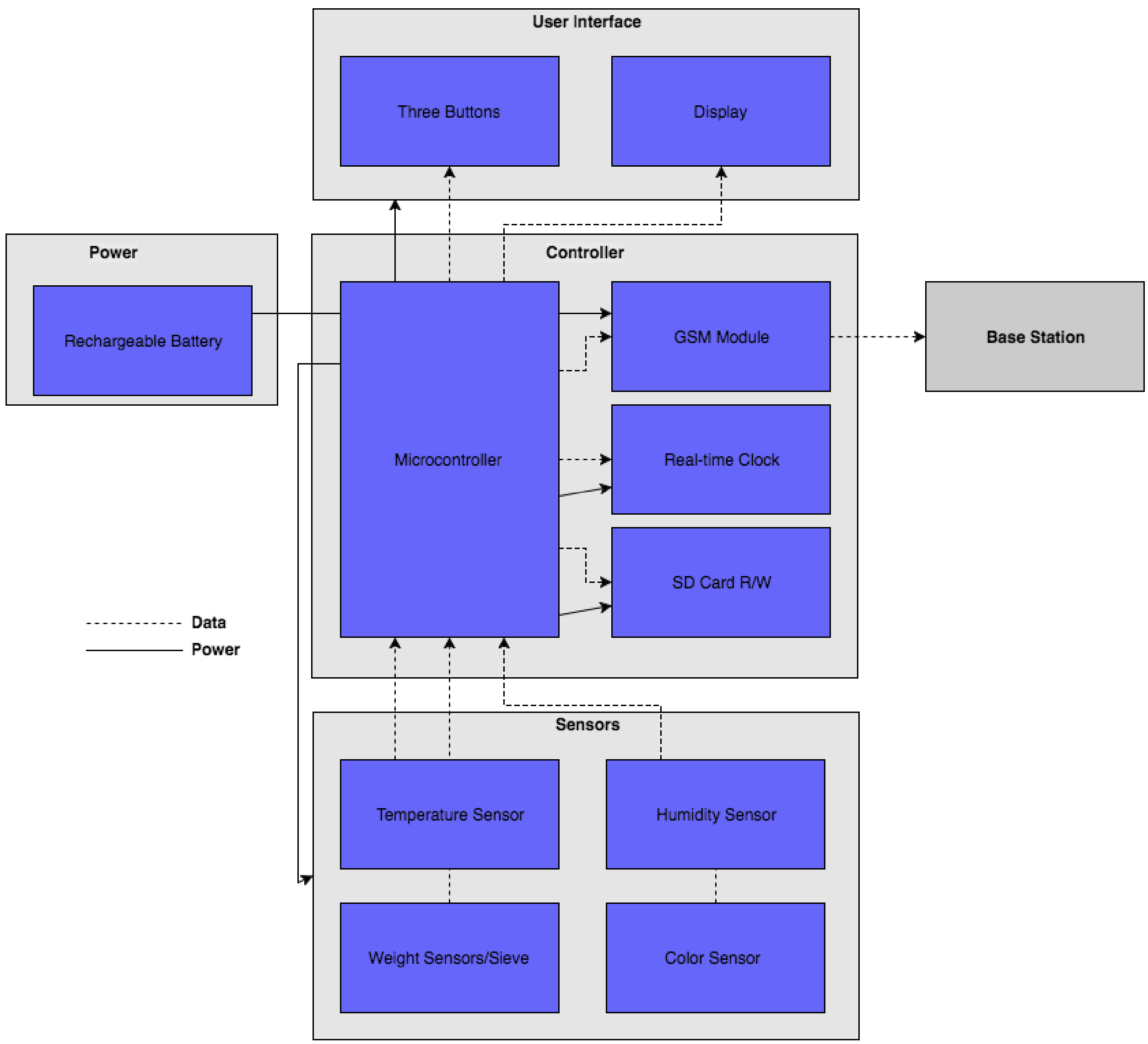
Automated Corn Quality Measurement Kit

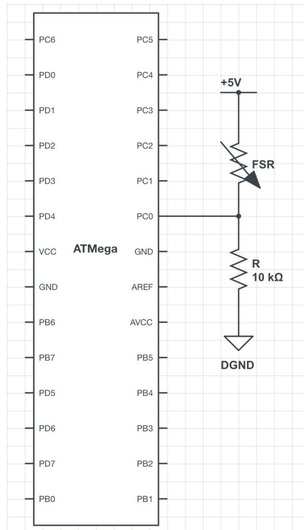
Team | Adam Long, Joan Brown, Kevin Villanueva
TA | Luke Wendt
20 September 2016 | ECE 445

1 Block Diagram



2 Circuit Schematic

The schematic below pertains to the weight sensor/sieve module. To accurately measure the weight of the sample we decided to utilise a force sensitive resistor (FSR). In the schematic below, we use the FSR as a pull up resistor in a simple voltage divider circuit. As force is applied to the FSR its resistance decreases. This decrease in resistance causes a change in the voltage at the node connected to pin PC0. When force is applied the potential increases towards +5V and when force is removed the potential decreases towards 0V. More details on this behavior and the choice in value for the 10KOhm resistor can be found in section 3.



3 Calculation

In the previous section the simple circuit for our force sensitive resistor (FSR) is explained. The way that it worked, was that when the resistance of the FSR decreased, the total resistance of the