BID4R
System Test Plan
Version <1.0>
12/5/2024

Document Control

The following list of people will receive a copy of this document every time a new version of this document becomes available:

Teaching assistants:

Luke Newcomb

Customer(s):

Dr. Bryan Watson

Project team members:

Turki Alturki

Mohammed Alasmari

Belal Abed

Change Summary

The following table details changes made between versions of this document:

Version	Date	Modifier	Description
1.0	11/24/2024	Belal	Initial creation- Introduction
1.0	11/24/2024	Mohammed	Testing Approach-Usability Testing
1.0	11/24/2024	Turki	Testing Approach-Functionality Testing
1.0	11/25/2024	Mohammed	Testing Approach -Testing Environment
1.0	11/25/2024	Turki	Testing Approach -Testing Assumptions
1.0	11/27/2024	Mohammed	Testing Approach -Testing Risks and Contingencies
1.0	11/28/2024	Belal	Testing Approach -Test Plan
1.0	12/2/2024	Belal	Test Schedule
1.0	12/4/2024	Turki	Test Cases
1.0	12/5/2024	Mohammed, Belal, Turki	Final revision

Table of Contents

Document Control ii
1. Introduction 1
1.1. Purpose 1
1.2. Scope 1
1.3. System Overview 1
1.4. Testing Approach Overview 1
1.5. References 2
2. Testing Approach 4
2.1.1. Usability Testing 4
2.1.2. Functionality Testing 4
2.2. Testing Suspension Criteria and Resumption Requirements 4
2.2.1. Suspension Criteria 5
2.2.2. Resumption Requirements 5
2.3. Testing Environment 5
2.4. Testing Assumptions 6
2.5. Testing Risks and Contingencies 6
2.6. Test Plan 7
3 Test Schedule 9
4 Test Cases 10
4.1 CH-001 10
4.2 CH-002 11
4.3 CH-003 13
4.4 CH-004 14
4.5 CH-005 16
4.6 CH-006 18
4.7 CH-007 19
4.8 CH-008 21
4.9 CH-009 22
4.10 CH-010 23
4.11 OP-001 25
4.12 OP-002 27
4.13 OP-003 28

4.14 OP-004 30
4.15 OP-005 32

1. Introduction

This System Test Plan outlines the testing process for the rover system. It includes test cases and methodologies to verify the system's functionalities, including charging, battery monitoring, and temperature management, ensuring reliable operation under various conditions. The plan is designed to ensure that all components function as expected in normal and edge-case scenarios.

1.1. Purpose

The purpose of this document is to define the testing approach, methods, and criteria for validating the functionalities of the rover system. It contains detailed test cases, a traceability matrix, and defect severity classifications to ensure comprehensive coverage of the system's capabilities.

1.2. Scope

This test plan covers all functionalities of the rover system, focusing on critical areas such as:

1. ***Wireless Charging:*** *Ensuring proper alignment and current handling capabilities.*
2. ***Battery Monitoring:*** *Providing accurate real-time voltage levels during operation and charging.*
3. ***Temperature Monitoring:*** *Detecting overheating and issuing alerts while maintaining safe operational parameters.*
4. ***LED Indicators:*** *Providing clear feedback on the system's status under different operational conditions.*

This plan applies to the current hardware and software versions of the rover system.

1.3. System Overview

The rover system is designed to operate as an autonomous platform with integrated functionalities for wireless charging, battery monitoring, temperature sensing, and feedback through LED indicators. The testing approach focuses on validating these functionalities to ensure the system operates reliably in various scenarios.

1.4. Testing Approach Overview

The testing approach focuses on validating functional, usability, and performance aspects of the rover system:

- ***Functional Testing:*** *Verifying individual modules (e.g., charging, monitoring, and LED feedback).*
- ***Stress Testing:*** *Evaluating the system's behavior under edge conditions, such as low battery or overheating.*
- ***Integration Testing:*** *Ensuring modules interact seamlessly (e.g., accurate LED feedback during charging).*
- ***Regression Testing:*** *Validating that resolved issues remain fixed after updates.*

Each test is executed based on predefined test cases, ensuring measurable and consistent outcomes.

1.5. References

This section lists the key references and resources consulted during the development of the BID4R project. These references provide background information, technical specifications, and industry standards relevant to the design and implementation of the wireless charging and battery integration solution.

