Electronics Experiment 5
ADC-DAC

Introduction:

An analog-to-digital converter (ADC) is a device that converts a continuous physical quantity (usually voltage) to a digital number that represents the quantity's amplitude. The conversion involves quantization of the input, so it necessarily introduces a small amount of error. The inverse operation is performed by a digital-to-analog converter (DAC). Instead of doing a single conversion, an ADC often performs the conversions ("samples" the input) periodically. The result is a sequence of digital values that have converted a continuous-time and continuous-amplitude analog signal to a discrete-time and discrete-amplitude digital signal.

Due to current advances in digital technologies, designers tend to depend more on digital processing, thus converting analog signals to digital domain and process the data in the digital form. The aim of this experiment is to familiarize students with using ADC/DAC blocks.

List of Required Components/Kits/Tools:

- NI Multisim.
- NI Elvis Kit.
- Resistors: 1 kΩ.
- Potentiometer: 1 kΩ.
- ADC.
- DAC.
- 741 Opamp.
- LEDs x 8.

A. Simulation (ADC)

Simulation Steps:

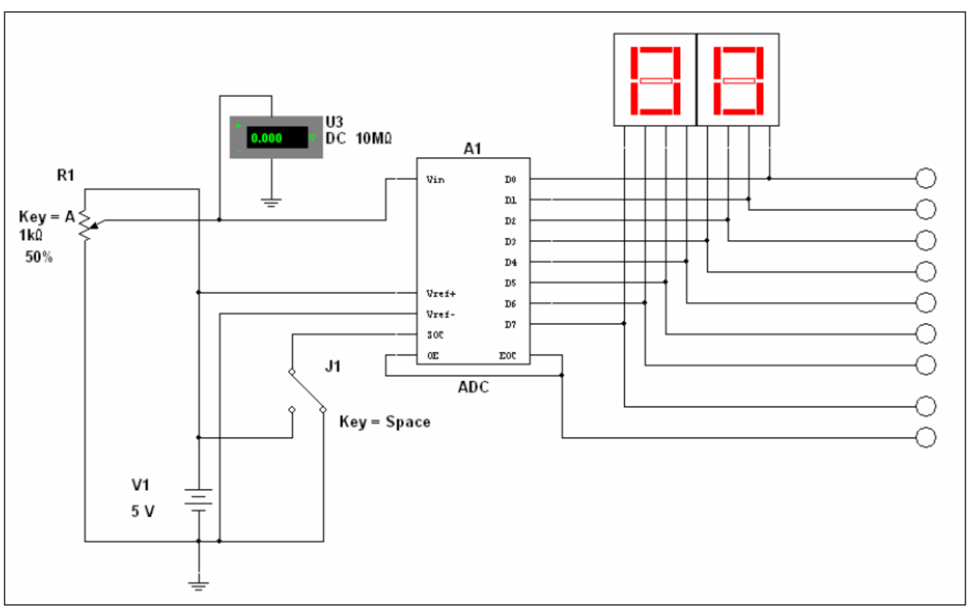

Fig.1 ADC

1. Connect the circuit components illustrated in Figure 1.
2. Note that:
    a. Digital output in decimal = 256 * Vin / Vref.
    b. To start a single conversion you should apply 0V at the pin SoC then reconnect it to 5V again.

Q1. Calculate the step size of this ADC. What is the expected error?

Q2. If the input potentiometer is set to 75%, what is the digital output?

Verify using hand calculations.

Q3. What is the potentiometer level required for the digital output to be 0x7F?

Verify using hand calculations.

Q4. Choose 4 more random values for the potentiometer, what is the digital output?

Verify your results.

