Cover Page

EE 316-08
Electric Circuits & Electronics Design Lab

Lab 4: Digital to Analog Converter using Op-Amps

By: Nolan Anderson

Lab Date: 02/14/2021

Lab Due: 02/16/2021

1. Introduction and objectives

Lab 4 will introduce and expand on the concept of using Op-Amps to construct a Digital to Analog converter. Examining the effects of differing digital inputs will provide us with a better understanding of the functionality of DAC's. First, we will analyze the theory behind Digital to Analog converters, run a simulation in Multisim, and the analyze our results.

2. Theoretical Analysis

2.1 Digital to Analog Converters

Digital to analog converters simply cvonver a binary digital value into an analog output, or voltage. A simple 8 bit converter diagram can be seen in figure 1. The actual circuit can be seen in figure 2 in section 3.

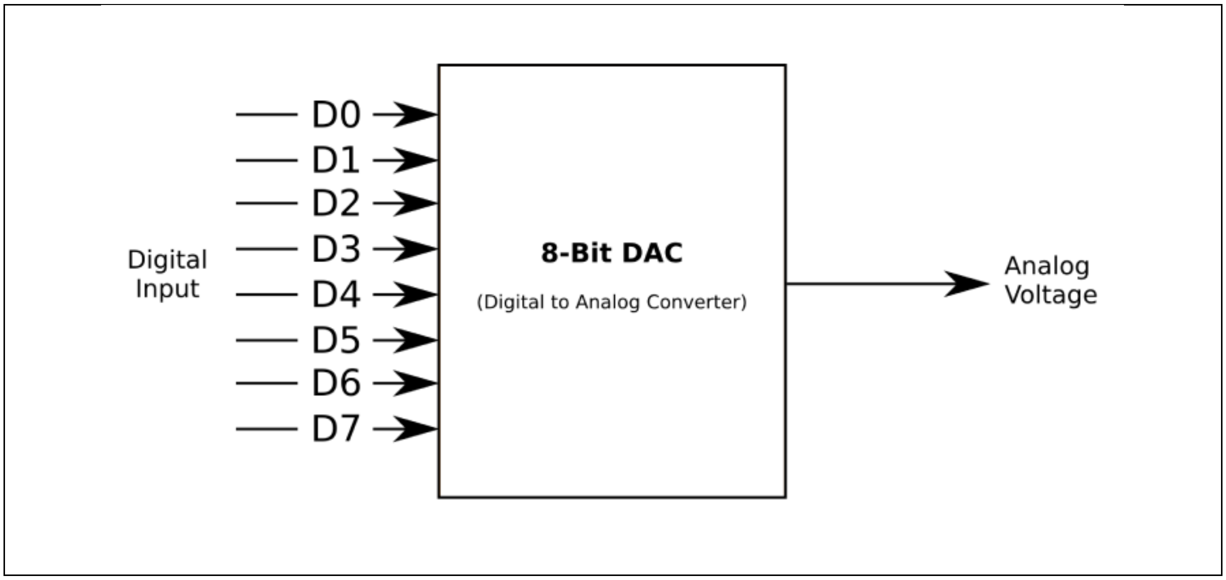


Figure 1: 8 bit Digital to Analog Conversion

3. Simulations

3.1 DAC Simulated

Figure 2 displays the Digital to Analog converter in multisim, the results that follow are shown in figure 3. Finally, figure 4 will display the DAC Voltage Plot in terms of the input state and the output voltage found at Vo.