FSR and the pulldown resistor decreased. This causes the current flowing through both resistors to increase which in turn causes the voltage across the fixed 10K resistor, as well as the node connected to pin PC0 on the microcontroller, to increase.

The formula can be seen in the equation below which is based on the voltage divider rule:

$$V_{PC0} = V_{CC}(\frac{R}{R+FSR})$$

Where V_{CC} is the supply voltage of the circuit (5V), R is the 10K Ohm pull down resistor, and FSR is the Force Sensitive Resistor, where resistance is a function of force (newtons), given by:

$$FSR = 7.138 * pressure^{-.0765}$$

Example calculation for FSR resistance and output voltage with an input of 10N of force shown below:

$$FSR = 7.138 * (10N)^{-.0765} \approx 1k\Omega$$

$$V_{PC0} = 5V(\frac{10k\Omega}{10k\Omega + 1k\Omega}) \approx 4.55V$$

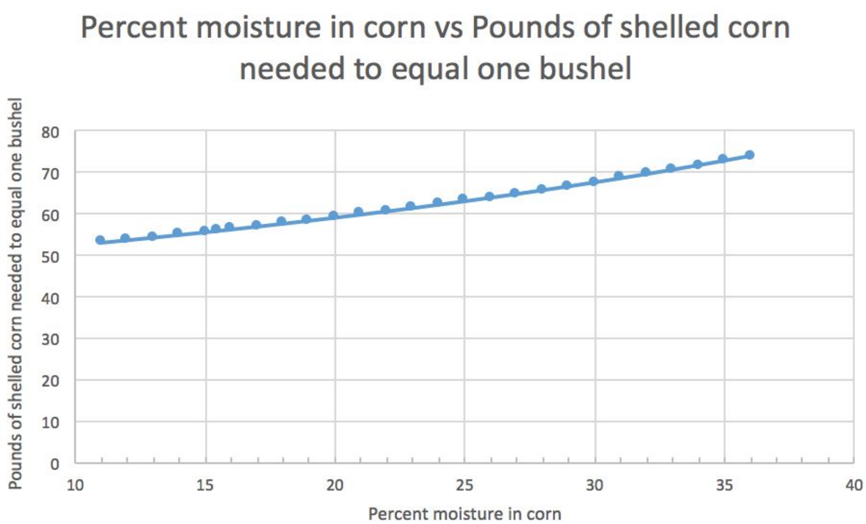
Note: we chose a $10k\Omega$ pull down resistor due to its wide availability and resistance value close to the range of values that the FSR will be between.

Table values to create equations for this section were given by [1].

