NAMAL UNIVERSITY MIANWALI

DEPARTMENT OF ELECTRICAL ENGINEERING

EE 345 (L) – Digital Signal Processing (Lab)

LAB # 08

REPORT

Title :

Quantization of Discrete time Signals using MATLAB

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Lab Engineer	*Engr. Faizan Ahmad*
Date Performed	*24-April-2024*
Marks	

Introduction

The purpose of this lab is to enable the students to study the effect of quantization on signals using MATLAB.

Course Learning Outcomes

CLO1: Develop algorithms to perform signal processing techniques on digital signals using MATLAB and DSP Kit DSK6713

CLO3: Deliver a report/lab notes/presentation/viva, effectively communicating the design and analysis of the given problem

Equipment

- Software
  - MATLAB

Instructions

1. This is an individual lab. You will perform the tasks individually and submit a report.
2. Some of these tasks are for practice purposes only while others (marked as 'Exercise') have to be answered in the report.
3. When asked to display an image/ graph in the exercise, either save it as jpeg or take a screenshot, in order to insert it in the report.
4. The report should be submitted on the given template, including:
   a. Code (copy and pasted, NOT a screenshot)
   b. Output values (from command window, can be a screenshot)
   c. Output figure/graph (as instructed in 3)
   d. Explanation where required
5. The report should be properly formatted, with easy to read code and easy to see figures.
6. Plagiarism or any hint thereof will be dealt with strictly. Any incident where plagiarism is caught, both (or all) students involved will be given zero marks, regardless of who copied whom. Multiple such incidents will result in disciplinary action being taken.

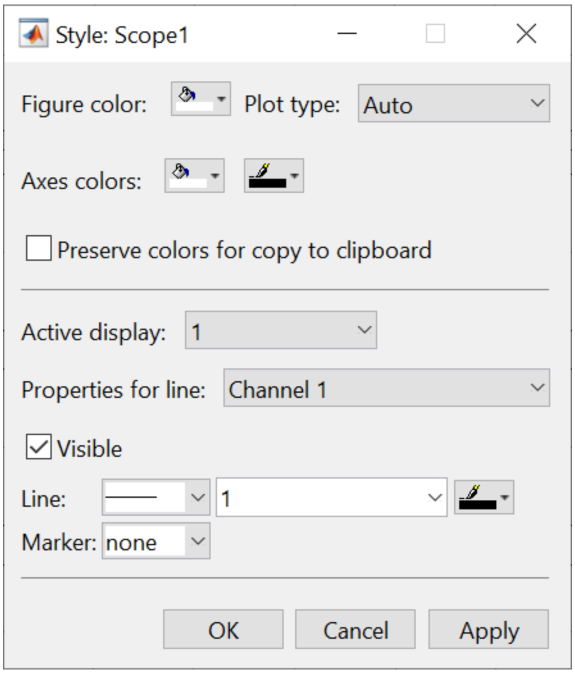
Background:

Everything stored on a computer is discrete time discrete valued signal. Because computer has finite number of registers and each register is a finite length register. We take too many samples to give the ‘effect’ of continuous time signals. But actually they are discrete time. We also take very fine resolution of amplitude axis to give the effect of continuous valued signal but due to finite word length of the computer register, the stored variables are already quantized. This lab aims to explain the quantization effects in a computer. Regardless of the medium (audio or image), the digitization of real world analog signal usually involves two stages: sampling, i.e. the measurement of signal at discretely spaced time intervals, and quantization, i.e. the transformation of the measurements (amplitudes) into finite-precision numbers (allowed discrete levels), such that they can be represented in computer memory. Quantization is a matter of representing the amplitude of individual samples as integers expressed in binary. The fact that integers are used forces the samples to be measured in a finite number of bits (discrete levels). The range of the integers possible is determined by the bit depth, the number of bits used per sample. The bit depth limits the precision with which each sample can be represented.

Within digital hardware, numbers are represented by binary digits known as bits—in fact, the term bit originated from the words Binary digit. A single bit can be in only one of two possible states: either a one or a zero. When samples are taken, the amplitude at that moment in time must be converted to integers in binary representation. The number of bits used to represent each sample, called the bit depth (bits/sample) or sample size, determines the precision with which the sample amplitudes can be represented. Each bit in a binary number holds either a 1 or a 0. In digital sound, bit depth affects how much you have to round off the amplitude of the wave when it is sampled at various points in time.

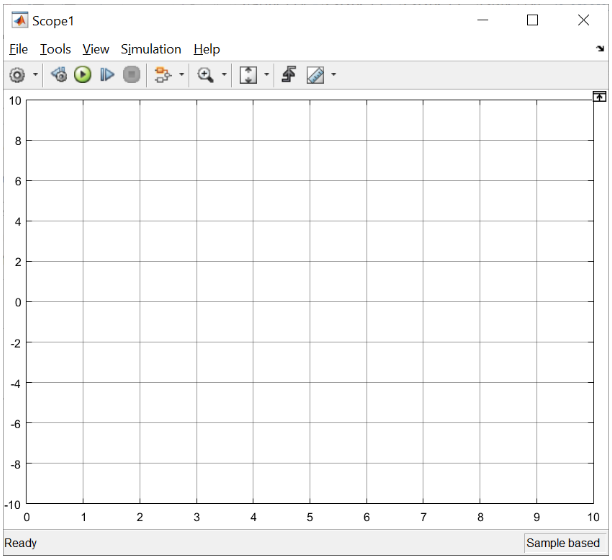
The number of different values that can be represented with b-bit is 2bb.The largest decimal number that can be represented with a b-bit binary number is 2bb−1. For example, the decimal values that can be represented with an 8-bit binary number range from 0 to 255, so there are 256 different values (levels of ADC). A bit depth of 8 allows 28=256 different discrete levels at which samples can be approximated or recorded. Eight bits together constitute one byte. A bit depth of 16 allows 216= 65,536 discrete levels, which in turn provides much higher precision than a bit depth of 8.

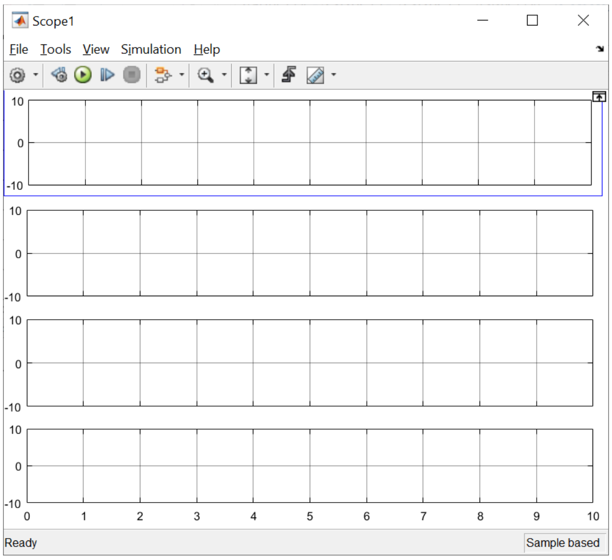
The default colour scheme for plots uses a lot of ink when printed. So change it to white background and dark curves by going to view > Style



**You must use white background and black plot lines while using the scope.

Then open view > Layout to plot all inputs separately.





