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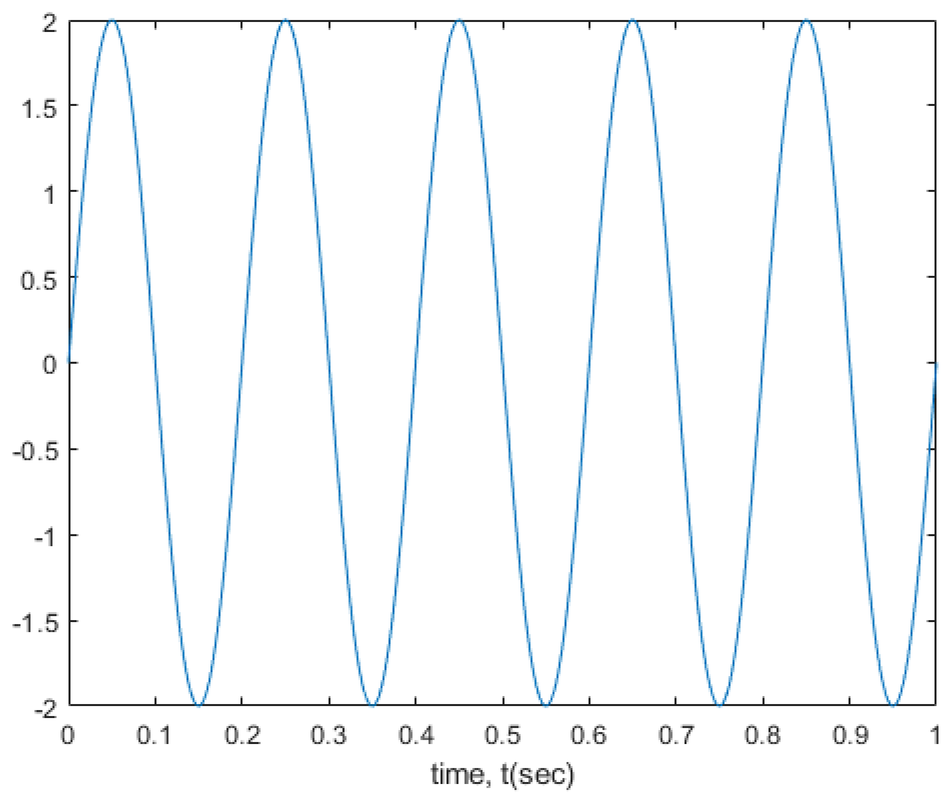
- Date Performed (d/m/y): 19/09/2021
- Date Modified (d/m/y): 22/09/2021

I. Analog to Digital Conversion

- a. Analog time and signal define "analog" time and signal

```
t = 0:0.001:1;                  % time in sec
freq = 5;                       % frequency is 5Hz
analog = 2*sin(2*pi*freq*t);    % analog signal

% plot the analog signal
figure; plot(t, analog)         % plot analog signal
xlabel('time, t(sec)')          % x-axis label
```

