Petal Radio Test Plan

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V1.0

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# Accessibility

Testing the accessibility of the AVAlink service for users. Covers all of 1-SW.

## Mobile Devices

Test the accessibility of the user interface on a mobile device.

1. Provide power to a Petal Radio using the micro-USB or an appropriate battery configuration.
2. Have a friend/parent follow these instructions without assistance:
3. Press the User button to activate the node.
4. Using a smartphone, connect to the AVAlink Wi-Fi network.
5. Scan the QR code or navigate to *avalink.local* in a web browser **(CHECKPOINT)**.

### Pass/Fail

Criteria for user accessibility requirements. The order of the below criteria corresponds to the order that checkpoints appear in the testing steps.

1-SW-C1.0. The user interface is rendered correctly and readably on a mobile device.

## PCs

Test the accessibility of the user interface on a PC/desktop computer.

1. Provide power to a Petal Radio using the micro-USB or an appropriate battery configuration.
2. Have a friend/parent follow these instructions without assistance:
   1. Press the User button to active the node.
   2. Using a desktop or laptop computer, connect to the AVAlink Wi-Fi network.
   3. Navigate to *avalink.local* in a web browser **(CHECKPOINT)**.

### Pass/Fail

Criteria for user accessibility requirements. The order of the criteria below corresponds to the order that checkpoints appear in the testing steps.

1-SW-C1.1. The user interface is rendered correctly and readably on a desktop/laptop computer.

# LoRa Networking

Tests the LoRa networking capabilities. Covers all of 2-SW, 3-SW, 5-SW, 10-HW.

## LoRa Tx/Rx & Collision Avoidance

Purposefully introduce the potential for packet collisions to test the performance of the collision avoidance protocol wde designed for the AVAlink network.

1. Connect a smartphone or PC to each node (Mobile Devices).
2. Send a message in the web application from both nodes with at least a 30 second delay between pressing send on the applications **(2 CHECKPOINTS).**
3. Next, introduce a packet collision scenario. Enter a message into the text box of both nodes’ web applications, but do not press send yet.
4. Once both applications are loaded with a message, press the send button on both node applications at the same time.
5. See that both messages are displayed correctly in the application at both nodes. If one or both messages do not appear, those packets were lost in a collision. Record the success or failure for that packet collision scenario.
6. Repeat Steps 3, 4, and 5 nineteen more times, for a total of 20 potential packet collision scenarios. **(CHECKPOINT)**.

### Pass/Fail

The order of the below criteria corresponds to the order that checkpoints appear in the testing steps.

2-SW-C1. The sent messages appear in the other device’s web application.

3-SW-C1. The messages appear in the chat box in the order they were sent with formatting and information that indicates which node sent each message (i.e. transmitted messages appear on the right in green and received messages appear on the left in blue with the associated node ID).

5-SW-C1. Out of 20 packet collision scenarios, 3 or less result in lost messages (packet loss of 15%).

## Impedance Match

Test the match between the LoRa module and the antenna.

1. Connect the IPEX connector on the LoRa module to a VSWR tap DUT input.
2. Connect a LoRa antenna to the VSWR tap DUT output.
3. Connect a spectrum analyser to the VSWR tap output.
4. Set the spectrum analyser to view the ISM band (900-928MHz) with persistence enabled.
5. Put the node into USB mode following the user manual instructions.
6. Provide 5V power to the node.
7. Put the node into its test configuration\* following the user manual instructions.
8. Clear the persistent traces on the spectrum analyser.
9. Press the User button on the node to initiate the test.
10. Upon completion of the test, save the spectrum analyser trace.
11. Note the frequency and peak power of the smallest peak on the analyser output **(CHECKPOINT)**.

\*The test configuration transmits LoRa packets at 14dBm at frequency slots across the ISM band.

### Pass/Fail

The order of the below criteria corresponds to the order that checkpoints appear in the testing steps.

10-HW-C1. The smallest peak in the ISM band has a peak power less than 4dBm (VSWR < 2).

# Power

Tests the power and battery management capabilities of the repeater node. Covers *4-HW, 8-HW, 9-HW, 11-HW, 12-SW.*

## A diagram of a circuit Description automatically generatedLow Voltage Disconnect

3V3 - Left J9 pin

Figure : LVD testing load circuit.

Test the low voltage disconnect capability of the node that protects batteries from full discharge.

