San Diego State University

ECE System Integration Test Report

EE/COMPE 496B Senior Design

Team 14, Project 25: Rapid Deployment Runway Closure System

The Blockage Brigade

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Executive Summary

In this system integration test report, the team has executed several tests and is on track to completing the project. The first test that was performed was the wind and resistance test. Here, the team conducted a wind and sand resistance test to see how the fans would handle the wind and sand. After this, the team carried out a wiring harness continuity test. This test verifies that the wires are properly connected to the harness. Then, the button/LED test was executed. This test is to verify the buttons and LEDs on the PCB are functional and interacting with each other correctly. Next, the team did a solar panel voltage and current test. For this test, the team used the solar panel and analyzed the voltage and current coming from it. Another test was the hall effect input test. In this test, the team has Hall effect sensors connected to the PCB and have it trigger the LEDs which are supposed to turn off the LED completely using a magnet. Lastly, the team executed a components test. For this test, the team grabbed a couple blocks of code and uploaded it to the Arduino to see if the fans and motors were able to work using the PCB and wiring harness.

Without these tests, the team would not know where the problems are located in the system. After concluding all these tests, the team experienced some failures and was able to determine the solutions. There was trouble having the LEDs stay lit when the Arduino was connected and there was a problem with putting a magnet to one of the hall effect sensors that the LED started to flicker rather than turn completely off. A more detailed explanation of how these problems were fixed are found in the individual test and results section of this report.

In conclusion, it is clear that the team is ready to move on with the project and begin the final stages of the system.

Test Plan

Wiring Harness Continuity Test

1. This test verifies that the wires are properly connected to the harness.
2. Need to analyze that there is throughput going through the wire.
3. When analyzing the wiring harness, the team is looking for resistance being less than or equal to 0.1Ω.

Button/LED Test:

1. This test is to verify the buttons and LEDs on the PCB are functional and interacting with each other.
2. Analyzing that the Arduino is outputting 5V using a digital multimeter and that it is able to reach the switches and LEDs prior to having them powered and tested.

Solar Panel Voltage and Current Test:

1. For this test, the solar panel is being used and will be analyzing the voltage and current coming from the solar panel.
2. In this test, the team will be looking at the voltage and the currents being outputted out of the solar panel as well as checking the battery to see the current when the solar panel is on.

Hall Effect Input Test:

1. For this test, the team has Hall effect sensors connected to the PCB and it is having it trigger the LEDs and are supposed to turn off the LED completely using a magnet.
2. For this code, the team added the hall effect inputs and a bit of the serial code.

Component C code Test:

1. For this test, the team grabbed parts of the block of code and uploaded it to the Arduino to see that the fans and motors were able to work using the PCB and wiring harness.
2. Observing that the Arduino is able to run the motors in one direction and turn another as well as that three fans could turn on for the inflate process and the two fans for the deflate process.

Wind and Sand Resistance Test:

1. For this test, the team is conducting a wind and sand resistance test to see how the fans would handle the wind and sand since this system will be used in desert-like conditions.

2. The team will use a bucket for the collection of dust and sand and conduct a variety of tests to see how much of an impact of having the filter or not for the fans would impact it.

Future Tests:

Power Consumption Test:

1. System will be operated to estimate power demands within a specific span of time.

Solar Powered System Operation Test:

1. System will be powered solely through the solar panel to confirm adequate power supply.

Full System Test

Procedure:

1) Verify that the device is aligned with the runway and facing the runway

2) Flip open the shield panel

3) Verify that the power switch is in the OFF position

4) Verify that the power LED is dim (OFF)

5) Switch the power switch to the ON position

6) The two LEDs should begin to blink indicating that the user should choose which button to press

7) Push the button to deploy and inflate the inflatable

8) Verify that the device deploys the inflatable material onto the runway evenly and consistently

9) Once the inflatable is completely inflated, leave however long you want the system to run

10) Once done using the system, press the retract button to begin the deflation and retracting process

11) Verify that the inflatable is being retracted back into the device evenly and consistently and within 180 seconds (per sponsor request)

13) Once inflatable is completely retracted, the LEDs should start to blink again

14) Switch the power switch to the OFF position

15) Verify that the power LED is dim (OFF)

Test Plan - Reference Schematic

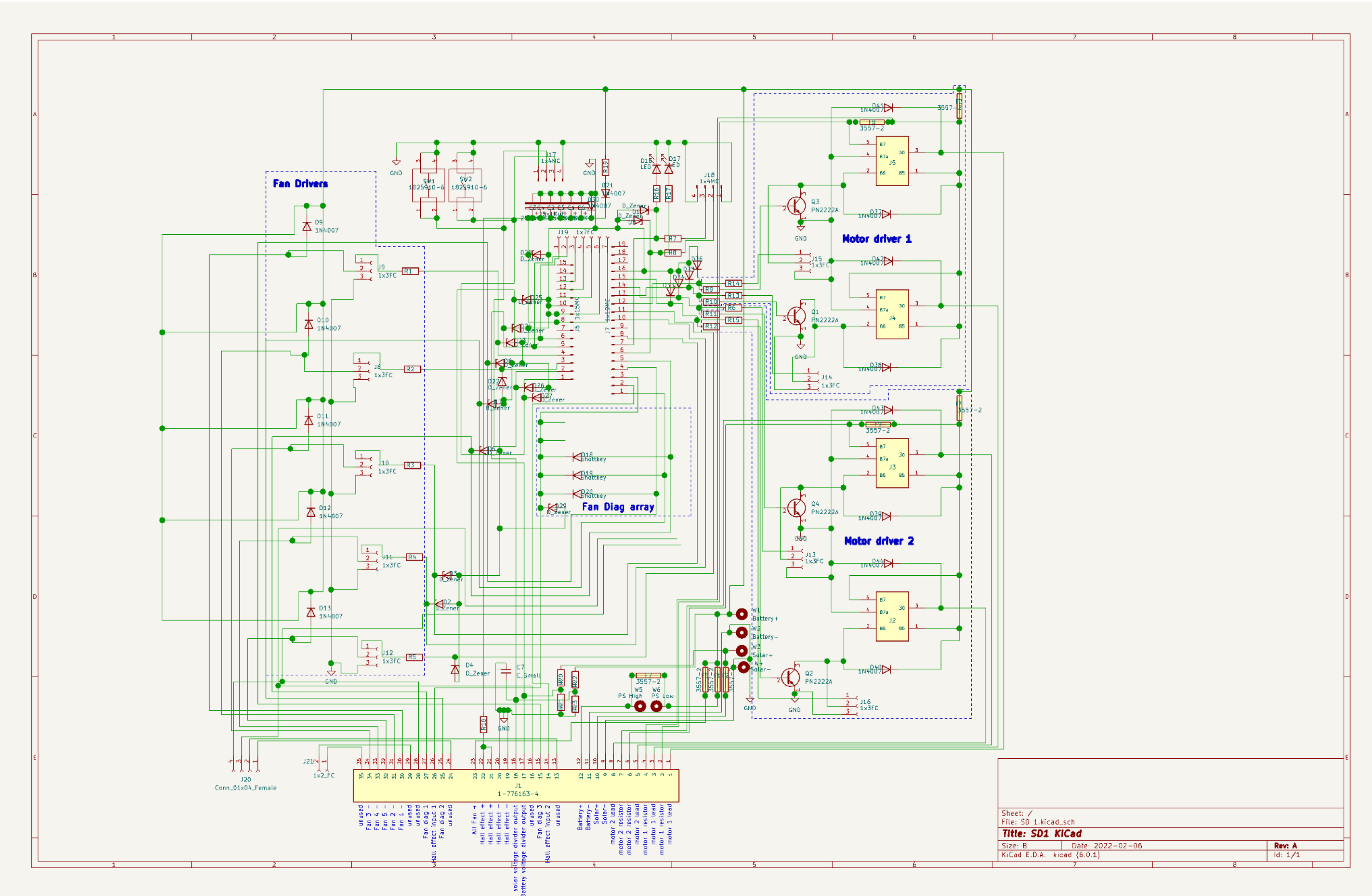


Figure 1: Shown above is the schematic that will be referenced throughout this document showcasing each test that was executed

Description of Individual Tests and Results

Wiring Harness Continuity Test:

Description of Test	Specific Criteria	Results
This test verifies that the wires are properly connected to the harness. Since the team had to manually strip each wire and crimp each one to be able to insert them into the harness, the team has to analyze that there is throughput going through the wire and that it will properly work once it is connected to the PCB.	When analyzing the wiring harness, the team is looking for resistance being less than or equal to 0.1Ω. This shows that the wires are functional and were not damaged during the stripping and crimping process. Shown in Figure 2 and Figure 3 is the wiring diagram for the wiring harness as well as the test setup and shows how the team measured each wire using a multimeter to measure the resistance.	The results for this test was that each wire was shown at exactly 0.1Ω, which satisfies that each wire is functional and is ready to be connected to the PCB and its corresponding components. However, for a set of wires, the team was not able to measure because it was difficult to have the probe touch the wire since the holes in one of the harnesses was too small.

