CHAPTER 6. DIGITAL AND DATA COMMUNICATION

6.0 Introduction to Digital Communication

In the design of large and complex digital systems, it is often necessary to have one device communicate digital information to and from other devices. One advantage of digital information is that it tends to be far more resistant to transmitted and interpreted errors than information symbolized in an analog medium. This accounts for the clarity of digitally encoded telephone connections, compact audio disks, and for much of the enthusiasm in the engineering community for digital communications technology. However, digital communication has its own unique pitfalls, and there are multitudes of different and incompatible ways in which it can be sent. Hopefully, this chapter will enlighten you as to the basics of digital communication, its advantages, disadvantages, and practical considerations

- Digital communication needs synchronization in synchronous modulation.
- High power consumption.
- It required more bandwidth as compared to analog systems.
- It has sampling error.
- Complex circuit, more sophisticated device making is also disadvantage of digital system.

There is lots of talk nowadays about buzzwords such as "Analog" and "Digital". Certainly, engineers who are interested in creating a new communication system should understand the difference. Which is better, analog or digital? What is the difference? What are the pros and cons of each? This chapter will look at the answers to some of these questions.

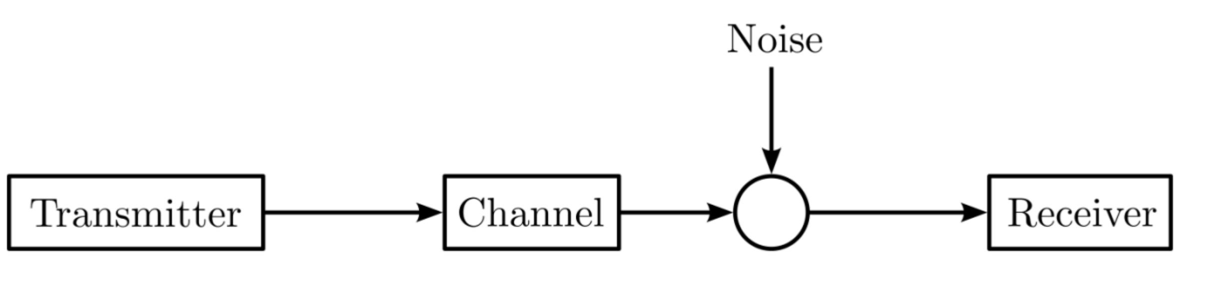

Fig. 6.1 Basic Block Diagram of Electronic Communication System

What exactly is an analog signal, and what is a digital signal ?

6.1.1 Analog Communication system

Analog signals are continuous in both time and value. Analog signals are used in many systems, although the use of analog signals has declined with the advent of cheap digital signals. All natural signals are Analog in nature or analog signal is that signal which amplitude on Y axis change with time on X axis...

6.1.2 Digital Communication system

Digital signals are discrete in time and value. Digital signals are signals that are represented by binary numbers, "1" or "0". The 1 and 0 values can correspond to different discrete voltage values, and any signal that *doesn't quite fit* into the scheme just gets rounded off.

or digital signal is that signal which have certain or fixed value on Y axis change with time on X axis...

Digital signals are sampled, quantized & encoded version of continuous time signals which they represent. In addition, some techniques also make the signal undergo encryption to make the system more tolerant to the channel.

6.2 BLOCK DIAGRAM OF DIGITAL COMMUNICATION SYSTEM

Up to this point we have described an electrical communication system in rather broad terms based on the implicit assumption that the message signal is a continuous time-varying waveform. We refer to such continuous-time signal waveforms as analog signals and to the corresponding information sources that produce such signals as analog sources. Analog signals can be transmitted directly via carrier modulation over the communication channel and demodulated accordingly at the receiver. We call such a communication system an analog communication system.

Alternatively, an analog source output may be converted into a digital form and the message can be transmitted via digital modulation and demodulated as a digital signal at the receiver. There are some potential advantages to transmitting an analog signal by means of digital modulation. The most important reason is that signal fidelity is better controlled through digital transmission than analog transmission. In particular, digital transmission allows us to regenerate the digital signal in long-distance transmission, thus eliminating effects of noise at each regeneration point. In contrast, the noise added in analog transmission is amplified along with the signal when amplifiers are used periodically to boost the signal level in long-distance transmission. Another reason for choosing digital transmission over analog is that the analog message signal may be highly redundant. With digital processing, redundancy may be removed prior to modulation, thus conserving channel bandwidth. Yet a third reason may be that digital communication systems are often cheaper to implement.

