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# AI Analysis & Processing Results

## Bring-Up Test Plan for LoRa Evaluation Boards

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### 1. SCOPE

This document outlines the bring-up test plan for the LoRa Base Station Evaluation Board and the LoRa Car Radio Evaluation Board. The purpose of these tests is to verify the fundamental hardware and software functionality of the evaluation boards designed by the Clemson Senior design team, ensuring they meet the specified hardware and software requirements to facilitate research into LoRa mesh networks for train applications.

### 2. Referenced Documents

\* \*\*AE104193-001:\*\* LoRa Evaluation Board Hardware Specification Document, Revision V2, 15 January 2025.  
\* \*\*AE304194-001:\*\* LoRa Evaluation Board Software Specification Document, Revision -, 27 January 2025.  
\* \*\*AE304195-001:\*\* LoRa Car Radio Programming Procedure (referenced in Firmware Programming section).  
\* \*\*AE104077-001:\*\* Drawing for PCBA visual inspection (referenced in Visual Inspection section).  
\* \*\*Netlist Data:\*\* Provided netlist information (e.g., Net: 327GPS\_TX\_READY, Net: 327NetD6\_1, etc.).

### 3. Test Execution and Recording

The procedure is to be run in the document order. If any failure is observed, the test is to be halted, marked as a failure, and the issue remedied before restarting the test from the beginning.

#### 3.1. Datasheet Reporting

The data sheets are indexed to the corresponding test procedure paragraphs. Record actual test data on applicable entry line on datasheet. Where directed, verify a satisfactory completion of an action or satisfactory observation by marking a “P” (for pass) on applicable data sheet. If completion of an action or an observation is unsatisfactory, mark an "F" (for fail) on applicable data sheet. No entry line left blank. If the specific test does not apply, write "N/A" for the entry.

#### 3.2. Test Equipment

The following test equipment is required to complete the testing herein. Equivalent equipment is acceptable.

\* DC Power Supply (Item 1)  
\* Multimeter (Item 2)  
\* Input Power Cable (Item 3)  
\* JTAG Programmer (Item 4)  
\* Test PC (Item 5)  
\* USB to TTL Serial Cable (Item 6)  
\* Oscilloscope (Item 7)  
\* External IO breakout board (for External IO verification)  
\* Ethernet Cable (for Base Station Ethernet tests)

\*(Note: A complete "Test Equipment Bill of Materials" table was not provided in the context, so specific items mentioned in the procedure are listed above.)\*

### 4. Procedure

#### 4.1. Visual Inspection

1. Visually inspect the PCBA to the IPC-610 standard and class specified in the drawing (AE104077-001).  
 \* \*\*Verify:\*\* No obvious manufacturing defects, solder bridges, missing components, or incorrect component orientations.

#### 4.2. Initial Power-Off Checks (Continuity/Shorts)

1. Set the multimeter (Item 2) in diode check (beep) mode.  
2. Using the multimeter, probe the ground pad (pin 2) of the input barrel jack (J3) (GND) with the black multimeter probe.  
3. With the red probe, verify the following locations are connected to ground:  
 \* P2 pin 1 (GPIO Header)  
 \* \*(Add other ground points as specified in a "Voltage Rails to Check" table if available)\*  
4. With the black multimeter probe still on the ground pad (pin 2) of the input barrel jack (J3) (GND) and using the red probe, verify that the following nets are \*\*NOT\*\* connected to ground (i.e., no short to ground):  
 \* J3 pin 1 (PWR\_JACK)  
 \* U6 pins 14-16 (+5V)  
 \* P2 pin 2 (+3V3)  
 \* U12 pin 1 (+3V3\_RF)  
 \* \*(Add other power nets as specified in a "Voltage Rails to Check" table if available)\*  
5. Place the black multimeter probe on U6 pins 14-16 (+5V) and using the red probe, verify that the following nets are \*\*NOT\*\* connected:  
 \* P2 pin 2 (+3V3)  
 \* U12 pin 1 (+3V3\_RF)  
6. Place the black multimeter probe on P2 pin 2 (+3V3) and using the red probe, verify that the following nets are \*\*NOT\*\* connected:  
 \* U12 pin 1 (+3V3\_RF)