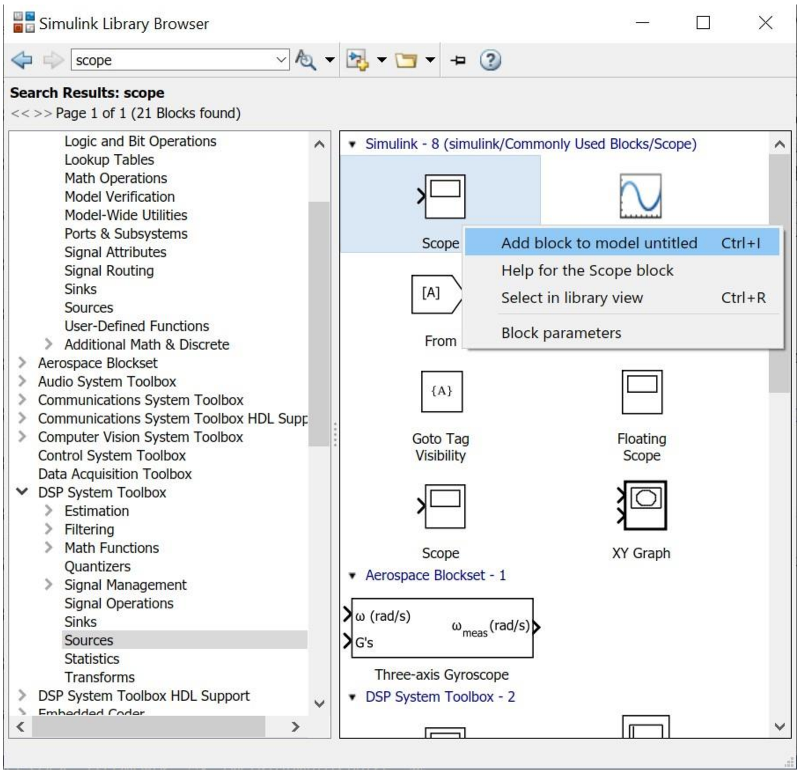
View > Legend will add the legend to the plots.

Simulink

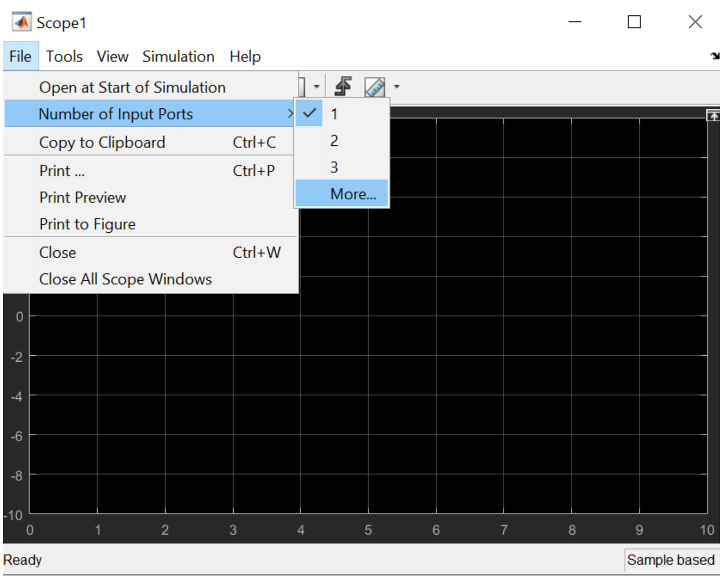
"Simulink is a block diagram environment used to design systems with multi-domain models, simulate before moving to hardware, and deploy without writing code" (Copied from https://www.mathworks.com/products/simulink.html)

Scope settings in Simulink

Go to Matlab Home > Simulink to open Simulink window.
In the Simulink window, open View > Library Browser
Search for scope in the Library Browser. Select and add it to your model.

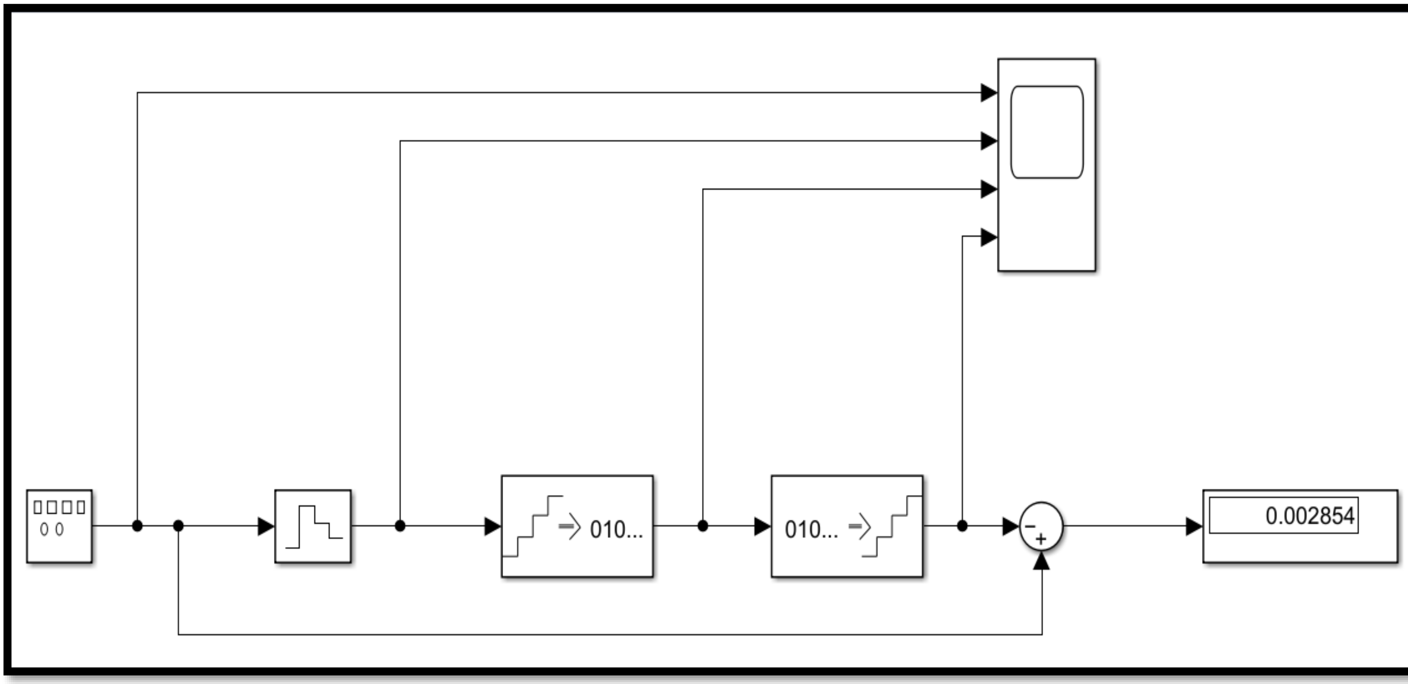


Double click on the scope to open its display window. The default window looks like the one shown below, with one display window (for the single input) and black background. You may increase the number of inputs to the scope by increasing the number of input ports.