1. ***Arduino Nano IoT Documentation*** *– Technical documentation for the Arduino Nano IoT, including pin configurations, power limitations, and programming guidelines essential for the control system of the BID4R project.*

   Link*:*
   https://github.com/turkia1/BID4R/blob/main/Wiring_documentation/Component_Documentation/ABX00027-datasheet.pdf

2. ***Adafruit PowerBoost 1000C Documentation*** *– Specifications and usage information for the PowerBoost 1000C module, including voltage conversion and output capabilities that enable efficient energy transfer from the Qi receiver to the LiPo battery.*

   Link*:*
   https://github.com/turkia1/BID4R/blob/main/Wiring_documentation/Component_Documentation/adafruit-powerboost-1000c-load-share-usb-charge-boost.pdf

3. ***3D Design and CAD Files for Charging Station*** *– CAD files and design guidelines used to model the physical structure of the wireless charging station, with specific features for alignment and thermal management.*

   Link*:*

   https://github.com/turkia1/BID4R/tree/main/Charging_Station_Documentation

4. ***Wiring and Circuit Design References*** *– Fritzing diagrams and wiring guidelines, used to assemble and validate the connectivity of electronic components, ensuring correct voltage levels, ground connections, and data flow between modules.*

   Link*:*

   https://github.com/turkia1/BID4R/tree/main/Wiring_documentation

5. ***Project Requirements Document*** *– A prior document detailing the functional and non-functional requirements of the BID4R project, which provided a foundation for the system design and identified specific operator needs.*

   Link*:*

   https://github.com/turkia1/BID4R/blob/main/class_documentation/SRSv1.docx

6. ***Components Analysis for BID4R Project*** *– Analysis report on component suitability and performance metrics, including the choice of sensors, LEDs, and connectors necessary for the seamless operation of the BID4R system.*

   Link*:*

   https://github.com/turkia1/BID4R/blob/main/Sprint2/Components%20Analysis%20and%20Suitability%20for%20BID4R%20Project.pdf

7. ***LiPo Battery Safety Regulations*** *-A Comprehensive guidelines on LiPo battery safety standards and implementation of*
   Qi wireless charging, focusing on safety protocols and regulatory compliance.

   Link:

   https://github.com/turkia1/BID4R/blob/main/Sprint2/LiPo_regulation.PDF

These references serve as foundational resources for understanding the technologies, safety protocols, and design considerations applied in this project. They provide essential information for the development team and stakeholders to understand the scope, constraints, and technical direction of the BID4R project.

2. Testing Approach

This testing approach outlines the plan to validate the rover system's components and functionality. It includes functional, usability, and stress tests designed to exercise system functions individually and in integrated scenarios. Additionally, it ensures the system meets operational requirements under normal and edge-case conditions.

2.1.1. Usability Testing

User interface attributes, particularly the LED feedback system, will be tested for clarity and usability. The objective of this test is to ensure that the system provides the user with consistent and appropriate feedback during charging, battery monitoring, and operational states. Usability testing focuses on the following:

- *Clear and distinct LED patterns for each status condition (charging, battery levels, overheating).*
- *Proper transition between LED statuses as system conditions change.*

2.1.2. Functionality Testing

Functionality tests ensure that each system component meets its respective requirements. These include:

- ***Wireless Charging Module**: Verify proper alignment and current handling capabilities.*
- ***Battery Monitoring System**: Validate accurate real-time voltage readings during operation and charging.*
- ***Temperature Monitoring Module**: Ensure reliable detection of overheating and issuance of alerts.*
- ***LED Feedback System**: Confirm accurate LED indicators for system states.*

Each of these tests corresponds to the test cases outlined in Section

2.2. Testing Suspension Criteria and Resumption Requirements

Stress tests evaluate the system's behavior under extreme conditions to ensure robustness. These include:

- *Operating with low battery levels (e.g., below 10% or 3.3V).*
- *Simulating overheating scenarios (> 45°C).*
- *Charging with high loads and alignment disruptions.*

2.2.1. Suspension Criteria

Testing will be suspended if:

- *Critical defects are discovered that prevent further testing, such as failure to detect battery voltage or overheating.*
- *Hardware malfunctions, such as the Qi wireless charging module or temperature sensor failure.*
- *Testing equipment (e.g., Arduino, multimeter) becomes inoperable.*

If testing is suspended, the Testing Manager will assess the situation and determine whether the test plan needs to be partially or fully re-executed after the issue is resolved.

2.2.2. Resumption Requirements

Testing will resume when:

- *The functionality that caused the suspension is verified to be operational.*
- *Hardware, software, or database fixes have been successfully implemented and validated.*
- *Required testing tools and configurations are restored to operational status*

2.3. Testing Environment

The testing environment includes the following:

- ***Hardware:***
  - *Qi wireless charging modules.*
  - *Battery (3.2V–4.2V range).*
  - *Arduino microcontroller with USB connection.*
  - *Temperature sensor.*
  - *Multimeter for voltage and current measurements.*
- ***Software:***
  - *Arduino IDE for monitoring serial output.*
  - *Custom firmware for battery voltage and temperature monitoring.*
- ***Configuration:***

- *Rover powered through the battery for normal operation tests.*
- *Arduino powered through USB to avoid dual-power issues.*

Tests will be executed in a controlled lab environment with a stable ambient temperature unless simulating overheating.

