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CHAPTER 5

DATE TRANSMISSION

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5.1 TRANSMISSION TYPES

The term data transmission and telemetry refers to the process by which the information regarding the quantity being measured is transmitted to a removed location for applications like data processing, recording or displaying. This may involve transduction of the quantity with the help of transducers and in addition, signal conditioning also.

The transmission of a measured variable from the point of measurement to a remote point is an important function in instrumentation systems because of the size and complexity of modern industrial plants. The most common variable encountered in industrial plants are; temperature, pressure and flow. The measuring elements can be pressure springs, thermocouples, bellows, floats etc. Most measuring device such as mercury thermometers, pressure gauges or flow rate meters would require fluid line connections of great length. This cannot be done because it would result in excessive measuring lags. Hence some form of transmission must be employed.

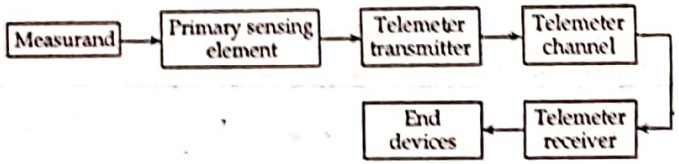
The method employed for data transmission depends upon the variable and also the distance involved. In case the data is to be transmitted over a short distance, the following methods may be used,

i) Hydraulic transmission
ii) Pneumatic transmission
iii) Electrical or electronic transmission

The hydraulic and pneumatic methods are useful for transmitting data over small distances and hence are limited in scope. The electrical and electronic methods of data transmission are extensively used in industrial measurement and instrumentation systems.

5.1.1 Telemetry

Telemetry is defined as the technology which enables a user to collect data from several measurement points at inaccessible or inconvenient locations, transmit that data to a convenient location and present the several individual measurements in a usable form.



The primary detector and end device of the telemetering system have the same functional positions as in any general measurement system. The function of the telemeter transmitter is to convert the output of a primary detector into a related quantity (translating means) which can be transmitted over the telemeter channel. The function of the telemeter receiver at the remote location is to convert the transmitted signal (translating means) into a related suitable quantity.

Types of telemetry systems

a) Landline telemetry system
b) Radio frequency telemetry system

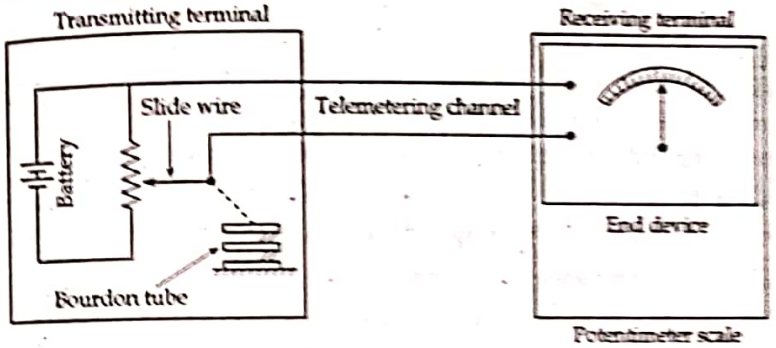
A. Landline telemetry system

It is also known as DC telemetry system. The telemetry system in which the signal is transmitted through a communication channel utilizing direct transmission via cables for conveying the desired information are called landline telemetry system. A landline telemetry system requires a telemeter channel which is physical link between the transmitter and receiver. This system is most suitable for short distance telemetry. So in the landline telemetry system, the information is transmitted directly through the cable or transmission lines. This information is conveyed in the form of voltage, current and position.

Types of Landline telemetry system are

i) Voltage telemetry system

A simple voltage telemetering system consists of a slide wire potentiometer connected in series with a battery at the transmitting end. The sliding contact is connected to the bourdon tube used for pressure measurement. At the receiving end, a null balance dc potentiometer or a recorder is used. In between the transmitting end and the receiving end, a pair of wires from a telemeter channel is connected.



When the pressure in the system changes, the bourdon tube actuates the slider of the potentiometer. Thus the voltage changes at the transmitting end. This voltage is carried by the telemetering channel to the receiving end. At the receiving end, it is measured with the help of null balance dc potentiometer indicator calibrated interms of pressure scale or recorded if required. Some systems uses the deflection type indicators to measure voltage. These indicators are calibrated for the line resistance. Basically a null balance dc potentiometer reduces the current carried by the telemetering channel with negligible resistance.

