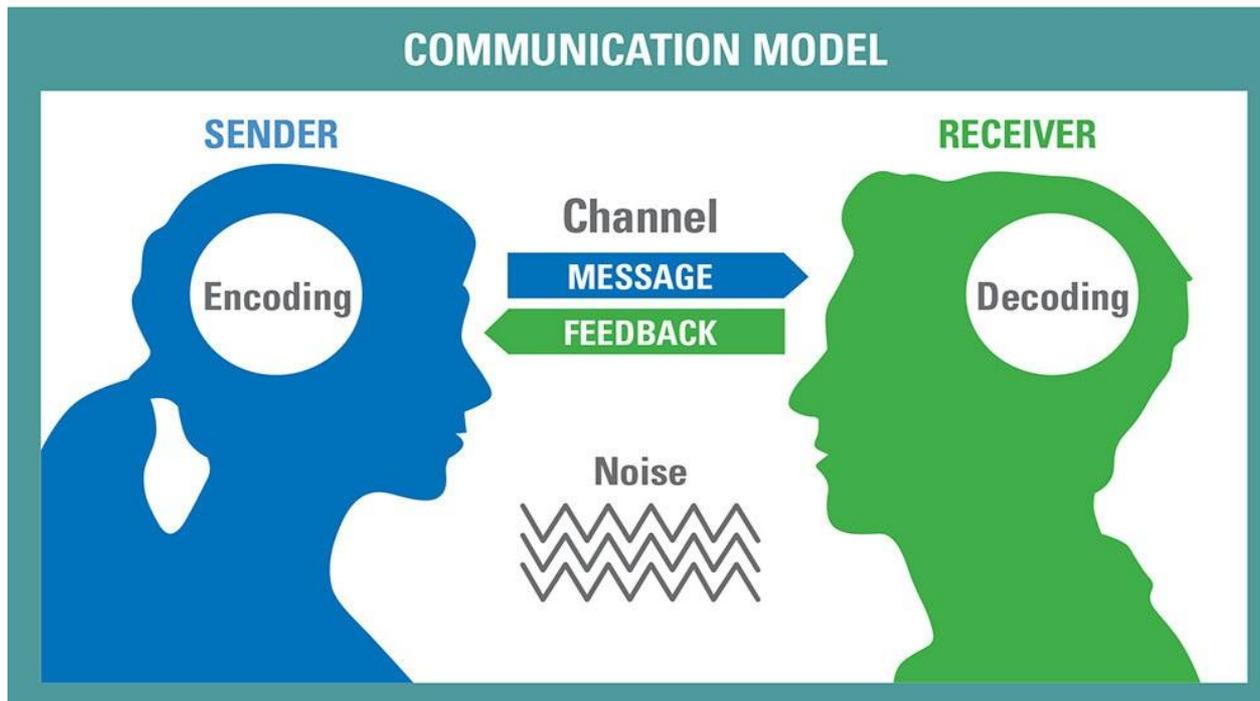
The modulator unit produces a varying signal at its output which is proportional in some way to the signal .input. For example as sinusoidal modulator may vary the amplitude, frequency or phase of a sinusoidal signal in direct proportion to the voltage input .The demodulator performs the inverse operation of the modulator to recover the signal in its original form.

Main Parts of Communication Systems



C. The transmission medium

The transmission medium it is the crucial link in the system .Without it; there would be no communication problems .The transmission medium may include the ionosphere, the troposphere, free space, or simply transmission line. In any case, attenuation and distortion as well as noise signal generated in the media and the transmission and receiving equipment.



The Frequency Bands (Radio Wave And Microwave)



<u>Range</u>	<u>Band</u>	<u>Propagation</u>	<u>Application</u>
3-30 KHz	VLF Very low frequency	Ground	Long range radio navigation
30-300 KHz	LF Low frequency	Ground	Radio beacons and navigational locator
300-3000 KHz	MF Medium frequency	Sky	AM radio
3-30 MHz	HF High frequency	Sky	Citizens band (CB) , ship/aircraft communication
30-300 MHz	VHF Very high frequency	Sky and line - of-sight	VHF TV ,FM radio
300-3000 MHz	UHF Ultra high frequency	line -of-sight	UHF TV ,cellular phones, satellite
3-30 GHz	SHF Super high frequency	line -of-sight	Satellite communication
30-300 GHz	EHF Extremely high frequency	line -of-sight	Radar , satellite

The Frequency Bands (Radio Wave And Microwave)



Ground propagation:- the radio waves travel through the lowest portion of the atmosphere ,hugging the earth .these low frequency signals emanate in all directions from the transmitting antenna and flow the curvature of the planet .Distance depend on the amount of power in the signal ,the greater the power the greater the distance.