2.4. Testing Assumptions

The following assumptions are made:

- *The battery and sensors meet their specification tolerances.*
- *Testing equipment is calibrated and functional.*
- *All components are integrated correctly before testing begins.*
- *The Qi wireless charging modules operate within their rated capacity.*

2.5. Testing Risks and Contingencies

Overheating Risk: *Extended charging or high loads may cause overheating.*

- ***Mitigation:*** *Limit testing durations and monitor temperature closely.*

Alignment Failures: *Misalignment of the Qi wireless charging module may result in failure to charge.*

- ***Mitigation:*** *Ensure proper alignment during tests and note alignment tolerances.*

Sensor Failures: *Voltage or temperature sensors may produce inaccurate readings.*

- ***Mitigation:*** *Cross-validate readings with external tools such as a multimeter.*

Dual Power Conflict: *Arduino powered by both USB and battery simultaneously may cause damage.*

- ***Mitigation:*** *Use protective circuitry, such as diodes, to isolate power sources.*

2.6. Test Plan

The test plan includes test cases for the two primary states of the robot: ***Charging State*** *and* ***Normal Operation State****. Each test case is named to reflect the functionality it validates and grouped under its respective state.*

2.6.1 Charging State

ID	***Test Name***	***Status***	***Date***	***Notes***
CH-001	*Wireless Charging Alignment*	*Completed*	*12/2/2024*	*Verify proper alignment between the Qi transmitter and receiver.*
CH-002	*Voltage Measurement During Charging*	*Completed*	*12/2/2024*	*Test voltage stability of the Qi receiver during charging.*
CH-003	*Current Measurement for Qi Receiver*	*Completed*	*12/2/2024*	*Validate the maximum current handling of the Qi receiver.*
CH-004	*Charging Under Full Load on PowerBoost*	*Completed*	*12/2/2024*	*Test charging behavior with a full load on the PowerBoost.*
CH-005	*Charging Under Reduced Load on PowerBoost*	*Completed*	*12/2/2024*	*Test charging functionality with a reduced load on the PowerBoost.*
CH-006	*LED Feedback: Low Battery (< 30%)*	*Pending*	*TBD*	*Validate flashing red LED when charging battery below 30%.*
CH-007	*LED Feedback: Medium Battery (30%-50%)*	*Pending*	*TBD*	*Validate flashing yellow LED when charging battery between 30%-50%.*
CH-008	*LED Feedback: High Battery (> 50%)*	*Pending*	*TBD*	*Validate flashing green LED when charging battery above 50%.*
CH-009	*LED Feedback: Charging Complete*	*Pending*	*TBD*	*Verify solid blue LED when battery is fully charged (4.2V).*
CH-010	*Overheat Alert During Charging*	*Pending*	*TBD*	*Test flashing orange LED when system temperature exceeds safe limits.*

2.6.2 Normal Operation State

ID	Test Name	Status	Date	Notes
OP-001	*Battery Monitoring: Green Level (> 50%)*	*Completed*	*12/2/2024*	*Test solid green LED during normal operation with battery > 50%.*
OP-002	*Battery Monitoring: Yellow Level (30%-50%)*	*Pending*	*TBD*	*Test solid yellow LED during normal operation with battery between 30%-50%.*
OP-003	*Battery Monitoring: Red Level (< 30%)*	*Pending*	*TBD*	*Test solid red LED during normal operation with battery < 30%.*
OP-004	*Critically Low Battery (< 10%) Condition*	*Pending*	*TBD*	*Validate flashing red LED and system shutdown at critically low battery.*
OP-005	*Battery Voltage Monitoring via Arduino*	*Completed*	*TBD*	*Monitor real-time battery voltage through Arduino serial output.*
OP-006	*Temperature Monitoring During Operation*	*Pending*	*TBD*	*Verify temperature readings during normal and edge conditions.*

3 Test Schedule

Table 1: Test Schedule

Document Event	*Date*
Test Plan released	*12/5/2024*
Testing completed with results	

4 Test Cases

The purpose of this section is to explain the nature and extent of each test and explain how the tests will evaluate system function or performance. This section also documents test input, specific test procedures, and outcomes.

