University of Southern California

Department of Electrical Engineering - Electrophysics

EE 326Lx   Essentials of Electrical Engineering

Lab #2

This lab examines voltage dividers and superposition. You will also measure some performace characteristics of a simple analog-to-digital converter.

Part A

1. Consider the voltage divider circuit of Fig. 1. Build the circuit subject to $R = 1$ kΩ. Note that 1/2-R resistance values derive from two R's in parallel. Use the MAX874 voltage reference at the top of the divider with $V_{IN} = 5$ V, and connect a 1.5-nF capacitor from the voltage reference output to ground. This new circuit element helps to suppress voltage reference fluctuations—you will see why later in the course.

(The datasheet at www.maxim-ic.com shows IC pinouts.)

2. Measure the node voltages within the divider. How do they compare with theoretical values?

3. Measure the resistances between the nodes of the divider — be careful. Are the measurements of §A2 consistent with the resistor values?

Part B

1. Connect a 3-V source with a 4.7-kΩ series resistance to node X in Fig. 1.

2. Measure the new node voltages along the divider.

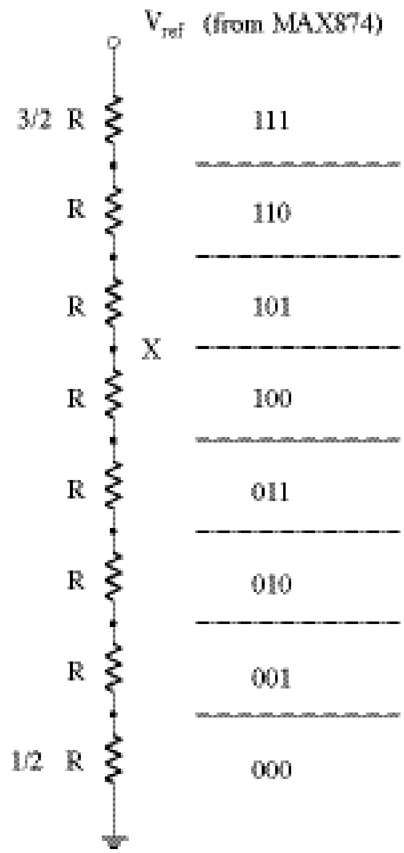

Figure 1: Voltage divider circuit with digital voltage “bins.” A flash analog-to-digital converter determines whether an input voltage lies between two adjacent node voltages in the resistor divider chain. The corresponding bin has a digital assignment.

3. Repeat the node-voltage measurements, but replace the 3-V source with a ground connection. Reconnect the 3-V source when finished.

4. Repeat the node-voltage measurements, but replace the voltage reference with a ground connection. Reconnect the voltage reference when finished.

5. Remove the 3-V source and 4.7-kΩ series resistor. Record the actual series resistance for future calculations.

In your writeuup . . . Show that superposition rules can explain the results of §B2, §B3, and §B4.

Part C

Warning: This section requires extensive circuit construction and debugging. Much of your grade will depend upon parts A and B. You will hopefully derive some pleasure and useful experience from part C. Do your work efficiently.

Build a 3-bit flash analog-to-digital converter (ADC) as follows:

1. Obtain two LM339 quad-comparator ICs from a TA. Download the data sheet from www.national.com/pf/LM/LM339.html for pinout specifications. Use 5 V for V^+, 0 V for GND.

Note: A comparator has two inputs, + and -. If the voltage at the + input exceeds the voltage at the - input, the output is HIGH. It is otherwise LOW. These values are HIGH and LOW in the digital sense.

2. Connect the voltage-divider nodes of Fig. 1 to individual + inputs of seven comparators. Each comparator draws essentially zero input current, so the connections should not corrupt the voltage-divider values of §A2.

3. Connect all seven comparator - inputs to the positive output of the voltage calibrator at your lab station. This instrument provides precise voltage levels. Connect the negative calibrator output to a common ground.

4. Connect the seven comparator outputs to LEDs as shown in Fig. 2.

Note: With the connection of Fig. 2, an LED is “on” if the comparator output is LOW. Thus, an “on” LED implies that the - comparator input has a greater voltage than the + input.

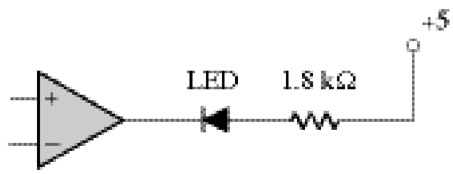

Figure 2: Comparator output connection.

5. The LEDs should light in succession as the calibrator ouput voltage is increased in relation to divider voltages. Convince yourself that this is correct. Use the calibrator to find the input voltages that produce digital transitions. How do these results compare to the data of §A2?

Note: The LEDs display digital information in the form 0000000, 1000000, 1100000, 111000, etc. An additional digital circuit is needed to convert this “thermometer” code to binary code: 000, 001, 010, 011, etc.

6. Determine the integral nonlinearity (INL) and differential nonlinearity (DNL) for your 3-bit flash converter. Assume $V_{ref} = 4.096$ V for theoretical voltage-bin boundary calculations.