Chapter-1: Introduction

The purpose of a Communication System is to transport an information bearing signal from a source to a user destination via a communication channel.

MODEL OF A COMMUNICATION SYSTEM

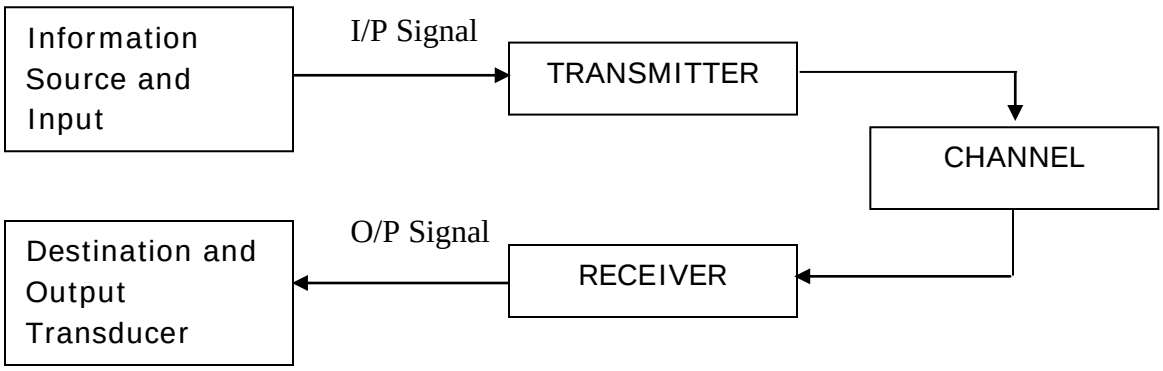

Fig. 1.1: Block diagram of Communication System.

The three basic elements of every communication systems are Transmitter, Receiver and Channel.

The Overall purpose of this system is to transfer information from one point (called Source) to another point, the user destination.

The message produced by a source, normally, is not electrical. Hence an input transducer is used for converting the message to a time – varying electrical quantity called message signal. Similarly, at the destination point, another transducer converts the electrical waveform to the appropriate message.

The transmitter is located at one point in space, the receiver is located at some other point separate from the transmitter, and the channel is the medium that provides the electrical connection between them.

The purpose of the transmitter is to transform the message signal produced by the source of information into a form suitable for transmission over the channel.

The received signal is normally corrupted version of the transmitted signal, which is due to channel imperfections, noise and interference from other sources.

The receiver has the task of operating on the received signal so as to reconstruct a recognizable form of the original message signal and to deliver it to the user destination.

Communication Systems are divided into 3 categories:

1. Analog Communication Systems are designed to transmit analog information using analog modulation methods.
2. Digital Communication Systems are designed for transmitting digital information using digital modulation schemes, and
3. Hybrid Systems that use digital modulation schemes for transmitting sampled and quantized values of an analog message signal.

ELEMENTS OF DIGITAL COMMUNICATION SYSTEMS:

The figure 1.2 shows the functional elements of a digital communication system.

Source of Information: 1. Analog Information Sources.
2. Digital Information Sources.

Analog Information Sources → Microphone actuated by a speech, TV Camera scanning a scene, continuous amplitude signals.

Digital Information Sources → These are teletype or the numerical output of computer which consists of a sequence of discrete symbols or letters.

An Analog information is transformed into a discrete information through the process of sampling and quantizing.

