



**AMERICAN INTERNATIONAL UNIVERSITY–BANGLADESH (AIUB)**

FACULTY OF ENGINEERING

Course name: Data Communication

Course code: COE 3201

Section: H

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Experiment no: 03

Experiment name: Analog Signal quantization using MATLAB

Submission date: Feb 28<sup>th</sup>, 2024

ID: AB-CDEFG-H

Write a MATLAB code that can generate an approximated quantized signal for the following analog function:

$$x_1(t) = A_1 \cos(2\pi(CDE * 100)t)$$

(a) Define the amplitude  $A_1 = \text{GD}$ , sampling frequency, define the time domain  $t$  for function  $x_1(t)$  that gives at least 3 complete cycles.

(b) Define the number of quantization levels, step size or resolution, then find the quantized signal  $x_q$ .

(c) Obtain the absolute quantization error,  $err = abs(x_1 - x_q)$

Finally, use 2x2 subplot to plot analog signal  $x_1(t)$ , sampling signal of  $x_1(t)$ , quantized signal  $x_q(t)$ , and quantized error signal  $err$ .

**ANSWER:**

(a) Define the amplitude  $A_1 = \text{GD}$ , sampling frequency, define the time domain  $t$  for function  $x_1(t)$  that gives at least 3 complete cycles.

My id:

ID = 22-47019-1

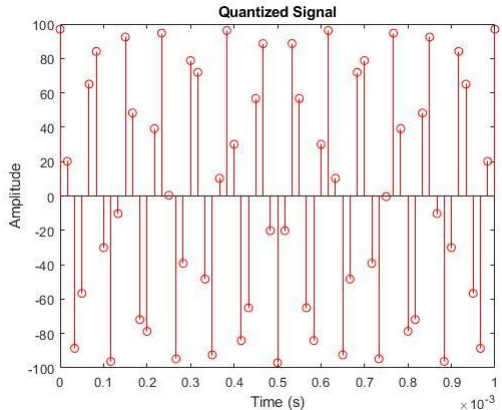
A1 = GD = 97; //Amplitude

F = CDE = 470; // Frequency

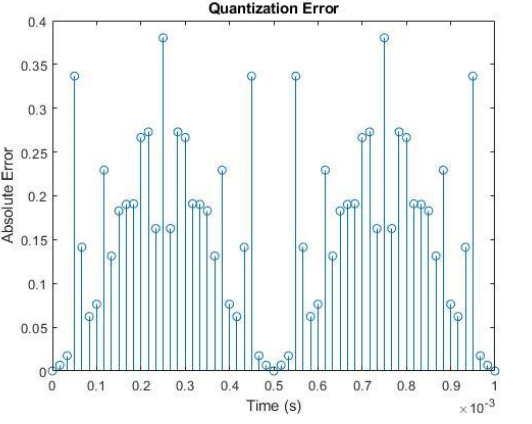
So,

$$x_1(t) = A_1 \cos(2\pi(CDE * 100)t)$$

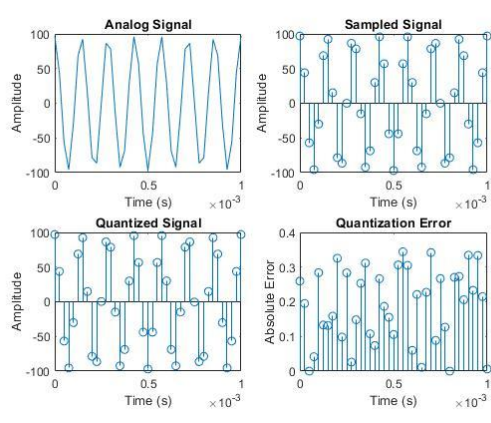
(b) Define the number of quantization levels, step size or resolution, then find the quantized signal  $x_q$ .