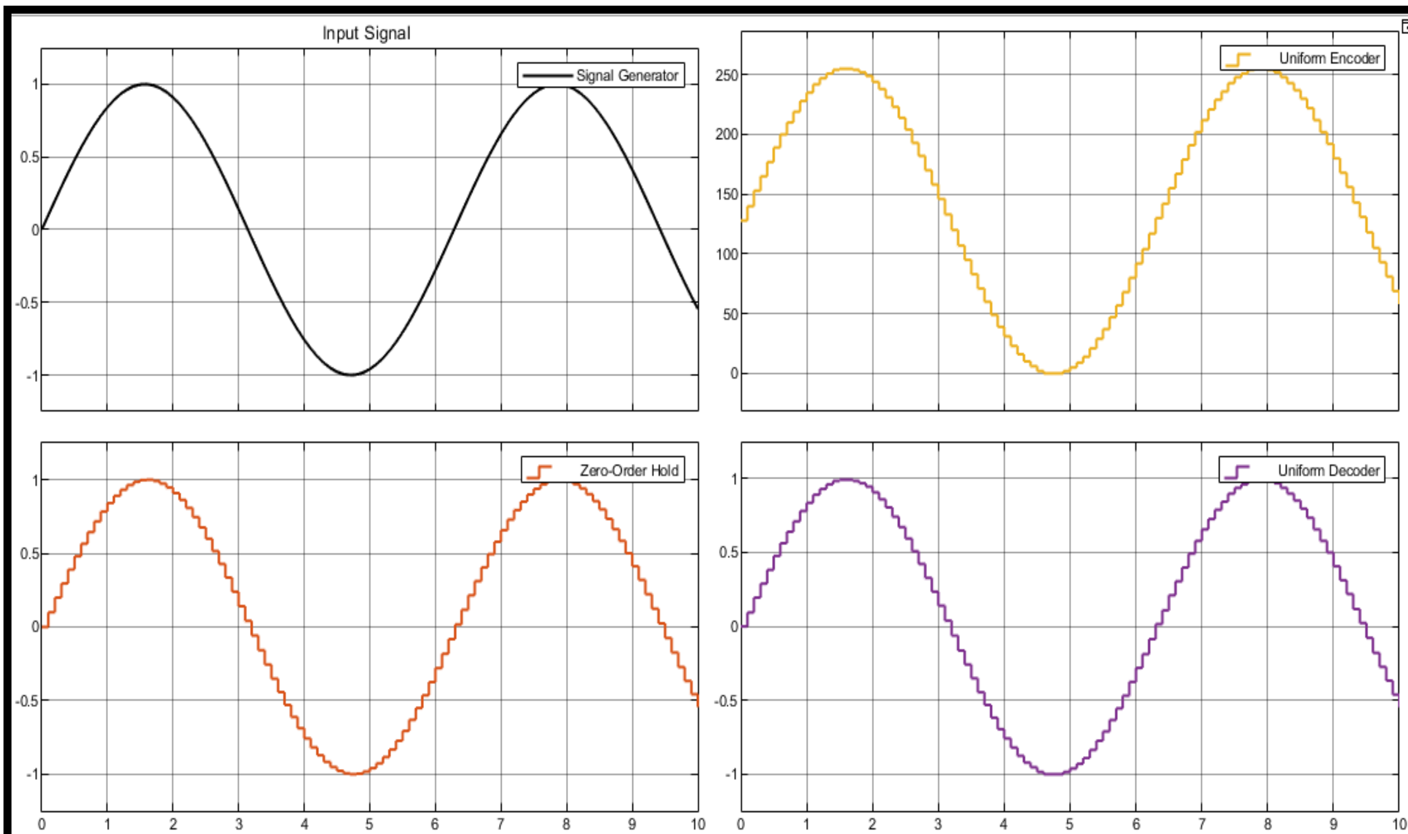


Exercise 1:

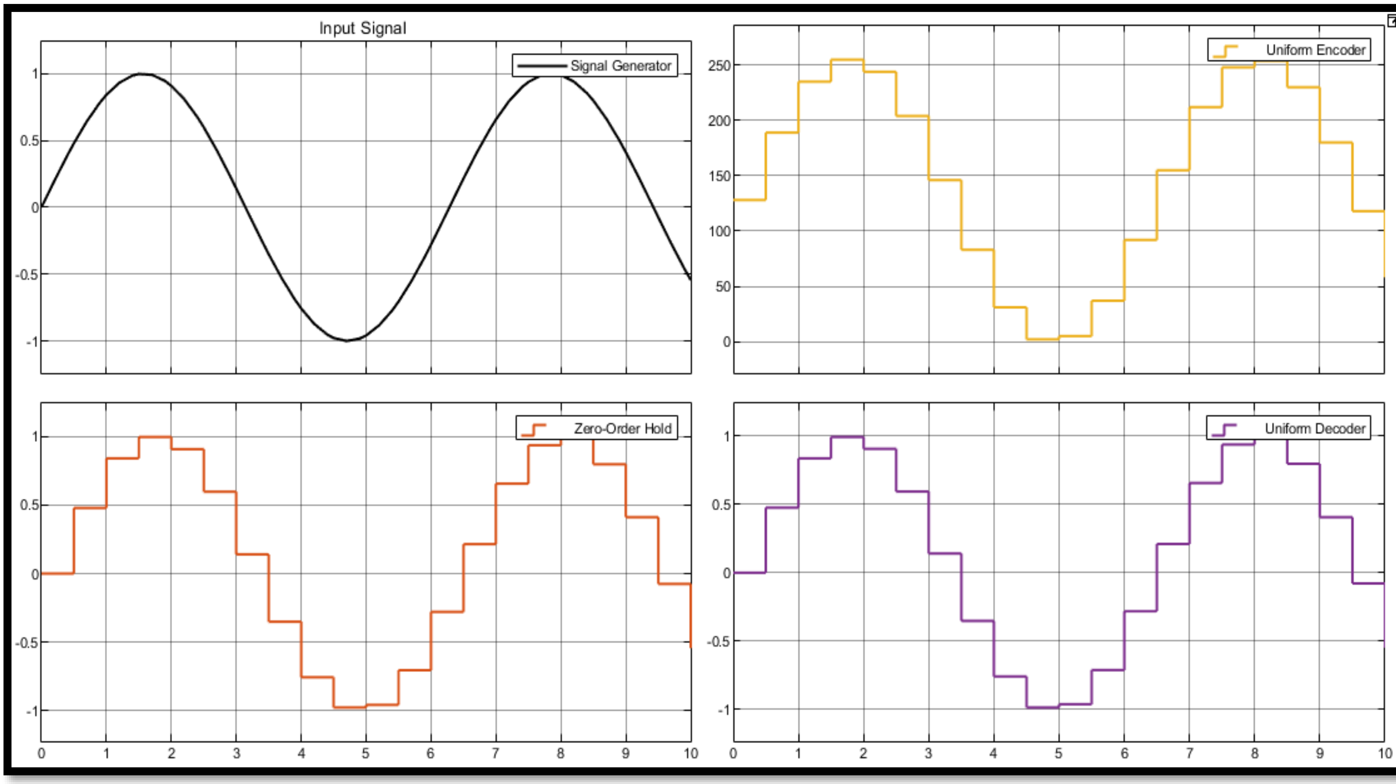
- ***Simulink Block Diagram:***



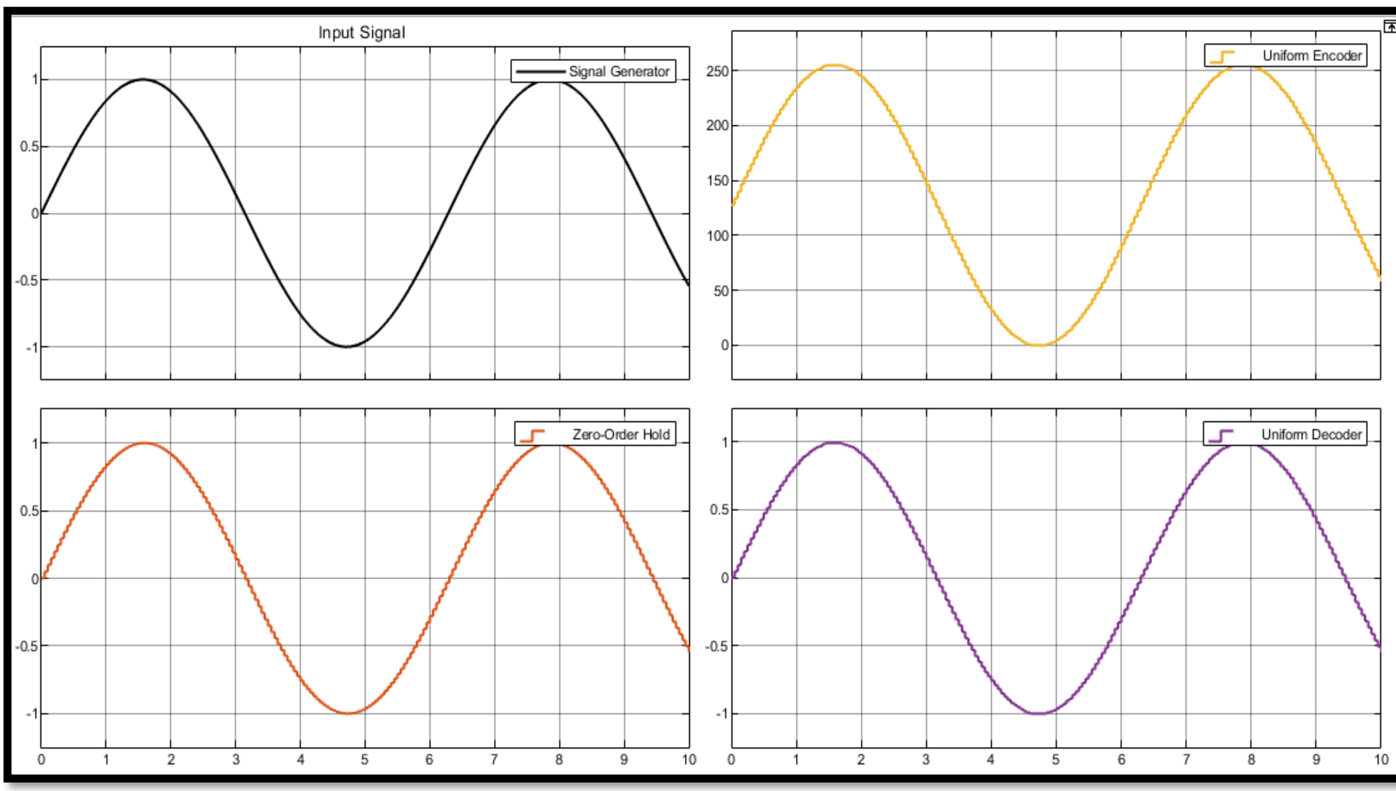
- ***1st Output When All the Parameters are same as given:***



