# Overview of Data:

Analog and digital data are two fundamental types of data representations used in various electronic systems and devices. They differ in how they represent information and are processed. Let's provide an overview of analog and digital data:

1. **Analog Data:** Analog data represents information in a continuous format, where values can vary smoothly and infinitely within a given range. Analog signals can take on any value within their range, making them well-suited for representing real-world phenomena that change continuously, such as sound, temperature, voltage, and pressure. Analog data can be visualized as a wave, where the signal's amplitude and frequency carry the information.

   Example: In an analog audio signal, the changing voltage levels directly represent the varying air pressure patterns of the sound wave.
2. **Digital Data:** Digital data represents information using discrete values, usually in the form of binary digits (0s and 1s). Each value in a digital representation is quantized, meaning it can only take on specific discrete states. Digital data is well-suited for storing, transmitting, and processing information using computers and other digital devices. It provides a more robust and reliable way of representing data compared to analog, as it is less susceptible to signal degradation and noise.

   Example: Digital data in the form of binary code is used in computers to represent text, images, videos, and other multimedia.

## Key differences between analog and digital data:

1. Representation:
- Analog: Continuous representation with infinite possible values within a range.
- Digital: Discrete representation with a finite set of distinct values (binary digits).

2. Precision:
- Analog: Can represent values with high precision, limited only by the measurement equipment.
- Digital: Limited to the number of bits used for representation, which determines the resolution or precision.

3. Noise Susceptibility:
- Analog: Prone to interference and noise, which can degrade the quality of the signal.
- Digital: More resilient to noise, as long as the noise does not lead to misinterpretation of the binary values.

4. Processing:
- Analog: Analog data processing requires specialized analog circuits and can be more complex.
- Digital: Digital data processing can be done using digital circuits and algorithms, often more straightforward and efficient.

5. Conversion:
- Analog: Requires analog-to-digital conversion (ADC) to convert analog signals into digital format for processing by computers.
- Digital: May require digital-to-analog conversion (DAC) to convert digital signals back to analog format for certain applications like audio output.

## Analog & Digital Signal:

Analog and digital signals are two different types of electrical signals used to transmit and process information in electronic systems. They vary in their representation, characteristics, and applications. Let's delve into each type:

1. **Analog Signal**: An analog signal is a continuous electrical signal that varies smoothly over time and can take on an infinite number of values within a specific range. In an analog signal, the amplitude, frequency, or phase of the waveform corresponds directly to the information being transmitted. Common examples of analog signals include audio signals, voltage levels in electronic circuits, and signals from sensors measuring physical quantities like temperature or pressure.

**Characteristics of Analog Signals:**

- **Continuous:** Analog signals have an infinite number of possible values within their range.
- Smooth Variation: The signal changes smoothly over time, forming a continuous waveform.
- **Susceptible to Noise**: Analog signals are more vulnerable to noise and interference, which can lead to signal degradation.

Applications of Analog Signals:

- Analog audio signals in music players, radios, and telephones.
- Analog voltage signals in analog electronic circuits for amplification and filtering.
- Sensor outputs, such as from temperature sensors, pressure sensors, etc.

2. **Digital Signal:** A digital signal is a discrete electrical signal represented by binary digits, typically 0s and 1s. It has a finite set of possible values, and each value corresponds to a specific discrete level of the signal. Digital signals are commonly used in computers, digital communication systems, and modern electronic devices. They offer higher accuracy and reliability compared to analog signals, as they are less affected by noise and can be easily processed and transmitted.

**Characteristics of Digital Signals:**

- **Discrete:** Digital signals have a finite set of discrete values, typically represented as binary digits.
- **Non-continuous:** The signal changes abruptly from one discrete level to another at specific intervals.
- **Noise Resistance:** Digital signals are more resistant to noise and can be accurately reconstructed even after transmission through noisy channels.

