Junior Design II (Winter 2021)

Smart Coop Developer Guide

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System Overview

The Smart Chicken Coop regulates and monitors the environment within the chicken coop. The sensors will measure food levels, water levels, minutes of daylight, and temperature. The system will control when the lights are turned on, an automatic door on the chicken coop, and the warning lights to alert the owner of low food, low water, and light failures. The data collected by the sensors and the total energy consumed by the system will be stored in an onboard SD card. By running the text file produced on the SD card through the MATLAB graphing script, graphs of the relevant data will be produced. The system is secured within a 3D printed enclosure, making it weather resistant. The enclosure has an LCD display that shows the current temperature of the chicken coop.

Electrical Specifications

Parameter	Min	Typical	Max	Units
12V_Vin Voltage	6	12	20	Volts
12V_Vin Current	2	N/A	3.5	Amps
Operating Temperature	-40	22	85	Celsius

Table 1: Electrical specifications of the entire system

User Guide

Setup:

1. Secure the enclosure to the wall or roof of the Chicken coop. Be sure to orient the enclosure in a way that the LCD can be seen and the SD card can be accessed.
2. Place the light sensor in a place where it is exposed to sunlight.
3. Place the food and water distance sensors over the food and water sensors.
4. Position the LED strip in a location where it will light up the desired area of the chicken coop.
5. Connect the patlite signal tower to the warning light wires, then position the tower where it can be easily seen.
6. Secure the automatic door structure to the door of the chicken coop.
7. Put SD card into the SD card reader located at the back of the enclosure
8. Connect 12V supply to a standard wall outlet.

Use:

- The LCD will display the current temperature in Celsius.
- To access the data on the SD Card, follower these steps:
    a. Remove the SD card gate to reveal the SD Card reader in the enclosure.
    b. Remove the SD card from the reader, then replace the gate.
    c. Use a computer to access the contents of the SD card and retrieve the text file.
    d. Place the text file and the provided “graphdata.m” MATLAB script into the same directory. Then run the MATLAB script. This will produce graphs of all the data stored on the SD card (food levels, water levels, minutes of lighting, and energy consumption).
    e. To clear the and start a fresh collection, delete the text file from the SD card.
    f. Return the SD card to the SD card reading in the enclosure to begin reading data again.

Electrical Schematics

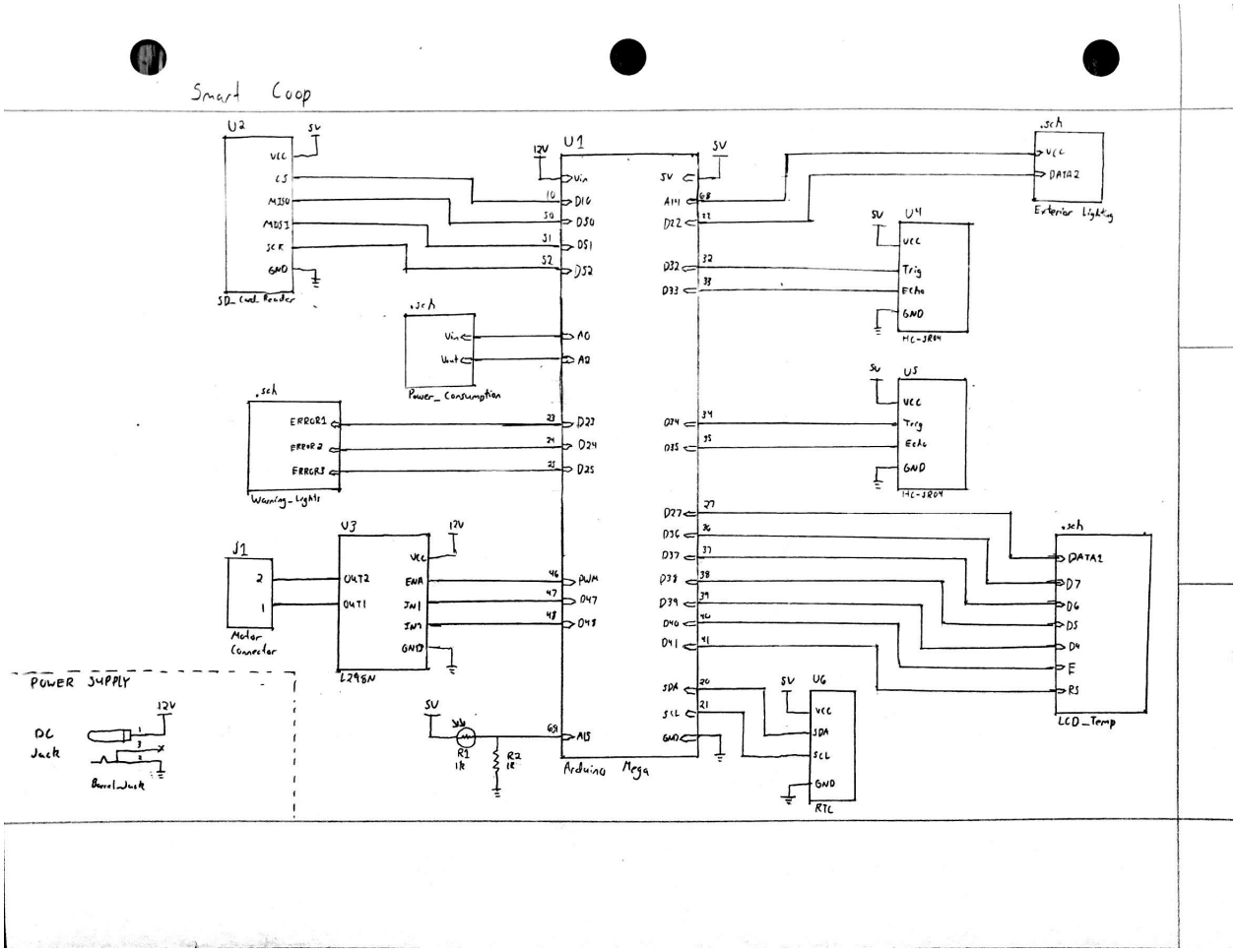


Figure 1: Top-Level schematic of the Smart Coop System

This schematic shows how all of the components connect to the Arduino Mega and the 12V power supply. There are a total of 9 different components that connect directly to the Arduino Mega, using 25 digital pins and 4 analog pins, as well as all of the Vout and GND connections.