In some applications, the information to be transmitted is inherently digital; e.g., in the form of English text, computer data, etc. In such cases, the information source that generates the data is called a discrete (digital) source.

In a digital communication system, the functional operations performed at the transmitter and receiver must be expanded to include message signal discretization at the transmitter and message signal synthesis or interpolation at the receiver. Additional functions include redundancy removal, and channel coding and decoding.

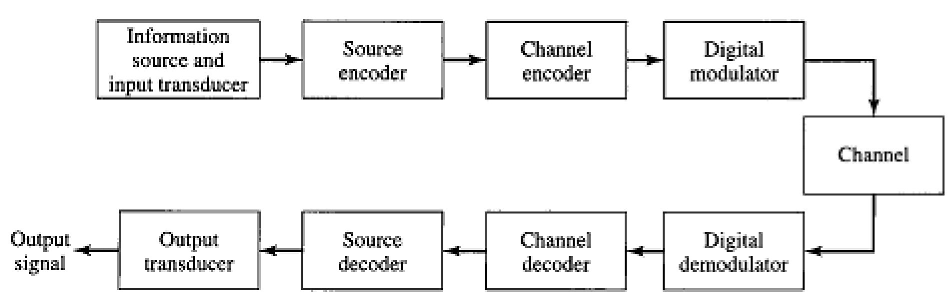

Fig. 6.2 Block Diagram of Digital Communication System

6.3 ADVANTAGES OF DIGITAL COMMUNICATION

There are some important advantages of digital communication are given below,

- Digital communication can be done over large distances though internet and other things.
- Digital communication gives facilities like video conferencing which save a lot of time, money and effort.
- It is easy to mix signals and data using digital techniques.
- The digital communication is fast, easier and cheaper.
- It can be tolerated the noise interference.
- It can be detect and correct error easily because of channel coding.
- Used in military application.
- It has excellent processing techniques are available for digital signals such as data compression, image processing, channel coding and equalization etc.

6.4 DISADVANTAGES OF DIGITAL COMMUNICATION

- Digital communication needs synchronization in synchronous modulation.
- High Power consumption.
- It required more bandwidth as compared to Analog systems.
- It has sampling error.
- Complex circuit, more sophisticated device making is also disadvantage of digital system.

6.5 DIFFERENCE BETWEEN DIGITAL AND TRANSMISSION

Analog and **digital** signals are used to transmit information, usually through electric signals. In both these technologies, the information, such as any audio or video, is transformed into electric signals. The **difference between analog and digital** technologies is that in analog technology, information is translated into electric pulses of varying amplitude. In digital technology, translation of information is into binary format (zero or one) where each bit is representative of two distinct amplitudes.

Comparison chart

Definitions of Analog vs. Digital signals

An **Analog signal** is any continuous signal for which the time varying feature (variable) of the signal is a representation of some other time varying quantity, i.e., analogous to another time varying signal. It differs from a digital signal in terms of small fluctuations in the signal which are meaningful.

A **digital signal** uses discrete (discontinuous) values. By contrast, non-digital (or analog) systems use a continuous range of values to represent information. Although digital representations are discrete, the information represented can be either discrete, such as numbers or letters, or continuous, such as sounds, images, and other measurements of continuous systems.

Differences in Applications

Digital technology has been most efficient in cellular phone industry. Analog phones have become redundant even though sound clarity and quality was good.

Analog technology comprises of natural signals like human speech. With digital technology this human speech can be saved and stored in a computer. Thus digital technology opens up the horizon for endless possible uses.

6.6 DATA COMMUNICATION

Definition - What does Data Communications (DC) mean?

Data communications (DC) is the process of using computing and communication technologies to transfer data from one place to another, and vice versa. It enables the movement of electronic or digital data between two or more nodes, regardless of geographical location, technological medium or data contents.

Techopedia explains Data Communications (DC)

Data communications incorporates several techniques and technologies with the primary objective of enabling any form of electronic communication. These technologies include telecommunications, computer networking and radio/satellite communication. Data communication usually requires existence of a transportation or communication medium between the nodes wanting to communicate with each other, such as copper wire, fiber optic cables or wireless signals.

For example, a common example of data communications is a computer connected to the Internet via a Wi-Fi connection, which uses a wireless medium to send and receive data from one or more remote servers.

Some devices/technologies used in data communications are known as data communication equipment (DCE) and data terminal equipment (DTE). DCE is used at the sending node, and DTE is used at the receiving node.