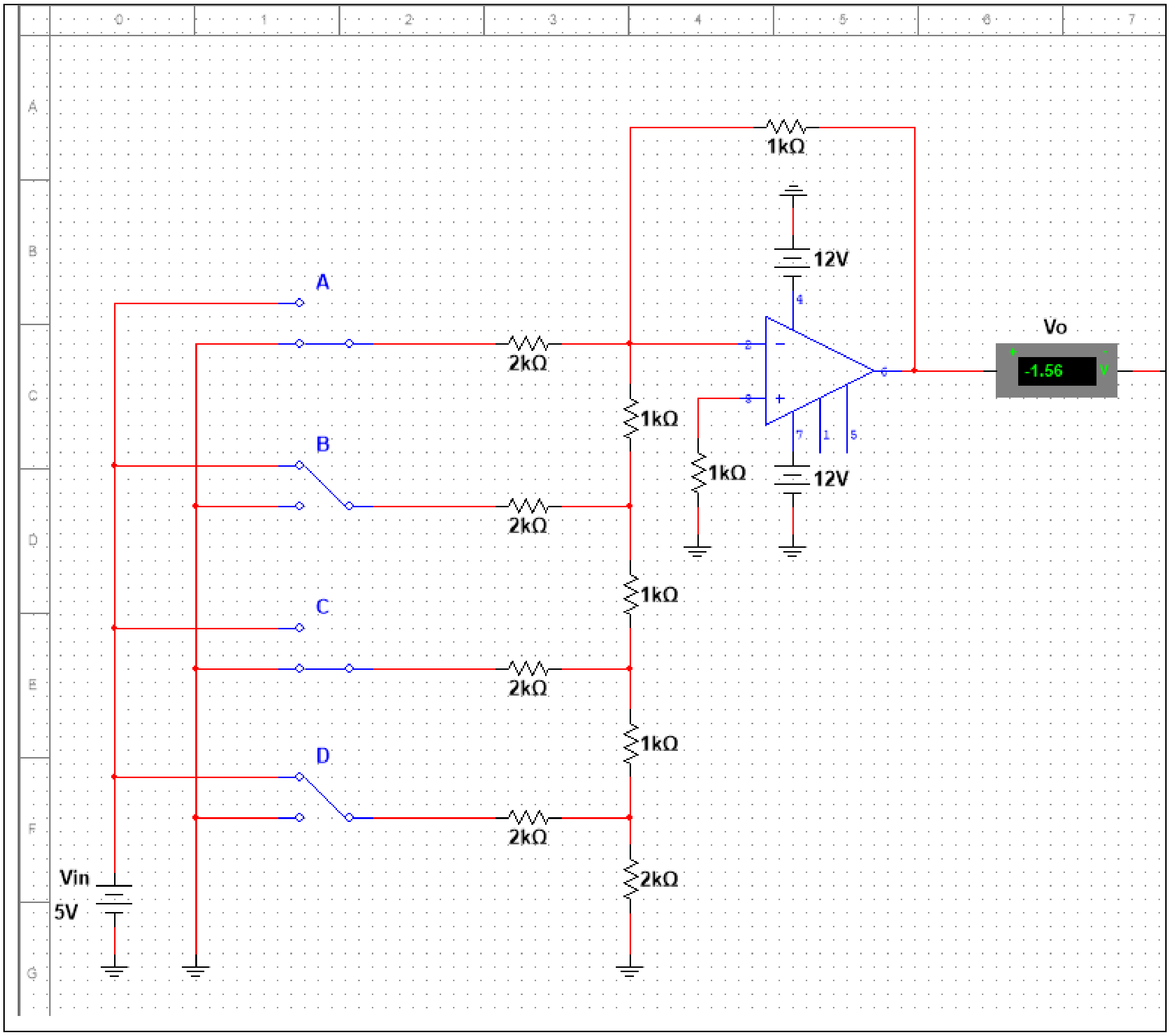


Figure 2: Simulated DAC in Multisim

Input State					Simulation	Theoretical
	V_A	V_B	V_C	V_D	V_O (V)	V_O (V)
0	0	0	0	0	-2.021 mV	-1.2 mV
1	0	0	0	1	-0.310	-0.3134
2	0	0	1	0	-0.623	-0.6280
3	0	0	1	1	-0.935	-0.9413
4	0	1	0	0	-1.248	-1.2566
5	0	1	0	1	-1.560	-1.5700
6	0	1	1	0	-1.873	-1.8845
7	0	1	1	1	-2.185	-2.1977
8	1	0	0	0	-2.498	-2.5272
9	1	0	0	1	-2.810	-2.8406
10	1	0	1	0	-3.123	-3.1551
11	1	0	1	1	-3.435	-3.4583
12	1	1	0	0	-3.748	-3.7837
13	1	1	0	1	-4.060	-4.0970
14	1	1	1	0	-4.373	-4.4115
15	1	1	1	1	-4.685	-4.7249