Digital Communication System

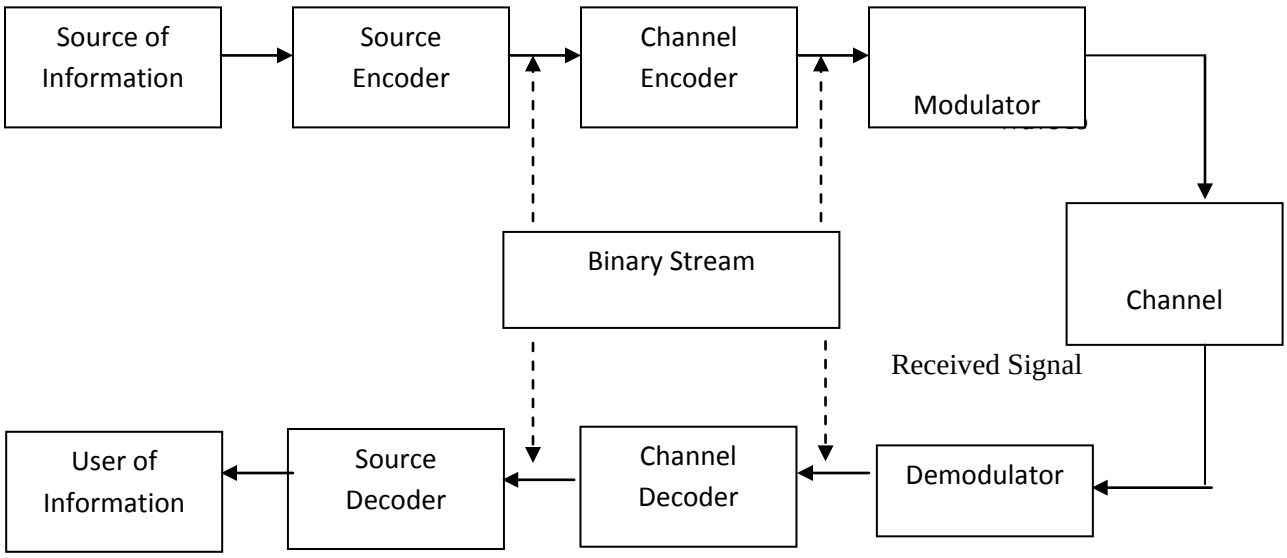

Fig 1.2: Block Diagram of a Digital Communication System

SOURCE ENCODER / DECODER:

The Source encoder (or Source coder) converts the input i.e. symbol sequence into a binary sequence of 0's and 1's by assigning code words to the symbols in the input sequence. For eg. :-If a source set is having hundred symbols, then the number of bits used to represent each symbol will be 7 because 2^7=128 unique combinations are available. The important parameters of a source encoder are **block size, code word lengths, average data rate and the efficiency** of the coder (i.e. actual output data rate compared to the minimum achievable rate)

At the receiver, the source decoder converts the binary output of the channel decoder into a symbol sequence. The decoder for a system using fixed – length code words is quite simple, but the decoder for a system using variable – length code words will be very complex.

Aim of the source coding is to remove the redundancy in the transmitting information, so that bandwidth required for transmission is minimized. Based on the probability of the symbol code word is assigned. Higher the probability, shorter is the codeword.
Ex: Huffman coding.

CHANNEL ENCODER / DECODER:

Error control is accomplished by the channel coding operation that consists of systematically adding extra bits to the output of the source coder. These extra bits do not convey any information but helps the receiver to detect and / or correct some of the errors in the information bearing bits.

There are two methods of channel coding:

1. Block Coding: The encoder takes a block of 'k' information bits from the source encoder and adds 'r' error control bits, where 'r' is dependent on 'k' and error control capabilities desired.
2. Convolution Coding: The information bearing message stream is encoded in a continuous fashion by continuously interleaving information bits and error control bits.

The Channel decoder recovers the information bearing bits from the coded binary stream. Error detection and possible correction is also performed by the channel decoder.
The important parameters of coder / decoder are: Method of coding, efficiency, error control capabilities and complexity of the circuit.

MODULATOR:

The Modulator converts the input bit stream into an electrical waveform suitable for transmission over the communication channel. Modulator can be effectively used to minimize the effects of channel noise, to match the frequency spectrum of transmitted signal with channel characteristics, to provide the capability to multiplex many signals.

DEMODULATOR:

The extraction of the message from the information bearing waveform produced by the modulation is accomplished by the demodulator. The output of the demodulator is bit stream. The important parameter is the method of demodulation.

