



AMERICAN INTERNATIONAL UNIVERSITY–BANGLADESH (AIUB)

FACULTY OF ENGINEERING

Course name: Data Communication

Course code: COE 3201

Section: H

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ID: 22-47019-1

Instructor name: Dr. Muhammad Morshed Alam

Experiment no: 03

Experiment name: Analog Signal quantization using MATLAB

Submission date: Feb 28th, 2024

Performance Task for Lab Report: (ID = AB-CDEFG-H)

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.

A	B	-	C	D	E	F	G	-	H
2	2	-	4	7	0	1	9	-	1

My id:

ID = 22-47019-1

A1 = GD = 97; //Amplitude

F = CDE = 470; // Frequency

So,

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

//MATLAB code where all the parameters are defined

```
A1 = 97; % Amplitude of the analog signal,
Sampling_Frequency = 60e3; % Sampling frequency
CDE = 470; %Frequency of the analog signal
Num_Quantization_Levels = 8; % Number of quantization levels
Duration = 3; % Duration of the signal in seconds
```

```

Resolution = (2 * A1) / (2^Num_Quantization_Levels); % Step size
t=0:1/Sampling_Frequency:0.001;

% Defining the analog signal
x1 = A1 * cos(2 * pi * (CDE * 100) * t);

L=(2^Num_Quantization_Levels)-1;

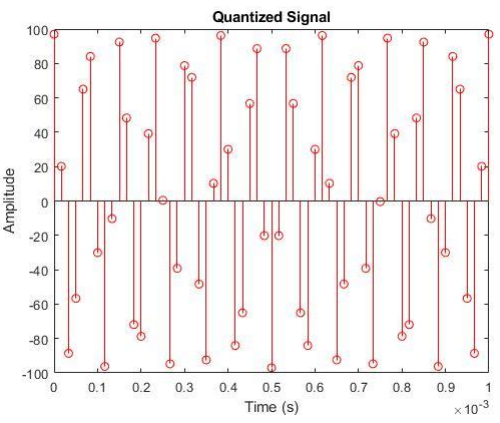
delta=(max(x1)-min(x1))/L;

% Quantization
Quantized_Signal = min(x1)+(round((x1-min(x1))/delta)).*delta;
%xq

% Plotting
stem(t, Quantized_Signal, 'r')
title('Quantized Signal')
xlabel('Time (s)')
ylabel('Amplitude')

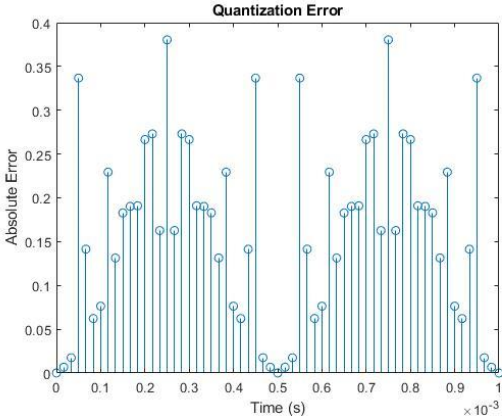
```

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

MATLAB Code	Output Figure
<pre> %{ ID: 22-47019-1 (AB-CDEFG-H); A1 = GD = 97; F = CDE = 470; %} A1 = 97; % Amplitude of the analog signal, Sampling_Frequency = 60e3; % Sampling frequency CDE = 470; %Frequency of the analog signal Num_Quantization_Levels = 8; % Number of quantization levels Duration = 3; % Duration of the signal in seconds Resolution = (2 * A1) / (2^Num_Quantization_Levels); % Step size t=0:1/Sampling_Frequency:0.001; % Defining the analog signal x1 = A1 * cos(2 * pi * (CDE * 100) * t); L=(2^Num_Quantization_Levels)- 1; delta=(max(x1)-min(x1))/L; % Quantization Quantized_Signal = min(x1)+(round((x1- min(x1))/delta)).*delta; %xq </pre>	 <p>The figure is a stem plot titled "Quantized Signal". The horizontal axis is labeled "Time (s)" and ranges from 0 to 1, with a multiplier of $\times 10^{-3}$ at the end. The vertical axis is labeled "Amplitude" and ranges from -100 to 100. The plot shows a periodic signal with discrete values at each sampling interval, represented by red circles connected by vertical lines. The signal oscillates between approximately -97 and 97, with the quantization levels visible as discrete steps.</p>