Sky propagation:- High frequency radio waves radiated upward into the ionosphere(the layer of the atmosphere where particles exist as ions) where they are reflected back to earth .This type of transmission allows for greater distances with lower output.

Line-of-side propagation:- very high frequency signals are transmitted in straight line directly from antenna to antenna. Antennas must be directional, facing each other.



AM Modulation



Amplitude Modulation (AM) is a modulation technique used in electronic communication, where the amplitude of a carrier wave is varied in proportion to the message or information signal. This method is commonly used in radio broadcasting and various communication systems.

Mathematical Representation

$m(t)$ = message signal.

$c(t) = A_c * \cos(2\pi f_c * t)$ (carrier signal), where A_c is the carrier amplitude and

f_c is the carrier frequency

Frequency Spectrum of AM



Carrier at frequency f_c

Upper Sideband at $f_c + f_m$ (containing information from the message signal)

Lower Sideband at $f_c - f_m$ (also containing the same information)

Power in AM Signal

Total power, p_t , in an AM signal is given by:

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



Example Of Power In AM Signal



An AM transmitter produces a carrier power of $P_c = 100$ watts. If the modulation index $\mu = 0.8$, calculate the total power P_t in the AM signal.

Sol.

$$\mu^2 = 0.8^2 = 0.64$$

$$P_t = 100 \times \left(1 + \frac{0.64}{2} \right)$$

$$P_t = 100 \times (1 + 0.32) = 100 \times 1.32 = 132 \text{ watts}$$



Types of AM



Double Sideband (DSB): Transmits both sidebands and the carrier (standard AM).

Double Sideband Suppressed Carrier (DSB-SC): Transmits only the sidebands, with the carrier suppressed.

Single Sideband (SSB): Transmits only one of the sidebands (USB or LSB), greatly improving power and bandwidth efficiency.



Applications



- **Radio broadcasting:** AM is used in the standard AM radio band.
- **TV broadcasting:** Analog TV used AM for video signal modulation.
- **Aircraft communication:** AM is used in the VHF frequency range for aviation communication.



Advantages and Disadvantages



Advantages

Simple to implement, widely used in AM radio broadcasting.

Disadvantages

Inefficient in terms of power and bandwidth, as much of the power is in the carrier, and both sidebands carry duplicate information.



Double Sideband Suppressed Carrier (DSB-SC)



Double Sideband Suppressed Carrier (DSB-SC) is a type of amplitude modulation (AM) in which only the sidebands are transmitted, while the carrier is suppressed. Unlike standard AM, where the carrier and two sidebands are transmitted, DSB-SC modulation reduces power consumption and bandwidth requirements by transmitting only the sidebands. This is achieved by modulating the carrier in such a way that the carrier component itself is canceled out, leaving only the information-carrying sidebands.