4.1 CH-001

Objective: *Verify the correct alignment between the Qi transmitter on the charging station and the Qi receiver on the rover.*

Notes: *This test ensures proper alignment for efficient wireless charging and tests the system's behavior in cases of misalignment. Estimated duration: 10 minutes. Resources required: charging station, rover, alignment markers, and LED feedback observation.*

Test No.: CH-001		*Current Status: Completed*		
Test title: Correct Alignment Between Qi Transmitter and Receiver				
Testing approach: Test the alignment process to ensure the Qi transmitter and receiver align properly for charging. Verify feedback using LEDs and actual power transfer. |				
STEP	*OPERATOR ACTION*	*PURPOSE*	*EXEPCTED RESULTS*	*COMMENTS*
1	*Place the rover on the charging station in the correct alignment position.*	*Test proper alignment for charging.*	*LED on the Transmitter lights up blue, indicating successful alignment.*	*Ensure alignment markers are visible to aid positioning.*
2	*Shift the rover slightly off-center 8 mm and observe behavior.*	*Test system response to misalignment.*	*Charging stops, and the LED indicates an error RED.*	*Misalignment tolerance should be within 5 mm.*

3	*Return the rover to the correct position and observe behavior.*	*Verify re-alignment restores charging.*	*Charging resumes, and the LED indicates proper alignment blue.*	*Ensure smooth transition from misalignment to aligned state.*
Concluding Remarks: The alignment between the Qi transmitter and receiver is vital to ensure reliable charging. Misalignment can result in incomplete or failed power transfer, which should be minimized with proper alignment markers and system feedback mechanisms.				
Testing Team: *Turki Alturki, Belal Abed and Mohammed Alasmari*		*Date Completed:* *12/2/2024*		

4.2 CH-002

Objective:

Measure the voltage output from the Qi receiver during charging to ensure it remains stable and within acceptable limits. Test how incorrect alignment affects voltage stability.

Notes:

This test ensures the Qi receiver outputs a stable voltage to the battery management system (BMS) and evaluates the impact of slight misalignment (within 5 mm tolerance). Voltage stability is critical for reliable charging.

Test No.: CH-002	*Current Status: Completed*
Test title: Voltage Measurement at Qi Receiver	
Testing approach: Place the rover on the charging station, check the LED indication for alignment and charging, use a multimeter to measure the voltage output of the Qi receiver, and verify the effects of slight misalignment on voltage stability.	

STEP *1*	*OPERATOR ACTION* *Place the rover on the charging station.*	*PURPOSE* *Ensure the system initiates charging.*	*EXEPCTED RESULTS* *LED on the Transmitter lights up blue, indicating successful alignment.*	*COMMENTS* *Confirm proper alignment and system activation.*
2	*Connect a multimeter to the output terminals of the Qi receiver circuit.*	*Measure voltage output during charging.*	*Voltage output is stable at 5V ± 0.1V.*	*Ensure no fluctuations or drops occur.*
3	*Slightly misalign the rover within 5 mm tolerance and measure voltage.*	*Test the effect of slight misalignment on charging voltage.*	*.* *Voltage output is lower but charging still occurs < 5V*	*There will be a voltage drop due to misalligmnet*
Concluding Remarks: Voltage stability is critical for proper charging. Misalignment within tolerance allows charging but results in reduced voltage output, potentially slowing the process. Severe misalignment halts charging altogether				
Testing Team: *Turki Alturki, Belal Abed and Mohammed Alasmari*		*Date Completed:* *12/2/2024*		

4.3 CH-003

Objective:

Test the maximum current that the Qi receiver can provide using an electronic load. Confirm that the receiver operates safely within its limits and identify the actual maximum current capability.

Notes:

The Qi receiver is rated to provide a maximum current of 500 mA. This test uses an electronic load to gradually increase the current draw and measure the point at which the receiver reaches its limit. After testing, it was found that the receiver can provide up to 600 mA, slightly exceeding the expected value.

Test No.: CH-003		*Current Status: Completed*		
Test title: Measure the current delivered to the receiver				
Testing approach: Place the rover on the charging station, verify alignment and charging initiation, and use an electronic load to incrementally test the current output of the Qi receiver. Record the maximum stable current.				
STEP	*OPERATOR ACTION*	*PURPOSE*	*EXEPCTED RESULTS*	*COMMENTS*
1	*Place the rover on the charging station.*	*Ensure the system initiates charging.*	*LED on the Transmitter lights up blue, indicating successful alignment.*	*Confirm proper alignment and system activation.*
2	*Connect an electronic load to the Qi receiver's output terminals.*	*Simulate and control the current draw.*	*The electronic load is connected and ready for testing.*	*Ensure all connections are secure.*

3	*Gradually increase the current draw using the electronic load.*	*Identify the receiver's current limit.*	*The receiver provides stable current up to 500 mA.*	*Ensure no sudden voltage drops during the test.*
4	*Observe behavior at 500 mA and higher current draws.*	*Test the receiver's response to overload.*	*At > 600 mA, the receiver stops providing stable current, and charging may terminate.*	*The LED light on the transmitter lights up Red indicating an error*

Concluding Remarks: The Qi receiver exceeded its expected 500 mA limit and safely delivered up to 600 mA. Current stability beyond 500 mA indicates a robust design, but prolonged use at this level may lead to potential thermal or hardware issues	
Testing Team: *Turki Alturki, Belal Abed and Mohammed Alasmari*	*Date Completed:* *12/2/2024*

4.4 CH-004

Objective:

Verify the system's behavior when charging the battery with a full load on the PowerBoost.

