Data Communication

Bachelor in Computer Engineering

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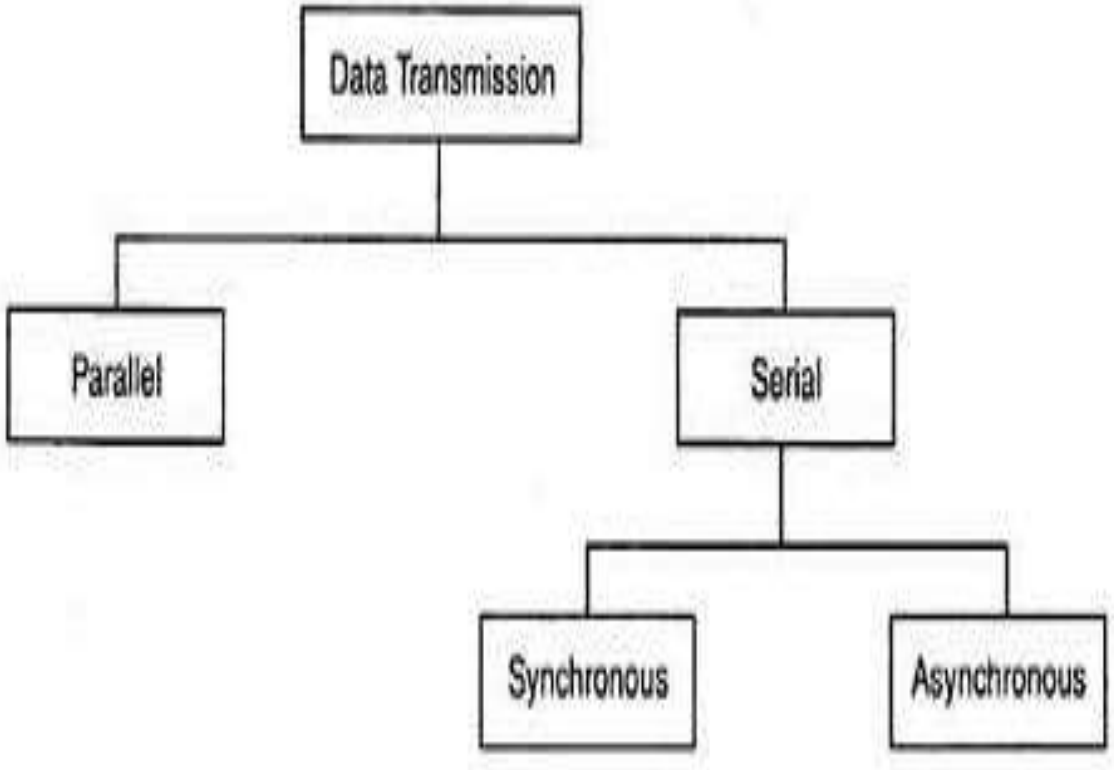
Unit 2: Data Transmission

- **Outline:**
- Parallel and Serial Transmission
- Line Configuration, Synchronous/Asynchronous
- Bit Rate, Baud Rate, Transmission Channel, RS 232 C, and RS 449 Interface Standards

Introduction

- Transmission is the way of sending and receiving information by the Source and the Destination.
- There are two types of transmission:-

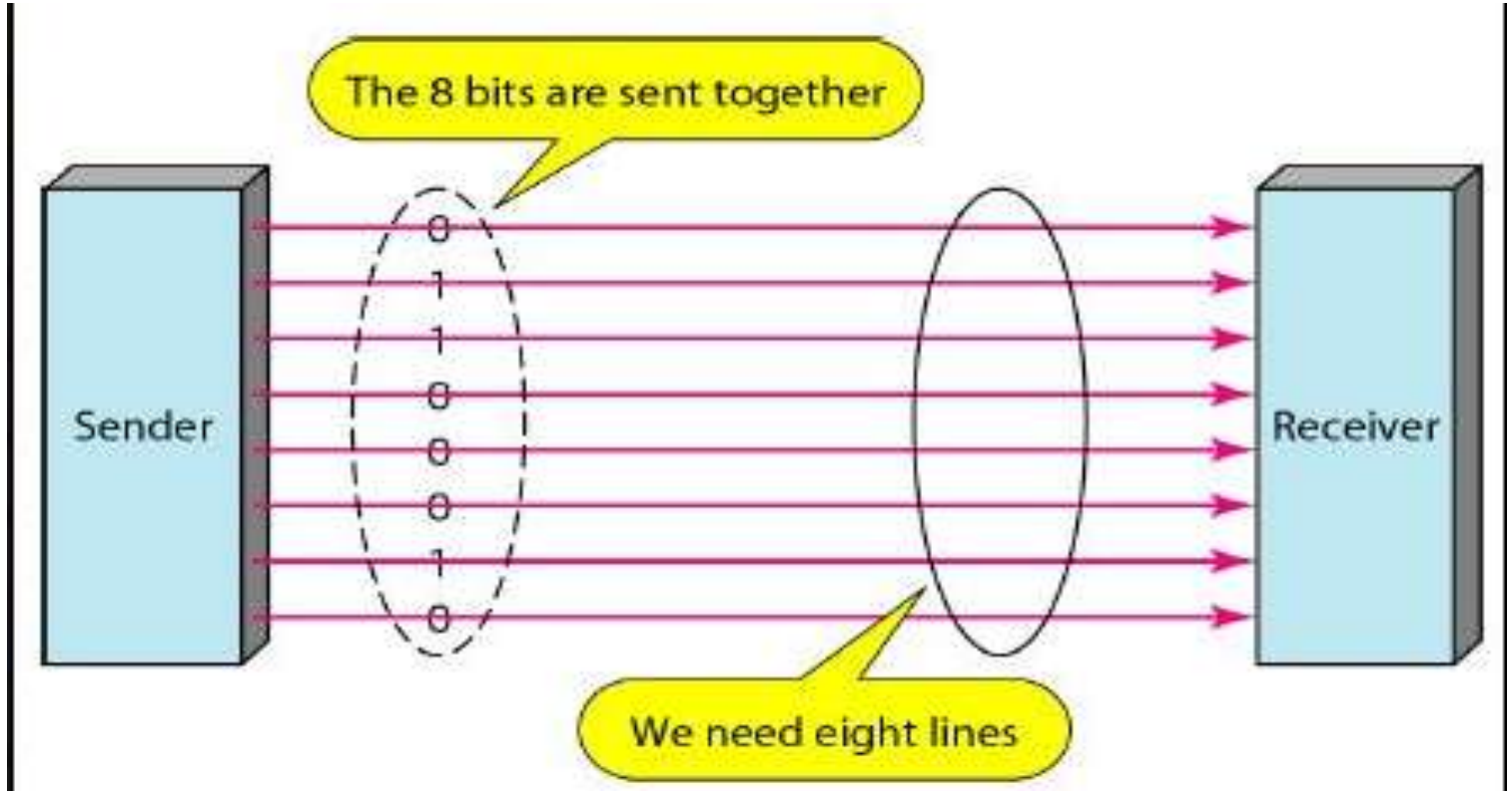
1. Serial Transmission
   A. Asynchronous Communication
   B. Synchronous Communication
2. Parallel Transmission



Parallel Transmission

- In parallel transmission, all the bits of data are transmitted simultaneously on separate communication lines.
- In order to transmit *n* bits, *n* wires or lines are used.
- Thus each bit has its own line.
- All n bits of one group are transmitted with each clock pulse from one device to another *i.e.* multiple bits are sent with each clock pulse.
- Parallel transmission is used for short-distance communication.
- Example: connections between a computer and a printer (parallel printer port and cable).

Parallel Transmission



Parallel Transmission

- **Advantage of Parallel transmission**
- It is a speedy way of transmitting data as multiple bits are transmitted simultaneously with a single clock pulse.
- Internally, computer and transmission hardware use parallel circuits, Thus, a parallel interface matches the internal hardware well.

- **Disadvantages of Parallel transmission**
- Transmission of n communication lines is required to transmit the data stream and for this n number of wires must be required.
- This is expensive so it is usually limited to shorter distances.