Wiring Harness Continuity Test - Schematic Reference

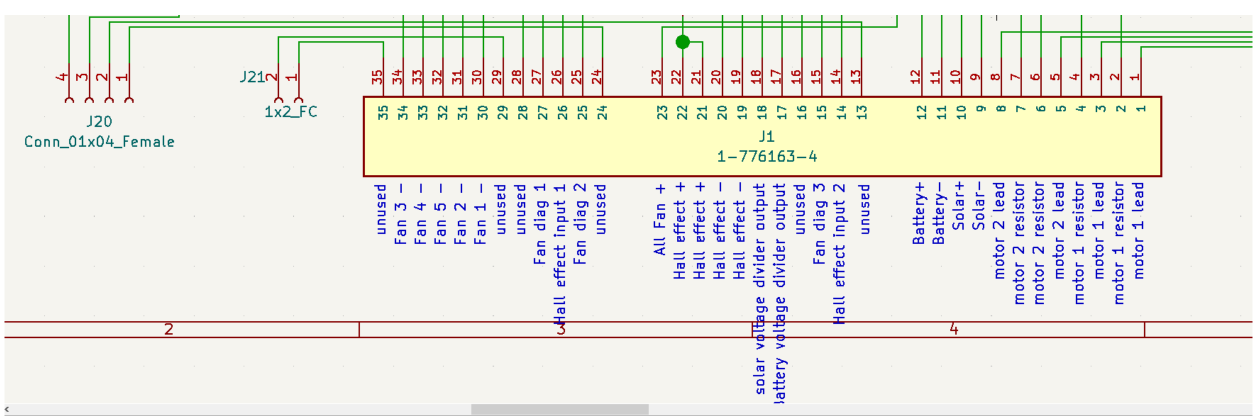


Figure 2: In the image above shows the wiring diagram for the wiring harness and what is connected to each pin. This was used as a reference so that the team knows what components are needed to be connected

Wiring Harness Continuity Test - Test Procedure

1. Gather all wires needed for the wiring harness and begin cutting to specific measurements needed for the system.
2. Once done cutting the wires, begin stripping a good amount of the wire so it is exposed.
3. Then, connect a female or male pin connectors and start crimpering on the exposed end so that it is able to connect into the wiring harness.
4. Once crimpered, begin inserting the wiring to the corresponding pin locations.
5. Start measuring pin connector to ground using a digital multimeter and analyze if there is resistance being measured.

Wiring Harness Continuity Test - Photographs

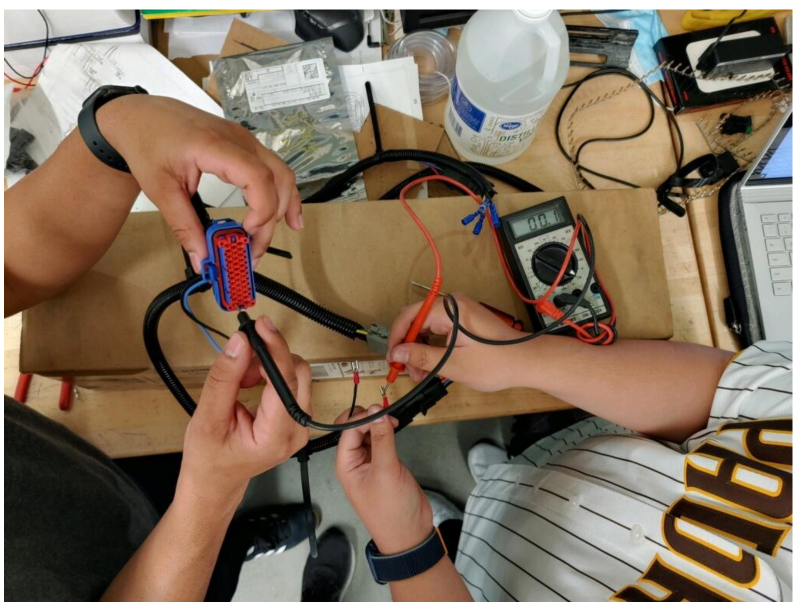


Figure 3: The figure above shows the team measuring each wire of the wiring harness. Displayed on the multimeter is the wanted resistance, which is at 0.1 Ω, to show that the wires were not damaged

Button/LED Test:

Description of Test	Specific Criteria	Results
This test is to verify the buttons and LEDs on the PCB are functional and interacting with each other. Show in Figure 4 is the reference schematic that allows the team to see what button and LED is connected to the Arduino.	The team is analyzing that the Arduino is outputting 5V using a digital multimeter and that it is able to reach the switches and LEDs prior to having them powered and tested. Then, the team should be able to see that the buttons and LEDs are functional. In Figure 5, it showcases a flow diagram of the code and how the code is run for this specific test. Figure 7 also shows the test setup for the button and LED test and shows how the PCB is connected to the overall system.	The results for this test was that at first the team was having trouble having the LEDs stay lit when the Arduino was connected. The A5 input pull up was not pulling up the voltage to 5V as intended, however, A4 was working properly. The team used the serial monitor mode on the Arduino application to see if there were any problems with the buttons as shown in Figure 6 and observed that it was not the issue. Then, the team analyzed the PCB and the connections with the buttons and LEDs, and found that it was properly connected since there was 5V running through the Arduino as well as the buttons and LEDs. After revising the code, the team found that it using an old pin assignment list for the Arduino and that the LEDs pins were changed, so shown in Figures 8 and 9 are the results of the test showing that when holding down one of the buttons, the LED turns off, and is the same for the other button as well.

Button/LED Test - Reference Diagram

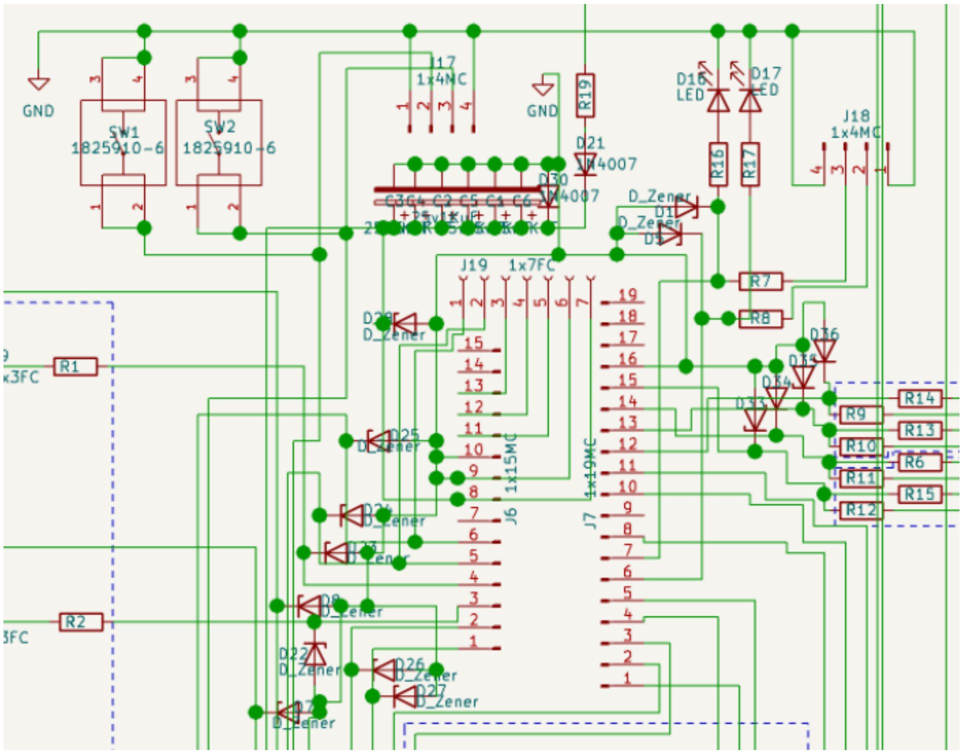


Figure 4: Shown above is a section of the schematic that shows the section for the button and LEDs. This is a significant reference because it is used to see which pins on the Arduino are connected to the switches and LEDs and if they are properly connected to each other

Button/LED Test - Test Procedure

1. Grab the block code specifically for the buttons and LEDs and upload it to the Arduino UNO while it is connected to the PCB.
2. Once uploaded completely, make sure that the system is powered on.
3. Both LEDs should be lit up as blue and white.
4. When pressing and holding the button, one LED should turn off.
5. Same process as Step 4 for the second button.