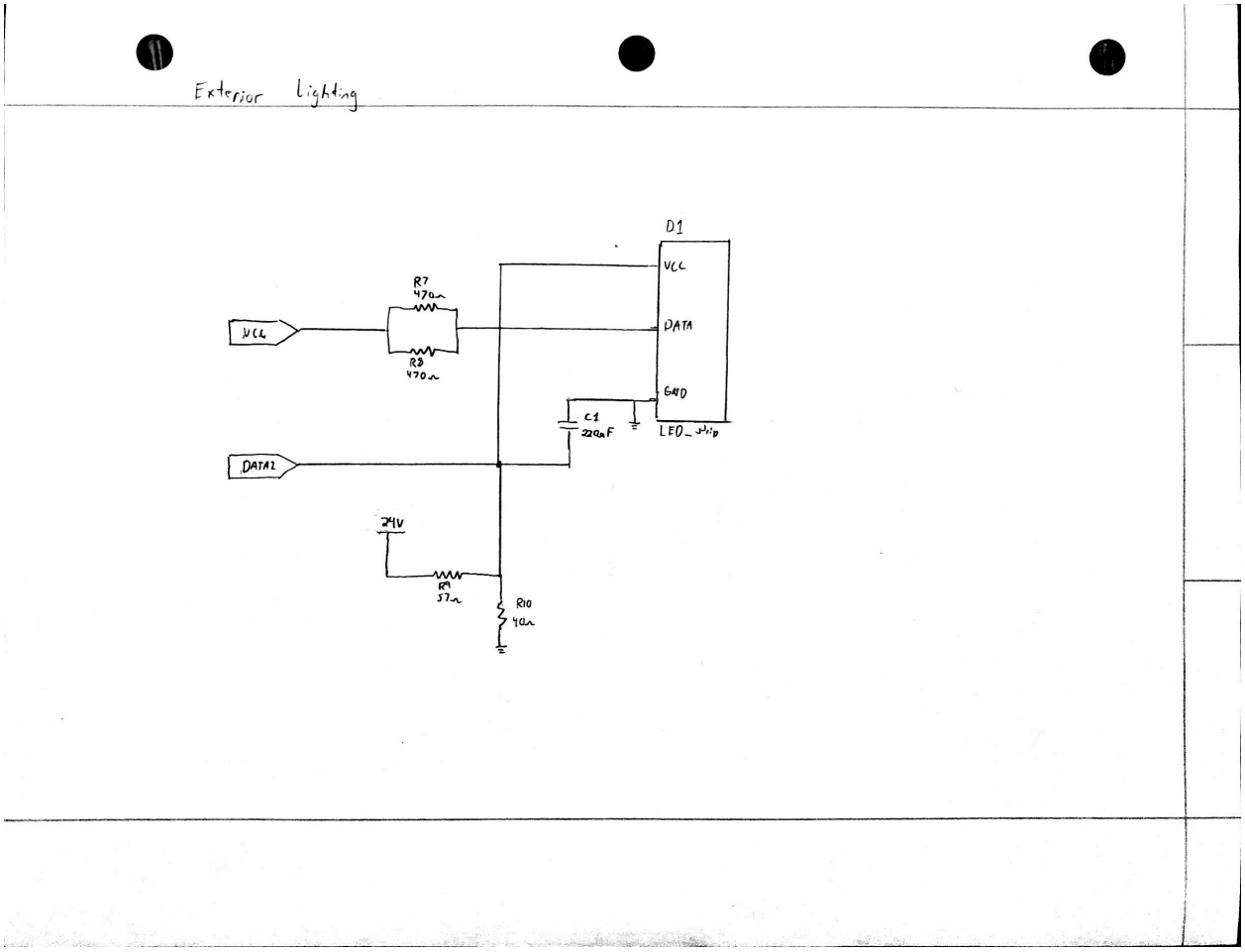


Figure 2: Exterior Lighting schematic

This schematic shows the connections between the Arduino, 12V main power supply, and WS2812B addressable LED strip. The system takes the 12V supply, and through a voltage divider, lowers the input voltage to the LED strip to 5V. Data is transmitted over a digital pin to the LED strip at a rate of 800KHz. There is a 220uF capacitor shorted from 5V to ground to filter out any residual AC voltage signal.