Notes:

This test evaluates the impact of a full load on the PowerBoost during charging. It checks whether the Qi receiver can handle the increased current demand and identifies the point of failure when the load exceeds its capacity.

Test No.: CH-004	*Current Status: Completed*

Test title: Charging System With Full Load on the PowerBoost				
Testing approach: *Test the system's response when the PowerBoost is under full load during charging. Observe the transmitter LED and charging status of the battery.*				
STEP *1*	*OPERATOR ACTION* *Connect the full load to the PowerBoost and ensure the system runs on battery.*	*PURPOSE* *Simulate a fully loaded system under battery operation.*	*EXEPCTED RESULTS* *System operates normally, with current draw as expected for full load.*	*COMMENTS* *Ensure stable operation with the load.*
2	*Place the rover on the charging station and ensure alignment.*	*Attempt to start charging under full load.*	*Transmitter LED flashes red, and PowerBoost LED flashing yellow indicating charging failure.*	*Verify the system response to overcurrent conditions.*
3	*Observe the battery charging status.*	*Verify the system's inability to charge under full load.*	*.* *Battery does not charge when the PowerBoost is under full load.*	*Confirm that the current exceeds the Qi receiver's capacity.*
Concluding Remarks: The system fails to charge the battery with a full load on the PowerBoost because the current demand exceeds the Qi receiver's 500 mA limit				

Testing Team:	*Date Completed:*
Turki Alturki, Belal Abed and Mohammed Alasmari	*12/2/2024*

4.5 CH-005

Objective:

Verify the system's behavior when charging the battery with a lower load on the PowerBoost by unplugging the Pixy camera.

Notes:

This test evaluates the system's ability to charge the battery when the PowerBoost has a reduced load. Unplugging the Pixy camera decreases the current draw by 140 mA, allowing the Qi receiver to handle the current demand within its 500 mA specification.

Test No.: CH-005		*Current Status: Completed*		
Test title: Charging System Without Load on the PowerBoost				
Testing approach: Charging System With Lower Load on the PowerBoost				
STEP *1*	*OPERATOR ACTION* *Unplug the Pixy camera from the PowerBoost to reduce the load.*	*PURPOSE* *Simulate a reduced load condition under battery operation.*	*EXEPCTED RESULTS* *System operates normally, with current draw reduced by approximately 140 mA.*	*COMMENTS* *Verify stable operation with reduced load.*
2	*Place the rover on the charging station and ensure alignment.*	*Attempt to start charging with the reduced load.*	*Transmitter LED solid blue, and PowerBoost LED solid yellow indicating normal charging.*	*Confirm proper operation of the charging system.*

3	*Measure the total current drawn by the Qi receiver during charging.*	*Verify that the current is within the Qi receiver's capacity.*	*Total current is 600 mA: 300 mA for battery charging and 300 mA for powering the PowerBoost and remaining load.*	*Ensure current measurements are accurate and stable.*
4	*Observe the battery charging status.*	*Verify successful charging under reduced load conditions.*	*Battery charges steadily without interruptions.*	*Confirm the current allocation between charging and powering the system.*
Concluding Remarks: When the Pixy camera is unplugged, reducing the PowerBoost load, the Qi receiver draws a total of 600 mA, of which 300 mA is used to charge the battery, and 300 mA powers the PowerBoost and remaining load. This configuration allows the system to charge successfully without exceeding the Qi receiver's capacity. This test highlights the need for load management or upgrading the transmitter and receiver to handle higher current demands.				
Testing Team: *Turki Alturki, Belal Abed and Mohammed Alasmari*		*Date Completed:* *12/2/2024*		

4.6 CH-006

Objective:

Verify that the ChargingLowBatteryLED (Red, Flashing) correctly indicates charging in progress when the battery level is below 30% (voltage < 3.5V).

Notes:

This test ensures that the LED flashes red when the battery voltage is below 3.5V (30%) during charging.