Button/LED Test - Flow Diagram for Code

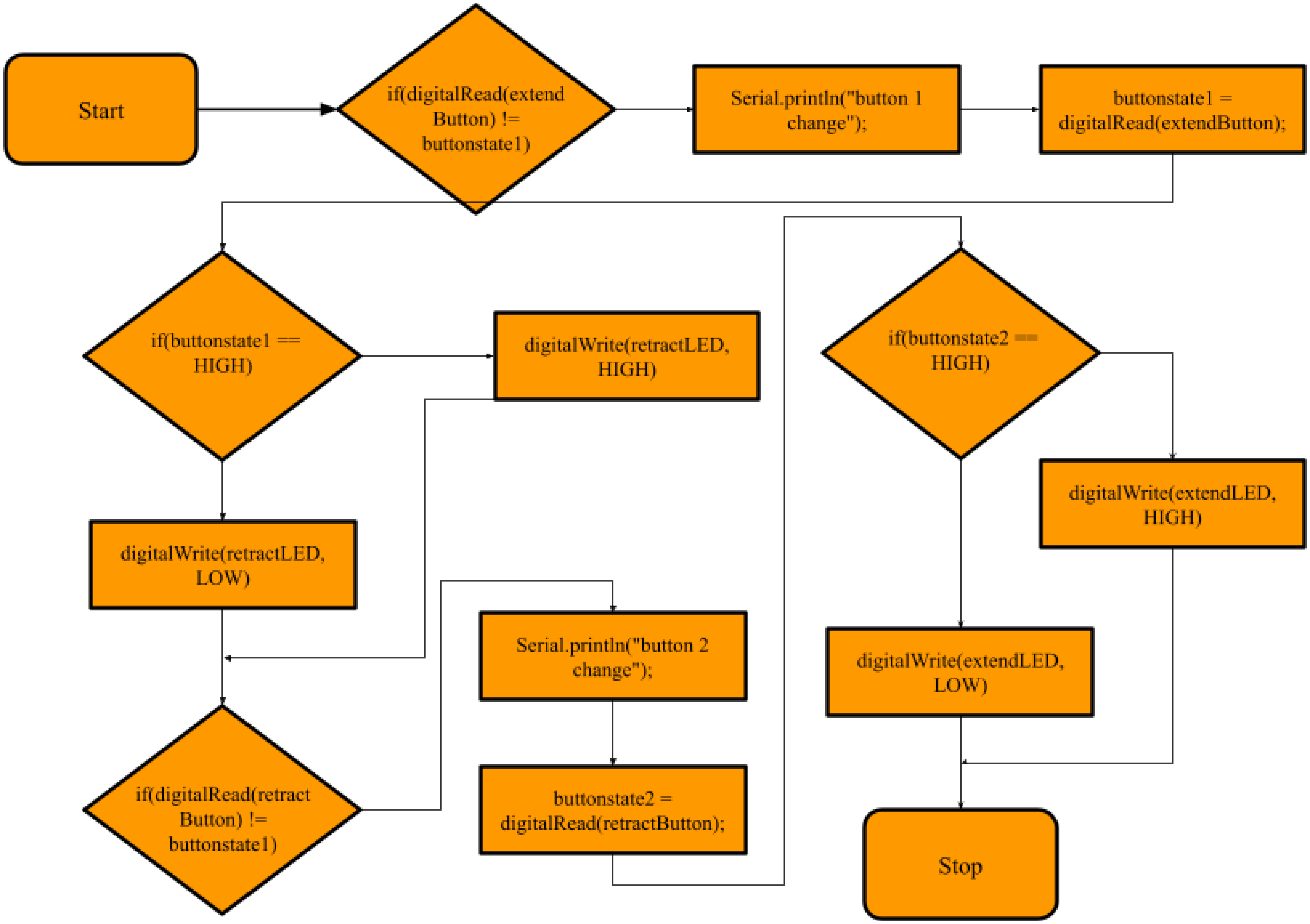


Figure 5: Flow diagram that shows how the code works for the interaction between the buttons and LEDs

Button/LED Test - Photographs

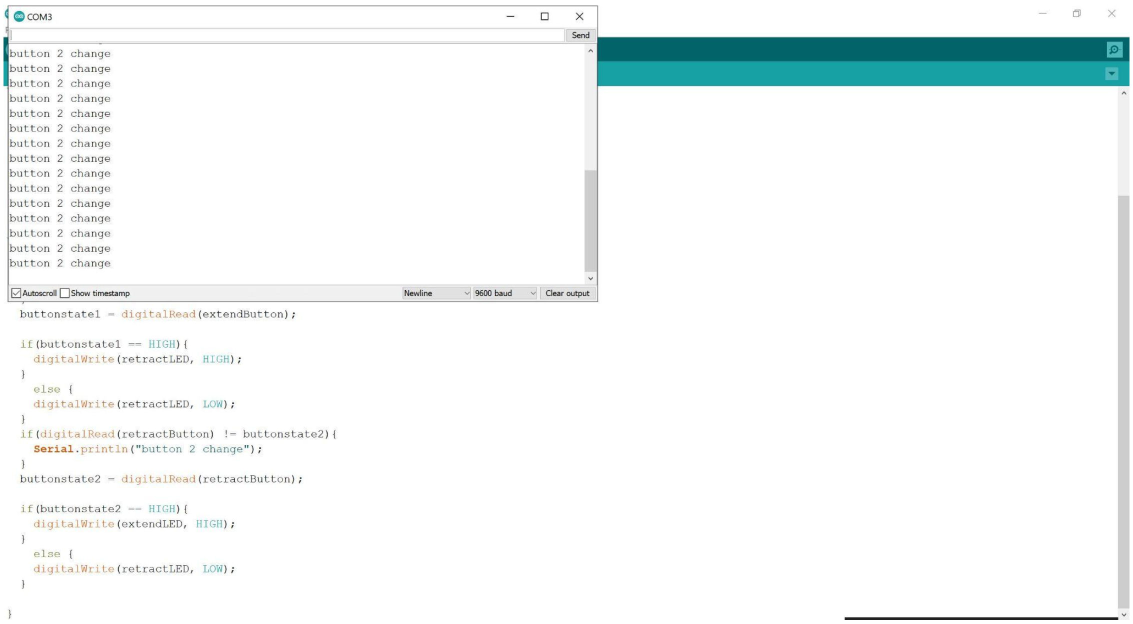


Figure 6: The photo above shows the serial monitor and how the team determined that one of the buttons works and the other does not

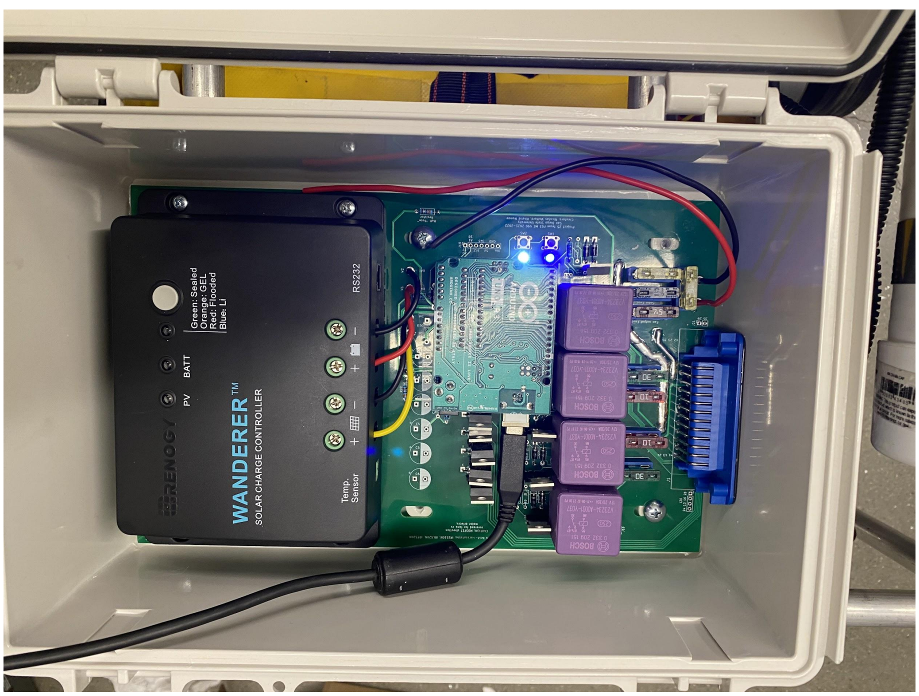


Figure 7: The photo above shows the test setup for using the buttons to interact with the LEDs on the PCB. Shown are the two LEDs (blue and white) fully lit up and once holding down the button, the LED should turn off

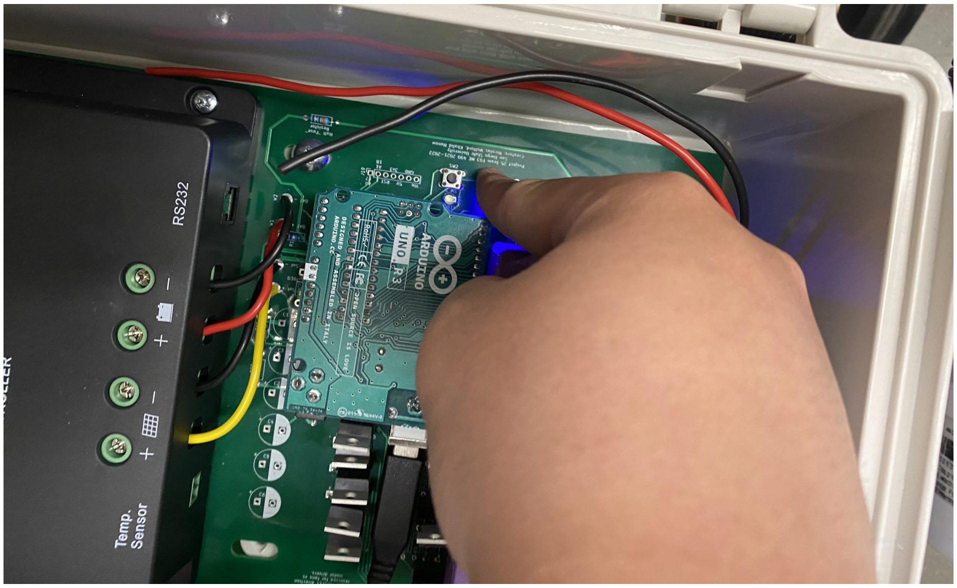


Figure 8: This photo shows holding the button down prompting the white LED to turn off

