Unit-3

DIGITAL COMMUNICATION

Prepared by,
Aiswarya S
Assistant Professor,
Department of Electronics and Communication Engineering ,
Velalar College of Engineering and Technology, Thindal.

- Introduction
- Basic digital communication system
- Importance of digital communication
- Sampling: Natural sampling, Flat top sampling,
- quantization: Uniform & non-uniform quantization
- Aliasing.

Introduction

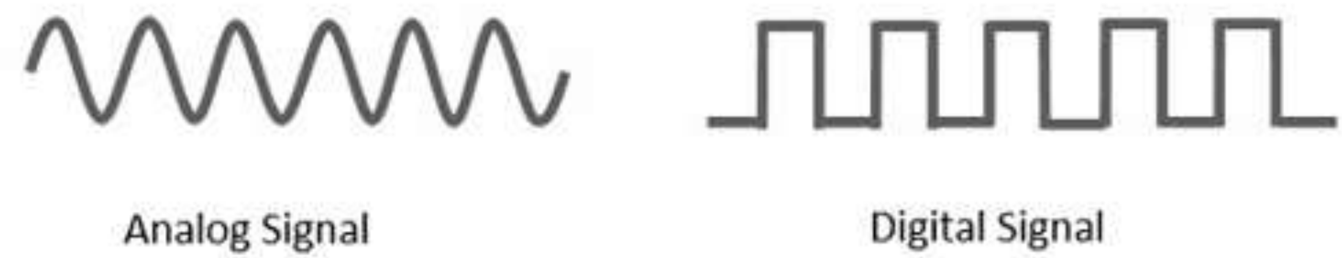
- The communication that occurs in our day-to-day life is in the form of signals.
- These signals, such as sound signals generally are analog in nature.
- When the communication needs to be established over a distance, then the analog signals are sent through wire, using different techniques for effective transmission.

The Necessity of Digitization

- The conventional methods of communication used analog signals for long distance communications, which suffer from many losses such as distortion, interference, and other losses including security breach.

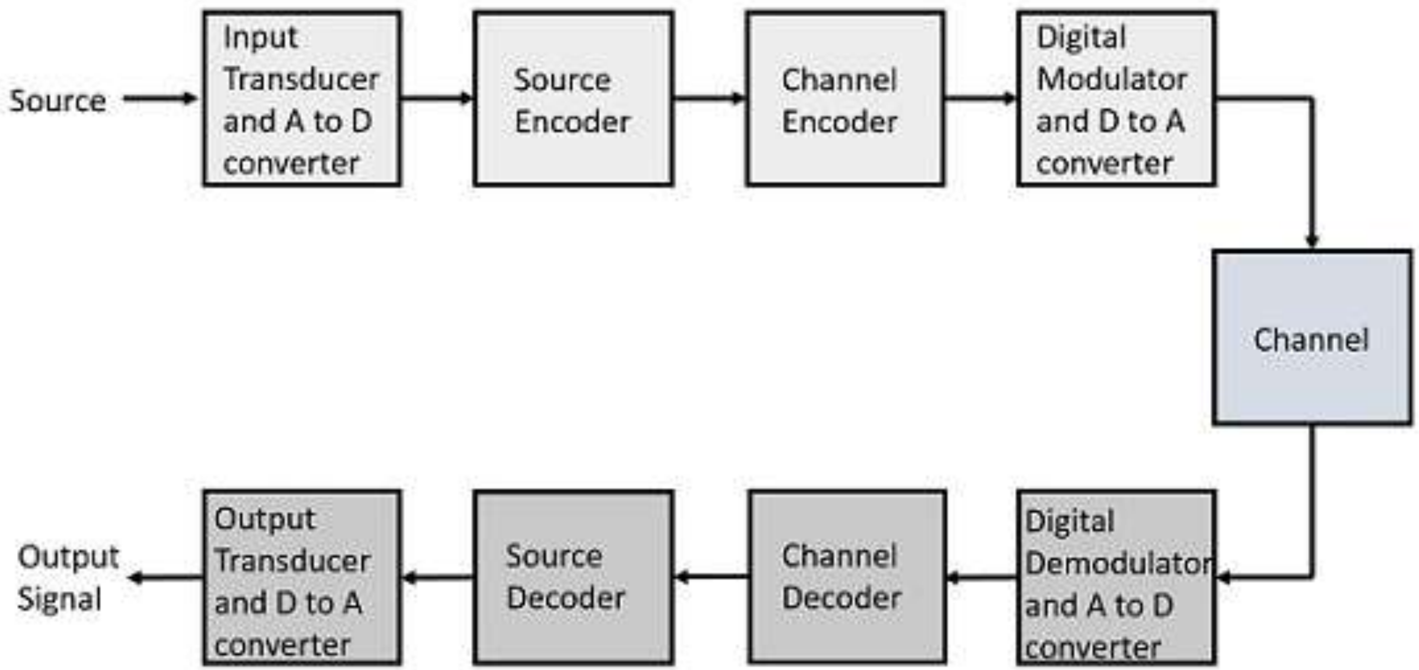
- In order to overcome these problems, the signals are digitized using different techniques. The digitized signals allow the communication to be more clear and accurate without losses

