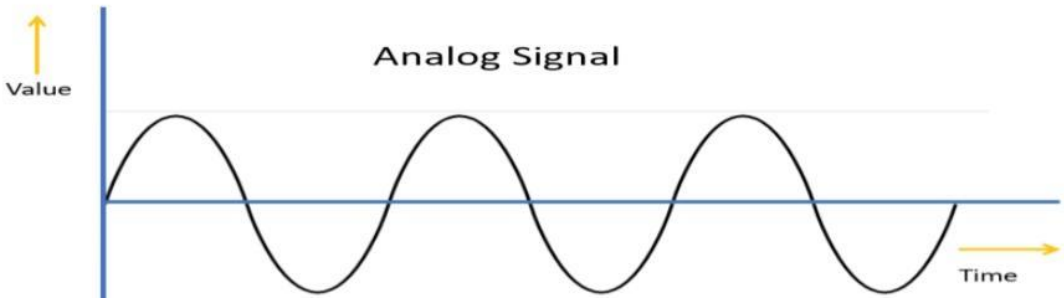
What is Signal?

● A signal is an electromagnetic or electrical current that is used for carrying data from one system or network to another.

● In electronics and telecommunications, it refers to any time-varying voltage that is an electromagnetic wave which carries information.

● A signal can also be defined as an observable change in quality such as quantity. There are two main types of signals: Analog signal and Digital signal.

What is an Analog Signal?

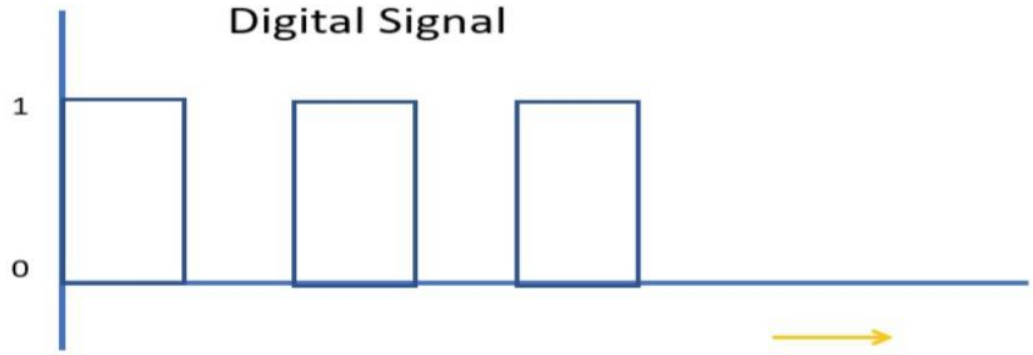


Analog Signal

● Analog signal is a continuous signal in which one time-varying quantity represents another time-based variable.

● These kind of signals works with physical values and natural phenomena such as earthquake, frequency, volcano, speed of wind, weight, lighting, etc.

What is a Digital Signal?



● A digital signal is a signal that is used to represent data as a sequence of separate values at any point in time.

● It can only take on one of a fixed number of values.

● This type of signal represents a real number within a constant range of values.

KEY DIFFERENCES:

● An analog signal is a continuous signal whereas Digital signals are time separated signals.

● Analog signal is denoted by sine waves while It is denoted by square waves.

● Analog signal uses a continuous range of values that help you to represent information on the other hand digital signal uses discrete 0 and 1 to represent information.

● Comparing Digital vs Analog signals, The analog signal bandwidth is low while the bandwidth of the digital signal is high.

● Analog instruments give considerable observational errors whereas Digital instruments never cause any kind of observational errors.

● Analog hardware never offers flexible implementation, but Digital hardware offers flexibility in implementation.

● Comparing Analog vs Digital signal, Analog signals are suited for audio and video transmission while Digital signals are suited for Computing and digital electronics.

Characteristics of Digital Signals

● Here, are essential characteristics of Digital signals

● Digital signal are continuous signals

● This type of electronic l signals can be processed and transmitted better compared to analog signal.

● Digital signals are versatile, so it is widely used.

● The accuracy of the digital signal is better than that of the analog signal.

Advantages of Analog Signals

● Easier in processing

● Best suited for audio and video transmission.

● It has a low cost and is portable.

● It has a much higher density so that it can present more refined information.

● Not necessary to buy a new graphics board.

● Uses less bandwidth than digital sounds

● Provide more accurate representation of a sound

● It is the natural form of a sound.

Advantages of Digital Signals

● Digital data can be easily compressed.

● Any information in the digital form can be encrypted.

● Equipment that uses digital signals is more common and less expensive.

● Digital signal makes running instruments free from observation errors like parallax and approximation errors.

● A lot of editing tools are available

● You can edit the sound without altering the original copy

● Easy to transmit the data over networks

Disadvantages of Analog Signals

● Here are cons/drawback of Analog Signals:

● Analog tends to have a lower quality signal than digital.

● The cables are sensitive to external influences.

