**EE 505**
**Experiment 4**
**Spring 2023**

## Characterization of Performance of ADCs

Experimental characterization of data converters is a critical part of the design process. The standard approach to experimental characterization and ultimately production testing of data converters is to put a known signal into the input and then experimentally observe the output. For characterizing/testing DACs, the input signal is the Boolean input and the output is measured with test equipment. For characterizing/testing ADCs, analog input signals are generated and a corresponding set or sequence of Boolean outputs are observed. A rule of the thumb is that the performance of the analog signal generators used for ADC testing is 3 to 4 bits better than the performance of the device under test (DUT) whereas for DAC testing, the analog measurement equipment is also 3 to 4 bits better than the DUT.

In this experiment, emphasis will be placed on processing the output data obtained when characterizing/testing an ADC. Since emphasis is on processing the output data, we will not make actual measurements in the laboratory but each student will be given a set of data that can be assumed to come from measurements in the laboratory for a 9-bit ADC. The behavioral model of the ADC that was used to generate the Boolean data you will be given may or may not include some or all of the following {Nonlinearity, Gain Error, Offset, Noise }. It will be assumed that measurements that were used to generate the data you will be given were obtained with inputs that are ideal. The simulated measurements that were made are given below in the DATA section of this experiment.

**Part 1:** Developing a toolset (you may use any standard software (MATLAB, EXCEL, C++,….) for obtaining the following characteristics for an ADC based upon a set of measured data where the input is either an ideal ramp or an ideal sinusoidal waveform. Your code should be parameterized – that is – you should be able to select any number of bits of resolution and handle any size of input data. You should write the algorithms for characterizing the ADC yourself using any appropriate functions or subroutines available for standard mathematical calculations (e.g FFT, regression analysis, …) in the software you choose.

- Pseudo-Static Properties
  - INL
  - DNL
  - Gain Error
  - Offset
  - ENOB from INL viewpoint
- Spectral Properties
  - DFT of Output
  - THD
  - SFDR
  - SNR

SDR
SNDR
ENOB from SNDR viewpoint

**Part 2:** Determine the following performance characteristics of the simulated output data measurements for the ADC you are assigned.

Pseudo-Static Properties
- INL
- DNL
- Gain Error
- Offset

Spectral Properties
- DFT of Output
- THD
- SFDR
- SNR
- SDR
- SNDR
- ENOB from

Also provide plots of what you believe was the ideal input, the actual interpreted output (converting the Boolean signal back to an analog signal), and the difference between the actual input and the interpreted output for all inputs.

To verify that you have not made any mistakes in developing your tools, please compare the results you obtain with that of one other student in the class. The spreadsheet lists a comparison partner for everyone. You have that data sets that were assigned to all students.

**DATA**

An EXCEL datasheet that is downloadable from the course WEB page contains the following four sets of data.

| | |
|---|---|
| Dataset 1 | 512 outputs for a linear ramp input that covers most or all of the input range from 0 to VREF. |
| Dataset 2 | 512x16 outputs for a linear ramp input that covers most or all of the input range from 0 to VREF |
| Dataset 3 | 8192 outputs for a perfect sinusoidal input that covers most or all of the input range from 0 to VREF. Coherent sampling but no sampling jitter was used to generate the 8192 outputs. The sinusoid frequency was 100 Hz. |
| Dataset 4 | 8192 outputs for a perfect sinusoidal input that covers most or all of the input range from 0 to VREF. The sampling was not coherent but no |

sampling jitter was used to generate the 8192 outputs. The sinusoid frequency was 100 Hz.

**DATA SET ASSIGNMENT**

| Name | Dataset | Compare With |
|---|---|---|
| Akash | 1 | Emmanuel A |
| Dakota | 2 | Emmanuel N. |
| Emmanuel A | 3 | Evan |
| Emmanuel N. | 4 | Harshithaa |
| Evan | 5 | Michael |
| Harshithaa | 6 | Patricia |
| Michael | 7 | Rizwan |
| Patricia | 8 | Si Yuan |
| Rizwan | 1 | Dakota |
| Si Yuan | 2 | Akash |