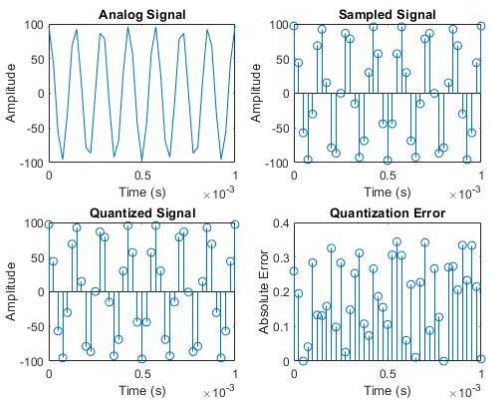
<pre>% Plotting stem(t, Quantized_Signal, 'r') title('Quantized Signal') xlabel('Time (s)') ylabel('Amplitude')</pre>	
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(C) Obtain the absolute quantization error, $err = abs(x_1 - x_q)$

MATLAB Code	Output Figure
<pre> %{ ID: 22-47019-1 (AB-CDEFG-H); A1 = GD = 97; F = CDE = 470; %} A1 = 97; % Amplitude of the analog signal, Sampling_Frequency = 60e3; % Sampling frequency CDE = 470; %Frequency of the analog signal Num_Quantization_Levels = 8; % Number of quantization levels Duration = 3; % Duration of the signal in seconds Resolution = (2 * A1) / (2^Num_Quantization_Levels); % Step size t=0:1/Sampling_Frequency:0.001;% % Defining the analog signal x1 = A1 * cos(2 * pi * (CDE * 100) * t); L=(2^Num_Quantization_Levels)-1; delta=(max(x1)-min(x1))/L; % Quantization Quantized_Signal = min(x1)+(round((x1- min(x1))/delta)).*delta; %xq % Calculating quantization error err = abs(x1 - Quantized_Signal); stem(t, err) </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 $\times 10^{-3}$. The y-axis is labeled "Absolute Error" and ranges from 0 to 0.4. The plot shows a periodic signal with peaks reaching approximately 0.35 and troughs near 0.05. The signal is composed of discrete points connected by vertical lines, representing the quantization error over time.</p>

<pre>title('Quantization Error') xlabel('Time (s)') ylabel('Absolute Error')</pre>	
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- (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> %{ ID: 22-47019-1 (AB-CDEFG-H); A1 = GD = 79; F = CDE = 470; %} A1 = 97; % Amplitude of the analog signal, Sampling_Frequency = 40e3; % Sampling frequency CDE = 470; %Frequency of the analog signal Num_Quantization_Levels = 8; % Number of quantization levels Duration = 3; % Duration of the signal in seconds Resolution = (2 * A1) / (2^Num_Quantization_Levels); % Step size t=0:1/Sampling_Frequency:0.001;% % Defining the analog signal x1 = A1 * cos(2 * pi * (CDE * 100) * t); L=(2^Num_Quantization_Levels)-1; delta=(max(x1)-min(x1))/L; % Quantization Quantized_Signal = min(x1)+(round((x1- min(x1))/delta)).*delta; subplot(2,2,1) plot(t, x1) title('Analog Signal') xlabel('Time (s)') </pre>	 <p>The figure consists of four subplots arranged in a 2x2 grid:</p> <ul style="list-style-type: none"> Analog Signal: A plot of the continuous-time cosine signal $x_1(t) = 97 \cos(2\pi \cdot 47000 \cdot t)$ over the time interval $t \in [0, 0.001]$ seconds. The amplitude ranges from -100 to 100. Sampled Signal: A plot showing the discrete samples of the analog signal. The signal is zero between samples, and the sample values are marked with blue circles. Quantized Signal: A plot showing the quantized version of the sampled signal. The values are rounded to the nearest quantization level, also marked with blue circles. Quantization Error: A plot showing the absolute error between the sampled signal and the quantized signal. The error values are marked with blue circles, and the plot shows the error signal err.


```
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')

subplot(2,2,4)
stem(t, Quantization_Error)
title('Quantization Error')
xlabel('Time (s)')
ylabel('Absolute Error')
```