6.7 DATA COMMUNICATION MODEL

To discuss computer networking, it is necessary to use terms that have special meaning. Even other computer professionals may not be familiar with all the terms in the networking alphabet soup. As is always the case, English and computer-speak are not equivalent (or even necessarily compatible) languages. Although descriptions and examples should make the meaning of the networking jargon more apparent, sometimes terms are ambiguous. A common frame of reference is necessary for understanding data communications terminology.

An architectural model developed by the International Standards Organization (ISO) is frequently used to describe the structure and function of data communications protocols. This architectural model, called the *Open Systems Interconnect (OSI) Reference Model*, provides a common reference for discussing communications. The terms defined by this model are well understood and widely used in the data communications community—so widely used, in fact, that it is difficult to discuss data communications without using OSI's terminology.

The OSI Reference Model contains seven *layers* that define the functions of data communications protocols. Each layer of the OSI model represents a function performed when data is transferred between cooperating applications across an intervening network. Figure 1-1 identifies each layer by name and provides a short functional description for it. Looking at this figure, the protocols are like a pile of building blocks stacked one upon another. Because of this appearance, the structure is often called a *stack* or *protocol stack.*

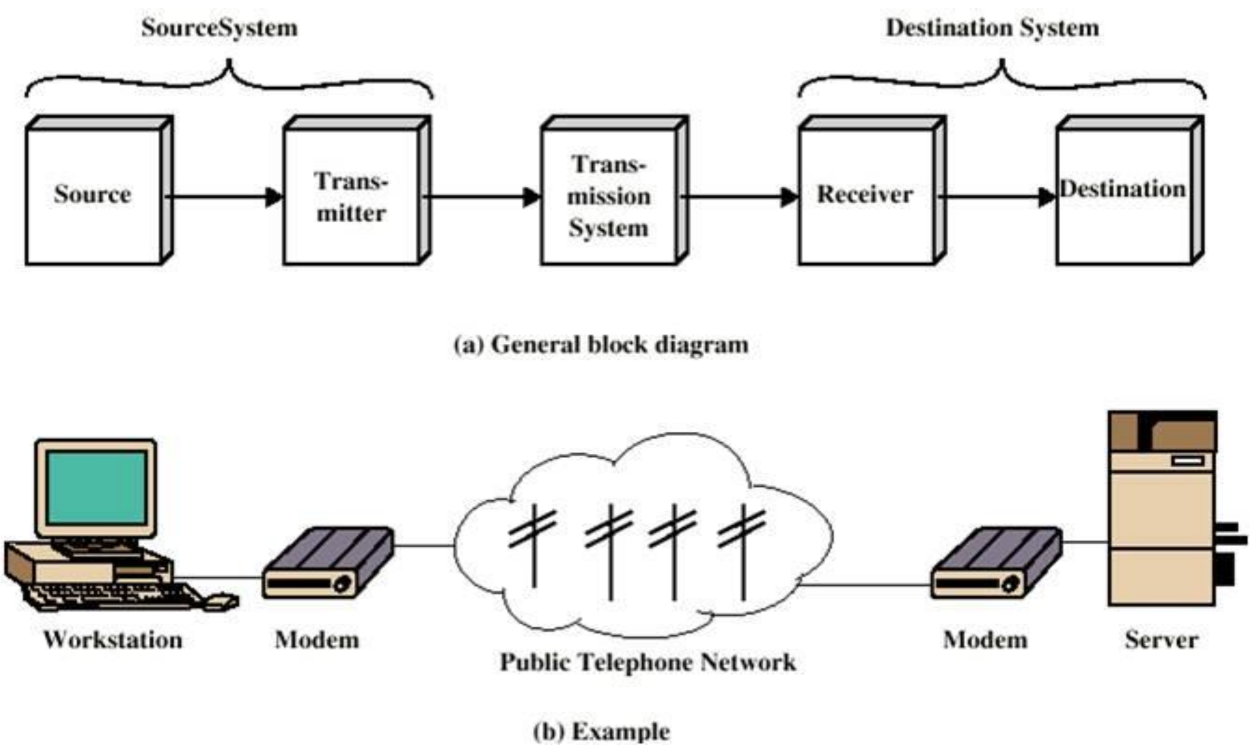

Fig.6.5 Block diagram of data communication System

6.8 DATA COMMUNICATION PRINCIPLES

This course provides an introduction to the field of data communications and computer networks. The course covers the principles of data communications, the fundamentals of signaling, basic transmission concepts, transmission media, circuit control, line sharing techniques, physical and data link layer protocols, error detection and correction, data compression, common carrier services and data networks, and the mathematical techniques used for network design and performance analysis. Potential topics include analog and digital signaling; data encoding and modulation; Shannon channel capacity; synchronous and asynchronously transmission; RS232 physical layer interface standards; FDM, TDM, and STDM multiplexing techniques; inverse multiplexing; analog and digital transmission; V series modem standards; PCM encoding and T1 transmission circuits; LRC, VRC, and CRC error detection techniques; Hamming and Viterbi forward error correction techniques; BSC and HDLC data link layer protocols; Huffman, MNP5, and V.42bis data compression algorithms; circuit, message, packet, and cell switching techniques; public key and symmetric encryption algorithms, authentication, digital signature, and message digest techniques, secure e-mail, PGP, and TSL/SSL security algorithms; Ethernet, Wi-Fi, Optical, and IP networks; reliability and availability; and queuing analysis network performance techniques.

6.8.1 Digital Data Transmission

Data transfer" redirects here. For sharing data between different programs or schemas, see Data exchange.

Data transmission also data communication or digital communications is the transfer of data (a digital bitstream or a digitized analog signal[1]) over a point-to-point or point-to-multipoint communication channel. Examples of such channels are copper wires, optical fibers, wireless communication channels, storage media and computer buses. The data are represented as an electromagnetic signal, such as an electrical voltage, radiowave, microwave, or infrared signal.