Figure 9: This photo shows holding the button down prompting the blue LED to turn off

Solar Panel Voltage and Current Test:

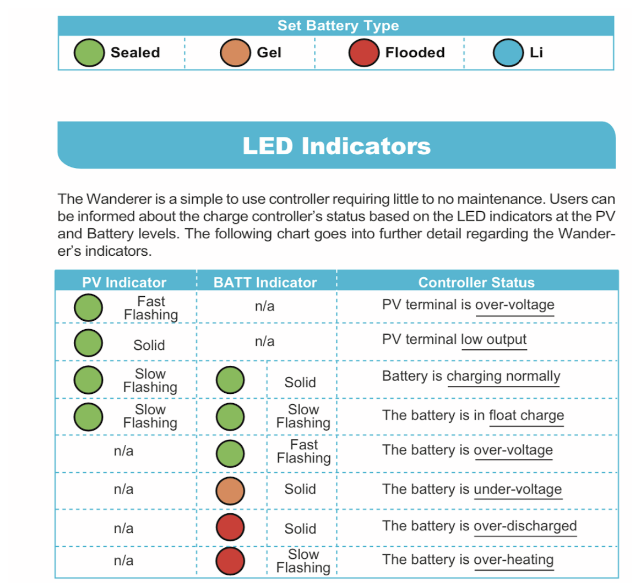
Description of Test	Specific Criteria	Results
For this test, the team is using the solar panel and analyzing the voltage and current coming from the solar panel. Shown in Figure 10 is the test setup and shows the solar panel on top of the system.	In this test, the team should be looking at the voltage and the currents being outputted out of the solar panel as well as checking the battery to see the current when the solar panel is on. In Figure 11 are the light indicators for the solar charge controller on the PCB that shows what the colors mean when they are lit up. For this, the team wants to have a slow flashing of the PV indicator as well as a solid green light to show that the battery is charging normally.	The results for the tests are fascinating because when testing in the evening, the reading was 20V out of the solar panel which is enough voltage to power the system. In Figure 12, is the PCB with the solar charge controller and shows three lights, which two are on the entire time, while the PV light is slow flashing. Shown in Figure 13 is the measuring of the current coming from the battery while the solar panel was on top of the system and found that it came out to be 14.59A.

Solar Panel Voltage and Current Test – Test Procedure

1. Grab the solar panel and place it on top of the system by sliding it into the slots that are on top of the system.
2. Connect the positive and negative ends of the solar panel onto the connections from the wiring harness.
3. Connect the battery to the system.
4. If all goes well, two light indicators (BATT and Sealed) should be green and remain on while the PV light should be blinking.
5. Measure the current coming from the battery and well as measure the voltage of the solar panel.

Solar Panel Voltage and Current Test – Photographs

Figure 10: Shown above is the test setup showing the solar panel placed on top of the entire system



Set Battery Type			
Sealed	Gel	Flooded	Li

LED Indicators

The Wanderer is a simple to use controller requiring little to no maintenance. Users can be informed about the charge controller's status based on the LED indicators at the PV and Battery levels. The following chart goes into further detail regarding the Wanderer's indicators.

PV Indicator	BATT Indicator	Controller Status
Fast Flashing	n/a	PV terminal is over-voltage
Solid	n/a	PV terminal low output
Slow Flashing	Solid	Battery is charging normally
Slow Flashing	Slow Flashing	The battery is in float charge
n/a	Fast Flashing	The battery is over-voltage
n/a	Solid	The battery is under-voltage
n/a	Solid	The battery is over-discharged
n/a	Slow Flashing	The battery is over-heating

Figure 11: Shown in the figure above is the lighting indicators and what the lights mean on the solar charge controller. For the battery, the team wants the light to be solid green and in this case, it means that it is sealed. For the PV indicator, the team would want a slow flashing so that it would indicate that the battery is charging normally

Figure 12: Shown is the PCB and the solar charge controller. As seen on the solar charge controller, the light indicators are on and are getting what the team is expecting where the PV indicator is flashing slowly and the battery is solid green

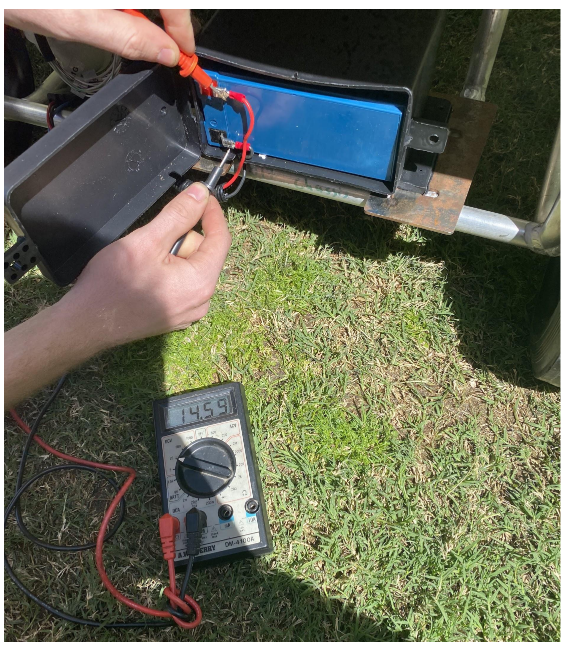


Figure 13: Shown in the picture above is us measuring the current from the battery and found that it is at 14.59A, which is enough current to supply the entire system

Hall Effect Input Test:

Description of Test	Specific Criteria	Results
For this test, the team will have Hall effect sensors connected to the PCB and have it trigger the LEDs and are supposed to turn off the LED completely using a magnet. Shown in Figure 14 is the reference schematic that shows that section of the PCB that the team will be dealing with.	The team needs to analyze how the Hall effect sensors will be affected by applying a magnet to it and see how it changes the LED. In Figure 15, is the flow diagram of the code that was similar to the button and LED test that occurred earlier. For this code, the team added the hall effect inputs and some of the serial code.	The results for this test were somewhat as expected as shown in Figure 16. However, the team ran into some problems with one of the Hall effect sensors. A problem that was encountered was that when putting a magnet to one of the hall effect sensors, the LED started to flicker rather than turn completely off. The team looked over the code and it was correct from the team's point of view and came to the conclusion that the hall effect input was not stable and that it was outputting an erratic pulse signal. The result of that is due to the Hall effect sensor being damaged through the soldering process since lots of heat could have roasted the sensor. Other than the defected sensor, the team was able to see the blue LED turn off. The team is going to try to remove diodes that are connected to the two Hall effects to see if there is a source of interference between the Hall effects and LED.

Hall Effect Input Test - Reference Diagram

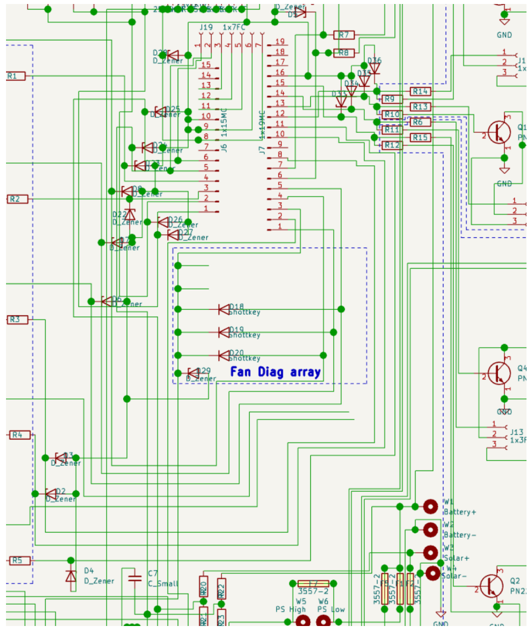


Figure 14: Shown above is a section of the schematic that shows the section for the Hall effect sensors. This is a significant reference because it is used to see what pins on the Arduino are connected to the Hall effects as well as the LEDs