Applications of Digital Signals:

- Digital communication systems, such as the internet, mobile networks, and Ethernet.
- Computers and digital devices that process and store data in binary format.
- Digital audio and video signals in modern multimedia systems.

## Digital Transmission in Computer Network

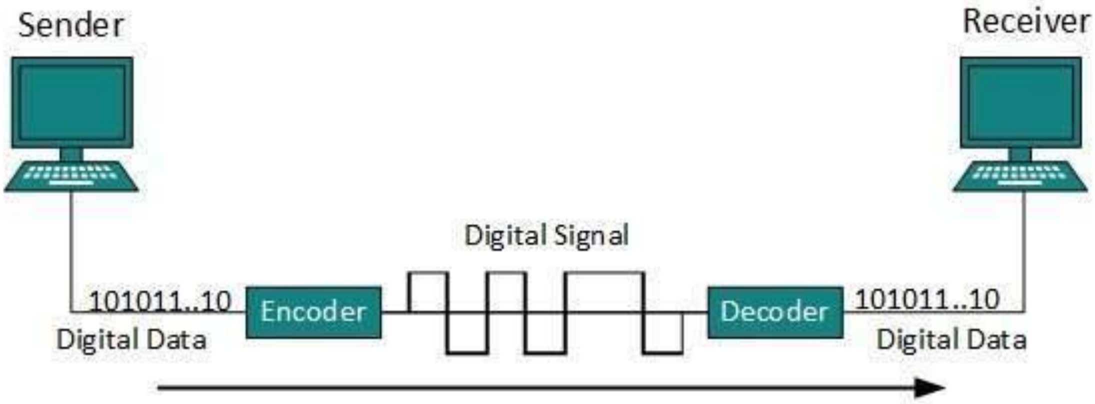
Data or information can be stored in two ways, analog and digital. For a computer to use the data, it must be in discrete digital form.Similar to data, signals can also be in analog and digital form. To transmit data digitally, it needs to be first converted to digital form.

## Digital-to-Digital Conversion

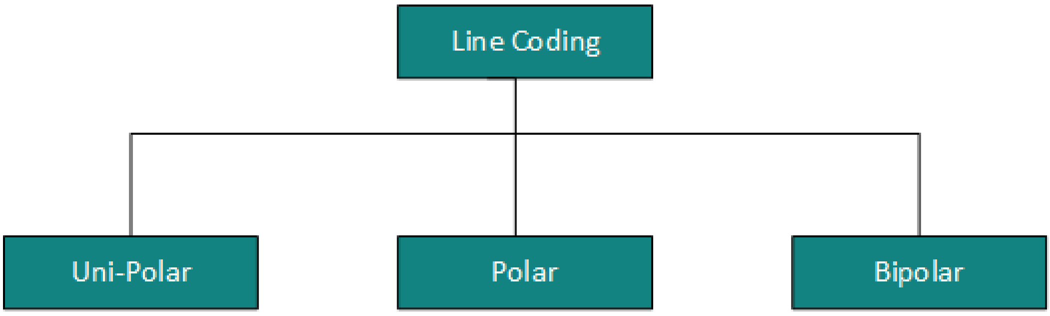
This section explains how to convert digital data into digital signals. It can be done in two ways, line coding and block coding. For all communications, line coding is necessary whereas block coding is optional.

## Line Coding

The process for converting digital data into digital signal is said to be Line Coding. Digital data is found in binary format.It is represented (stored) internally as series of 1s and 0s.

