LNMIIT
The LNM Institute of Information Technology
DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Experiment No. # 2
Discretization of signals : Quantization and Encoding

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1) **Objectives:**
   a) Quantization and Encoding.
   b) Simulink based Quantization.

2) **Software used:**
   a) MATLAB.

A. Pre-Lab

a) Read about analog to digital conversion.
b) practice simulink.

I. Quantization

A. Theory

1) J. Proakis and D. Manolakis, Digital signal processing: principles, algorithms, and applications

B. Procedure

1) Generate a sinusoidal signal,

$$x(t) = A\cos(2\pi ft)$$

of frequency 3000 Hz and 1Vpp for four complete cycles with sampling rate 100000 Hz.

2) The discrete time sampled signal is given by replacing t with nTs

$$x(nTs) = A\cos(2\pi fnTs) \tag{1}$$

where n is sample number and Ts is time period of signal having frequency Fs.

3) Generate sampled signal, y(t), with message signal frequency $F = 3000$ Hz and sampling frequency $Fs = 8000Hz$.

4) Make your own function myquantizer(y,L) for following quantizer specification.
   - Type of Quantizer - Uniform.
   - Input Range of Quantizer - 1Vpp.
   - Levels of Quantizer - L.

5) Generate quantized signal g(t) by quantizing y(t) for different quantizer levels 'L' i.e. 8, 16, 32, 64 etc.

6) Compute Mean Square error between g(t) and y(t) i.e. quantization noise power(Qe) and verify it with the theoretical expression for SQNR of sinusoidal signal given by

$$\begin{aligned} SQNR &= \frac{3}{2}(2^{2b}) \\ &= 1.76 + 6.02(b) \qquad\qquad (In \;\; dB) \end{aligned}$$

where b is the no. of bits representing a particular level (i.e.Total levels $L = 2^b$).

7) Now, Fix the number of quantization level L to 64 and change peak to peak amplitude of input signal x(t) from 0.1Vpp to 1Vpp with the difference of 0.1Vpp. Compute Signal to quantization noise ratio(SQNR) for all cases.

8) **Encoding:**
Obtain quantized signal and represent each level by a definite binary number. The number of digits $b >= log(L)$.

9) **Observation:**
   a) Plot 5 cycles of sampled signal and quanitized signal for various values of L = 8.
   b) Plot the graph between quantization noise power(Qe) and quantization level L= 16, 32, 64.
   c) Plot SQNR vs input voltage for various voltage levels as given in step.
   d) Plot the sampled, quantized and encoded signal of a single complete cycle for L = 8.
   e) Repeat the experiment in simulink.

10) **Conclusion:** Conclude the effect of increasing quantization level on SQNR. Also mention effect of signal amplitude on SQNR.

II. Quantization in Simulink

1) Open simulink and create a model file with .slx extension.

2) Find various sources(sinewave, Quantizer) and sinks(display, scope) etc.

3) Drag the various functions to model file.

4) Search for matlab function in simulink blockset.

5) Repeat all the 'Procedure' steps and recreate the Quantization and Encoding of discrete signal into simulink.

Well Done