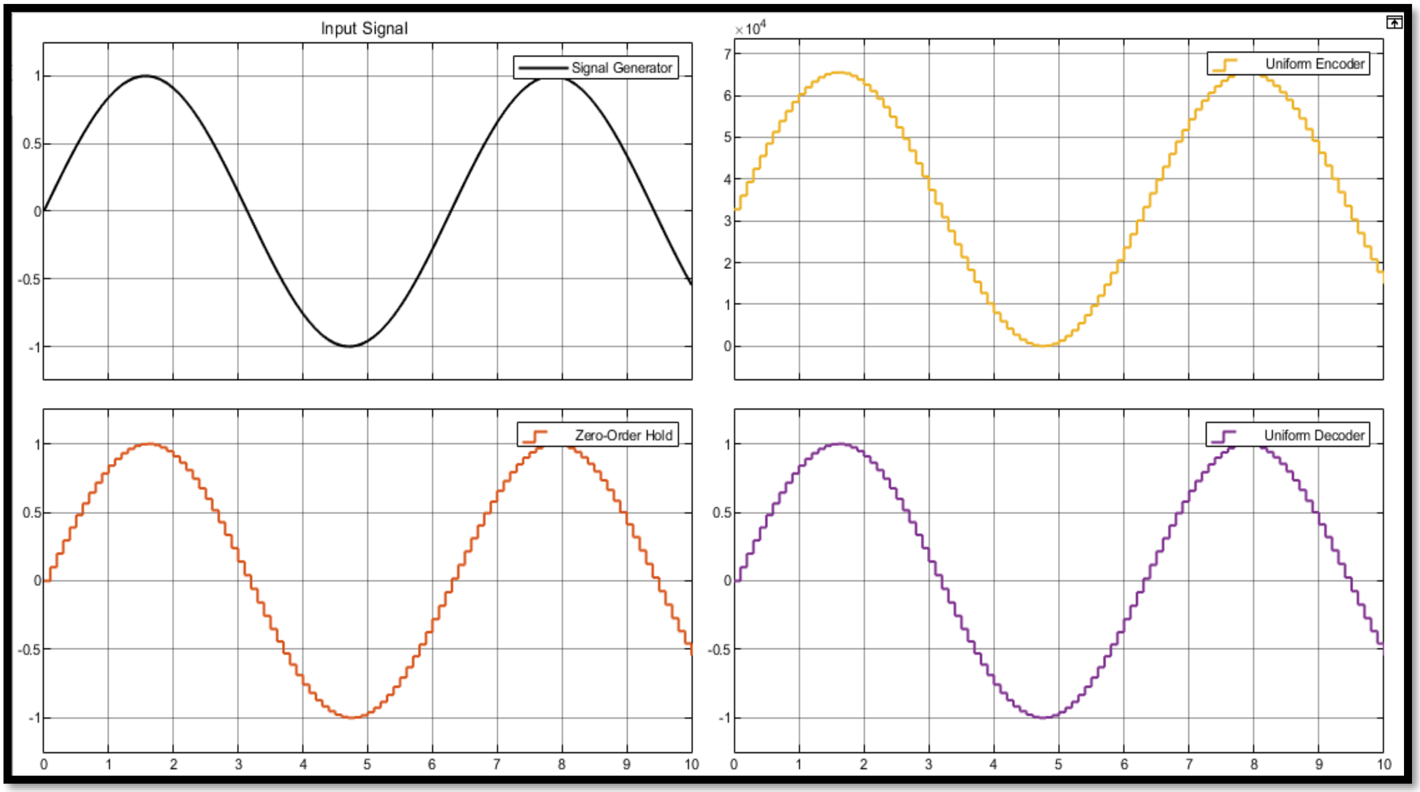
- ***Effect of increasing the sampling frequency (in the zero order hold block) on the signals (Ts = 0.01 , f_s = 100 Hz).***



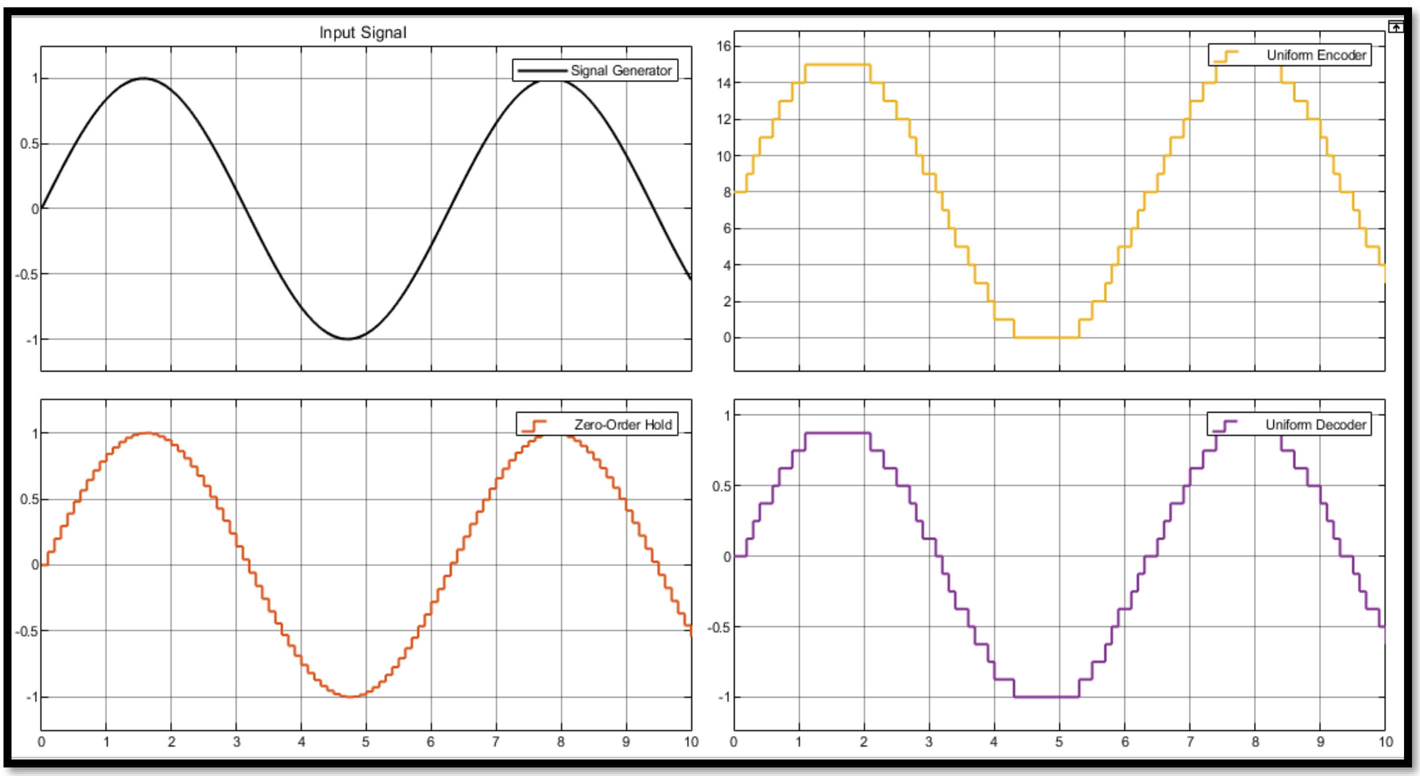
- ***Effect of decreasing the sampling frequency (in the zero order hold block) on the signals (Ts = 0.1 , f_s = 10 Hz).***



- ***Effect of increasing the number of bits in the Encoder and Decoder blocks (16 bits):***



- ***Effect of decreasing the number of bits in the Encoder and Decoder blocks(4 bits):***



Explanations and Answers:

- Increasing the sampling frequency in the zero order Hold block made the outer Signal smother while decreasing made it jagged.

