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Study on performance analysis of Delta Modulation (DM)

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***Abstract*— Delta Modulation (DM) is kind of DPCM (differential pulse code modulation) which works as analog to digital converter. It has sampling rate much higher than Nyquist rate. It overcomes the principle of PCM (pulse code modulation) by sending only the difference between previous and present sample. It provides high SNR and is cost effective however slope overload and granular noise are two of its disadvantages. Its presentation is shown in Simulink model.**

***Index Terms*—Quantization, Sampling, Encoding, Simulink Model etc.**

I. INTRODUCTION

Delta Modulation is an analog to digital converter, which converts analog signal to digital signal [4]. Although PCM (Pulse Code Modulation) is also a type of A-D converter but, in PCM system all bits are transmitted that are used to encode a sample. However, it increases the signaling rate and transmission channel bandwidth. On the other hand, DM transmits only one bit per sample. It has sampling rate much higher than the Nyquist Rate.
An assembled delta modulator is shown in fig:- 1

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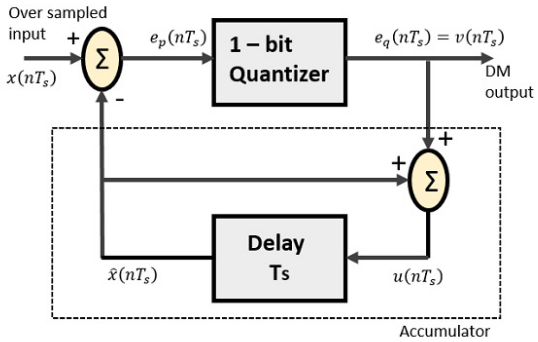

Fig 1 : Block diagram of delta modulation

As we move forward take a look at the concept of signal and
its various types.
SIGNAL :- In general, a signal is referred as the electrical function which conveys information about the behavior or attributes of some phenomenon.

CLASSIFICATION OF SIGNALS :- On the basis of time domain, signals can be classified mainly in two categories:

a)Continues time signal:- A signal x(t), is said to be continuous if 't' is a continuous variable.

Analog signal is an example of continuous signal.

b)Discrete time signal :- If x(t) is defined at discrete time then the signal x(t) is discrete time signal. A digital signal is an example of Discrete time signal.

Now,
It is a kind of DPCM (Differential Pulse Code Modulation) in which difference signal Δ (t) is encoded in just a single bit and comparator is used to compare the present sample from the previous one and the difference weather positive or negative is transmitted. Thus, only a single bit transmission is done in delta modulation as shown in the above fig 1 .

So, first thing first we will describe Pulse Code Modulation in short which consists of following processes:

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II. SAMPLING

First of all sampling of analog signals is done on the basis of time which provides discrete signal. Samples are taken at regular intervals and these regular intervals define the sampling rate as the rate at which samples are taken known as sampling frequency, Fs. Sampling follows Nyquist theorem which defines that the sampling rate must be at least twice the highest frequency the signal contains to avoid aliasing effect.

Mathematically, $Fs \geq 2Fm$

Where, Fs = Sampling Frequency

Fm = Modulating Frequency

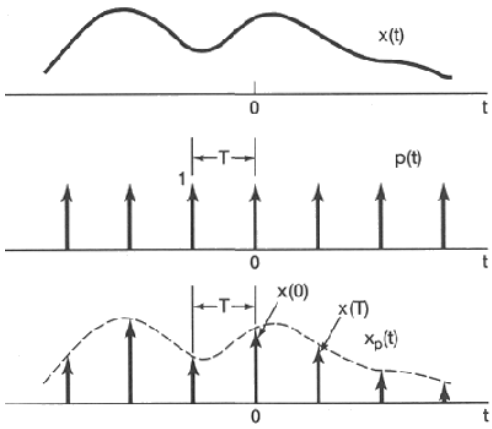

Fig 2 :- Sampling of signal

III. QUANTIZATION

It refers to the process of approximating the continuous set of values in the image data with a finite set of values. A sampled analog signal may have any range of discrete amplitudes. Basically, there are two types of quantization

1)Uniform quantization

2)Non-uniform quantization

Quantization could be seen the fig given below

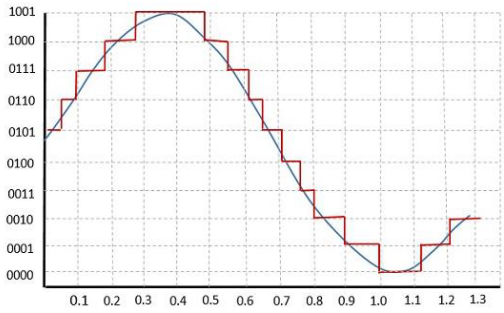

Fig 3 :- Quantization of signal

IV. ENCODING

It is the process of assigning the binary codes to the quantized output. It provides security, stability as well as the flexibility of the signal.

There are basically two types of Encoding :-

a)Linear Encoding

b)Non-linear Encoding

it could be better understood with the help of below provided figure

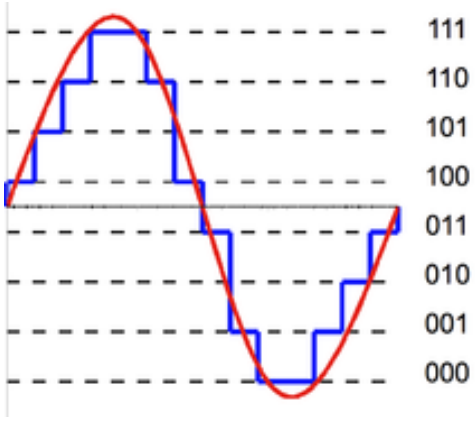

FIG 4:- ENCODING OF SIGNAL

Now for the DPCM we have,

The input signal X(t) is approximated to step size, which is kept fixed. So, the result of the comparator is confined to two levels +Δ or -Δ, for the positive and negative compare respectively, i.e. if the signal is positive, the step size Δ is increase by one level. Otherwise, it is reduced to one level by Δ.

When the step size is increased by Δ, 1 is transmitted and if the step size reduced by Δ, 0 is transmitted. Therefore, for each sample single bit transmission occurs.

The principle of Delta Modulation can be best understood by the following equations [4]:

The error between the sample value of X(t) and last approximated sample is given as,

$$Ep(nTs) = X(nTs)-X'(nTs)$$

Where,

Ep(nTs) = error at present sample

X(nTs) = sampled signal of x(t)

X'(nTs) = last sampled approximation of the staircase waveform

Let, U(nTs) be the present sample approximation of staircase output,

Then,

$$U[(n-1)Ts] = X'(nTs)$$

Let a quantity B(nTs) be in such a way that,

$$B(nTs) = \Delta \text{ sgn } [E(nts)]$$

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Therefore, sign of error Ep(nTs), decides the step size Δ, as follow :

$$B(nTs) = \begin{cases} +\Delta & \text{if } X(nTs) \geq X'(nTs) \\ -\Delta & \text{if } X(nTs) < X'(nTs) \end{cases}$$

Also if,

B(nTs) = + Δ then a binary '1' is transmitted

B(nTs) = - Δ then a binary '0' is transmitted.

Here,

Ts = sampling interval.

Thus, after the accumulator adds quantizer output with the previous sample

We get,

$$U(nTs) = u(nTs-Ts) + [\pm\Delta]$$

$$U(nTs) = u[(n-1)Ts] + B(nTs)$$

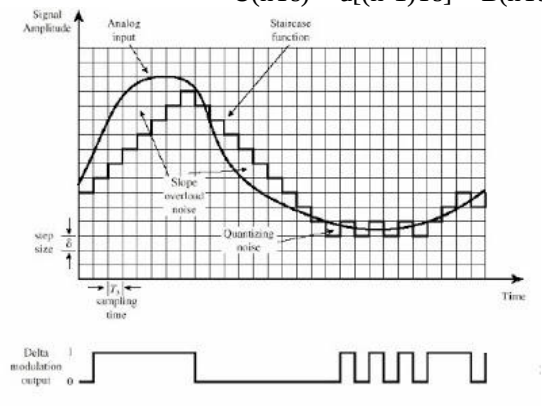

Fig 5 : An example of Delta Modulation

V. SIMULINK MODEL

We have carried out our study of Delta modulation using Simulink model.