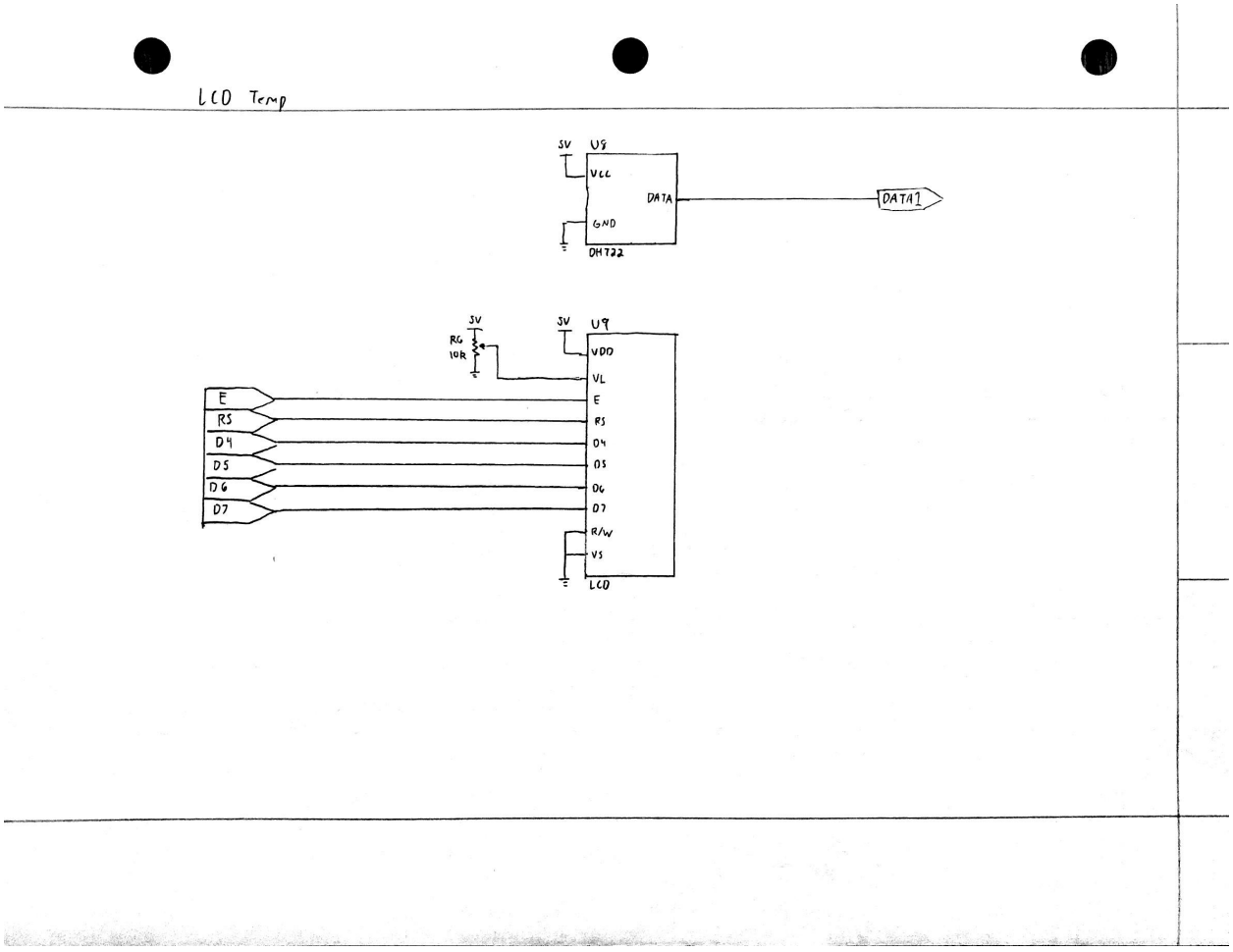


Figure 3: LCD Temperature Display schematic

This schematic shows the connections between the Arduino, DHT22 temperature sensor and the LCD. Both the temperature sensor and display are powered by the micontroller's 5v pin showing the ambient temperature within ± 1 degree celsius.