MATLAB Code	Output Figure
<pre> A1 = 97; Sampling_Frequency = 60e3; CDE = 470; Num_Quantization_Levels = 8; Duration = 3; Resolution = (2 * A1) / (2^Num_Quantization_Levels); t=0:1/Sampling_Frequency:0.001;  x1 = A1 * cos(2 * pi * (CDE * 100) * t);  L=(2^Num_Quantization_Levels)- 1;  delta=(max(x1)-min(x1))/L;  Quantized_Signal = min(x1)+(round((x1- min(x1))/delta)).*delta;  stem(t, Quantized_Signal, 'r') title('Quantized Signal') xlabel('Time (s)') ylabel('Amplitude') </pre>	

(C) Obtain the absolute quantization error,  $err = abs(x_1 - x_q)$

MATLAB Code	Output Figure
<pre> A1 = 97; Sampling_Frequency = 60e3; CDE = 470; Num_Quantization_Levels = 8; Duration = 3; Resolution = (2 * A1) / (2^Num_Quantization_Levels); t=0:1/Sampling_Frequency:0.001;  x1 = A1 * cos(2 * pi * (CDE * 100) * t);  L=(2^Num_Quantization_Levels)- 1;  delta=(max(x1)-min(x1))/L;  Quantized_Signal = min(x1)+(round((x1- min(x1))/delta)).*delta; %xq  err = abs(x1 - Quantized_Signal);  stem(t, err) title('Quantization Error') xlabel('Time (s)') ylabel('Absolute Error') </pre>	 <p>The figure is a stem plot titled "Quantization Error". The x-axis is labeled "Time (s)" and ranges from 0 to 1 with a multiplier of <math>\times 10^{-3}</math>. The y-axis is labeled "Absolute Error" and ranges from 0 to 0.4. The plot shows a periodic signal with peaks reaching approximately 0.38 and troughs near 0.02. The signal is composed of discrete points connected by vertical lines, representing the absolute error at each sampling interval.</p>

- (d) Finally, use 2x2 subplot to plot analog signal  $x_1(t)$ , sampling signal of  $x_1(t)$ , quantized signal  $x_q(t)$ , and quantized error signal  $err$ .

MATLAB Code	Output Figure
<pre> A1 = 97; Sampling_Frequency = 40e3; CDE = 470; Num_Quantization_Levels = 8; Duration = 3; Resolution = (2 * A1) / (2^Num_Quantization_Levels); t=0:1/Sampling_Frequency:0.001;  x1 = A1 * cos(2 * pi * (CDE * 100) * t);  L=(2^Num_Quantization_Levels)- 1;  delta=(max(x1)-min(x1))/L;  Quantized_Signal = min(x1)+(round((x1- min(x1))/delta)).*delta;  subplot(2,2,1) plot(t, x1) title('Analog Signal') xlabel('Time (s)') ylabel('Amplitude')  subplot(2,2,2) stem(t, x1) title('Sampled Signal') xlabel('Time (s)') ylabel('Amplitude')  subplot(2,2,3) stem(t, Quantized_Signal) title('Quantized Signal') xlabel('Time (s)') ylabel('Amplitude') </pre>	 <p>The figure consists of four subplots arranged in a 2x2 grid, all sharing a common x-axis representing Time (s) from 0 to 1, scaled by <math>\times 10^{-3}</math>.</p> <ul style="list-style-type: none"> <li><b>Analog Signal (Top Left):</b> A continuous-time cosine wave with an amplitude ranging from -100 to 100.</li> <li><b>Sampled Signal (Top Right):</b> A discrete-time signal represented by blue circles at each sampling interval, showing the values of the analog signal at those points.</li> <li><b>Quantized Signal (Bottom Left):</b> A discrete-time signal represented by blue circles, where the values are rounded to the nearest quantization level, resulting in a staircase-like appearance.</li> <li><b>Quantization Error (Bottom Right):</b> A plot of the absolute error between the sampled signal and the quantized signal. The error values are small, fluctuating between 0 and approximately 0.3.</li> </ul>

<pre>subplot(2,2,4) stem(t, Quantization_Error) title('Quantization Error') xlabel('Time (s)') ylabel('Absolute Error')</pre>	
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