Advantages

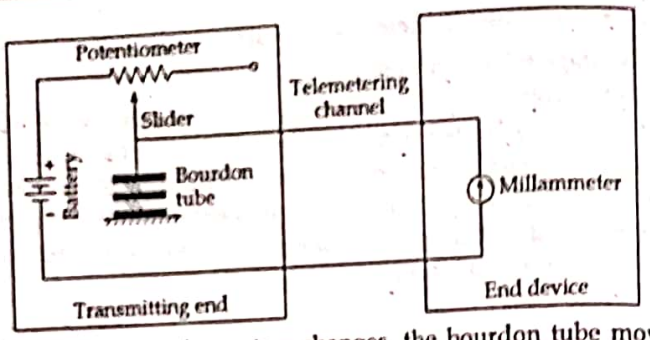
- Several output voltages can be added in series under linear measurement conditions.

Disadvantages

- It requires highly quality circuits and it demand higher signal to noise ratio. The power level is small and hence the telemeter channel must be protected from various sources of interferences.

ii) Current telemetry system

The construction of current telemetry system is similar to the voltage telemetering system, the current telemetering system also consists a slide wire potentiometer in series with a battery. Again the slider is connected to the bourdon tube which measure pressure. The telemetering channel is nothing but a pair of wires. At the receiving end, the milliameter is connected in series, which is calibrated in terms of pressure scale.



When the pressure in the system changes, the bourdon tube moves the sliding contact there by changing the current at the transmitting end. This current passes to the receiving end through the pair of wires and at the receiving end it is measured by the milliameter or end device.

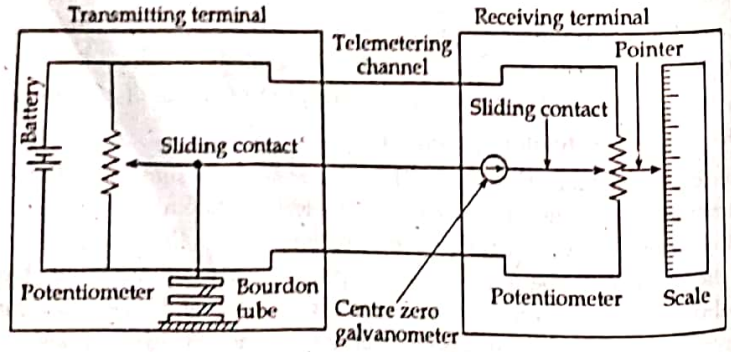
Advantages

- It shows good linearity and accuracy of the system is increased.

iii) Position telemetry system

The position telemetry system is also known as bridge type telemetry system. A position telemetry system transmits and reproduces the measured variable by positioning variable resistor or other electrical component in a bridge circuit so as to produce a proportional change at both the transmitter and the receiver ends.

Figure below shows two potentiometers, one at transmitting end and the other at the receiving end. The two potentiometers are energized by a common power supply. The sliding contact at the transmitting end is positioned by the bourdon tube as pressure is applied to the latter. If the sliding contact at the receiving end is positioned until the centre zero galvanometer indicates zero, the position of the contact will assume the same position of the contact will assume the same position as the contact at the transmitter. The receiving contact moves the pointer which indicates the pressure which is being measured.



Advantages of landline telemetry system

i) It is simple in construction
ii) It is reliable system
iii) The information can be transmitted in the form of current, voltage and position easily with modern sophisticated electronic circuitry.
iv) This system is very effective for short distance transmission as the telemeter channel or communication channel can be established with the help of simple cable used for the telephone and telegraph applications and transmission line.
v) There is wide variety of the primary sensing elements which produce electrical signal (voltage or current) in relation with the variable being measured at the input stage of the system.

Disadvantages

i) All the transmission link distortion are directly introduced into the system.
ii) The frequency response is limited.
iii) The signal multiplexing tends to be impracticable.
iv) The effect of thermo-electric emf may be introduced in DC telemetry system.
v) The EMI effects of main frequency from nearby cable affect the information transmitted through the link.

B. Radio frequency (RF) telemetry system

The main difference between the radio frequency (RF) telemetry system and the landline telemetry system is that in RF telemetry system there is no physical link between the telemetry transmitter and telemeter receiver. Bur the link between the transmitting end and the receiving end is established through the radio links. The RF telemetry systems are more suitable for the transmissions of data distances more than 1 km. Certain parts of the radio frequency spectrum have been allocated for telemetry and microwave links above 4 MHz. Radio waves at these frequencies tend to travel in straight lines requires repeater stations with disc like antennas on high buildings and towers every 30 to 60 km.

Different modulation techniques like amplitude modulation, frequency modulation and phase modulation techniques are used for data transmission in RF telemetry which helps to maintain the antenna size.

Applications of telemetry system

- Metetology
- Motor racing
- Transportation
- Agriculture
- Defense, space and resource exploration
- Space science
- Flight testing

- Military intelligence
- Energy monitoring
- Medicine/health care
- Communications
- Mining etc

5.2 DATA TRANSMISSION MEDIUMS

A data transmission medium is a physical path between the transmitter and the receiver *i.e.*, it is the channel through which data is sent from one place to another. Data transmission medium may be guided media and unguided media.