CHANNEL:

The Channel provides the electrical connection between the source and destination. The different channels are: Pair of wires, Coaxial cable, Optical fibre, Radio channel, Satellite channel or combination of any of these.

The communication channels have only finite Bandwidth, non-ideal frequency response, the signal often suffers amplitude and phase distortion as it travels over the channel. Also, the signal power decreases due to the attenuation of the channel. The signal is corrupted by unwanted, unpredictable electrical signals referred to as noise.

The important parameters of the channel are Signal to Noise power Ratio (SNR), usable bandwidth, amplitude and phase response and the statistical properties of noise.

Modified Block Diagram: (With additional blocks)

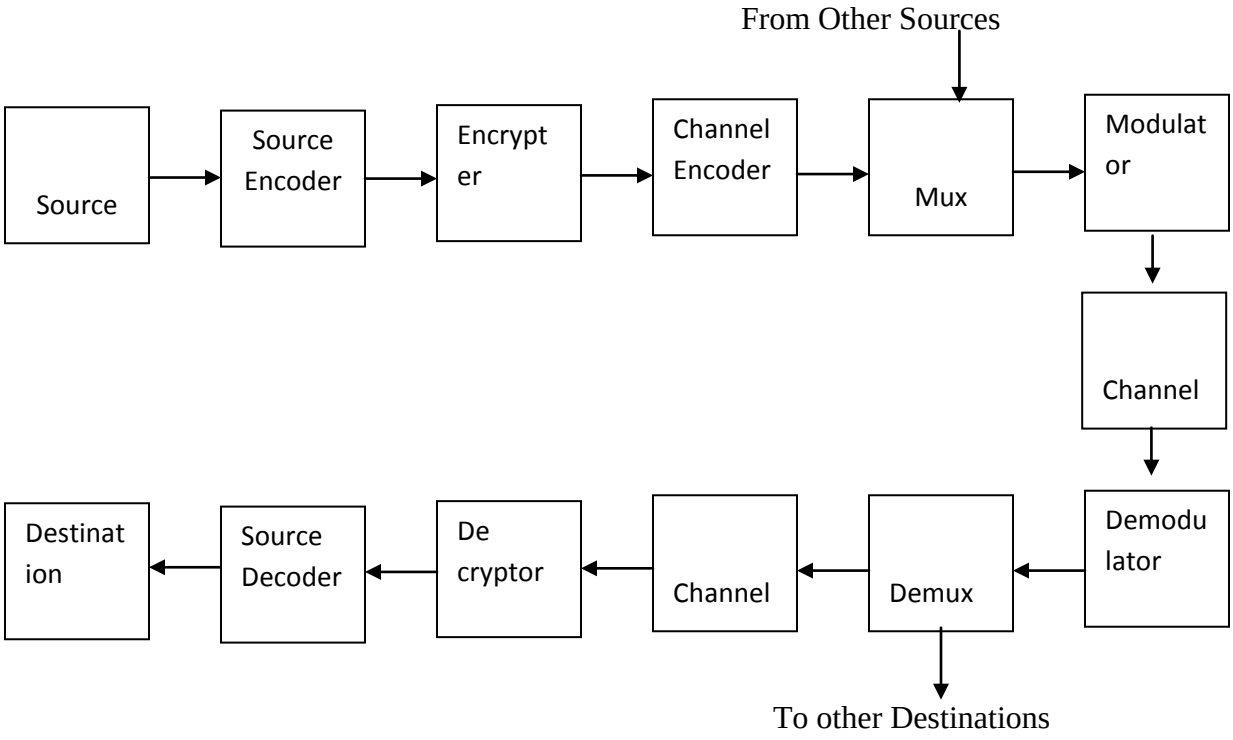

Fig 1.3 : Block diagram with additional blocks

Some additional blocks as shown in the block diagram are used in most of digital communication system:

- Encryptor: Encryptor prevents unauthorized users from understanding the messages and from injecting false messages into the system.

- MUX : Multiplexer is used for combining signals from different sources so that they share a portion of the communication system.