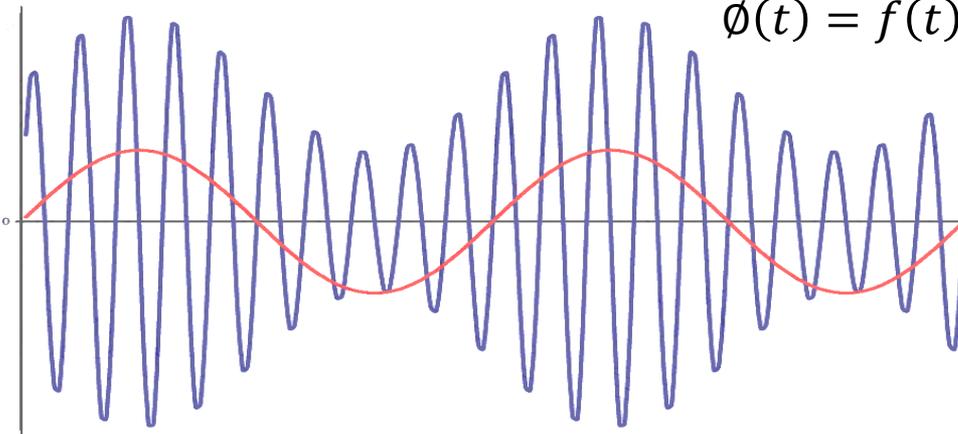
$$\phi(t) = a(t) \cos \theta(t)$$

$$\theta(t) = \omega_c t + \gamma(t)$$

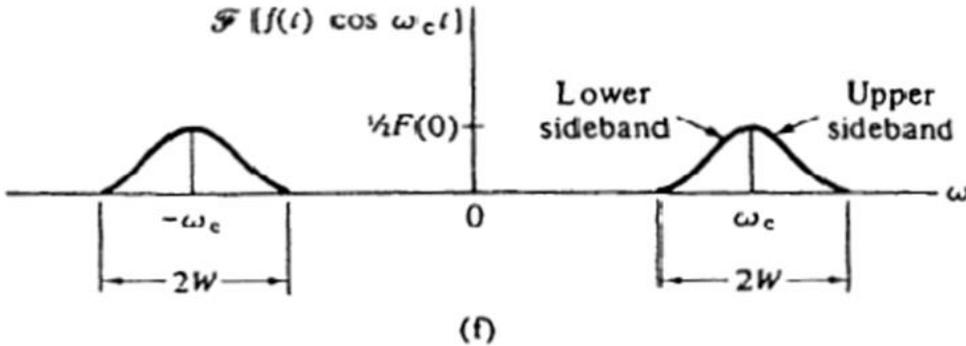
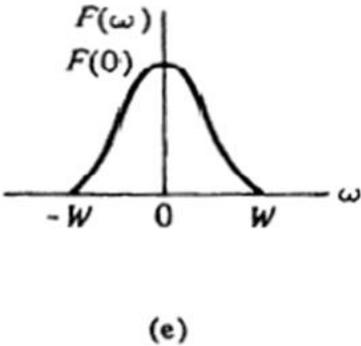
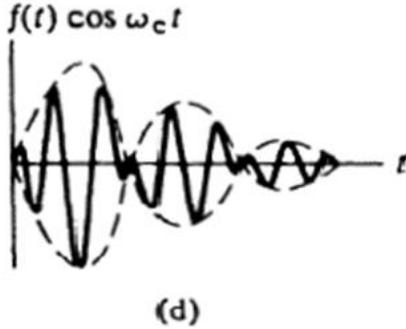
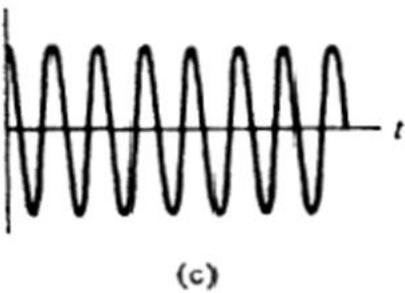
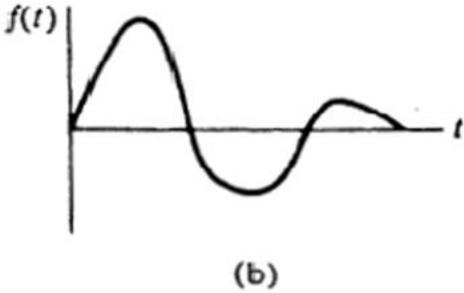
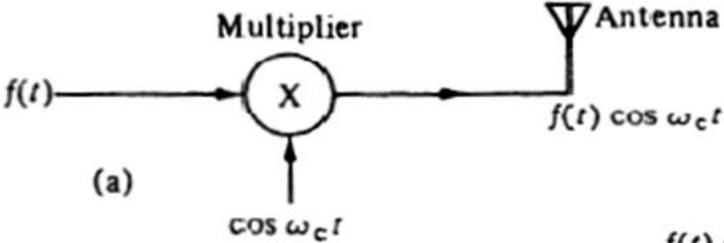
$$\phi(t) = a(t) \cos[\omega_c t + \gamma(t)]$$

Or

$$\phi(t) = f(t) \cos \omega_c t$$



Double Sideband Suppressed Carrier (DSB-SC)



Double Sideband Suppressed Carrier (DSB-SC)



Recovery of the original signal $f(t)$ from the DSB-SC signal $\phi(t)$ requires another translation in frequency to shift the spectrum to its original position. The process of retranslating the spectrum to its original position in frequency is called demodulation or detection.