- Increasing the number of bits in encoder and decoder blocks makes the output block make more precisor while decreasing made it less precise.

What is the purpose of the Sum block?

The purpose of Sum block is to add the quantized signal and the quantization error, giving the output error.

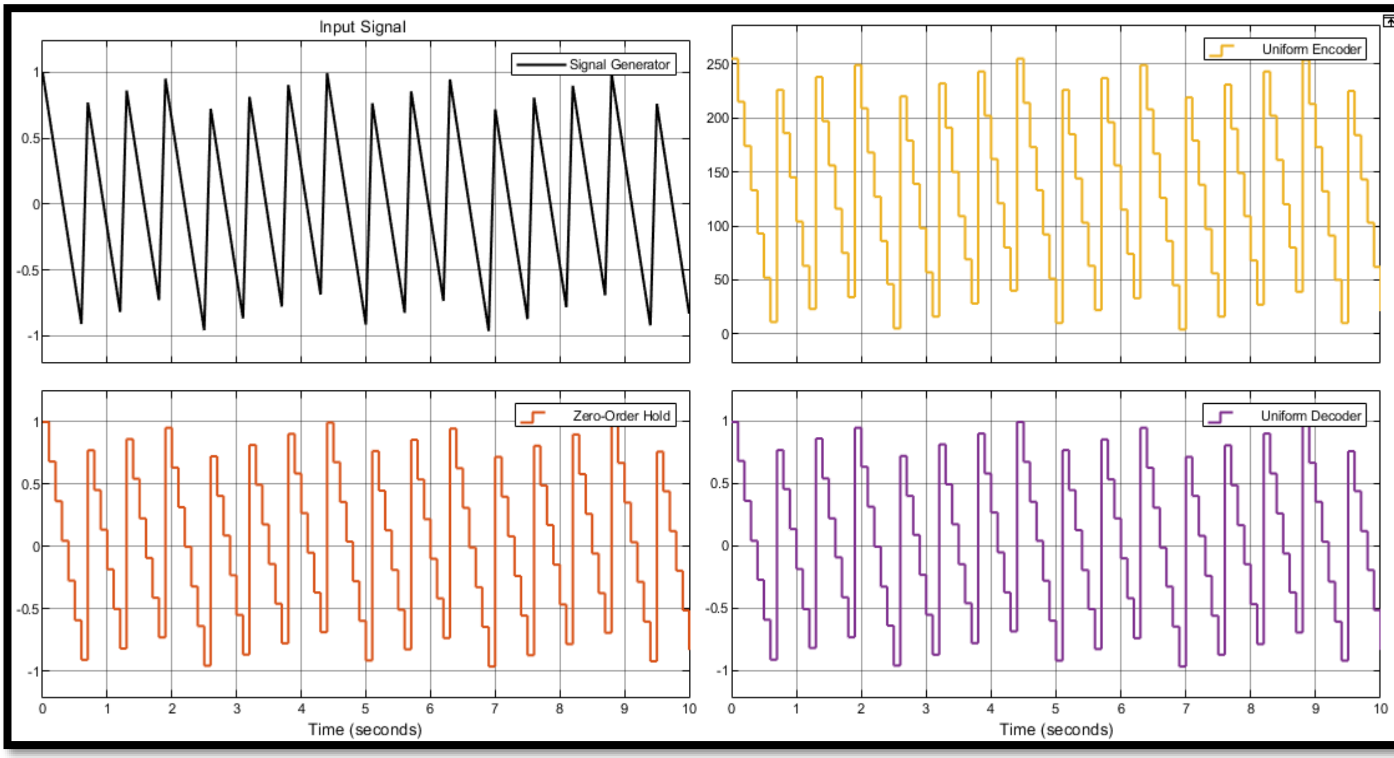
Which blocks are affecting the quantization levels?

Encoder and Decoder block ~~are~~ affecting the quantization levels. The quantization error is the difference b/w the input signal and quantized signal.

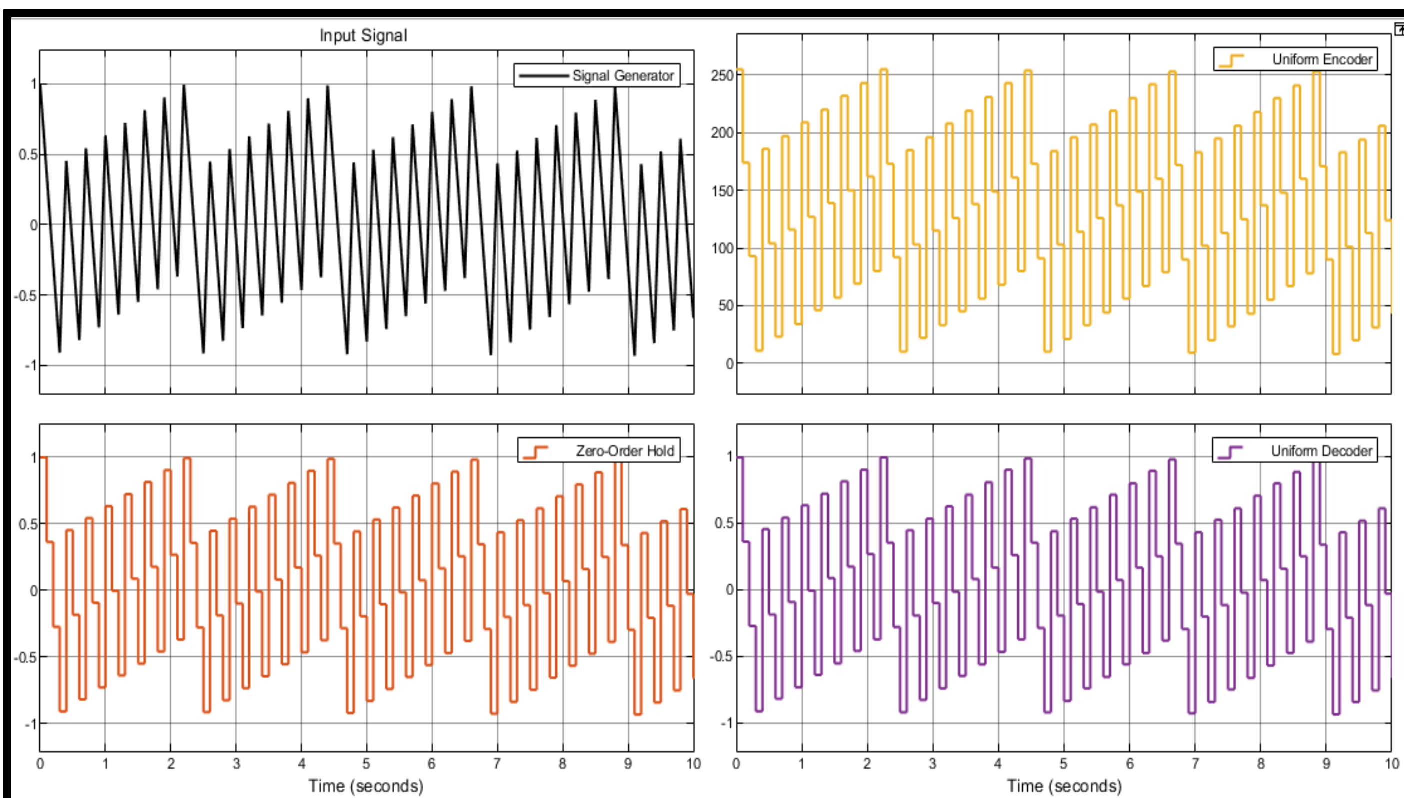
Exercise 2:

Generate saw-tooth wave for f=10 rad/sec to observe the effects of quantization? What happens, if frequency and sampling frequency increases and decreases?

