**UNIVERSITY of PENNSYLVANIA**
**DEPARTMENT OF ELECTRICAL ENGINEERING**
**ESE Undergraduate Laboratory**
EE206: Electrical Circuits and Systems II Laboratory

# Analog-to-Digital (ADC) and Digital-to-Analog (DAC) Converter

## Overview

- **Goals**
- **In-lab assignment**
- **Extra Credit**

## Goals:

To design and build a simple Digital-to-Analog (DAC) and Analog-to-Digital (ADC) converter using OpAmp circuits and resistors. You will apply Thévenin's theorem to analyze an R-2R ladder network.

## In-lab assignment:

### *A. Equipment:*

1. Digital multimeter (HP34401A)
2. Triple output programmable power supply (HP E3631A): 5V, -5V
3. Protoboard
4. Blue box with cables and connectors
5. Resistors: two 1kOhms, four 2kOhms
6. Potentiometer
7. OpAmp 741

### *B. Procedure*

***DAC:***

1. You will build the R-2R ladder DAC of Figure 4a (refer to previous lab assignment) including the OpAmp interface circuit you have designed. To implement the voltages $V_i = (b_i) \times (V_{REF})$ ;
bi corresponds to bit values as shown in Table I (refer to previous lab assignment)
Vi corresponds to voltages $V_0$, $V_1$... in Fig 1.
use jumper wires to the 5V or Ground busses as is schematically shown in Figure 1.

2. Build the circuit on your protoboard including the OpAmp circuit you designed as part of the pre-lab. Use 1 kOhm resistors for R. First connect the power supplies and ground to the protoboard. Adjust the power supplies to 5V for VREF and 5V for the supply to the
OpAmp. Set the current limit to 100mA to prevent accidental damage to the components. You can use a potentiometer in your OpAmp circuit in order to adjust the amplification to the desired level.

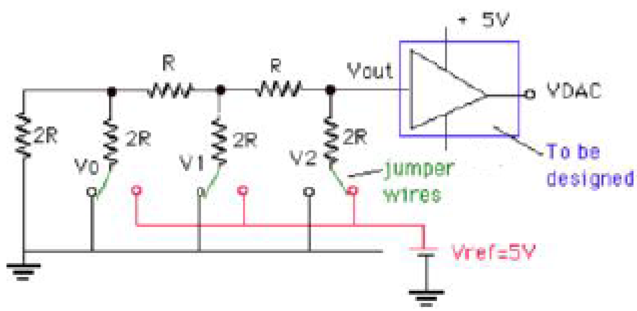


Figure 1: R-2R ladder DAC converter

3. Switch on the power supply and check the amplification of the OpAmp circuit (e.g by checking the value of the LSB = 0.5V; refer to task 3 of pre-lab of previous lab assignment). Compare with the desired value. If it is off, adjust the potentiometer (of the OpAmp circuit) until you have the proper amplification.
4. Record the output voltages for all combinations of the digital word in a table similar to table I (refer to previous lab assignment). The calculation of the error (difference between the measured and calculated value divided by the calculated value in %) can be done after you finish the lab.
5. (This can be done later when writing the report). Plot a graph similar to the one of Figure 2b of the previous lab assignment for the measured output values. How well does it compare to the calculated (theoretical graph)?
Is it linear? Discuss as part of your report
6. Get the screen capture of the input Analog Signal (ADC input) and the reconstructed Analog Signal (DAC output)
7. When done***, give a demo to the lab instructor***.

**Extra Credit**

Design and build a simple 2-bit Digital-to-Analog (DAC) and Analog-to-Digital (ADC) converter using OpAmp circuits and resistors.

Compare the results of the 3-bit Digital-to-Analog (DAC) and Analog-to-Digital (ADC) and 2-bit Digital-to-Analog (DAC) and Analog-to-Digital (ADC), with respective screen captures.

(Refer the below description, to get a 2-bit output from the Priority Encoder)

Connect the PINS 8, 6, 5 and 1 to GND, PIN 16 to +5V, PINS 2, 3 and 4 to output of your 2-bit ADC, with PIN 4 connected to least significant comparator level and PIN 2 connected to most significant comparator level.

Output is obtained at PINS 7(MSB) and 9(LSB).