Because the modulation property of the Fourier transform proved useful in translating spectra for modulation, we try it again for demodulation. Assuming that $\phi(t) = f(t) \cos \omega_c t$ the transmitted signal, we have

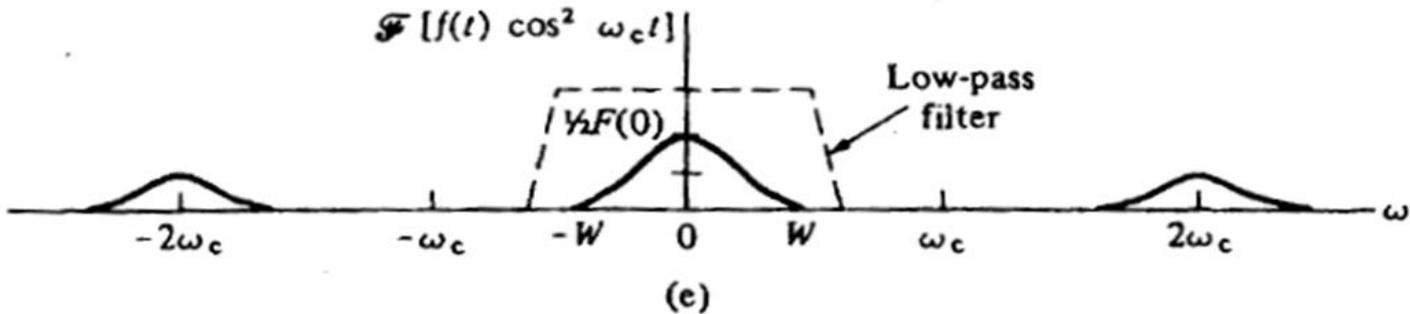
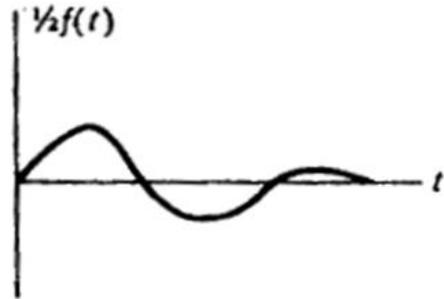
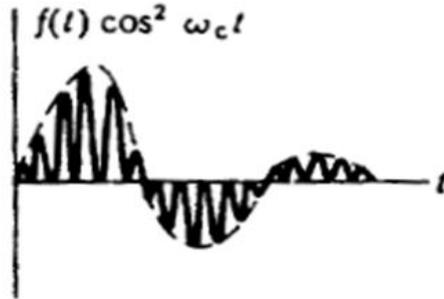
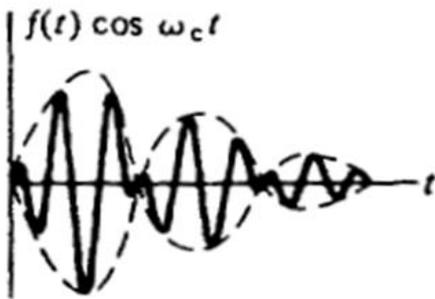
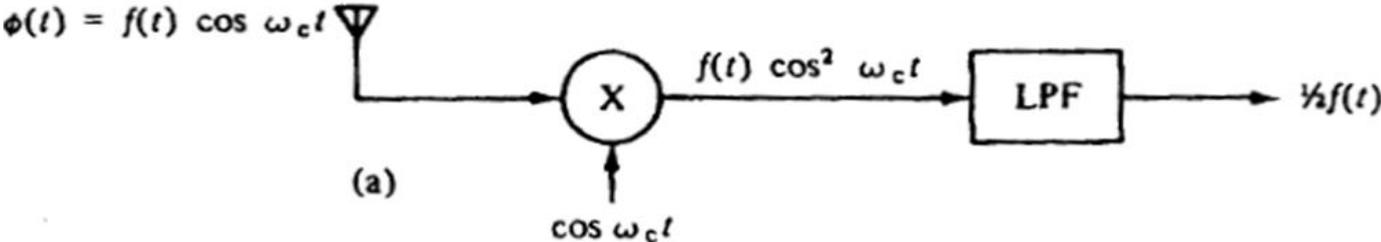
$$\begin{aligned}\phi(t) \cos \omega_c t &= f(t) \cos^2 \omega_c t \\ &= \frac{1}{2} f(t) + \frac{1}{2} f(t) \cos 2\omega_c t\end{aligned}$$

Taking the Fourier transform of both sides and using the modulation property, we get