- The following figure indicates the difference between analog and digital signals.
- The digital signals consist of **1s** and **0s** which indicate High and Low values respectively



Representation of Signals

Basic digital communication system



Basic Elements of a Digital Communication System

Source

- The source can be an **analog** signal.
- **Example**: A Sound signal

Input Transducer

- This is a transducer which takes a physical input and converts it to an electrical signal (**Example**: microphone).

- This block also consists of an **analog to digital** converter where a digital signal is needed for further processes.

- A digital signal is generally represented by a binary sequence.

Source Encoder

- The source encoder compresses the data into minimum number of bits.
- This process helps in effective utilization of the bandwidth.
- It removes the redundant bits

Channel Encoder

- The channel encoder, does the coding for error correction.
- During the transmission of the signal, due to the noise in the channel, the signal may get altered and hence to avoid this, the channel encoder adds some redundant bits to the transmitted data. These are the error correcting bits.

Digital Modulator

- The signal to be transmitted is modulated here by a carrier. The signal is also converted to analog from the digital sequence, in order to make it travel through the channel or medium.

Channel

- The channel or a medium, allows the analog signal to transmit from the transmitter end to the receiver end.

Digital Demodulator

- This is the first step at the receiver end.
- The received signal is demodulated as well as converted again from analog to digital.
- The signal gets reconstructed here.

Channel Decoder

- The channel decoder after detecting the sequence does some error corrections.
- The distortions which might occur during the transmission, are corrected by adding some redundant bits.
- This addition of bits helps in the complete recovery of the original signal.

Source Decoder

- The resultant signal is once again digitized by sampling and quantizing so that the pure digital output is obtained without the loss of information.
- The source decoder recreates the source output.

Output Transducer

- This is the last block which converts the signal into the original physical form, which was at the input of the transmitter.
- It converts the electrical signal into physical output (**Example**: loud speaker).

Output Signal

- This is the output which is produced after the whole process.
- **Example** – The sound signal received.

