

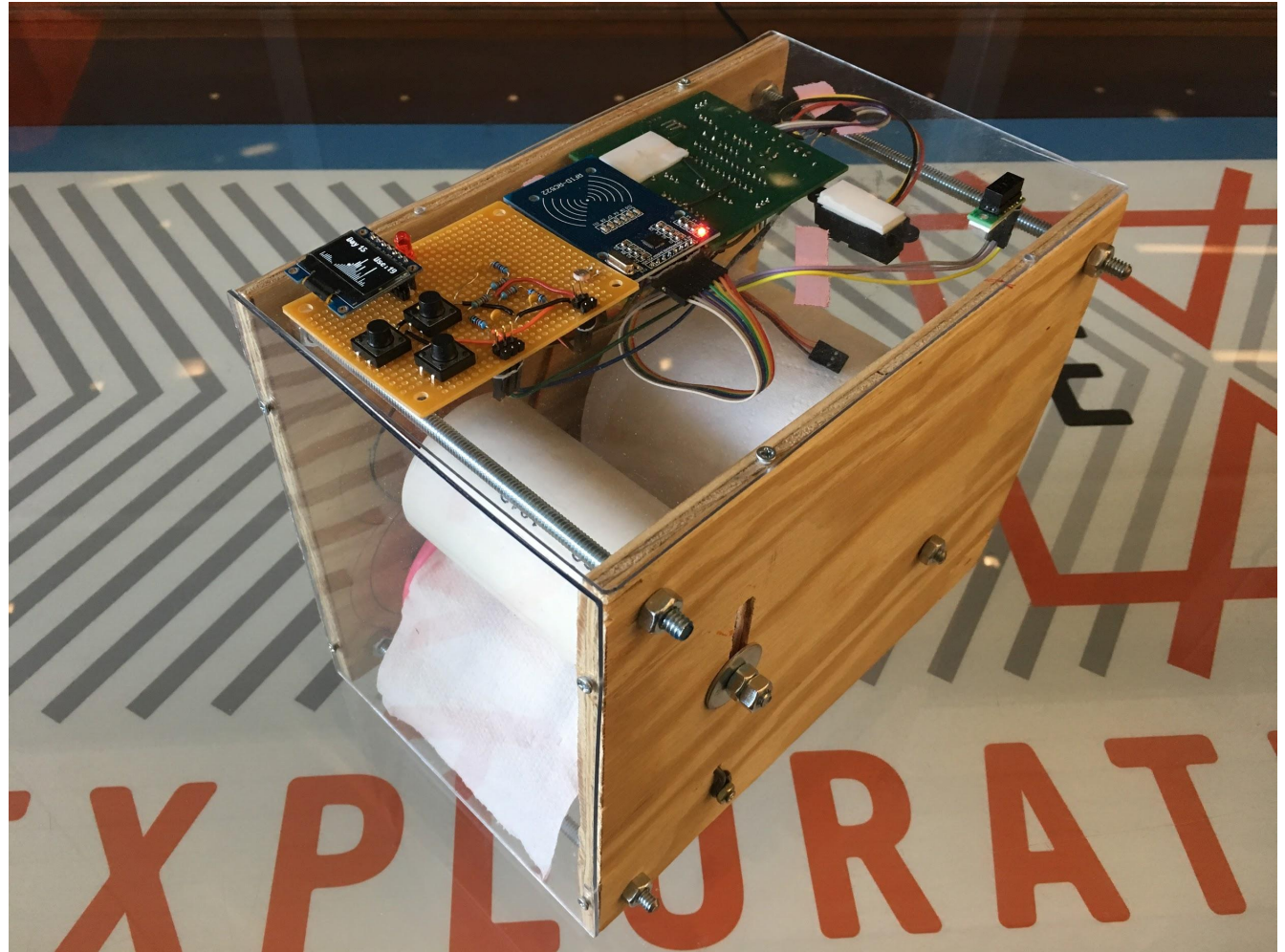
# The TP Tracker

ECE 445-Senior Design

Group 7: Kevin Wang and William Rick

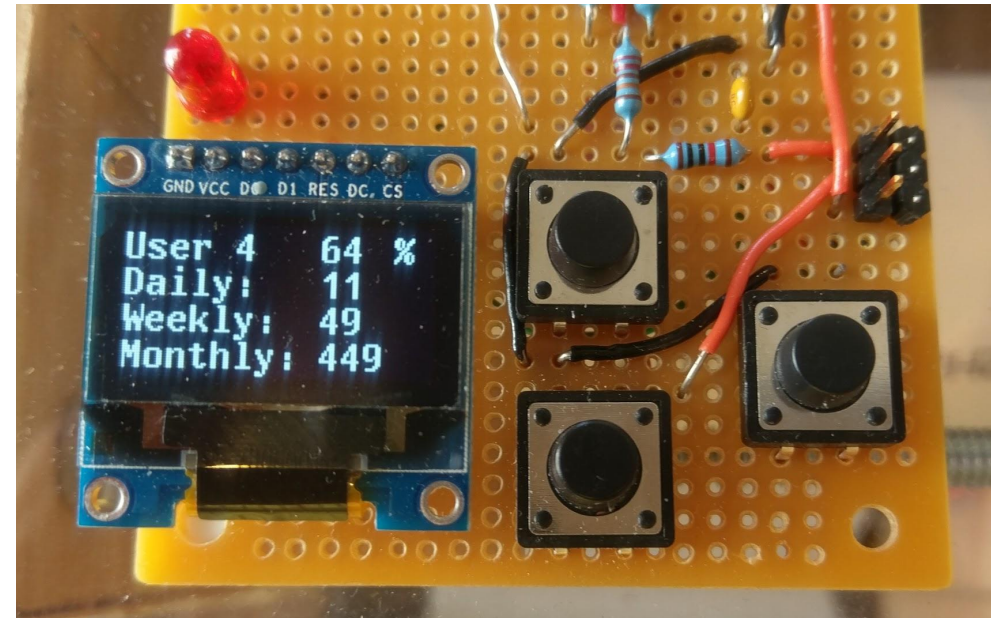
# Introduction

- U.S. uses most TP per capita in the world
- Allows environmentally conscious users to monitor their toilet paper usage
- Adaptable for residential or commercial use



# Objectives

- Dispense “serving” when prompted by user
- Store a month’s worth of data for four users
- Very low power when not in use



# Main Features

## Hardware

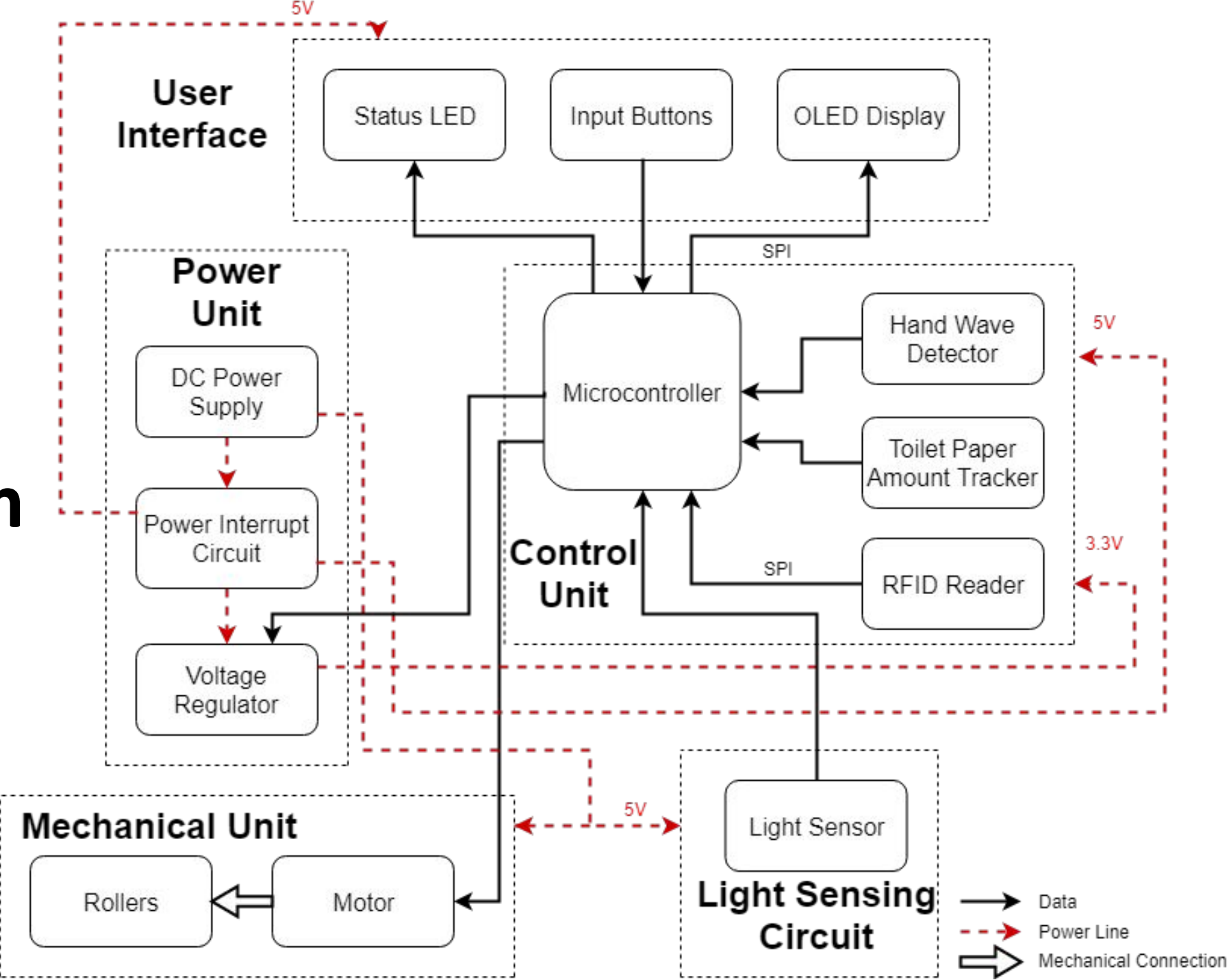
- RFID Login
- OLED Display
- Hand Wave Sensor
- Thickness Sensor
- Light Sensor
- 3.3V Switching Regulator
- MOSFET Power Interrupt



