Chapter 1

INTRODUCTION

Why Digital?

Why in military and commercial communication systems use digits ?

There are many reasons . the main advantage is the ease of restoring digital signals compared to analog .the pulse is amplified by a digital amplifier that restores its original ideal forum.

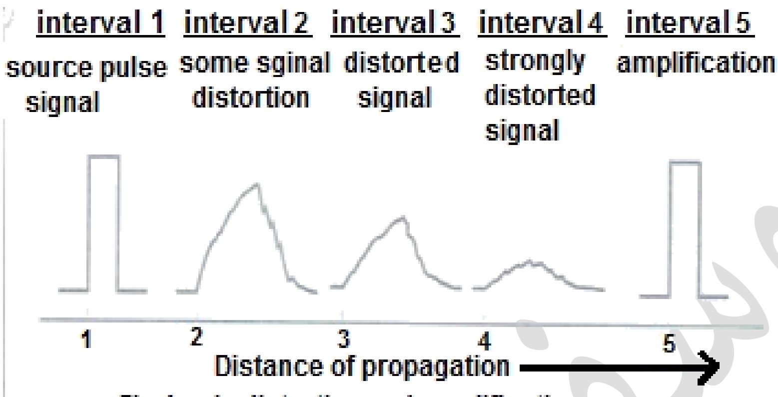


Fig.1 puls distortion and amplification

Digital channels are less prone to distortion and interference than analog channels. Since binary digital channels give a meaningful signal only when working in one of two states- on or off- The outrage must be sufficiently large ,to translate the channel work point from one state to another . Analogue signals , on the contrary , are not signals with two states ; they can take a countless number of forms . With the use of digital technologies , the very low error rate plus the use of detection and error correction procedures make it possible to achieve high signal accuracy .Digital channels are more reliable and can be produced at low prices , than analog . Besides, Digital software allows for more flexible implementation than analog (for example, microprocessor, digital switch, large scale integrated circuit).

Using digital signals and time division multiplexing (TDM) easier to use analog signal and frequency division multiplexing (FDM). During transmission and switching separate types of digital signal (data, telegraph, telephone, television) can be considered as identical ; after all-this bit is the bit. But digital systems require more intensive processing then analog. In addition, foe digital systems-it is necessary to allocate a significant amount of resources for synchronization at various levels. Conversely, analog systems are easier to synchronize.

Another drawback of digital communication systems is that deterioration in quality is of a threshold nature. If the ration S/N falls below a certain threshold, quality of service can jump from very good to very bad. In analog systems, the deterioration of quality occurs more smoothly.

In digital communication the message signal to be transmitted is digital in nature . This means that digital communication involves the transmission of information in digital form .

Model of a digital communication system

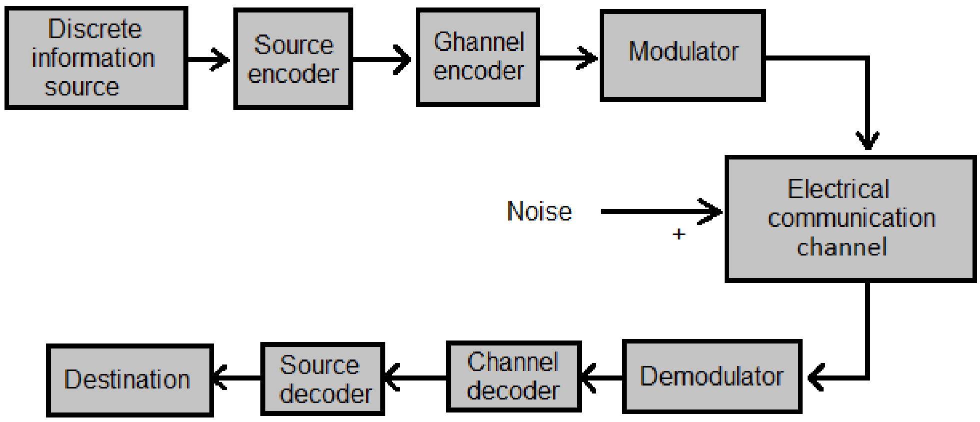


Fig.1 *Model of a Digital Communication System.*

The overall purpose of the system is to transmit the message or sequences of symbols coming out of a source to destination point at as high a rate and accuracy as possible .
Now let us have a detailed look at each of the functional blocks in a digital communication system .