Importance of digital communication

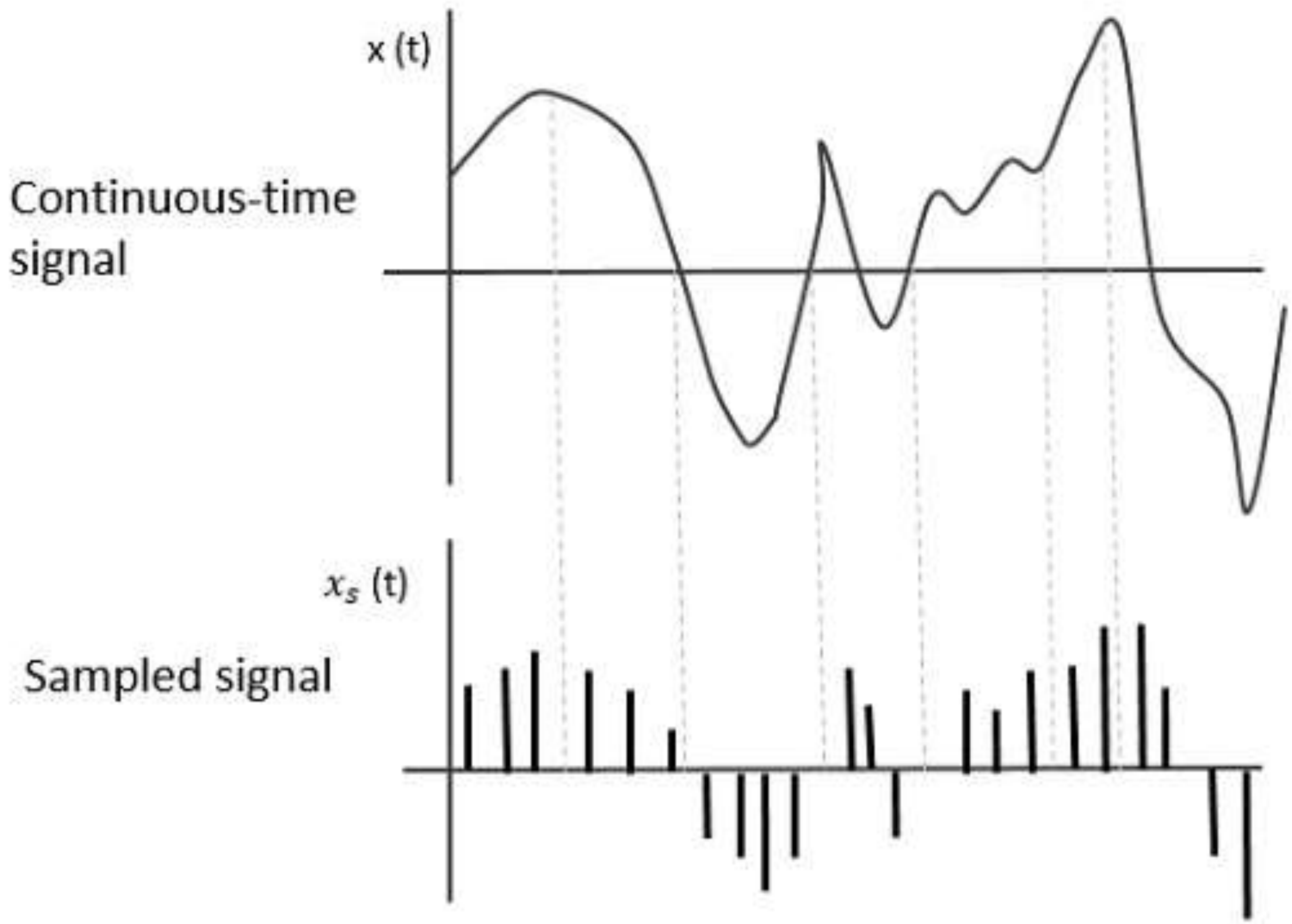
- During long car trips or going to places we have never been before, we always use navigation/ GPS.
- The web is communicating with the user to tell us where to go as if someone was talking to them in real life.
- This is how Digital Communication can help you in your life.

- Signal processing functions such as encryption and compression are employed in digital circuits to maintain the secrecy of the information.
- The probability of error occurrence is reduced by employing error detecting and error correcting codes.
- Spread spectrum technique is used to avoid signal jamming.

- The capacity of the channel is effectively utilized by digital signals.
- Digital signals can be saved and retrieved more conveniently than analog signals.
- Many of the digital circuits have almost common encoding techniques and hence similar devices can be used for a number of purposes.

Sampling

- **Sampling** is defined as, "The process of measuring the instantaneous values of continuous-time signal in a discrete form."
- The following figure indicates a continuous-time signal **x(t)** and a sampled signal $\mathbf{x_s}$**(**t). When **x(**t) is multiplied by a periodic impulse train, the sampled signal $\mathbf{x_s}$ **(t)** is obtained.


x (t)
Continuous-time signal
x_s (t)
Sampled signal

Sampling Rate

- To discretize the signals, the gap between the samples should be fixed. That gap can be termed as a **sampling period T_s**

