Lab Manual #1

Introduction to DC and Probability Distribution of signals

Communication and it's Enhancements:

Communication can be defined as the imparting or exchange of information [Hanks]. Telecommunication refers to communication over a distance greater than would normally be possible without artificial aids. In the present day such aids are invariably electrical, electronic or optical and communication takes place by passing signals over wires, through optical fibres or by wireless transmission through space using electromagnetic waves.

Table 1.1 *Important events in the history of electronic communications.*

Year	*Event*	*Originator*	*Information*
1837	Line telegraphy perfected	Morse	Digital
1875	Telephone invented	Bell	Analogue
1887	Wireless telegraphy	Marconi	Digital
1897	Automatic exchange step by step switch	Strowger	
1905	Wireless telephony demonstrated	Fessenden	Analogue
1907	First regular radio broadcasts	USA	Analogue
1918	Superheterodyne radio receiver invented	Armstrong	Analogue
1928	All electronic television demonstrated	Farnsworth	Analogue
1928	Telegraphy signal transmission theory	Nyquist	Digital
1928	Information transmission	Hartley	Digital
1931	Teletype		Digital
1933	FM demonstrated	Armstrong	Analogue
1937	PCM proposed	Reeves	Digital
1939	Voice coder	Dudley	Analogue
1939	Commercial TV broadcasting	BBC	Analogue
1940	Spread spectrum proposed		Digital
1943	Matched filtering proposed	North	Digital
1945	Geostationary satellite proposed	Clarke	
1946	ARQ systems developed	Duuren	Digital
1948	Mathematical theory of communications	Shannon	
1955	Terrestrial microwave relay	RCA	Analogue
1960	First laser demonstrated	Maiman	
1962	Satellite communications implemented	TELSTAR 1	Analogue
1963	Geostationary satellite communications	SYNCOM II	Analogue
1966	Optical fibres proposed	Kao & Hockman	
1966	Packet switching		Digital
1970	Medium scale data networks	ARPA/TYMNET	Digital

1970	LANs, WANs and MANs		Digital
1971	The term ISDN coined	CCITT	Digital
1974	Internet concept	Cerf & Kahn	Digital
1978	Cellular FDMA radio		Analogue
1978	Navstar GPS launched	Global	Digital
1980	OSI 7 layer reference model adopted	ISO	Digital
1981	HDTV demonstrated	NHK, Japan	Digital
1985	ISDN basic rate access in UK	BT	Digital
1986	SONET/SDH introduced	USA	Digital
1991	GSM TDMA cellular system	Europe	Digital
1991	MPEG video standards	International	Digital
1992	ETSI formed	Europe	
1993	PCN concept launched	Worldwide	Digital
1994	IS-95 CDMA specification	Qualcom	Digital
1995	ADSL transmission	International	Digital
1998	Wideband 3G CDMA	ITU Standards	Digital
2000	IMT 2000/UMTS	International	Digital
2002	Smartphone (PDA)	Blackberry, Canada	Digital
2004	WiMAX	ITU Standard	Digital

for detail go to:
https://catalogue.pearsoned.co.uk/assets/hip/gb/hip_gb_pearsonhighered/samplechapter/Glover_Digital%20Comms_C01%20reduced%20file%20size.pdf

The basic need is to facilitate the **rapidly increasing demand of better and fast communication**. Increasing demand for traditional services (principally analogue voice communications) has been an important factor in the development of telecommunications technologies. Such developments, combined with more general advances in electronics and computing, have made possible the provision of entirely new (mainly digitally based) communications services.

Table 1.2 *Comparison of nominal bandwidths for several information signals.*

Information signal	*Bandwidth*
Speech telephony	4 kHz
High quality sound broadcast	15 kHz
TV broadcast (video)	6 MHz

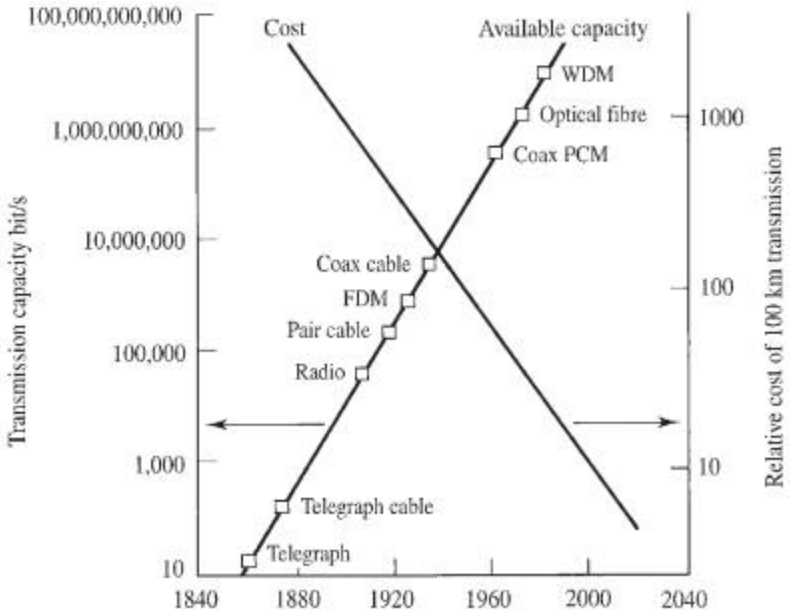
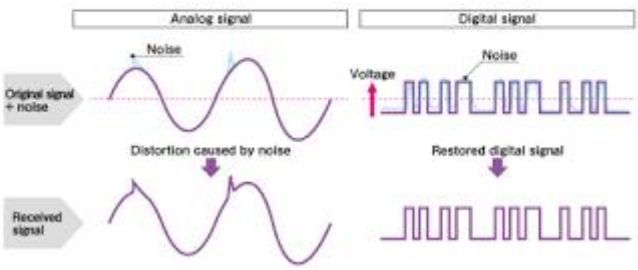