Test No.: CH-006		*Current Status: Pending*		
Test title: ChargingBelow30PercentLED Behavior				
Testing approach: Simulate a battery voltage below 3.5V, initiate charging, and observe the LED behavior.				
STEP *1*	*OPERATOR ACTION* *Discharge the battery to a voltage below 3.5V.*	*PURPOSE* *Simulate a low battery condition.*	*EXEPCTED RESULTS* *The system detects the low battery voltage correctly.*	*COMMENTS* *Ensure the voltage measurement matches system specifications.*
2	*Place the rover on the charging station and ensure alignment.*	*Start the charging process.*	*The LED flashes red, indicating charging with the battery below 30% charge (voltage < 3.5V).*	*Confirm immediate LED activation.*

3	*Monitor the LED behavior as the battery voltage rises above 3.5V.*	*Verify LED transition to the next state.*	*. he LED transitions from red flashing to yellow flashing when the voltage exceeds 3.5V.*	*Confirm a seamless state transition.*
Concluding Remarks:				
Testing Team: *<< List members of testing team and lead >>*			*Date Completed:*	

4.7 CH-007

Objective:

*Verify that the **ChargingMediumBatteryLED (Yellow, Flashing)** correctly indicates charging in progress when the battery voltage is between 3.5V and 3.7V (30% to 50%).*

Notes:

This test ensures that the LED flashes yellow when the battery voltage is in the range of 3.5V to 3.7V during charging.

Test No.: CH-007	*Current Status: Pending*
Test title: ChargingBetween30And50PercentLED Behavior	
Testing approach: Simulate a battery voltage between 3.5V and 3.7V, initiate charging, and observe the LED behavior.	

STEP *1*	*OPERATOR ACTION* *Discharge the battery to a voltage between 3.5V and 3.7V.*	*PURPOSE* *Simulate a moderately low battery condition.*	*EXEPCTED RESULTS* *The system detects the battery level correctly.*	*COMMENTS* *Ensure the voltage measurement matches system specifications.*
2	*Place the rover on the charging station and ensure alignment.*	*Start the charging process.*	*The LED flashes yellow, indicating charging with the battery between 30% and 50% charge (3.5V to 3.7V).*	*Confirm immediate LED activation.*
3	*Monitor the LED behavior as the battery voltage rises above 3.7V.*	*Verify LED transition to the next state.*	*. The LED transitions from yellow flashing to green flashing when the voltage exceeds 3.7V.*	*Confirm a seamless state transition.*
Concluding Remarks:				
Testing Team: *<< List members of testing team and lead >>*			*Date Completed:*	

4.8 CH-008

Objective:

*Verify that the **ChargingHighBatteryLED (Green, Flashing)** correctly indicates charging in progress when the battery voltage is above 3.7V but below 4.15 V.*

Notes:

This test ensures that the LED flashes green when the battery voltage is above 3.7V but not yet fully charged during charging.

Test No.: CH-008		*Current Status: Pending*		
Test title: ChargingAbove50PercentLED Behavior				
Testing approach: Simulate a battery voltage above 3.7V but below 4.2V, initiate charging, and observe the LED behavior.				
STEP	*OPERATOR ACTION*	*PURPOSE*	*EXEPCTED RESULTS*	*COMMENTS*
1	*Discharge the battery to a voltage between 3.7V and 4.2V.*	*Simulate a battery condition above 50%.*	*The system detects the battery voltage correctly.*	*Ensure the voltage measurement matches system specifications.*
2	*Place the rover on the charging station and ensure alignment.*	*Start the charging process.*	*The LED flashes green, indicating charging with the battery above 50% charge (voltage > 3.7V).*	*Confirm immediate LED activation.*

3	*Monitor the LED behavior as the battery voltage approaches 4.2V.*	*Verify LED transition to the next state.*	*.* *The LED transitions from green flashing to solid blue when the battery reaches > 4.15V (full charge).*	*Confirm a seamless state transition.*
Concluding Remarks:				
Testing Team: *<< List members of testing team and lead >>*		*Date Completed:*		

4.9 CH-009

Objective:

*Verify that the **ChargingCompleteLED (Blue, Solid)** correctly indicates that the battery is fully charged at 4.2V.*

Notes:

This test ensures that the LED lights up solid blue only when the battery voltage reaches 4.2V, indicating 100% charge.

Test No.: CH-009	*Current Status: Pending*
Test title: ChargingCompleteLED Behavior	
Testing approach: Verify the battery voltage is above 4.15V before placing the rover on the charging station, initiate charging, and observe the LED behavior as the battery reaches full charge at 4.2V.	

STEP	*OPERATOR ACTION*	*PURPOSE*	*EXEPCTED RESULTS*	*COMMENTS*
1	*Ensure the battery voltage is above 4.15V.*	*Confirm that the battery is nearly fully charged.*	*The battery voltage is measured and confirmed to be above 4.15V.*	*Use an accurate multimeter or battery monitoring system.*
2	*Place the rover on the charging station and ensure alignment.*	*Start the charging process.*	*The LED shows solid blue, indicating fully charged.*	*Confirm proper alignment and charging initiation.*
3	*Observe the LED behavior when the battery reaches 4.2V.*	*Confirm the LED remains solid blue.*	*. The LED remains solid blue, indicating 100% charge.*	*Verify the LED remains solid blue without flickering.*
Concluding Remarks:				
Testing Team: *<< List members of testing team and lead >>*		*Date Completed:*		

4.10 CH-010

Objective:

*Verify that the **OverheatAlertLED (Orange, Flashing)** correctly indicates an overheat alert when the temperature exceeds safe operational limits (> 45°C).*

Notes:

This test ensures that the LED flashes orange when the system temperature rises above 45°C, signaling a potential overheating issue.