- Sampling Frequency=1/Ts= fs

- Ts is the sampling time
- fs is the sampling frequency or the sampling rate

Nyquist Rate

- Suppose that a signal is band-limited with no frequency components higher than **W** Hertz.
- That means, **W** is the highest frequency.
- For such a signal, for effective reproduction of the original signal, the sampling rate should be twice the highest frequency, Which means

$$fS=2W$$

Where,

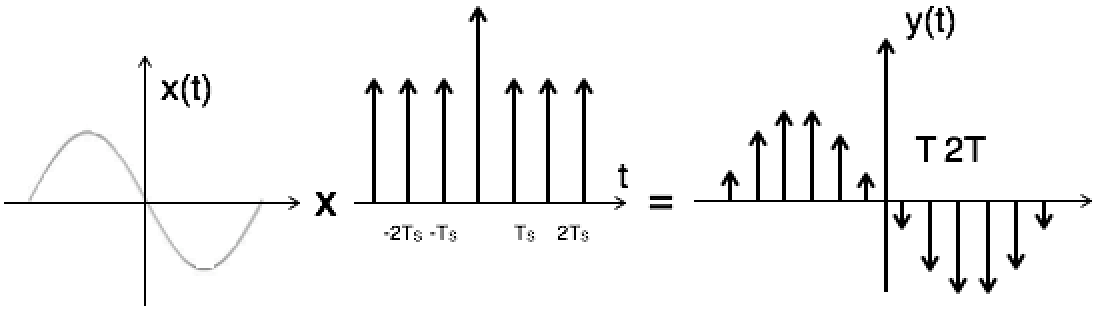
- fS is the sampling rate
- **W** is the highest frequency
- This rate of sampling is called as **Nyquist rate**.
- A theorem called Sampling Theorem, was stated on the theory of this Nyquist rate.

Types of sampling

- Impulse sampling
- Natural sampling
- Flat top sampling

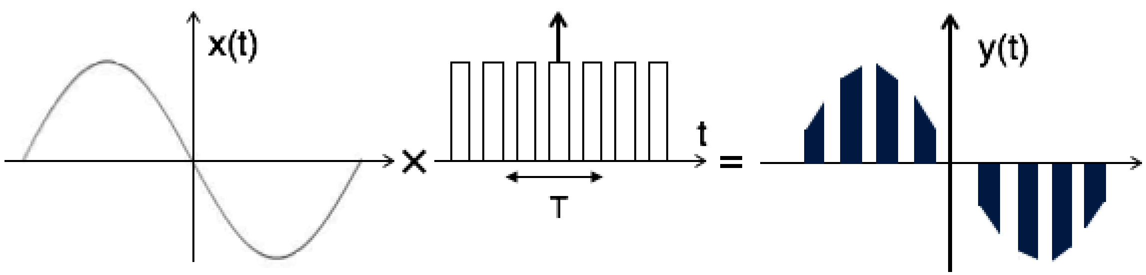
Impulse Sampling

- Impulse sampling can be performed by multiplying input signal x(t) with impulse train of period 'T‘.
- The amplitude of impulse changes with respect to amplitude of input signal x(t).



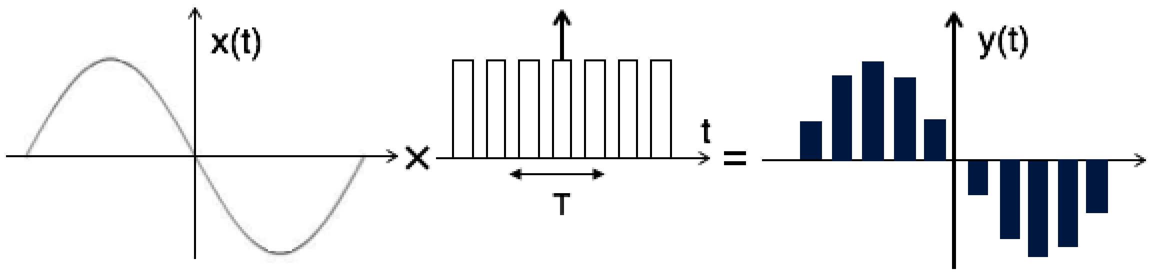
Natural Sampling

- Natural sampling is similar to impulse sampling, except the impulse train is replaced by pulse train of period T.