1.Discrete information source

The output of discrete information sources such as a teletype or the numerical output of a computer consists of a sequence of discrete symbols or letters . Discrete information sources are characterized by the following parameters :

a. Source alphabet : These are the letters , digits or special characters available from the information source .
b. Symbol rate : It is the rate at which the information source generates source alphabets . (symbols / sec) .
c .Source alphabet probabilities : Hence probability of the occurrence of each source alphabet can become one of the important property which is useful in digital communication .
d. Probabilistic dependence of symbols in a sequence : The information carrying capacity of each source alphabet is different in a particular sequence . This parameter

defines average information content of the symbols . Entropy may be defined in terms of bits per symbols .

Information rate = Symbol rate * Source entropy
(bits/sec) (symbols/sec) (bits/symbol)

2.Source Encoder and Decoder

The symbols produced by the information source are given to the source encoder. These symbols cannot be transmitted directly. They are first converted into digital form (i.e., binary sequence of 1's and 0's) by the source encoder. Each binary '1' and '0' is known as a bit. The group of bits is called a code word. Source encoders must have following important parameters:

a-Block size

Block size describes the maximum number of distinct code words which can be represented by a source encoder. This depends on the number of bits in the code word. As an example, the block size of 8 bits source encoder will be 2^8, i.e. 256 code words.

b-Code word length

Code word length is the number of bits used to represent each code word. As an example, if 8 bits are assigned to each code ward, then the code word length will be 8 bits.

C- Average data rate

Average data rate is the output bits per second from the source encoder .

Data rate = Symbol rate * code word length
= 10* 8

Data rate = 80 bits / seconds

Also , since the information rate is the minimum number of bits per second needed to convey information from source to destination .

d- Efficiency of the Encoder

The efficiency of the encoder is the ratio of minimum source information rate to the actual output data rate of the source encoder .

3- Channel Encoder and Decoder

After converting the message or information signal in the form of binary source encoder , the signal is transmitted through the channel .The communication channel adds noise and interference to the signal being transmitted .Hence errors are introduced in the binary sequence received at the receiver end .This means that the channel encoder and coder serve to increase the a reliability of a received signal . The coding and decoding operation at the encoder and decoder needs the memory and processing of binary data .

Output of Source encoder			Bit to be added channel encoder for an even parity	Output of a Channel encoder			
b_3	b_2	b_1	b_0	b_3	b_2	b_1	b_0
1	0	0	0	1	0	0	0
0	1	0	1	0	1	0	1
0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1
	:		:		:		
	:		:		:		

A channel encoder must have the following important parameters:

a)The coding rate that depends upon the redundant bits added by the cannel encoder .
b)The coding method used.
c)Coding efficiency which is the ratio of data rate at the input to the data rate at the output of the encoder.
d)Error control capabilities.
e)Feasibility of the encoder and decoder.

4.Digital Modulators and Demodulators

If the modulation signal is digital ,then digital modulation techniques are used. The carrier signal used by digital modulation is a always continuous sinusoidal wave of high frequency . A digital modulation method must have following important parameters :
a-Bandwidth needed to transmit the signal ,
b-Probability of symbol or bits error ,
c-Synchronous or asynchronous method of detection,
d-Complexity of implementation .
5. Communication channel has some inherent problems .These are :
a- Signal attenuation.
b- Amplitude and phase distortion .
c- Additive noise interference .
d- Multipath distortion .

ADVANTAGES AND DISADVANTAGES OF DIGITAL COMMUNICATION

Advantages:

1.The digital communication systems are simpler and cheaper compared to analog communication systems because of the advances made in the IC technologies.
2. In digital communication, the speech, video and other data may be merged and transmitted over a common channel using multiplexing.
3. Using data encryption, only permitted receivers may be allowed to detect the transmitted data. This property is of its most importance in military applications.
4. Since the transmission is digital and the channel encoding is used, therefore the noise does not accumulate from repeater to repeater in long distance communications.
5. Since the transmitted signal is digital in nature, therefore a large amount of noise interference may be tolerated.

6. Since in digital communication, channel coding is used, therefore the errors may be detected and corrected in the receivers.
7. Digital communication is adaptive to other advanced branches of data processing such as digital signal processing, image processing and data compression, etc.

Disadvantages

1-Due to analog to digital conversion, the data rate becomes high. Therefore more transmission bandwidth is required for digital communication.
2-Digital communication needs synchronization in case of synchronous modulation.