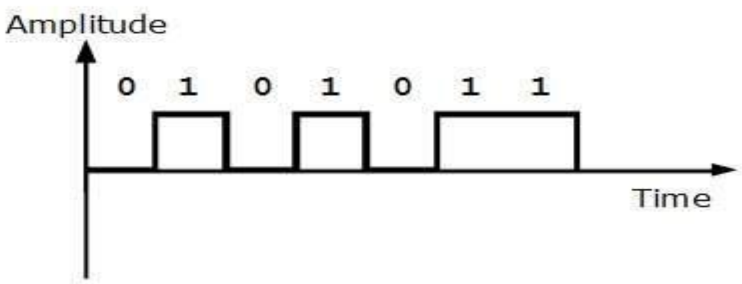



Digital signal is denoted by discreet signal, which represents digital data.There are three types of line coding schemes available:




### Uni-polar Encoding

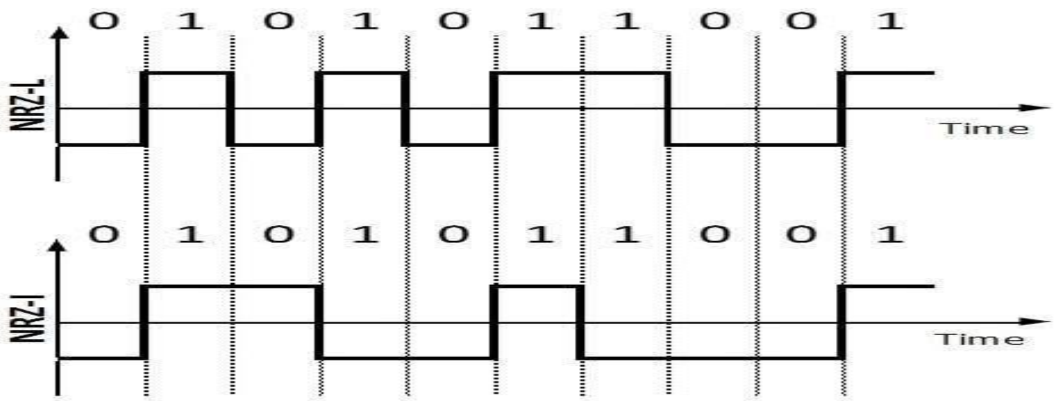
Unipolar encoding schemes use single voltage level to represent data. In this case, to represent binary 1, high voltage is transmitted and to represent 0, no voltage is transmitted. It is also called Unipolar-Non-return-to-zero, because there is no rest condition i.e. it either represents 1 or 0.




### Polar Encoding

Polar encoding scheme uses multiple voltage levels to represent binary values. Polar encodings is available in four types:

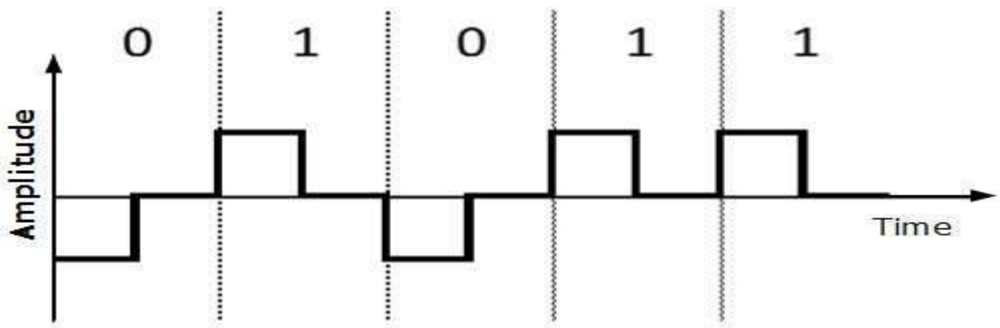
- Polar Non-Return to Zero (Polar NRZ)
  It uses two different voltage levels to represent binary values. Generally, positive voltage represents 1 and negative value represents 0. It is also NRZ because there is no rest condition.
  NRZ scheme has two variants: NRZ-L and NRZ-I.




NRZ-L changes voltage level at when a different bit is encountered whereas NRZ-I changes voltage when a 1 is encountered.