Test No.: CH-010		*Current Status: Pending*		
Test title: Over-heat-Alert-LED Behavior				
Testing approach: Verify the battery voltage is above 4.15V before placing the rover on the charging station, simulate an overheat condition, and observe the LED behavior.				
STEP	*OPERATOR ACTION*	*PURPOSE*	*EXEPCTED RESULTS*	*COMMENTS*
1	*Ensure the battery voltage is above 4.15V.*	*Confirm that the battery is charged to a safe level for testing.*	*The battery voltage is measured and confirmed to be above 4.15V.*	*Use an accurate multimeter or battery monitoring system.*
2	*Place the rover on the charging station and ensure alignment.*	*Start the charging process.*	*LED shows solid blue, indicating fully charged.*	*Confirm proper alignment and charging initiation.*

3	*Simulate a temperature increase using external heat near the sensor..*	*Test the system's ability to detect overheating.*	*.* *The temperature sensor detects the overheat condition accurately.*	*Ensure a reliable temperature sensor reading.*
4	*Observe the LED behavior as the temperature exceeds 45°C.*	*Test overheat alert mechanisms.*	*The LED starts flashing orange, indicating an overheat alert.*	*Ensure the flashing pattern is consistent.*
5	*Reduce the temperature to below 45°C and observe the LED behavior.*	*Test the system's recovery behavior.*	*The LED stops flashing orange, and the normal charging LEDs are restored.*	*Confirm a smooth transition back to normal operation.*
Concluding Remarks:				
Testing Team: *<< List members of testing team and lead >>*			*Date Completed:*	

4.11 OP-001

Objective:

*Verify that the **Green Battery Status LED (Solid)** correctly indicates the battery level is above 50% during normal operation.*

Notes:

This test ensures that the Green LED remains solid during normal operation when the battery voltage is above 3.7V (50% charge).

Test No.: OP-001		*Current Status: Completed*		
Test title: Green-Battery-Status-LED Behavior During Normal Operation				
Testing approach: Ensure the battery voltage is above 3.7V before powering on the system. Monitor the LED behavior during normal operation.				
STEP *1*	*OPERATOR ACTION* *Ensure the battery voltage is above 3.7V.*	*PURPOSE* *Confirm the battery level is above 50%.*	*EXEPCTED RESULTS* *Voltage is measured and confirmed to be above 3.7V.*	*COMMENTS* *Use an accurate multimeter or monitoring system.*
2	*Power on the rover.*	*. Start normal operation.*	*The Green LED lights up solid, indicating battery > 50%.*	*Confirm the LED remains consistent without flickering.*

3	*Operate the system for 5 minutes and monitor the LED.*	*Verify the LED behavior over time.*	*.* *The Green LED remains solid as long as the voltage stays above 3.7V.*	*Document any deviations in LED behavior.*
*Concluding Remarks: The **GreenBatteryStatusLED** accurately indicates the battery is above 50% during normal operation when the voltage is greater than 3.7V.*				
Testing Team: *Turki Alturki, Belal Abed and Mohammed Alasmari*		*Date Completed:* *12/2/2024*		

4.12 OP-002

Objective:

*Verify that the **Yellow Battery Status LED (Solid)** correctly indicates the battery level is between 30% and 50% during normal operation.*

Notes:

This test ensures that the Yellow LED remains solid during normal operation when the battery voltage is between 3.5V and 3.7V.

Test No.: OP-002	*Current Status: Pending*
Test title: Yellow-Battery-Status-LED Behavior During Normal Operation	
Testing approach: Ensure the battery voltage is between 3.5V and 3.7V before powering on the system. Monitor the LED behavior during normal operation.	

STEP *1*	*OPERATOR ACTION* *Ensure the battery voltage is between 3.5V and 3.7V.*	*PURPOSE* *Confirm the battery level is between 30% and 50%.*	*EXEPCTED RESULTS* *Voltage is measured and confirmed to be within the specified range.*	*COMMENTS* *. Use an accurate multimeter or monitoring system.*
2	*Power on the rover.*	*Start normal operation.*	*The Yellow LED lights up solid, indicating battery between 30% and 50%.*	*Confirm the LED remains consistent without flickering.*
3	*Operate the system for 5 minutes and monitor the LED.*	*Verify the LED behavior over time.*	*.* *The Yellow LED remains solid as long as the voltage stays between 3.5V and 3.7V.*	*Document any deviations in LED behavior.*
Concluding Remarks:				
Testing Team: *<< List members of testing team and lead >>*		*Date Completed:*		

4.13 OP-003

Objective:

*Verify that the **Red Battery Status LED (Solid)** correctly indicates the battery level is below 30% during normal operation.*

Notes:

This test ensures that the Red LED remains solid during normal operation when the battery voltage is below 3.5V (low battery).