● The cost of the Analog wire is high and not easily portable.

● Low availability of models with digital interfaces.

● Recording analog sound on tape is quite expensive if the tape is damaged

● It offers limitations in editing

● Tape is becoming hard to find

● It is quite difficult to synchronize analog sound

● Quality is easily lost

● Data can become corrupted

● Plenty of recording devices and formats which can become confusing to store a digital signal

● Digital sounds can cut an analog sound wave which means that you can't get a perfect reproduction of a sound

● Offers poor multi-user interfaces

Disadvantages of Digital Signals

● Sampling may cause loss of information.

● A/D and D/A demands mixed-signal hardware

● Processor speed is limited

● Develop quantization and round-off errors

● It requires greater bandwidth

● Systems and processing is more complex.

Data Encoding

● Encoding is the process of converting the data or a given sequence of characters, symbols, alphabets etc., into a specified format, for the secured transmission of data.

● Decoding is the reverse process of encoding which is to extract the information from the converted format.

Data Encoding

● Encoding is the process of using various patterns of voltage or current levels to represent 1s and 0s of the digital signals on the transmission link.

● The common types of line encoding are Unipolar, Polar, Bipolar, and Manchester.

Encoding Techniques

The data encoding technique is divided into the following types, depending upon the type of data conversion.

● Analog data to Analog signals − The modulation techniques such as Amplitude Modulation, Frequency Modulation and Phase Modulation of analog signals, fall under this category.

● Analog data to Digital signals − This process can be termed as digitization, which is done by Pulse Code Modulation PCMPCM.

● Hence, it is nothing but digital modulation. As we have already discussed, sampling and quantization are the important factors in this. Delta Modulation gives a better output than PCM.

● Digital data to Analog signals − The modulation techniques such as Amplitude Shift Keying ASKASK, Frequency Shift Keying FSK, Phase Shift Keying PSK, etc., fall under this category.

Digital data to Digital signals –

There are several ways to map digital data to digital signals.

Non Return to Zero NRZ

● NRZ Codes has 1 for High voltage level and 0 for Low voltage level. The main behavior of NRZ codes is that the voltage level remains constant during bit interval.

● The end or start of a bit will not be indicated and it will maintain the same voltage state, if the value of the previous bit and the value of the present bit are same.

Line Coding

A line code is the code used for data transmission of a digital signal over a transmission line. This process of coding is chosen so as to avoid overlap and distortion of signal such as inter-symbol interference.

Properties of Line Coding

● As the coding is done to make more bits transmit on a single signal, the bandwidth used is much reduced.

● For a given bandwidth, the power is efficiently used.

● The probability of error is much reduced.

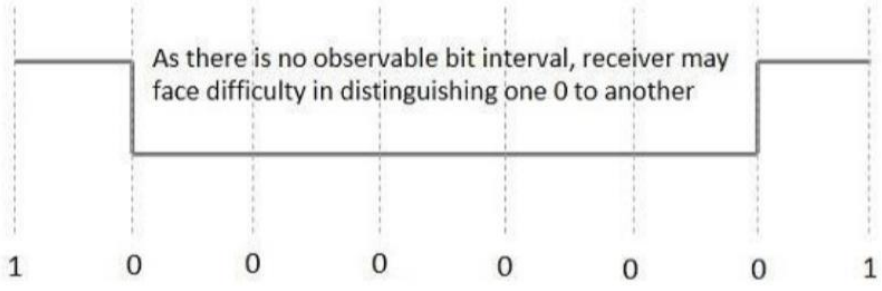
● Error detection is done and the bipolar too has a correction capability.

● Power density is much favourable.

● The timing content is adequate.

● Long strings of 1s and 0s is avoided to maintain transparency.

The following figure explains the concept of NRZ coding.



NRZ Coding

If the above example is considered, as there is a long sequence of constant voltage level and the clock synchronization may be lost due to the absence of bit interval, it becomes difficult for the receiver to differentiate between 0 and 1.

There are two variations in NRZ namely –

NRZ - L

NRZ–LEVEL

● There is a change in the polarity of the signal, only when the incoming signal changes from 1 to 0 or from 0 to 1.

● It is the same as NRZ, however, the first bit of the input signal should have a change of polarity.

NRZ - I

NRZ–INVERTED

● If a 1 occurs at the incoming signal, then there occurs a transition at the beginning of the bit interval. For a 0 at the incoming signal, there is no transition at the beginning of the bit interval.

● NRZ codes has a disadvantage that the synchronization of the transmitter clock with the receiver clock gets completely disturbed, when there is a string of 1s and 0s. Hence, a separate clock line needs to be provided.

Bi-phase Encoding

● The signal level is checked twice for every bit time, both initially and in the middle.

● Hence, the clock rate is double the data transfer rate and thus the modulation rate is also doubled. The clock is taken from the signal itself. The bandwidth required for this coding is greater.

● There are two types of Bi-phase Encoding.