- Return to Zero (RZ)

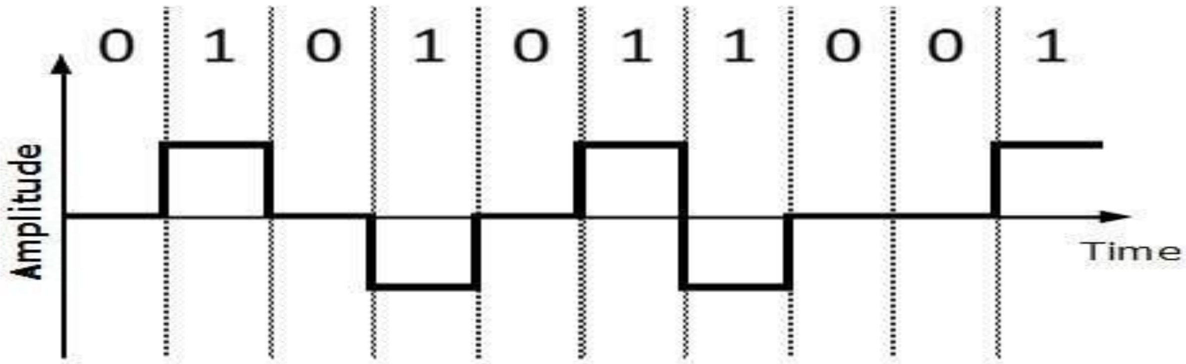
  Problem with NRZ is that the receiver cannot conclude when a bit ended and when the next bit is started, in case when sender and receiver's clock are not synchronized.




RZ uses three voltage levels, positive voltage to represent 1, negative voltage to represent 0 and zero voltage for none. Signals change during bits not between bits.

## Bipolar Encoding

Bipolar encoding uses three voltage levels, positive, negative and zero. Zero voltage represents binary 0 and bit 1 is represented by altering positive and negative voltages.




## Analog-to-Digital Conversion

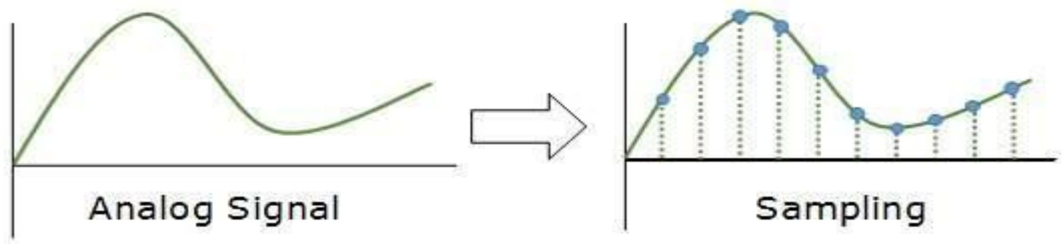
Microphones create analog voice and camera creates analog videos, which are treated is analog data. To transmit this analog data over digital signals, we need analog to digital conversion.

Analog data is a continuous stream of data in the wave form whereas digital data is discrete. To convert analog wave into digital data, we use Pulse Code Modulation (PCM).

PCM is one of the most commonly used method to convert analog data into digital form. It involves three steps:

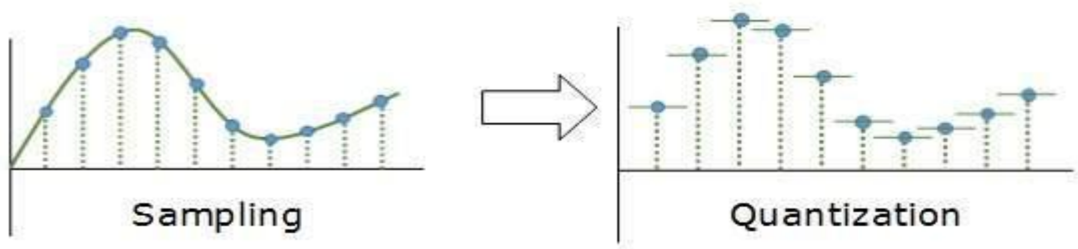
- Sampling
- Quantization
- Encoding.