Performance Comparison of Analog and Digital Modulation

S.NO.	Analog modulation	Digital modulation
(a)	Transmitted modulated signal is analog in nature.	Transmitted signal is digital, i.e. train of digital pulses.
(b)	Amplitude, frequency or phase variations in the transmitted signal represent the information or message.	Amplitude, width or position of the transmitted pulses is constant. The message is transmitted in the form of code words.
(c)	It is not possible to separate out noise and signal. Therefore, repeaters cannot be used.	It is possible to separate signal form noise. Therefore, repeaters can be used.
(d)	Coding is not possible.	Coding techniques can be used to detect and correct the errors.
(e)	Bandwidth required is lower that for the digital modulation methods.	Due to higher bit rates, higher channel bandwidth is required.
(f)	FDM is used for multiplexing.	TDM is used for multiplexing.
(g)	Not suitable for transmission of secret information in military applications.	Due to coding techniques, it is suitable for military applications.
(h)	Analog modulation systems are AM FM, PM, PAM, PWM, etc.	Digital modulation systems are PCM, DM, ADM, DPCM, etc.

Signals may be classified as under:

a. Continuous –time and discrete – time signals .

b. Real and complex signals.

c. Deterministic and random signals.

d. Periodic and Non – periodic signals.

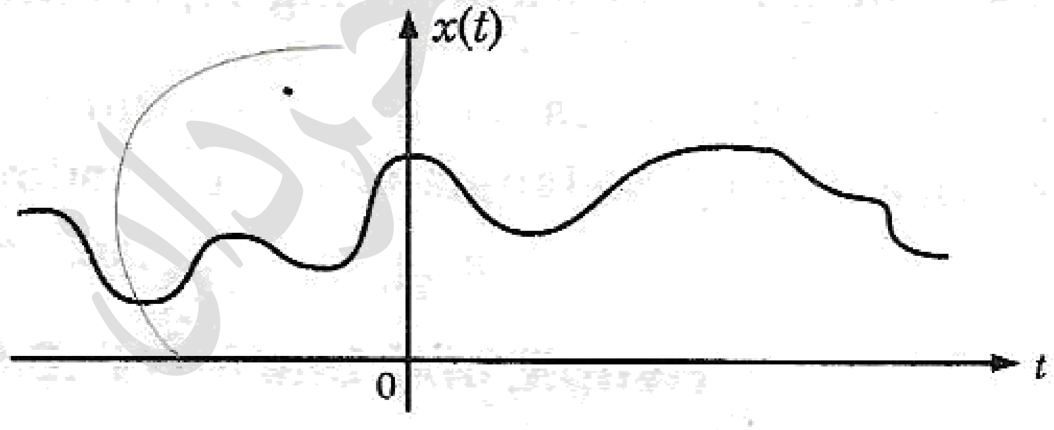
e. Even and odd signals.

f. Energy and power signals.

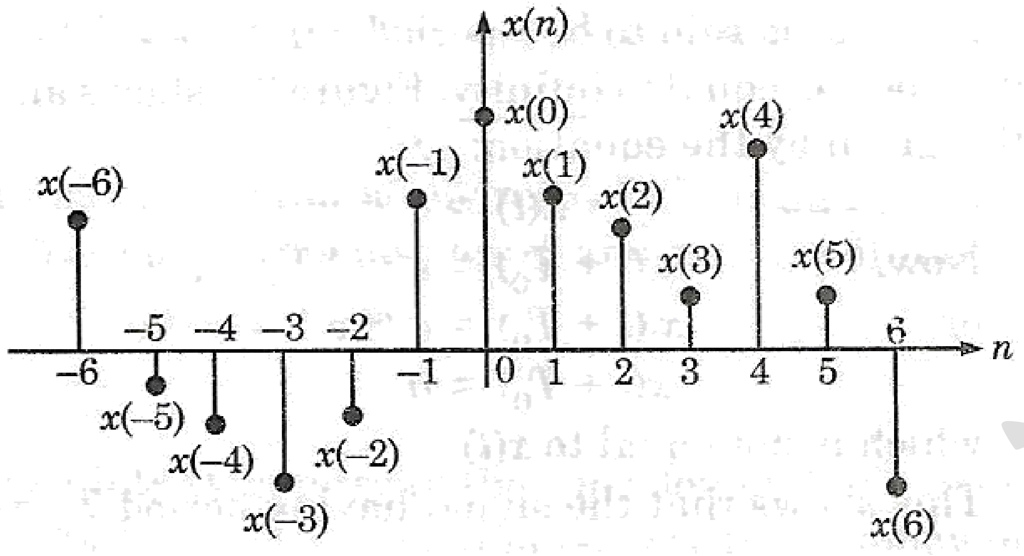
g. Analog and digital signals.