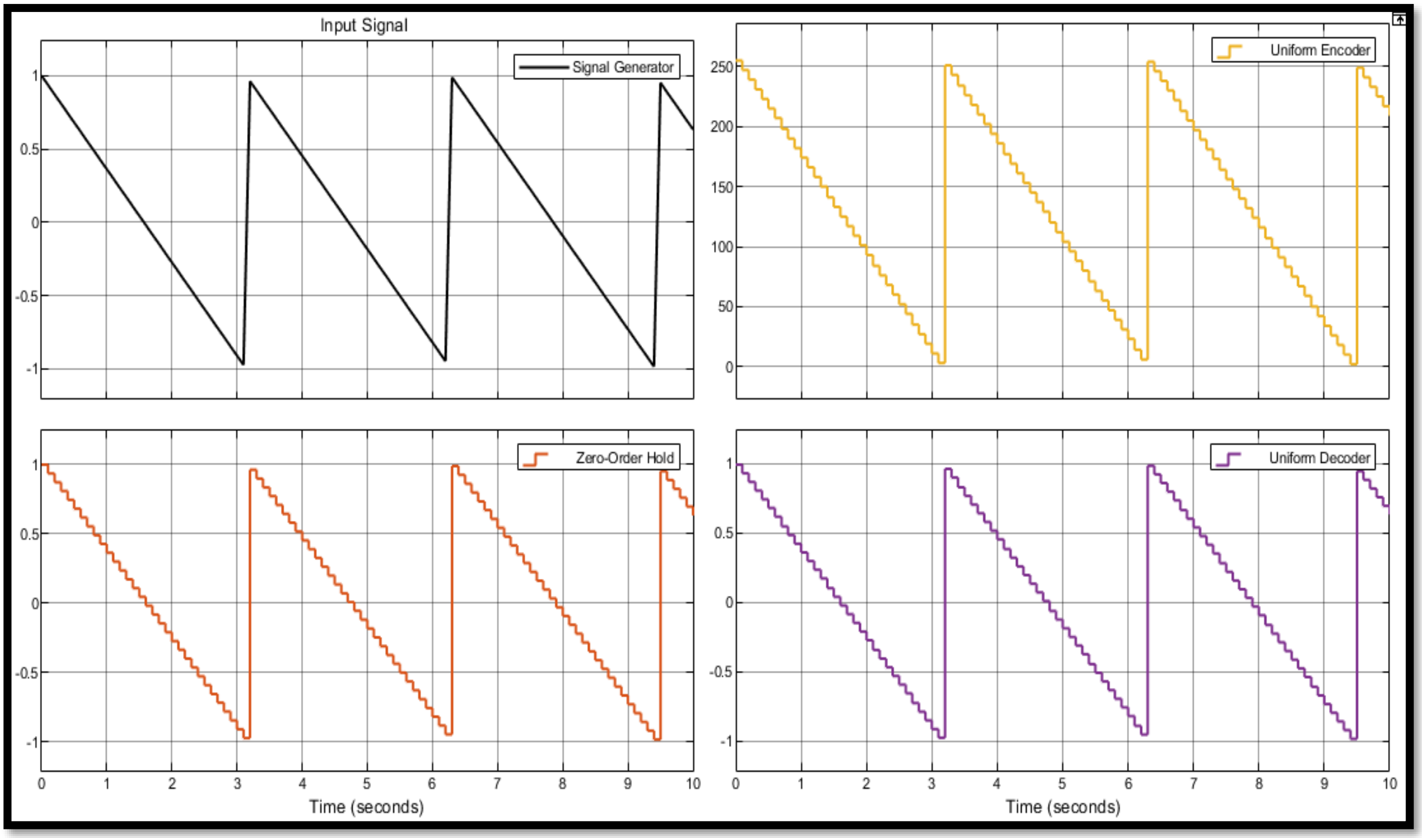
Output:



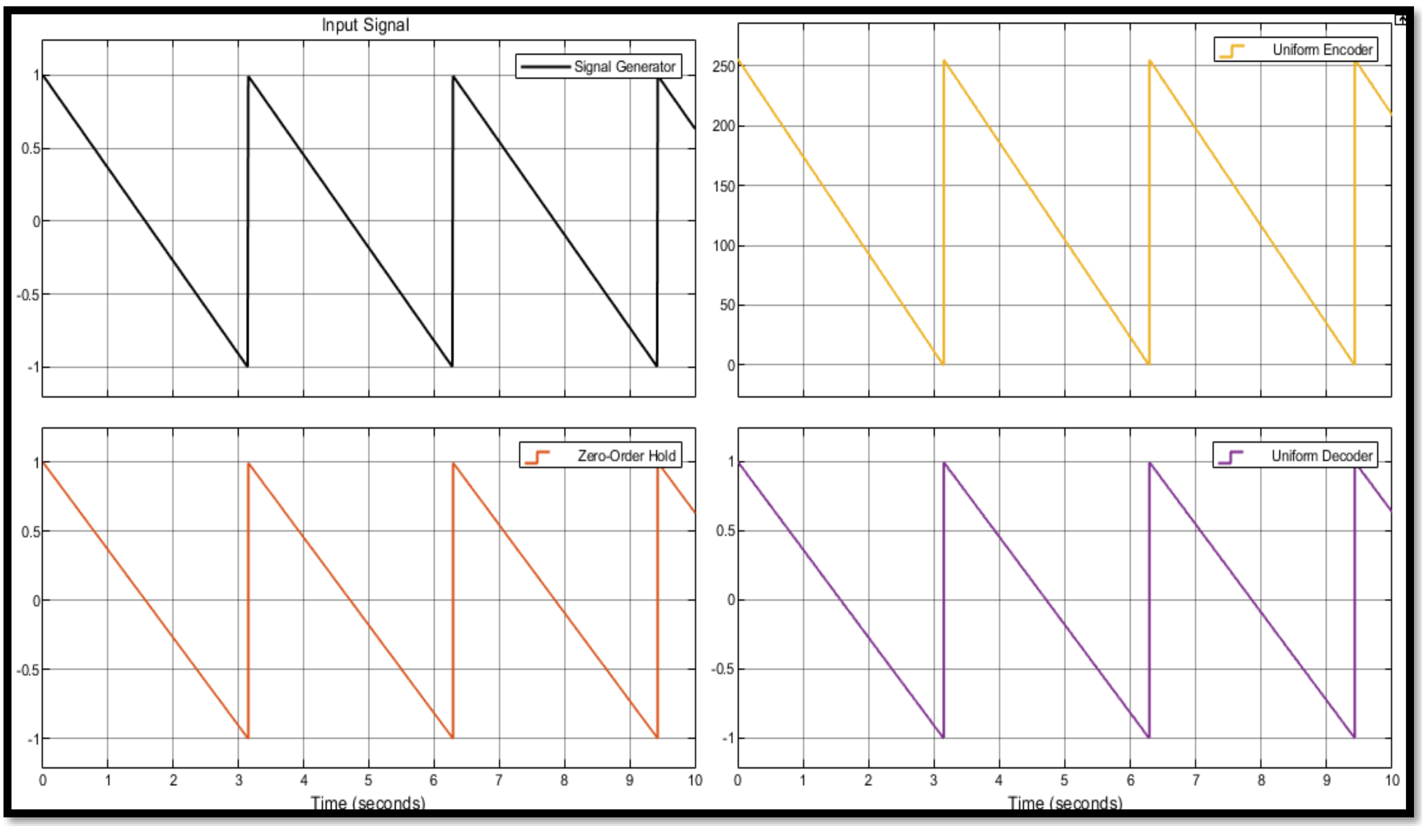
Frequency increase (20 rad/sec):