1. Use a variable voltage supply that can provide at least 0V-20V and 3A and set the supply to 7V.
2. Follow the instructions in the user manual to set the power supply to the TPS62933P option in 6V Lithium mode.
3. Remove the jumper from J9 to expose the pins.
4. Connect the circuit shown in Figure 1 from the left-most pin of J9 to ground.
5. Connect the power supply to the board at the battery terminal block and power up the board.
6. Measure the input voltage across the battery terminal screw heads and verify it is 7.00V.
7. Measure the output voltage across the load circuit and confirm it is between 3.25V and 3.35V.
8. Place a lead on that pin and continue to monitor the voltage there using an oscilloscope.
9. Set the oscilloscope to single capture, triggering on a falling edge between 3.3V and 0V and capturing at least 20ms after the falling edge.
10. Slowly decrease the input voltage at a rate of ≈10mV/second until the load circuit LED turns off. This is the low voltage disconnect.
11. Record the input voltage that caused the low voltage disconnect in Table 1 in the appropriate column.
12. Save the oscilloscope trace. If the trace shows the load resistor voltage cycling between 0V and 3.3V after the initial power disconnect, put a “y” in the Power Cycling row of Table 1, otherwise put an “n”**.**
13. Repeat Steps 5-12 for the 12V Pb/AGM battery mode and the 12V Lithium mode but have the starting voltages about 0.5V higher than the “Reconnect” target voltages in Table 1 **(CHECKPOINT)**.

### Pass/Fail

Complete Table 1 below and compare to the requirement specifications.

Table : Low voltage disconnect testing values.



4-HW-C1.1. All actions in Table 1 pass.

## Power Supply

Tests the TPS62933P switching power supply circuit we designed for the Petal v0.0.

1. Put Petal v0.0 into USB mode by following the user manual instructions.
2. Remove the jumper from J9 to expose the pins.
3. Connect a programmable load to the far left pin of J9 and to ground.
4. Set the load to draw 10mA at 3.3V.
5. Connect a power supply (see “Supply Voltage” for the applicable mode voltage in Table 2).
6. Measure the output voltage across the programmable load and note it in Table 2.
7. Connect an oscilloscope across the programmable load.
8. Measure the ripple voltage across the programmable load with the oscilloscope, record it in Table 2, and save the trace data for later documentation.
9. Increase the load current draw to 650mA.
10. Repeat Steps 6-8.
11. Program the load to quickly increase from 10mA to 650mA, hold for 5ms, and then decrease back down to 10mA.
12. Set the oscilloscope to perform a single capture on an AC-coupled rising edge with a vertical range of -350mV to 350mV and a horizontal range of 10ms.
13. Run the load transient.
14. Using the oscilloscope, measure the peak-to-peak voltage change for the two load transient peaks. Divide this number in half to average the two peaks and record in Table 2.
15. At each transient spike, estimate the time it took for the voltage to correct back to it’s typical 3.3V waveform. Record in Table 2.
16. Repeat Steps 4-15 for the remaining modes in Table 2 **(CHECKPOINT)**.

### Pass/Fail

Complete Table 2 below and compare to the requirement specifications.

Table : Power supply unit testing criteria.



8-HW-C1.0 & C1.1. All modes have a “PASS” grade.

## Efficiency

Tests that the firmware switches between power modes based on demands.

1. Put the Petal v0.0 into 6V Li mode following instructions from the user manual.
2. Connect a 7V power supply to the board through an ammeter.
3. Ensure that the Wi-Fi access point is not on.
4. Record the current drawn in this standby mode.
5. Press the User Switch to initiate the Wi-Fi access point.
6. Ensure the Wi-Fi access point is up **(CHECKPOINT)**.
7. Record the current drawn in this state.
8. Wait 5 minutes.
9. Ensure the access point has turned off **(CHECKPOINT)**.
10. Measure the current drawn by the board again **(CHECKPOINT)**.

### Pass/Fail

Criteria for efficiency requirements. The order of the below criteria corresponds to the order that checkpoints appear in the testing steps.

11-HW-C1. The access point is available.

11-HW-C2. The access point turns off after 5 minutes of inactivity.

12-HW-C1. The current draw when the Wi-Fi access point is up is greater than the current draw when the node is in a standby mode.

# Appendix – Requirements and Tests v1.2

A legend is available in Table 4 describing the reference number syntaxes for each section.

Table 3: Requirement Specifications, related tests, and pass/fail criteria for the prototyping stage of Petal radio and AVAlink.

