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Communication System I

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1. Introduction.

1.1. Analog and digital communication system

Communication is the process of establishing connection or link between two or more points for information exchange.

The electronic equipments that are used for communication purpose are called communication equipments. Different communication equipments when assembled together form a communication system. Communication can be broadly categorized into,

a. voice communication :
   - telephony, radio broadcasting, cellular mobile etc.
b. video communication :
   - TV broadcasting, moving objects etc
c. data communication :
   - sms, facsimile communication.

Depending on the nature of soure, a communication system can be classified as,

i) analog communication system
ii) digital communication system.

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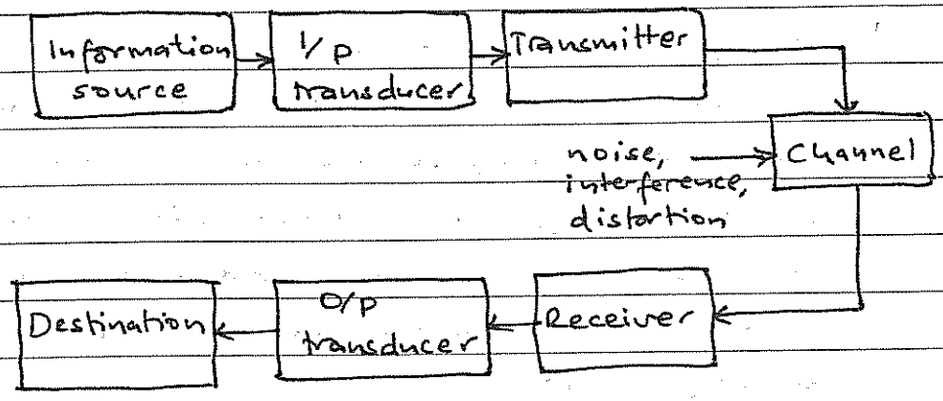
1. Analog communication system.

In such system, the source is in analog form. The block diagram of comm^{n} system is shown below;



a. Information source:

An information source is the originator of information that needs to be transmitted. The information could be speech, image, ~~message~~, video, text etc. The source generates the required message that has to be transmitted.

b. Input transducer:

The message from the source may or may not be in electrical form. If the message is not in electrical form, an input transducer

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is used to convert any non-electrical signal to its electrical counterpart.

c. Transmitter:

The transmitter modifies the message signal for efficient transmission. Transmitter makes a signal suitable for transmission over a channel. Modulation is the main function of transmitter.

d. Channel:

Channel is a medium through which the message signal travels, i.e. a channel is the physical connection between the transmitter and receiver. During the process of transmission and reception of signals through channel it is prominent that unwanted signals are added in the form of noise.

e. Receiver:

The main function of a receiver is to reproduce the message signal. Thus a receiver extracts the message signal from the signal attained from the channel. Demodulation is the main process in receiver.

f. Destination :

It is the final stage where the received electrical signal is converted into the original message form.

ii) Digital communication system (DCS).

In such system, the message to be transmitted in discrete form. With digital communication we tend to achieve maximum possible rate and accuracy. The block diagram of DCS is shown below:

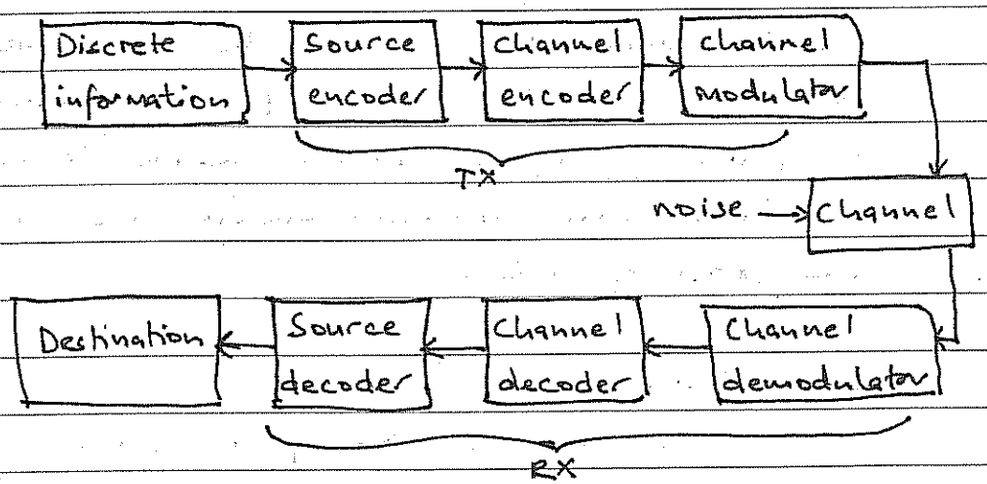

Fig. Block diagram of DCS.