## Sampling



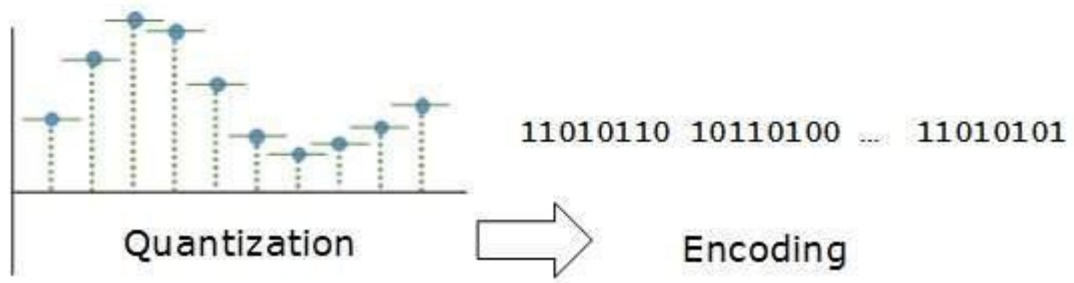

The analog signal is sampled every T interval. Most important factor in sampling is the rate at which analog signal is sampled. According to Nyquist Theorem, the sampling rate must be at least two times of the highest frequency of the signal.

## Quantization




Sampling yields discrete form of continuous analog signal. Every discrete pattern shows the amplitude of the analog signal at that instance. The quantization is done between the maximum amplitude value and the minimum amplitude value. Quantization is approximation of the instantaneous analog value.

## Encoding




In encoding, each approximated value is then converted into binary format.

## What is Data Transmission? Types of Data Transmission.

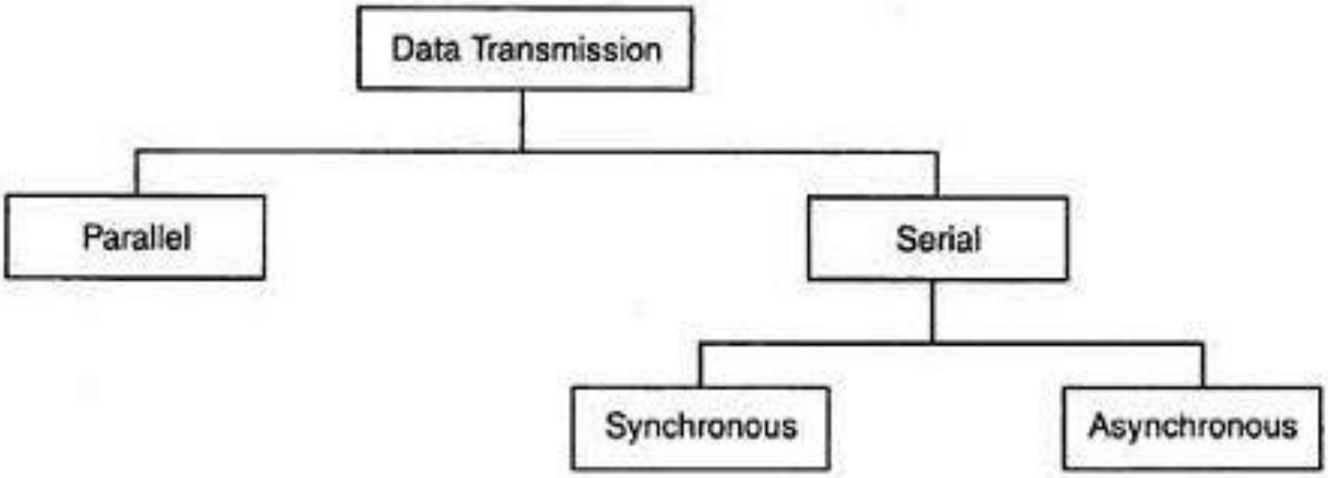
**Definition Data Transmission:** When we enter data into the computer via keyboard, each keyed element is encoded by the electronics within the keyboard into an equivalent binary coded pattern, using one of the standard coding schemes that are used for the interchange of information. To represent all characters of the keyboard, a unique pattern of 7 or 8 bits in size is used. The use of 7 bits means that 128 different elements can be represented, while 8 bits can represent 256 elements. A similar procedure is followed at the receiver that decodes every received binary pattern into the corresponding character.