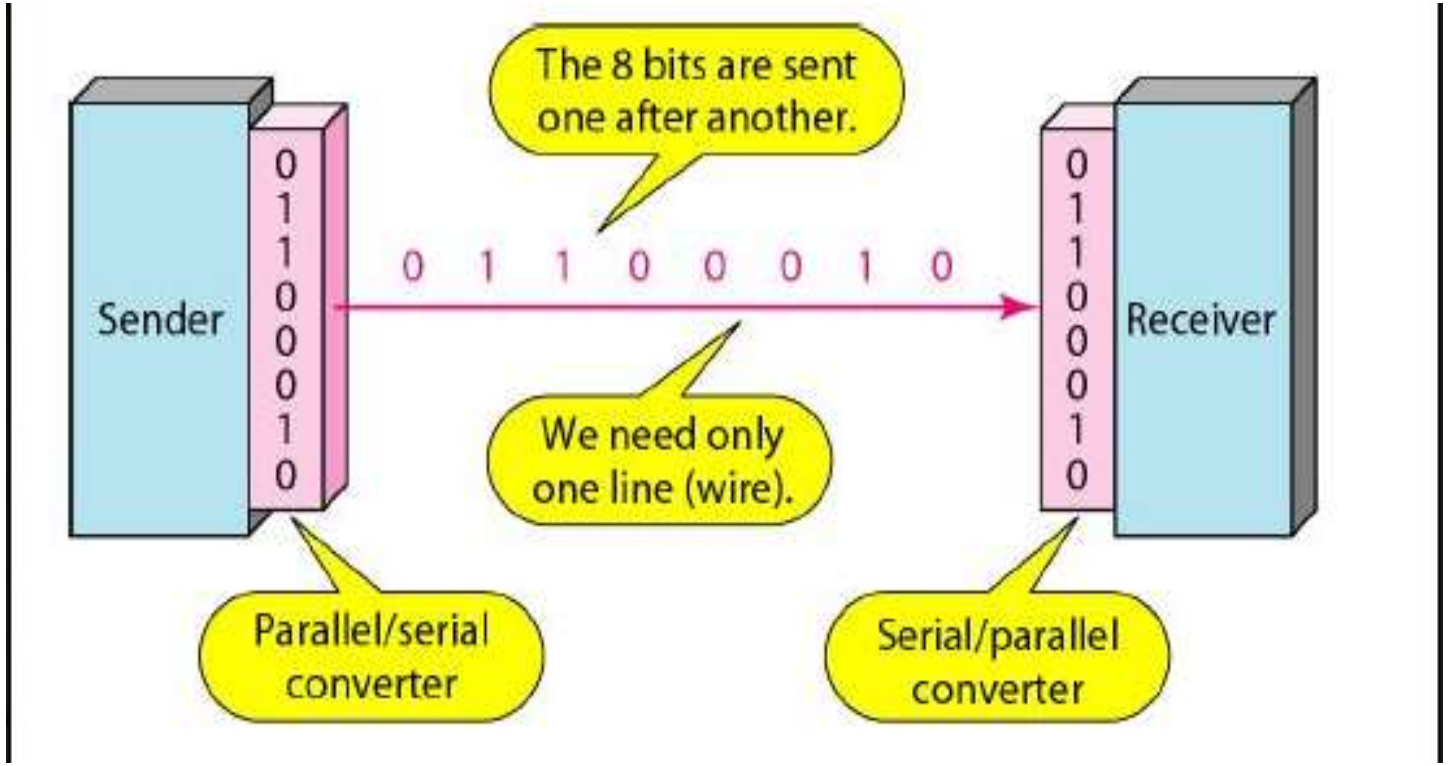
Serial Transmission

- **Serial Transmission**
- In serial transmission, the various bits of data are transmitted serially one after the other.
- It requires only one communication line rather than *n* lines to transmit data from sender to receiver.
- Thus all the bits of data are transmitted on a single line in a serial fashion.
- In serial transmission, only a single bit is sent with each clock pulse.
- Serial transmission is used for long-distance communication.

Serial Transmission

- **Advantage of Serial transmission**
- Use of a single communication line reduces the transmission line cost by the factor of *n* as compared to parallel transmission.
- **Disadvantages of Serial transmission**
- Use of conversion devices at source and destination end may lead to an increase in overall transmission cost.
- This method is slower as compared to parallel transmission as bits are transmitted serially one after the other.

Serial Transmission



Comparison of Serial and Parallel Transmission

Sr. No.	Factor	Serial	Parallel
1.	Number of bits transmitted at one clock pulse	One bit	*n* bits
2.	No. of lines required to transmit *n* bits	One line	*n* lines
3.	Speed of data transfer	Slow	Fast
4.	Cost of transmission	Low as one line is required	Higher as *n* lines are required.
5.	Application	Long distance communication between two computers	Short distance communication. like computer to printer.

Types of Serial Transmission

- **Asynchronous Transmission**
- Asynchronous transmission sends only one character at a time where a character is either a letter of the alphabet or number or control character *i.e.* it sends one byte of data at a time.
- Bit synchronization between two devices is made possible using the start bit and stop bit.
- Start bit indicates the beginning of data *i.e.* alerts the receiver to the arrival of a new group of bits.
- A start bit usually 0 is added to the beginning of each byte.
- Stop bit indicates the end of data *i.e.* to let the receiver know that byte is finished, one or more additional bits are appended to the end of the byte.
- These bits, usually 1s are called stop bits.

Types of Serial Transmission

- Addition of start and stop increase the number of data bits.
- Hence more bandwidth is consumed in asynchronous transmission.
- There is idle time between the transmissions of different data bytes. This idle time is also known as Gap
- The gap or idle time can be of varying intervals.
- This mechanism is called Asynchronous because at the byte level sender and receiver need not be synchronized.
- But within each byte, the receiver must be synchronized with the incoming bitstream.
- This communication is used in internet traffic for email, blogs, etc.