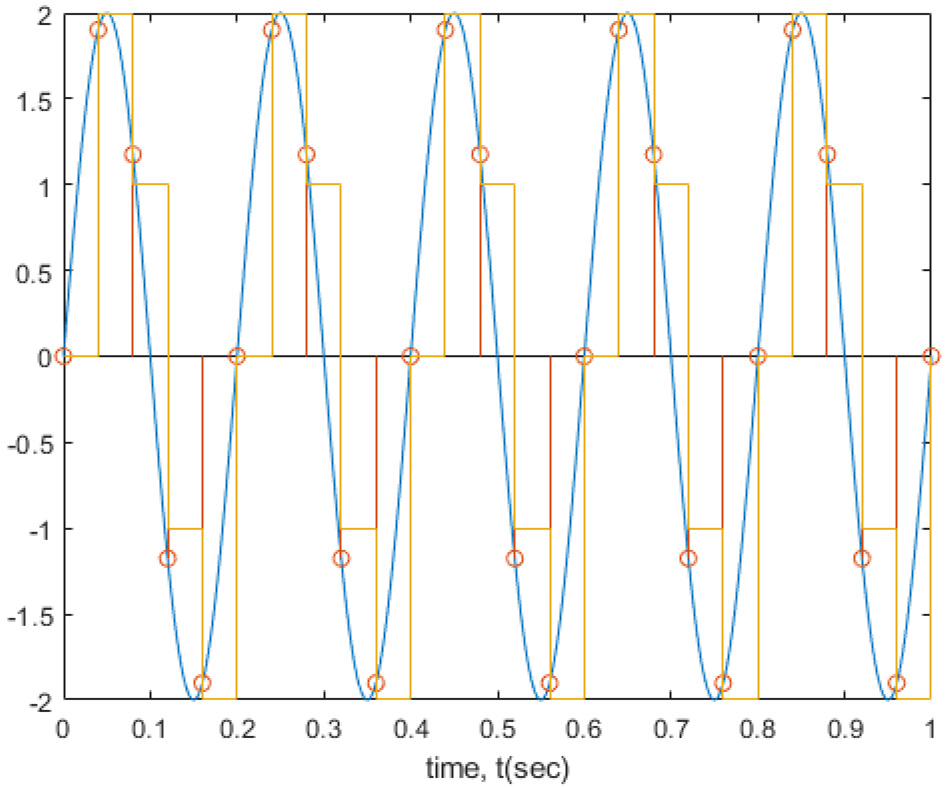


Discussion: The defined analog signal above contain five sinusoidal cycles over the 1-sec timeframe. The above-generated plot of the defined analog signal is consistent with the definition of the analog signal. The 'freq' variable of the signal dictates the number of cycles the analog signal should have whilst the contant value multiplied with the sine function determines the amplitude of the signal.

- b. ADC: Sampling and Quantization sampling

```
Fs = 25;                          % sampling frequency is 25Hz
n = 0:1/Fs:1;                     % sampling intervals
sampled = 2*sin(2*pi*freq*n)

% plot the samples of the same figure
hold;
stem(n, sampled);

% quantization
% define 5 quatization levels as positive and negative integers
quantized = round(sampled)
stairs(n, quantized)
```

```
sampled =

  Columns 1 through 7

         0    1.9021    1.1756   -1.1756   -1.9021   -0.0000    1.9021

  Columns 8 through 14

    1.1756   -1.1756   -1.9021   -0.0000    1.9021    1.1756   -1.1756

  Columns 15 through 21

   -1.9021   -0.0000    1.9021    1.1756   -1.1756   -1.9021   -0.0000

  Columns 22 through 26

    1.9021    1.1756   -1.1756   -1.9021   -0.0000

Current plot held

quantized =

  Columns 1 through 13

     0     2     1    -1    -2     0     2     1    -1    -2     0
 2     1

  Columns 14 through 26

    -1    -2     0     2     1    -1    -2     0     2     1    -1
 -2     0
```



Discussion: From the generated plot of the digitized signal above, there are five samples per sinusoidal. This is expected since the sampling rate is 1/25. The sampling rate when multiplied by 5 is equal to 0.2 sec timeframe which is equal to 1-sec timeframe when multiplied to the number of cycles.

- c. ADC Percentage Error

```
% Computes the percentage error of the actual over quantized values.
PercentageError = (abs(sampled-quantized)./abs(sampled))*100;
PercentageError(1,2:26) % shows the percentage error
```

```
ans =

  Columns 1 through 7

    5.1462   14.9349   14.9349    5.1462  100.0000    5.1462   14.9349

  Columns 8 through 14

   14.9349    5.1462  100.0000    5.1462   14.9349   14.9349    5.1462

  Columns 15 through 21
```

```
  100.0000    5.1462   14.9349   14.9349    5.1462  100.0000    5.1462

  Columns 22 through 25

   14.9349   14.9349    5.1462  100.0000
```

```
Discussion: The percentage error of the computed sampled and quantized
values yields a mean of 7.8518% while individual Percentage Error is
shown above.
```

- Exercise 1: Hand Calculation (see the attached data.csv for the computed values)

```
This section consider the sampling and quantizing computations over 1-
sec timeframe. The actual and quantized values in data.csv are already
in the absolute form. To determine the sampled(actual) and quantized
values, data.csv must be loaded first. The author of this report uses
MSExcel to manually compute each values and verify its similarity with
the values computed through MATLAB.
```

```
data = importfile("data.csv", [2, 26]);
```