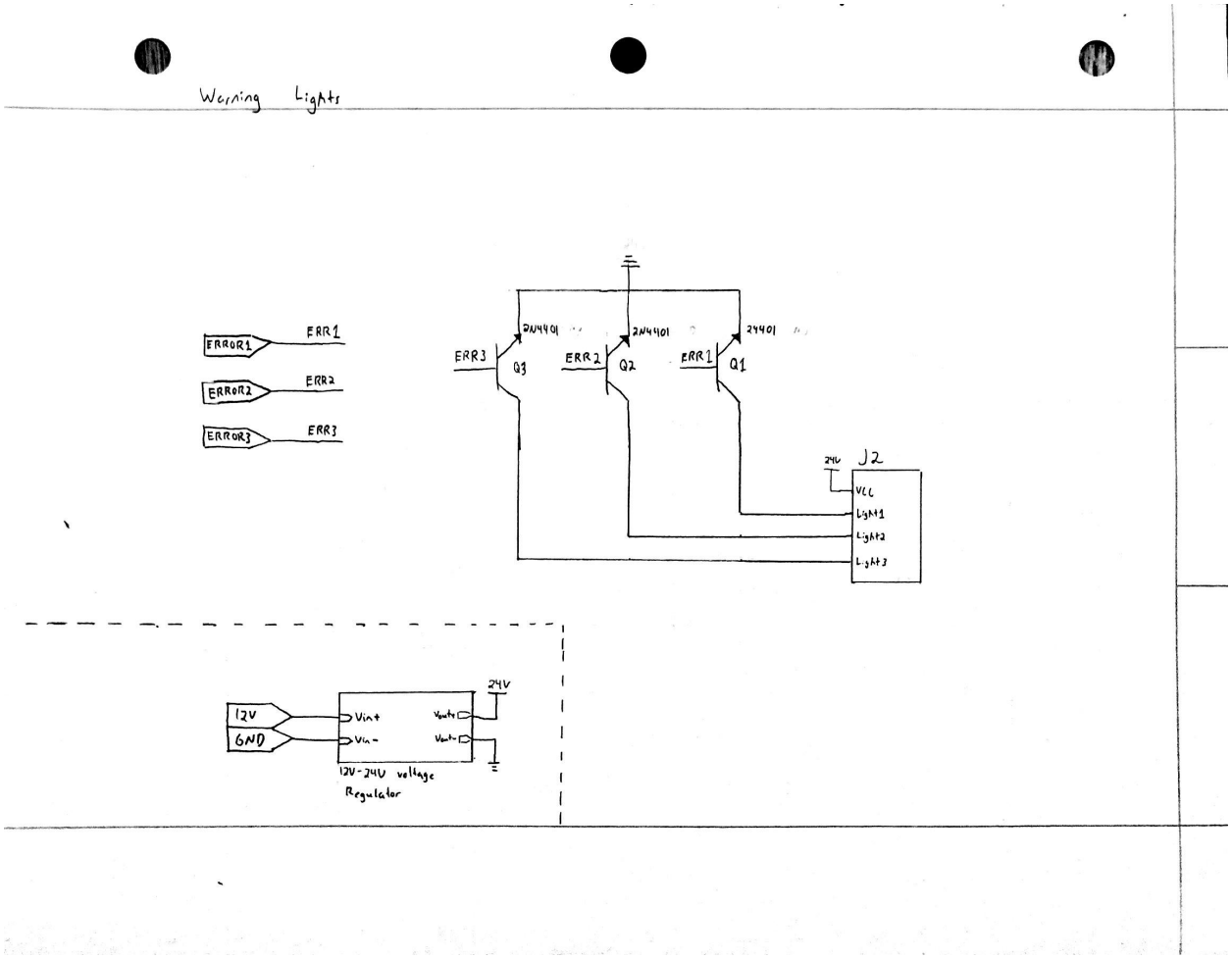


Figure 4: Warning Lights schematic

This schematic shows the transistor connection for the warning light module. The transistors get a signal from the Arduino at the base connection when one of the warning lights needs to turn on. This will allow current to flow from the 24V source through the Patlite Signal Tower and turn on the corresponding light.

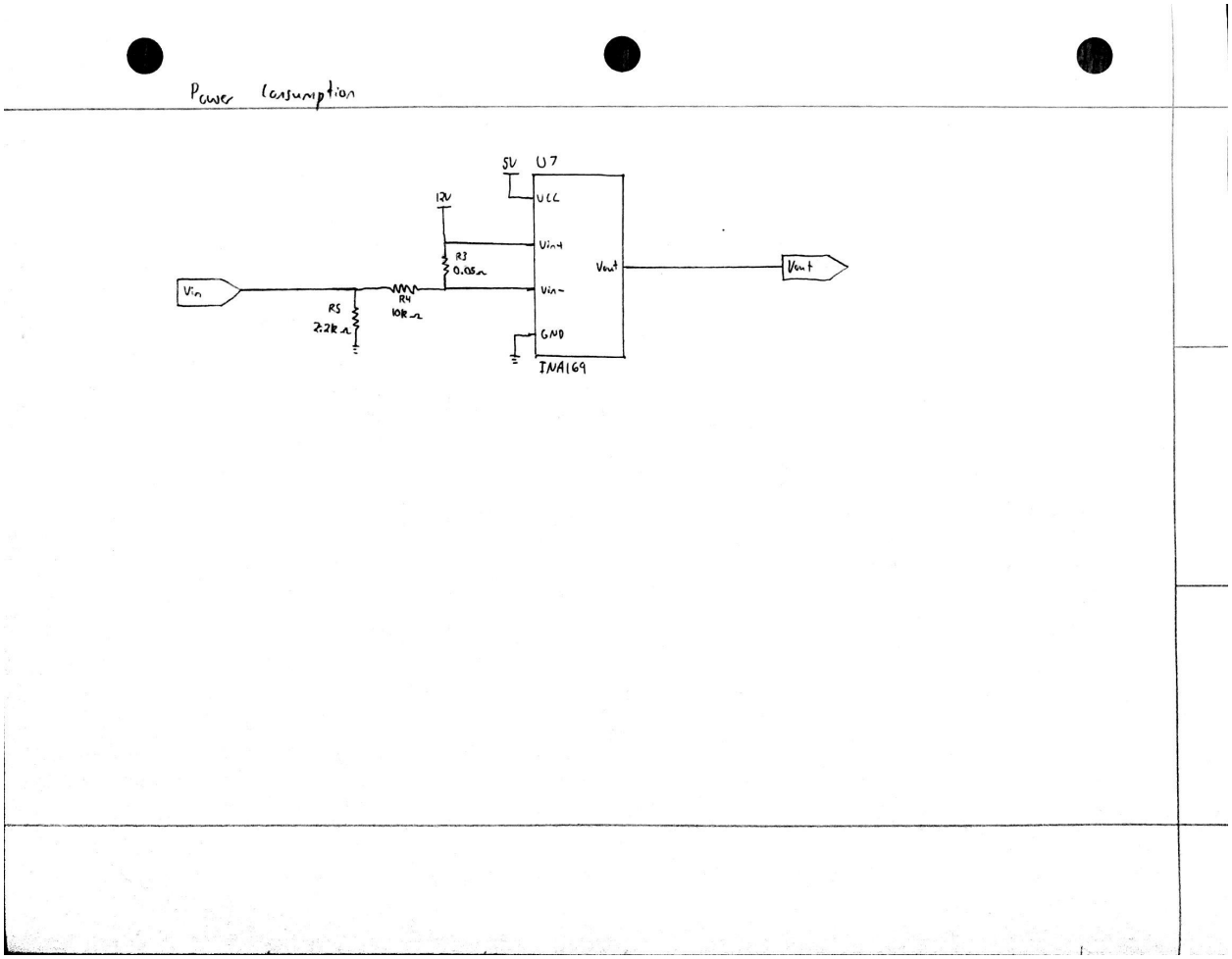


Figure 5: Power Consumption Schematic

This schematic shows how the system determined the overall energy consumption. Since the whole system is powered by a single 12v DC source, the input power is measured with the INA169 current-sense board and the voltage across a divider to not damage the microcontroller.