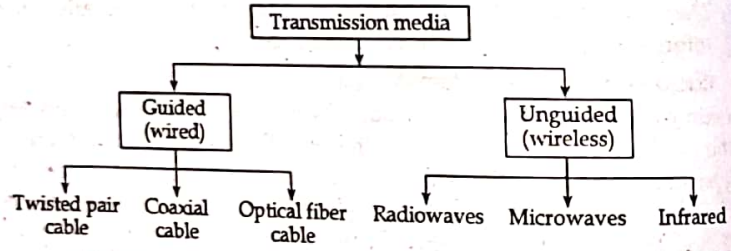
A. Guided media

Transmission capacity depends critically on the medium, the length and whether the medium is point to point or multipoint (*e.g.*, LAN). Examples are coaxial cable, twisted cable and optical fiber.

B. Unguided media

It provides a means for transmitting electromagnetic signals but do not guide them.

Example is wireless transmission.



A. Guided transmission media

i) Twisted transmission media

In twisted pair technology, two copper wires are strung between two points. The two wires are typically twisted together in a helix to reduce interference between the two conductors. Twisting decreases the cross talk interference between adjacent pairs in a cable.

Typically, a number of pairs are bundled together into a cable by wrapping them in a tough protective sheath. It can carry both analog and digital signals. The data rate that can be supported over a twisted pair is inversely proportional to the square of the line length. For analog voltage signals, amplifiers are required about every 6 km and for digital signals repeaters are needed for about 2 km.

Twisted pair is of two types; unshielded twisted pair (UTP) and shielded twisted pair (STP) uses:

The oldest and the most popular use of twisted pair are in telephony.

Advantages

- Inexpensive and readily available
- Flexible and light weight
- Easy to work with and for installation
- Eliminates cross talk using STP

Disadvantages

- Susceptibility to interference and noise
- Relatively low bandwidth (3,000 Hz)
- Attenuation problem

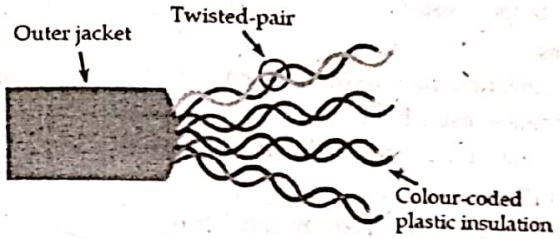
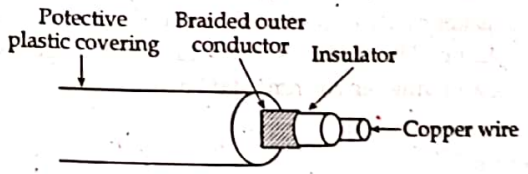


Figure: Twisted pair cable

Figure: UTP and STP

ii) Coaxial cable

With 'coax' the medium consists of a copper core surrounded by insulating material and a braided outer conductor. Physical connection consists of metal pin touching the copper core.



Characteristics

i) Coaxial cable has superior frequency characteristics compared to twisted pair cable and can be used for both analog and digital signaling.

ii) Coaxial cables are used for both base band and broadband communication.

iii) This cable offers band width of 300 to 400 MHz facilitating high speed data communication with low bit error rate

iv) Because of shielded, concentric construction coaxial cable is less susceptible to interference and cross talk than the twisted pair.

Use

One of the most popular use of coaxial cable is in cable TV (CATV) for the distribution of TV signals. Another importance use of coaxial cable is in LAN.

Advantages

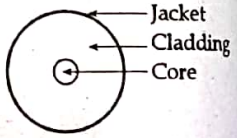
i) Inexpensive
ii) High bandwidth
iii) Better noise immunity
iv) Easy to install and expand
v) Much less susceptible to interference than twisted pair
vi) Can be tapped easily

Disadvantages

i) High attenuation rate makes it expensive over long distance.
ii) Maintenance cost is high.
iii) Single cable failure can take down an entire network.

iii) Optical fiber cable

In fiber optic technology, the medium consists of a hair-width strand of silicon or glass, and the signal consists of pulses of light. For instance, a pulse of light means "1", lack of pulse means "0". It has a cylindrical shape and consists of three concentric sections; the core, the cladding and the jacket.



The core innermost section consists of a single solid dielectric cylinder of diameter d_1 and of refractive index n_1. The core is surrounded by a solid dielectric cladding of refractive index n_2 that is less than n_1. As a consequence, the light is propagated through multiple total internal reflection. The core material is usually made of ultra pure fused silica or glass and the cladding is either made of glass or plastic. The cladding is surrounded by a jacket made of plastic. The cladding is surrounded by a jacket made of plastic. The jacket is used to protect against moisture, abrasion, crushing and other environmental hazards.