a. Continuous – time and Discrete – time signals

A signal x(t) is a continuous – time signal if t is a continuous variable . This means that a continuous – signal is defined continuously in the time – domain . On the other hand , if time t is a discrete variable , i. e. x(t) is defined at discrete times , then x(t) is a discrete – time signal . since a discrete – time signal is defined at discrete times , it is often identified as a sequence of numbers is denoted by x(n) , where n = integer . figure 2. 1 shows the graph of continuous – time and discrete – time signal.



(a) A continuous-time signal



(b) A discrete-time signal

b. Real and complex signals

A signal x(t) is a real signal if its value is a real number . Similarly , a signal x(t) is a complex signal if its value is a complex number

c. Deterministic and random signals

The nature and amplitude of deterministic signals at any time can be predicted .

A typical example of a random signal is thermal noise , generated in an electrical circuit . such a noise signal has probabilistic behavior .

d. Periodic and Aperiodic signals

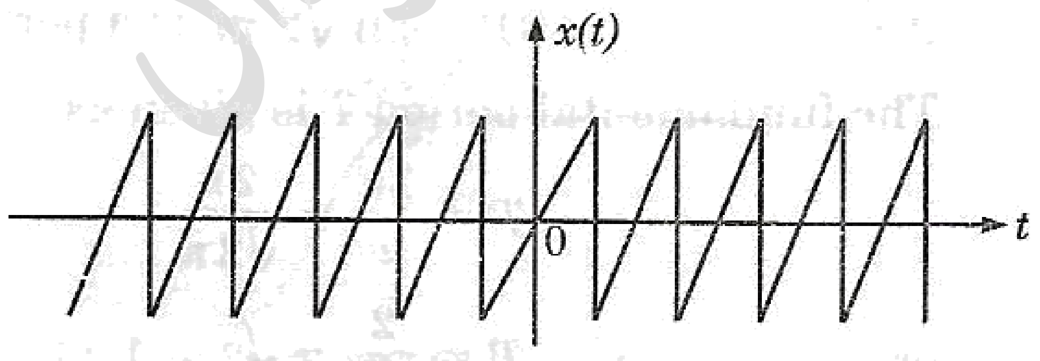


Fig. 2.2 *A periodic signal*

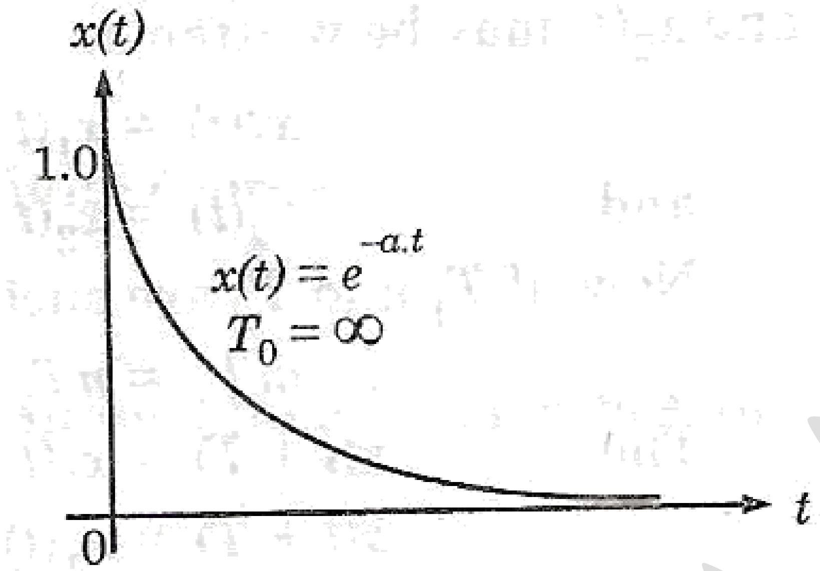


Fig. 2.3 An aperiodic signal

A periodic signal is that type of signal which has a definite pattern and repeats over and over with a repetition period of T .

$$x\ (t + T) = x(t), -\infty\ < t\ <\ \infty$$

T is the period of the signal . The smallest value of period T which satisfies above equation is called the fundamental period T0 . Fig 2 .2 shows a periodic signal .

