RCET 3375 Experiment 1

Analog to Digital and Digital to Analog Conversion

Goals: At the completion of this experiment, the student will be able to:

- Construct, calibrate, and predict the outputs of various types of discreet Analog to Digital (A/D) and Digital to Analog (D/A) Converters.
- Connect, calibrate, and predict the outputs of various types of integrated A/D and D/A Converters.

Background Information

Most phenomena in the natural world is analog in nature or changes in a smooth fashion. Examples of these are temperature, pressure, flow, weight, light, sound, etc. Unfortunately, it is impossible for a computer, since it is digital in nature, to directly read these types of analog inputs or to drive analog voltages or currents out. Therefore, if a computer is required to read a temperature or a pressure or any other type of sensor, the analog value must first be converted to digital using an *Analog to Digital Converter* (ADC). Likewise, if the computer is required to drive smoothly changing voltages or currents out to control valves, motors, or other analog devices, it's digital output must be converted by means of a *Digital to Analog Converter* (DAC). In summary, ADCs are used to input analog information into digital system, and DACs are used to output digital information into analog systems.

Objectives: (For all of the following tasks, note the speed and accuracy of each converter)

1. Construct the following circuit. A 7490 BCD counter driving a resistive network DAC. Connect the 7490 to count up from 0 to 9 in a binary fashion. (Not all necessary 7490 connections are shown on the diagram.)

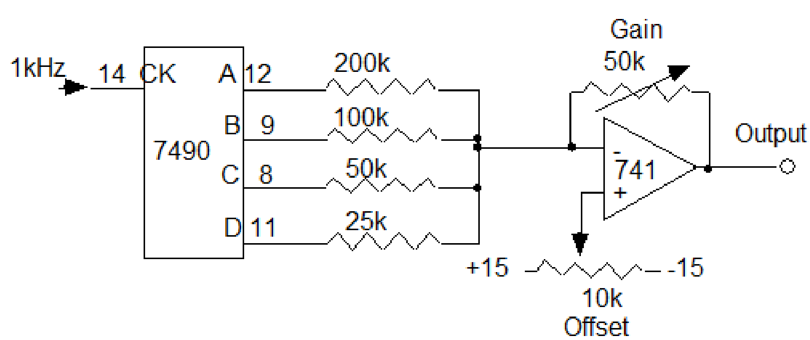

Figure 1: 7490 DAC

   a. Describe the proper procedure for calibrating the DAC. Count zero equals 0v out. Count nine equals -9v out.
   b. Calculate the output voltages for each count of the counter.

c. Draw the output waveform for each count of the counter.
d. What is the resolution and accuracy of this DAC? Is this DAC in spec?
e. Measure worst case settling time for this DAC.
f. Your schematic should include all IC pins and connections used in industry-standard form.
g. Remove the binary weighted resistors one at a time and draw output waveform.
h. Disconnect the counter only. Leave the ladder and op-amp connected for use in step 4.

2. Connect the following simultaneous ADC with an adjustable, 0 to 9-volt DC input signal. Adjust the *Full Scale Adjust pot* until the digital output is count 9 with 9 volts at the input. Hereafter, the input will be varied by changing the analog input voltage source.

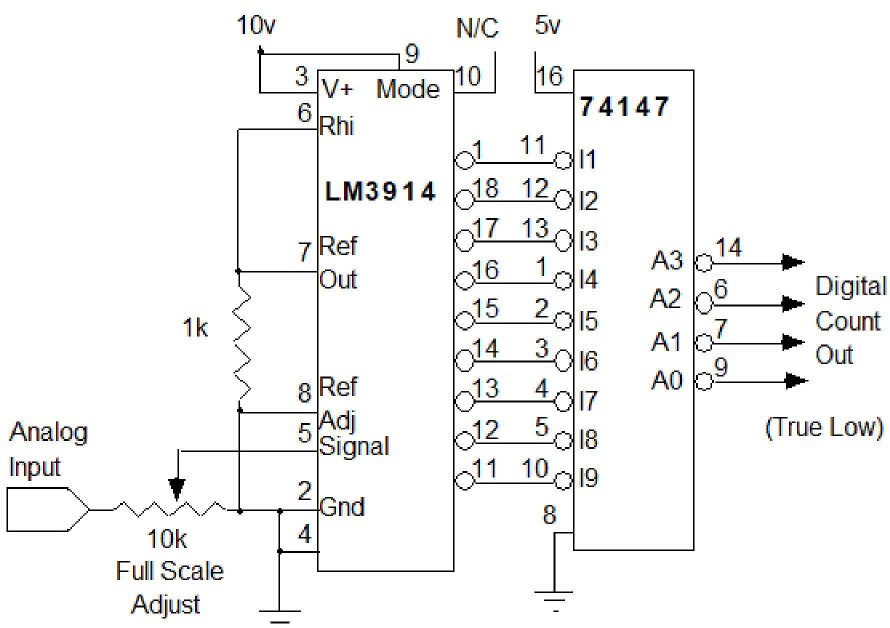

Figure 2: Continuous ADC

a. Test and develop a truth table for the input vs. the output.
b. Determine the speed of the ADC.
c. Be able to describe circuit operation at any point in the circuit and the function of each pin.

3. Reconstruct the analog input voltage of experiment 2 by connecting the DAC from objective 1 to the digital outputs of the simultaneous ADC of experiment 2
   a. Calibrate the D/A section such that the analog output voltage most closely approximates the input voltage.
   b. Graph the input vs. output voltage if a ramp were applied to the input. The output voltage superimposed over the input ramp in a different color.
   c. Determine the speed accuracy of the overall circuit.