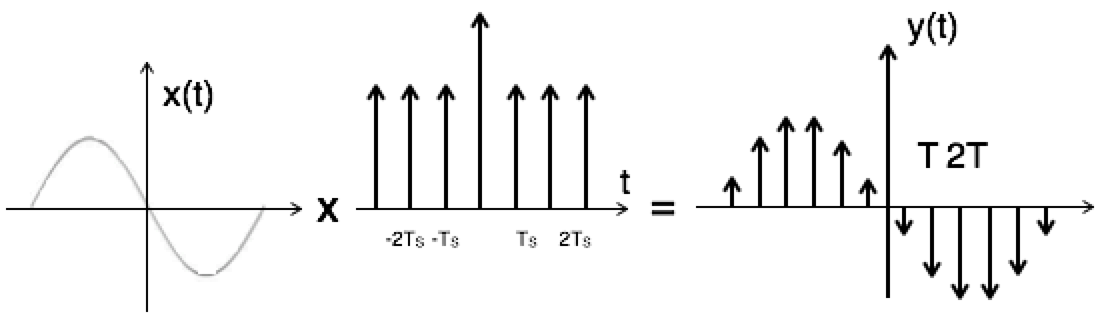


Flat Top Sampling

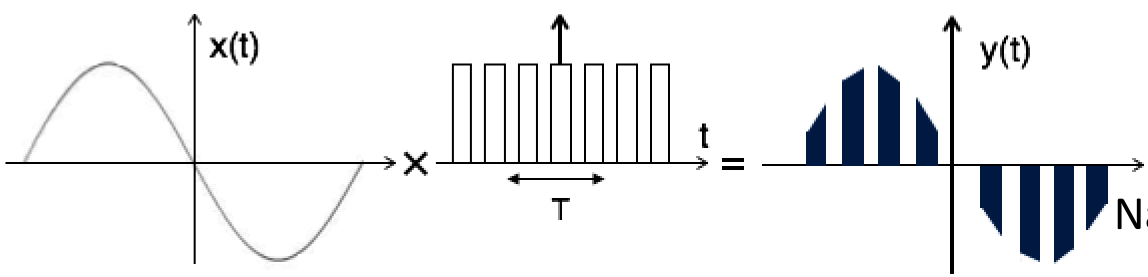
- During transmission, noise is introduced at top of the transmission pulse which can be easily removed if the pulse is in the form of flat top.
- Here, the top of the samples are flat i.e. they have constant amplitude.
- Hence, it is called as flat top sampling or practical sampling.
- Flat top sampling makes use of sample and hold circuit.



Flat top sampling



Impulse sampling



Natural sampling

Quantization

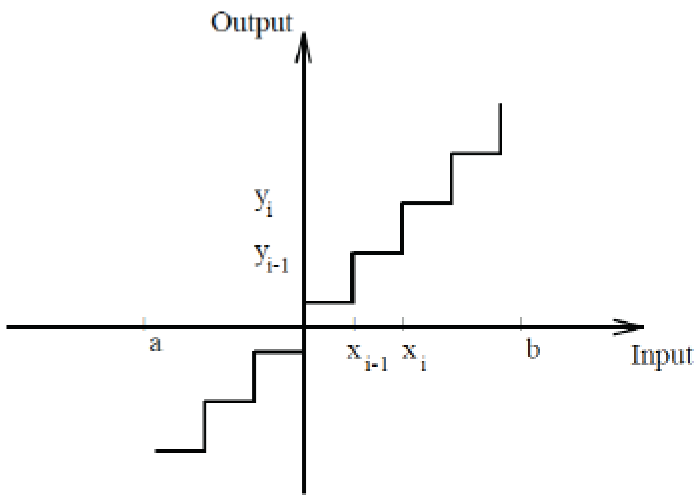
- The digitization of analog signals involves the rounding off of the values which are approximately equal to the analog values.
- The method of sampling chooses a few points on the analog signal and then these points are joined to round off the value to a near stabilized value.
- Such a process is called as **Quantization**.