Hall Effect Input Test - Flow Diagram for Code

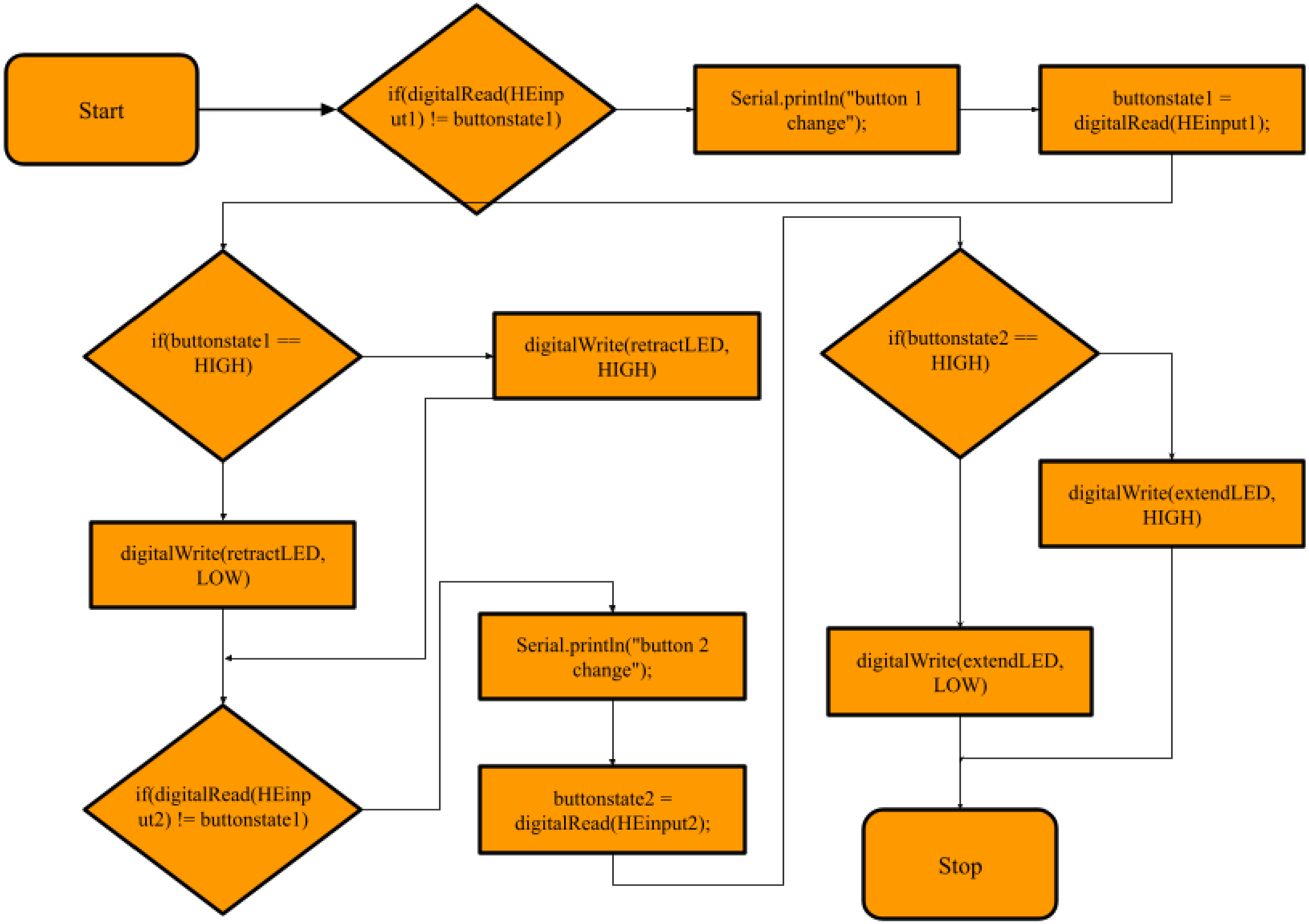


Figure 15: Flow diagram that shows how the code works for the interaction between the Hall effect sensors and LEDs

Hall Effect Input Test - Test Procedure

1. Connect the two Hall Effect Input Sensor wiring harnesses to the system.
2. Upload code into Arduino.
3. Grab a magnet and put it in front of one of the Hall effect sensors.
4. The LED should turn off when the magnet is in front of the sensor.
5. Repeat steps 3 and 4 for the second Hall effect sensor.

Hall Effect Input Test - Photographs

Figure 16: Shown in the picture above is the team applying a magnet to one of the Hall effects and observing that it was able to turn off the blue LED

Components Test:

Description of Test	Specific Criteria	Results
For this test, the team grabbed parts of our block of code and uploaded it to the Arduino to see that the fans and motors were able to work using the PCB and wiring harness. In Figure 18, the test setup is shown for testing the components.	The team wants to see that the Arduino is able to run the motors in one direction and turn another as well as that three fans could turn on for the inflate process and the two fans for the deflate process. Shown in Figure 17 is the flow diagram of the code that allows the team to analyze each section of the components. This flow will be similar to how the actual system will function.	Shown in Figures 19 and 20 are the test results showcasing the before and after of the wheels and spool turning. The team was successfully able to have the motors and fans turn on and off and do what they were intended to do. The team also checked if the MOSFETs were too hot to the touch and found they were not.

Components Test - Flow Diagram for Code

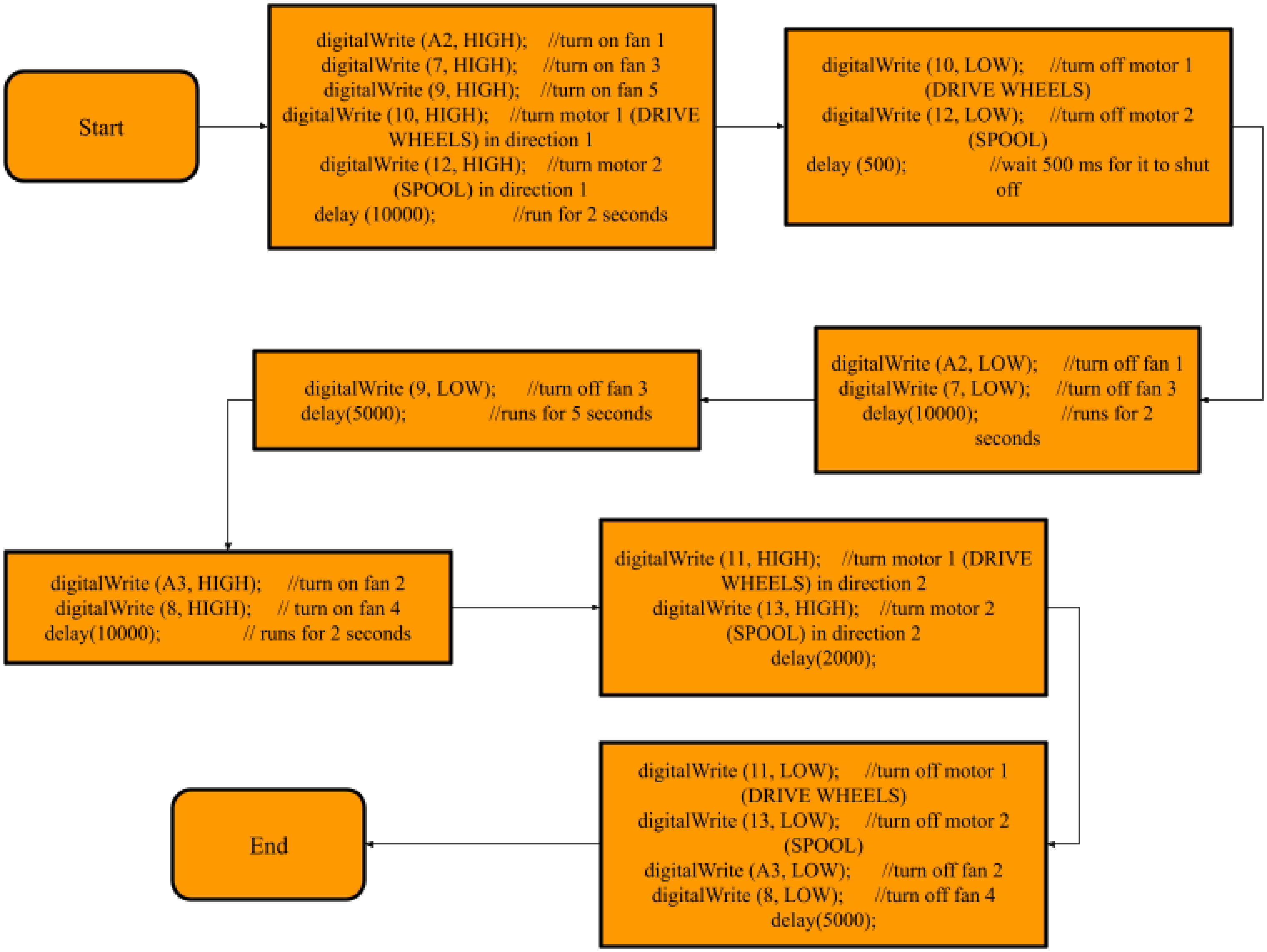


Figure 17: Flow diagram that shows how the code works for the interaction between the Arduino, fans, and motors for the wheels and spool

Components Test - Test Procedure

1. Have the wiring harness connected to the PCB on one end and have the other ends connected to their corresponding components (fans and motors).
2. Connect the USB to the Arduino to fully upload the code.
3. Connect the battery to the system.
4. Should be able to see the Arduino run the code where the wheels and spool should turn as well as the fans to turn on and off between delays.