Analog or analogue transmission is a transmission method of conveying voice, data, image, signal or video information using a continuous signal which varies in amplitude, phase, or some other property in proportion to that of a variable. The messages are either represented by a sequence of pulses by means of a line code (*baseband transmission*), or by a limited set of continuously varying wave forms (*passband transmission*), using a digital modulation method. The passband modulation and corresponding demodulation (also known as detection) is carried out by modem equipment. According to the most common definition of digital signal, both baseband and passband signals representing bit-streams are considered as digital transmission, while an alternative definition only considers the baseband signal as digital, and passband transmission of digital data as a form of digital-to-analog conversion.

Data transmitted may be digital messages originating from a data source, for example a computer or a keyboard. It may also be an analog signal such as a phone call or a video signal, digitized into a bit-stream for example using pulse-code modulation (PCM) or more advanced source coding (analog-to-digital conversion and data compression) schemes. This source coding and decoding is carried out by codec equipment.

Distinction between related subjects

Courses and textbooks in the field of *data transmission* as well as *digital transmission* and *digital communications* have similar content.

Digital transmission or data transmission traditionally belongs to telecommunications and electrical engineering. Basic principles of data transmission may also be covered within the computer science/computer engineering topic of data communications, which also includes computer networking or computer communication applications and networking protocols, for example routing, switching and inter-process communication. Although the Transmission control protocol (TCP) involves the term "transmission", TCP and other transport layer protocols are typically *not* discussed in a textbook or course about data transmission, but in computer networking.

The term tele transmission involves the analog as well as digital communication. In most textbooks, the term analog transmission only refers to the transmission of an analog message signal (without digitization) by means of an analog signal, either as a non-modulated baseband signal, or as a passband signal using an analog modulation method such as AM or FM. It may also include analog-over-analog pulse modulatated baseband signals such as pulse-width modulation. In a few books within the computer networking tradition, "analog transmission" also refers to passband transmission of bit-streams using digital modulation methods such as FSK, PSK and ASK. Note that these methods are covered in textbooks named digital transmission or data transmission, for example.

Applications and history

Data (mainly but not exclusively informational) has been sent via non-electronic (e.g. optical, acoustic, mechanical) means since the advent of communication. Analog signal data has been sent electronically since the advent of the telephone. However, the first data electromagnetic transmission applications in modern time were telegraphy (1809) and teletypewriters (1906), which are both digital signals. The fundamental theoretical work in data transmission and information theory by Harry Nyquist, Ralph Hartley, Claude Shannonand others during the early 20th century, was done with these applications in mind.

Data transmission is utilized in computers in computer buses and for communication with peripheral equipment via parallel ports and serial ports such as RS-232 (1969), Firewire(1995) and USB (1996). The principles of data transmission are also utilized in storage media for Error detection and correction since 1951.

Data transmission is utilized in computer networking equipment such as modems (1940), local area networks (LAN) adapters (1964), repeaters, repeater hubs, microwave links, wireless network access points (1997), etc.

In telephone networks, digital communication is utilized for transferring many phone calls over the same copper cable or fiber cable by means of Pulse code modulation (PCM), i.e. sampling and digitization, in combination with Time division multiplexing (TDM) (1962). Telephone exchanges have become digital and software controlled, facilitating many value added services.

