2 Labwork

2.1 DM Modulator

a. Construct a time array with a duration of 0.05 seconds. Set the sampling frequency $F_s = 2000Hz$

b. Construct an input signal $m(t) = 0.8cos(2\pi f_1 t) + 0.7sin(2\pi f_2 t)$ where $f_1 = 60Hz$ and $f_2 = 90Hz$.

c. **Report** Find the limit step size Δ which makes that the delta modulation has minimum granular noise and slope over distortion.

The basic principle of delta modulation is formalized in the following set of three discrete-time relations:

$$e(nT_s) = m(nT_s) - m_q(nT_s - T_s)$$

$$e_q(nT_s) = \Delta sgn[e(nT_s)] \tag{1}$$

$$m_q(nT_s) = m_q(nT_s - T_s) + e_q(nT_s),$$

where T_s is the sampling period, $m_q(nT_s)$ is the staircase approximation of input signal, $e(nT_s)$ is the error signal, $m(nT_s)$ is the present sample value of the input signal, $m_q(nT_s - T_s)$ is the latest staircase approximation, $e_q(nT_s)$ is the quantized version of $e(nT_s)$ and $sgn[.]$ is signum function. The quantizer output is $e_q(nTs)$ finally encoded to produce the desired DM data.

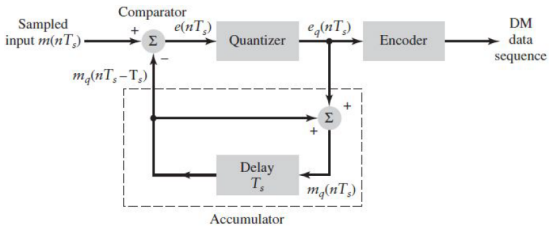

Figure 1: DM encoder

d. Write an encoder part, whose output 'encode' is given to the decoder part of the code as the input, by following the steps given below:

- Find the size of the signal, $m(t)$
- Set initial value of latest staircase approximation $m_q(nT_s - T_s)$, to zero
- Compare the input signal $m(nT_s)$ with the latest staircase approximation, for all samples at sampling instant.
  1. When the input signal $m(nT_s)$ is greater than or equal to the latest staircase approximation, $m_q(nT_s - T_s)$, the staircase approximation $m_q(nT_s)$ can be obtained by applying a positive increment $+\Delta$ to the latest staircase approximation. Error signal $e(nT_s)$ is 1.
  2. When the input signal $m(nT_s)$ is less than or equal to the latest staircase approximation, $m_q(nT_s - T_s)$, the staircase approximation $m_q(nT_s)$ can be obtained by applying a negative increment $-\Delta$ to the latest staircase approximation. Error signal $e(nT_s)$ is -1.
  3. Finally, the outputs of encoder 'encode' as: if the error signal $e(nT_s)$ is 1, encoder output is 1, if the error signal $e(nT_s)$ is -1, encoder output 'encode' is 0.

2.2 DM Demodulator

a. Write decoder part of the code whose output is named as 'decode' is given to the low pass filter (LPF) part as the input. The following steps describe the procedure to write this part.

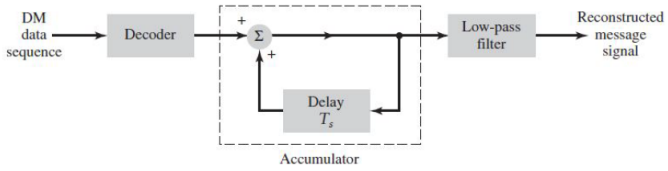

Figure 2: DM decoder

- Find the size of the signal, 'encode'.
- Set initial value of latest staircase approximation, $m_q(nT_s - T_s)$, is zero.
- Compare input signal 'encode' with 0 for all samples.
  1. When the input signal 'encode' is not equal to 0, the staircase approximation, $m_q(nT_s)$, can be obtained by applying a positive increment $+\Delta$ to the latest staircase approximation.
  2. When the input signal 'encode' is equal to 0, the staircase approximation, $m_q(nT_s)$, can be obtained by applying a negative increment $-\Delta$ to the latest staircase approximation.
  3. Write a low pass filter (LPF) part with input signal 'decode' which is the output of the demodulator, n defining the filter order and taken as 100 and cf representing the cut off frequency that is 0.1 in our case. 'out' is the output. This part is given below:

```
cf=0.1;
n=100;
b=fir1(n,cf);
out=conv2(decode,b,'same');
```

- Note that the length of output of the decoder 'decode' and time array will be the same.

3 Results

1. Create 2×1 figure using 'subplot'.
2. Plot both the signal of modulating message signal $m(t)$, and the demodulator output in the first row of the figure by using **hold on** with the found step size.
3. Plot both the low pass filter output and the signal of modulating message signal $m(t)$ in the time domain in the second row of the figure by using **hold on** with the found step size.
4. Change the step size to two different other values which are 0.1 and 0.5. Note that your code must give three different 2×1 figures as output for each corresponding Δ value.
5. **Report** Comment on the effect of step size. What happens in each case?

The figures must be shown in the format that we define to get full credit
Note that when you submit your code you must send only one .m file

3.1 Remaining Questions for Report

- We give three different step size values. For which value does slope over distortion? When does slope over distortion occur?
- We give three different step size values. For which value it occurs Granular noise? When does Granular noise occur?