Types of Serial Transmission

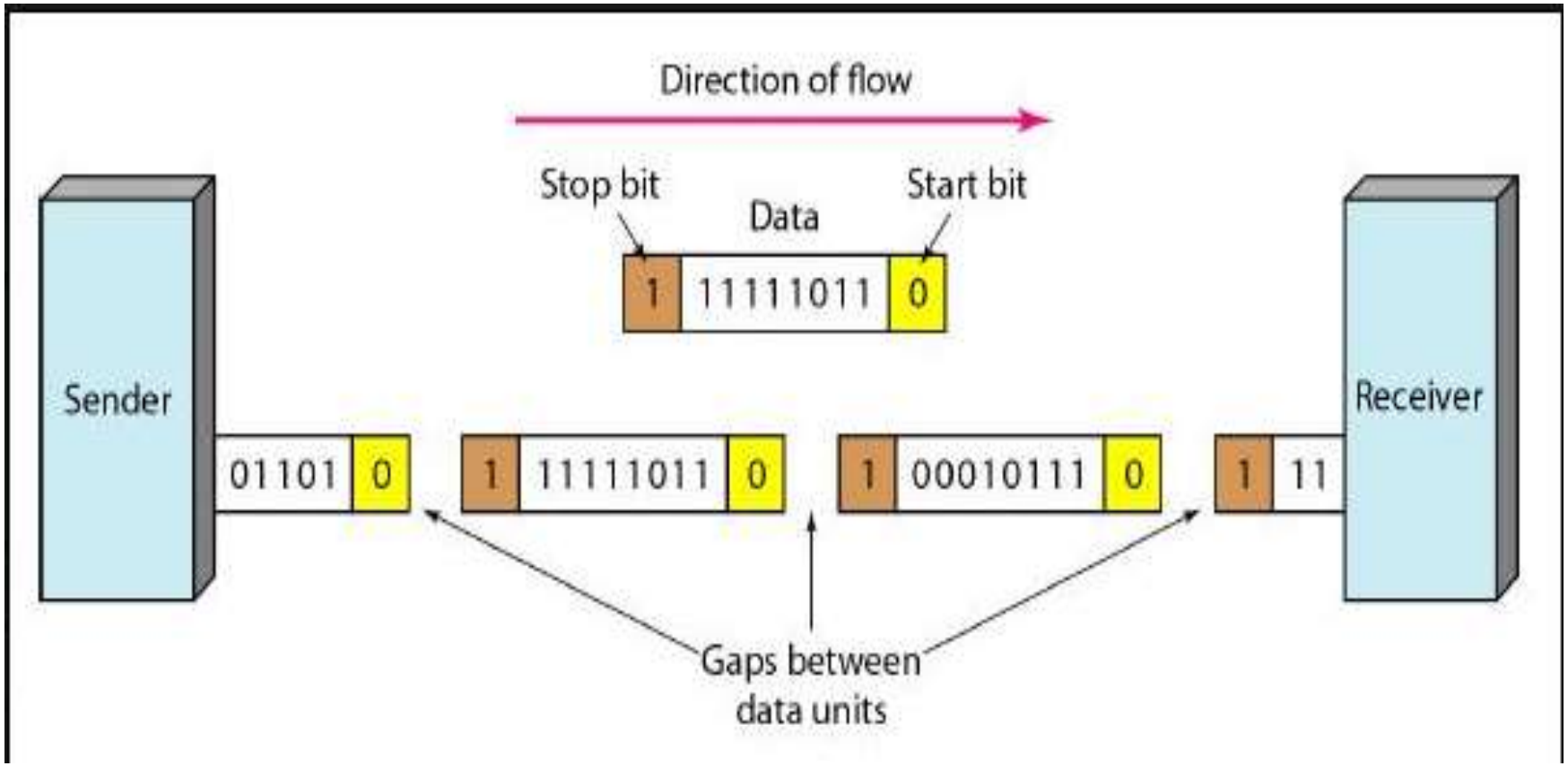


Fig: Asynchronous Communication

Types of Serial Transmission

- **Advantages of Asynchronous Communication**
- Cheaper in cost as compared to synchronous *e.g.* If lines are short, asynchronous transmission is better, because line cost would be low and idle time will not be expensive.
- It is possible to transmit signals from sources having different bit rates.
- The transmission can start as soon as the data byte to be transmitted becomes available.
- **Disadvantages of asynchronous transmission**
- This method is less efficient and slower than synchronous transmission due to the overhead of extra bits and insertion of gaps into the bitstream.
- Successful transmission inevitably depends on the recognition of the start bits.
- These bits can be missed or corrupted.

Types of Serial Transmission

- **Synchronous Transmission**
- Synchronous Transmission does not use start and stop bits.
- In this method bit stream is combined into longer frames that may contain multiple bytes.
- There is no gap between the various bytes in the data stream.
- In the absence of start & stop bits, bit synchronization is established between sender & receiver by *'timing'* the transmission of each bit.
- Since the various bytes are placed on the link without any gap, it is the responsibility of the receiver to separate the bitstream into bytes so as to reconstruct the original information.
- In order to receive the data error-free, the receiver and sender operate at the same clock frequency.
- This communication is used for chat, video conferencing, etc.

Types of Serial Transmission

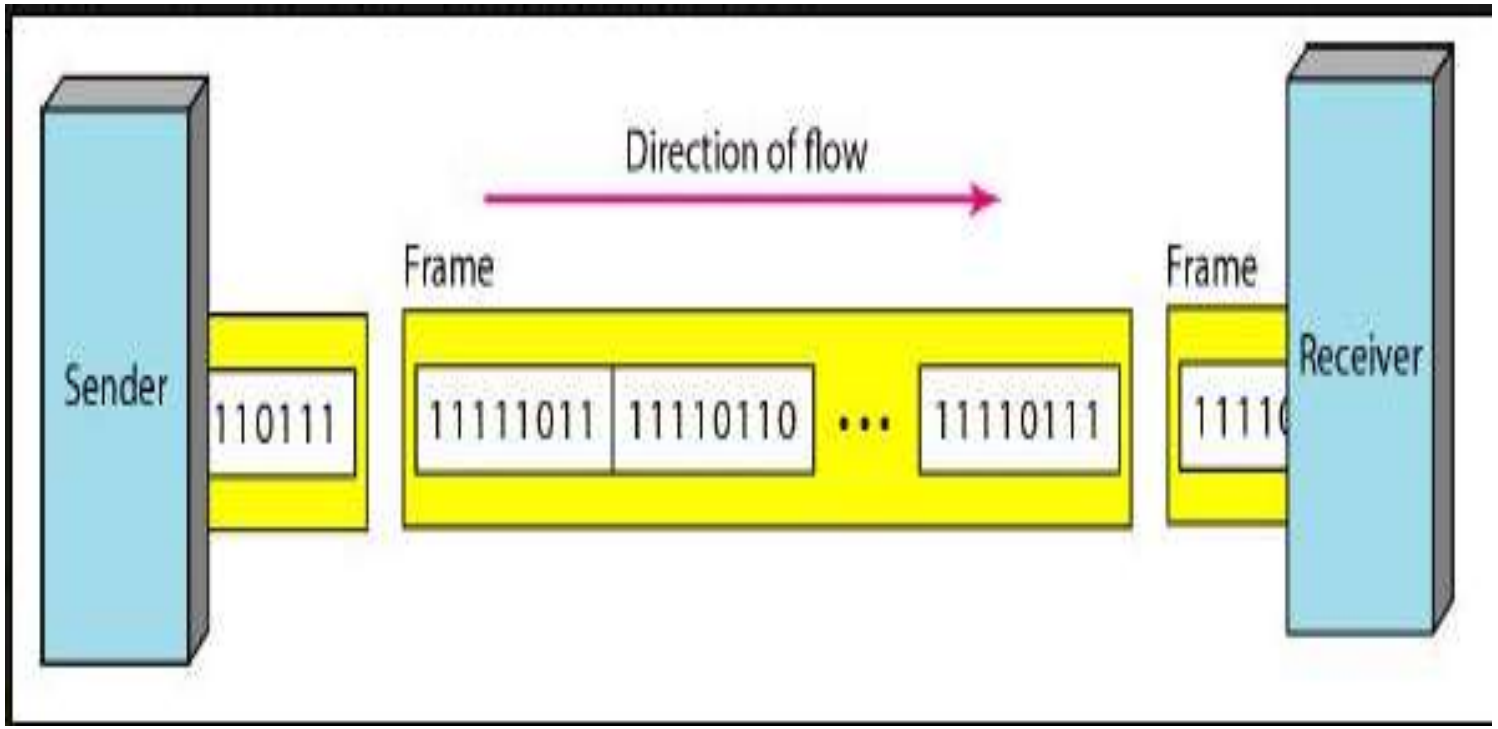


Fig : Synchronous Communication

Types of Serial Transmission

- **Advantages of Synchronous Transmission**
- This method is faster as compared to asynchronous as there are no extra bits (start bit & stop bit) and also there is no gap between the individual data bytes.
- **Disadvantages of Synchronous Transmission**
- It is costly as compared to the asynchronous method.
- It requires local buffer storage at the two ends of the line to assemble blocks and it also requires accurately synchronized clocks at both ends.
- The sender and receiver have to operate at the same clock frequency.
- This requires proper synchronization which makes the system complicated.

Comparison of Synchronous and Asynchronous Communication

Sr. No.	Factor	Asynchronous	Synchronus
1.	Data send at one time	Usually 1 byte	Multiple bytes
2.	Start and Stop bit	Used	Not used
3.	Gap between Data units	Present	Not present
4.	Data transmission speed	Slow	Fast
5.	Cost	Low	High

Line Configuration

- A network is two or more devices connected through a link.
- A link is a communication pathway that transfers data from one device to another.
- Devices can be a computer, printer, or any other device capable of sending and receiving data.
- For visualization purposes, imagine any link as a line drawn between two points.
- For communication to occur, two devices must be connected in some way to the same link at the same time.
- There are two possible types of connections:
- Point to Point Connection
- Multipoint Connection

Line Configuration

- **Point-to-Point Connection**
- A point-to-point connection provides a dedicated link between two devices.
- The entire capacity of the link is reserved for transmission between those two devices.
- Most point-to-point connections use an actual length of wire or cable to connect the two ends, but other options such as microwave or satellite links are also possible.
- Point to point network topology is considered to be one of the easiest and most conventional network topologies.
- It is also the simplest to establish and understand.
- Example: Point-to-Point connection between the remote control and Television for changing the channels.