Components Test - Photographs

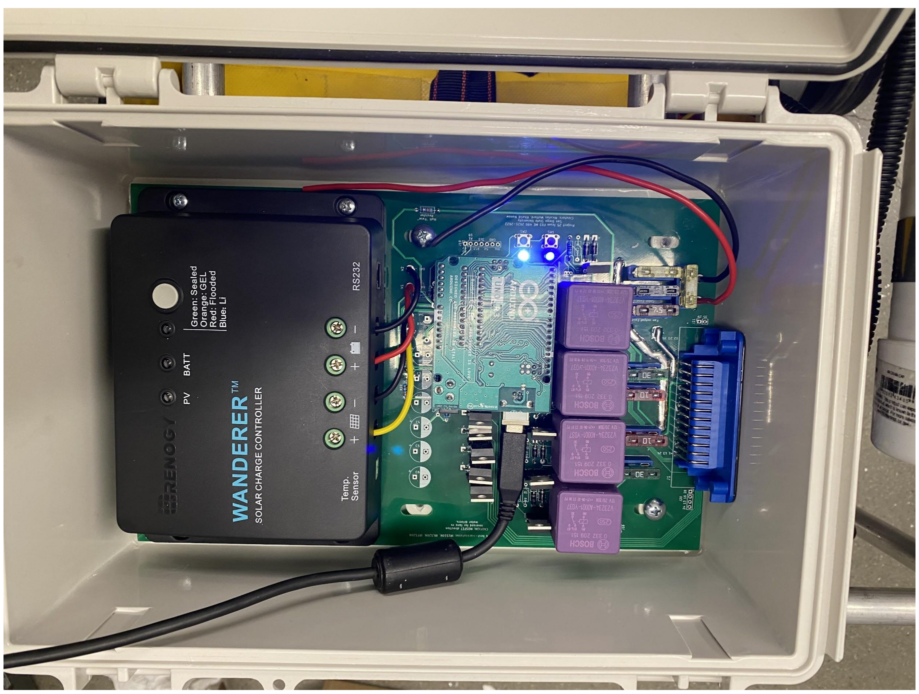


Figure 18: In this figure, it shows the test setup for the components test. Shown is the solar charge controller connected to one side of the PCB and on the other side are the fuses, relays, MOSFETs, and Arduino connected and ready for testing the fans and motors

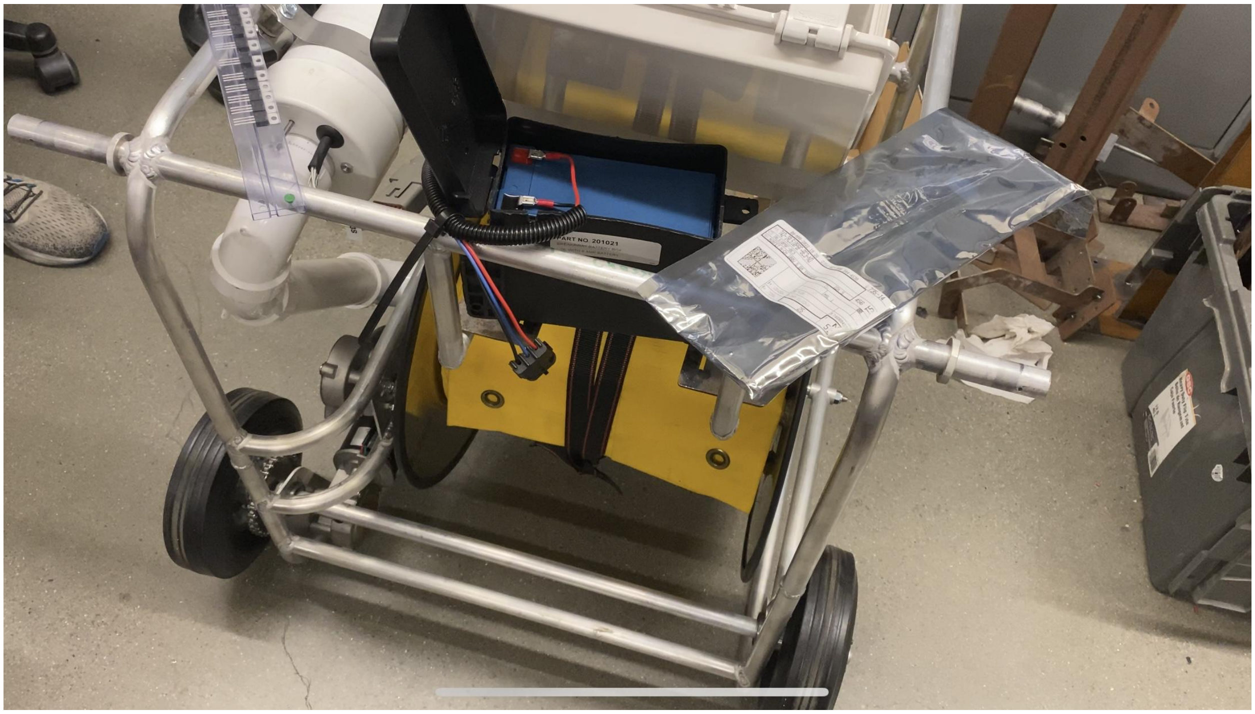


Figure 19: This is an image of the wheels and spool before they start turning

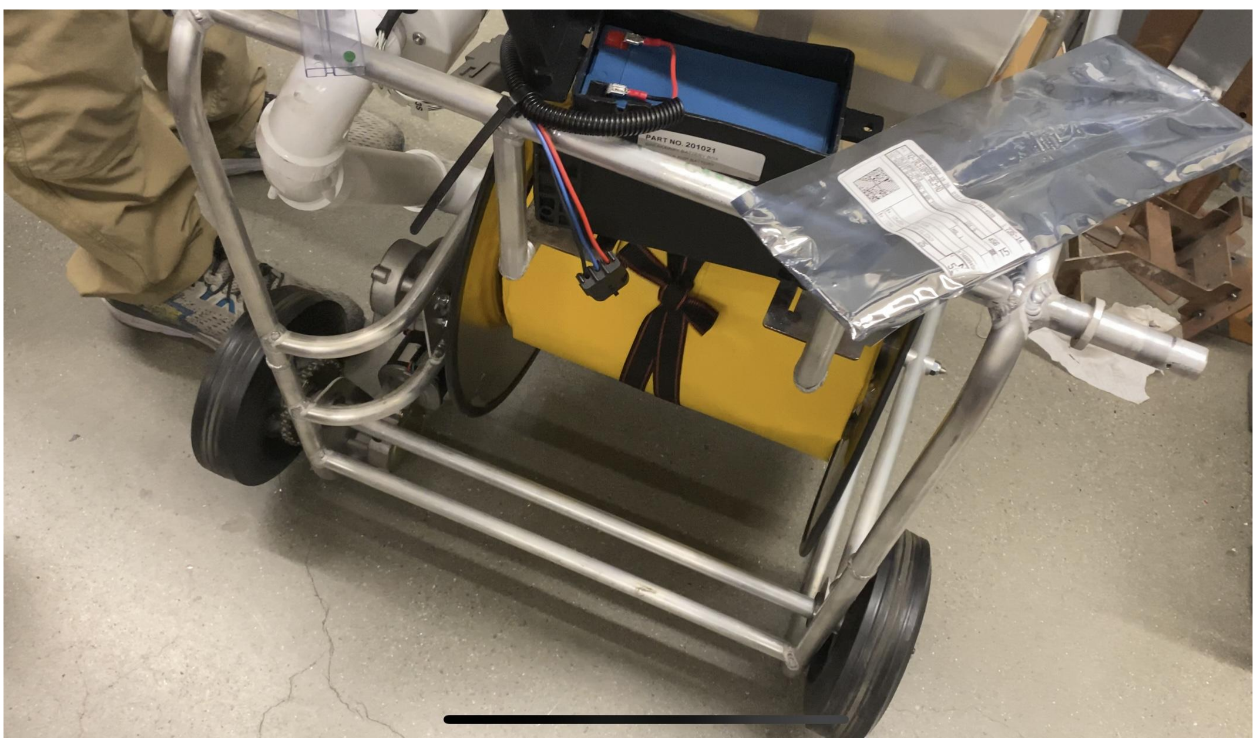


Figure 20: This is an image of the wheels and spool after they start turning

Wind and Sand Resistance Test:

Description of Test	Specific Criteria	Results
For this test, the team is conducting a wind and sand resistance test to see how the fans would handle the wind and sand since this system will be used in desert-like conditions. Shown in Figure 21 is the test setup where someone would drop sand onto the fan and it would send it towards the fans.	In this test, the team will use a bucket for the collection of dust and sand and conduct a variety of tests to see how much of an impact of having the filter or not for the fans would impact it.	The results from this test were that the filtration system for the fans are properly functioning. There were a total of 4 tests and on the first test, the team found that the sand weighed 50.8lbs, but since there was a hole opening for the bucket, it allowed more sand to go through. Therefore, a prototype was created to allow for the sand to just pass through the filtration system as shown in Figure 22. For the second test, the team weighed it at 49lbs. In the third test, the team added the filter and found that it weighed 47.2lbs and found that it was an improvement compared to the previous tests. Finally, on the fourth test, the team measured 37.4lbs and this shows that it is working properly and that that filtration system would most likely last a long time.