#### 4.3. Power-On and Voltage Rail Checks

1. Disconnect any connected output power cables from the DC power supply (Item 1). Power on the supply without enabling output.  
2. Set the DC power supply to output 5V and set the current limit to 200mA.  
3. Connect the input power cable (Item 3) banana jacks to the output jacks of the DC power supply, and the barrel connector to the UUT’s barrel jack, as shown in Figure 4-1 (if provided).  
4. \*\*(WARNING:\*\* If the UUT draws too much current, be prepared to turn off power supply quickly to reduce damage to the UUT) Enable the power supply.  
5. \*\*(WARNING)\*\* Verify that the UUT does not draw more than the current limit, entering the power supply into constant current mode. If the board is drawing more than 200mA, disable the power supply, end this procedure, and diagnose the issue.  
6. Place the black multimeter probe on the ground pad (pin 2) of the input barrel jack (J3) (GND) and using the red probe, verify the following nets voltages:  
 \* U6 pins 14-16 (+5V) - \*\*Expected: +5VDC\*\*  
 \* P2 pin 2 (+3V3) - \*\*Expected: +3.3VDC\*\*  
 \* U12 pin 1 (+3V3\_RF) - \*\*Expected: +3.3VDC\*\*  
 \* \*(Note: A complete "Voltage Rails to Check" table was not provided in the context, so common rails are listed.)\*

#### 4.4. Clock Signal Verification

1. Power on and set up the Oscilloscope (Item 7) with the following settings on channel 1: 1V/div, 5us/div, measurement frequency channel 1.  
2. Probe Y1 pin 1 with the channel 1 probe.  
 \* \*\*Verify:\*\* The clock signal is 16MHz.  
3. Probe Y2 pin 1 with the channel 1 probe.  
 \* \*\*Verify:\*\* The clock signal is 32MHz.  
4. Power off the UUT.

#### 4.5. Firmware Programming

1. Connect the JTAG Programmer (Item 4) to the test PC (Item 5) with the included USB cable.  
2. Connect the JTAG Programmer to the UUT with the included JTAG cable, as shown in Figure 4-2 (if provided).  
3. Connect the USB to TTL Serial Cable (Item 6) to the test PC (Item 5) and to the UUT debug header (P2) with the following pinout:  
 \* \*(Note: Specific pinout for P2 was not provided in the context. Placeholder for pin connections: e.g., TX to P2.X, RX to P2.Y, GND to P2.Z)\*  
4. Program the UUT according to AE304195-001 LoRa Car Radio Programming Procedure.  
 \* \*\*Verify:\*\* Programming is successful (e.g., programmer reports success, UUT reboots).

#### 4.6. Functional Tests (Serial Interface)

1. Open a serial terminal to the UUT on the test PC (Item 5) using the following parameters:  
 \* Baud Rate: 115200  
 \* Parity: None  
 \* Stop Bits: 1

##### 4.6.1. Basic Console Interaction

1. Reset the UUT by pressing SW1.  
 \* \*\*Verify:\*\* The welcome screen prints to the console.  
2. Type a simple command (e.g., "help") and press enter.  
 \* \*\*Verify:\*\* The console responds with a list of available commands or an acknowledgment.

##### 4.6.2. Built-in Tests (LoRa, GPS, IMU, I2C)

1. Enter command “bit.lora” into the console.  
 \* \*\*Verify:\*\* Built-in test shows as "Pass". (Checks LoRa radio chipset SX1276 as per AER-LORA-HW/SW).  
2. Enter command “bit.gps” into the console.  
 \* \*\*Verify:\*\* Built-in test shows as "Pass". (Checks GPS subsystem, Ublox M8 or M10 series as per AER-LORA-HW).  
3. Enter command “bit.imu” into the console.  
 \* \*\*Verify:\*\* Built-in test shows as "Pass". (Checks IMU subsystem for 6 or 9 axis sensing as per AER-LORA-HW).  
4. Enter command “bit.i2c” into the console.  
 \* \*\*Verify:\*\* Built-in test shows as "Pass".

##### 4.6.3. Power Monitoring (Car Radio Only)

1. \*\*(Car Radio Only)\*\* Enter a command (e.g., `status.power` or `bit.power`) into the console to check power draw from the primary input source.  
 \* \*\*Verify:\*\* The UUT reports its current power draw. (AER-LORA-HW requirement for power monitoring).

##### 4.6.4. GPIO Braking (Car Radio Only)

1. \*\*(Car Radio Only)\*\* Connect a multimeter or oscilloscope to the designated GPIO output pin for braking (as per AER-LORA-SW).  
2. Enter a command (e.g., `set.braking 50`) to set braking percentage to 50%.  
 \* \*\*Verify:\*\* The GPIO output voltage/state changes to reflect 50% braking.  
3. Enter a command (e.g., `set.braking 100`) to set braking percentage to 100%.  
 \* \*\*Verify:\*\* The GPIO output voltage/state changes to reflect 100% braking.  
4. Enter a command (e.g., `set.braking 0`) to set braking percentage to 0%.  
 \* \*\*Verify:\*\* The GPIO output voltage/state changes to reflect 0% braking.