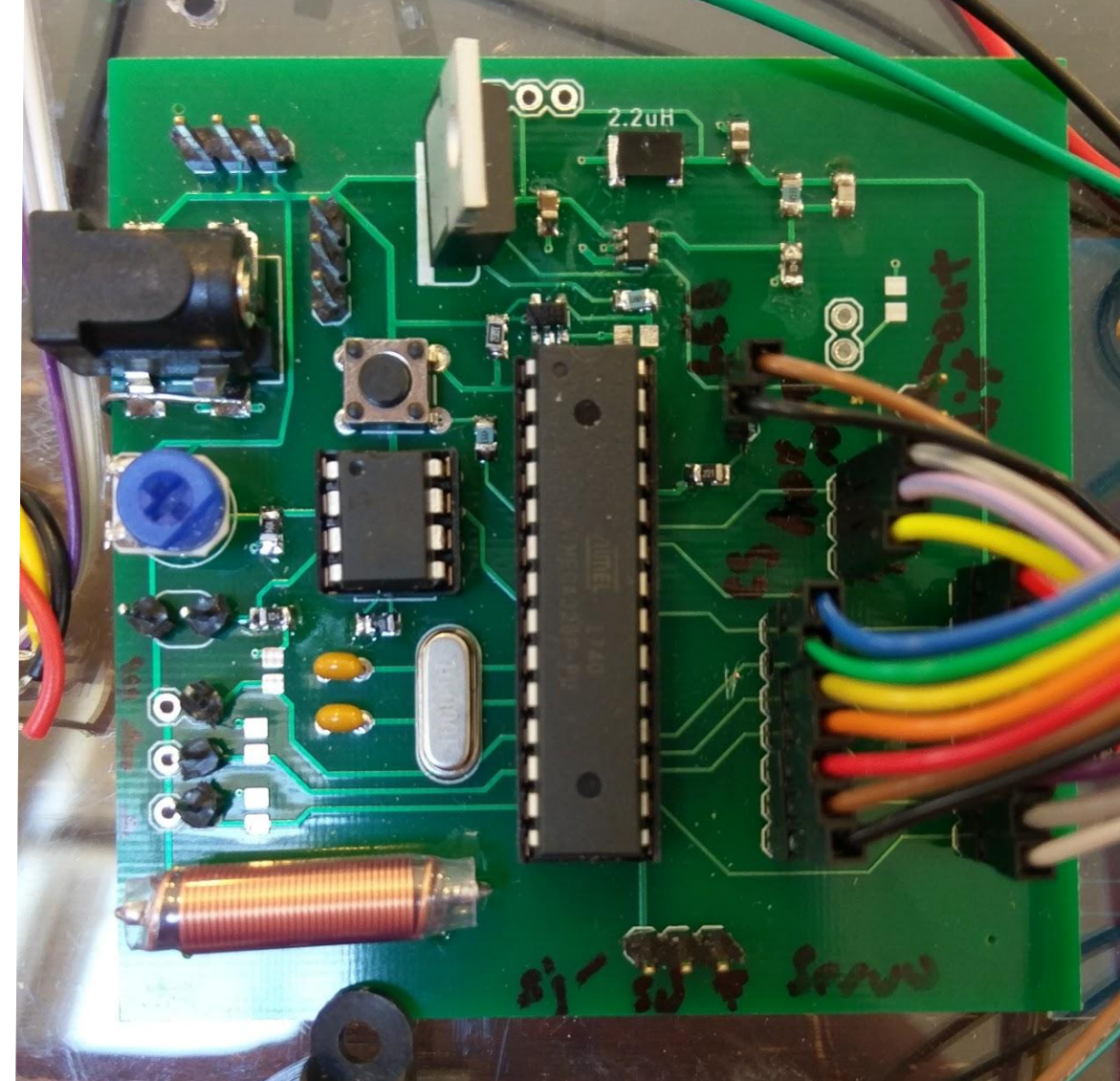
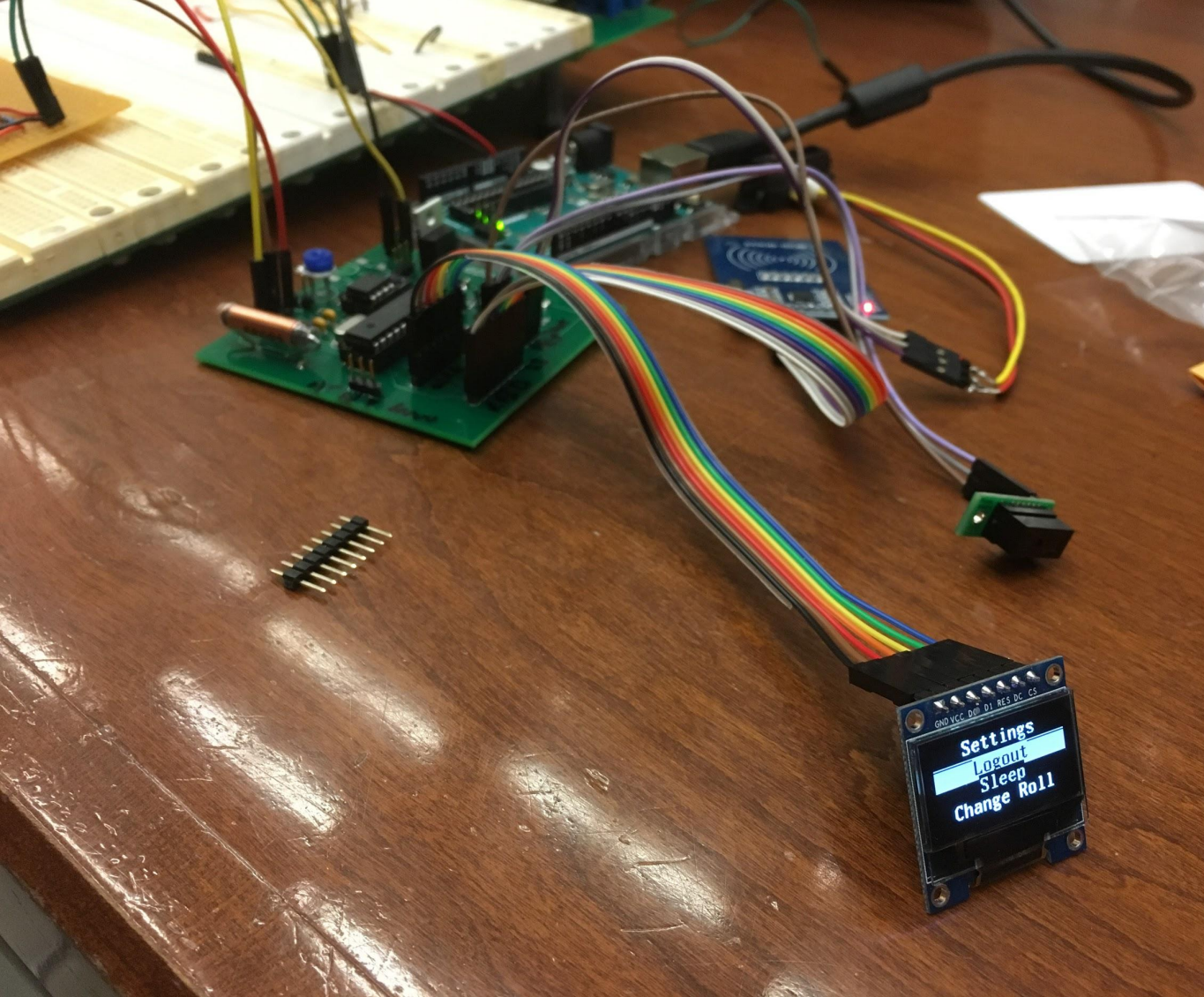
## Software

- Sensor Hub
- User ID recognition
- Clean User Interface
- Graphical Data Display
- Low Power Mode
- EEPROM Storage