Wind and Sand Resistance Test - Photographs

Figure 21: Shown above is the test setup for the test and showcases the use of a fan for the sand to travel to the fans and filtration system as well as a bucket for measuring the weight of the sand when accumulated into the bucket

Figure 22: Shown in the picture above is the aftermath of the test showing the sand as well as the fans and its filtration system

Schedule

Week	Schedule
Week 13	• Start Soldering PCB for Second System • Start wiring the wiring harness • Begin Full System Testing/Last minute debugging of First System
Week 14	• Begin putting together the Second System • Work/continue on debugging for both systems
Week 15	• Finish working on the Second System
Week 16	• Prep for Senior Design Day • Submit Final Report • Do Customer Sign-Off on May 5th

Figure 23: Shown above is the table showcasing the schedule for the next four weeks

Appendix

SAN DIEGO STATE UNIVERSITY

System Description, Requirements, and Validation Document

EE/COMPE 496A Senior Design

Team 14, Project 25: Rapid Deployment Runway Closure System

The Blockage Brigade

Sean Connolly, Khalid Nunow, Jomari Paguia, Marc Tanwangco, Bianca Yousif

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Executive Summary

The Rapid Deployment Runway Closure System (RDRCS) will allow aviation workers to deploy multiple rapid deployment systems across the runway to prevent any unauthorized aircraft from landing based on the situation. The user of the RDRC system will use a series of buttons to activate the blower to release the inflatable across the runway as well as retract the inflatable back into the system. If an aircraft needs to land on the runway, the inflatable will be able to deflate so that the aircraft could land safely. Once the inflatable has done its job, it will retract back into the system within 2 minutes or less.

The core of the Rapid Deployment Runway Closure System is using an Arduino Uno Microcontroller which is a dominant component to the system. The RDRCS will include writing firmware, containing C code, to allow for the buttons to work properly. For more information and descriptions on the different components can be found in the "Development and Procurement" section of this report.

Functionality

The Rapid Deployment Runway Closure System (RDRCS) will allow aviation workers to deploy multiple rapid deployment systems across a personal aircraft runway in order to prevent any unauthorized aircrafts from landing. These remote runways are used by owners/operators rather than a full team of people like normal airport runways. Therefore, the user of the RDRC system will have to first toggle the ON switch in order to turn the system on, and then press a button to activate the blower fan and deploy the inflatable. This will then create an inflatable bouncy house type of object that will be laid out across the runway. These runways contain no type of lighting therefore, the RDRCS would be a way for pilots to see the runway easier. If an aircraft is going to land on the runway, the inflatable will deflate from the system and the aircraft will be able to safely land on it. Once there is no need for the inflatable, it will retract back into the system.

Inputs/Outputs

The Rapid Deployment Runway Closure System will be using an Arduino Uno Microcontroller that has a maximum 5V that the input and output pins could tolerate. Developing C code for the inputs and outputs is required for the system and then it would have to be downloaded to the microcontroller. One of the inputs that would be used would be a pin switch, which has a maximum AC voltage rating of 125 to 250 volts and maximum current rating of 8 to 16 amps. Another input would be a push button and it has a power rating of mac 50mA 24V DC. Figure 4 under the physical description shows the PCB layout and schematic. All components of the PCB will be on one side while there will be a solar charge controller on the other. This project also requires a 200W ruggedized solar panel. On average, a 200W solar panel can be able to produce 10 to 12 amps of power per hour. This is roughly 60 to 70 amps of power per day. This information is not exact because there can be days of no sunlight which could affect the amount of power that can be provided.

Use Case

The purpose of the Rapid Deployment Runway Closure system is to deploy an obstacle on the aircraft runway in order to prevent any unwanted individuals from landing their aircraft without any authorizations or permissions. This system shall be able to operate with a single person and inflate and deflate through a powered system. In Figure 1 and Figure 2, both show the basic system while also showing how an individual may use the system.

