Why?

CS601 Lecture No 14 Topic 67 to 72

MODULATION

- Modulation is a modification of a frequency to carry data. In other words, we can say modulation is a process of converting digital signal into analog signal.
- The process of converting analog signal back to digital signal is known as demodulation. Thus the term **MODEM** is used for modulation and demodulation.
- When a signal is to be transmitted from one computer to another via some analog channel (eg, telephone line), conversion of signal is required.
- As computer generate digital signals and the telephone wire carries analog signal, modulation is performed at the sending end.
- At receiving end, the analog signal being carried by telephone line is again converted back to digital signal and demodulation needs to be performed.

MODULATION

1. Digital to digital conversion: Digital to digital conversion is required while converting digital data into digital signal. For example, when computer generated data is to be sent to a printer.

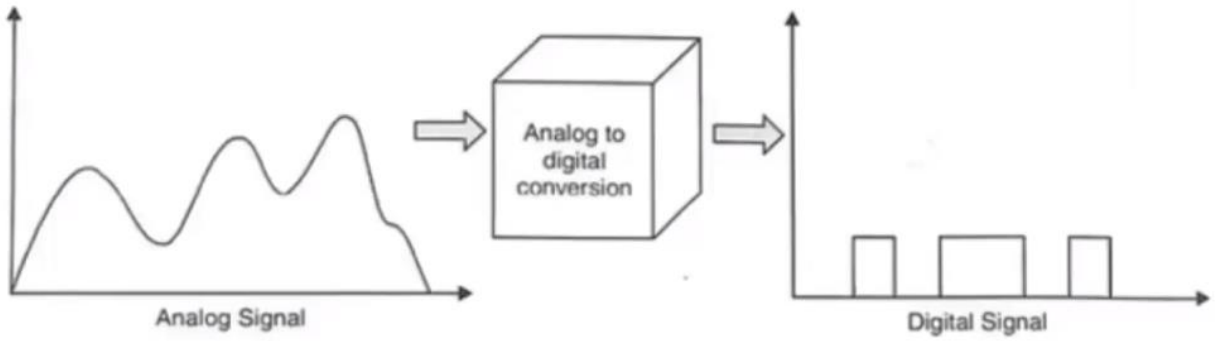
2. Analog to digital conversion: Analog to digital conversion is required to convert Analog signal into digital signal. For example, when human voice is to be transmitted over digital channel.

3. Digital to analog conversion: Digital to analog conversion is required when digital signal is to be transformed into analog signal. For example, when digital signal is to be transmitted over telephone line.

4. Analog to analog conversion: Analog to analog conversion is required when some analog information is to be carried on in the form of analog signals. For example, radio station convert voice signals (analog) into radio waves (analog)

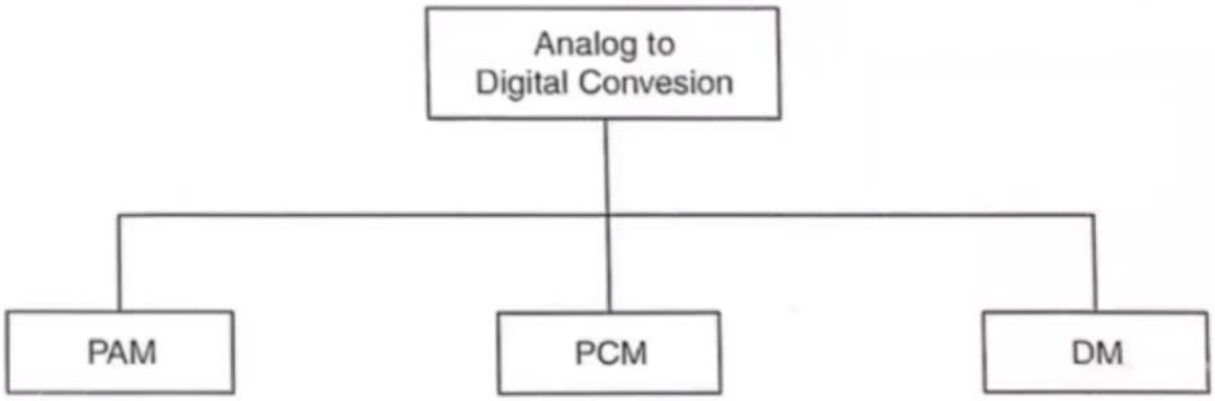
Analog to Digital Conversion

The process of converting analog signal to digital signal is also known as digitizing, as shown in the figure as follows