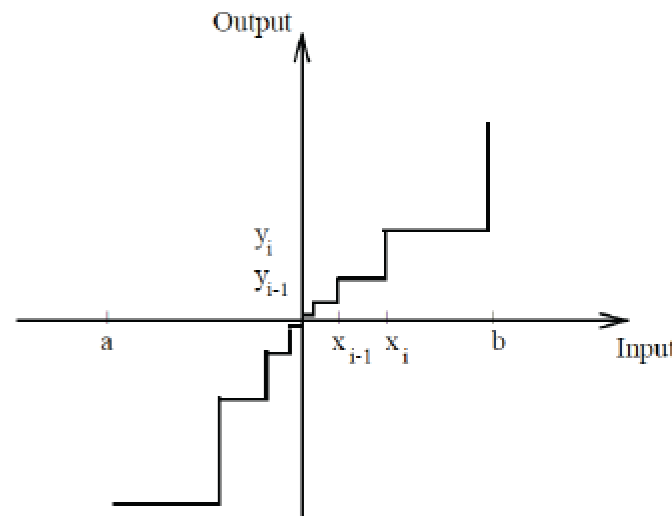
Uniform Quantization

- The type of quantization in which the quantization levels are uniformly spaced is termed as a **Uniform Quantization**.

Non uniform Quantization

- The type of quantization in which the quantization levels are unequal and mostly the relation between them is logarithmic, is termed as a **Non-uniform Quantization**.