4 Plot (Sim/Exp)

Include one plot from a simulation experiment pertaining to our system

The plot below is from experimental data gathered from [2]. It relates the corn moisture and weight of corn needed to create a bushel of corn. This data is helpful as moisture varies with temperature and humidity, the number of corn kernels to create one bushel (a unit of selling) increases with moisture. Since we will be calculating moisture from our humidity and temperature sensors, and the end goal for our product is so that farmers get adequate prices for their corn, we decided to add the below plot.



From the graph it is shown that with increasing percent coin moisture, the pounds of corn required to sell one bushel increase dramatically. Farmers may be undervaluing or overvaluing their corn if their percent moisture of corn is different from expected.

5 Block Description

Include description for one module from the block description
Weight Sensor/Sieve Module:

The purpose of this module is to measure the weight of the total corn sample and individual components. The sieve will separate the corn from its impurities, pushing smallest objects to the bottom. Corn and sieve are then removed from the sensor and the weight is recalculated to get the weight of just the impurities. The weight of just the corn can be calculated from:

$$Weight_{corn} = Weight_{total} - Weight_{impurities}$$

Setup of module will simply be a pressure sensor (circuit schematic above) with a metal bowl on top. A sieve will also be placed inside the bowl. At the start of the system, the pressure sensor will calibrate and read the bowl as a net 0 weight. Corn sample will be placed inside the bowl and total pressure will be recorded on the pressure sensor. The more weight placed inside the bowl the higher analog voltage will be inputted to the ADC of our processor. Here end's the description of this specific module.

6 R&V

Include R&V for one module from the block diagram

Impurity/Weight Measurement	
Requirement	Verification
1. Measure and record weight of kernels, unwanted material, and sieves upon command, expected weights TBD by ACES	1. View live data upon command in correspondence with visual text cues given to the user. Ensure proper timing and utilize messages to simplify the process for the user. 2. After 15 samples, when capture button pressed, correct weight (verified in Requirement 2) must be recorded and stored on SD card within 10 seconds of button press
2. Report weight of impurities and kernels as total weight	1. Utilize analytical balance or scale or digital scale of known desired accuracy (1/10 or 1/100 g) and compare its

and percentages by weight with 95% accuracy	weight of each part (sieves, impurities, kernels) of test samples to the values of the kit system. 2. Measure weight of sieve and total sample separately (expected), then measure overall weight (actual). After 15 samples, actual weight must be no less than 95% accurate compared to expected weight. 3. Measure weight of total sample (expected), then measure just corn grain separated from impurities and just impurities (actual). After 15 samples, weight of just corn and just impurities must be no less than 95% accurate compared to total weight.
3. Weight sensor must accurately capture weight of impurities	1. Add 2g of impurities to sample, weigh the total. Push impurities through sieve and weigh again. New weight (total - impurities) must reflect the amount of impurities added with 90% accuracy after 20 samples

7 Safety Statement

The end product will be in an entirely closed case, with most electrical components (aside from the user interface and sensors) being insulated from the end user. That being said, there aren't any major electrical and mechanical safety concerns with our end project, granted each module of the project isn't damaged.

Concerning minor safety considerations:

- Sieves in the weight/impurity module may scratch end user when placing in corn sample
- Frayed wires from any sensor may induce electrical shock if not properly handled
- Case closing may pinch fingers of end user.

Concerning project team safety: there are several electrical components that will need to be soldered on the PCB. This brings up the chance of injury from heat/burning that can occur from improper use of a soldering iron. Frayed electrical components may induce electric shock when testing the end product. Placing sharp mechanical enclosing in the end product may subject the team to minor cuts and injury.

The above being said, there is a very low chance of injury for both end user and project team with minor injury being possible, but still unlikely.

8 Citations

[1] lady ada, "Using an FSR," in *Adafruit*, 2012. [Online]. Available: https://learn.adafruit.com/force-sensitive-resistor-fsr/using-an-fsr. Accessed: Sep. 20, 2016.

[2] J. Lauer, "Methods for Calculating Corn Yield," *Argonomy Advice*, vol. 28, no. 47-33, pp. 1–4, Jan. 2012.