- Sampled(Actual) Value/sample(n) are shown below:

```
ex1_sampled = data(1:25,1); % load the sampled(actual) values
ex1_sampled = table2array(ex1_sampled); % convert table to vector
ex1_sampled = transpose(ex1_sampled); % transpose the vector
ex1_sampled % display the sampled values
```

```
ex1_sampled =

  Columns 1 through 7

    1.9021    1.1756    1.1756    1.9021         0    1.9021    1.1756

  Columns 8 through 14

    1.1756    1.9021         0    1.9021    1.1756    1.1756    1.9021

  Columns 15 through 21

         0    1.9021    1.1756    1.1756    1.9021         0    1.9021

  Columns 22 through 25

    1.1756    1.1756    1.9021         0
```

- Quantized Value/sample(n) are shown below:

```
ex1_quantized = data(1:25,2); % load the sampled(actual) values
ex1_quantized = table2array(ex1_quantized); % convert table to vector
ex1_quantized = transpose(ex1_quantized); % transpose the vector
```

```
ex1_quantized % display the quantized values


ex1_quantized =

  Columns 1 through 13

     2     1     1     2     0     2     1     1     2     0     2
 1     1

  Columns 14 through 25

     2     0     2     1     1     2     0     2     1     1     2
  0
```

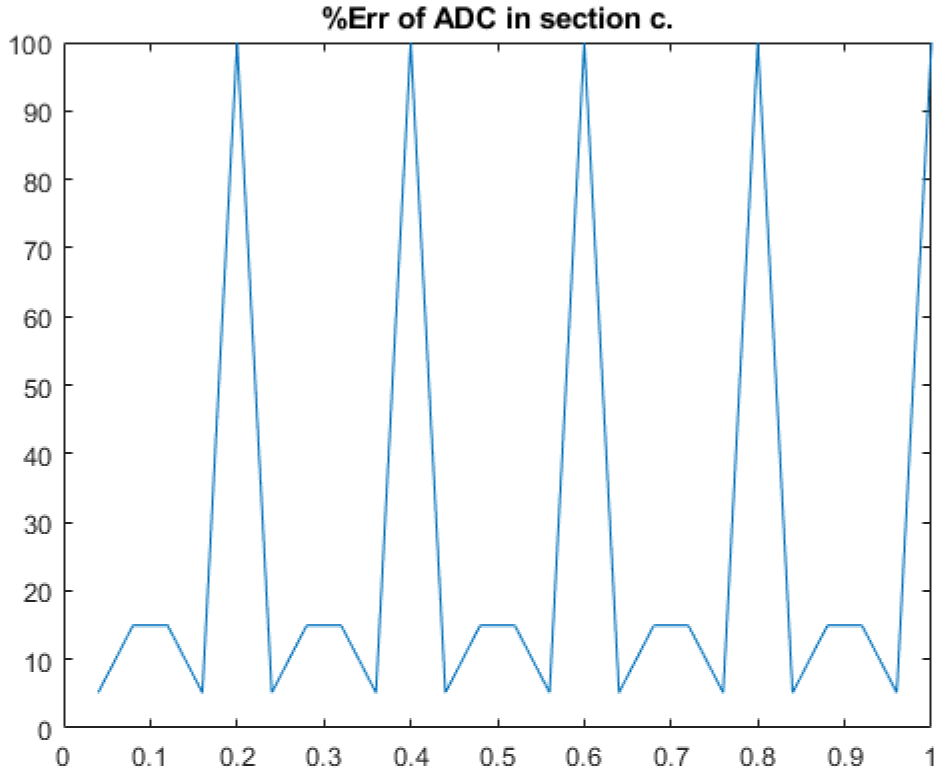
- Corresponding Percentage Error

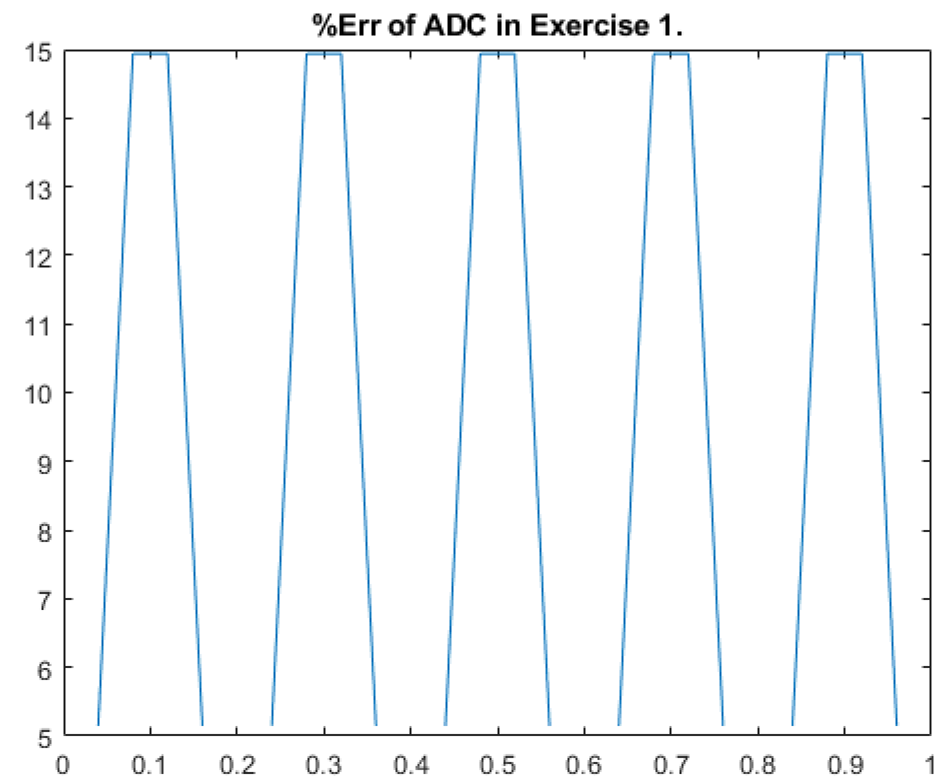
```
ex1_PercentageError = (abs(ex1_sampled-ex1_quantized)./
abs(ex1_sampled))*100;
ex1_PercentageError % shows the percentage error for exercise 1


ex1_PercentageError =

  Columns 1 through 7

    5.1469   14.9371   14.9371    5.1469       NaN    5.1469   14.9371

  Columns 8 through 14

   14.9371    5.1469       NaN    5.1469   14.9371   14.9371    5.1469

  Columns 15 through 21

       NaN    5.1469   14.9371   14.9371    5.1469       NaN    5.1469

  Columns 22 through 25

   14.9371   14.9371    5.1469       NaN
```

Discussion: The corresponsing percentage error yields a mean of 7.8530% while individual Percentage Error is shown above.

- Exercise 2-3(bonus): Plot the percentage error of the ADC.

```
figure; plot(n(1,2:26),PercentageError(1,2:26)); title('%Err of ADC in