a) Discrete information Source :

A discrete information source generates the discrete or digital message to be transmitted.

b) Source encoder :

It converts the sequence of symbols occuring at fixed intervals of time into binary sequence of '0's and '1's by assigning codeword to each symbol.

c) Channel encoder :

The channel encoder adds some error control bits to the codewords generated at the source encoder. These en error control bits donot carry any information but let the receiver detect and to some extent correct the errors.

d) Channel modulator :

The channel modulator converts the bit streams from channel encoder in electrical wave form suitable for transmission over a channel.

e) Channel :

It is the medium linking transmitter section and receiving section.

f) Channel demodulator:

It converts the received waveform into sequence of bits.

g) Channel decoder.

It recovers information bearing bit stream from coded bit stream with minimum error and maximum efficiency.

h) Source decoder:

It performs the reverse operation of source encoder and converts binary output of channel decoder into sequence of symbols.

1.2 Noise, interference and distortion.

(#) Noise:

It is any unwanted signal that adds up to the received signal and to certain extent degrades the performance of the communication system. No matter how good a system be, noise is bound to occur as

i) Internal noise
ii) External noise

i) Internal noise:

This type of noise is generated within the system with randomness of free electrons one of the major cause. Various types of internal noises are;

a. Thermal noise:

It is due to the random movement of free electrons within the system. The term thermal points that with the increase in temperature internal kinetic energy increases resulting in the increase in random motion of electrons.

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The thermal noise power can be deduced as,

$P_n = KTB$ watts

where,

K = Boltzmann's constant (1.38×10^{-23} J/°K)

T = temperature of conductor in Kelvin

B = Bandwidth of noise spectrum, Hz.

b. Shot noise :

In vacuum tubes, the noise due to random fluctuation in electron emission from the cathode is known as shot noise. This random variation would result in change in current. In semiconductor devices, the shot noise is used to describe the ~~number~~ variation in the number of electrons crossing potential barrier.

c. Partition noise :

It is the noise generated due to the random fluctuation in division of current into two or more path. This partition noise is more prominent in transistors than in diodes.

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d. Flicker or low-frequency noise :

This type of noise arises due to the fluctuation in carrier density. Below frequencies of a few kilo Hertz, a noise appear in the devices whose spectral density increases as the frequency in decreased. Such noise is termed as flicker noise or sometimes called as 1/f noise.

e. Transit time or High frequency noise.

In semiconductors, if a signal has very high frequency then some of the carriers may diffuse back to the source before crossing the junction barrier and produce noise. The psdf of such noise increases with frequency.

f. Generation - recombination noise :

Random process of generation and recombination of free electrons in semiconductor devices due to random ionization of impurities produce this type of noise.

g. White noise :

It is the ideal case of description of noise.

ii) External noise :

Noise that are generated outside the communication system are termed as external noise and are basically ,

a. Natural noise or extraterrestrial noise

The noise due to solar radiation or cosmic influence is known as natural noise. Even the lightening accounts for natural noise.

b. Manmade noise or Industrial noise :

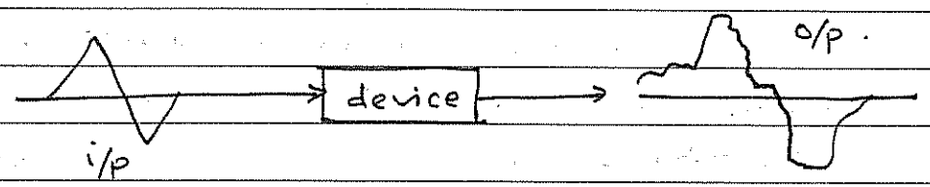
It is the noise generated when a fluorescent light or welding machine or high current circuits are brought close to the communication system.

(B) Interference :

Interference is the contamination of received signals by any other signals that is similar to the desired signal. It can occur due to the existence of various broadcasting and communication system is a close distance. Such interference is termed as external interferences. But if the interference occurs internally then it is termed as intersymbol interference where the transmitted bits interferes with the each other at the receiver end.

(C) Distortion :

It is defined as any unwanted change in the output waveform of the device in comparison to the input waveform.