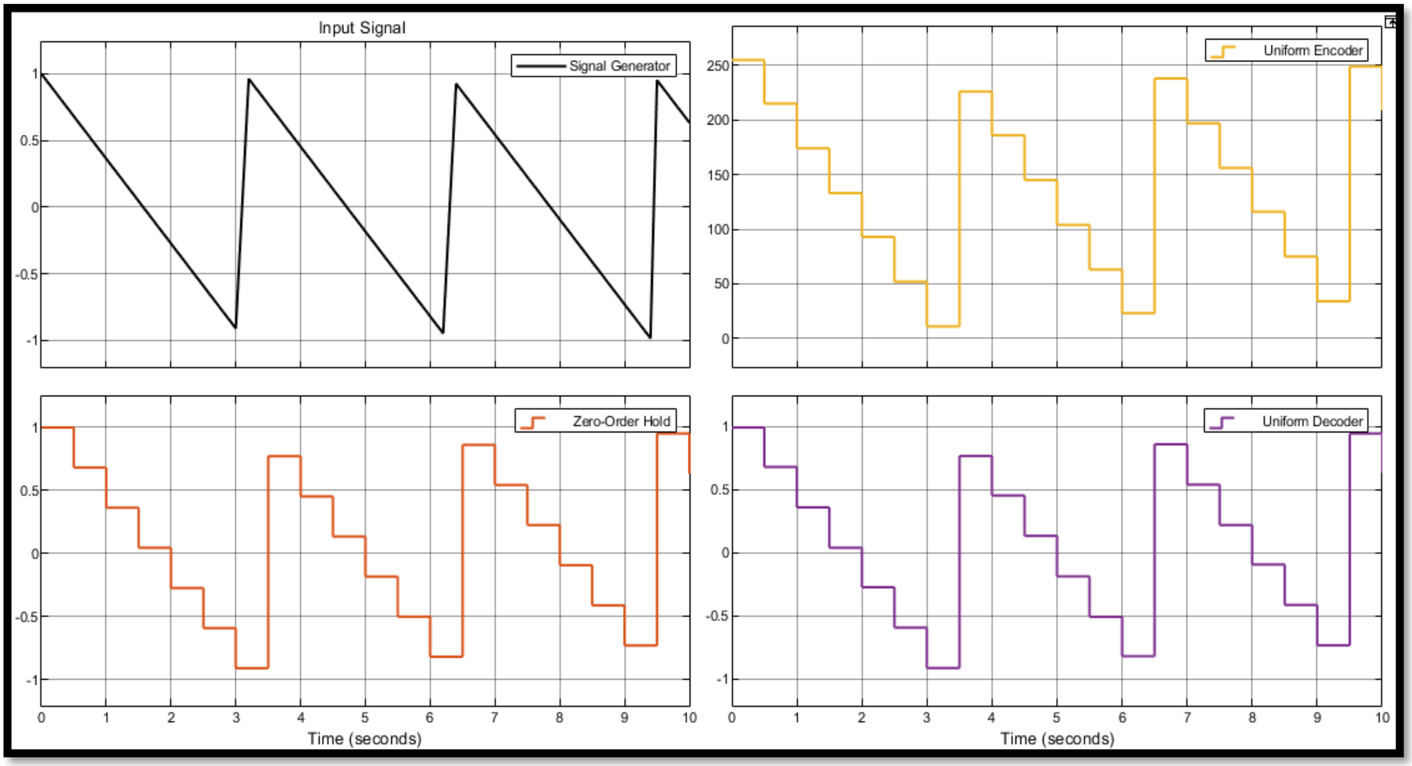
Frequency decrease (2 rad /sec):



Sampling frequency increase (Ts = 0.01 , f_s = 100Hz):



Sampling frequency decrease (Ts = 0.5 , f_s = 2Hz):



Explanation:

→ When I increased the frequency it increased the number of cycles per second and vice versa.

→ When I increade the sampling frequency it makes the decoder output signal more smother.

Exercise 3:

*Consider a continues signal S=a*cos(2*pi*f*t), plot this signal using MATLAB where a=8, f=1Hz, Ts=0.001, and t=0:Ts:2. Take continues signal as a reference and plot the following signals?*