 section c.');
figure; plot(n(1,2:26),ex1_PercentageError); title('%Err of ADC in
 Exercise 1.');
```


%Err of ADC in section c.
100
90
80
70
60
50
40
30
20
10
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


%Err of ADC in Exercise 1.
15
14
13
12
11
10
9
8
7
6
5
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

Discussion: The ADC percentage error in section c and exercise 1 shows similar results except for every 5th sample of the cycles which peaks to 100 in section c and cut-off in exercise 1. In general, the two plots show similar results on samples 1 to 4 of every cycle and differ on every 5th sample. The 5th sample of every cycle contributes to the percentage error of the digitized analog signal.

II. Matrix Operations

- 1. Multiplication and Element-wise Multiplication

```
M1_M = [1 2 3; 4 5 6; 7 8 9]; M1_N = [1 1 1; 1 -8 1; 1 1 1];
M1_A = M1_M*M1_N; % computes the product of M1_M and M1_N matrices
M1_B = M1_M.*M1_N; % computes the element-wise product of M1_M and
 M1_N
M1_A % shows the product of M1_M and M1_N
M1_B % shows the element-wise product of M1_M and M1_N
```

```
M1_A =

     6   -12     6
    15   -30    15
    24   -48    24


M1_B =

     1     2     3
     4   -40     6
     7     8     9
```

'*' or 'matrix multiplication' output the linear product of the matrices. The number of the rows and columns of the matrices multiplied in this operator must be equal. '.*' or 'Element-wise Multiplication' output the element-by-element product of the multiplied matrices.

- 2. Solving the unknowns of the Linear Systems

```
% input values of the linear systems
M2_A = [ 1 -2 3; -1 3 -1; 2 -5 5];

% output values of the linear systems
M2_B = [9; -6; 17];

% solve the unknowns of the linear systems
M2_xyz = linsolve(M2_A,M2_B);
M2_xyz % shows the unknowns of the linear systems
```

```
M2_xyz =

     1
```

```
   -1
    2
```

The solutions to the unknowns of the linear systems are shown by the variable 'M2_xyz', x=1, y=-1, z=2.

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