The most widely used codes that have been adopted for this function are the Extended Binary Coded Decimal (EBCDIC) and the American Standard Code for Information Interchange codes (ASCII). Both coding schemes cater to all the normal alphabetic, numeric, and punctuation characters, collectively referred to as *printable characters* and a range of additional control characters, known as *non-printable characters.*

Data transmission refers to the movement of data in form of bits between two or more digital devices.

This transfer of data takes place via some form of transmission media (for example, coaxial cable, fiber optics etc.)

## Types of Data Transmission




## Parallel transmission

Definition: Within a computing or communication device, the distances between different subunits are too short. Thus, it is normal practice to transfer data between subunits using a separate wire to carry each bit of data. There are multiple wires connecting each sub-unit and data is exchanged using a *parallel transfer* mode. This mode of operation results in minimal delays in transferring each word.

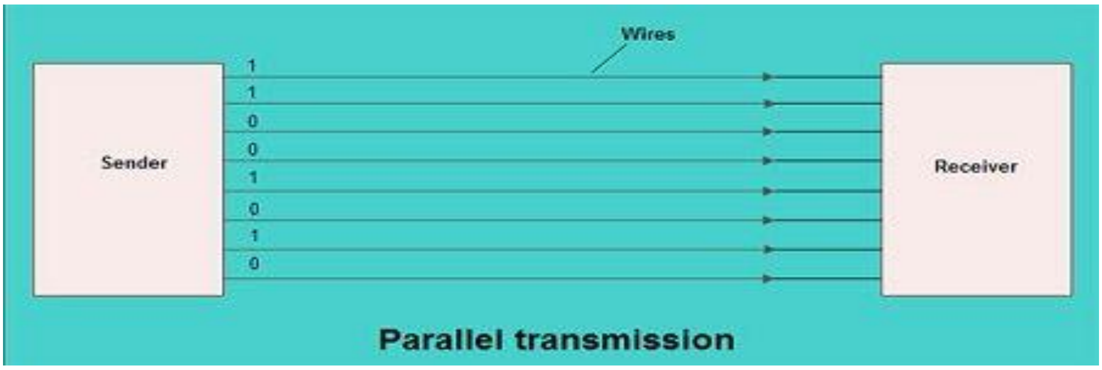
• In parallel transmission, all the bits of data are transmitted simultaneously on separate communication lines.

• 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.

• ***As shown in the fig, eight separate wires are used to transmit 8 bit data from sender to receiver.***



## Advantage of parallel transmission

It is speedy way of transmitting data as multiple bits are transmitted simultaneously with a single clock pulse.

## Disadvantage of parallel transmission

*It is costly method of data transmission as it requires* n *lines to transmit* n *bits at the same time.*

## Serial Transmission

Defination: When transferring data between two physically separate devices, especially if the separation is more than a few kilometers, for reasons of cost, it is more economical to use a single pair of lines. Data is transmitted as a single bit at a time using a fixed time interval for each bit. This mode of transmission is known as *bit-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 single line in serial fashion.

