

## **Arduino Lab 3—Digital/Analog (D/A) Converter, Analog/Digital (A/D) Conversion**

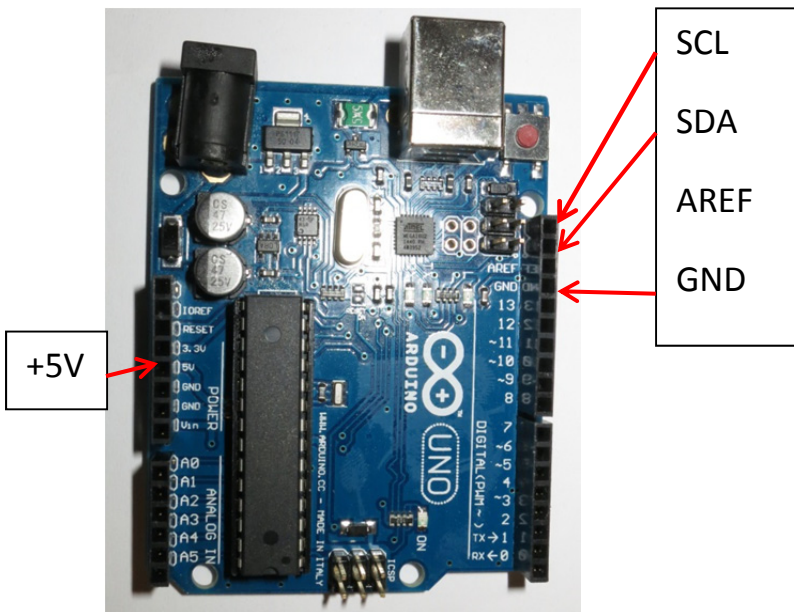
1. Serial Monitor for printing output from Arduino.

It is very useful to be able to display a number from the Arduino on the PC display. This can be done using the Serial library, which allows communication between the PC and the Arduino over the USB port while your program is executing. Download the program `SerialMonitor_Print.ino` from the Cluster's Smartsite under `/Resources/Arduino lab`. You can read it and then use it as a template for serial output. To see the serial output when your program is running, in the Arduino IDE go to Tools, Serial Monitor. A window will open. Check the baud rate and make sure that it is the same as the argument in the call to the function `Serial.begin(BaudRate)`. Then you should see the printed data coming from the Arduino.

2. The Arduino has six analog input lines, and each can convert a 10 bit number, i.e., 0 to +5V corresponds to values 0 to 1023. Connect the two end pins of the potentiometer to GND and +5V. Connect the middle pin of the “pot” to pin A0 (i.e., analog input pin 0). (See the right side of the diagram at the end of Arduino Lab 2. Also see the program `Potentiometer.ino` for an example of reading data from pin A0 with the `analogRead` function.) Use `analogRead(0)` to read the data from A0 into a variable. Then use the serial monitor to print variable with the digitized value.

You can find more information on the analog input pins at <https://www.arduino.cc/en/Tutorial/AnalogInputPins>

3. We are going to use the PCF8591 chip, which has one 8 bit D/A converter output and four 8-bit A/D converters for input. See the 5 I/O pins on the one end of the board. You can see that it is a surface mount chip soldered to the small printed circuit (PC) board. It connects to the Arduino through the I2C interface, which has 4 wires, labeled as Vcc (connect to +5V on Arduino), GND, SCL (Serial clock), and SDA (Serial data). On your Arduino, if you hold it so that the digital pins go from 13 to 0 on the right side of the board, the pins above 13 from top to bottom are SCL, SDA, AREF, GND. Note that SDA is connected to pin A4, and SCL is connected to pin A5. Therefore A4 and A5 cannot be independently used if you are using a device on the I2C interface.



To use a device on the I2C bus, you use the Wire library. See <https://www.arduino.cc/en/reference/wire> for additional information.

Download the program PCF8591\_DAC\_Triangle.ino. Read the program to see how to communicate with the DAC converter on the chip. Look at the triangle wave on the DAC output with your oscilloscope. Draw a picture of the wave in your lab notebook. What is its frequency?

Modify the program to print on the serial monitor each value that is sent to the DAC. Now what is the frequency of the triangle wave? Does the speed surprise you?

You can generate a sine wave if you use a lookup table. Download and run the program PCF891\_DAC\_Sine.ino. Observe the wave on the oscilloscope and measure its frequency. Draw the wave in your lab notebook.

4. Using the 4 ADCs on the PCF8591. Read the part of the tutorial on the two methods of reading the ADC's – sequentially, and then using autoincrementing -- at <http://tronixstuff.com/2013/06/17/tutorial-arduino-and-pcf8591-adc-dac-ic/> Those 2 programs have also be uploaded to the cluster's Smartsite. Try them both.

Read the description about how the ADCs on the PCF8591 can be used as differential inputs.

With the 3 black jumpers connected, 3 of the ADCs are connected to devices on the board.

IN0 – Thermistor – counts decrease when heated with a hairdryer.

IN1 – Photocell – counts decrease when light is incident from flashlight.

IN2 – Separate input, not already connected to device on the board.

IN3 – Potentiometer – i.e., a variable voltage

Measure how IN0, IN1, and IN3 change when the properties of the 3 the sensors change.

Try making a “passthrough function.” Get a separate waveform generator. Connect its output to IN2. Read in digital values and pass them on to the DAC. Look at the output of the DAC on the oscilloscope. How does it compare with the original waveform at the output of the waveform generator? Draw pictures in your lab notebook