3D Models

Main Enclosure

This enclosure design contains many of the electronic components of the Smart Chicken Coop. This includes the Arduino Mega, PCB, SD card, LCD, and any other circuit components that need to be protected. This enclosure consists of 4 main components: the base plate, the top plate, the SD card gate, and the 8 identical opening caps. In the final presented enclosure, the top plate has been manually extended taller to fit more components. The following figures are the enclosure 3D model assembled and taken apart.

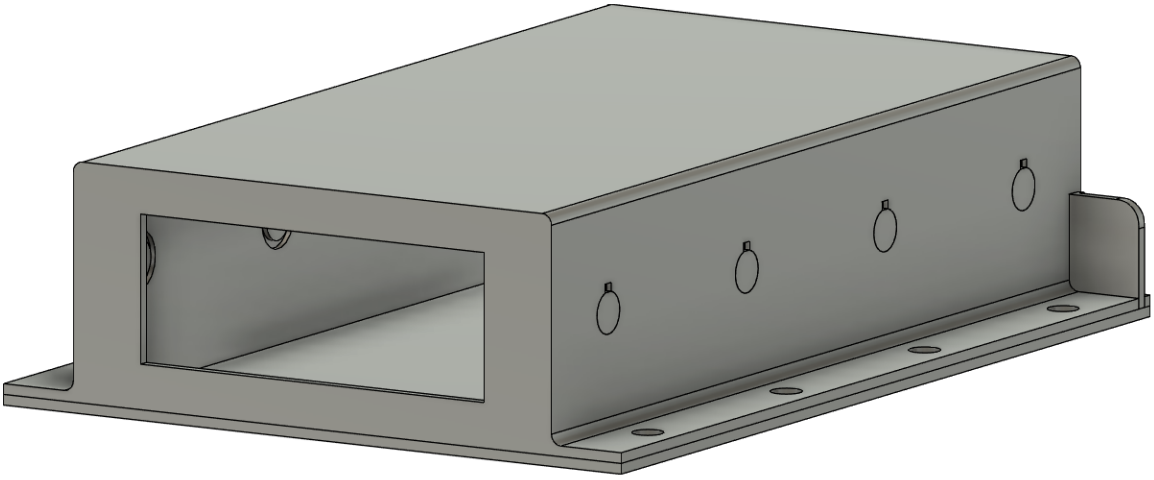


Figure 6: Assembled enclosure model

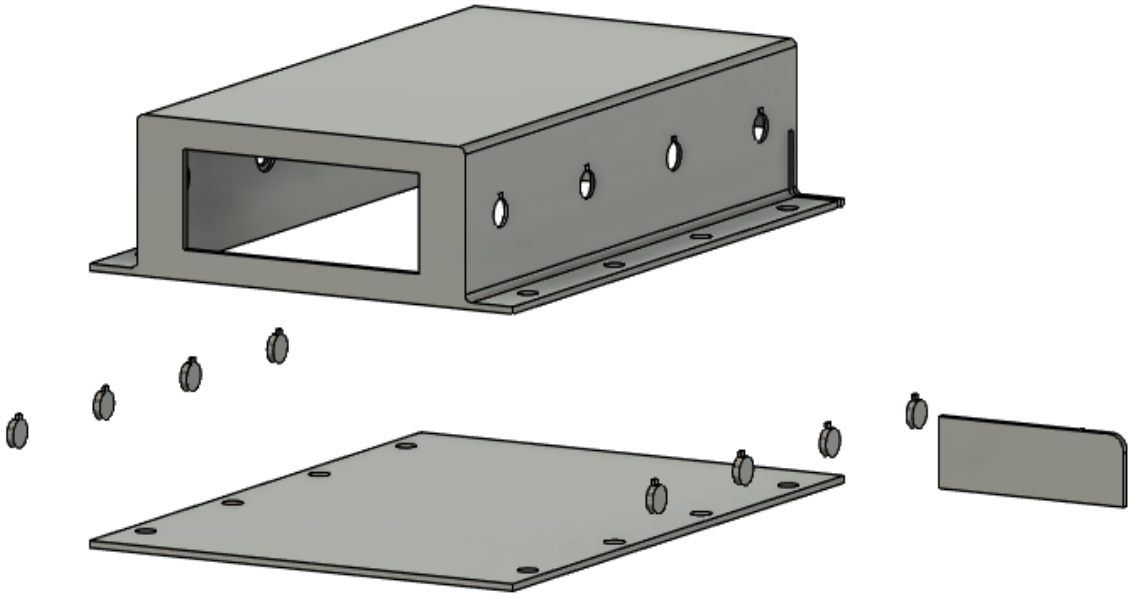


Figure 7: Disassembled enclosure model

Distance Sensor Enclosure

The enclosure design is meant to contain an HC-SR04 ultrasonic distance sensor. It is also designed to fit on top of a cylinder that has a radius of 6.25 inches that acts at the container that holds the food and water. The enclosure is designed to keep water out and away from the HC-SR04 when the base of the enclosure is attached to the cylinder.