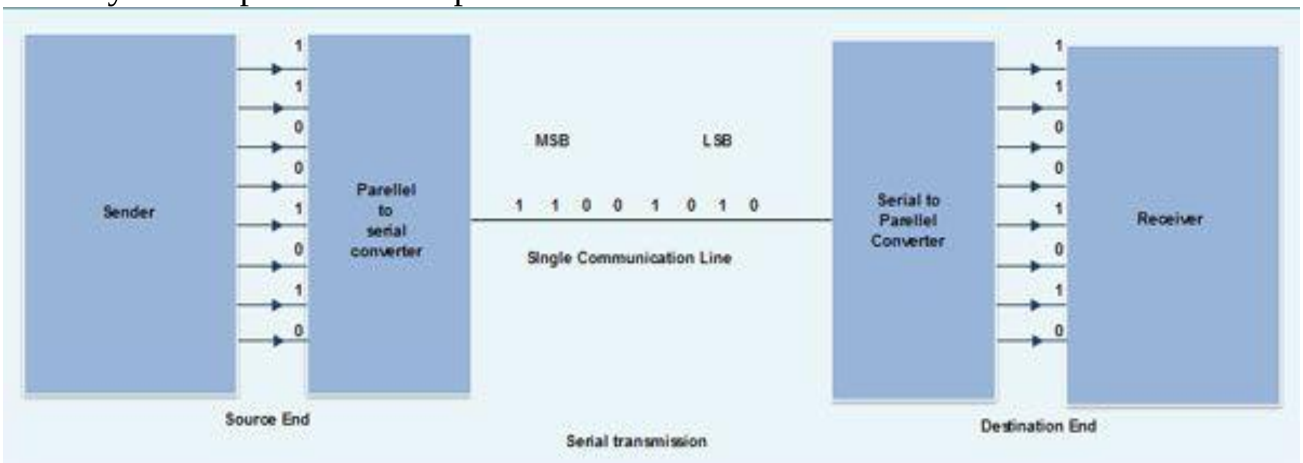
• In serial transmission, only single bit is sent with each clock pulse.

• As shown in fig., suppose an 8-bit data 11001010 is to be sent from source to destination. Then least significant bit (LSB) *i,e.* 0 will be transmitted first followed by other bits. The most significant bit (MSB) *i.e.* 1 will be transmitted in the end via single communication line.

• The internal circuitry of computer transmits data in parallel fashion. So in order to change this parallel data into serial data, conversion devices are used.

• These conversion devices convert the parallel data into serial data at the sender side so that it can be transmitted over single line.

• On receiver side, serial data received is again converted to parallel form so that the interval circuitry of computer can accept it




• Serial transmission is used for long distance communication.

## Advantage of Serial transmission

Use of single communication line reduces the transmission line cost by the factor of *n* as compared to parallel transmission.

## Disadvantages of Serial transmission

1. Use of conversion devices at source and destination end may lead to increase in overall transmission cost.

2. This method is slower as compared to parallel transmission as bits are transmitted serially one after the other.

## Types of Serial Transmission

There are two types of serial transmission-synchronous and asynchronous both these transmissions use '**Bit synchronization**'

Bit Synchronization is a function that is required to determine when the beginning and end of the data transmission occurs.

Bit synchronization helps the receiving computer to know when data begin and end during a transmission. Therefore bit synchronization provides timing control.

## 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 start bit and stop bit.

• Start bit indicates the beginning of data *i.e.* alerts the receiver to the arrival of 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.