# Block Diagram





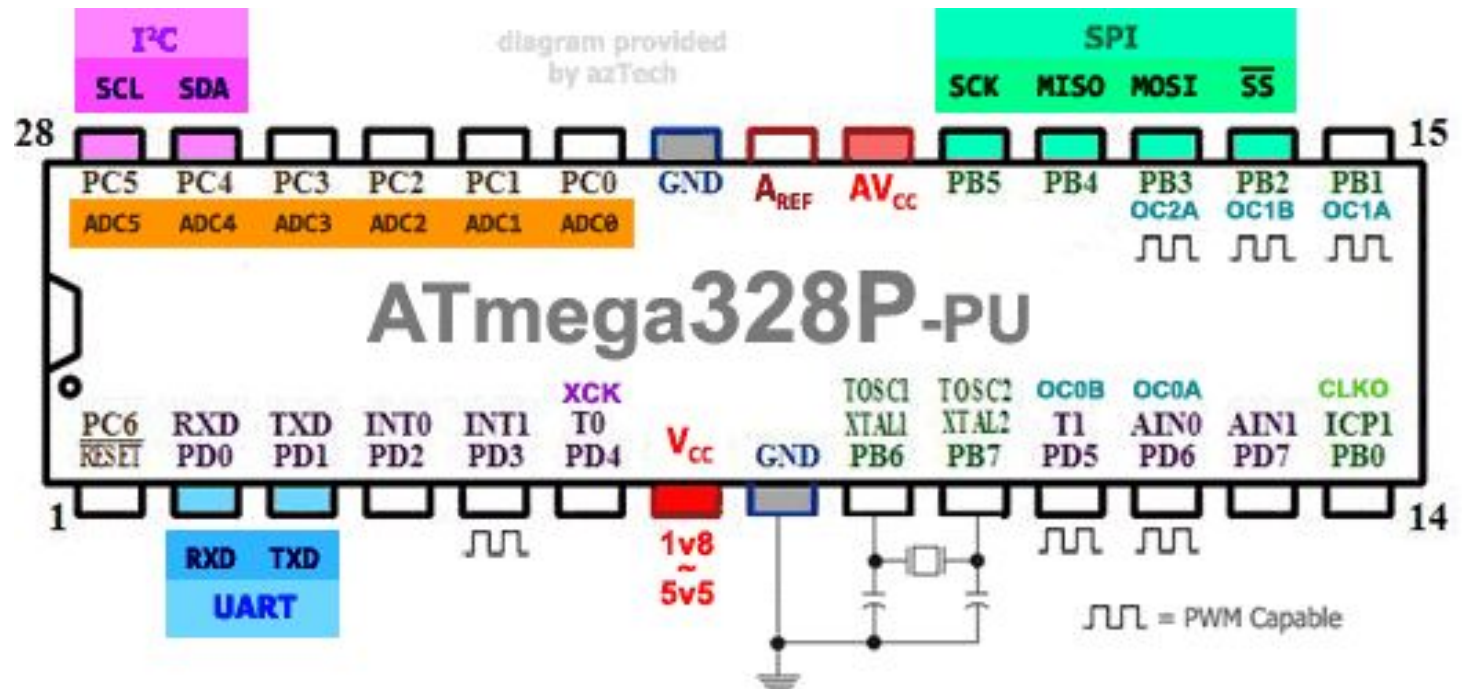


# Sensors and Hardware



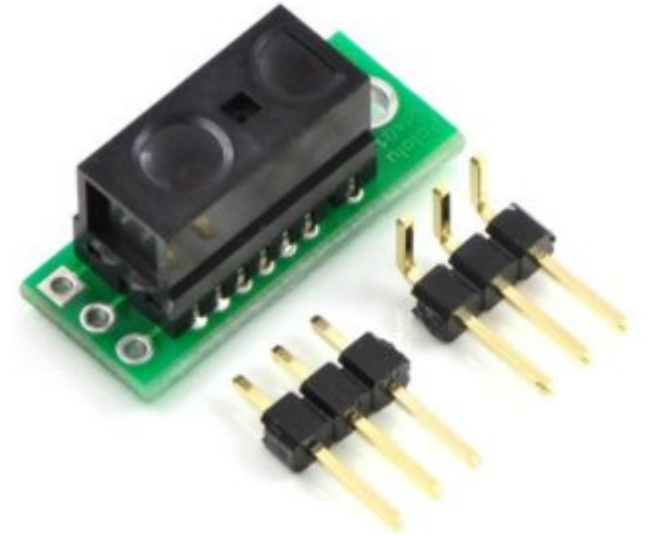
# ATmega328p

- Accessible for rapid prototyping
- 14 Digital I/O, 6 Analog Inputs
- SPI Bus
- 1kB EEPROM

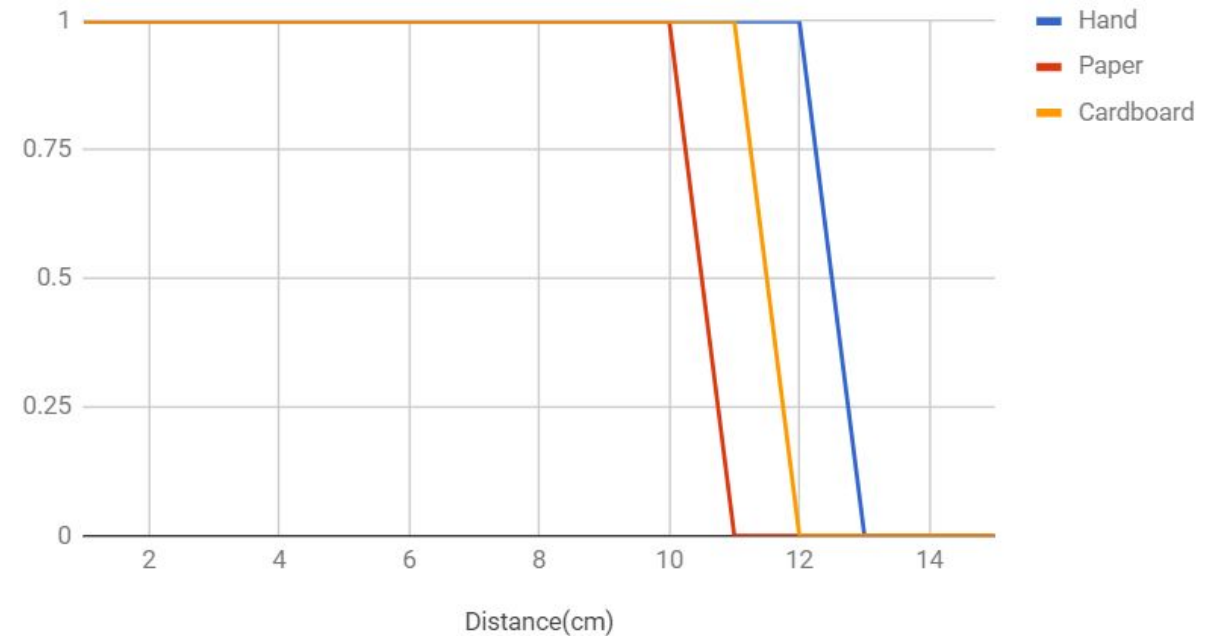


# Hand Wave Sensor

- Sharp GP2Y0D810Z0F IR Sensor
- Detects if object present between 2 - 10 cm range



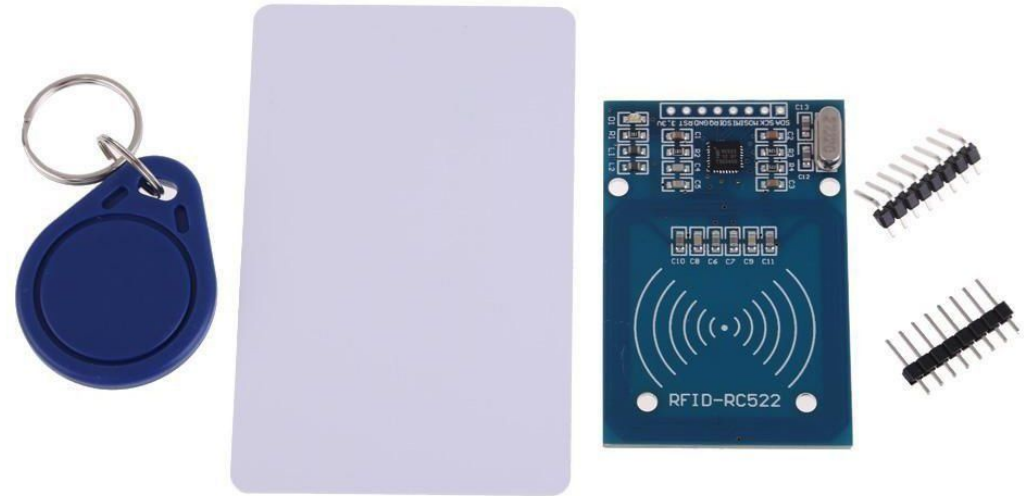
IR Proximity Sensor Output





# RFID Reader

- Mifare RC522
- SPI Bus Interface
- Arduino Library Support
- Cheap (\$6)