Line Configuration

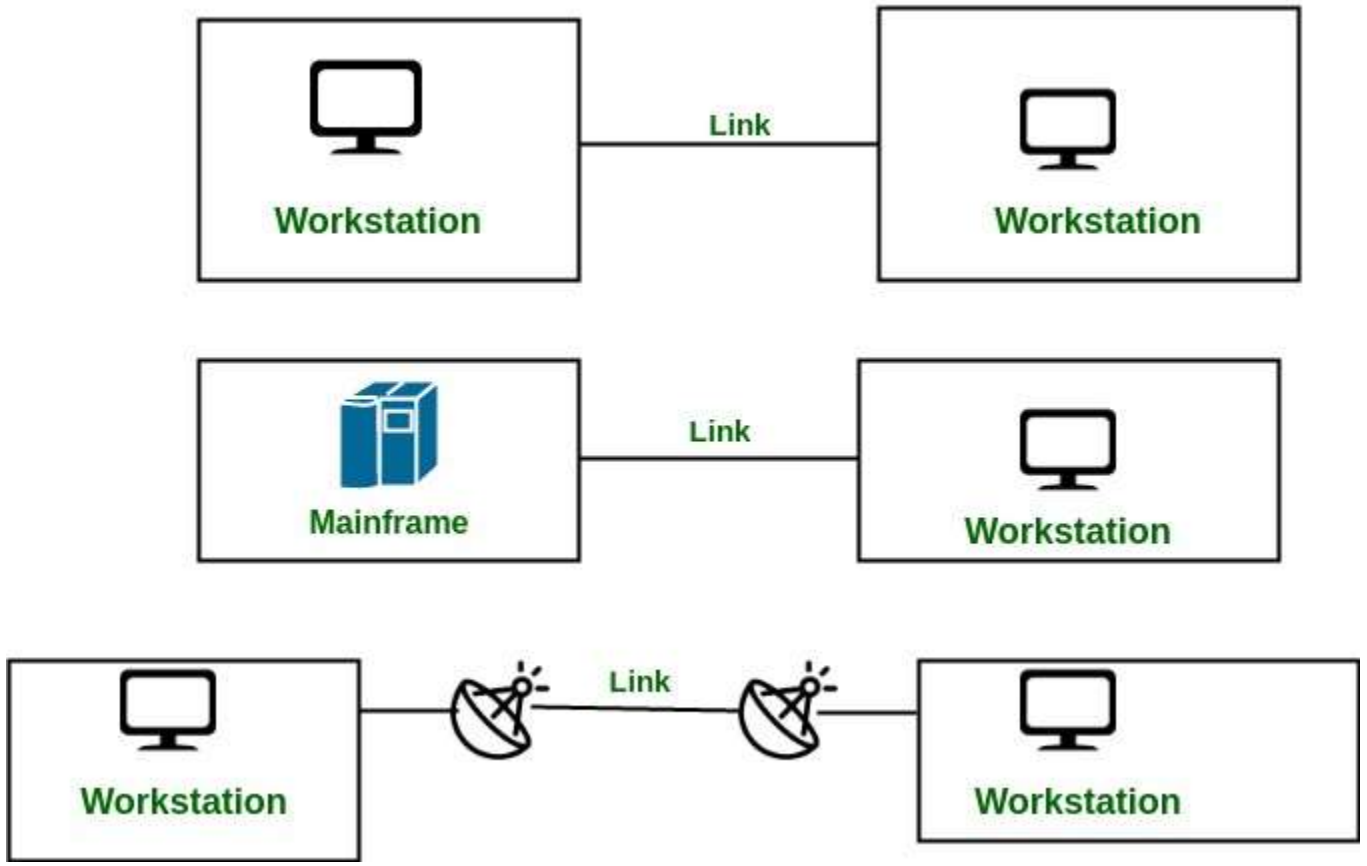


Fig: Point to Point Connection

Line Configuration

- **Multipoint Connection**
- It is also called Multidrop configuration.
- In this connection, two or more devices share a single link.
- More than two devices share the link that is the capacity of the channel is shared now.
- With shared capacity, there can be two possibilities in a Multipoint Line configuration:
- **Spatial Sharing:** If several devices can share the link simultaneously, it’s called Spatially shared line configuration.
- **Temporal (Time) Sharing:** If users must take turns using the link, then it’s called Temporally shared or Time Shared Line configuration.

Line Configuration

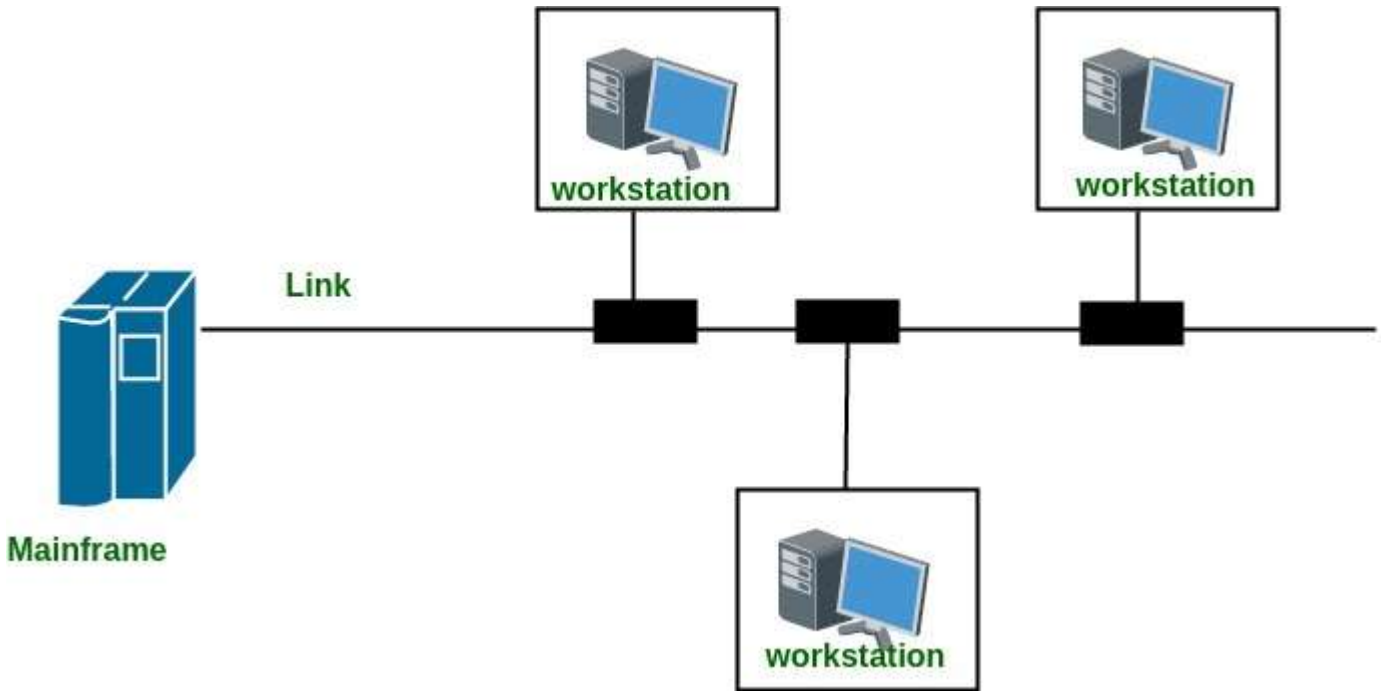
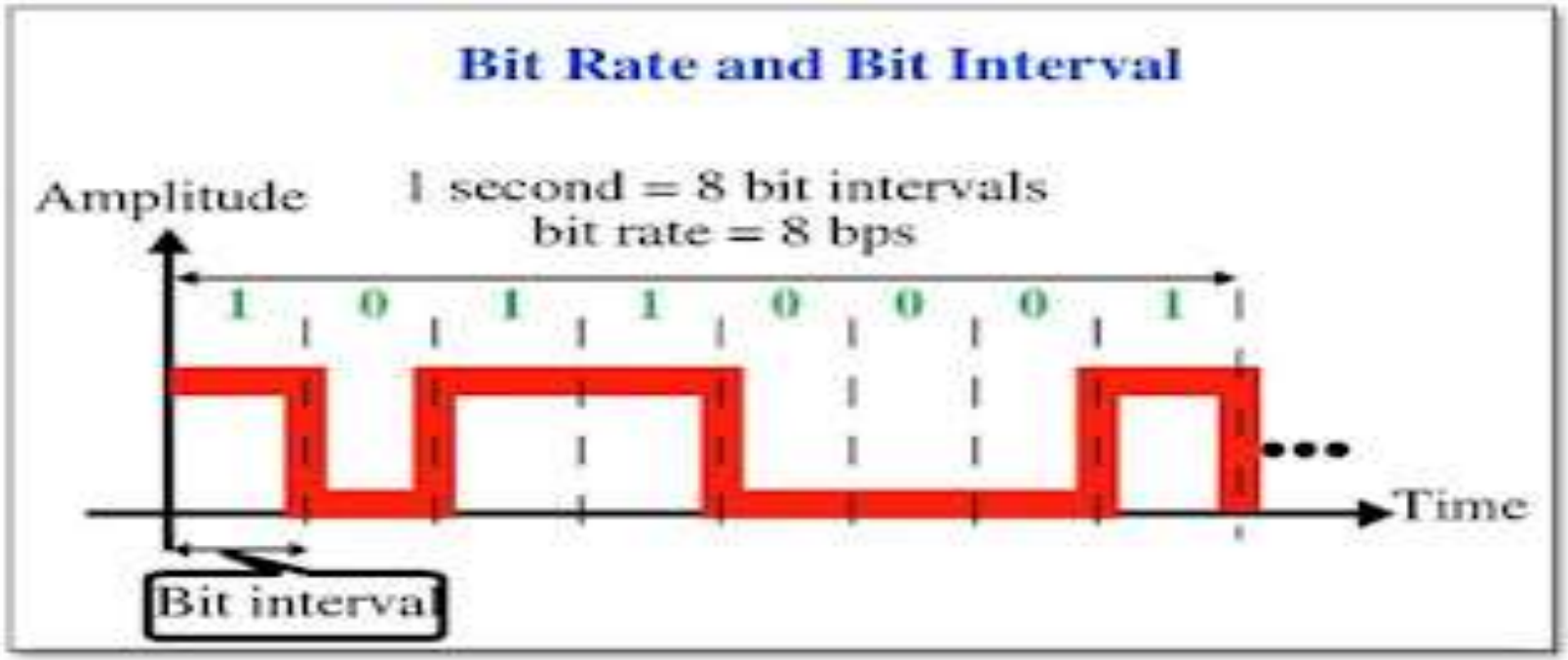


