Analog and Digital Communication

Part - 4

Data Encoding and Communication Technique

We know that data (information) may be of analog or digital type and the signal that is transmitted through the channel, whether guided or unguided, are also of Analog and Digital type. Now data needs to be encoded into signal, before they are actually transmitted through the channel. Based on this data and signal types, there are four encoding techniques.

1. Analog Data to Analog Signal
2. Analog Data to Digital Signal
3. Digital Data to Analog Signal
4. Digital Data to Digital Signal

To send a signal over a physical medium, we need to encode or transform the signal in some way so that the transmission medium can transmit it. The sender and receiver must agree on what kind of transmission has been done so that the signal may be received properly and the information may be recovered without error.

The information content in a signal is based upon having some changes in it, i.e. having some variation in the signal. Thus the signal needs to be modified in some way to carry the information we want to convey. This is called modulation. Thus the act of changing or encoding the information in the signal is known as **modulation**.

2. Analog to Digital Modulation

One example of coding analog data in digital form is when we want to record sound on digital media such as a DVD or in other forms such as MP3 or as ".wav" file.

In case of analog to analog encoding, the motivation was to be able to transmit the signal for long distances, but here the main reason is to be able to change the information itself to digital form. That digital signal can then be transmitted by any suitable method.

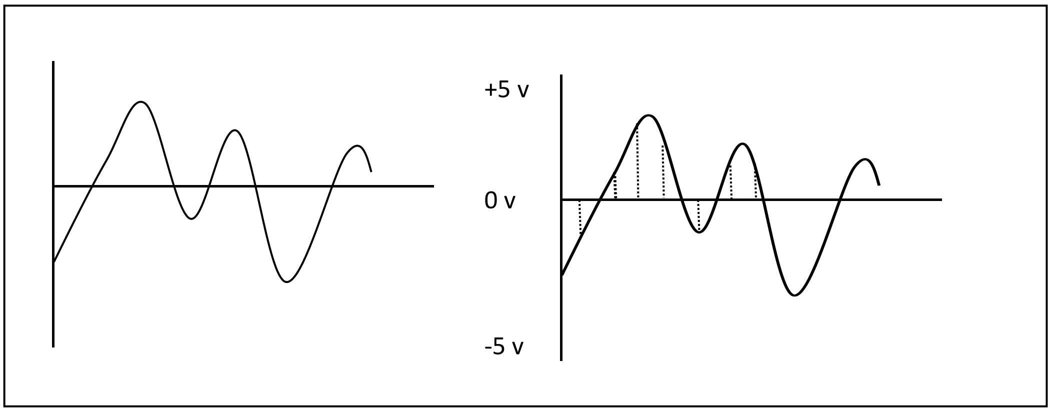
One method of encoding is called Pulse Code Modulation (PCM), which gives very good quality and when used in conjunction with error correction techniques, can be regenerated at every hop on the way to its final destination.

Pulse Code Modulation (PCM)

<u>Step 1</u> (converting the Analog signal to PAM signal)

The first step in PCM is to convert the analog signal into a series of pulses, also called Pulse Amplitude Modulation (PAM). To do this the analog signal is sampled at fixed intervals and the amplitude at each sample decides the amplitude of the pulse. The PAM signal is still an analog signal, because the pulses can have any amplitude.

The rate of sampling is an important issue here and the solution comes from the **Nyquist's Theorem**, which states that, to be able to get back the original signal, we must sample at a rate, which should be at least twice that of the highest frequency contained in the original signal.



Pulse Amplitude Modulation

Let us take an example:

We know that the voice conversation over a telephone has a range of frequencies from 300 Hz to 3,400 Hz. Since the maximum frequency is 3,400 Hz, we need at least 6,800 samples per second to digitize the voice to be sent over the phone line. For safety we take 8,000 samples per second, corresponding to a sampling interval of 125 microseconds. (1 sec/8000 → 1,000,000 microsec /8000 = 125 microseconds).

<u>Step 2</u> (Quantization of the analog pulses)

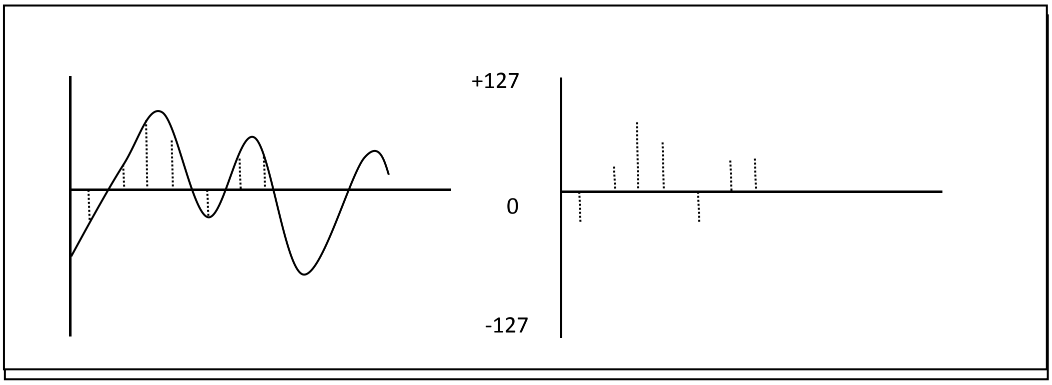
Next stage in the digitization of the analog signal is quantization of the PAM pulses. In this stage, the analog values of the sampled pulses are quantized, i.e. converted to discrete values. For example, suppose the original analog signal has an amplitude ranging from +5v to -5v and the PAM might have produced pulses of the following amplitudes, each samples taken at an interval of 125 microseconds.

-1.5, +1, 3.4, 2.7, -1.4, 2, …. and so on

In quantization, we may decide to give the amplitude 256 discrete values, so that it ranges from -127 to +128. Now the actual amplitude must be represented in this range, which means each value is of 0.039v. (10v/256 = 0.039v)

Thus the decimal values, represented in the 256 discrete units will be as follows: -38, +26, +87, +69, -36, 51 …. and so on (Note that -1.5v/0.039v = -38)

The analog values, now has become the quantized values, as given above.



<u>Step 3</u> (Conversion of the Binary digits to digital signals)

The above discrete values are now represented as 8 binary digits with the Left most bit giving the sign value while the other 7 bits represents the values of the sample. The binary digits are then transformed into a digital signal using any of the digital to digital encoding mechanism. This digital signal is now the representation of the original analog signal.

Thus the converted digital values are as follows:

10100110 00011010 01010111 01000101 ……. and so on.

Delta Modulation

PCM is commonly used to transmit voice signals over a telephone line. It gives good voice quality but is a fairly complex method of encoding the signal. There is another simpler method for analog to digital modulation, called the **Delta Modulation**.

Here samples are taken as described above, but instead of quantizing them into 256 or more levels, only the direction of change is retained. If the sample is larger in value than the previous one, it is considered a 1 while otherwise it is considered as 0.

Hence the sequence for the above example would be 1 1 1 0 0 1 …. And so on.