# TP Thickness Sensor

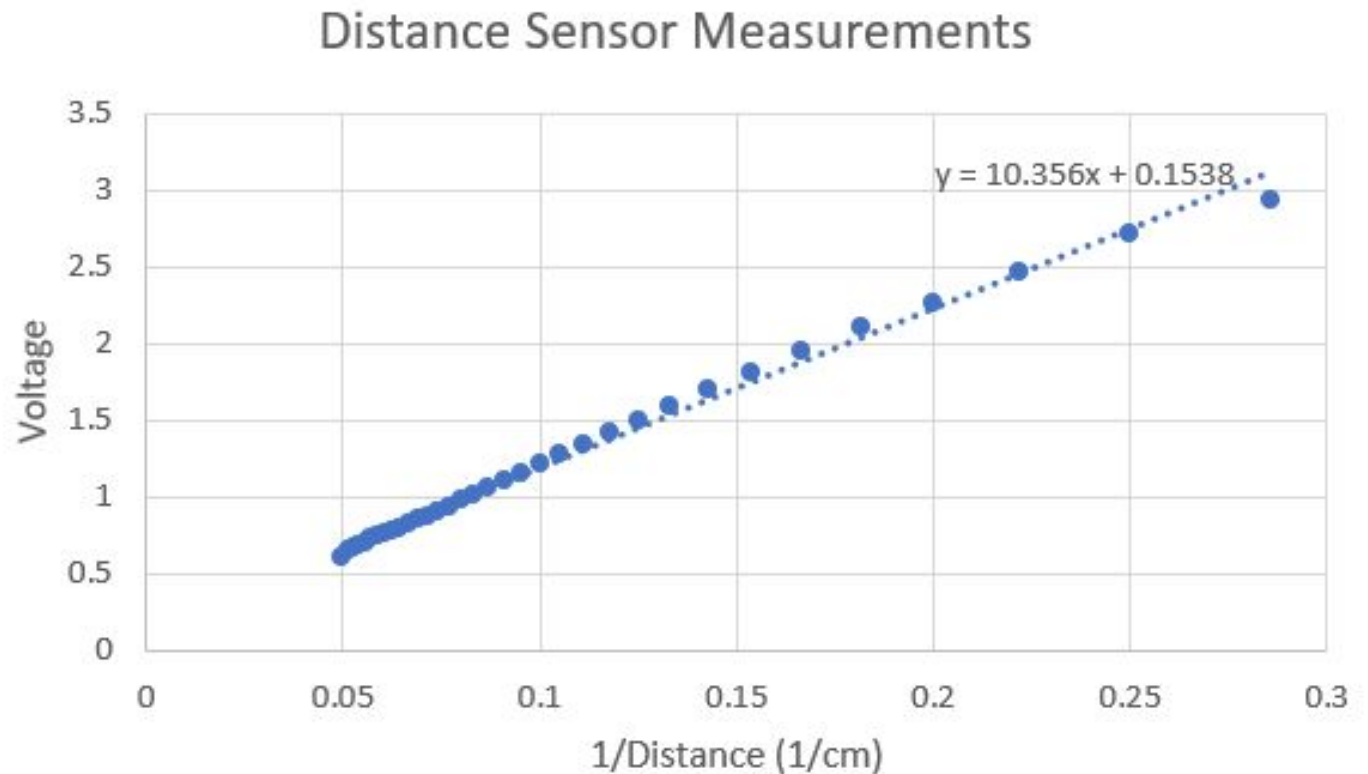
- IR Distance Sensor
  - SHARP GP2Y0A41SK0F
  - 4 - 30 cm measurement range
- Measure radius of roll to accuracy of 10%



# TP Thickness Sensor Calculations

$$TP\% = \frac{(Outer\ Radius)^2 - (2.5\ cm)^2}{(7.5\ cm)^2 - (2.5\ cm)^2}$$

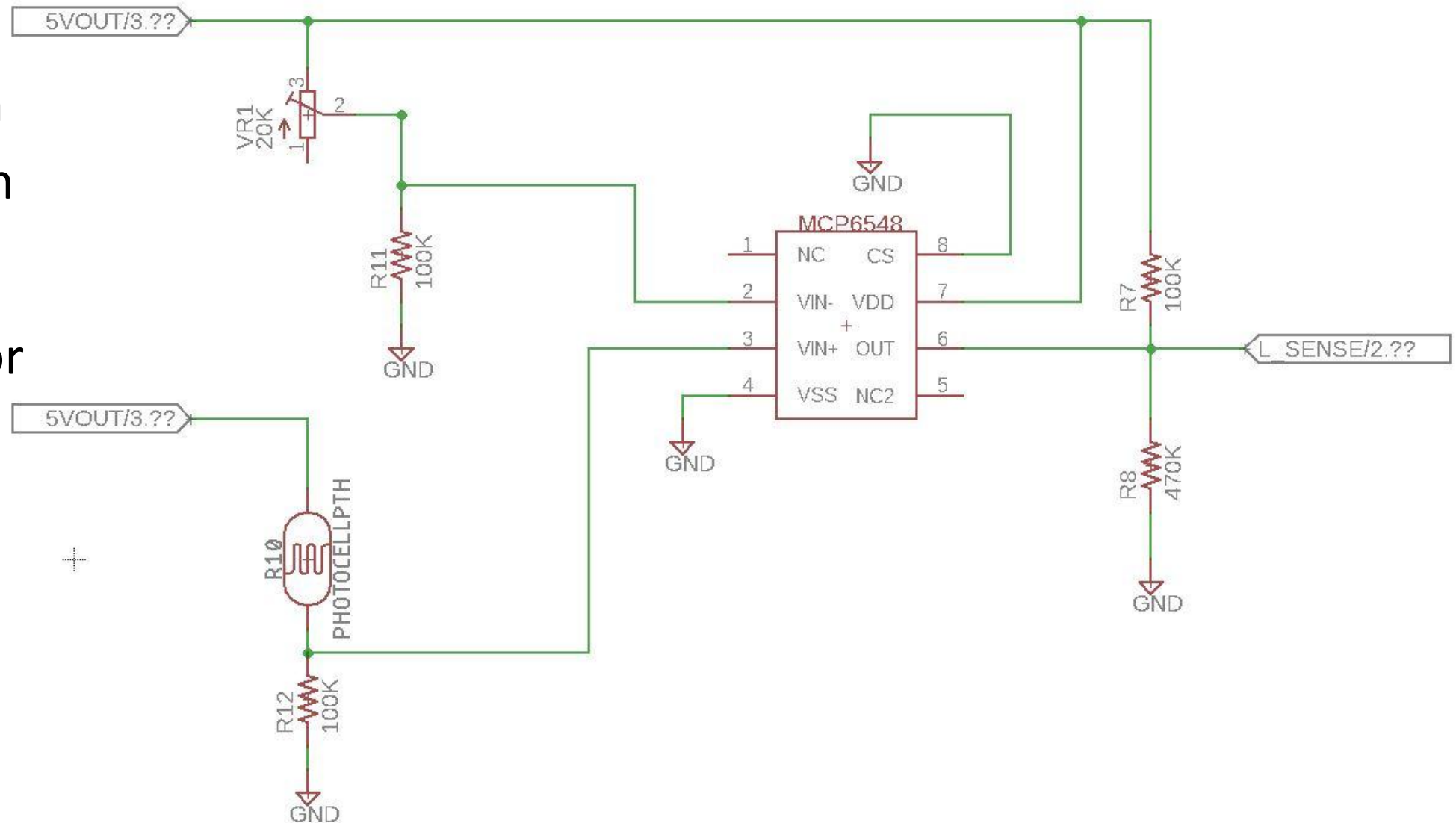
- Voltage Linear with inverse Distance
- Know distance to center of roll