Fig :Multipoint Connection

Bit Rate/ Baud Rate

- Bit Rate
- The number of bits per second that can be transmitted along with a digital network.
- Bitrate, as the name implies, describes the rate at which bits are transferred from one location to another.
- It measures how much data is transmitted in a given amount of time.
- Bitrate is commonly measured in bits per second (bps), kilobits per second (Kbps), or megabits per second (Mbps).
- Bit rate = number of bits transmitted/ total time (in seconds)
- The bit rate can also be defined in terms of baud rate
- **Bit rate = Baud rate x bits per signal or symbol**

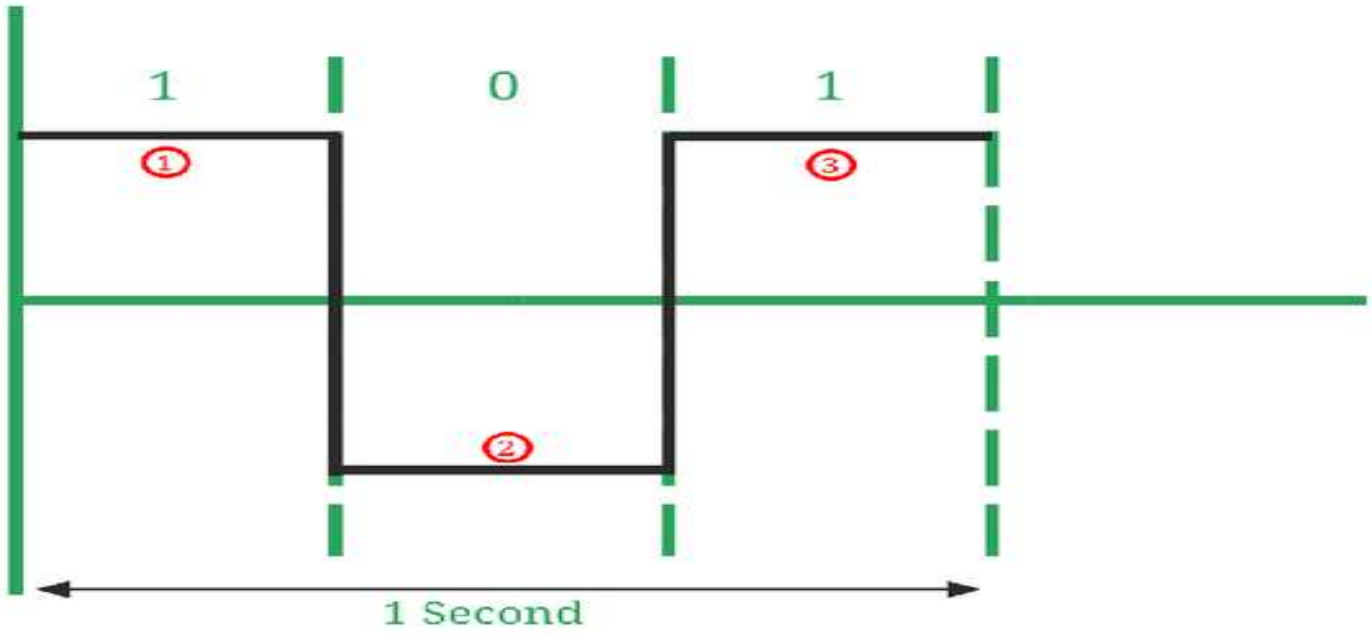
Bit Rate/ Baud Rate



Bit Rate/ Baud Rate

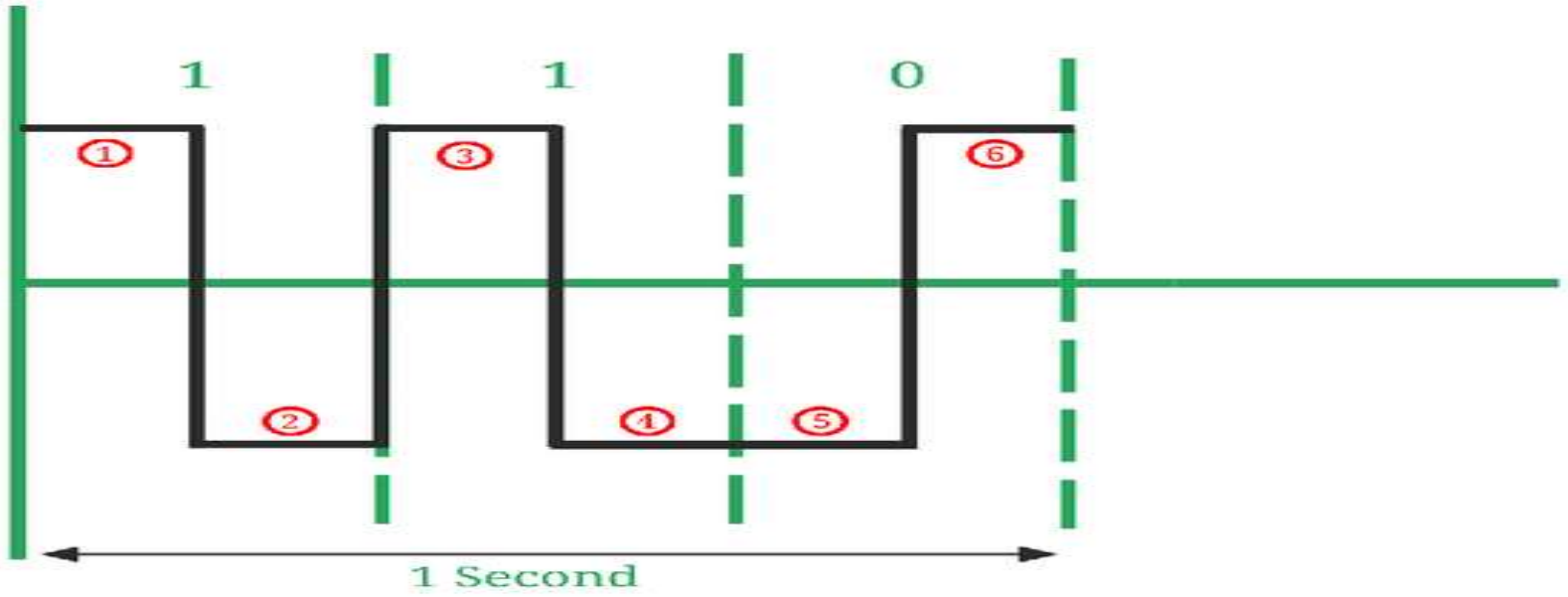
- **Baud Rate**
- Baud rate is the rate at which the number of signal elements or changes to the signal occurs per second when it passes through a transmission medium.
- The higher a baud rate is the faster the data is sent/received.
- Baud rate = number of signal elements/total time (in seconds)

Bit Rate/ Baud Rate



In *fig*, Number of signal elements (marked in red color) = 3, Number of bits transmitted (1, 0, 1) = 3.
So, Here Bit rate = 3/1 = 3 bits per second. And, Baud rate = 3/1 = 3 baud per second.