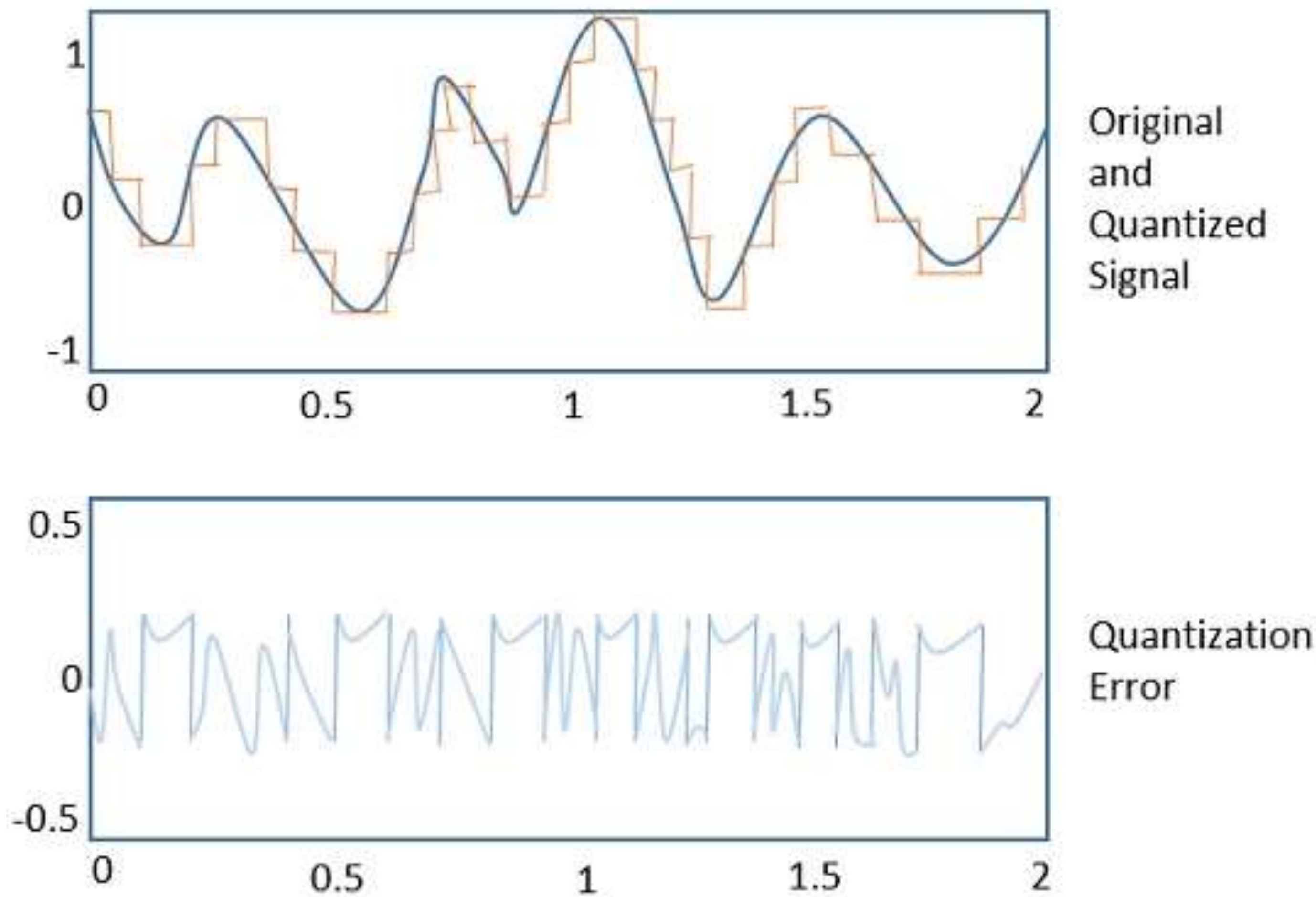

Output
y_i
y_{i-1}
a
x_{i-1}
x_i
b
Input


Output
y_i
y_{i-1}
a
x_{i-1}
x_i
b
Input

Quantization Error

- For any system, during its functioning, there is always a difference in the values of its input and output.
- The processing of the system results in an error which is the difference of those values.

- The difference between an input value and its quantized value is called a **Quantization Error**.
- A **Quantizer** is a logarithmic function that performs Quantization rounding off the value.
- An analog-to-digital converter (**ADC**) works as a quantizer.


1
0
-1
0
0.5
1
1.5
2
Original
and
Quantized
Signal
0.5
0
-0.5
0
0.5
1
1.5
2
Quantization
Error

Quantization Noise

- It is a type of quantization error, which usually occurs in analog audio signal, while quantizing it to digital.
- For example in music the signals keep changing continuously where a regularity is not found in errors.
- Such errors create a wideband noise called as **Quantization Noise.`**

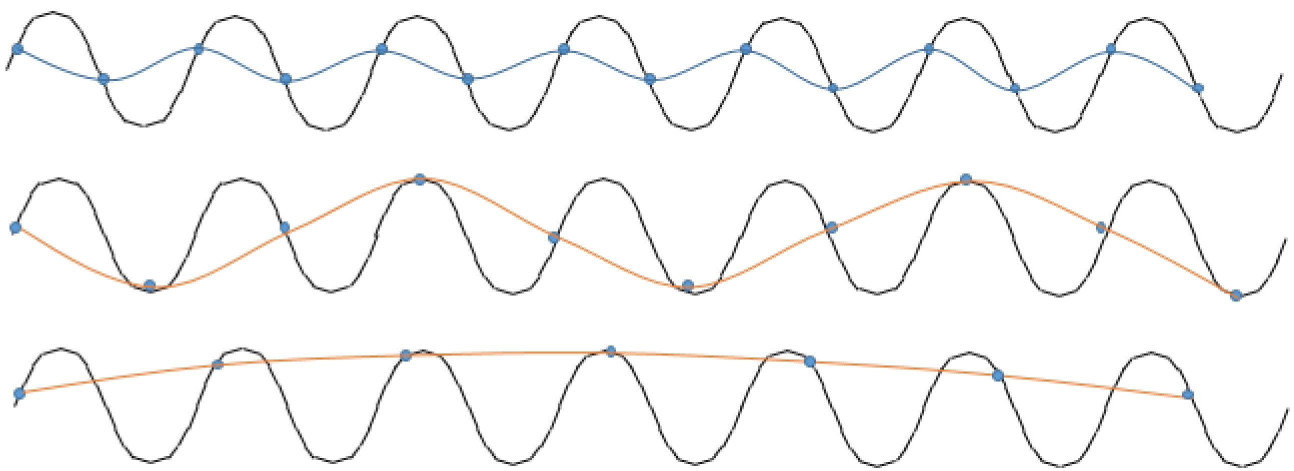
Aliasing

- Aliasing can be referred to as "the phenomenon of a high-frequency component in the spectrum of a signal, taking on the identity of a low-frequency component in the spectrum of its sampled version."

- The corrective measures taken to reduce the effect of Aliasing are:
- In the transmitter section of PCM, a **low pass anti-aliasing filter** is employed, before the sampler, to eliminate the high frequency components, which are unwanted.

- The signal which is sampled after filtering, is sampled at a rate slightly higher than the Nyquist rate.
- This choice of having the sampling rate higher than Nyquist rate, also helps in the easier design of the **reconstruction filter** at the receiver.

Example of aliasing



Aliasing Examples