B. Simulation (DAC)

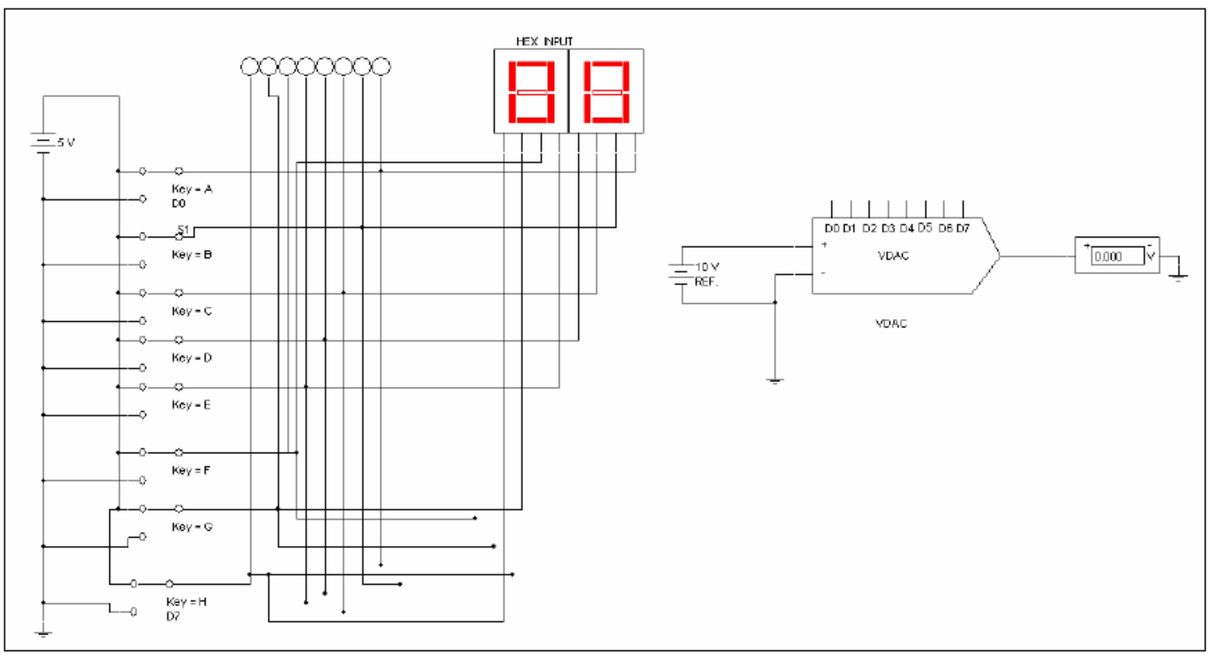

Fig.2 ADC

3. Connect the circuit components illustrated in Figure 2.
4. Note that:
    a. Analog Output (V) = Digital Output in decimal * V_{ref} / 256.
    b. Since there are many digital signals, you might need to connect them using a bus. To do so, select Place/Bus from the main menu. Left-click on the workspace directly above the VADC IC. Drag the bus horizontally across until it is exactly

parallel to the VADC and double-click. Highlight the VADC by right-clicking on it. Select Place/Bus Vector Connect to make the connections. The Bus Vector Connect dialog will appear. Highlight D0-D7 by highlighting D0 then pressing SHIFT-D7. Click the left down-arrow key to place all selected pins to the lower-left field in the Bus Bus Vector Connect dialog box. Select Bus1 then click Auto-assign. Click OK to close the dialog; the connections to the bus are made automatically. Click on each wire and change the color according to the list provided in the Circuit Description Box. Now, each time you connect a wire to the bus, a dialogue box will appear and ask you which signal to connect to.

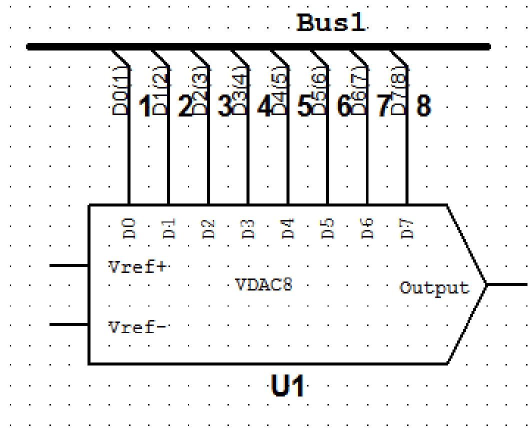

Fig. 3 Using Bus Connection

Q5. Calculate the step size of this DAC. What is the expected error?

