**Digital Communication Systems Laboratory**

**Fall 2021**

**Laboratory 01: Fourier Decomposition**

**Laboratory Goals:**

* How to generate desired periodic signals in MATLAB.
* How to visualize the desired number of periods of a signal.
* How to compute Fourier series coefficients and Fourier complex coefficients.
* How to visualize estimated spectrum of a signal.
* Compare the computed Fourier coefficients with estimated spectrum of a signal.
* Find and plot the reconstruction mean square error (MSE) versus number of harmonics.

**Description:**

In this experiment, we study the spectrum estimation and its relationship with Fourier series coefficients.

In Section 01, the first step for the simulation of communication systems is to learn how to generate a waveform and how to sample it. Several waveforms will be generated at the end of the given live script. Every waveform will be generated by function definition in MATLAB.

In Section 02 of the live script, the numeric sliders are used to produce visualization of waveforms based on the desired periods.

In Section 03, the Fourier series coefficients and complex Fourier coefficients are calculated based on mathematical equations.

Section 04 belongs to reconstruction of the original signal. The mean square error of the reconstructed signal is one of the most common parameters to describe the similarity between two signals in time domain.

Finally, in Section 05, the spectrum analyzer will be used to estimate the spectrum of a periodic signal. There are several parameters in this tool of MATLAB Digital Signal Processing Toolbox that will be discussed.

Functions should appear at the end of live script and they have a separate section. The definition of all the generated signals definition can be found in this section.

**Tasks:**

1. Use these parameters for all the following tasks:
   1. Amplitude (): TUID(9) + 1 Volt
   2. Frequency (): TUID(8) + 1 KHz
2. Generate one of the following waveforms based on your TUID(7) and draw three plots for end time equal to Tb, 2Tb, and 4Tb.

|  |  |
| --- | --- |
| **TUID(7): 0, 1**  T/2  T  t  f(t)  A | **TUID(7): 2, 3**  T/2  T  t  f(t)  T/4  A |
| **TUID(7): 4, 5, 6**  T/2  T  t  f(t)  3T/4  A  -A | **TUID(7): 7, 8, 9**  T/2  T  t  f(t)  A  -A |

1. Plot the estimated spectrum in dBm and Watts.
2. Fill the following table:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 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 |  |  |  |  |  |
| 1 |  |  |  |  |  |
| 2 |  |  |  |  |  |
| 3 |  |  |  |  |  |
| 4 |  |  |  |  |  |
| 5 |  |  |  |  |  |
| 6 |  |  |  |  |  |
| 7 |  |  |  |  |  |
| 8 |  |  |  |  |  |
| 9 |  |  |  |  |  |
| 10 |  |  |  |  |  |

1. Plot the reconstruction MSE versus number of harmonics between 1 to 20.