A signal is said to be Aperiodic if it does not repeat . Some times aperiodic signals are said to pulse given by the equation :

$$x(t) = e^{-at}$$

$$x(t + T0) = e^{-a(t+T0)} = e^{-a(t+\infty)}$$

$$x(t + T0) = e^{-at} . e^{-\infty} = e^{-at} .0$$

$$x(t + T_0) = 0$$

Which is not equal to x(t) . This shows that the signal having period $T_0=\infty$ is nothing but a periodic signal .

EXAMPLE 2.1 Determine whether the following signals are periodic or not:

a. x(t)=sin 15πt

b. x(t)=sin √2πt

Solution: (a) x(t)=sin 15πt is a periodic signals.

The fundamental period T is given as

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{15\pi}$$

Or

T=0.133 seconds Ans.

[ω=15 π]

(b) x(t)=sin√2 πt is a period signal.

The fundamental period T is given as

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{2}\pi} \qquad [\omega=\sqrt{2}\,\pi]$$

Or

$T= \frac{2}{\sqrt{2}}=\sqrt{2}=1.41$ seconds Ans.

e. Even and Odd signal

An even signal is that type of signal which exhibits symmetry in the time domain.

Mathematically ,

$$x(t) = x(-t)$$

An odd signal is that type of signal which exhibits anti- symmetry .

Mathematically ,

$$x(t) = -(-t)$$

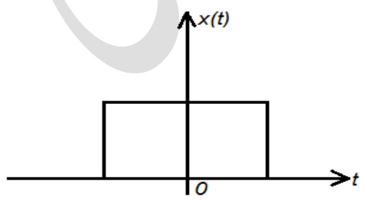


Fig.2.4 Even signal

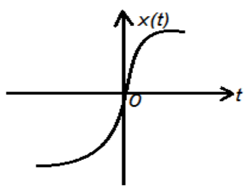


Fig.2.5 Odd signal

f. Energy and power signals

The energy signal is one which has finite energy and zero average power . The power signal , is one which has finite average power and infinite energy .

Hence , $x(t)$ is a power signal if : $0 < P < \infty \; and \; E = \infty$

Unit Impulse Function

An Unit Impulse Function is one of the most important functions in the analysis of signals and system . This function was invented by (PAM) called Delta function . Mathematically ,

$\delta(t) = 0 \; , t \neq 0$

And

$$\int_{-\infty}^{\infty} \delta(t)\, dt = 1$$

Shifting property of the Impulse Function

If we take the product of unit impulse function $\delta(t)$ and any give function $x(t)$ existing only at $t = 0$ since $\delta(t)$ exists only at $t = 0$.

Mathematically ,

$\int_{-\infty}^{\infty} x(t)\, \delta(t)\, dt = x(0) \;\; \int_{-\infty}^{\infty} \delta(t)\, dt = x(0).$

The shifting or sampling may also be done at any instant $t=t_0$ if we define the impulse function at the instant t_o , Mathematically

$$\int \boldsymbol{x(t)\, \infty\, (t - t_0)\, dt = x(t_0)}$$

EXAMPLE 1 Solve the following integral

$$\int_{-\infty}^{\infty} [t^2 + 1]\, \delta(t) dt.$$

Solution : The given integral may be written as

$$\int_{-\infty}^{\infty} [\, t^2 + 1]\, \delta(t)\, dt = \int_{-\infty}^{\infty} t^2\, \delta(t)\, dt + \int_{-\infty}^{\infty} \delta(t)\, dt$$

Using shifting property of impulse function for first factor

$$\int_{-\infty}^{\infty} [t^2 + 1]\, \delta(t)\, dt = [t^2]_{at\; t=0} + 1$$

= 0+1= 1

EXAMPLE (2) Find the Fourier transform of an impulse function

$$x(t) = \delta(t)$$

Solution : The expression for Fourier transform is given by

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

Using shifting property of impulse function

$$x(\omega) = [e^{-j\omega t}]_{at\ \ t=0}$$

$$x(\omega) = 1$$

$$\delta(t) \leftrightarrow 1$$

$$[\delta(t) exits\ at\ t = 0]$$