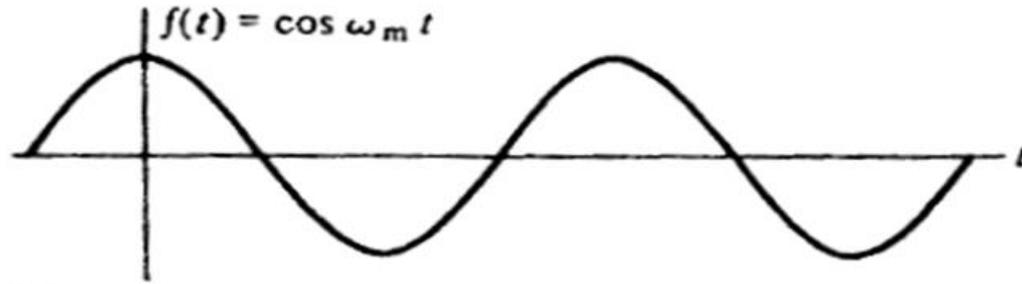
$$\mathcal{F}\{\phi(t) \cos \omega_c t\} = \frac{1}{2} F(\omega) + \frac{1}{4} F(\omega + 2\omega_c) + \frac{1}{4} F(\omega - 2\omega_c)$$



Double Sideband Suppressed Carrier (DSB-SC)



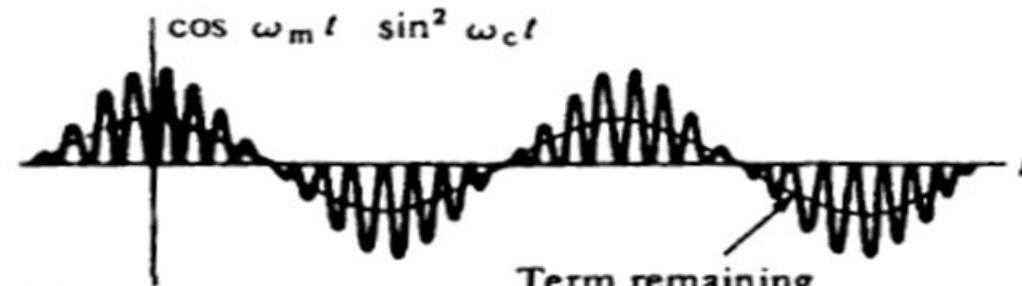
Double Sideband Suppressed Carrier (DSB-SC)



(a)



(b)



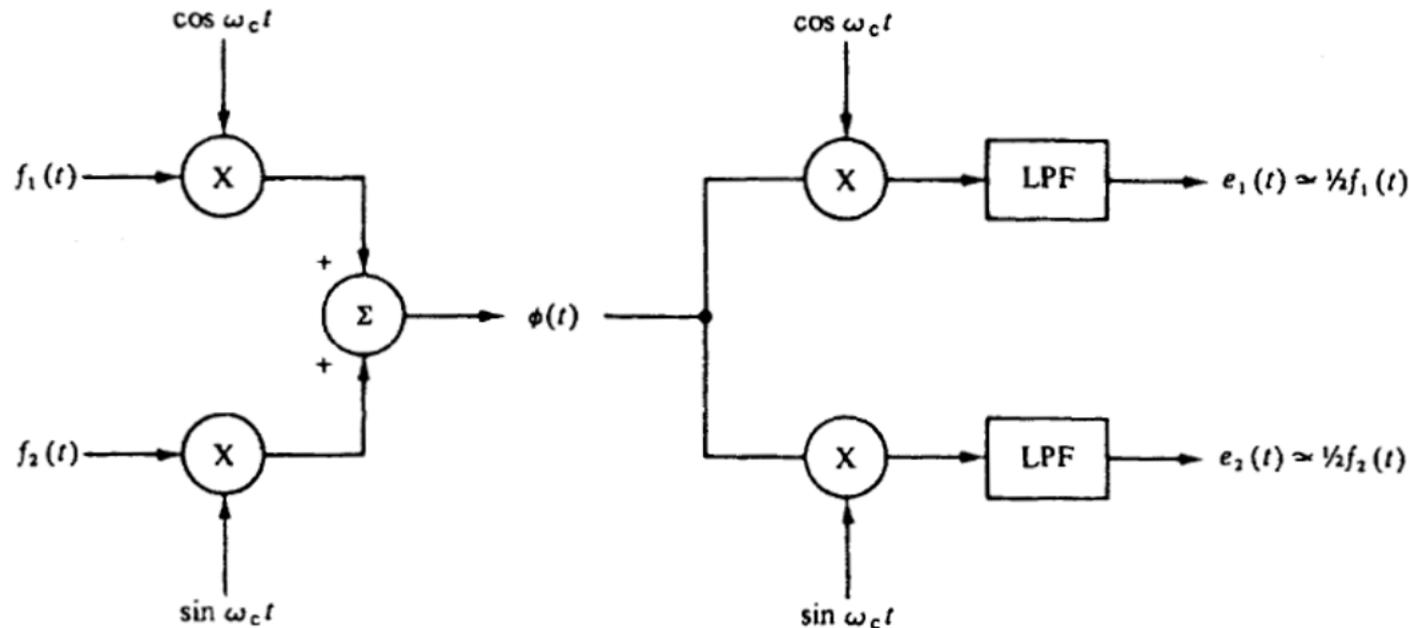
(c)