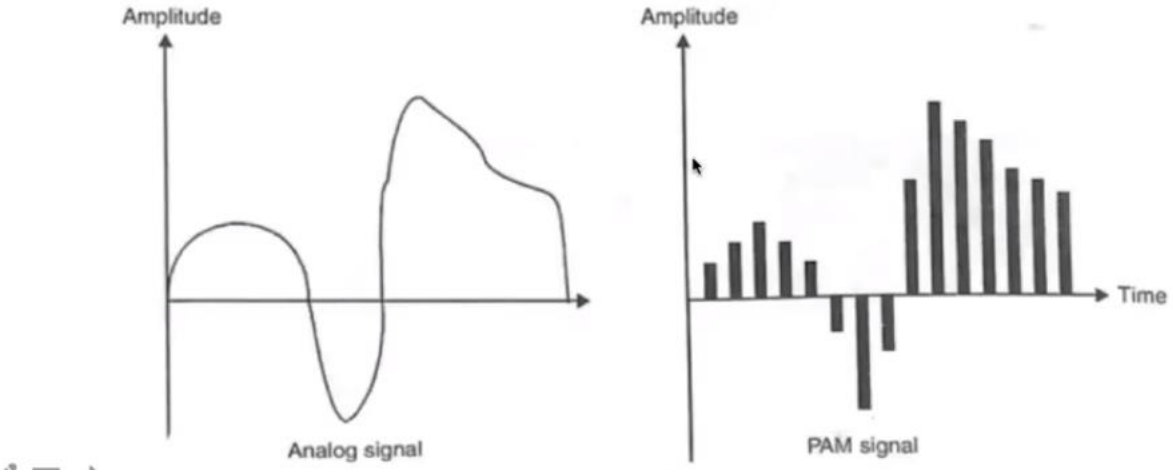
Analog to Digital Conversion

- In analog to digital conversion, information is converted from continuous waveform to a series of bits (0 and 1).
- The various techniques used to perform analog to digital conversion are shown in figure as follows



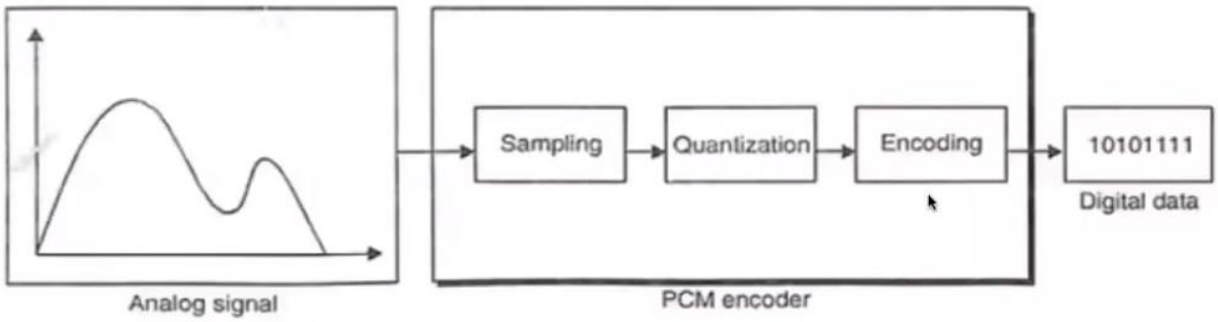
PAM: PULSE AMPLITUDE MODULATION

- PAM techniques takes an analog signal and samples it at a very high speed.
- Sampling means measuring the amplitude of signal at equal intervals.
- It then generates a series of pulses based on the results of sampling as shown in figure as follows



2. Pulse Code Modulation (PCM)

PCM consists three different processes as shown in figure as follows:



(i) Sampling: analog signal is sampled at equal intervals as in PAM.

(ii) Quantization: integral values are assigned to each PAM signal.

(iii) Encoding: The quantized values are encoded as stream of bits.