Figure 1.1 *Past and predicted growth of telecommunications traffic (source: Technical demographics, 1995, reproduced with permission of the IEE).*

Advantages of Digital Transmission

1. **Noise Immunity**: Digital signals are inherently less susceptible than analogue signals to interference caused by noise because with digital signals it is not necessary to evaluate precise amplitude, frequency or phase. Instead pulses are evaluated during the precise time interval and simple determination is made whether the pulse is above or below a prescribed reference level. Give Example?



2. **Multiplexing**: Digital signals are better suited than analogue signals for processing and combining using a technique multiplexing. Can you explain How?
3. **Transmission errors can be detected easily**: The transmission errors can be detected and corrected more easily and accurately than is possible with analogue signals. HOW?

Disadvantages of Digital Transmission

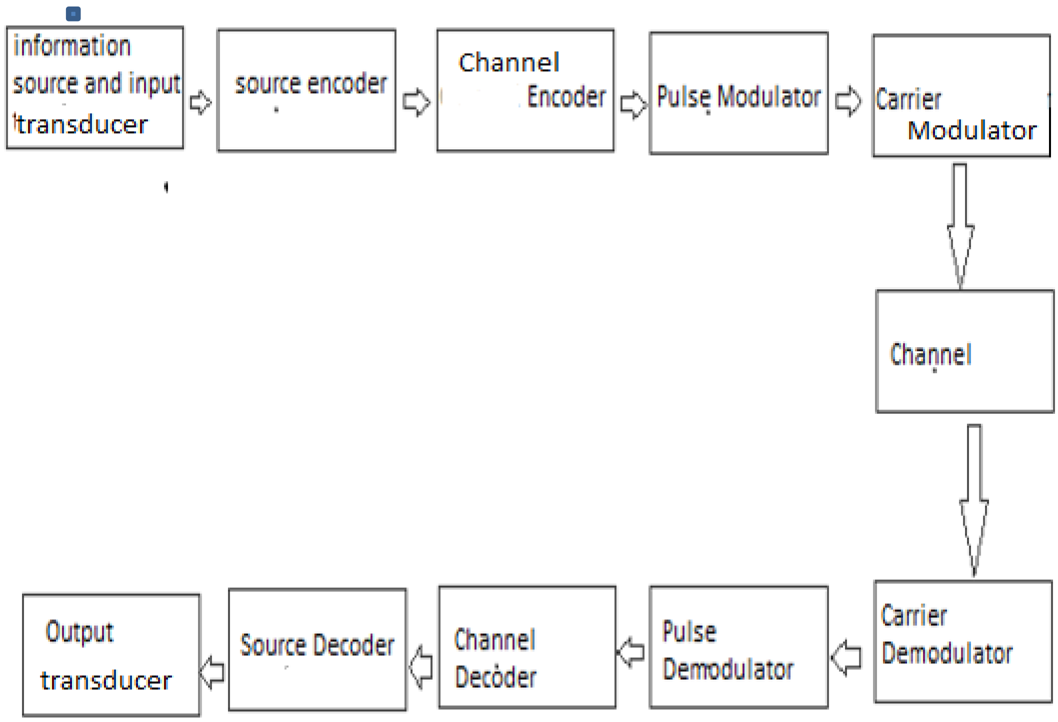
1. More Bandwidth Requirement: The transmission of digitally encoded original analogue signal. BW is one of the important aspects of any communication system because it is costly and limited.

2. Extra Circuitry for encoding and Decoding: Analog signals must be converted to digital pulses prior to transmissions and converted back to their original analogue form at receiver, thus require additional circuitry for encoding and decoding.

3. Require precise Synchronization: Digital transmissions require precise time synchronization between the clocks in transmitter and receiver. Why?

Basic Digital Communication System:

The whole digital communication system is divided as per the figure shown below.



Basic Elements of digital communication system

1. ***Information Source and Input Transducer:***

The source of information mostly always analog, e.g. analog: audio,ECG,EEG, or video signal. Every information that we collect is analogue.

2. ***Source Encoder***

In digital communication we convert the signal from source into digital signal as mentioned above. The point to remember is we should like to use as few binary digits as possible to represent the signal.