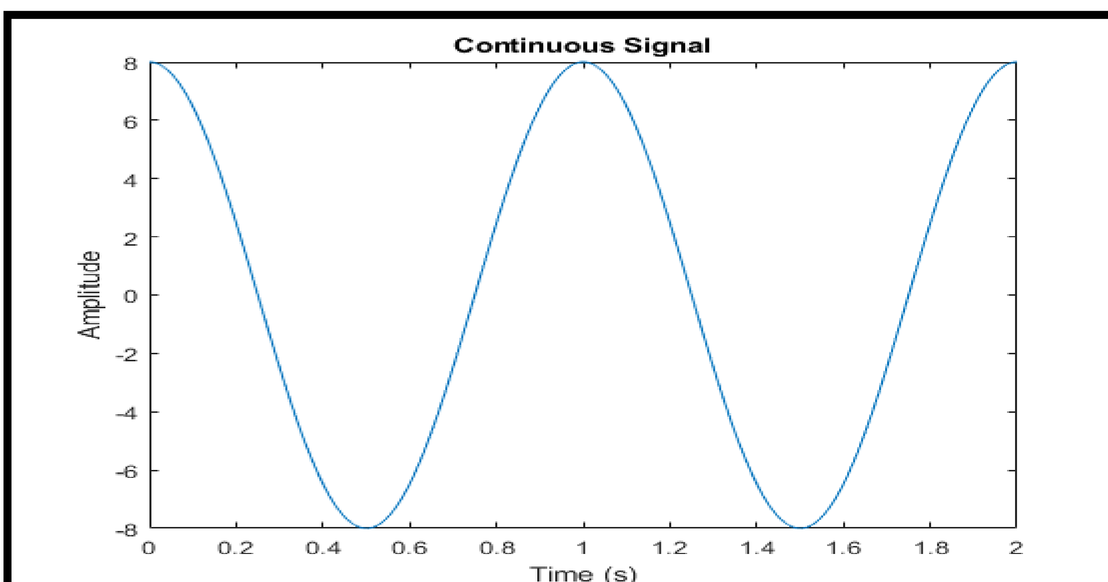
1. Sampled signal of S

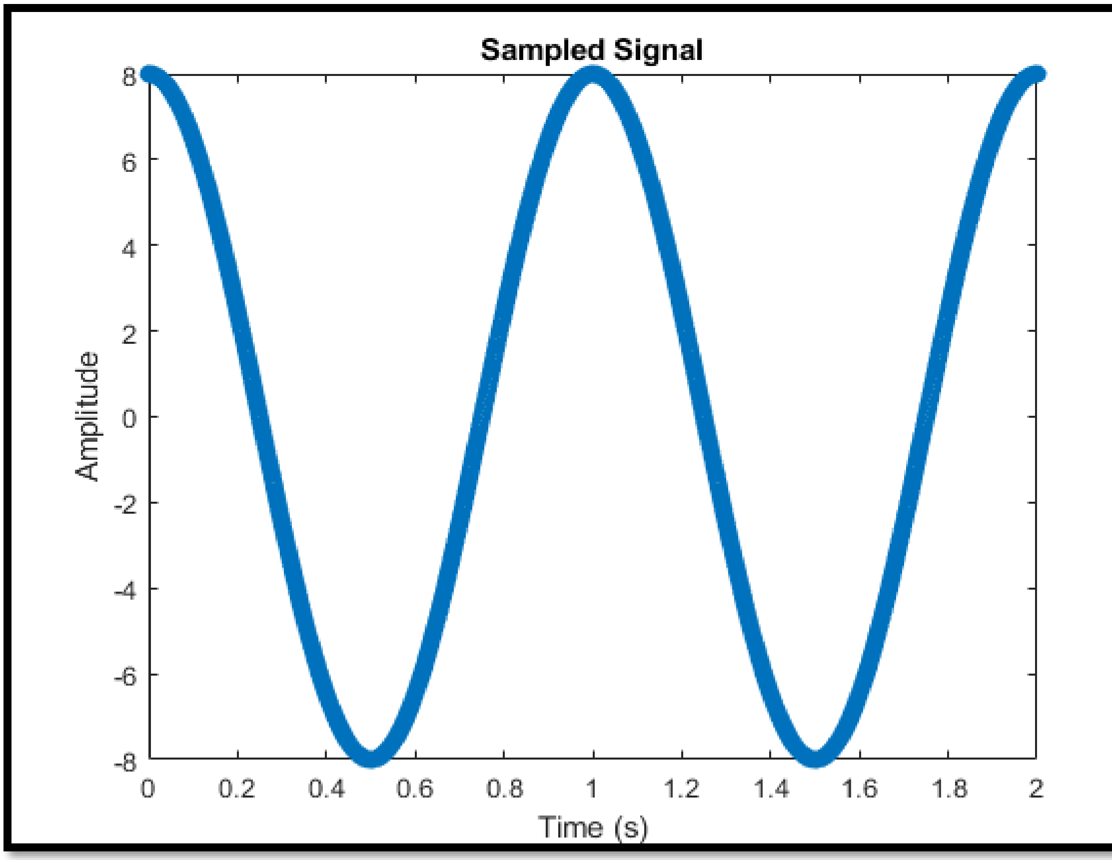
2. Quantization Signal of S

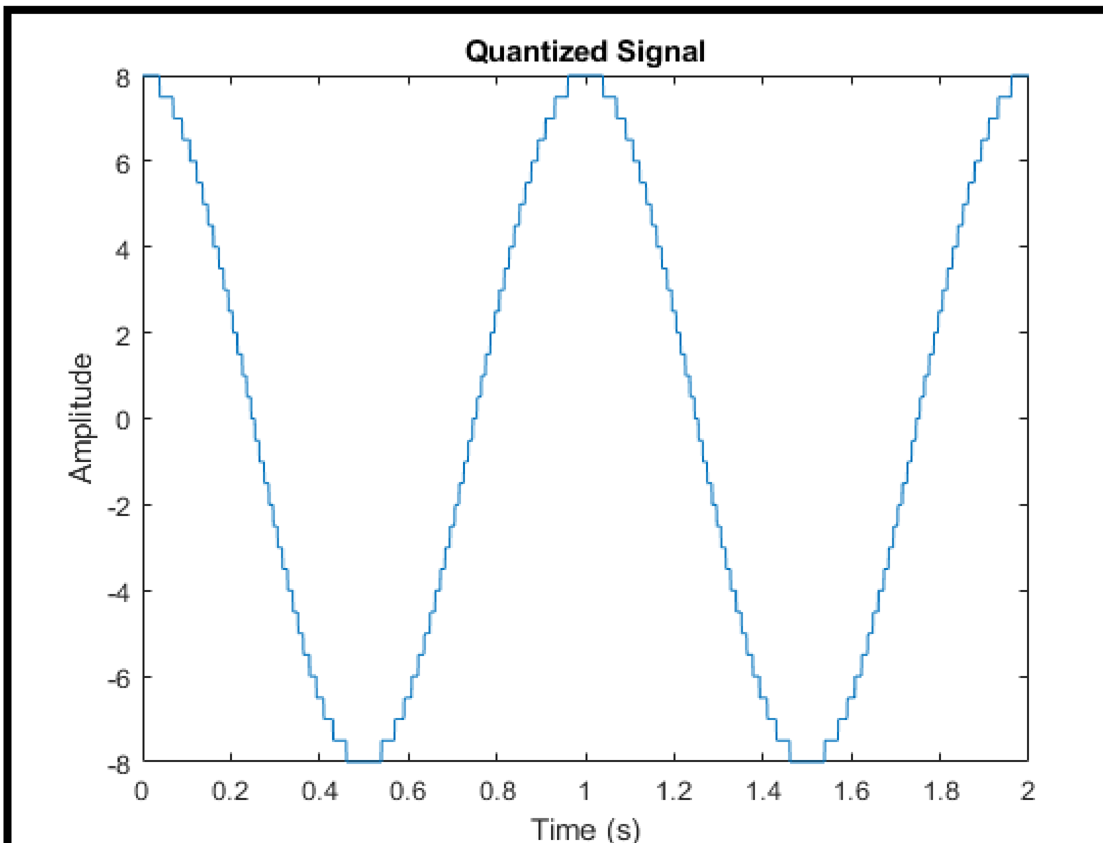
Code :

```
% Define the continuous signal parameters
a = 8;
f = 1;
Ts = 0.001;
t = 0:Ts:2;
% Calculate the continuous signal
S = a*cos(2*pi*f*t);
% Plot the continuous signal
plot(t, S);
xlabel('Time (s)');
ylabel('Amplitude');
title('Continuous Signal');
% Sample the signal
N = length(t);
dt = t(2) - t(1);
fs = 1/dt;
n = 0:N-1;
t_s = n*dt;
S_s = S(n+1);
% Plot the sampled signal
plot(t_s, S_s, 'o');
xlabel('Time (s)');
ylabel('Amplitude');
title('Sampled Signal');
% Quantize the signal
q = 2;
S_q = round(S*q)/q;
% Plot the quantized signal
plot(t, S_q);
xlabel('Time (s)');
ylabel('Amplitude');
title('Quantized Signal');
```

Outputs:




Sampled Signal
8
6
4
2
0
-2
-4
-6
-8
Amplitude
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Time (s)


Quantized Signal
8
6
4
2
0
-2
-4
-6
-8
Amplitude
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Time (s)

Explanation:

In this code I defined the signal parameter, according to the given parameter then sampled it and and quantized it, and then plotted.

Conclusion:

In this lab I learned about the quantization of Discrete Time Signals using simulink and script. By increasing sampling frequency accuracy of the sampled signal increases and vice versa. I also concluded that for more application more the number of bits generate more accurate information.

Evaluation Rubric

- **Method of Evaluation**: In-lab marking by instructors, Report submitted by students
- **Measured Learning Outcomes**:

CLO1: Develop algorithms to perform signal processing techniques on digital signals using MATLAB and DSP Kit DSK6713
CLO3: Deliver a report/lab notes/presentation/viva, effectively communicating the design and analysis of the given problem

	Excellent 10	Good 9-7	Satisfactory 6-4	Unsatisfactory 3-1	Poor 0	Marks Obtained
Tasks (CLO1)	All tasks completed correctly. Correct code with proper comments.	Most tasks completed correctly.	Some tasks completed correctly.	Most tasks incomplete or incorrect.	All tasks incomplete or incorrect.	
Output (CLO1)	Output correctly shown with all Figures/Plots displayed as required and properly labelled	Most Output/Figures/Plots displayed with proper labels	Some Output/Figures/Plots displayed with proper labels OR Most Output/Figures/Plots displayed but without proper labels	Most of the required Output/Figures/Plots not displayed	Output/Figures/Plots not displayed	
Answers (CLO1)	Meaningful answers to all questions. Answers show the understanding of the student.	Meaningful answers to most questions.	Some correct/ meaningful answers with some irrelevant ones	Answers not understandable/ not relevant to questions	Not Written any Answer	
Report (CLO3)	Report submitted with proper grammar and punctuation with proper conclusions drawn and good formatting	Report submitted with proper conclusions drawn with good formatting but some grammar mistakes OR proper grammar but not very good formatting	Some correct/ meaningful conclusions. Some parts of the document not properly formatted or some grammar mistakes	Conclusions not based on results. Bad formatting with no proper grammar/punctuation	Report not submitted	
Total						