Lab I: Building a System

Due March 31 9 pm

1 Introduction

The Agri-Food industry is one of Canada's biggest industries and employs all manner of engineers in a variety of tasks. Automated monitoring and watering of plants is an important element of this industry and is a fantastic example of mechatronics in action: sensors and actuators connected together to do useful work.

In this lab, you will try out two key components in an automated monitoring and watering system that is the subject of your project: moisture sensing and water pumping. The moisture sensor returns a voltage that is inversely proportional to the presence of water, allowing you to determine in the soil is in need of watering. The immersible pump can be placed in a water reservoir and we can use a MOSFET amplifier to driver an electric motor within it to deliver water to your plants.

2 What you will need

1. 9 v battery (with wired adapter that ends in "barrel" connector)
2. Grove kit (main board)
3. Container for water (the pump will go in here)
4. Water Pump (with"barrel" connector)
5. MOSFET Grove board
6. Barrel connector (to go from battery cable to MOSFET board)
7. Potted plant (or just a pot of soil if you are loathe to own a plant)
8. Soil moisture sensor
9. Optionally, container for spills

3 Background

As part of your major project you will need to connect a pump and a moisture sensor to your Grove board. You'll use MATLAB to send signals to the pump in response to dry soil conditions measured by the sensor. You will connect the soil sensor to pin A0 and the water pump to pin D2. For an overview of all the connections you will need to establish, please review the lab video at this URL.

When you have connected everything you will be able to test both the sensor and the pump. You should be able to read the voltage of the signal being sent from the soil sensor using the following commands:

```
a = arduino( "your_port", "Nano3"); //replace your_port with your Grove port
voltage = readVoltage(a, 'A0');
```

And you should then be able to send voltage to the pump (located at pin D2) for 0.2 seconds using the following commands:

```
writeDigitalPin(a, 'D2', 1);
pause(0.2);
writeDigitalPin(a, 'D2', 0);
```

Note that the pause ensures that the pump is only turned on for a brief period of time, hopefully avoiding spills.

4 Connect the Soil Moisture Sensor

In this part of the lab, you will be creating a function called $state = currentSoilState(a)$. To begin, we will measure some voltages off of the soil sensor, to get a sense as to which voltages correspond to which states. Record the voltages that are sent to your board by the soil sensor under the following four conditions and place this information **in the comments of your currentSoilState function**. Record these values to one decimal point (i.e. one tenth of a Volt):

Not immersed (in air):	____________	Volts
Immersed in dry soil:	____________	Volts
Immersed in water-saturated soil:	____________	Volts
Immersed in a glass of water:	____________	Volts

Once you have done this, write the body of $state = currentSoilState(a)$. Your function should:

1. Accept an initialized arduino object (a) and returns one of the following strings to indicates soil sensor state: *'dry_air', 'dry_soil', 'wet_soil', 'water'*

2. Determine the state of the soil based on the voltage that is returned by the soil sensor connected to the arduino at pin 'A0'. Pick the state from the table above that is closest to the measured voltage. If there are two states that are equidistant from the measured voltage, return the string

value that corresponds to the state with the higher voltage (i.e. the dryer state).

5 Connect the Pump

In this part of the lab, you will be creating a function called $pumpWater(a, litres)$. To start, we will test the pump. You should have connected up the MOSFET switch (or "solid state relay") board as described earlier. The black wire goes to "GND" (or ground), Red wire goes to +5v and yellow wire goes to 'D2' pin. The white wire is not connected. Then, connect the battery pack to the screw terminal on the switch board, where the red wire connects to the "+" terminal and the black wire connects to the "-" terminal. Also, connect your pump so that the blue wire goes to "GND" on the screw terminal and the brown wire goes to the terminal marked "OUT". Ensure that the screwed terminals hold the wires tightly.

Your source of water will need to be lower than the soil that you are pumping into. If the water reservoir is below your potted plant then flow will stop when your pump is off. Otherwise, if the water reservoir is above your potted plant, water will continue to flow even if you turn off the pump.

Try running your pump and validate that it will shut off reliably using the following command:

```
writeDigitalPin(a, 'D2', 1);
pause(0.2);
writeDigitalPin(a, 'D2', 0);
```

Then, take some measurements to assess the time required for the pump to do some predefined tasks. **Place your results in the comments of your pumpWater function.**

Time to for water to begin flowing from the pump:	____________________	Seconds
Time to empty 1 litre of water:	____________________	Seconds

Finally, write the body of $pumpWater(a, litres)$. Your function should:

1. Accept an initialized arduino object (a) as well as the amount of water to pump ($litres$) and return nothing.
2. Turn on the pump for whatever amount of time is required for water to begin flowing.
3. Keep the pump on for whatever amount of time is required to pump the number of litres of water held in the argument $litres$. To determine the

correct amount of time, assume there is a linear relationship between the amount of time the pump is on and the number of litres that are pumped. If it takes X seconds to pump 1 litre of water, assume it will take $2X$ seconds to pump 2 litres of water, and so on. As you do this you might want to ask yourself if making such an assumption is reasonable; why might it be? Why might it not be? **You can answer this question in the comments of your** $pumpWater(a, litres)$**.**

6 Putting the System Together

Finally, try putting your system together. It does not need to be perfect now; perfecting it will be the subject of your major project. Measure the soil moisture level with your Grove board using your function when the soil is dry. Try pumping a little water from the pump using the digital write command to the soil and measure moisture again. Has the moisture level changed? (It should have).

Take a photo of your Grove + pump + sensor + plant setup and include this photo in your eClass submission. Save your photo such that it is **less than 2MB** in size and has the title **image.jpg**.

7 What to Submit

Submit, via eClass:

1. Your **image.jpg** file. This should be an image of your setup.
2. Your **pumpWater.m** file.
3. Your **currentSoilState.m** file.

You will receive 1/3 mark for a well commented currentSoilState file that performs to specification and includes calibration information in comments and 1/3 for a pumpWater file that includes the timing information as well as a reflection on its linear assumptions in the comments. Make sure to use the template covered in class for comments. You will receive 1/3 mark for an image that shows your setup.

HAVE FUN AND GOOD LUCK!