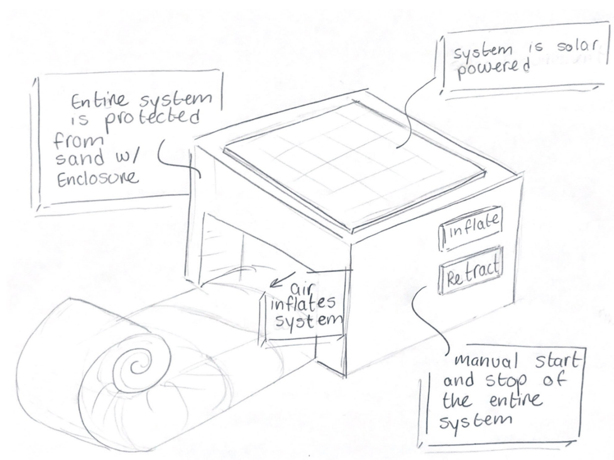

Figure 1: Basic System with Expectations

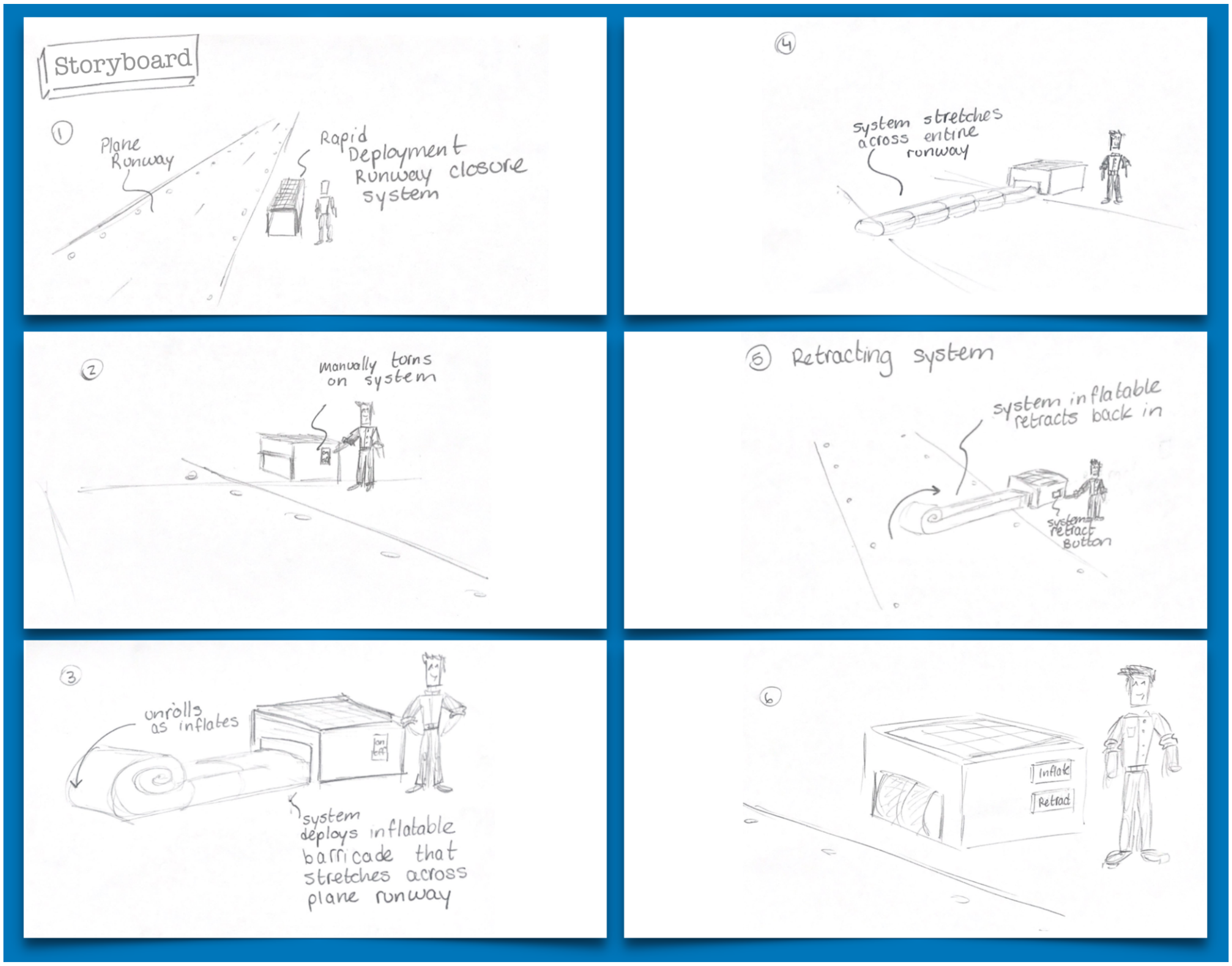

Figure 2: Storyboard of Use Case

Physical Description and User Interface

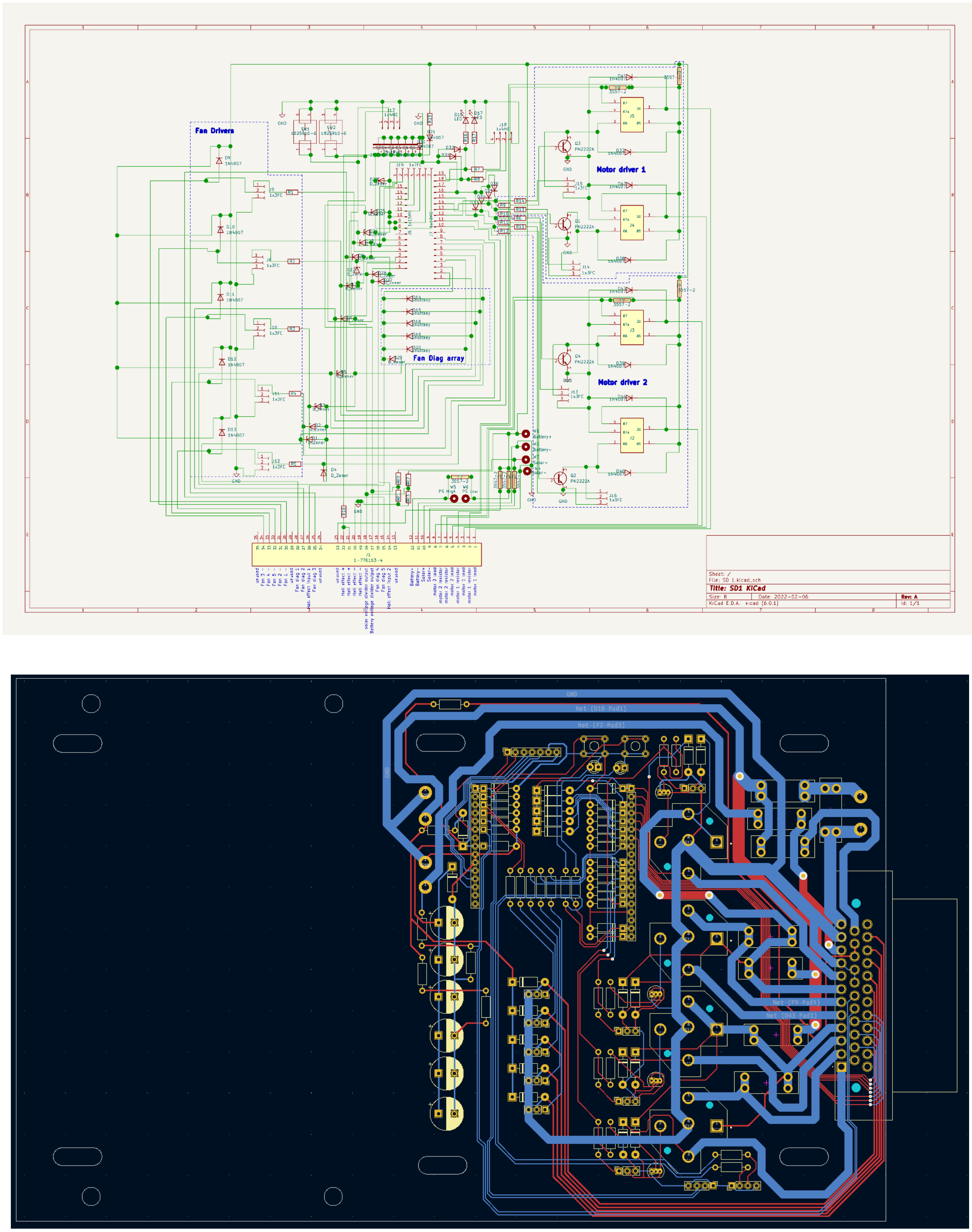

Figure 4: Schematic and Layout of the PCB

Development and Procurement

Arduino Uno Microcontroller:

The Arduino Uno Microcontroller will be used as the base for the Rapid Deployment Runway Closure System where this is all the firmware and hardware aspects of the system. This microcontroller allows for the system to use buttons/switches to operate the system when needed. The Arduino Uno Mircrocontroller runs on 5V and the maximum voltage that the I/O pins can tolerate is 5V. Applying voltages higher than 5V to any I/O pin could possibly damage the board.

Embedded Systems:

The Rapid Deployment Runway Closure System will induce an embedded system that deals with interrupts and delays. In order to be able to use interrupts and delays within the Arduino Uno Microcontroller, C code will have to be used. After this, the downloaded code that was created into the microcontroller, will be attached to the PCB.

Electromechanical Hardware:

The Rapid Deployment Runway Closure System will use an ON/OFF switch, RGB LEDs, and 2 push buttons. These components will allow for the system to work correctly with the physical system and power supply. These components and the layout could be seen in the physical description section of the report.

Specifications

1) The system shall operate during the daytime hours (R1-003) and withstand any environmental issues (R1-002) (desert-like temperatures, sand, dust, etc).
2) The system shall be operable at 50 knots of wind and survivable at 80 knots (R1-005).
3) The system must be able to operate by a single person (R1-004).
4) The system shall deflate when an aircraft must make an emergency landing.
5) The inflatable system shall retract (S1-001) more than 5 minutes.
6) The system must use a 200W ruggedized solar panel as per sponsor's request.

Table 1: Rapid Deployment Runway Closure System ECE Test Fixture Specifications

Reference	Title	Specification	Notes
Material Cost			
TF-1	Material Cost	The Material Cost of the Rapid Deployment Runway Closure System shall be less than $2500.	What the sponsor provided
Construction			
TF-2	PCB Components	The Rapid Deployment Runway Closure System shall use through-hole PCB components.	
Physical			
TF-3	PCB Dimensions	The PCB shall have dimensions less than 8.5" x 11"	
TF-4	Enclosure	The enclosure that the system is stored in shall be 1 cubic yard.	May change depending on sponsor's preference
TF-5	Ruggedized Solar Panel	A 200W ruggedized solar panel that must be on top of the system.	Sponsor's Request

TF-6	Buttons	Buttons that shall be used to deploy, retract, and turn off the inflatable	
TF-7	RGB LEDs	The LED shall be used to let the user know what the system is doing.	There will be a few color codes such as: Blue: RETRACT White: DEPLOY
TF-8	ON/OFF Switch	The ON/OFF switch shall be used to power up the system.	
TF-9	Arduino Uno Microcontroller	The Arduino Uno Microcontroller must be used to allow for delays and connections of the power supply with the control system and placed on the PCB.	Will use C to code the interrupts/delays needed for the switches and buttons
TF-10	Fan	The fan must be used for the electrical box so that the system won't overheat inside.	
Power Supply			
TF-11	Input Voltage	The Rapid Deployment Runway Closure System must pass all performance tests with an input voltage of 12V.	
TF-12	Operating Current	The Rapid Deployment Runway Closure System shall have 10-12 amps of power coming from the solar panel per hour.	

Table 2: Functional and Physical Requirements and Details

Requirement Number	Priority Level (1-highest 5- lowest)	User Requirement	Justification	User Requirement Information Sources
R1-001	1	System shall retract fast	An operator of the device needs to be able to open the runway quickly	Sponsor Request

R1-002	1	System shall be sand resistant	System will be operating in remote locations including the southern california desert	Sponsor Request, it will operate in remote locations
R1-003	1	Shall be daylight operable	Planes will only use the runway in the daytime, system needs to work during that time	Sponsor Request
R1-004	1	The system shall be operable by a single person	Remote runways are used by owner/operators, not a team of people	Sponsor Request
R1-005	1	System shall survive high winds	System will be operating in remote locations including the southern california desert	Sponsor request
R1-006	1	System shall span 60 feet	A remote runway is typically that wide	Airport Design and Operation Antonín Kazda and Robert E. Caves, page 96
R1-007	1	System shall operate using solar power	Typical runway will be in a remove environment without power to it	Sponsor request

Table 3: Functional and Physical Specifications and Details

Specification Number	User Requirement	Engineering Specification	Justification	Engineering Specification Information Sources
S1-001	System shall retract fast	System shall retract within 3-5 minutes	Sponsor requirement, need to verify with sponsor	Sponsor Request
S1-002	System shall be sand resistant	System shall operate to Mil-STD-810 sand and dust testing, or equivalent ASME specification	System will be operating in remote locations including the southern california desert	Sponsor request
S1-003	Shall be daylight operable	System shall last for 5 years without becoming inoperable due UV	System will be operating in remote locations including the southern california desert	Sponsor Request, need to do some research
S1-004	The system shall be operable by a single person	Each sub system shall weigh less than 51 lbs,	Remote runways are used by owner/operators, not a team of people	NIOSH 94-110
S1-005	System shall survive high winds	System shall survive 80 knots (92 mph)	System will be operating in remote locations including the southern california desert	Sponsor request

S1-006	System shall span 60 feet	System shall span 20 m (60 feet)	A remote runway is typically that wide	Airport Design and Operation Antonín Kazda and Robert E. Caves, page 96
S1-007	System shall operate using solar power	System shall use 200 watt ruggedized solar system	Sponsor request	Sponsor request

Validation and System Test

System Test: Rapid Deployment Runway System

Procedure:

1) Verify that the device is aligned with the runway and facing the runway

2) Flip open the shield panel

3) Verify that the power switch is in the OFF position

4) Verify that the power LED is dim (OFF)

5) Switch the power switch to the ON position

6) The two LEDs should begin to blink indicating that the user should choose which button to press

7) Push the button to deploy and inflate the inflatable

8) Verify that the device deploys the inflatable material onto the runway evenly and consistently

9) Once the inflatable is completely inflated, leave however long you want the system to run

10) Once done using the system, press the retract button to begin the deflation and retracting process

11) Verify that the inflatable is being retracted back into the device evenly and consistently and within 180 seconds (per sponsor request)

13) Once inflatable is completely retracted, the LEDs should start to blink again

14) Switch the power switch to the OFF position

15) Verify that the power LED is dim (OFF)