|  |  |  |  |
| --- | --- | --- | --- |
| Reference Number | Requirement | Test | Pass/Fail Criteria |
| 1-SW | R.1 – The user interface MUST be accessible through a modern web browser without the need for a separate application. | T1.0 – Connect a smartphone with a modern browser to the node and navigate to avalink.local.  T1.1 – Connect a PC to the node and navigate to avalink.local. | C1.0 – UI is rendered and readable on a mobile device.  C1.1 – UI is rendered and readable on a PC. |
| 2-SW | R1 – Users MUST be able to send LoRa packets using the web interface from one device to another. | T1 – Send a message using the UI to another node | C1 – The sent message is shown on the other device's UI |
| 3-SW | R1 – Chats on UI must have a username or device identifier and appear in the order the messages were received. | T1 – Send chat messages from multiple devices over the UI | C1 – The UI renders chat history with usernames in chronological order according to message timestamp |
| 4-HW | R1 – The repeater node MUST monitor battery voltage and disconnect when dropping below the low voltage threshold.  R2 – The repeater node low-voltage disconnect MUST implement hysteresis to prevent power cycling.  F1 – The repeater SHOULD indicate to the rest of the mesh network that it is powering down. | T1 – Supply voltage to the node with a variable power supply and document which voltages result in disconnect and reconnect. The node voltage monitor will be compared to that of the power supply and measured with an external meter. | C1.0 – The reported battery voltage is accurate within 3%.  C1.1 – The load disconnects when the battery voltage drops below the low voltage threshold and turns back on when the battery charges above threshold voltage. The implemented hysteresis prevents power cycling of the device.  FC1 – Before the low-voltage disconnect, the device transmits an alert that it is powering down. |
| 5-SW | R1 – The software MUST implement a collision avoidance or multiple access protocol that deals with the hidden-node problem | T1 – Transmit a LoRa packet from two devices to a single receiver at the same time without a connection between the two senders to coordinate between them | C1.0 – Packet loss of less than 15%.  C1.1 – Messages are displayed in the UI in the correct order. |
| 6-HW | R1 – MUST Design and order a PCB | T1 – Before each revision is submitted for manufacturing, it will be subject to an internal review by the group and an external review by the Capstone Committee. | C1 – The PCB design passes an internal review process and review from the Capstone Committee. |
| 7-HW | R1 – MUST have a bespoke enclosure.  F1 – SHOULD be protected against rain and moisture ingress | T1 – The enclosure will be inspected by professors.  T2 – Third-party parts like cable glands are IPX4 certified. | C1 – All third-party enclosure components have IPX4 or greater certification. |
| 8-HW | R1 – Voltage regulator MUST effectively provide the required 3.3V to the hardware for a range of typical battery voltages. | T1 – Input a range of voltages from 3.8V-20V and measure the voltage regulator output. | C1.0 – The hardware receives a stable 3.3V +/- 0.1V out across the range of test voltages.  C1.1 – The output voltage, ripple voltage, and load transient response meets the hardware specifications provided by the manufacture in the datasheet. |
| 9-HW | R1 – MUST provide recommendations for sizing batteries and solar panels based on expected insolation. | T1 – Use recommendations to size solar and battery power for a mock installation at Camosun College using insolation data for that location. | C1 - Recommended panel wattages and battery Ah meet or exceed node requirements as calculated by our power audit (datasheet specifications, duty cycle, solar insolation modeling) |
| 10-HW | R1 – Antennas MUST be well matched to the driving Hardware | T1 – SWR/Impedance testing of antenna and source using VNA (may require tuning to meet these requirements) | C1 – Source impedance is matched to antenna so that VSWR < 2 and return loss < -10 dB at some point between 900-928MHz. |
| 11-HW | R1 – Nodes MUST incorporate an accessible user button at access points for users to initiate the web server.  R2 – The Wi-Fi access point MUST time-out after 5 minutes of inactivity to save power. | T1 – Check that the Wi-Fi access point is powered down. Press the user button to initiate the Wi-Fi access point.  T2 – Leave the access point for 5 minutes without activity. | C1 – The Wi-Fi access point is available after pressing the user button.  C2 – The Wi-Fi access point is disabled after 5 minutes of inactivity. |
| 12- SW | R1 – The firmware has multiple power consumption modes to conserve battery.F1 – An LED indicates different states to the user.  offline until the battery can be recharged.  F1 – An RGB LED indicates the state the hardware is in with different colours (Passive, New message Available, Active, Waiting, Low battery) | T1.0 - - Measure node current draw when access point is up and when it is down. | C1 – The current draw in AP down mode is less than the current draw in active mode.  FC1.0 – The LED indicates a New Message state.  FC1.1 – The LED indicates low voltage. |

## Legend

Table 4: A legend describing the syntax used for the reference numbers.

|  |  |  |  |
| --- | --- | --- | --- |
| Reference Number | Requirement | Testing | Pass/Fail Criteria |
| *#-(ID):*  HW: Indicates a hardware requirement  SW: Indicates a software requirement | *R#*:  A requirement, something the component MUST have, followed by an identification number that begins at 0.  *F#:*  A feature, something the component SHOULD have, followed by an identification number that begins at 0. | *T#.#:*  The test identification number. The number matches the requirement it corresponds to. If multiple tests relate to the same requirement, a second reference number is added with a decimal point.  *FT.#.#:*  Same as requirement tests but relates to a feature. | *C#.#.#:*  The criteria identification number. The number matches the test it corresponds to. If multiple criteria exist for the same test, a second sub-reference number is added. A Pass is required.  *FC.#.#.#:*  Same as requirement criteria but relates to a feature and is not required to pass. |