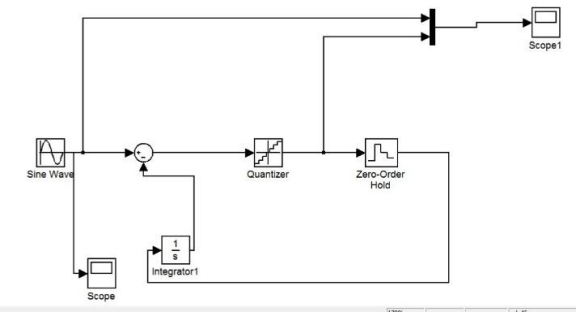

Fig 6 :-Simulink model of DM

Sine wave is taken as an input frequency .the input sine wave is provided to the quantizer from where it is provided to the zero order hold which further passes through integrator. Now both the sine wave and the output of quantizer is fed to the multiplexer to the scope 1 which provides the delta modulated waves.

VI. SIMULINK RESULT

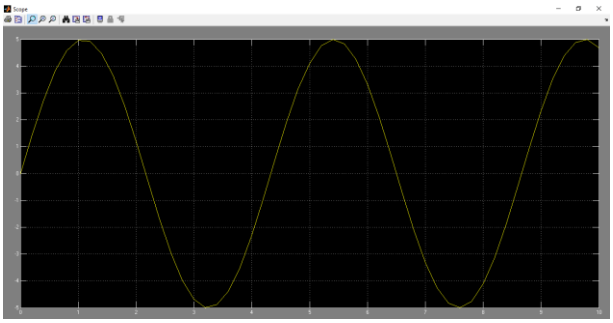

Fig 7:- output of scope – sine wave

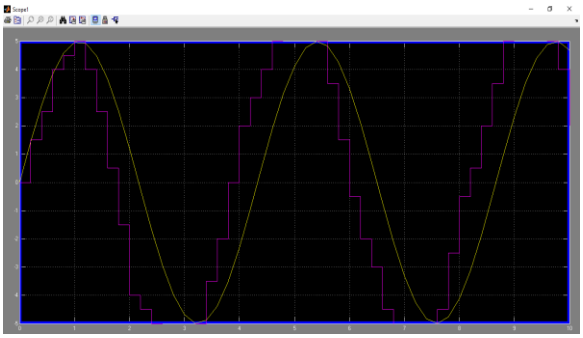

Fig :- 8 output of scope 1 – DM wave

Advantages of DM

- High SNR ratio.
- It offers a Lower channel bandwidth consumption, thus reducing the cost and management of transmission network.
- The transmission technique of delta modulation makes it Cost Effective Systems.
- Unlike PCM and DPCM, delta modulation provides Feedback Mechanism.
- It provides Low Noise.
- It has a Long Distance transmission capability as it uses repeaters which regenerates signals at each stations without degrading the quality of data..

Disadvantages of DM

- Granular Noise occurs due to large step size.
- Slope overloading causes quantization noise.

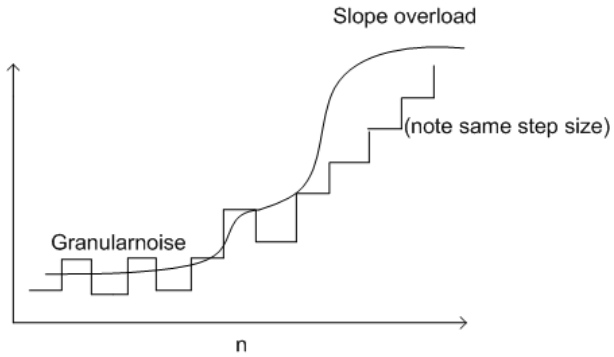

Fig 9:- diagram showing Granular noise and Slope overload

VII) CONCLUSION :

We have successfully done performance analysis of Delta modulation and the output has been depicted in the shown above.

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