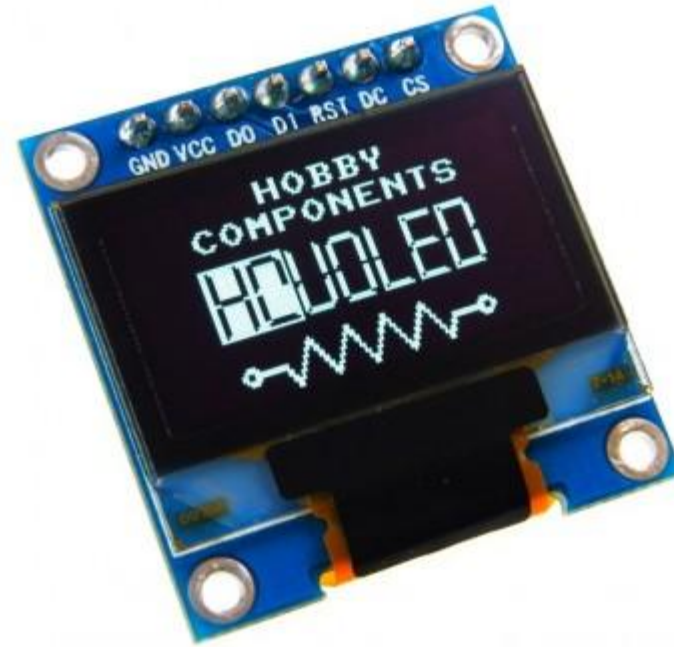
# Light Sensor Circuit

- Outputs High when light on
- Adjustable for varying light conditions



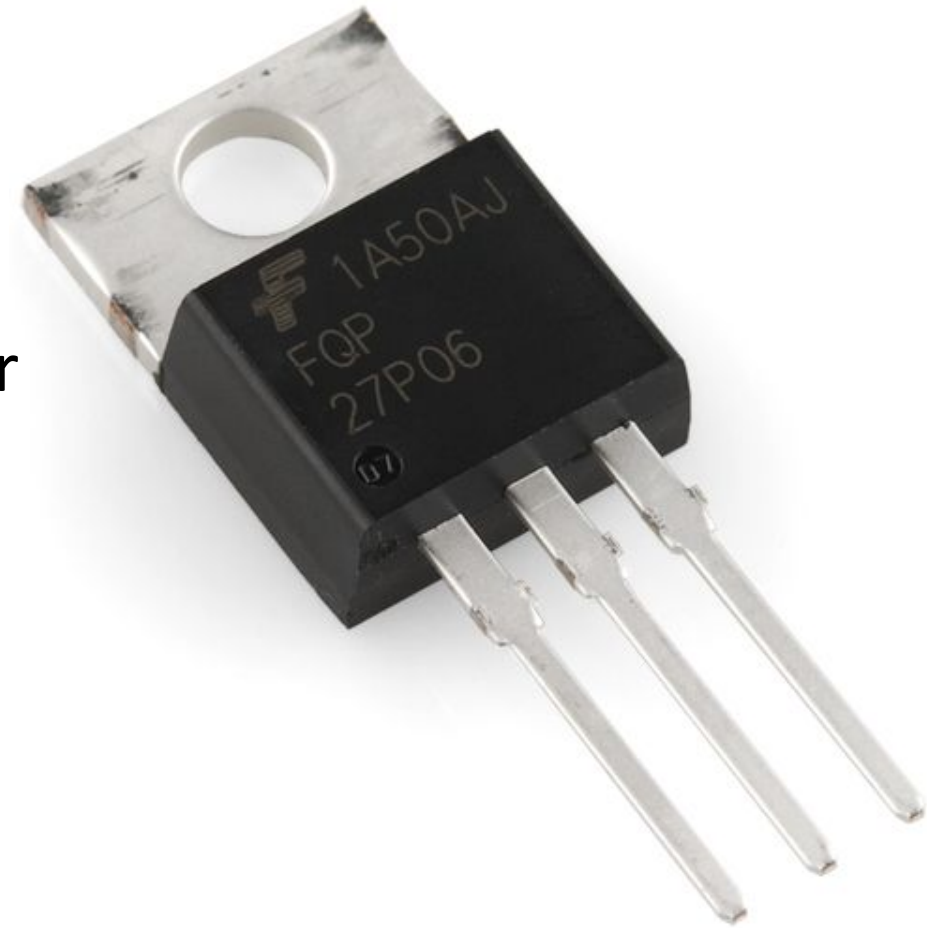
# OLED Screen

- SSD1306 Driver
- Communicates on SPI bus
- 128x64 pixels
- Power considerations
- U8g2 Graphics Library



# MOSFET Power Interrupt

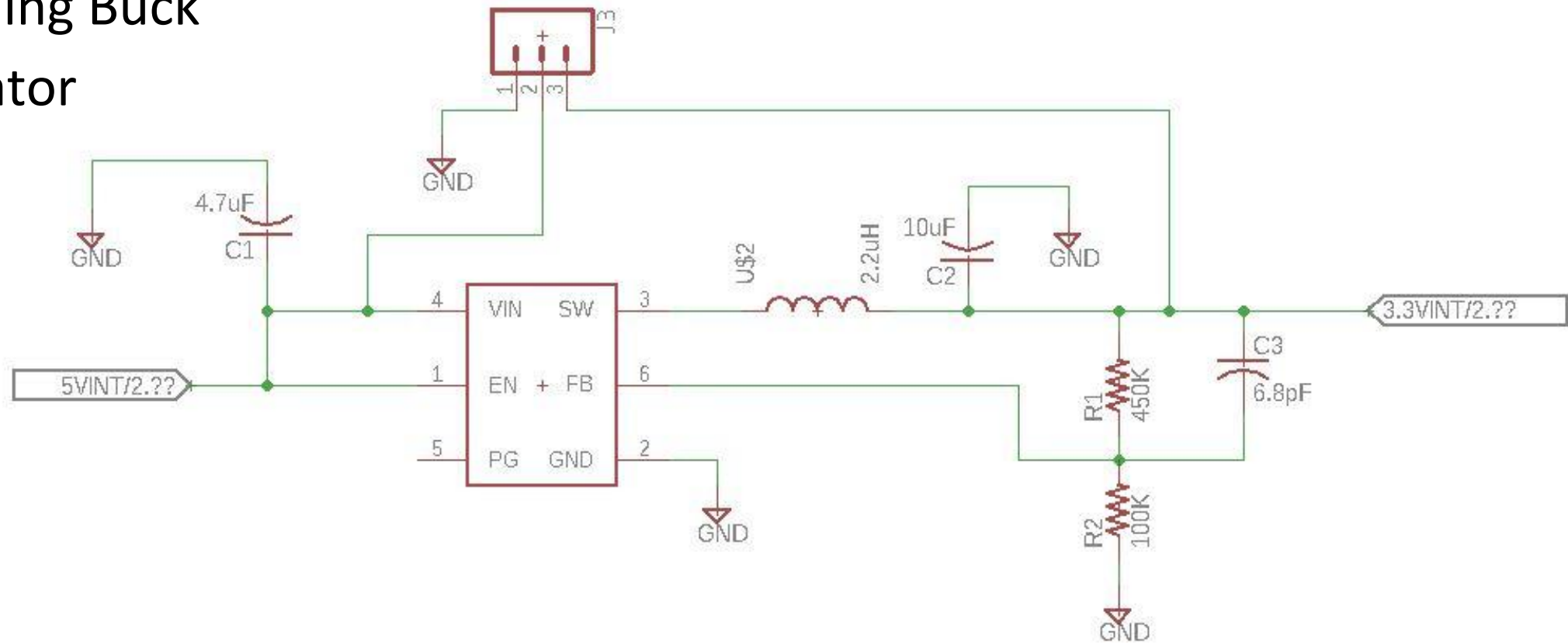
- Cuts power to all sensors and 3.3V regulator
- PNP MOSFET
  - Between Vcc and Sensors
- 2 Amp max
- Inverter used at Gate
  - ATmega sleep mode constraints