Bit Rate/ Baud Rate



In *Fig*, Number of signal elements (marked in red color) = 6, Number of bits transmitted (1, 1, 0) = 3. So, Here Bit rate = 3/1 = 3 bits per second. and, Baud rate = 6/1 = 6 baud per second.

Bit Rate/ Baud Rate

- **Why baud rate is important?**
- Baud rate is important because:
- Baud rate can determine the bandwidth requirements for transmission of the signal.
- Baud rate is also used for the calculation of the Bit rate of a communication channel.
- It is a tuning parameter (i.e., it adjusts the Network congestion in data networking) for the transmission of a signal.
- It specifies how fast data can be sent over a serial line or serial interface (it’s an interface that sends data as a series of bits over a single wire.).

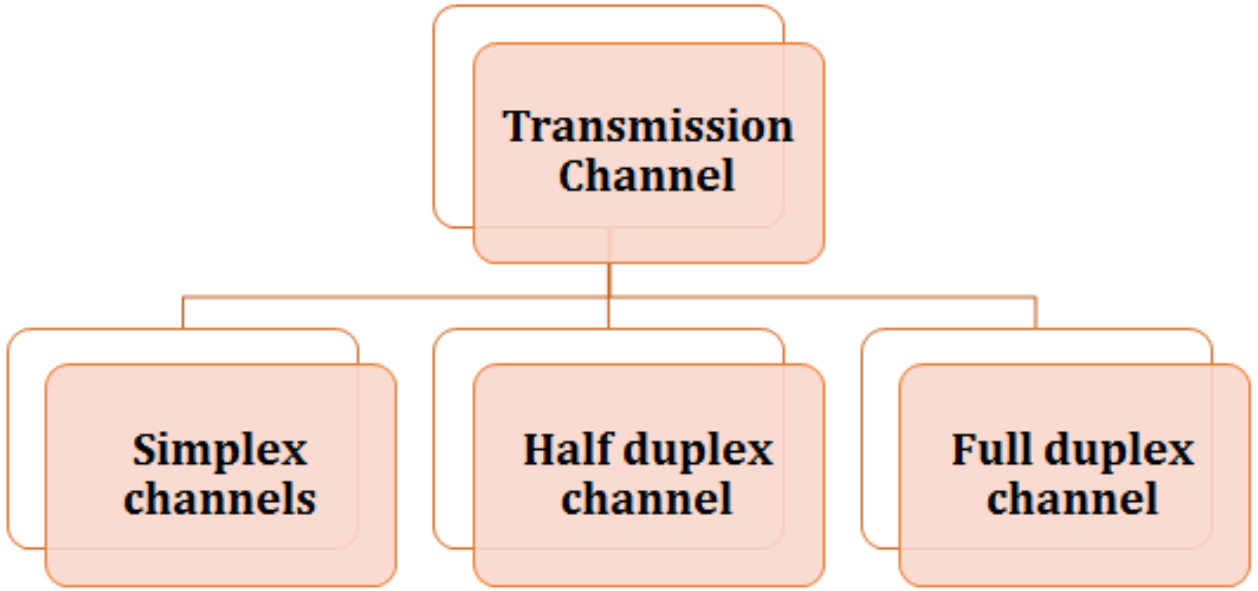
Bit Rate/ Baud Rate

Sr. No.	Key	Bit Rate	Baud Rate
1	Definition	Bit rate is transmission of number of bits per second.	Baud rate is number of signal units per second.
2	Definition	It can be defined as per second travel number of bits.	It can be defined as per second number of changes.
3	Focus	Bit rate focusses on computer efficiency.	Baud rate focusses on data transmission.
4	Formula	Bit Rate = Baud rate x the number of bit per baud	Baud Rate = Bit rate / the number of bit per baud

Transmission Channel

- **Transmission Channel**
- Media use to describe the data path that forms the physical channels between the sender & receiver.
- The medium by which information is transmitted is known as transmission channels.
- The transfer of data is measured in the form of bandwidth the higher the bandwidth the more data will transfer.
- Transmission Channel can also be called Transmission Modes.

Transmission Channel



Transmission Channel

- **Simplex Mode/Channel**
- In Simplex mode, the communication is unidirectional, as on a one-way street.
- 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.
- Example: Keyboard and traditional monitors.
- The keyboard can only introduce input, the monitor can only give the output.

Transmission Channel

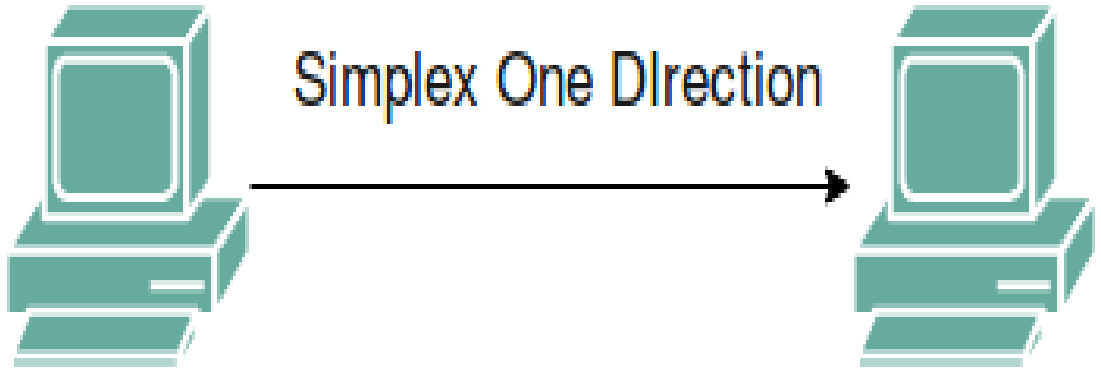


Fig : Simplex Mode

Transmission Channel

- **Half-Duplex Mode**
- In half-duplex mode, each station can both transmit and receive, but not at the same time.
- When one device is sending, the other can only receive, and vice versa.
- The half-duplex mode is used in cases where there is no need for communication in both directions at the same time.
- The entire capacity of the channel can be utilized for each direction.
- Example: Walkie-talkie in which message is sent one at a time and messages are sent in both directions.

