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**Laboratory Report**

Fall 2021

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| --- | --- |
| Laboratory Number: | **2** |
| Laboratory Title: | **Fourier Decomposition 02** |
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| TUID: | **915614617** |

**Description:**

Using the MATLAB file and function generated in Lab 1, Lab 2 continues the Fourier Decomposition analysis by reconstructing a signal based upon my TU ID using the Fourier Series and examining the signal using MATLAB’s Spectrum. Based upon the signal reconstruction, the mean square error (MSE) versus the number of harmonics will also be collected by hand and compared to MATLAB’s Spectrum analysis.

**Images:**

Chart

Description automatically generated

Figure 1. Estimated Spectrum in dBm vs Watts

Figure 2. MSE vs Number of Harmonics graphed in Excel

**Numerical Tables:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Harmonic Number | Exact Frequency | Estimated Harmonic | Computed Magnitude of Complex Fourier Coefficient | Estimated Magnitude of Spectrum | Error Percentage between Computed and Estimated Magnitude of Spectrum |
| 0 | 0 | 0 | 4.00000074 | 2.7995714 | 35.3089671 |
| 1 | 1002 | 977 | 8.33523531 | 1.56641629 | 136.72101 |
| 2 | 2004 | 1954 | 1.62113906 | 1.30571896 | 21.5534952 |
| 3 | 3006 | 2932 | 1.33739951 | 1.053833 | 23.7171837 |
| 4 | 4008 | 4886 | 1.85E-07 | 0.56444486 | 199.999869 |
| 5 | 5010 | 7166 | 1.14828287 | 0.56083866 | 68.7422403 |
| 6 | 6012 | 9121 | 0.18012653 | 0.42541486 | 81.0145548 |
| 7 | 7014 | 11075 | 0.6613964 | 0.41071304 | 46.7645092 |
| 8 | 8016 | 13030 | 3.88E-08 | 0.32363869 | 199.999952 |
| 9 | 9018 | 14984 | 0.60591249 | 0.29970919 | 67.6227835 |
| 10 | 10020 | 16938 | 0.06484554 | 0.23538607 | 113.605981 |

Table 1. Harmonics vs Frequency Table

|  |  |
| --- | --- |
| **Harmonics** | **MSE** |
| 1 | 38.6961 |
| 2 | 3.9927 |
| 3 | 2.6372 |
| 4 | 1.7439 |
| 5 | 1.7439 |
| 6 | 1.0854 |
| 7 | 1.0647 |
| 8 | 0.8463 |
| 9 | 0.8463 |
| 10 | 0.663 |
| 11 | 0.6593 |
| 12 | 0.5644 |
| 13 | 0.5644 |
| 14 | 0.4801 |
| 15 | 0.4788 |
| 16 | 0.426 |
| 17 | 0.426 |
| 18 | 0.3779 |
| 19 | 0.3772 |
| 20 | 0.3438 |

Table 2. MSE vs Harmonics table for Figure 2

**Descriptive Answers to Tasks:**

This lab completed tasks 3, 4, and 5 from the Fourier Decomposition lab manual. I utilized the MATLAB live script to reconstruct the signal based upon on the signal I programed in the previous lab. By changing the number of harmonics I was able to chart in table 2 the Mean Square Error (MSE) given from the reconstruction section of the code, which allowed for task 5’s completion by plotting the MSE versus number of harmonics using excel. By using the spectrum analyzer, I was able to plot the estimated spectrum in dBm and Watts using MATLAB’s DSP toolbox. From this I was able to columns for table 1 such as the estimated harmonics from the spectrum analysis’s frequency, as well as the estimated magnitude of the spectrum by using the graph’s peaks which is , and converting it to using the equation,

Using the MATLAB script and my TUID, I calculated the exact frequency, and computed te magnitude of the complex fourier coefficient using section 3 of the MATLAB script. Finally I took the percentage error between the computed magnitude and estimated magnitude of the spectrum as,

.

**Code:**.

**Section 01**

Task1:

clc; clear; %TUID: 915614617

A = 8; % Signal amplitude in Volts

rb = 2000; % (Fundamental) frequency of signal in kHz

Tb = 1 / rb; % Period of signal

fs = 1000 \* rb; % Sampling frequency

Ts = 1 / fs; % Sampling period

**Section 02**

Task2:

figure();

t = 0:Ts:4\*Tb;

plot(t, signal6(A, Tb, t));

ylim([-A-1, A+1]);

**Function Definitions**

Task 2 TUID(7):4,5,6:

function s = signal6(A, T, t)

t = mod(t, T);

s = 0 .\* t;

s(t <= T/2) = A; %Pulse on positive cycle

s((t > T/2)&(t<3\*T/4)) = -4 \* A / T \* (t((T/2 < t) & (t < 3\*T/4)) - T/2); %First half of Negative Triangle cycle

s(3\*T/4 <= t ) = 4 \* A / T \* (t(3\*T/4 <= t ) - T); %Second half of Negative Triangle cycle

end