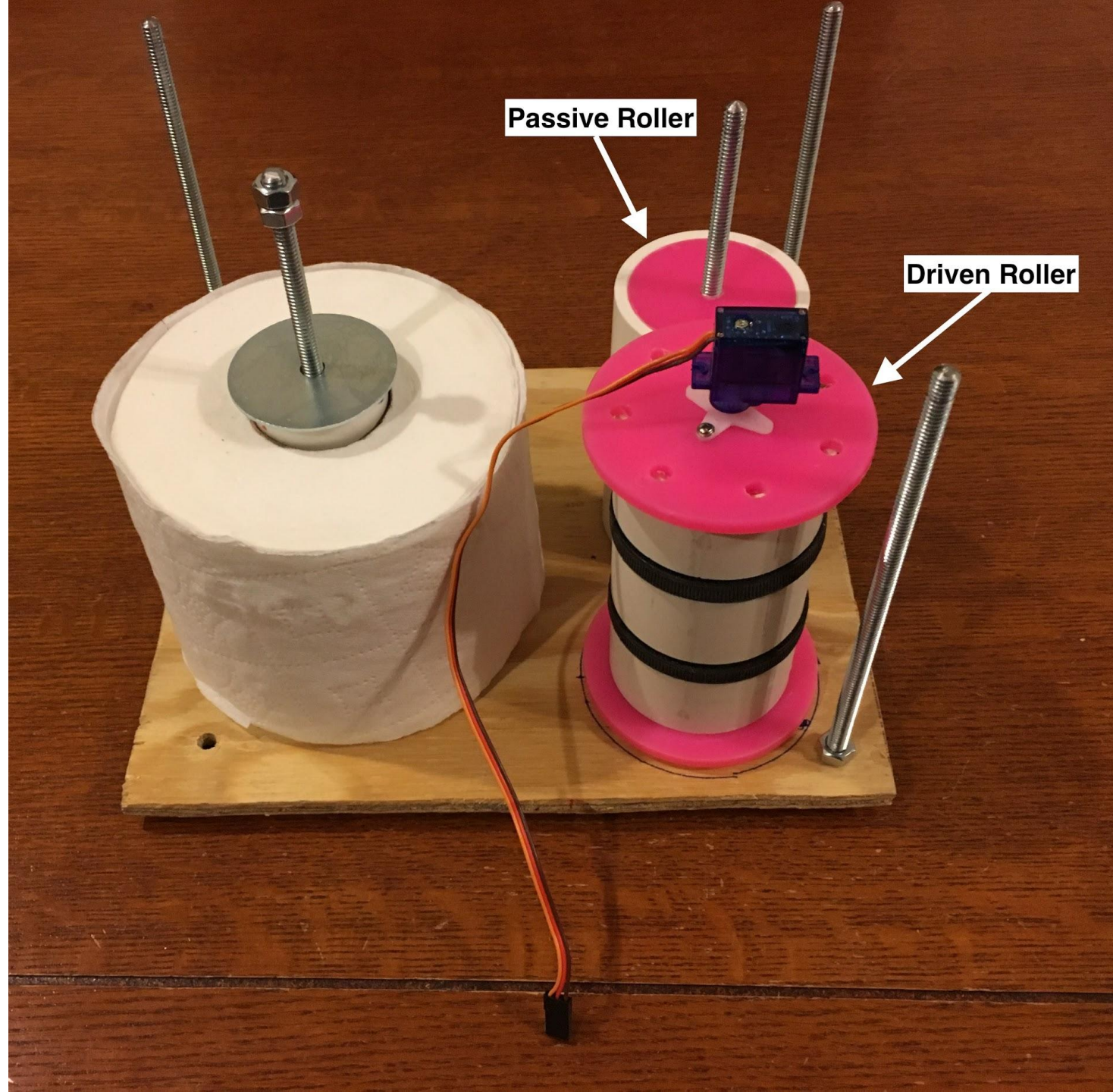


# 3.3V Regulator

- TI TLV62568DBVR
- Switching Buck Regulator

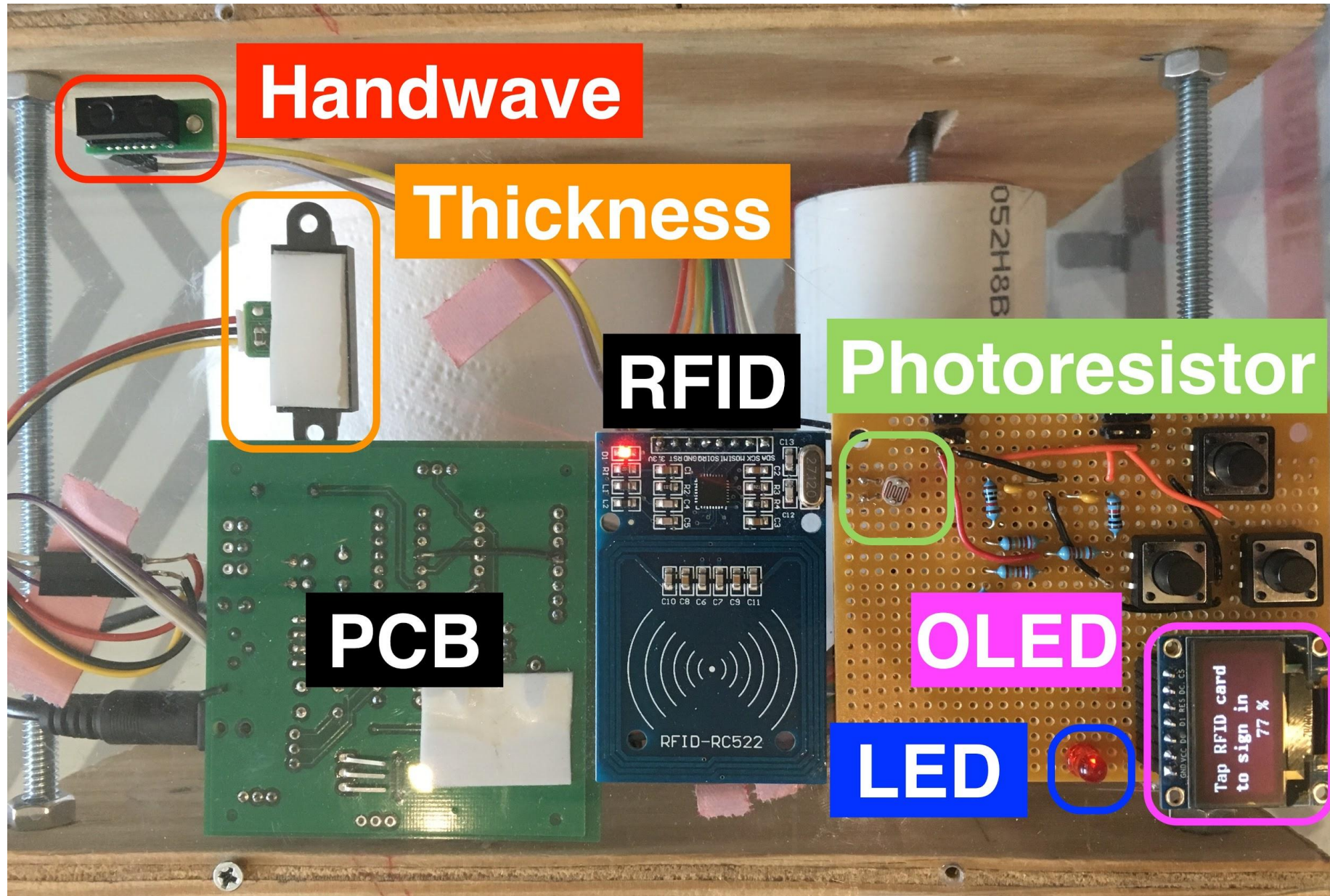


# Mechanical Rollers

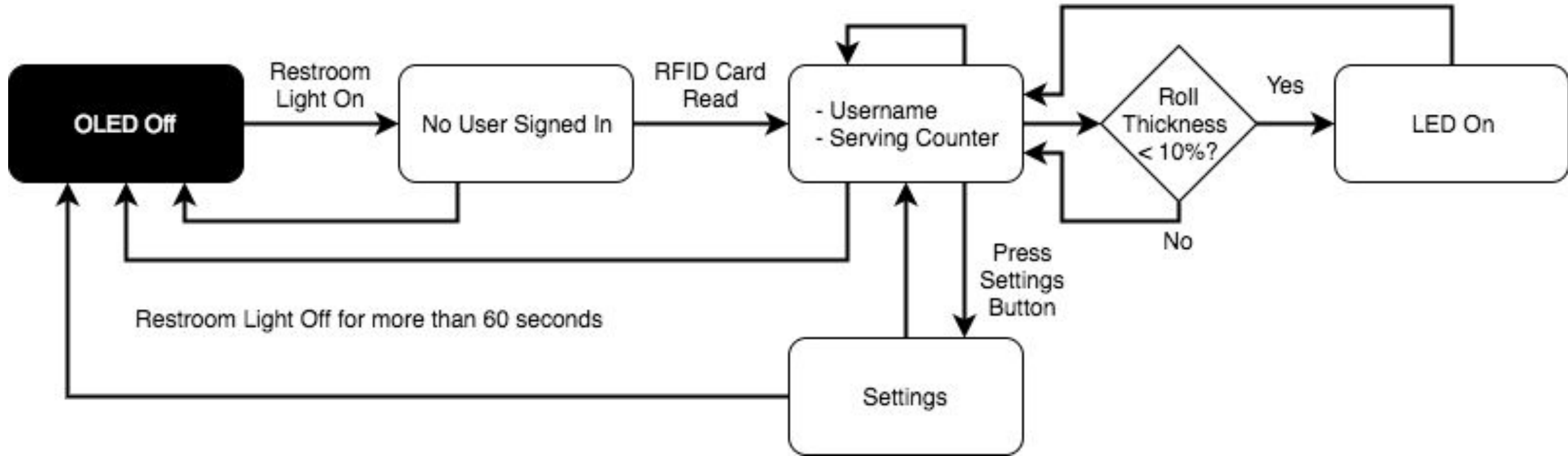




# Design + User Experience

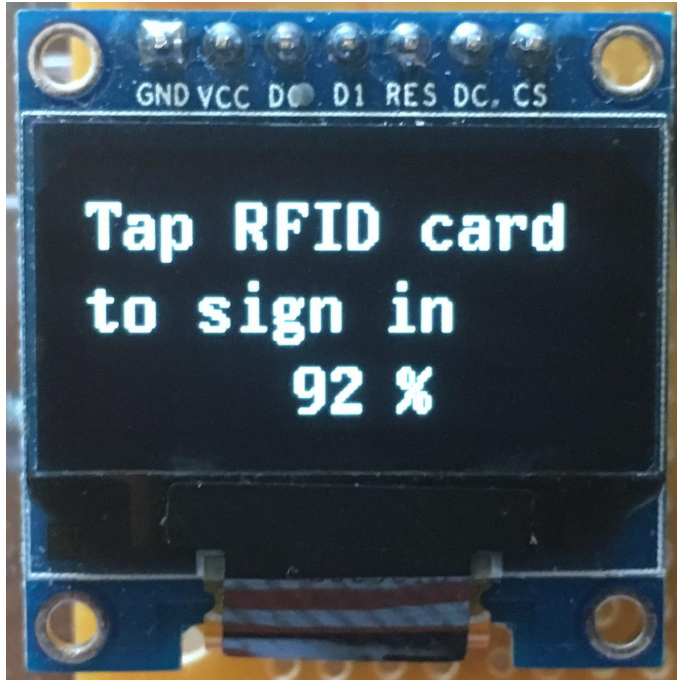






# Software and Functionality

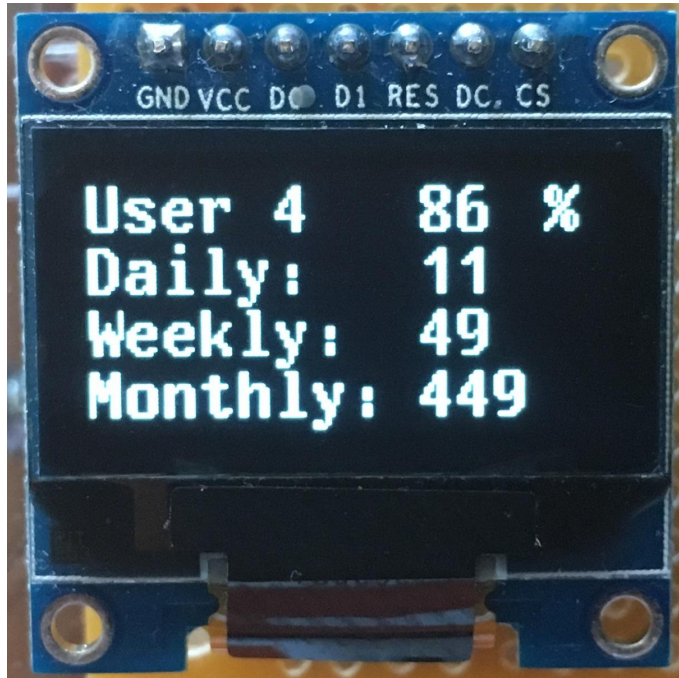
# User Interface



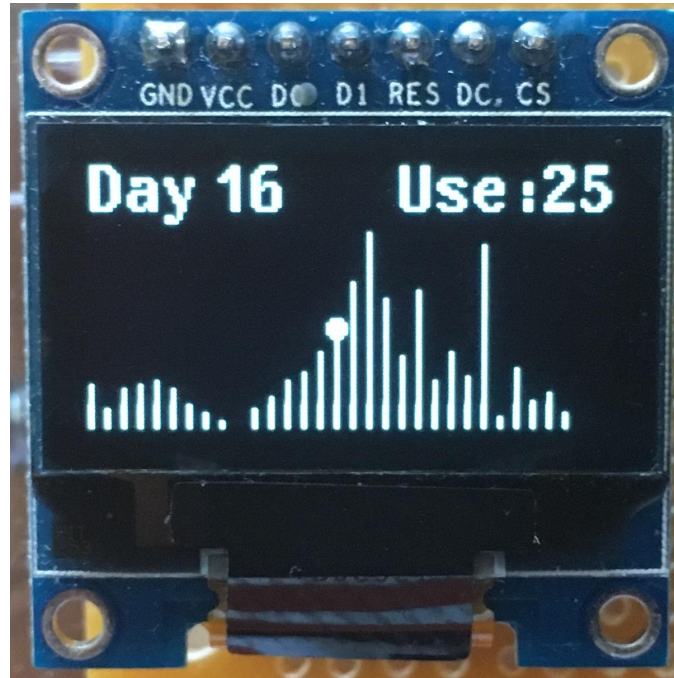
Login Screen

- Login Instructions
- TP Remaining Percentage
- **Core functionality** - hands free