Three components are required:

i) Fiber medium
ii) Light source – LED or laser diode
iii) A photo diode light detector

Optical fiber works in three different types of modes. Optical fibers are available in two varieties; multimode fibers and single mode fiber. Both single mode and multimode fibers can have two types; step index and graded index.

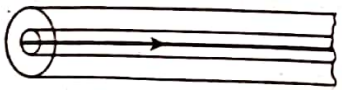


Figure: Single mode step index

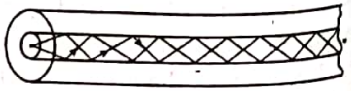


Figure: Multi-mode step index

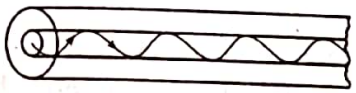


Figure: Multimode graded index

Characteristics

i) Optical fiber acts as a dielectric wave guide that operates at optical frequencies (10^{14} to 10^{15} Hz).
ii) In a multimode fiber, the quality of signal encoded light deteriorates more rapidly than single mode fiber because of interference of many light rays. As a consequence, single mode fiber allows longer distances without repeater. For multimode fiber, the typical maximum length of the cable without a repeater is 2 km, whereas for single mode fiber it is 20 km.
iii) Large bandwidth (theoretical 50 THz)
iv) Low attenuation
v) Immune to electromagnetic interference

Advantages

i) Very high data rate, error rate. Error rates are very low and are almost negligible.
ii) Difficult to tap, which makes it hard for unauthorized taps as well.
iii) Light weight and smaller in size
iv) Less signal attenuation
v) Greater capacity and band width (2 Gbps)
vi) Immunity to environmental interference.

Disadvantages

i) Expensive over short distance
ii) Requires highly skilled installers and for maintenance.
iii) Adding additional nodes is difficult.
iv) One- way channel. Two fibers needed to get full duplex.
v) Requires specialized and sophisticated tools for repairing and maintenance.
vi) Fiber cable can be broken or have transmission losses when wrapped around curves of only a few centimeters radisu.

B. Unguided transmission media

There are 3 major types of unguided media,

i) Radio waves

These are easy to generate and can penetrate through buildings. The sending and receiving antennas need not be aligned. Its frequency range is 3 kHz to 1 GHz. AM and FM radios and cordless phone use Radio waves for transmission.

ii) **Infrared**

Infrared waves are used for very short distance communication. They cannot penetrate through obstacles. This prevents interference between systems.

It is used in TV remotes, wireless mouse, printer, keyboard etc

iii) **Micro waves**

It is a line of sight transmission *i.e.*, the sending and receiving antennas need to be properly aligned with each other. The distance covered by the signal is directly proportional to the height of the antenna. These are majorly used for mobile phone communication and television distribution.

5.3 DATA TRANSMISSION MODES

Transmission mode means transferring of data between two devices. It is also known as communication mode. There are three types of transmission mode.

A. Simplex mode
B. Half-duplex mode
C. Full-duplex mode

A. Simplex mode

In this type of data transmission, data can be sent only in one direction *i.e.*, communication is unidirectional. Only one of the two devices on a link can transmit, the other can only receive. The simplex mode can use the entire capacity of the channel to send data in one direction.

Figure: Simplex mode

For example; television broadcasting, loudspeaker, keyboard etc.

B. Half duplex mode

In half duplex mode, data can be sent in both the directions but not simultaneously. *i.e.*, when one device is sending data, the other can only receive and vice versa. The entire capacity of the channel can be utilized for each direction.

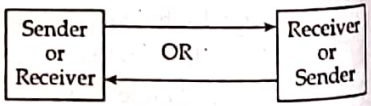


Figure: Half duplex mode

For example: Walkie talkie in which message is sent one at a time and messages are sent in both the directions.

C. Full duplex mode

In full duplex mode, data can be sent in both the directions simultaneously. Full duplex mode is used when communication in both direction is required all the time. The capacity of the channel low ever must be divided between the two directions.

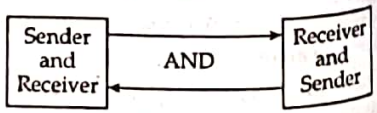


Figure: Half duplex mode

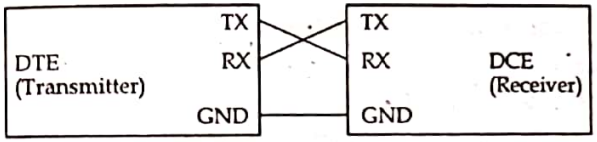
For example; Telephone network in which there is communication between two persons by a telephone line through which both can talk and listen at the same time.