Transmission Channel

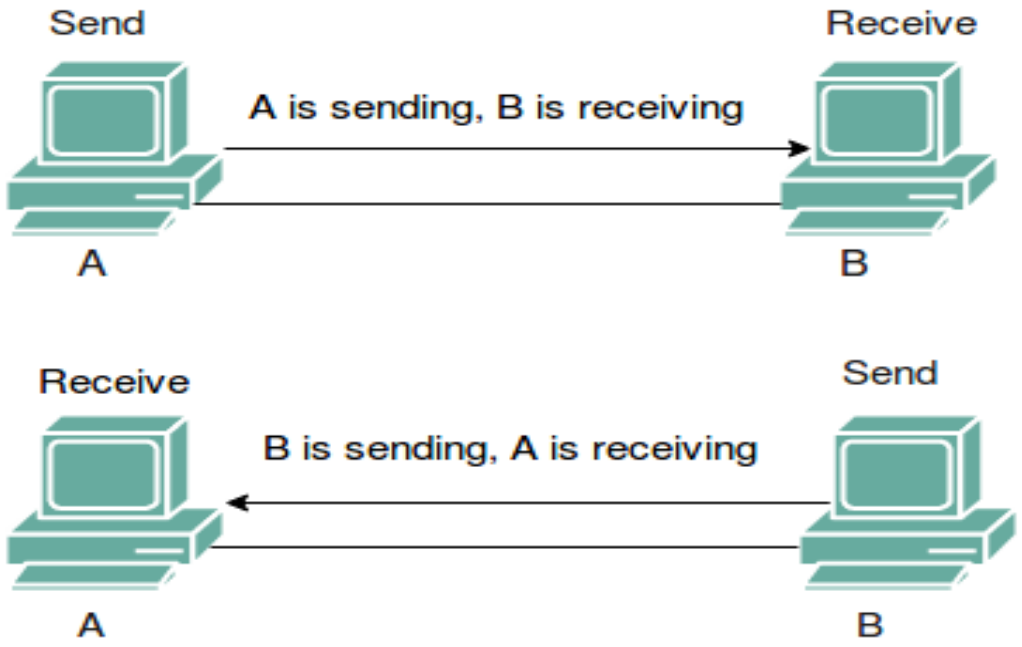


Fig : Half-Duplex Mode

Transmission Channel

- **Full Duplex Mode**
- In full-duplex mode, both stations can transmit and receive simultaneously.
- In full-duplex mode, signals going in one direction share the capacity of the link with signals going in another direction, this sharing can occur in two ways:
- Either the link must contain two physically separate transmission paths, one for sending and the other for receiving.
- Or the capacity is divided between signals traveling in both directions.
- Full-duplex mode is used when communication in both directions is required all the time.
- The capacity of the channel, however, must be divided between the two directions.
- 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.

Transmission Channel

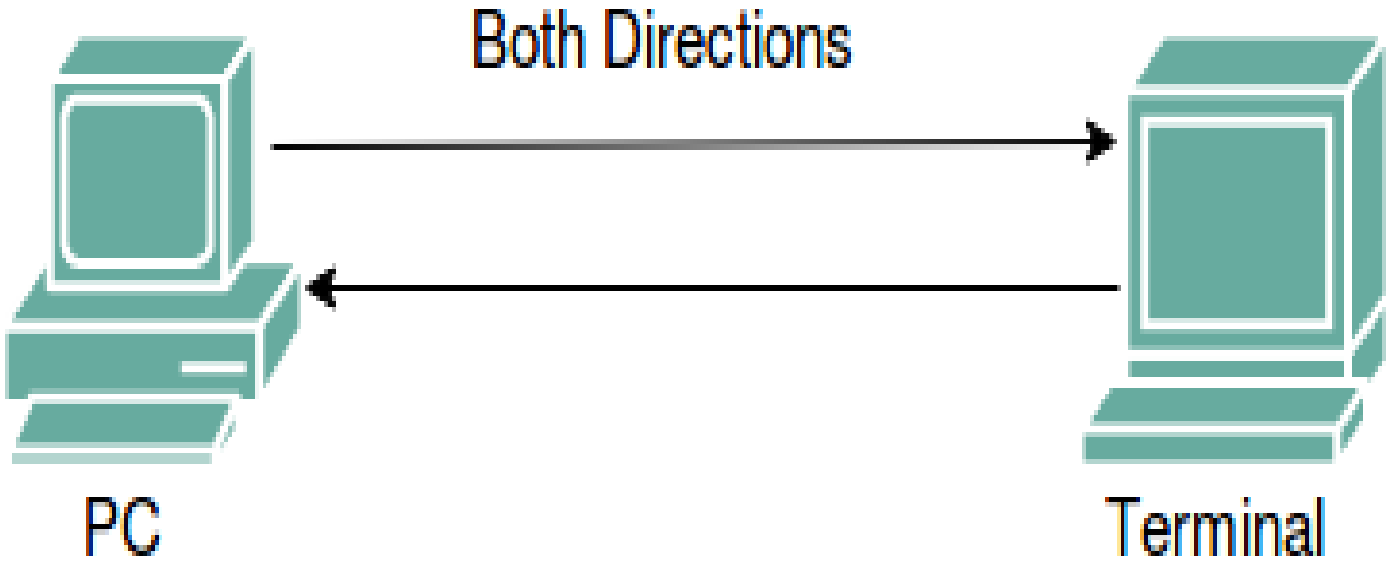


Fig : Full- Duplex Mode

Channel Capacity

- Channel capacity is a maximum information rate that a channel can transmit.

- Two theoretical formulas were developed to calculate the data rate.

- Nyquist for a noiseless channel
- Shannon for a noisy channel

Channel Capacity

- **Noiseless Channel: Nyquist Bit Rate**
- For a noiseless channel, the Nyquist bit rate formula defines the theoretical maximum bit rate .
- ***Nyquist*** proved that if an arbitrary signal has been run through a low-pass filter of bandwidth, the filtered signal can be completely reconstructed by making only 2*Bandwidth (exact) samples per second.
- Sampling the line faster than 2*Bandwidth times per second is pointless because the higher-frequency components that such sampling could recover have already been filtered out.

Nyquist Rate

- If the signal consists of L discrete levels, Nyquist's theorem states:

- Bit Rate = 2 * Bandwidth * $\log_2(L)$ bits/sec

- bandwidth is the bandwidth of the channel,
- L is the number of signal levels used to represent data,
- Bit Rate is the bit rate in bits per second.
- Bandwidth is a fixed quantity, so it cannot be changed.
- Hence, the data rate is directly proportional to the number of signal levels.

Nyquist rate

- **Examples:**
- **Input1 :** Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with two signal levels. What can be the maximum bit rate?
  Output1 : Bit Rate = 2 * 3000 * $\log_2(2)$ = 6000bps

- **Input2 :** We need to send 265 kbps over a noiseless channel with a bandwidth of 20 kHz. How many signal levels do we need?
  Output2 : 265000 = 2 * 20000 * $\log_2(L)$
  $\log_2(L) = 6.625$
  $L = 2^{6.625} = 98.7$ levels

Channel Capacity

- **Noisy Channel: Shannon Capacity**

- In reality, we cannot have a noiseless channel;
- the channel is always noisy.
- Shannon capacity is used, to determine the theoretical highest data rate for a noisy channel:

- Capacity = bandwidth * $\log_2(1 + SNR)$ bits/sec

- bandwidth is the bandwidth of the channel,
- SNR is the signal-to-noise ratio,
- capacity is the capacity of the channel in bits per second

Shannon Capacity

- Bandwidth is a fixed quantity, so it cannot be changed.
- Hence, the channel capacity is directly proportional to the power of the signal,
- as SNR = (Power of signal) / (power of noise).

- The signal-to-noise ratio (S/N) is usually expressed in decibels (dB) given by the formula:

$$10 * \log_{10}(S/N)$$

- So for example a signal-to-noise ratio of 1000 is commonly expressed as:

$$10 * \log_{10}(1000) = 30 \text{ dB}.$$

Shannon Capacity

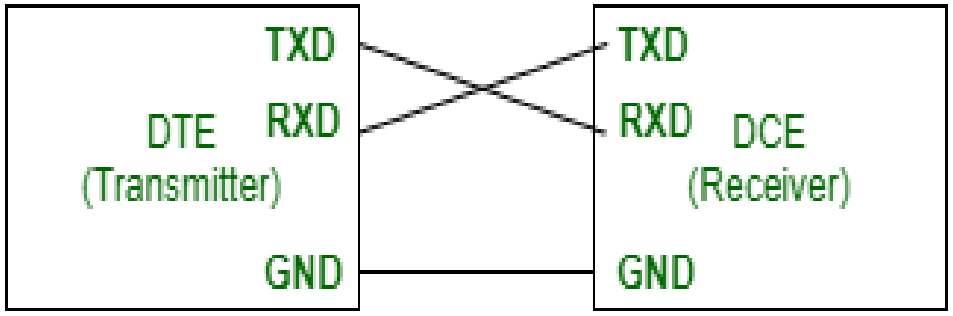
- **Examples:**
- **Input1 :** A telephone line normally has a bandwidth of 3000 Hz (300 to 3300 Hz) assigned for data communication. The SNR is usually 3162. What will be the capacity for this channel?