For example, the first AXE telephone exchange was presented in 1976. Since the late 1980s, digital communication to the end user has been possible using Integrated Services Digital Network (ISDN) services. Since the end of the 1990s, broadband access techniques such as ADSL, Cable modems, fiber-to-the-building (FTTB) and fiber-to-the-home (FTTH) have become widespread to small offices and homes. The current tendency is to replace traditional telecommunication services by packet mode communication such as IP telephony and IPTV.

Transmitting analog signals digitally allows for greater signal processing capability. The ability to process a communications signal means that errors caused by random processes can be detected and corrected. Digital signals can also be sampled instead of continuously monitored. The multiplexing of multiple digital signals is much simpler to the multiplexing of analog signals.

Because of all these advantages, and because recent advances in wideband communication channels and solid-state electronics have allowed scientists to fully realize these advantages, digital communications has grown quickly. Digital communications is quickly edging out analog communication because of the vast demand to transmit computer data and the ability of digital communications to do so.

The digital revolution has also resulted in many digital telecommunication applications where the principles of data transmission are applied. Examples are second-generation (1991) and later cellular telephony, video conferencing, digital TV (1998), digital radio (1999), telemetry, etc.

Data transmission, digital transmission or digital communications is the physical transfer of data (a digital bit stream or a digitized analog signal[1]) over a point-to-point or point-to-multipoint communication channel. Examples of such channels are copper wires, optical fibers, wireless communication channels, storage media and computer buses. The data are represented as an electromagnetic signal, such as an electrical voltage, radiowave, microwave, or infrared signal.

While analog transmission is the transfer of a continuously varying analog signal over an analog channel, digital communications is the transfer of discrete messages over a digital or an analog channel. The messages are either represented by a sequence of pulses by means of a line code (baseband transmission), or by a limited set of continuously varying wave forms (passband transmission), using a digital modulation method. The passband modulation and corresponding demodulation (also known as detection) is carried out by modem equipment. According to the most common definition of digital signal, both baseband and passband signals representing bit-streams are considered as digital transmission, while an alternative definition only considers the baseband signal as digital, and passband transmission of digital data as a form of digital-to-analog conversion.

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Serial and parallel transmission

In telecommunications, serial transmission is the sequential transmission of signal elements of a group representing a character or other entity of data. Digital serial transmissions are bits sent over a single wire, frequency or optical path sequentially. Because it requires less signal processing and less chances for error than parallel transmission, the transfer rate of each individual path may be faster. This can be used over longer distances as a check digit or parity bit can be sent along it easily.

In telecommunications, parallel transmission is the simultaneous transmission of the signal elements of a character or other entity of data. In digital communications, parallel transmission is the simultaneous transmission of related signal elements over two or more separate paths. Multiple electrical wires are used which can transmit multiple bits simultaneously, which allows for higher data transfer rates than can be achieved with serial transmission. This method is used internally within the computer, for example the internal buses, and sometimes externally for such things as printers, The major issue with this is "skewing" because the wires in parallel data transmission have slightly different properties (not intentionally) so some bits may arrive before others, which may corrupt the message. A parity bit can help to reduce this. However, electrical wire parallel data transmission is therefore less reliable for long distances because corrupt transmissions are far more likely.

Asynchronous and synchronous data transmission

Asynchronous start-stop transmission uses start and stop bits to signify the beginning bit ASCII character would actually be transmitted using 10 bits. For example, "0100 0001" would become "**1** 0100 0001 **0**". The extra one (or zero, depending on parity bit) at the start and end of the transmission tells the receiver first that a character is coming and secondly that the character has ended. This method of transmission is used when data are sent intermittently as opposed to in a solid stream. In the previous example the start and stop bits are in bold. The start and stop bits must be of opposite polarity.[*citation needed*] This allows the receiver to recognize when the second packet of information is being sent.

Synchronous transmission uses no start and stop bits, but instead synchronizes transmission speeds at both the receiving and sending end of the transmission using clocksignal(s) built into each component.[*vague*] A continual stream of data is then sent between the two nodes. Due to there being no start and stop bits the data transfer rate is quicker although more errors will occur, as the clocks will eventually get out of sync, and the receiving device would have the wrong time that had been agreed in the protocol for sending/receiving data. so some bytes could become corrupted (by losing bits). Ways to get around this problem include re-synchronization of the clocks and use of check digits to ensure the byte is correctly interpreted and received