A distortion can lead to the change in amplitude or phase of a signal. In case of audible signals any ~~than~~ amplitude distortion is easily recongised as human ear is more sensitive to amplitude distortion but in case of video signals, human eye is more sensitive to phase distortion and thus any phase distortion in video signal is easily noticed than amplitude distortion.

Based on the types of device used in a system, the distortion can be classified as,

i) Linear distortion :

It is produced by linear devices due to non-uniform frequency and phase responses. In such distortion, the different frequency components of input signal experience different gain.

ii) Non-linear distortion :

It is produced due to non-linear devices in a system having non-linear input/output characteristics. A non-linear distortion produces new frequency component at the output that is not present at the input.

This addition of newer frequency components can interfere with other signals and may overlap the original spectrum, causing intermodulation distortion or cross talk.

Such generation of newer frequencies may be termed as harmonics. This generation of harmonics of fundamental frequency of input signal due to non-linearity of device is evaluated in terms of harmonic distortion.

$$\%\ n^{th}\ \text{harmonic distortion} = \%\ D_n = \frac{|A_n|}{|A|} \times 100\%$$

where;

A_n : amplitude of n_{th} harmonic component

A : amplitude of fundamental frequency component.

1.3 Modulation :

Modulation is the process of imposing a low frequency signal to a very high frequency radio wave called carrier wave. It is performed at transmitting signal.

The low frequency signals are generally termed as message signal / baseband signal or modulating signal and the combined signal of message signal and carrier signal is termed as modulated signal.

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Need for modulation:

i) Practical antenna size.

A size of antenna depends on the frequency of the signal. The length of the antenna is approximately quarter of the wavelength i.e.

$$l = \lambda/4 = \frac{c}{f \times 4}$$ where $c = 3 \times 10^8$ m

f: freq. of signal

$\therefore l \propto \frac{1}{f}$

i.e. if the frequency is low, the required antenna length will be large, hence the frequency must be increased to reduce the antenna length.

ii) Long range transmission.

Low frequency signals cannot travel a long distance when they are transmitted. The low frequency signals get heavily attenuated. Thus modulating them to higher frequencies reduces the attenuation and hence increases the range of transmission.

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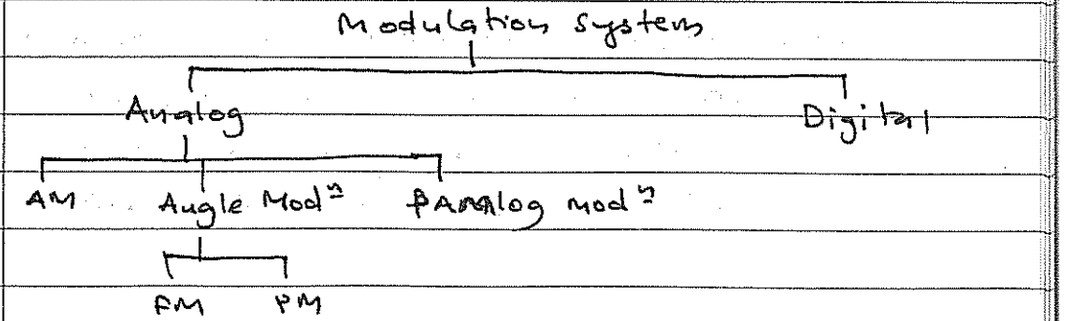
iii) Multiplexing.

Multiplexing is the process in which two or more signals can be transmitted over the same communication channel simultaneously. This is possible only with modulation, which allows the same channel to be used by many signals.

iv) Reduction of noise and ~~interfeace~~ interference.

With frequency modulation (FM) and the digital communication techniques like PCM, the effect of noise and interference is reduced to a great extent. This eventually leads to the improved quality of reception.

The different types of practically used modulation systems are;



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So, a modulation system can be broadly classified as,

i) analog modulation system:

In such system, the modulating as well as carrier signal are continuous in nature.

It can be further divided into

a) Amplitude Modulation:

Here the amplitude of carrier wave is varied in accordance to the modulating signal.

b) Angle Modulation:

Here the angle of carrier is varied in terms of the modulating signal. The angle comprises of frequency and phase thus angle modulation where frequency is altered is termed as frequency modulation and if phase is varied then the modulation is phase modulation.

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ii) Digital modulation system:

In such system, the modulating signal is digital in nature whereas the carrier can be digital or analog. few digital modulation systems are,

a. Amplitude shift keying
b. Phase shift keying
c. Frequency shift keying.
~~d. Pulse amplitude modulation~~
~~e. Pulse position modulation~~
f.