● Bi-phase Manchester

● Differential Manchester

Bi-phase Manchester

● In this type of coding, the transition is done at the middle of the bit-interval.

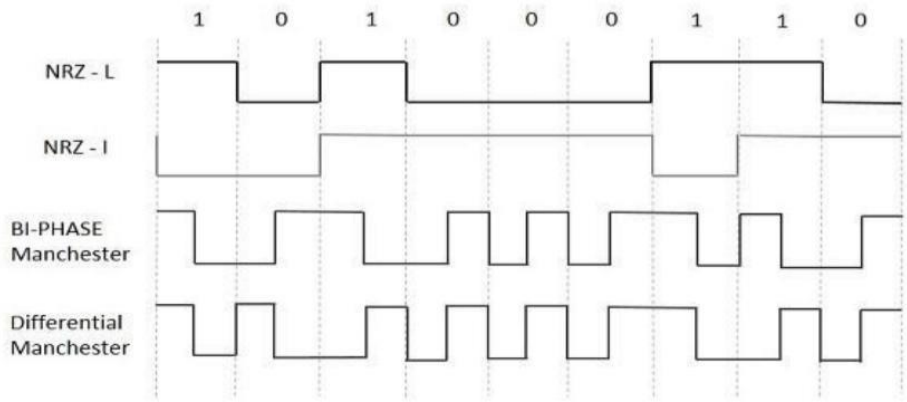
● The transition for the resultant pulse is from High to Low in the middle of the interval, for the input bit 1.

● While the transition is from Low to High for the input bit 0.

Differential Manchester

● In this type of coding, there always occurs a transition in the middle of the bit interval.

● If there occurs a transition at the beginning of the bit interval, then the input bit is 0. If no transition occurs at the beginning of the bit interval, then the input bit is 1.



Digital to Analog Signals:

● Digital Modulation provides more information capacity, high data security, quicker system availability with great quality communication.

● Hence, digital modulation techniques have a greater demand, for their capacity to convey larger amounts of data than analog modulation techniques.

● There are many types of digital modulation techniques and also their combinations, depending upon the need.

ASK – Amplitude Shift Keying

The amplitude of the resultant output depends upon the input data whether it should be a zero level or a variation of positive and negative, depending upon the carrier frequency.

FSK – Frequency Shift Keying

The frequency of the output signal will be either high or low, depending upon the input data applied.

PSK – Phase Shift Keying

The phase of the output signal gets shifted depending upon the input. These are mainly of two types, namely Binary Phase Shift Keying BPSK and Quadrature Phase Shift Keying QPSK, according to the number of phase shifts. The other one is Differential Phase Shift Keying DPSK which changes the phase according to the previous value.

M-ary Encoding

M-ary Encoding techniques are the methods where more than two bits are made to transmit simultaneously on a single signal. This helps in the reduction of bandwidth.

The types of M-ary techniques are −

- M-ary ASK
- M-ary FSK
- M-ary PSK

Analog to Digital Signals

Digital Signal: A digital signal is a signal that represents data as a sequence of discrete values; at any given time it can only take on one of a finite number of values.

Analog Signal: An analog signal is any continuous signal for which the time varying feature of the signal is a representation of some other time varying quantity i.e., analogous to another time varying signal.

The following techniques can be used for Analog to Digital Conversion:

a. PULSE CODE MODULATION:

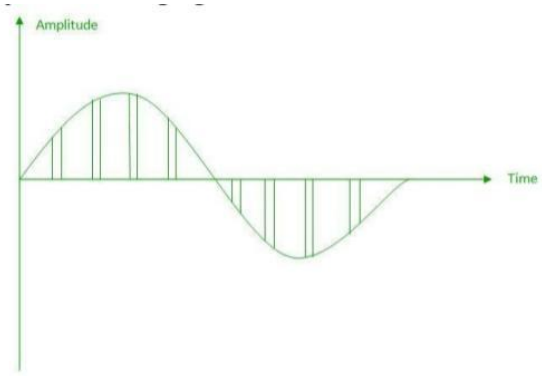
The most common technique to change an analog signal to digital data is called pulse code modulation (PCM). A PCM encoder has the following three processes:

1. Sampling
2. Quantization
3. Encoding

1. Sampling – The first step in PCM is sampling. Sampling is a process of measuring the amplitude of a continuous-time signal at discrete instants, converting the continuous signal into a discrete signal. There are three sampling methods:

(i) Ideal Sampling: In ideal Sampling also known as Instantaneous sampling pulses from the analog signal are sampled. This is an ideal sampling method and cannot be easily implemented.

(ii) Natural Sampling: Natural Sampling is a practical method of sampling in which pulse have finite width equal to T.The result is a sequence of samples that retain the shape of the analog signal.



(iii) Flat top sampling: In comparison to natural sampling flat top sampling can be easily obtained. In this sampling technique, the top of the samples remains constant by using a circuit. This is the most common sampling method used.