Lab 7: Basic Voltmeter + Measuring Resistances

Lab Objectives:

1. Gain additional familiarity with the analog input functionality of the Arduino
2. Build a basic voltmeter capable of measuring 0 – 3.3V accurately
3. Use a voltmeter to accurately determine the value of the internal pull-up resistance
4. Use a voltmeter to accurately determine the value of the internal parasitic resistances

Required Equipment:

• Computer with Arduino IDE & Teensy extensions installed and working
• Teensy board and USB cable
• Working pair of 7-segment displays and associated resistors (from previous labs)
• Resistors of a wide variety of different values (eg. 220Ω – 10KΩ)

References and Resources:

• You will need to combine this lab with some circuitry and code from the previous lab.
• Reminder of the "resistor colour code" (BBROYGBVGW, silver, gold)
• Course textbook: Chapter 5: Advanced Input & Output", Getting Started with Arduino
• PartsList-Explanations file with part numbers, for referencing data sheets
• familiarity with the analogRead() function in Arduino

Task 1: Basic Digital Voltmeter (demo)

A simple formula is all that's necessary to convert raw analogRead() values to a voltage, however care must be taken to **minimize rounding errors**. Our voltmeter will be limited to two digits, so proper formatting of the display is necessary to get the most precise results.

1. Add a voltage divider circuit that can generate a variable voltage in a reasonable location on your protoboard. The 10 kΩ potentiometer is a reasonable choice of device that can help to generate the variable voltages but if you want to experiment with the light sensor in your electronics package then this will suffice as well. A few schematics of this additional circuit are found in theory slides.
2. Connect the output of the voltage divider circuit to an analogue capable pin on your microcontroller; you will be adding code to a sketch that will analogRead() from this pin and then, using the ADC capabilities of the microcontroller, send out the calculated voltage to the SER pin of the first shift register.
3. Verify (and modify your code if necessary) from the previous lab to display the value of the voltage on a pair of 7-segment displays. For this first step, simply display the voltage to the nearest tenth (ie. 0.1) volt. Don't forget to illuminate the decimal point!
4. **Be sure** that you **round off** (not truncate!) the displayed value. Code it properly!
5. **Test** your voltmeter by using a potentiometer to generate a smoothly varying voltage across the entire 0 – 3.3V range.

6. Add an extra red LED to act as a leading decimal point. Modify your code so that voltages in the range 0.0 – 0.99V are displayed using an assumed leading "0" ie. using the two digits for two decimal places; voltages of 1.0V and above are displayed as in step 1.
7. your voltmeter again by using the potentiometer to generate a smoothly varying voltage across the entire 0 – 3.3V range, taking particular note of the range 0 – 1V.

Task 2: Measuring the Internal Pull-up Resistance (graph #1)

It's not difficult to develop the formula for measuring an unknown resistor based on a second resistor in series and the voltage at their common point. The most accurate measurement is obtained when the second resistor is as close as possible to the unknown resistor. At this point, you should see approximately one half of the source voltage, as it would divide evenly between the two equal size resistors.

1. Use your voltmeter from the previous task to make suitable measurements of the internal pull-up resistance. Record all measurements for the next step.
2. Enter the value(s) from the previous step into a spreadsheet.
3. Plot a graph of the resistance values for all of your measurements.
4. Determine the most accurate value for the internal pull-up resistance, with some estimate of the accuracy.
5. Complete the spreadsheet & graph: add a title, your name, date, course, etc.
6. Save the spreadsheet in **Open Document format (.ods) or Excel 97 format (.xls)**.
   Do **NOT** save in any other format!

Task 3: Measuring the Internal Parasitic Resistances (graph #2)

The Teensyduino's outputs aren't perfect sources of 0V and 3.3V. Knowing that there is an unavoidable (parasitic) resistance, can you measure it accurately?

1. Use your voltmeter from the previous task to make suitable measurements of the each of the internal parasitic resistances (output = low, output = high). Record all measurements for the next step.
2. Enter the value(s) from the previous step into a spreadsheet.
3. Plot a graph of the resistance values for all of your measurements.
4. Determine the most accurate value for each parasitic resistance, with some estimate of the accuracy.
5. Complete the spreadsheet and graph by adding all the info as in the previous task.
6. Save the spreadsheet in **Open Document format (.ods) or Excel 97 format (.xls)**. Do **NOT** save in any other format!

Deliverables:

1. Demonstrate task #1, your voltmeter accurately measuring voltages between 0 – 3.3V
2. Upload a spreadsheet of the data collected and the graph created for the internal pull-up resistance and the data collected and the graph created for the internal parasitic resistances.