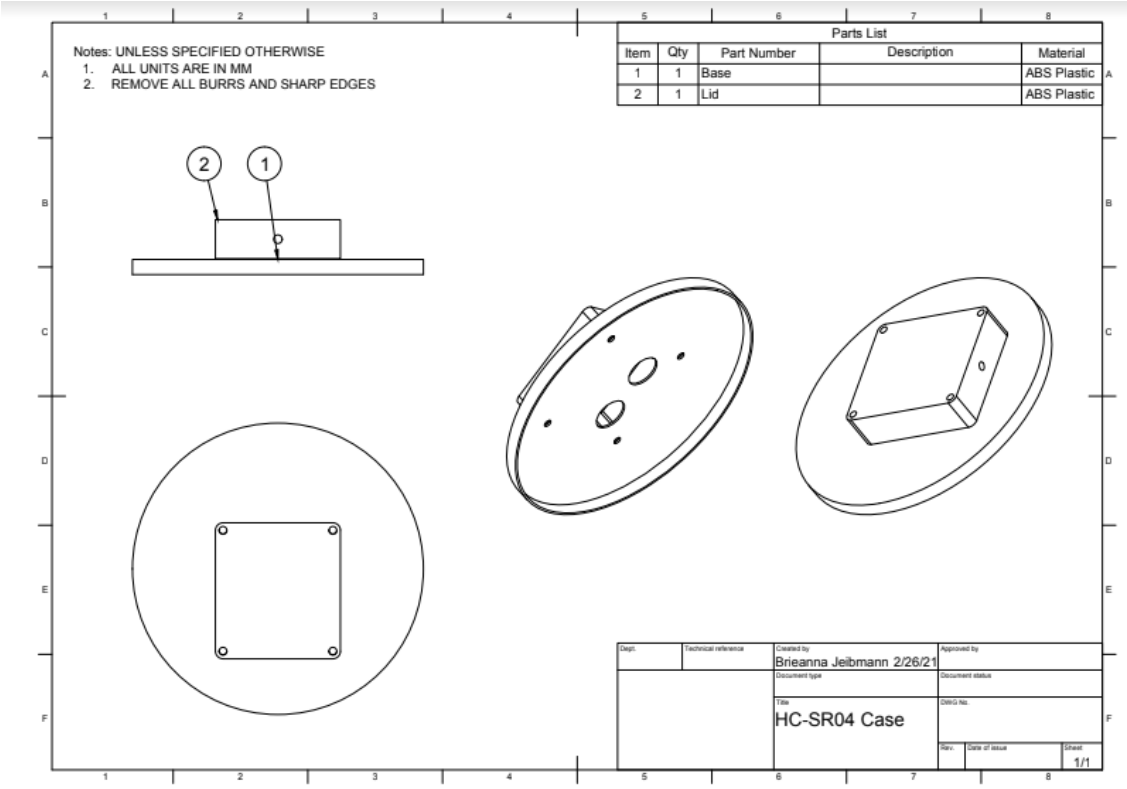


Figure 8: Distance Sensor Enclosure Mechanical Drawing

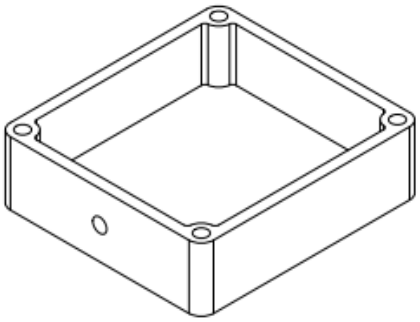


Figure 9: Internal structure of the enclosure. Screw holes are separate from the main space that will hold the sensor to prevent water from seeping in.

Block Diagrams and Interface definitions

Top-Level Block Diagram and Interface Definitions

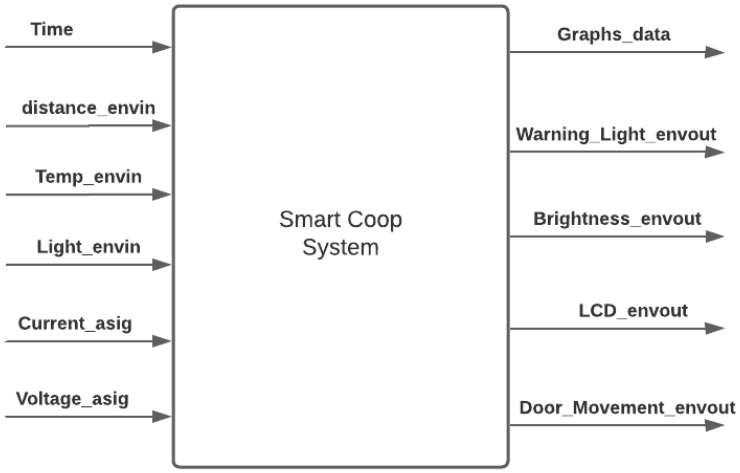


Figure 10: Black Box Diagram of system

The black box diagram shows the inputs that affect the Smart Coop system, and what those inputs produce. There are 6 inputs, time from the RTC, distance from distance sensors, temperature from temperature sensors, light from light sensor, voltage from the 12V source, and current from the 12V source. There are 5 outputs, the SD card data to graph in MATLAB, the warning lights, the lighting of the chicken coop, the LCD temperature reading, and the door movement.