Example



Using the orthogonality of sines and cosines makes it possible to transmit and receive two different signals simultaneously on the same carrier frequency. A scheme for doing this, known as quadrature multiplexing, is shown in Fig. below. Show that each signal can be recovered by synchronous detection of the received signal using carriers of the same frequency but in phase quadrature.



Solution



$$\phi(t) = f_1(t) \cos \omega_c t + f_2(t) \sin \omega_c t$$

$$\begin{aligned} \phi(t) \cos \omega_c t &= f_1(t) \cos^2 \omega_c t + f_2(t) \sin \omega_c t \cos \omega_c t \\ &= \frac{1}{2} f_1(t) + \frac{1}{2} f_1(t) \cos 2\omega_c t + \frac{1}{2} f_2(t) \sin 2\omega_c t \end{aligned}$$

$$\phi(t) \sin \omega_c t = f_1(t) \cos \omega_c t \sin \omega_c t + f_2(t) \sin^2 \omega_c t$$

$$\frac{1}{2} f_1(t) \sin 2\omega_c t + \frac{1}{2} f_1(t) - \frac{1}{2} f_2(t) \cos 2\omega_c t$$

$$e_1(t) = \frac{1}{2} f_1(t)$$

$$e_2(t) = \frac{1}{2} f_2(t)$$



Generation of DSB-SC Signals



There are two basic methods of generating DSB-SC

1-Nonlinear device.

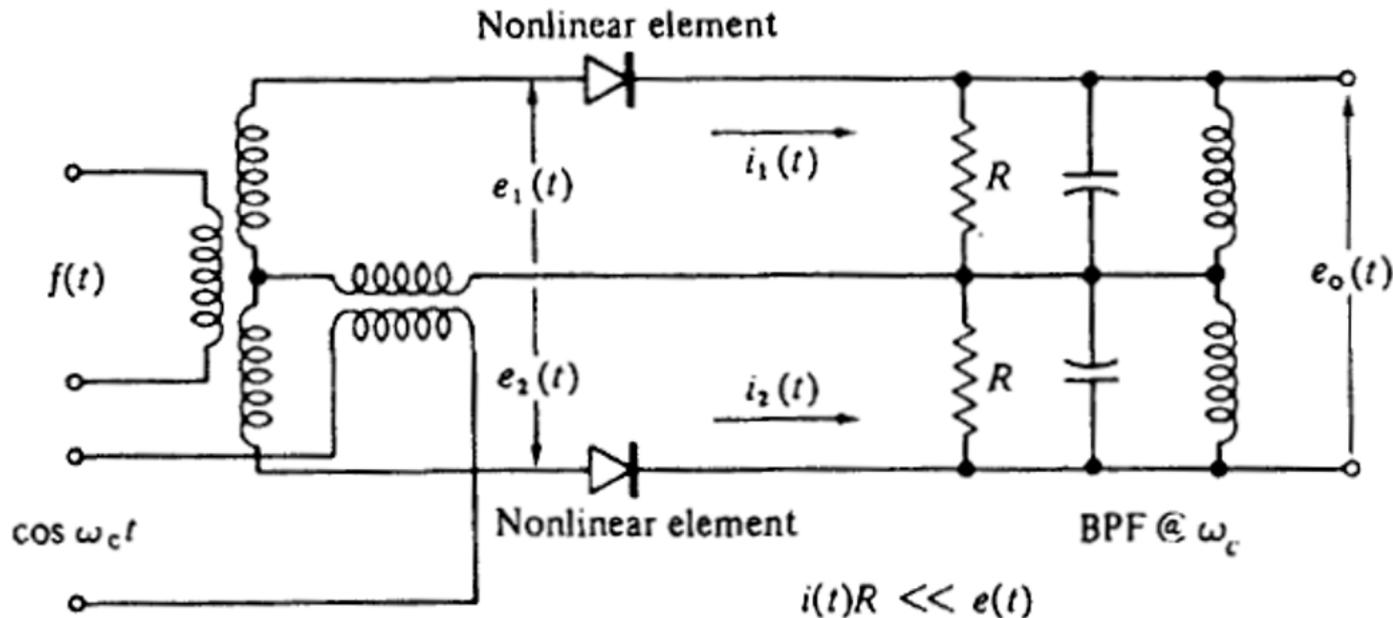
2-Chopper modulator.