Test No.: OP-003			*Current Status: Pending*	
Test title: RedBatteryStatusLED Behavior During Normal Operation				
Testing approach: Ensure the battery voltage is below 3.5V before powering on the system. Monitor the LED behavior during normal operation.				
STEP *1*	*OPERATOR ACTION* *Ensure the battery voltage is below 3.5V.*	*PURPOSE* *Confirm the battery level is below 30%.*	*EXEPCTED RESULTS* *Voltage is measured and confirmed to be below 3.5V.*	*COMMENTS* *. Use an accurate multimeter or monitoring system.*
2	*Power on the rover.*	*Start normal operation.*	*The Red LED lights up solid, indicating battery < 30%.*	*Confirm the LED remains consistent without flickering.*
3	*Operate the system for 5 minutes and monitor the LED.*	*Verify the LED behavior over time.*	*.* *The Red LED remains solid as long as the voltage stays below 3.5V.*	*Document any deviations in LED behavior.*

Concluding Remarks:	
Testing Team: *<< List members of testing team and lead >>*	*Date Completed:*

4.14 OP-004

Objective:

Verify that the system stops all functions and displays a flashing red LED when the battery is critically low (10% charge, approximately 3.3V).

Notes:

This test ensures that the system enters a power-saving mode when the battery voltage drops to a critically low level, halting all operations and showing a flashing red LED to preserve power.

Test No.: OP-004			*Current Status: Pending*	
Test title: CriticallyLowBattery Condition				
Testing approach: Discharge the battery to approximately 3.3V (10% charge), operate the system under normal conditions, and verify that it stops all functions and displays red LED.				
STEP *1*	*OPERATOR ACTION* *Discharge the battery to approximately 3.3V.*	*PURPOSE* *Simulate a critically low battery condition.*	*EXEPCTED RESULTS* *Voltage is measured and confirmed to be near 3.3V.*	*COMMENTS* *. Use an accurate multimeter or monitoring system.*

2	*Power on the rover and operate under normal conditions.*	*. Observe the system behavior as the battery reaches 3.3V.*	*The system stops all functions immediately.*	*Ensure proper detection of critically low voltage.*
3	*Observe the LED behavior after the system halts operations.*	*Verify the red LED activation.*	*. The LED solid red, indicating a critically low battery condition.*	*Confirm the LED remains consistent without flickering.*
4	*Attempt to operate the rover after it halts.*	*Test the system's preservation mode.*	*The rover remains inoperable until the battery is recharged above the critically low threshold >3.5V .*	*Ensure no unintended functions are active.*
Concluding Remarks:				
Testing Team: *<< List members of testing team and lead >>*			*Date Completed:*	

4.15 OP-005

Objective:

Verify the battery monitoring functionality during rover operation by observing the real-time battery voltage readings on the Arduino serial monitor.

Notes:

This test ensures that the battery monitoring system accurately reads and reports battery voltage during operation. The test is conducted by powering the rover through the battery and monitoring the voltage readings via the Arduino serial monitor.

Test No.: OP-005			*Current Status: Completed*	
Test title: Battery Monitoring During Operation				
Testing approach: Power the rover through the battery, connect the Arduino to a PC via USB, and monitor the battery voltage readings on the Arduino serial monitor.				
STEP	*OPERATOR ACTION*	*PURPOSE*	*EXEPCTED RESULTS*	*COMMENTS*
1	*Power the rover through the battery.*	*Simulate normal operational conditions.*	*Rover operates on battery power.*	*Ensure the Arduino is disconnected from the PowerBoost*
2	*Connect the Arduino to a PC via USB cable, ensuring it is not powered by the battery.*	*Prevent the Arduino from drawing power from both sources simultaneously.*	*Arduino powers on through the PC, and serial communication is established.*	*Verify that the Arduino is exclusively USB-powered.*

3	*Open the Arduino IDE and monitor the serial output.*	*Observe real-time battery voltage readings.*	*.* *Serial monitor displays accurate battery voltage values in real-time.*	*Verify readings align with expected battery voltage (within ±0.1V).*
*Concluding Remarks: The **battery monitoring system** accurately reports real-time battery voltage during rover operation while the Arduino is powered exclusively through USB.*				
Testing Team: *Turki Alturki, Belal Abed and Mohammed Alasmari*		*Date Completed:* *12/2/2024*		