4. Connect the following integrated A/D converter in a free run mode as shown. Some power pins are not shown. Connect the analog and digital power for minimum noise.

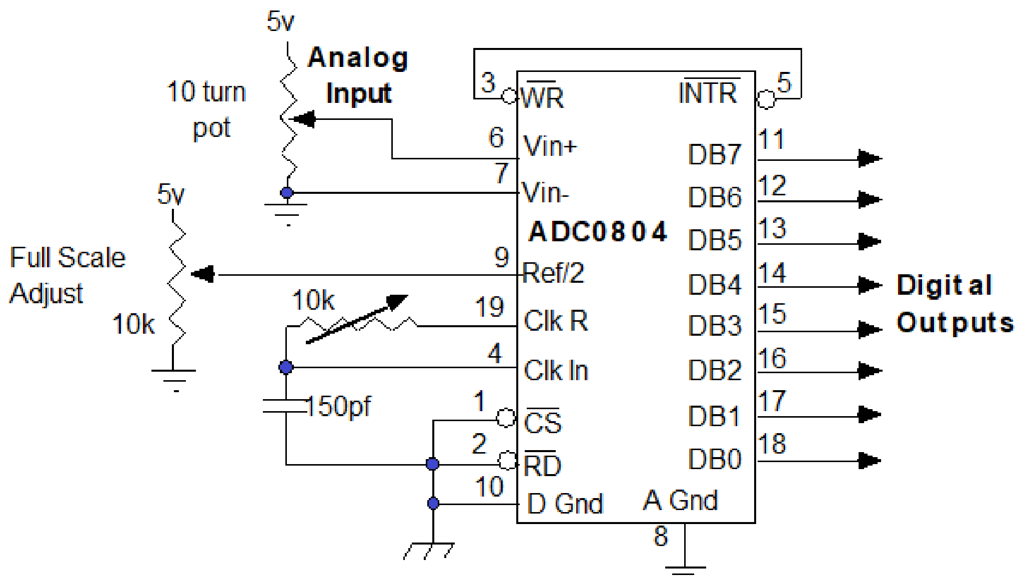

Figure 3: 8 Bit ADC

a. Calibrate the ADC such that 2.56 volts at the input (Vin+) produces all 1's out.
b. While observing the LSB output and measuring the input with a DVM, determine the amount of input change required to cause an LSB toggle. How does this compare to the resolution?
c. Draw waveforms that illustrate the *handshake* for one conversion.
d. What is the conversion time of this A/D and how is it measured?
e. Determine the minimum conversion time by tweaking the 10 KΩ pot on pin 19 until it stops giving correct results on the digital outputs.

5. Properly diagram, connect, and measure an LM34 temperature sensor to the ADC0804 in order to digitize temperature.

5. Connect the following integrated D/A converter to the outputs of the A/D of experiment 4 and verify that it is calibrated. Continue to maintain analog ground integrity.

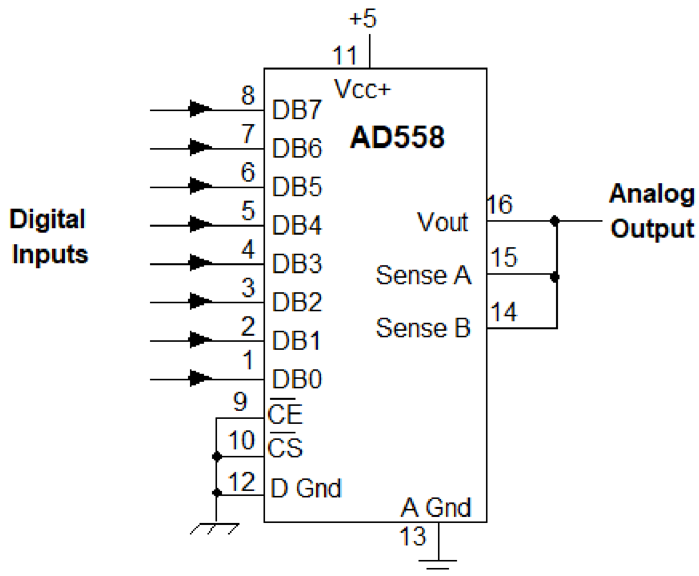

Figure 4: 8 Bit DAC

a. Connected as above, the DAC is factory calibrated to output 2.56 volts with an input of all 1's and 0 volts with an input of all zeros.
b. Be able to explain the operation of this DAC and the function of each pin.
c. Draw the waveforms to illustrate one conversion.

6. Add a sine wave generator in parallel with the pot set at 1.25v to the input of the A/D as shown in Figure 5. Compare and plot the input sine wave input vs. DAC output waveforms. Use approximately 200Hz input frequency

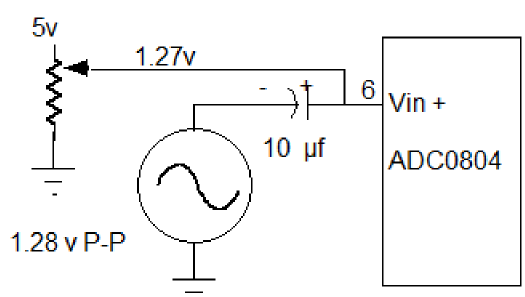

Figure 5: Input Sine Wave with Offset

7. Determine the speed and resolution of the ADC. How do the measured values compare to the device specifications?