5.4 DATA TRANSMISSION STANDARDS

There are three types of data transmission standards. They are,

A. RS-232

In telecommunications, RS-232, Recommended standard 232 refers to a standard originally introduced in 1960 for serial communication transmission of data. It formally defines signals connecting between a data terminal equipment (DTE). Such as a computer terminal and a data communication equipment (DCE) such as a modem. The standard defines the electrical characteristics and timing of signals, the meaning of signals and the physical size and pin out of connectors.



It is used in serial communication up to 50 feet with the rate of 19.2 Kbps. RS-232 works on the two way communication that exchanges data to one another. From DTE source, the request to send (RTS) generate the request to send the data. Then from the other side DCE, the clear to send (CTS) clears the path for receiving the data. After clearing a path, it will give a signal to RTS of the DTE source to send the signal. Then the bits are transmitted from DTE. Now again from DCE source, the request can be generated by RTs and CTs of DTE sources clears the path for receiving the signal to send the data.

RS-232 specifications

Transmitted signal

Voltage levels:

Binary 0: + 5 to + 15 V_{dc} (called a "space" or "on")

Binary 1: – 5 to –15 V_{dc} (called a "mark" or "off")

Received signal

Voltage levels

Binary 0: +3 to +13 V_{dc}

Binary 1: –3 to –3 V_{dc}

Data format

Start bit : binary 0

Data 5, 6, 7 or 8 bits

Parity: odd, even, mark or space

Stop: Binary 1, one or two bits

Hand shaking is the process of inter changing information signals between the sender and receiver. These signals build a communication link between the transmitter and receiver. In RS-232, there are two types of handshaking. They are software handshaking and software handshaking.

When no handshaking is performed, only one the transmitter and receiver are cross coupled. To used the handshaking techniques, RTS and CTS are also cross coupled. Also DTR and DSR are also connected in cross mode. Handshaking allows the transmitter and receiver device to agree before the communication is going to start.

Advantages

i) Simple protocol design
ii) Low cost protocol for development
iii) Compatible with DTE and DCE communication
iv) Hardware overhead is lesser than parallel communication

Disadvantages

i) Single ended protocol
ii) It does not support full duplex communication
iii) Suitable only for small distance

B. RS-422

RS-422 also known as TIA/EIA - 422, is a technical standard originated by the electronic industries alliance that specifies electrical characteristics of a digital signaling circuit. Differential signaling can transmit data at rates as high as 10 Mbps or may be sent on cables as long as 1,500 meter some systems directly interconnect using RS-422 signals are RS-422 converters may be used to extend the range of RS-232 connections.

Several key advantages offered by this standard include the differential receiver, a differential driver and data rates as high as 10 Mbps at 12 meter. Since the signal quality degrades with cable length, the maximum data rate decreases as cable length increases. The most wide spread use of RS-422 was on the early Macintosh computers.

RS-422 specifications

Physical media = twisted pair
Network topology = points to point, multi dropped
Maximum devices = 10
Maximum distance =1,500 meter
Mode of operation = differential
Maximum binary rate = 100 Kbps - 10 Mbps
Voltage levels = -6 V to + 6 V (maximum differential voltage)
Mark (1) = negative voltages
Space (0) = positive voltages

C. RS-485 standard

RS-485 standard is a standard defining the electrical characteristics of drivers and receivers for use in serial communication systems. Electrical signaling is balanced and multipoint systems are supported. Digital communications network implementing this standard can be used effectively over long distances and in electrically noisy environments. Multiple receivers may be connected to such a network in a linear, multi drop bus. These characteristics make RS-485 useful in industrial control systems and similar applications.

RS-485 supports inexpensive local networks and multi drop communication links using the same differential signaling over twisted pair as RS-422. RS-485 driver use three state logic allowing individual transmitters to be deactivated. This allows RS-485 to implement linear bus topologies using only two wires.

RS-485 signals are used in wide range of computer and automation system. These are used in programmable logic controllers and on factory floors. It is also used in building automation as the simple bus wiring and long cable length is ideal for joining remote devices. It may be used to control video surveillance systems or to connect security control panels and devices such as access control and readers. It is also used in digital command control (DCC) for model railways. It is used as the physical layer underlying many standard and proprietary automation protocols used to implement industrial control systems, including the most common versions of modbus and profibus.