PCM: SAMPLING

- In sampling analog signal is sampled every **Δ**T seconds as in PAM.
- According to the Nyquist theorem, to reproduce the original signal, one necessary condition is that the sampling rate be at least twice the highest frequency in the original signal.
- For example: If a telephone line supports a highest frequency of 5000 Hz. The sampling rate should be 10,000 samples per second.

PCM: QUANTIZATION

1. We assume that the original signal has instantaneous amplitudes between V_{min} and V_{max}. In our example

V_{min} = -127 and V_{max} = + 127

2. We divided the range into L zones, each of height Δ (delta).

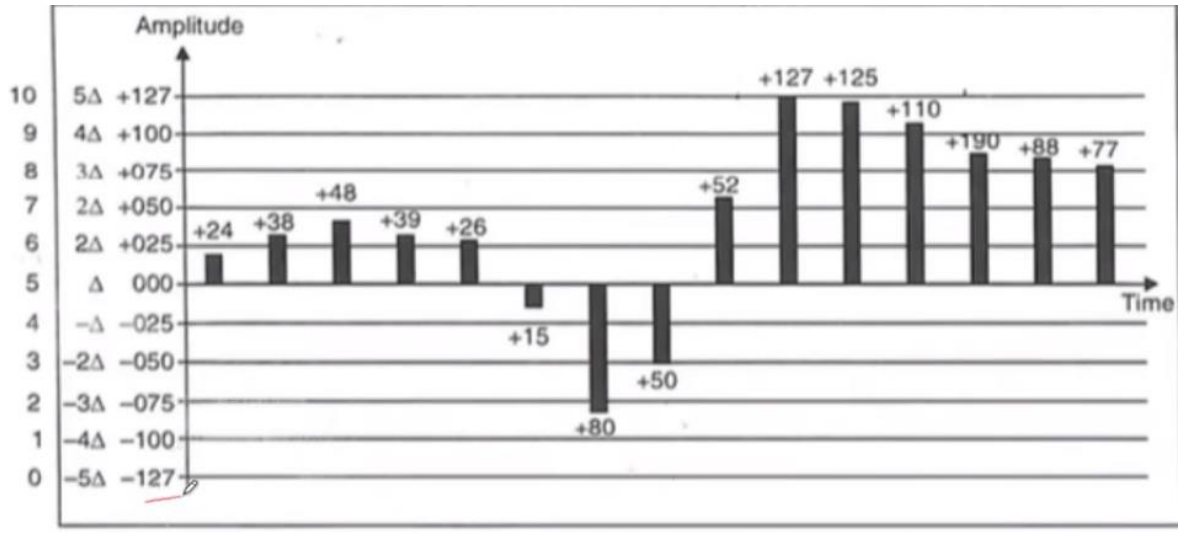
$\Delta = V_{max} - V_{min} / L$

In our example, we have 10 zones (i.e. L 10), therefore height of Δ each zone is:

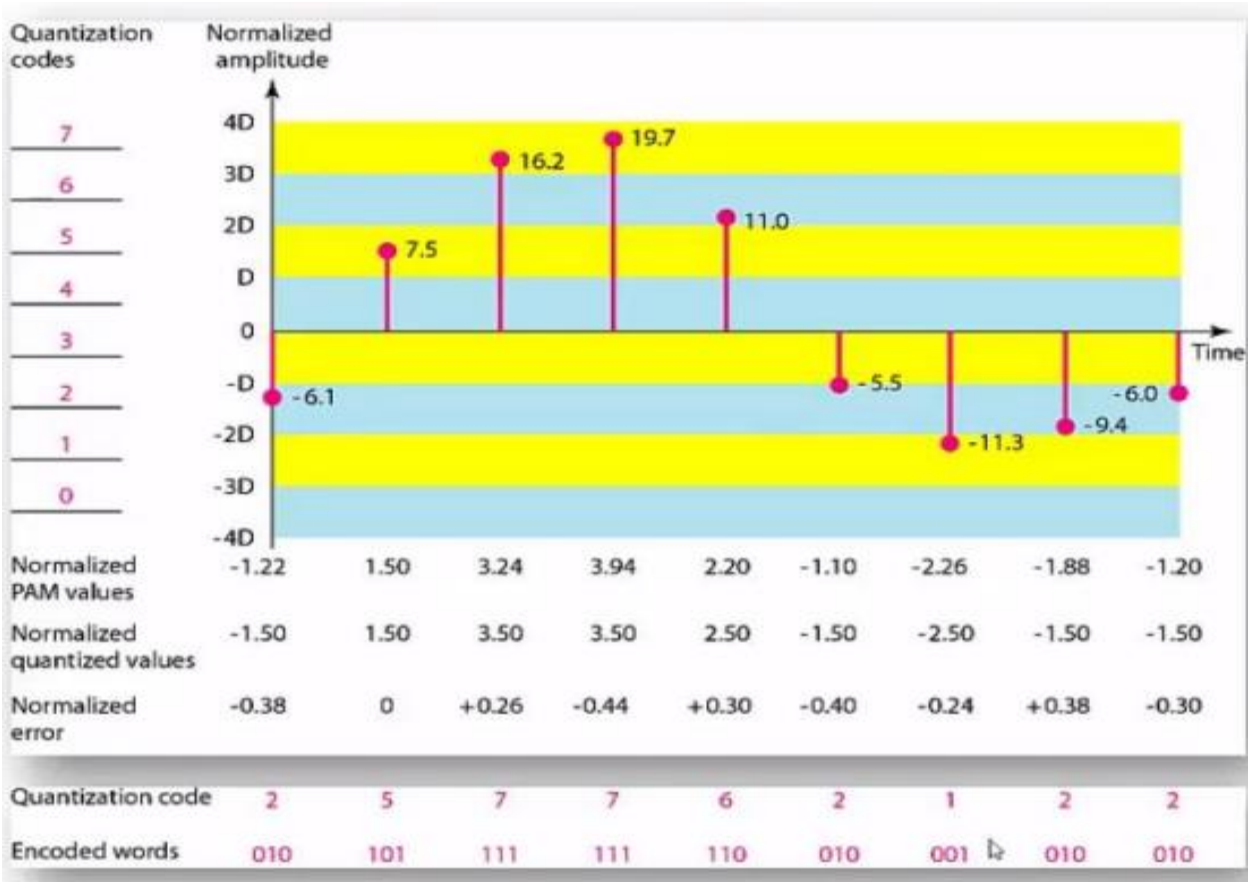
$\Delta = 127 + 127/ 10 = 25.4 \approx 25$

3. We assign quantized values of 0 to L-1 to the midpoint of each zone.

4. We approximate the value of the sample amplitude to the quantized values.



Row 1	Normalized PAM values	(actual values)	0.96	1.52	1.92	1.56	1.04	-0.6	-3.2	-2	2.08	5.08	5	4.4	3.6	3.52	3.08
Row 2	Normalized quantized values		1	1.5	2	1.5	1	−0.5	−3.5	−2	2	5	5	4.5	3.5	3.5	3
Row 3	Normalized error		+0.04	−0.02	+0.08	−0.06	−0.04	+0.1	−0.3	0	−0.08	−0.08	0	+0.1	−0.1	−0.02	−0.08
Row 4	Quantization code		5	6	6	6	5	4	1	3	7	10	10	9	8	8	8
Row 5	Encoded word		0101	0110	0110	0110	0101	0100	0001	0011	0111	1010	1010	1001	1000	1000	1000



Normalized PAM values	-1.22	1.50	3.24	3.94	2.20	-1.10	-2.26	-1.88	-1.20
Normalized quantized values	-1.50	1.50	3.50	3.50	2.50	-1.50	-2.50	-1.50	-1.50
Normalized error	-0.38	0	+0.26	-0.44	+0.30	-0.40	-0.24	+0.38	-0.30
Quantization code	2	5	7	7	6	2	1	2	2
Encoded words	010	101	111	111	110	010	001	010	010

3. Delta Modulation (DM)

- Delta modulation technique is developed to overcome the complexity of PCM.
- PCM finds the value of the signal amplitude for each sample. But DM finds the change from the previous sample.
- In DM, codewords are not generated rather bits are sent one after the other.
- The delta modulation process is shown in figure as follows:

