Experiment 5

Delta Modulation

Objectives:

After this experiment the student should be able to :

1. Implement the Delta Modulator .
2. Observe effects of step size and sampling rate change .

Introduction:

Various techniques exist for converting analog message signals into a digital stream of bits. PCM is one of these techniques. In PCM, the amplitude of each sample in the message signal is converted into an 8-bit word. This offers high resolution of the signal amplitude. However, audio signals do not have a large amplitude variation from one sample to the next, i.e. there is a strong similarity between consecutive samples. This implies that we can decrease the number of bits per sample if we utilize the information we have about the previous sample. In the simplest method, the information sent indicates whether the sample is merely larger or smaller than the previous one. This is called delta modulation.

To generate delta modulation the amplitude of each sample of the message signal m(t) is compared with the amplitude of the previous sample, a 1 is sent to indicate that the new sample is larger than its predecessor, while a zero is

sent otherwise. The resulting stream of bits is transmitted to the receiver. The output mq(t) is a staircase approximation of the original message. See figure 1.

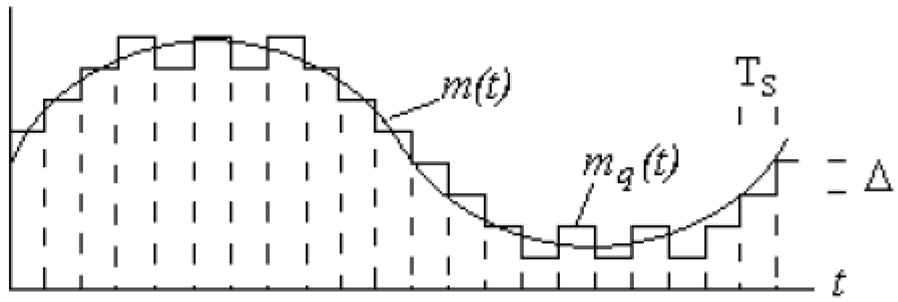


Figure 1. The message signal m(t), the staircase approximation of the message signal mq(t) , and the binary sequence output eq(t).

The step size is fixed to a certain value Δ while the sample period is denoted by TS. To increase the correlation between consecutive samples, the sampling rate is increased to a value much higher than the Nyquist rate. This results in a close approximation to the original message.
The staircase approximation of the message signal mq(t) is given by the relation

$$m_q(nT_S) = m_q(nT_S - T_S) + e_q(nT_S)$$

$$e_q(nT_S) = \Delta sign\left[m(nT_S) - m_q(nT_S - T_S)\right]$$

The main advantage of Δ modulation over other methods is its simplicity. The simple logic behind it, and the small amount of hardware required to implement it, make it the most attractive for new systems.

There are two sources of error in Δ modulation. The first is Slope Overload Distortion, this distortion occurs when the input signal rises or drops (increases or decreases in amplitude) at a rate higher than the slope of the staircase approximation of the signal. Figure 2shows this distortion. To avoid this case, the slope of the input signal must be less than the staircase approximation; this is satisfied under the condition:

$$\frac{\Delta}{T_S} \geq max\left|\frac{dm(t)}{dt}\right|$$

In the case of a sinusoidal signal this condition simplifies to

$$\frac{\Delta}{T_S} \geq 2\pi A f_m$$

where A is the amplitude of the sinusoid and fm is its frequency.

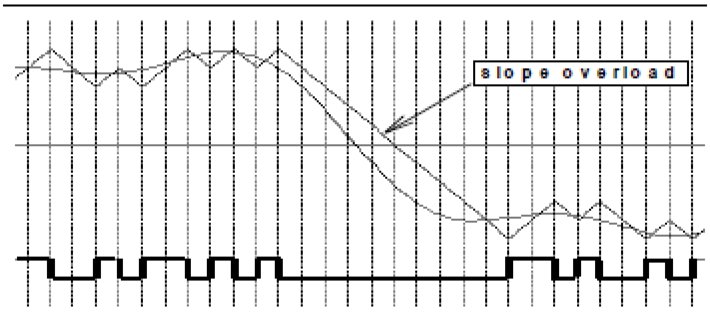


Figure 2. Slope overload distortion

The second source of error is Granular Noise, which occurs when the change in the amplitude of the input signal is smaller than the step size Δ. This causes the staircase approximation to hunt up and down around the signal. See figure 3. The solution to this case seems to be in reducing the step size. However this contradicts the condition for avoiding slope overload.