RS-485 specifications

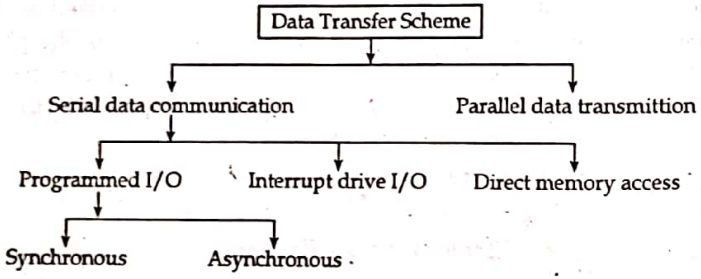
Cabling = multi drop
Number of devices = 32 transmitters and 32 receivers
Communication modes = half duplex
Maximum distance = 4,000 feet @ 100 Kbps
Maximum data rate = 10 Mbps @ 50 feet
Signaling = balanced
Mark (1) = 1.5 V to 5 V (B greater than A)
Space (0) = 1.5 V to 5 V (A greater than B)
Physical media = Balanced interconnecting cable
Available signals = A, B, C
Network topology = Point to point, multi dropped, multi point

Comparison chart

		RS-232	RS-422	RS-485
1	Cabling	Single ended	Single ended	Multi-drop
2	Number of devices	1 transmit 1 receive	5 transmitters 10 receivers	32 transmitters 32 receivers

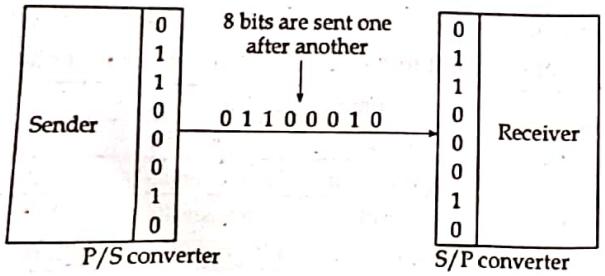
3	Communication mode	Full duplex	Half duplex full duplex	Half duplex
4	Maximum distance	50 feet at 19.2 Kbps	4,000 feet at 100 Kbps	4000 feet at 100 Kbps
5	Maximum data rate	19.2 Kbps for 50 feet	10 Mbps for 50 feet	10 Mbps for 50 feet
6	Signaling	Unbalanced	Balanced	Balanced
7	Mark (data 1)	-5 V min -15 V max	2 V min (B > A) 6 V max (A > B)	1.5 V min (B > A) 5 V max (A > B)
8	Space (data 0)	5 V min 15 V max	2 V min (A > B) 6 V max (A > B)	1.5 V min (A > B) 5 V max (A > B)
9	Input level minimum	± 3 V	0.2 V difference	0. 2 V difference
10	Output current	500 mA	150 mA	250 mA
11	Source impedance	300 Ω	100 Ω	100 Ω
12	Load impedance	3 to 7 kΩ	4 kΩ	12 kΩ

5.5 DATA TRANSMISSION SCHEMES



A. Serial data transmission

Serial data transmission is the process of sending data one bit at a time sequentially over a communication channel. Serial communication is used for all long haul communication and most computer networks, where the cost of cable and synchronization difficulties make parallel communication impractical. This transmission is suitable for long distances.



Advantages

i) Only one wire is required
ii) Reduction in cost due to less number of conductor wires
iii) It supports long distance data communication

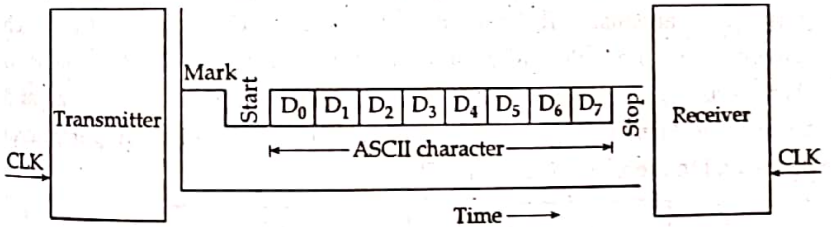
Disadvantages

i) It is slow method as only one bit of data is transmitted at a time.
ii) Serial to parallel converter is needed at receiving end and parallel to serial converter is needed at sending end which may, increase in overall cost of transmission.

Types of serial communication are

i) **Asynchronous serial communication**

Asynchronous serial communication is a form of serial communication in which the communicating end points interfaces are not continuously synchronized by a common clock signal. Instead of common synchronizing signal, the data synchronizing stream contains synchronization information in form of start and stop signals before and after each unit of transmission, respectively. The start signal prepares the receiver for arrival of data and the stop signal resets its state to enable triggering of a new sequence.