- **Output1 :** $C = 3000 * \log_2(1 + SNR) = 3000 * 11.62 = 34860$ bps

- **Input2 :** The SNR is often given in decibels. Assume that SNR(dB) is 36 and the channel bandwidth is 2 MHz . Calculate the theoretical channel capacity.
  Output2 : $SNR(dB) = 10 * \log_{10}(SNR)$
  $SNR = 10^{(SNR(dB)/10)}$
  $SNR = 10^{3.6} = 3981$
- Hence, $C = 2 * 10^6 * \log_2(3981) = 24$ MHz

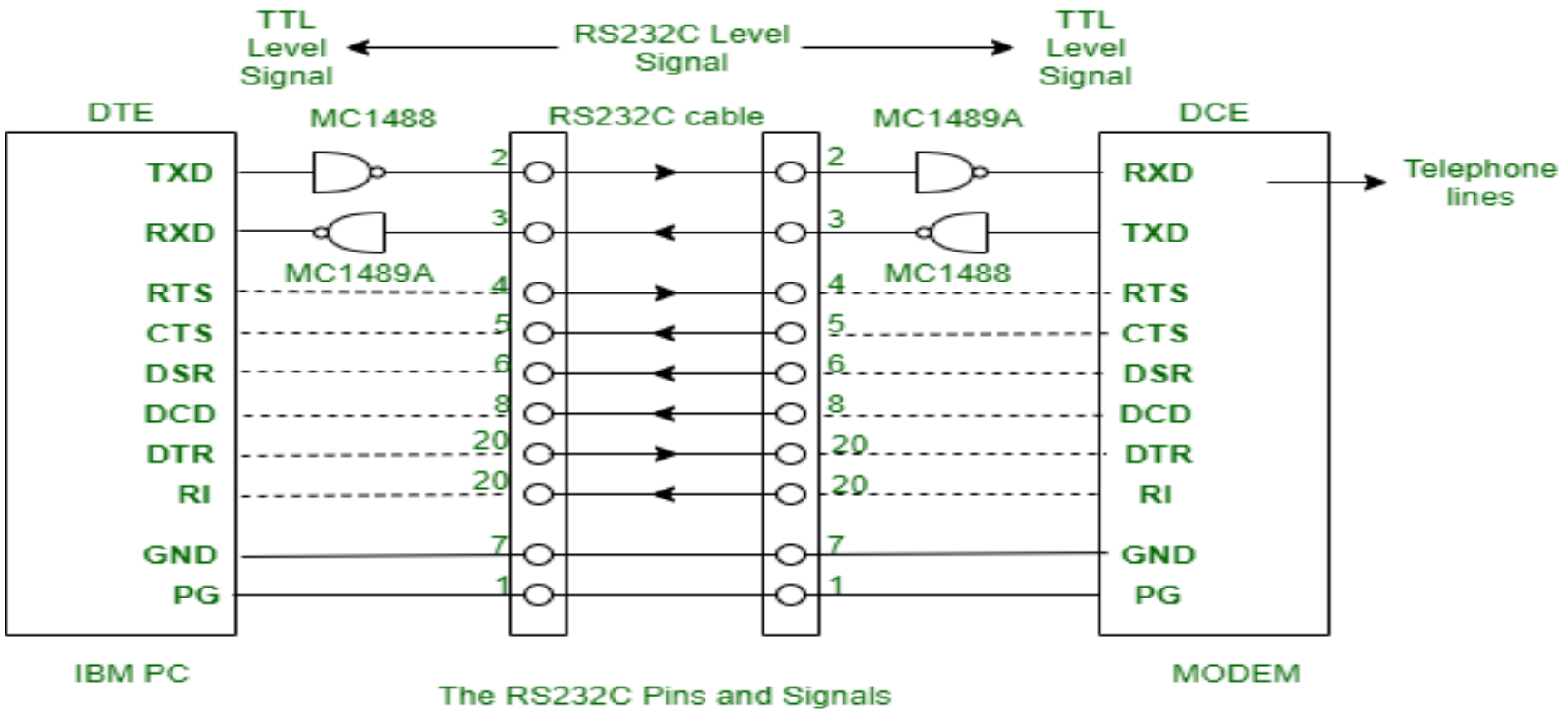
RS 232C

- RS232 is an Interface and the protocol between DTE(data terminal equipment) and DCE(data communication equipment) using serial binary data exchange.
- Here C is used for the current version.
- Universal Asynchronous Data Receiver & Transmitter (UART), attached to a motherboard, used in connection with RS232 for transmitting data to any serial device like modem or printer from its DTE interface.



RS232 PROTOCOL

RS 232C



The RS232C Pins and Signals

RS 232C

- RS232C requires 25 pins connector for connecting DTE and DCE.
- Here is the list of pins and signals of RS232C and the connection between DTE and DCE using drivers and receivers.
- **TXD & RXD**
- Transmit Data and Receive Data on the DTE are the serial data lines.
- These lines have opposite functions on a DCE.
- TXD sends outgoing data to DCE.
- RXD receives incoming data from DTE.

RS 232C

- **RTS & CTS**
- Transmitter activates the Request to Send when it requires transmitting data over the line.
- The line itself gets deactivated when the communication stops.
- Receiver activates the Clear To Send to tell the transmitter whether it is ready or not to receive the data.
- It remains active during the transmission.
- **DTR & DSR**
- Through the Data Terminal Ready line, DTE informs the DCE that it is in online mode and the process of communication can occur.
- The main task of the Data Set Ready signal is to inform that DCE is ready for communication.

RS 232C

- **DCD**
  DCE activates the Data Carrier Detect in order to show that it has been connected to DTE.
- **RI**
- When an incoming call on the telephone line is detected by DCE, then the Ring Indicator gets activates.

RS 232C

- **Applications**
- However, most of the functions performed by RS232C have been taken by the USB, but they are still successful in performing the following applications.

1. It is used in establishing communication between the computer and embedded systems.
2. Due to its lower costs, It plays a vital role in CNC machines and servo controllers
3. Some microcontroller boards and PLC machines use RS232C.
4. RS232C ports are used to communicate in headless systems in the absence of any network connection.
5. Many Computerized Numerical Control Systems use RS232C port.

RS 449

- The RS449 serial data standard was intended as an enhancement to RS232.
- It was aimed at providing serial data transmission at speeds up to 2 Mbps whilst still being able to maintain compatibility with RS232.
- Though never applied on personal computers, this interface was found on some network communication equipment.
- The RS449 standard has now been discontinued and may also be seen in some references as EIA-449, TIA-449 and ISO 4902.

RS 449

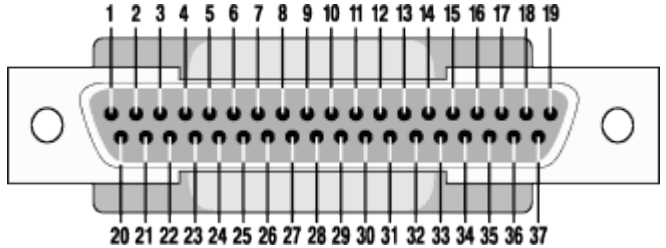


Fig: Pin Configuration

Pin A	Pin B	EIA CKT	Description	From DCE	To DCE
1 2		 SI	Shield Signaling Rate Indicator	 *C	
4 5	22 23	SD ST	Send Data Send Timing	 *T	*D
6 7	24 25	RD RS	Receive Data Request to Send	*D	 *C
8 9	26 27	RT CS	Receive Timing Clear to Send	 *T	 *C
10 11	 29	LL DM	Local Loopback Data Mode	 *C	*C
12 13	30 31	TR RR	Terminal Ready Receiver Ready	 *C	*C
14 15		RL IC	Remote Loopback Incoming Call	 *C	*C
16 17	 35	SR TT	Signaling Rate Selector Incoming Call		*C *T
18 19		TM SG	Test Mode Signal Ground	*C	
20 28		RC IS	Receive Common Terminal in Service		 *C
32 33		SS SQ	Select Standby Signal Quality	 *C	*C
34 36 37		NS SB SC	New Signal Standby Indicator Send Common	*C	 *C

Signal Type: D = Data, C = Control, T = Timing
Note: On the DB37 connector that is commonly used for RS449; Pins 3 and 21 are undfined
B = Return

Fig : Pin Description

THANK YOU