In such a way this efficient representation of the source output results in little or no redundancy. This sequence of binary digits is called ***information sequence.***

Source Encoding or Data Compression: the process of efficiently converting the output of wither analog or digital source into a sequence of binary digits is known as source encoding.

3. ***Channel Encoder:***

The information sequence is passed through the channel encoder. The purpose of the channel encoder is to introduce some redundancy in the binary information sequence that can be used at the receiver to overcome the effects of noise and interference encountered in the transmission on the signal through the channel.

e.g. take k bits of the information sequence and map that k bits to unique n bit sequence called code word. The amount of redundancy introduced is measured by the ratio *n/k* and the reciprocal of this ratio (k/n) is known as *rate of code or code rate.*

4. ***Pulse Modulator:***

The binary sequence is passed to digital modulator which in turns convert the sequence into electric signals so that we can transmit them on channel. The digital modulator maps the binary sequences into signal wave forms, for example we represent 1 by +5 and 0 by -5.

5. Carrier Modulator:

In electronics and telecommunications, **modulation** is the process of varying one or more properties of a periodic waveform, called the *carrier signal*, with a modulating signal that typically contains information to be transmitted.
In telecommunications, modulation is the process of conveying a message signal, for example a digital bit stream or an analogue audio signal, inside another signal that can be physically transmitted. Modulation of a sine waveform transforms a baseband message signal into a passband signal.

6. ***Channel:***

The communication channel is the physical medium that is used for transmitting signals from transmitter to receiver. In wireless system, this channel consists of atmosphere, for traditional telephony, this channel is wired, there are optical channels, under water acoustic channels etc.

We further discriminate this channels on the basis of their property and characteristics, like AWGN channel etc.

7. Carrier Demodulator:

Demodulation is extracting the original information-bearing signal from a modulated carrier wave. A **demodulator** is an electronic circuit (or computer program in a software-defined radio) that is used to recover the information content from the modulated carrier wave. There are many types of modulation so there are many types of demodulators. The signal output from a demodulator may represent sound (an analog audio signal), images (an analog video signal) or binary data (a digital signal).

8. ***Pulse Demodulator:***

The pulse demodulator processes the channel corrupted transmitted waveform and reduces the waveform to the sequence of numbers (1‘s and 0’s) that represents estimates of the transmitted data symbols.

9. ***Channel Decoder:***

This sequence of numbers then passed through the channel decoder which attempts to reconstruct the original information sequence from the knowledge of the code used by the channel encoder and the redundancy contained in the received data

The average probability of a bit error at the output of the decoder is a measure of the performance of communication system THIS IS THE MOST IMPORTANT POINT, BER (Bit Error Rate) will be discussed.

10. ***Source Decoder***

At the end, if an analog signal is desired then source decoder tries to decode the sequence from the knowledge of the encoding algorithm. And which results in the approximate replica of the input at the transmitter end.

11. ***Output Transducer:***

Finally we get the desired signal in desired format analog or (may be digital).

Probability Density Function of a Signal:

Probability Function

The probability function *P* is the probability that a certain event will occur. It is calculated based on the **probability density function** and **cumulative distribution function**, described below.

We can use the *P* operator in a variety of ways:

$$P[\text{A coin is heads}] = \frac{1}{2}$$
$$P[\text{A dice shows a 3}] = \frac{1}{6}$$

Probability Density Function

The Probability Density Function (PDF) of a random variable is a description of the distribution of the values of the random variable. By integrating this function over a particular range, we can find the probability that the random variable takes on a value in that interval. The integral of this function over all possible values is 1.

We denote the density function of a signal *x* as f_x. The probability of an event x_i will occur is given as:

$$P[x_i] = f_x(x_i)$$

Cumulative Distribution Function

The Cumulative Distribution Function (CDF) of a random variable describes the probability of observing a value at or below a certain threshold. A CDF function will be non-decreasing with the properties that the value of the CDF at negative infinity is zero, and the value of the CDF at positive infinity is 1.

We denote the CDF of a function with a capital F. The CDF of a signal *x* will have the subscript F_x.

We can say that the probability of an event occurring less than or equal to x_i is defined in terms of the CDF as:

$$P[x_i] = f_x(x_i)$$

The CDF and PDF are related to one another by a simple integral relation:

$$F_x(x) = \int_{-\infty}^{x} f_x(\tau)d\tau$$

TASKS:

Task: **Evaluate the Probability density and cumulative distribution function of a sinusoidal wave (both through matlab functions and simply by using loops)**

By taking a random variable, x=sin(2*pi*fm*t), where fm is the frequency say 1 Hz and t is [0:0.01:1].

Steps:

1: Generate Histogram of given signal x by using built in function hist(x,no_bins) and also by loops.

No_bins=total number of intervals in signal.(we will be finding probability in those interval ranges)

2: Using histogram create Probability Density Function (PDF).

3: Using PDF create cumulative Distribution function(CDF).

Google Drive:

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