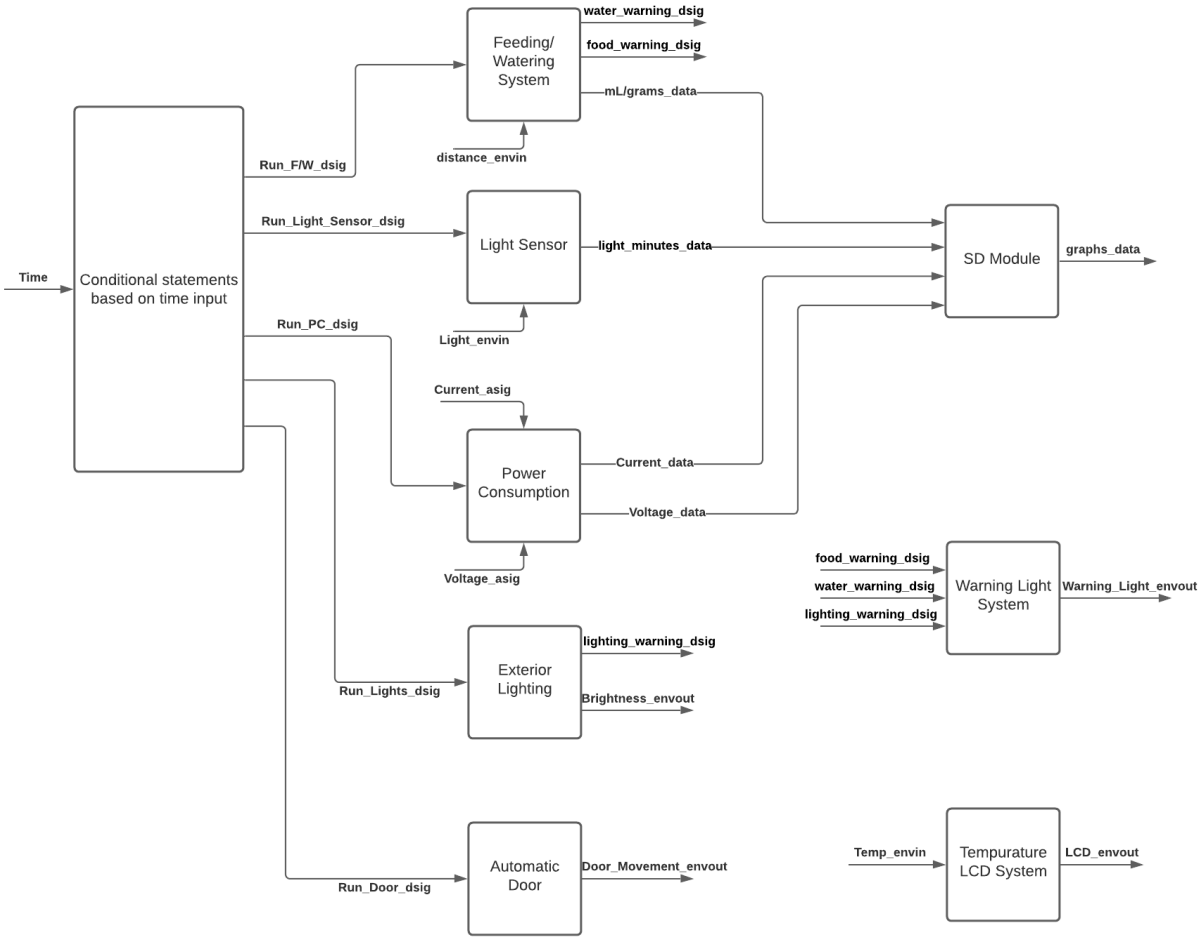


Figure 11: Top-Level Block Diagram

The top level block diagram shows the inputs and outputs of each individual block. In total, there are 8 blocks that represent physical components and one conditional statement block that represents the RTC decision making in the Arduino code.

Interface Name	Interface Type	Specifies
Time	Other	● Frequency = 1Hz ● Hour, minute, seconds
food_warning_dsig	Digital signal	● Vmax = 5V ● Vmin = 0V ● When signal is high, corresponding light turns on
water_warning_dsig	Digital signal	● Vmax = 5V ● Vmin = 0V ● When signal is high, corresponding light turns on
lighting_warning_dsig	Digital signal	● Vmax = 5V ● Vmin = 0V ● When signal is high, corresponding light turns on
mL/grams_data	Data	● Float value ● Converted from distance measurement
Temp_envin	Environmental Input	● The ambient temperature
LCD_envout	Environmental Output	● Measured temperature on the LCD
Door_Movement_envout	Environmental Output	● Door opens or closes ● RPMmax = 520 RPM ● RPMmin = 0 RPM
Voltage_asig	Analog signal	● Voltage measured from 12v source powering the rest of the system through a divider
Current_asig	Analog signal	● Current measured using a current sensing breakout board
Current_data	Data	● C/C++ Language ● Value will be written to an SD card via txt file
Voltage_data	Data	● C/C++ Language ● Value will be written to an SD card via txt file
light_minutes_data	Data	● Integer of value 0-60 ● Specifies the amount of daylight minutes per hour
Brightness_envout	Environmental Output	● Vmax = 5.5V ● Vmin = 0V ● Imax = 1.2A ● Imin = 0A
Warning_Light_envout	Environmental Output	● Vmax = 24V ● Vmin = 0V ● Red Light = Food Warning ● Yellow Light = Water Warning

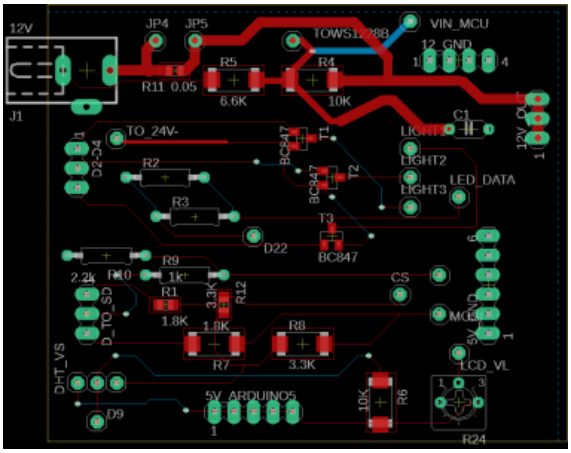
		• Green Light = Light Warning
Run_F/W_dsig	Digital signal	• Signal to run Feeding/Watering System • Vmax = 5V • Vmin = 0V
Run_Light_Sensor_dsig	Digital signal	• Signal to run Light Sensor • Vmax = 5V • Vmin = 0V
Run_PC_dsig	Digital signal	• Signal to run Power Consumption • Vmax = 5V • Vmin = 0V
Run_Lights_dsig	Digital signal	• Signal to run Exterior Lighting • Vmax = 5V • Vmin = 0V
Run_Door_dsig	Digital signal	• Signal to run Automatic Door • Vmax = 5V • Vmin = 0V
distance_envin	Environmental Input	• Range of 2cm to 400cm • Is measured using an Ultrasonic signals at 40Hz
Graphs_data	Other	• Tab-delimited text file where data is written to