Figure 3: Input configurations and output voltages

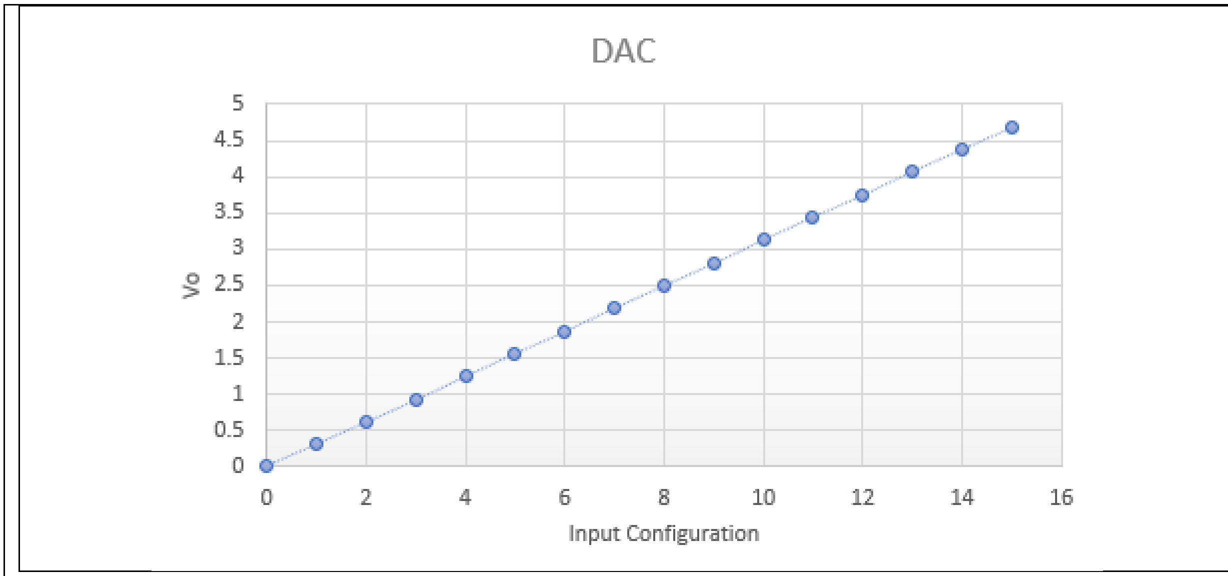
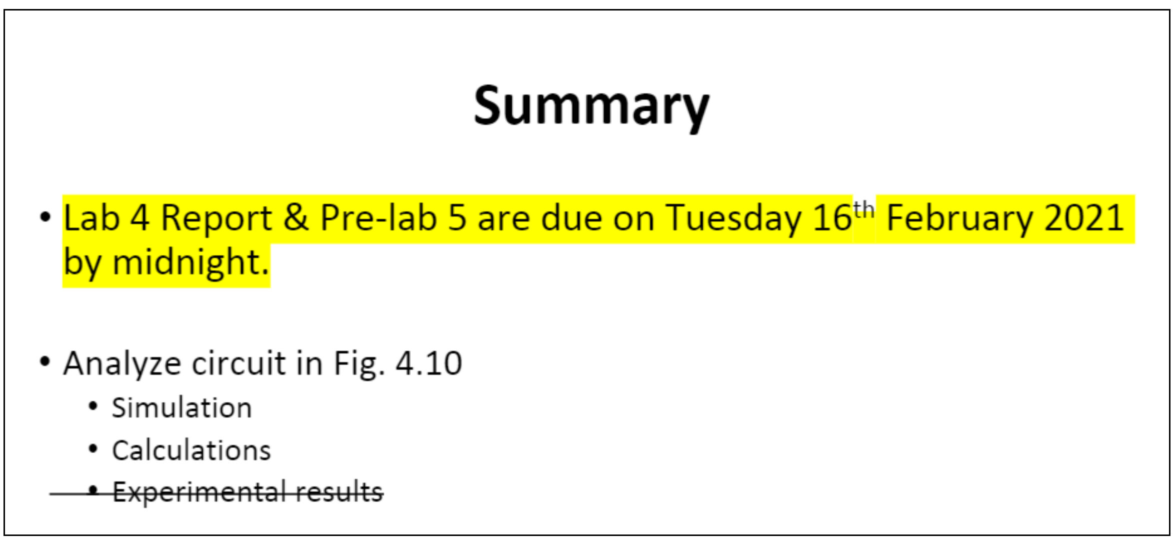