Nonlinear device method



The nonlinear device method is a demodulation technique often used in communication systems, particularly for recovering signals in amplitude modulation (AM) systems. In this method, a nonlinear device (such as a diode or transistor circuit) is used to demodulate the signal.



Chopper Modulator



A chopper modulator is a type of amplitude modulation technique commonly used in signal processing and instrumentation, particularly for low-frequency signals. The concept is based on periodically interrupting or "chopping" a signal at a high frequency to create a modulated signal that is easier to transmit or process.



AM modulation (DSB-LC)



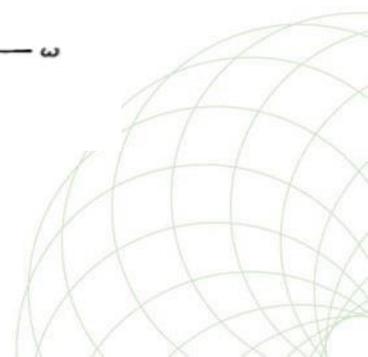
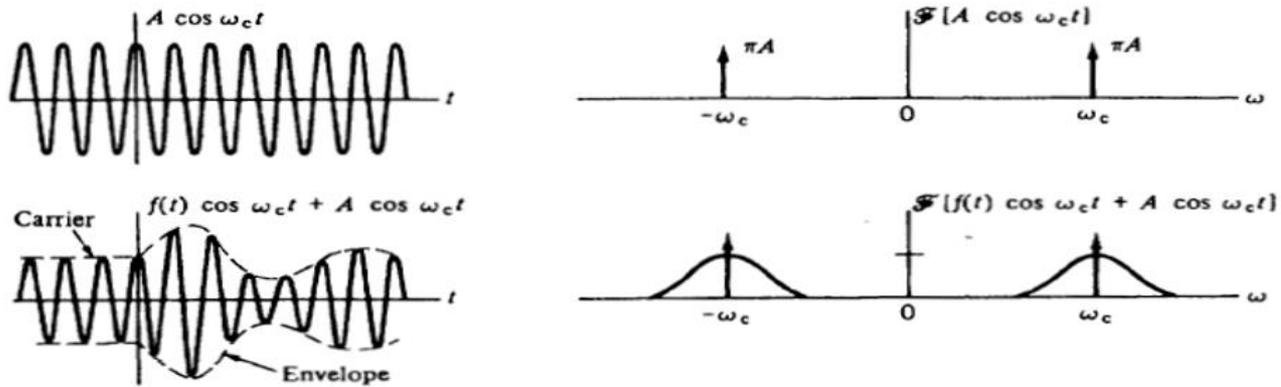
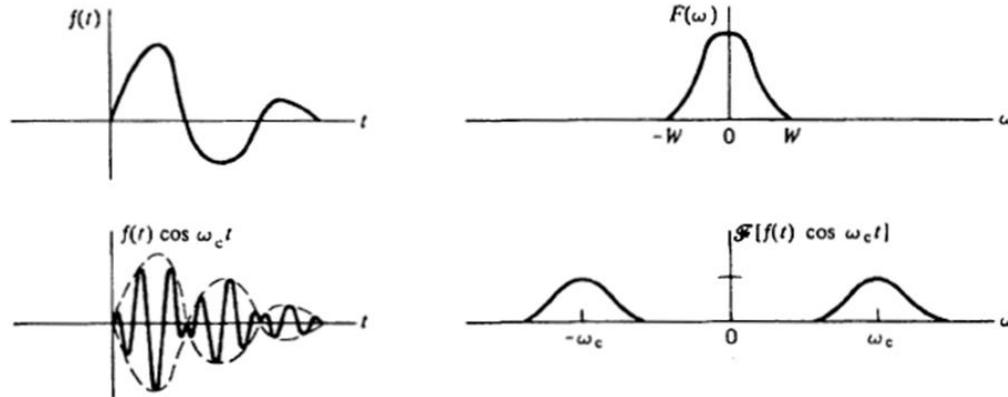
The Double-Sideband Large-Carrier (DSB-LC), often known as Amplitude Modulation (AM), is a type of modulation used in radio broadcasting and other communication systems. It is a form of double-sideband modulation where the carrier signal is included as a large component of the transmitted signal, unlike in Double-Sideband Suppressed-Carrier (DSB-SC) modulation.