Q6. If the digital input is set to 0x7F, what is the analog output?
Verify using hand calculations.

Q7. What is the digital input required for the analog output to be 7.5V?
Verify using hand calculations.

Q8. Choose 4 more random values for the digital input, what is the analog output?
Verify your results.

C. Simulation (ADC/DAC)

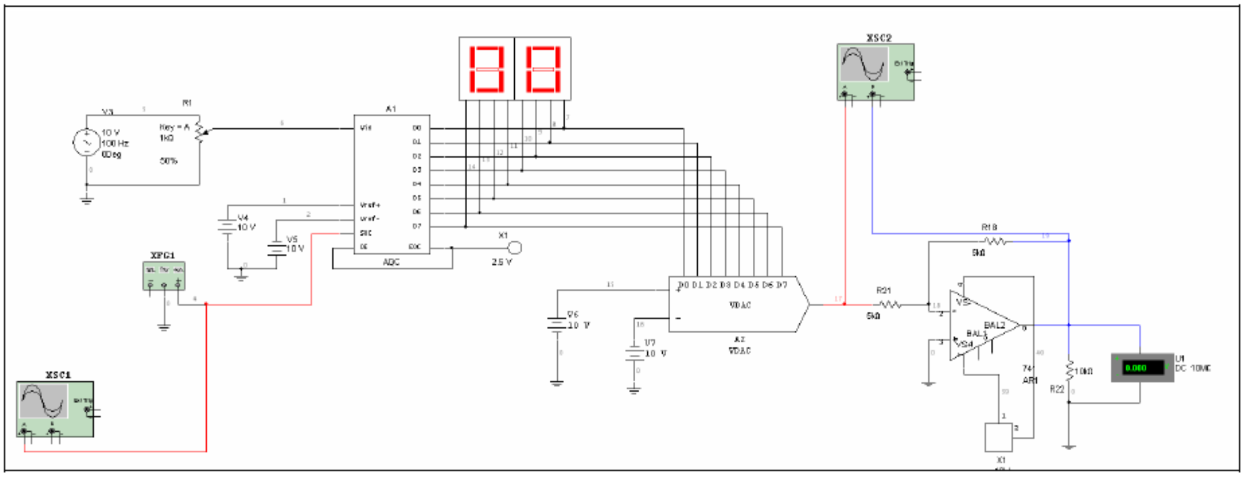

Fig. 4 Using Bus Connection

5. Connect the circuit components illustrated in Figure 4.
6. Set the input source to be 10Vp, 100Hz.
7. Set the function generator to generate a square wave of frequency 1kHz, amplitude 5Vp and offset 5V.
8. Note that:
    a. The function generator sets the value for the sample rate of the ADC.
    b. The total gain of the system is ideally unity.

Q9. If the potentiometer is set to 50% what is the peak-to-peak reading at the output? Verify using hand calculations.

Q10. For the input frequency of 100Hz, what is required number of samples to represent one cycle of the input? Sketch a rough estimate of the resulting output.

Q11. Set the input frequency to 1kHz, 1.5kHz, what is the frequency of the analog output in each case? Comment on the results.

Experiment 5 - Answer Sheet

Name:	**Sec:**	**B.N:**

A1: ADC step = ________________ V

Expected error = ± ________________ V, standard deviation = ________________ V

A2: Digital output = ________________

Calculations: ____

A3: Potentiometer level = ________________

Calculations: ____

A4:

Potentiometer Level	Simulated Value of Digital Output	Verification

A5: DAC step = ________________ V

Expected error = ± ________________ V, standard deviation = ________________ V

A6: Analog output = ________________ V

Calculations: ____

A7: Digital input = ________________

Calculations: ____

A8:

Digital Word	Simulated Value of Analog Output	Verification

A9: Output Amplitude = __________________ V_{pp}.

Calculations: ____

A10: No. of Samples = __________________.

A11: Output frequency at 1 kHz input = _______________Hz.
Output frequency at 1.5 kHz input = _______________Hz.
Comment:
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