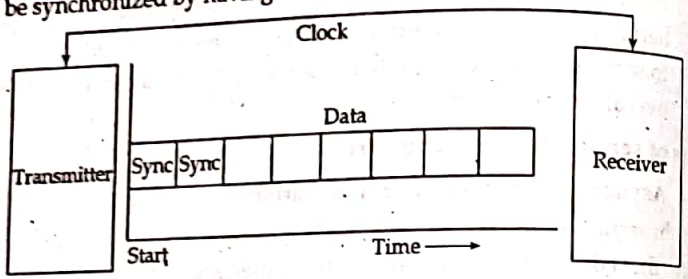


Asynchronous formats are character oriented. In this, the bits of a character or data word are sent at a constant rate, but characters can come at any rate (asynchronously) as long as they do not overlap. When no characters are being sent, a line stays high at logic 1 called mark, logic 0 is called space. The beginning of a character is indicated by a start bit which is always low. This is used to synchronize the transmitter and receiver.

After the start bit, the data bits are sent with least significant bit first, followed by one or more stop bits (active high). The stop bits indicate the end of character. Different systems use 1, 1 $\frac{1}{2}$ or 2 stop bits. The combination of start bit, character and stop bits is known as frame. The start and stop bit carry no information but are required because of the synchronous nature of data. The asynchronous format is generally used in low speed transmission (less than 20 Kbps).

ii) Synchronous serial communication

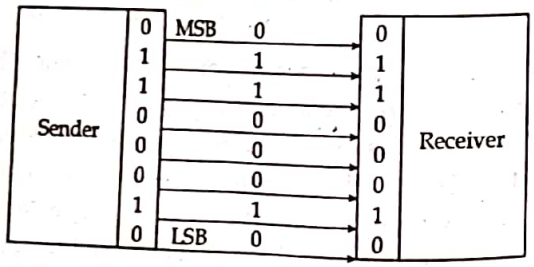
Synchronous communication requires that the clocks in the transmitting and receiving devices are synchronized – running at the same rate- so the receiver can sample the signal at the same time intervals used by the transmitter. No start or stop bits are required. Receiver and transmitter can be synchronized by having a common clock signal.



A block of characters, enclosed by synchronizing bytes, is sent at a time. The transmitted shifts the data on to the serial line using its own clock and the receiver extracts the data using the clock provided by the transmitter.

B. Parallel data transmission

Parallel data transmission is a method of conveying multiple binary digits (bits) simultaneously. It contrasts with serial communication, which conveys only a single bit at a time; this distinction is one way of characterizing a communication link. Parallel communication is and always has been widely used within integrated circuits, in peripheral buses, and in memory devices like RAM.



In order to transmit n bits, n wire or lines are used multiple bits are sent with each clock pulse in this communication.

5.6 BOARD EXAM QUESTIONS SOLUTION

1. **Discuss about various data transmission standards.** **[2011/F]**

Solution: See the definition of 5.4.

2. **Write short notes on synchronous serial data communication.** **[2011/S]**

Solution: See the definition of 5.5 A (ii).

3. **What is data transmission?** **[2013/F, 2015/F, 2018/S]**

Solution:

Data transfer or transmission is the physical transfer of data over a point to-point or point-to-multipoint channel.

4. **Write short notes on RF telemetry.** **[2013/S]**

Solution: See the definition of 5.1.1. B.

5. **Write short notes on data transmission mode.** **[2016/F, 2018/S]**

Solution: See the definition of 5.3.

6. **Explain different wired data transmission medium.** **[2016/S]**

Solution: See the definition of 5.2. A.

7. **Discuss about various types of data transmission system.** **[2011/S]**

OR,

Briefly explain the various schemes of data transmission. **[2015/S]**

Solution: See the definition of 5.5.

8. **Explain the types of landline telemetry system in detail.** **[2013/S, 2014/F]**

Solution: See the definition of 5.1.1 A.

9. **Define telemetry.** **[2012/S, 2013/S, 2014/F, 2014/S, 2016/S, 2017/S]**

Solution: See the definition of 5.1.1.

10. **What are the methods of data transmission? Explain the typical telemetering system with a block diagram.** **[2012/F, 2012/S, 2014/S, 2017/F, 2019/F]**

Solution: See the definition of 5.1.1.

The methods of data transmission are;

i) Hydraulic data transmission
ii) Pneumatic data transmission
iii) Electrical or electronic data transmission

11. **Explain synchronous and asynchronous data transmission in brief.** **[2015/S, 2018/F]**

Solution: See the definition of 5.5. A.

	Synchronous data transmission	Asynchronous data transmission
a)	Transfer a group or block of character at a time.	Transfer one character at a time
b)	High data transfer rate	Low data transfer rate
c)	No start and stop bit is added in each character.	Start and stop bit is added in each character.
d)	High cost	Low cost
e)	Gap between data units is not present.	Gap between data units is present.
f)	It uses constant time interval to transfer data.	It uses random or irregular time interval to transfer data.
g)	It requires accurately synchronized clocks at both ends.	It does not require any synchronized clocks.
h)	It is used in high speed application like the transmission of data from one computer to another.	It is used is low speed communication like the connection of a terminal to a computer.