- **Advanced** - button input

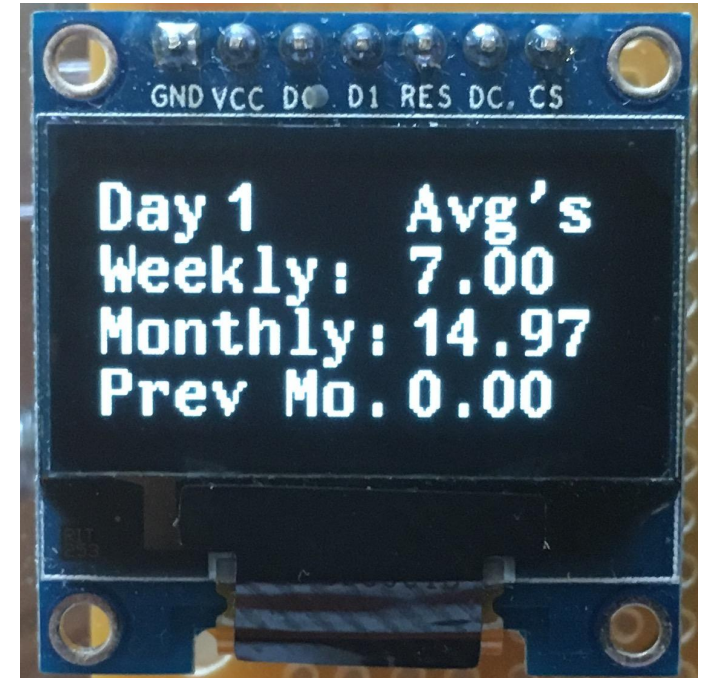
# Information Screens



Usage



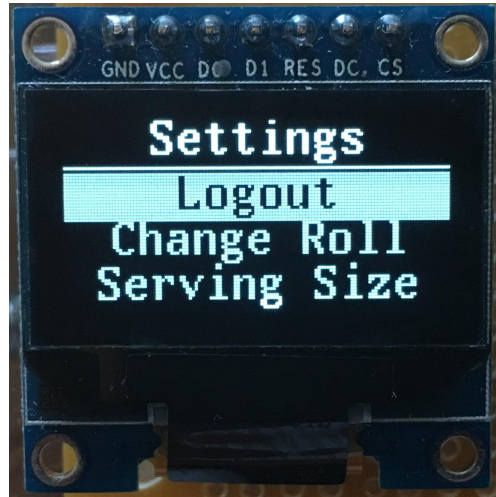
Graph



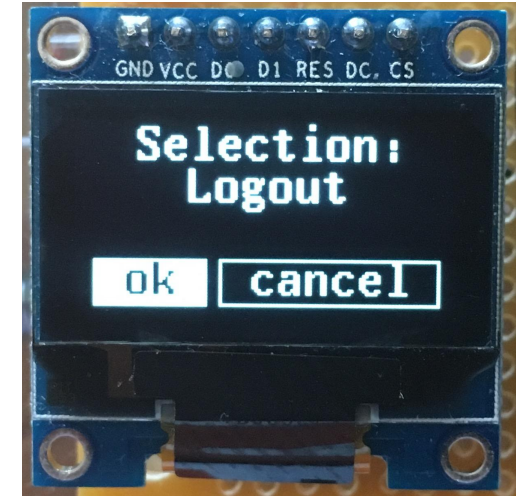
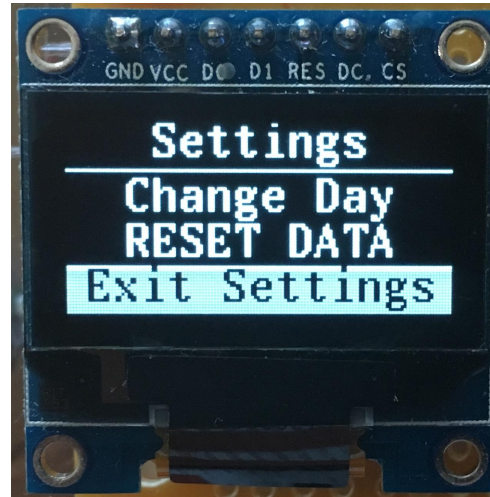
Averages



# Settings



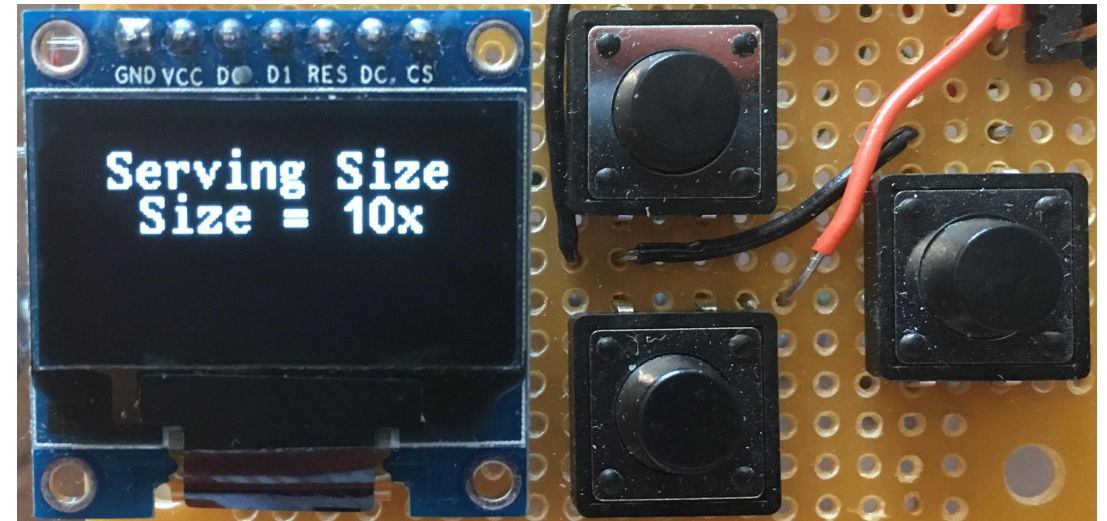
Scrolling



Confirmation



Change Roll -  
Live Updating



User Adjustable  
Serving

# Sleep Mode

- 330uA!
- MOSFET cuts power to sensors
- Write to sleep register
- Watchdog Timer wakes up every 4 seconds
  - Track sleep time

