Digital-to-Analog Conversion

Acknowledgements: Developed by Ronnie Wilson, Faculty of Austin Community College, Austin, Texas. Special thanks to Electronic Workbench for providing this simulation as a stand-alone activity.

Special Notes: This simulation should be completed after the WRE Data Conversion Part 1 Module and before starting the Digital-to-Analog Converters Lab.

Approximate Time Required: ½ hour.

Equipment: These simulations require no special software to run, but your computer needs to have internet access to download the required simulation file from the WRE web site.

Simulation Summary: The purpose of this interactive simulation is to prepare you for the hands-on labs related to the digital-to-analog (DA) converters. These circuit simulation labs introduce the operating characteristics typical of a digital-to-analog converter circuit.

Simulation Goal: Observe the operation of a representative digital-to-analog converter and the demonstration of Nyquist Theorem utilizing a digital-to-analog converter circuit.

Learning Objectives

1. Explain the input-output terminal relationships of digital-to-analog converters
2. Determine the affect the reference voltage has on the digital-to-analog converters output signal.
3. Determine the affect a failed binary bit has on the analog output signal.

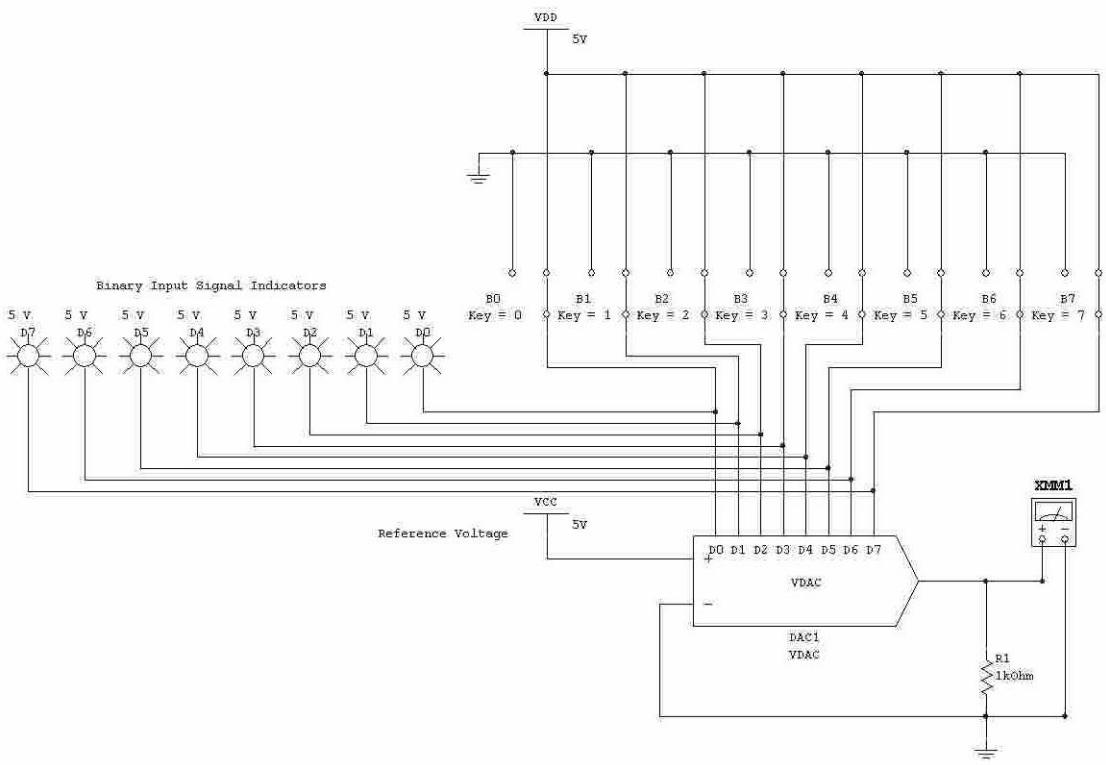
Grading Criteria: Your grade for this interactive simulation will be determined by your performance on the simulation and your answers to the simulation questions.

Simulation Preparation

1. Print a copy of the procedure to use as a reference, schematic, and workbook while completing the simulation.
2. Read the Introduction.
3. Review the Simulation Procedures.

Software Alert: When performing circuit simulations, failing to read and follow directions exactly can result in incorrect circuit operation and data measurements. For instance, if you fail to stop or pause the circuit at the appropriate times and leave circuits running, functions within Multisim 7 may become inoperative.

Introduction



Digital-to-Analog Circuit

The major component of this circuit is the digital-to-analog converter labeled VDAC. Note the binary inputs are connected to a set of switches labeled B_7 through B_0. These switches can be connected to either zero volts, which represent a binary zero, or they can be connected to five volts, which represents a binary one. By placing the appropriate switch in either position for a binary one or zero, we are able to control the DAC analog output voltage. In addition to these input switches, we have a required voltage reference of five volts connected to the voltage reference (+) terminal. Note the voltage reference (-) terminal is connected to ground. The result of this connection is to have a converter circuit reference voltage of five volts.