Advanced Δ modulation techniques use a variable step size that adapts to the signal at hand. When the signal increases rapidly (large slope), the step size is increased until the error is reduced. Inversely, when the change in signal amplitude is small, the step size is reduced to decrease granular noise.

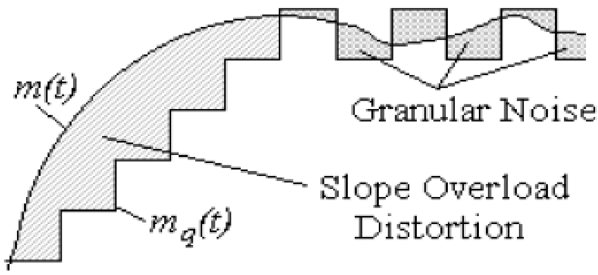


Figure 3. Slope overload distortion and granular noise in delta modulation.

Delta Modulation Block Diagram

The transmitter consists of a hard limiter (comparator), whose output is high or low depending on the difference between the input signal and its approximation. See figure 4. The output of the limiter is multiplied with the sampling clock. This product is transmitted through the channel to the receiver. The product is also feedback through an integrator (LPF) to the summing junction of the limiter.

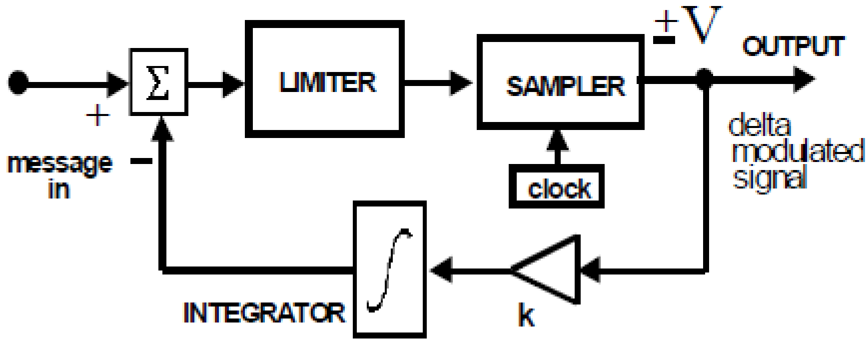
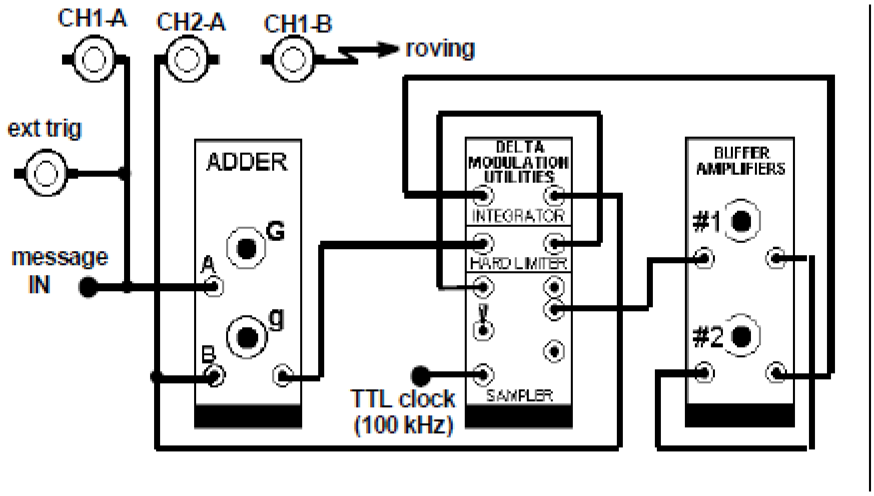


Figure 4. Block diagram of a Delta modulation system.

LAB Work:

1. *Construct the following TIMS Model*



1. Using sinusoidal Set the Adder gains to be unity Do not change these for the duration of the experiment.

2. Likewise set both of the BUFFER AMPLIFIER gains to about unity (they are connected in series to make a non-inverting amplifier). One or both of these will be varied during the course of the experiment.

3. Vary the amplifier gain and observe the until you get best approximation for the message signal ,then plot it in your lab sheets.

4. Increase the amplifier gain and observe what happen to the signal approximation and plot it in your sheet.

5. Decrease the amplifier gain and observe what happen to the signal approximation and plot it in your sheets.

6. Vary the clock rate ,select intermediate ,moderate ,write your observation in your lab sheets.