COMMUNICATIONS LAB. Experiment #6: ADC / DAC

OBJECTIVES
Introduction to analog-to-digital conversion and digital-to-analog conversion.
(*You need to have a 'multimeter' ready for this experiment, or use the oscilloscope or the meter on the test set.)

GENERAL INFORMATION on ADC and DAC
An analog-to-digital converter, or ADC as it is more commonly called, is a device that converts analog signals into digital signals. A/D converters are electronic circuits that have the following characteristics;

- The input to the A/D converter is a voltage.
- The output of the A/D converter is an n-bit binary signal corresponding to the voltage at the input at a specific instance. Therefore Analog to Digital conversion is a mapping from continuous ranges to discrete values represented by binary numbers.

The conversion involves quantization of the input, so it unavoidably introduces a known amount of error, called quantization error or quantization noise. The resolution of the converter is the number of discrete values it can yield over the range of analog values. For example, an 8-bit ADC can encode an analog input to one in 256 different digital values. Resolution for an n-bit ADC can be expressed as

$$Resolution = 2^n$$

There is also another term while dealing with ADC and it is the step size which can be expressed as

$$Step\ size = \frac{V_{reference}}{Resolution}$$

An example of a 4-bit ADC coding scheme with uniform quantization levels is given in the following graph.
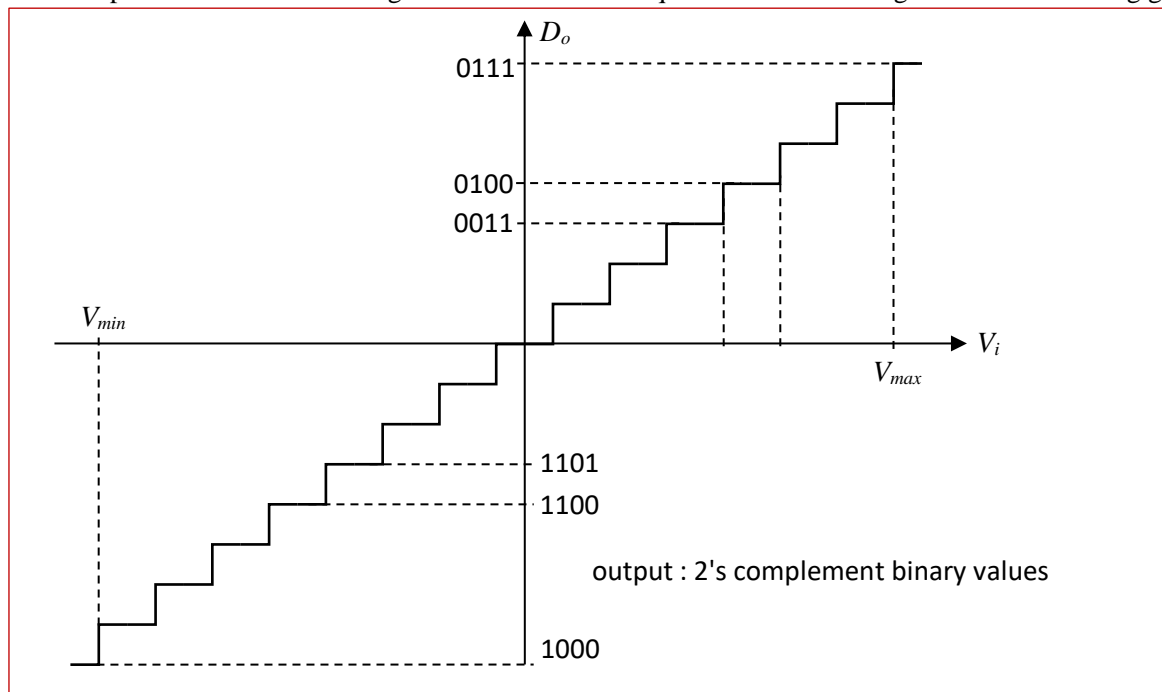
If the input signal is uniformly distributed across the input range (V_{min} to V_{max} in the example), then the average absolute quantization error for this uniform quantizer would be $(V_{max}-V_{min})/(4\times2^4)$ where 2^4 is the number of quantization levels.

The device that generates voltage values from binary numbers is called a DAC or digital-to-analog converter. The quantization error introduced by ADC can never be recovered via DAC.

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EXPERIMENT

1. Analog to Digital Conversion

a) Connect DC Supply to Analog Input of the Analog to Digital Converter module.

b) Select BP (bipolar) switch position.

c) Adjust DC Supply and measure it with the multimeter (or scope) in order to have the voltage levels given in Table 1 in your report and fill in the corresponding digital/binary values you are observing.

d) Calculate the resolution using Table 1 and find the approximated step size for this ADC module.

e) Select UP (unipolar) switch position.

f) Repeat step c in order to fill Table 2.

g) Calculate the resolution using Table 2 and find the approximated step size for this ADC module.

h) Comment about the values you obtained in the steps d and g and compare resolutions and the step sizes. Also, state the performed operation.

i) Draw the conversion graphs (an example is given in the General Information section) according to the Tables 1 and 2. Comment about these graphs in your report.

2. Digital to Analog Conversion

j) Make sure that the DC Supply is still connected to Analog to Digital Converter module. Now, connect Analog to Digital Converter outputs to Digital to Analog Converter module. (That is, D0→D0, D1→D1,…, D7→D7)

k) Select BP (bipolar) switch position.

l) Measure Aout voltage using multimeter/scope for each DC Supply voltage given in Table 3 by setting DC Supply voltage and measuring it at the same time. Fill in the Table 3 with the obtained Aout voltage values. Comment about the results and state the performed operation.

m) Select UP (unipolar) switch position.

n) Repeat step l according to the values in Table 4 and fill out the Table. Comment about the results and state the performed operation.