**Digital Communication Systems Laboratory**

**Fall 2021**

**Laboratory 02: Geometrical Representation**

**Laboratory Goals:**

* How to find inner product of two signals?
* What is the benefit of inner product?
* What are orthogonal space and orthonormal basis?
* How to make orthogonal space from a signal space?
* What is Gram-Schmidt algorithm?
* How to find geometrical representation of a signal in orthonormal space?

**Description:**

In this experiment, we study the orthogonal function space and the benefits of them. Most of the laboratory content can be found in the MATLAB live script. This document gives a brief description about every section, then states the laboratory tasks.

1. Parameter initialization.
2. Definitions of inner product, energy of a signal, signal decomposition, and geometrical representation of a signal.
3. The inner product of two pulses (rectangle waves) with different frequencies is computed. The orthogonality is discussed. The same procedure is also applied to two sinusoids.
4. The Gram-Schmidt algorithm is described and the relationship between signals’ space and orthonormal basis is explained.
5. The Gram-Schmidt algorithm is implemented on different signals with similar frequencies. The energy, correlation coefficient, and projection coefficients are computed. The orthonormal signals and signal projections in constellation diagram are shown.
6. The same procedure of Section 5 is implemented on similar or different signals with different frequencies.
7. The orthonormal bases for similar signals with different phases are discussed. They form the foundation of most future communication systems such as BPSK and QAM.

**Tasks:**

1. Use these parameters for all the following tasks:
   1. Amplitude (): TUID(9) + 1 Volt
   2. Frequency (): TUID(8) + 1 KHz
2. Use two of the following waveforms based on your TUID(7) and plot signal space and orthonormal basis functions.

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

1. Fill the following table by the assigned waveforms of Task 2.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Just use | Use & | Just use |
|  |  |  |  |
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1. Plot the constellation diagram for every column of the table in Task 3.