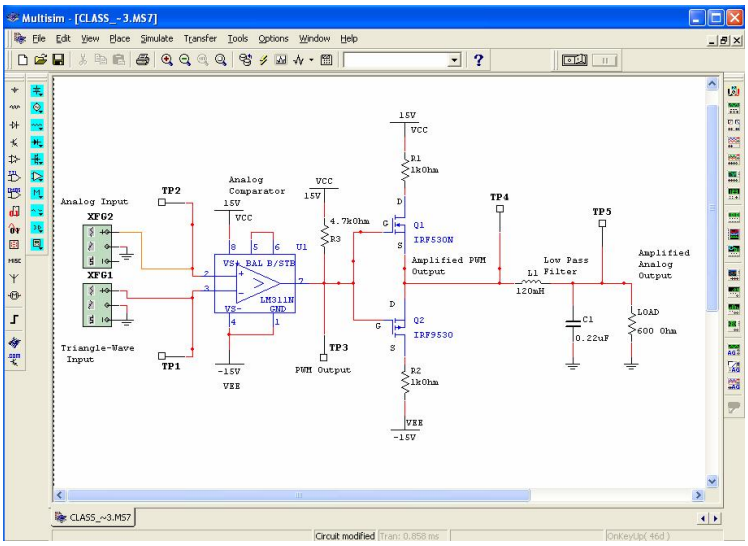
Connected to the DAC output is a 1 kΩ load resistor and Multimeter, labeled XMM1. This meter will be used to measure the analog output signal while the indicators, labeled D_7 through D_0 will indicate the binary input signals value. Note, when the indicator indicates red, that bit is set to a binary one.

Simulation Procedures

NOTE: The schematic, tables, and lab questions are at end of this section.

Using Multisim

1. Download the Multisim demo from the WRE Module Learning Resource tab.
2. Open the file called DAC Simulation Lab 1.
3. If you have not used Multisim before, please review the following section.



a. The simulation circuit is in the center of the screen.

NOTE: This is an example only. The circuit you are using is at the end of this procedure.

b. The Run/Stop and Pause/Resume simulation buttons are on the tool bar near the Help (?) button. Run/Stop is on the left and Pause/Resume is on the right.

c. The instrument toolbar is on the right border. As you move your mouse over the instrument, the name should appear. For this simulation, you will use the multimeter.

d. Double click on an instrument to transfer it to the circuit. Use your mouse to place it in position.

e. Connect the wires by placing the mouse over the end of the wire connection for the instrument. A small bull's eye symbol will appear when you are in the correct position. Use your mouse and drag the wire it to the correct terminal point. Click once to connect.

DAC Simulation

4. Set the input switches for a binary value of 00000000_2 by using the number key on your keyboard associated with each switch.
5. Observe the output voltage during the simulation.
6. Activate circuit simulation by pressing the Run/Stop switch found in the top portion of Multisim.
7. Double click on the multimeter (XMM1). The multimeter should indicate 0 volts for a binary input of 00000000_2.
8. Press Run/Stop to stop the simulation.
9. Change the binary input to 11111111_2.
10. Press Run/Stop to start the simulation.
11. Double click on the multimeter (XMM1). You should measure approximately 4.98 Volts.
12. Press Run/Stop to stop the simulation.
13. Select a second multimeter from the right border.
14. Connect the meter to the V_{REF} attached to the DAC at the (+) terminal and ground.
15. Press Run/Stop to start the simulation.
16. Run the simulation again and double click on the multimeter and read its display. The voltage indicated is the reference for the DAC and is needed to calculate the output analog voltage. Enter the value of V_{REF} in the blank below:

    V_{REF} _____

17. Calculate the output voltage from the following formula:

$$V_{OUT} = \frac{V_{REF}}{2^N} \times (B)_{10}$$

Where B_{10} = decimal value of the binary output signal
N = number of bits in output
V_{REF} = reference voltage

18. Enter the measured value and your calculated value for each of the binary values in Table 1 following this section of the procedure.
19. For the simulation circuit, double click on the reference voltage symbol. A window will appear which allows you to change the reference voltage value. Change the value from 5 volts to 2.5 volts.
20. Complete Table 2.
21. Load DAC Simulation Lab 1-A. This circuit has a fault that prevents the circuit from operating correctly. Troubleshoot the circuit and determine the cause of its failure.

NOTE: If the question appears asking to you to save changes, select No.

Table 1

Binary Value	Decimal Value	Expected V_{OUT}	Measured V_{OUT}
00000000	0		
00000001	1		
00000010	2		
00000100	4		
00001000	8		
00010000	16		
00100000	32		
01000000	64		
10000000	128		

Table 2

Binary Value	Decimal Value	Expected V_{OUT}	Measured V_{OUT}
00000000	0		
00000001	1		
00000010	2		
00000100	4		
00001000	8		
00010000	16		
00100000	32		

Post Simulation Questions

1. From Table 1 determine the resolution of the DAC.

2. When you changed the value of V_{REF} what effect did it have on the DAC output?

3. What is the fault associated with the simulation circuit in the file: DAC Simulation Lab 1-A?

Digital-to-Analog Circuit