	Sleep Current
<b>ATMEGA328P</b>	100uA
<b>Light Sensor</b>	115uA
<b>MOSFET</b>	100nA
<b>Inverter</b>	60uA
<b>TOTAL</b>	<b>275uA</b>



# Power Comparison

	Peak Current	Nominal Current	Sleep Current
<b>Servo</b>	500mA	100mA	<b>0A</b>
<b>OLED</b>	100mA	20mA	<b>0A</b>
<b>Prox Sensor</b>	10.5mA	5mA	<b>0A</b>
<b>RFID</b>	150mA	100mA	<b>0A</b>
<b>ATMEGA</b>	20mA	20mA	<b>100uA</b>
<b>Light Sensor</b>	-	115uA	<b>115uA</b>
<b>3.3V Regulator</b>	-	35uA	<b>0A</b>
<b>Inverter</b>	-	60uA	<b>60uA</b>
<b>TOTAL</b>	<b>800mA</b>	<b>250mA</b>	<b>275uA</b>

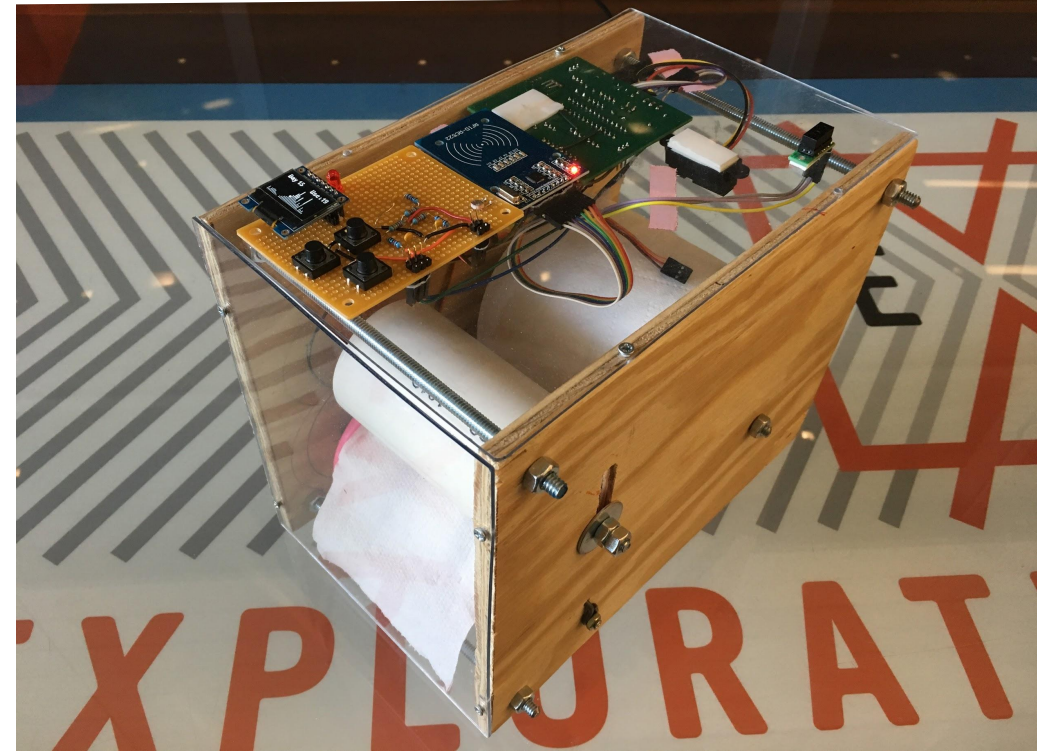
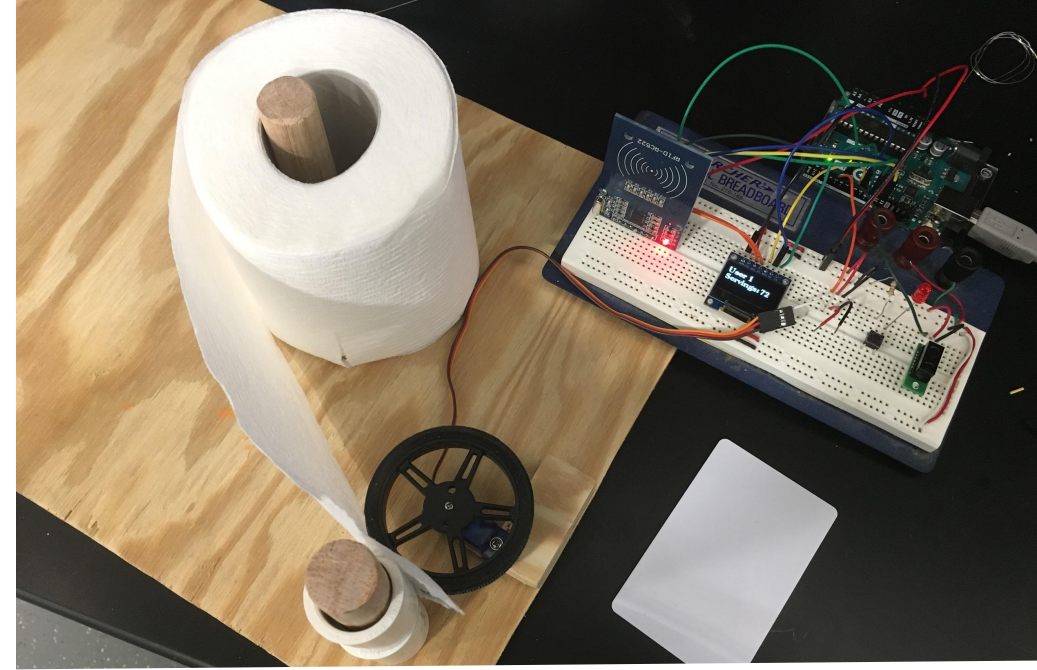
# User Struct

- Object stored in EEPROM
- Weekly and Monthly averages calculated at runtime
- previous\_month - last month's daily average

```
// User Object
struct User {
    uint8_t daily_servings[31];
    int previous_month;
};
User CurrentUser;
```

# Testing and Verification

- Unit tests for each attached sensor + hardware component
- Functional test for each major feature
- Tests ran for each hardware revision
- Serial monitor for debugging and data logging



# Cost Analysis

- Cost will drop 30-50% when components bought in bulk.

Component	Manufacturer	Price (\$)	Quantity
IR Prox Sensor	Sharp	\$5.95	1
IR Distance Sensor	Sharp	\$14.00	1
Microcontroller	Atmel	\$3.00	1
OLED	HiLetgo	\$9.99	1
Servo	Adafruit	\$5.95	1
RFID reader	Mifare	\$6.00	1
RFID card	QIAOYUAN	\$0.80	5
Photoresistor	API	\$0.95	1
Potentiometer	Bourns	\$1.02	2
Comparator	Microchip	\$0.58	1
Inverter	Texas Instruments	\$0.52	1
Pushbutton		\$0.50	4
Voltage Regulator	Texas Instruments	\$1.10	1
MOSFET interrupt	Fairchild	\$0.95	2
Assorted RLC		\$5.00	1
Enclosure Wood		\$5.00	1
TOTAL		\$67.98	



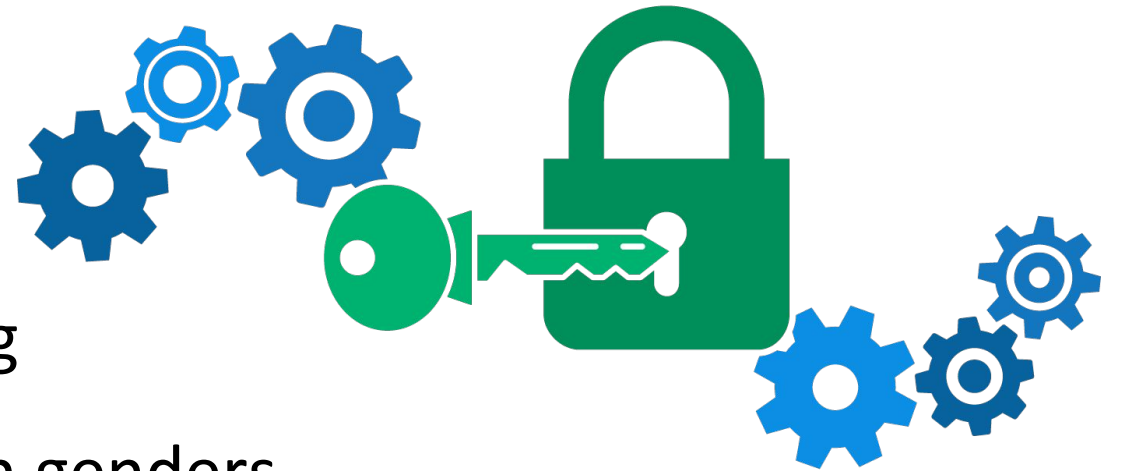
# Is this reasonable?

- Commercial dispenser cost:  
**\$20 - \$50**
- Portioned Paper Towel Dispensers  
**Cut usage by 30%**



# Ethics

- RFID is not most secure sign in
- Data is not encrypted
- Device is only for personal tracking
- Toilet paper usage differs between genders



# Conclusion and Further Work

- Works as expected!
- Wifi connection with server, stream statistics
- Mobile phone + NFC