Figure 4: DAC Input Configuration and Vo output

~~4. Experimental:~~

We were not instructed to provide experimental results for this lab, see the following screenshot.



5. Results and Discussion:

As shown in figure 3, the simulated and theoretical output voltages are all very similar which shows us that the simulation performed as expected.

6. Conclusion:

While this lab was very straightforward, it provided a much-needed review of DAC's and their functionality. Analyzing the results from the simulation and matching them to the hand calculations (see figure 5) helped me to better understand how these circuits work. Most of the time it is hard to see their true functionality when you are just doing the hand calculations. Being able to flip the digital inputs and quickly seeing the results is very useful.

7. Appendix:

	Input State				Output
	V_A	V_B	V_C	V_D	Voltage (V_o)
1	0	0	0	0	0.00
2	0	0	0	1	-.3134
3	0	0	1	0	-.6280
4	0	0	1	1	-0.94
5	0	1	0	0	-1.2866
6	0	1	0	1	-1.5706
7	0	1	1	0	-1.8845
8	0	1	1	1	-2.1977
9	1	0	0	0	-2.5272
10	1	0	0	1	-2.8406
11	1	0	1	0	-3.13
12	1	0	1	1	-3.485
13	1	1	0	0	-3.7837
14	1	1	0	1	-4.0470
15	1	1	1	0	-4.415
16	1	1	1	1	-4.69

Case 2: $V_o = -\left(\frac{0}{2} + \frac{0}{4} + \frac{0}{8} + \frac{5}{16}\right) = -.3134$

Case 3: $V_o = -\left(\frac{0}{2} + \frac{0}{4} + \frac{5}{8} + \frac{0}{16}\right) = -.6280$

Case 5: $V_o = -\left(\frac{0}{2} + \frac{5}{4} + \frac{0}{8} + \frac{0}{16}\right) = -1.2866$

Case 6: $V_o = -\left(\frac{0}{2} + \frac{5}{4} + \frac{0}{8} + \frac{5}{16}\right) = -1.8700$

Case 7: $V_o = -\left(\frac{0}{2} + \frac{5}{4} + \frac{5}{8} + \frac{0}{16}\right) = -1.8845$

Case 8: $V_o = -\left(\frac{0}{2} + \frac{5}{4} + \frac{5}{8} + \frac{5}{16}\right) = -2.1977$

Case 10: $V_o = -\left(\frac{5}{2} + \frac{0}{4} + \frac{0}{8} + \frac{5}{16}\right) = -2.8406$

Case 9: $V_o = -\left(\frac{5}{2} + \frac{0}{4} + \frac{0}{8} + \frac{0}{16}\right) = -2.5272$

Case 12: $V_o = -\left(\frac{5}{2} + \frac{0}{4} + \frac{5}{8} + \frac{5}{16}\right) = -3.485$

Case 13: $V_o = -\left(\frac{5}{2} + \frac{5}{4} + \frac{0}{8} + \frac{0}{16}\right) = -3.7837$

Case 14: $V_o = -\left(\frac{5}{2} + \frac{5}{4} + \frac{0}{8} + \frac{5}{16}\right) = -4.0470$

Case 15: $V_o = -\left(\frac{5}{2} + \frac{5}{4} + \frac{5}{8} + \frac{0}{16}\right) = -4.415$

Figure 5: DAC Hand Calculations