- DeMUX: DeMultiplexer is used for separating the different signals so that they reach their respective destinations.

- Decryptor: It does the reverse operation of that of the Encryptor.

Synchronization: Synchronization involves the estimation of both time and frequency coherent systems need to synchronize their frequency reference with carrier in both frequency and phase.

Advantages of Digital Communication

1. The effect of distortion, noise and interference is less in a digital communication system. This is because the disturbance must be large enough to change the pulse from one state to the other.

2. Regenerative repeaters can be used at fixed distance along the link, to identify and regenerate a pulse before it is degraded to an ambiguous state.

3. Digital circuits are more reliable and cheaper compared to analog circuits.

4. The Hardware implementation is more flexible than analog hardware because of the use of microprocessors, VLSI chips etc.

5. Signal processing functions like encryption, compression can be employed to maintain the secrecy of the information.

6. Error detecting and Error correcting codes improve the system performance by reducing the probability of error.

7. Combining digital signals using TDM is simpler than combining analog signals using FDM. The different types of signals such as data, telephone, TV can be treated as identical signals in transmission and switching in a digital communication system.

8. We can avoid signal jamming using spread spectrum technique.

Disadvantages of Digital Communication:

1. Large System Bandwidth:- Digital transmission requires a large system bandwidth to communicate the same information in a digital format as compared to analog format.

2. System Synchronization:- Digital detection requires system synchronization whereas the analog signals generally have no such requirement.

Channels for Digital Communications

The modulation and coding used in a digital communication system depend on the characteristics of the channel. The two main characteristics of the channel are BANDWIDTH and POWER. In addition the other characteristics are whether the channel is linear or nonlinear, and how free the channel is free from the external interference.

Five channels are considered in the digital communication, namely: telephone channels, coaxial cables, optical fibers, microwave radio, and satellite channels.

Telephone channel: It is designed to provide voice grade communication. Also good for data communication over long distances. The channel has a band-pass characteristic occupying the frequency range 300Hz to 3400hz, a high SNR of about 30db, and approximately linear response.

For the transmission of voice signals the channel provides flat amplitude response. But for the transmission of data and image transmissions, since the phase delay variations are important an equalizer is used to maintain the flat amplitude response and a linear phase response over the required frequency band. Transmission rates upto16.8 kilobits per second have been achieved over the telephone lines.

Coaxial Cable: The coaxial cable consists of a single wire conductor centered inside an outer conductor, which is insulated from each other by a dielectric. The main advantages of the coaxial cable are wide bandwidth and low external interference. But closely spaced repeaters are required. With repeaters spaced at 1km intervals the data rates of 274 megabits per second have been achieved.

Optical Fibers: An optical fiber consists of a very fine inner core made of silica glass, surrounded by a concentric layer called cladding that is also made of glass. The refractive index of the glass in the core is slightly higher than refractive index of the glass in the cladding. Hence if a ray of light is launched into an optical fiber at the right oblique acceptance angle, it is continually refracted into the core by the cladding. That means the difference between the refractive indices of the core and cladding helps guide the propagation of the ray of light inside the core of the fiber from one end to the other.

Compared to coaxial cables, optical fibers are smaller in size and they offer higher transmission bandwidths and longer repeater separations.

Microwave radio: A microwave radio, operating on the line-of-sight link, consists basically of a transmitter and a receiver that are equipped with antennas. The antennas are placed on towers at sufficient height to have the transmitter and receiver in line-of-sight of each other. The operating frequencies range from 1 to 30 GHz.

Under normal atmospheric conditions, a microwave radio channel is very reliable and provides path for high-speed digital transmission. But during meteorological variations, a severe degradation occurs in the system performance.

Satellite Channel: A Satellite channel consists of a satellite in geostationary orbit, an uplink from ground station, and a down link to another ground station. Both link operate at microwave

frequencies, with uplink the uplink frequency higher than the down link frequency. In general, Satellite can be viewed as repeater in the sky. It permits communication over long distances at higher bandwidths and relatively low cost.