Table 2: Interface definitions for the top-level block diagram of the system

PCB Layers

The custom PCB in the Smart Coop system is 2.625 inches **X** 2.1875 inches. The PCB is designed to contain all of the components that are not a part of premade modules. It also acts as a power rail that supplies all the 12V and 5V sources of the system and contains a common ground for the system.

a)



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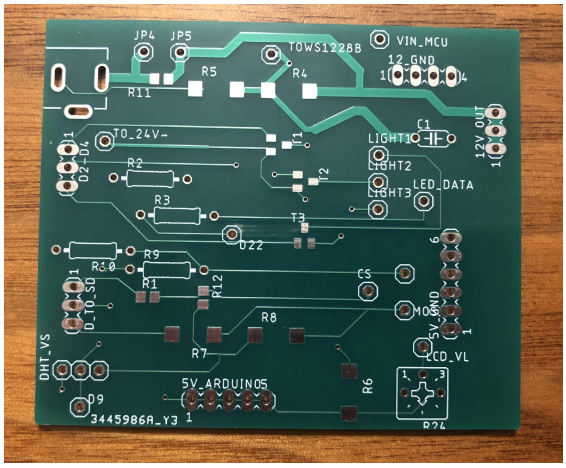

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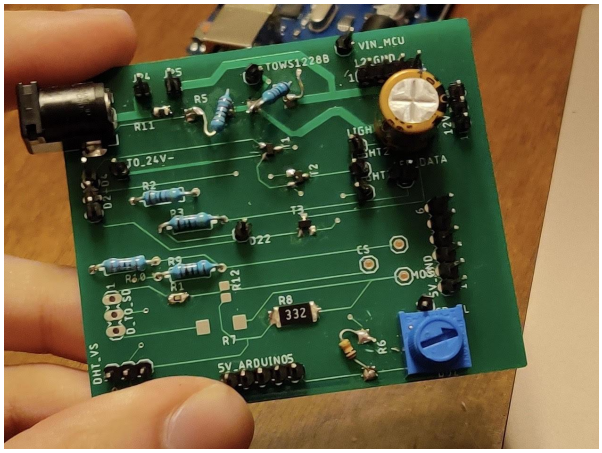

Figure 12: a) PCB Layout in Eagle b) Manufactured PCB
c) Fully assembled PCB

Parts Information

Item Name	Vendor/Retailer	Quantity	Cost (Price + S/H)	Notes
Modules				
ELEGOO MEGA 2560 R3 Board	Amazon	1	$16.99	Equivalent to Arduino Mega Board
2x16 LCD Module	TekBots	1	$9.00	
DHT22 Temperature Humidity Sensor	Amazon	1	11.98	2 pcs per order
WS2812B LED Strip, 3.3ft	Amazon	1	$9.99	(Trimed to length, only used 1/5 of total length due to power draw)
Ultrasonic Sensor (HC-SR04)	TekBots	2	$12.00	$6.00 per sensor
SD Card Module Slot Socket Reader	TekBots	1	$2.00	
Kingston Canvas Select 16GB microSDHC	TekBots	1	$9.00	
12V DC Gear Motor	TekBots	1	$5.00	
DC Motor Controller (L298N)	TekBots	1	$5.00	H-bridge motor driver
DS3231 Real Time Clock Module	Amazon	1	$8.99	2 pcs per order
INA169 High Side DC Current Sensor Breakout	Digikey	1		Previously Owned
dkplnt 12V to 24V Voltage Regulator	Amazon	1	$9.99	Weather Proof (IP68)
Enclosure 3D Print	TekBots	1	used free voucher	One print for all enclosure components
12V 3.5A Switching Wall Adapter	TekBots	1	$9.00	
Individual Components				
Potentiometer, 10K	Amazon	1	$6.99	10 pcs per order
DC Power Connector	Digikey	1	$0.60	
Shunt Resistor, 0.05 Ohm		1		Previously Owned
Capacitor, 220uF		1		Previously Owned
Resistor, 470 Ohm	Digikey	2	$0.20	
NPN Transistor	Digikey	3		Previously Owned

Resistor, 1k Ohm		1		Previously Owned
Resistor, 57 Ohm		1		Previously Owned. Replaced with a 47 ohm and 10 ohm resistors
Resistor, 40 Ohm		1		Previously Owned. Replaced with 2 20 ohm resistors
Resistor, 10k Ohm		1		Previously Owned
Resistor, 2.2k Ohm		1		Previously Owned
Photoresistor, 1k		1		Previously Owned
Photocell Enclosure	Amazon	1	$6.50	Used enclosure only, gutted internal components that didn't work for project
Wiring and Connecter things				
3/16in Vinyl Tubing, 25ft	Amazon	1	$6.99	
1X4 0.1" Female Header	TekBots	2	$1.00	3 pcs per order
JST PH 2pin Plug and Connectors	TekBots	1	$1.00	10 pcs
1X34 0.1" Male Header	TekBots	1	$1.00	Broken into several peices for different uses
Female to Female .1" Jumper set	TekBots		$6.00	40 wires in a set
Male to Male .1" Jumper set	Amazon		$5.99	80 wires in a set with 4 and 8 inch wires
Male to Female .1" Jumper set	Amazon		$5.99	80 wires in a set with 4 and 8 inch wires
26 AWG 4-core Shielded Copper Wire Cable	Amazon	1	$8.99	for external wiring, cut to length
4pin Plastics Waterproof IP65 Connector	Amazon	2	$9.99	
33ft RGB wire 22AWG	Amazon	1	$9.99	for external wiring, cut to length
4 inch Zip Ties	Dollar Tree	many	$1.00	wire management.

Table 3: Parts Information