$$\phi_{AM}(t) = f(t) \cos \omega_c t + A \cos \omega_c t$$

$$\phi_{AM}(t) = [f(t) + A] \cos \omega_c t$$



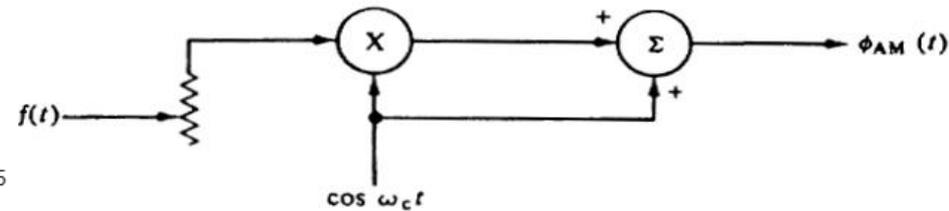
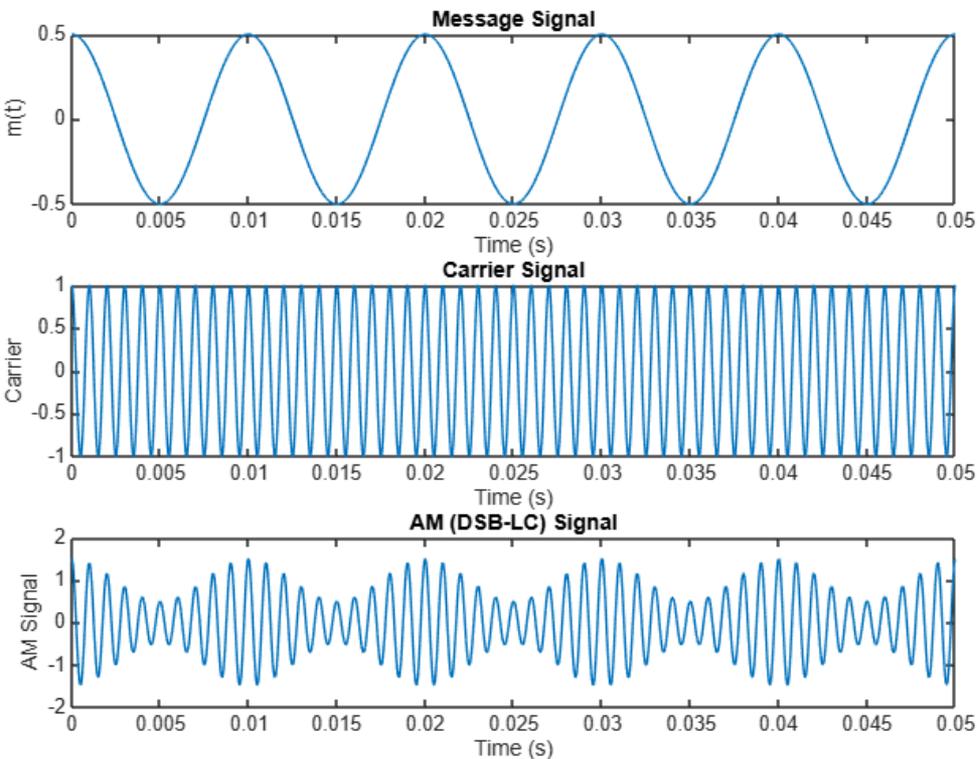
AM modulation (DSB-LC)



Generation of DSB-LC



The generation of a Double-Sideband Large-Carrier (DSB-LC) signal, also known as Amplitude Modulation (AM), involves combining a carrier wave with the message (or baseband) signal. The main purpose of DSB-LC is to transmit a modulated signal with both sidebands and a large carrier component, making it easier for receivers to detect and demodulate the signal.



Carrier and side band power in AM



In Amplitude Modulation (AM), the total power of the transmitted signal is divided between the carrier and the two sidebands (upper and lower). Understanding the distribution of power among these components is important in evaluating the efficiency of AM signals.

- Carrier Power

$$p_c = \frac{A^2}{2R}$$

- Total Power

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

- Transmission efficiency

$$\mu = \frac{m^2}{2 + m^2}$$





Thank You

Q & A

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