12. Explain various types of telemetry and application of telemetry system. [2016/F, 2017/S]

Solution: See the definition of 5.1.1.

13. Distinguish between serial and parallel communication. [2018/F]

	Serial communication	Parallel communication
a.	Data is transmitted bit after the bit in a single line	Data is transmitted simultaneously through group of lines (bus)
b.	Data congestion takes place	No data congestion takes place
c.	Low speed transmission	High speed transmission
d.	No cross talk problem	Cross talk creates interference between the parallel lines
e.	The bandwidth of serial wire is much higher	The bandwidth of parallel wires is much lower
f.	Implementation of serial link is not an easy task .	Parallel data links are easily implemented in hardware
g.	Only two lines are needed to connect transmitter and receiver	9 lines are needed to connect receiver and transmitter
i.	One line is-required to transmit n bits.	n lines are required to transmit n bits.
j.	It is suitable for long distance transmission	It is suitable for short distance transmission

14. Distinguish between half duplex and full duplex communication. [2018/F]

	Half duplex communication	Full duplex communication
a.	Data can be sent or received at a time	Data can be sent and received simultaneously
b.	*Example*: walk *i.e.*, talkie	*Example*: telephone
c.	Direction of communication is two directional but one at a time	Direction of communication is two directional and simultaneously
d.	Sender ⇄ (or) Receiver	Sender ⇄ (and) Receiver

15. Optical fiber is the best wired transmission methods. Support this statement with relevant data. [2017/F]

Solution:

The following properties make fiber optic cable superior to other wired transmission methods,

a) Bandwidth

Optical fiber provides more bandwidth than copper and has standardized performance up to 10 Gbps and beyond, more bandwidth means that fiber can carry more information with far greater efficiency than copper wire. Fiber-grade silica is transparent from 1 μm to 1.6 μm thin. The total bandwidth it can carry is

$$\Delta\lambda = \frac{c}{\lambda_1} - \frac{c}{\lambda_2} = 11 \text{ THz}$$

Bandwidth of a telephone signal goes from 100 Hz to 3000 Hz. By Nyquist criteria, one conversation requires 2 × 3 kHz = 6 kHz bandwidth. So the number of conversations that can be simultaneously carried over a fiber is approximately,

$$N_F = \frac{1.1 \times 10^{14}}{3 \times 10^3} = 36.66 \text{ billion}$$

So in principle, a single optical fiber is sufficient to carry ten times all the conversation generated worldwide.

b) Range of transmission

Since data travels in the form of light (in total internal reflections, the loss of quality is negligible) in fiber optic cables, very little signal loss occurs during transmission and data can more at higher speeds and at greater distances.

c) Non susceptible to interference

Fiber optic cables are immune to electromagnetic interference. Fiber optic has very low bit error rate and thus fiber optic transmission is virtually noise free.

d. Low power loss

Signals in optical fiber degrades less than a copper wire cable and need low power transmitters.

e. Small size and weight

In comparison to copper, a fiber optic cable has nearly 4.5 times as much capacity as the wire cable has and a cross sectional area that is 30 times less. Fiber optic cables are much thinner and lighter than metal wires. They also occupy less space with cables of the same information capacity light weight makes fiber easier to install.

f. Secure transmission

Optical fiber cabling provides an extremely secure transmission medium. Optical fiber is a dielectric, it does not present a spark hazard. It also does not produce or radiate magnetic fields. The light is confined within the fiber which makes it impossible to tap the signal without cutting into the fiber. Fiber is the most secure medium for carrying sensitive data.

g. Flexibility

An optical fiber has greater tensile strength than copper or steel fibres of the same diameter. It is flexible, bends easily and resists more corrorsive elements that attack copper cable.

h. Cheap cost

The availability and low production cost of glass are considered relatively cheaper than using copper that is mainly used in another medium.

16. Compare the wired channels used in data transmission. [2018/S]

	Twisted pair cable	Coaxial cable	Optical fiber cable
a.	Transmission of signals take place in the electrical form over the metallic conducting wires.	Transmission of signal takes place in the electrical form ove the inner conductor of cable.	Signal transmission takes place in an optical form over a glass fiber
b.	Cheapest medium	Moderate expensive	Expensive
c.	Low bandwidth	Moderately high bandwidth	Very high bandwidth
d.	Attenuation is very high	Attenuation is low	Attenuation is very low
e.	Installation is easy	Installation is fairly easy	Installation is difficult
f.	Noise immunity is low	Higher noise immunity	Highest noise immunity
g.	It is affected by external magnetic field	It is less affected by external magnetic field	Not affected by external magnetic field