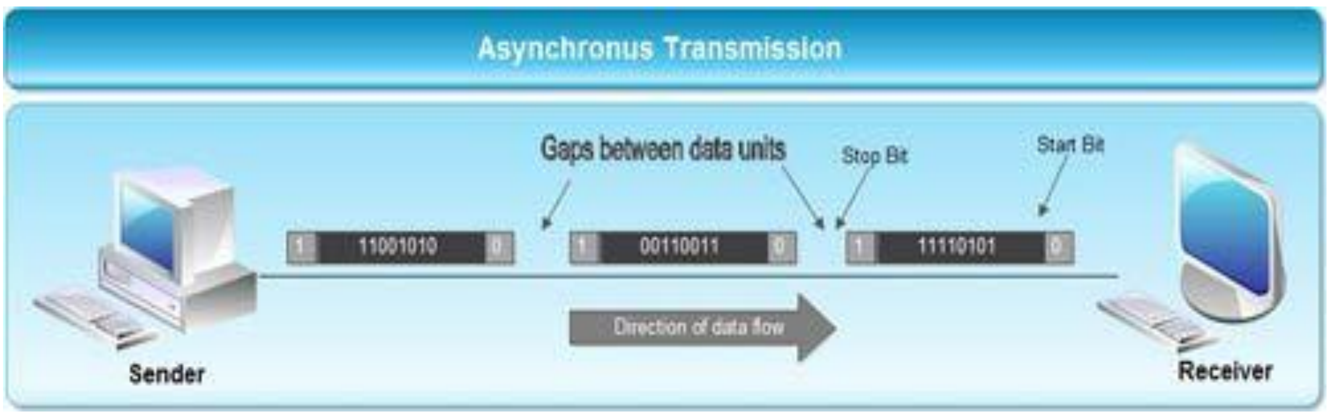

• Addition of start and stop increase the number of data bits. Hence more bandwidth is consumed in asynchronous transmission.

• 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 byte level sender and receiver need not to be synchronized. But within each byte, receiver must be synchronized with the incoming bit stream.

## Application of Asynchronous Transmission

1. Asynchronous **transmission** is well suited for keyboard type-terminals and paper tape devices. The advantage of this method is that it does not require any local storage at the terminal or the computer as transmission takes place character by character.




2. Asynchronous transmission is best suited to Internet traffic in which information is transmitted in short bursts. This type of transmission is used by modems.

### *Advantages of Asynchronous transmission*

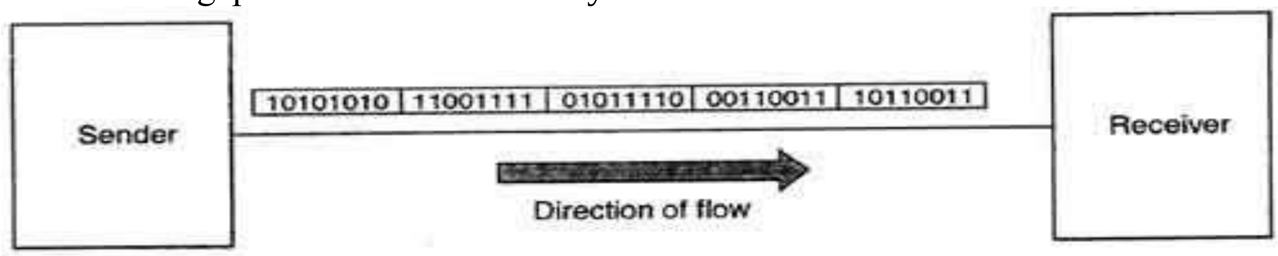
1. This method of data transmission is cheaper in cost as compared to synchronous *e.g.* If lines are short, asynchronous transmission is better, because line cost would be low and idle time will not be expensive.
2. In this approach each individual character is complete in itself, therefore if character is corrupted during transmission, its successor and predecessor character will not be affected.
3. It is possible to transmit signals from sources having different bit rates.
4. The transmission can start as soon as data byte to be transmitted becomes available.
5. Moreover, this mode of data transmission in easy to implement.

### *Disadvantages of asynchronous transmission*

1. This method is less efficient and slower than synchronous transmission due to the overhead of extra bits and insertion of gaps into bit stream.
2. Successful transmission inevitably depends on the recognition of the start bits. These bits can be missed or corrupted.

### 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.




Synchronous Transmission

• 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 receiver to separate the bit stream into bytes so as to reconstruct the original information.
• In order to receive the data error free, the receiver and sender operates at the same clock frequency.

### Application of Synchronous transmission

• Synchronous transmission is used for high speed communication between computers.

### *Advantage of Synchronous transmission*

1. 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*

1. It is costly as compared to asynchronous method. It requires local buffer storage at the two ends of line to assemble blocks and it also requires accurately synchronized clocks at both ends. This lead to increase in the cost.
2. The sender and receiver have to operate at the same clock frequency. This requires proper synchronization which makes the system complicated.

## Comparison between 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. |

## Comparison between Asynchronous and Synchronous.

| 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 |