##### 4.6.5. External IO Verification

1. Connect an external IO breakout board or appropriate test equipment to the 2-row 100mil header.  
2. \*\*(GPIO Signals)\*\* For each of the 8x GPIO signals:  
 \* Enter a command to set a GPIO pin high (e.g., `gpio.set <pin\_num> 1`).  
 \* \*\*Verify:\*\* Pin voltage is +3.3VDC with a multimeter.  
 \* Enter a command to set a GPIO pin low (e.g., `gpio.set <pin\_num> 0`).  
 \* \*\*Verify:\*\* Pin voltage is 0VDC with a multimeter.  
 \* Connect a jumper from a GPIO output to a GPIO input and verify read-back commands (e.g., `gpio.read <pin\_num>`).  
3. \*\*(DAC Signals)\*\* For each of the 2x DAC signals:  
 \* Enter a command to set a DAC output voltage (e.g., `dac.set <dac\_num> 1.5V`).  
 \* \*\*Verify:\*\* Output voltage is 1.5VDC with a multimeter. Repeat for 0V and 3.3V.  
4. \*\*(ADC Signals)\*\* For each of the 2x ADC signals:  
 \* Apply a known voltage (e.g., 0V, 1.5V, 3.3V) to an ADC input pin.  
 \* Enter a command to read the ADC input (e.g., `adc.read <adc\_num>`).  
 \* \*\*Verify:\*\* The console output matches the applied voltage within tolerance.  
5. \*\*(UART Serial Interface)\*\* Perform a loopback test or connect to another serial device.  
 \* Enter a command to send data via UART (e.g., `uart.send "hello"`).  
 \* \*\*Verify:\*\* Data is received correctly on the loopback/connected device.  
6. \*\*(I2C Serial Interface)\*\* Connect an I2C slave device (e.g., a known sensor).  
 \* Enter a command to communicate with the I2C device (e.g., `i2c.scan` or `i2c.read <address> <register>`).  
 \* \*\*Verify:\*\* The UUT successfully communicates with and reads data from the I2C device.  
7. \*\*(SPI Serial Interface)\*\* Connect an SPI slave device.  
 \* Enter a command to communicate with the SPI device (e.g., `spi.transfer <data>`).  
 \* \*\*Verify:\*\* The UUT successfully communicates with and exchanges data with the SPI device.  
8. \*\*(Power Pins)\*\* With the multimeter, verify the +3.3V Power pins on the external header output +3.3VDC.

##### 4.6.6. Low Power Mode & Wake-From-Low-Power (Car Radio Only)

1. \*\*(Car Radio Only)\*\* Enter a command to put the UUT into a low-power state (e.g., `power.low`).  
 \* \*\*Verify:\*\* The current draw significantly decreases (monitor with DC power supply or integrated power monitoring).  
2. \*\*(Car Radio Only)\*\* Simulate motion input via the IMU (e.g., physically shake the board, if IMU is functional).  
 \* \*\*Verify:\*\* The UUT wakes from low-power mode and resumes normal operation, potentially printing a message to the console.

##### 4.6.7. Battery Power Subsystem (Car Radio Only)

1. \*\*(Car Radio Only)\*\* Connect a charged battery to the UUT and disconnect primary power.  
 \* \*\*Verify:\*\* The UUT continues operating without interruption (Hot Swapping requirement).  
2. \*\*(Car Radio Only)\*\* Connect primary power while the battery is connected.  
 \* \*\*Verify:\*\* The UUT switches to primary power and begins charging the battery (Hot Swapping and Charging requirements).  
3. \*\*(Car Radio Only)\*\* Monitor battery charge status via a console command (e.g., `battery.status`).  
 \* \*\*Verify:\*\* The unit reports battery levels and indicates charging status.  
4. \*\*(Car Radio Only)\*\* Allow the battery to charge fully.  
 \* \*\*Verify:\*\* The charging status changes to "trickle charge" or similar to prevent overcharge degradation.

##### 4.6.8. Ethernet Subsystem (Base Station Only)

1. \*\*(Base Station Only)\*\* Connect the Base Station to a network using an Ethernet cable.  
2. Enter a command to check network connectivity (e.g., `net.status` or `ping google.com`).  
 \* \*\*Verify:\*\* The device obtains an IP address and can communicate over the network (RJ45 Connection, Ethernet Speed requirements).  
3. \*\*(Base Station Only)\*\* If possible, verify 10/100Mbps communication rates by checking network interface status or transferring a file and monitoring speed.

##### 4.6.9. Web Interface (Base Station Only)

1. \*\*(Base Station Only)\*\* On the test PC, open a web browser and navigate to the IP address of the Base Station.  
 \* \*\*Verify:\*\* The web interface loads successfully.  
2. Interact with the web interface to send a command message to a simulated or actual Car Radio.  
 \* \*\*Verify:\*\* The Base Station forwards the command via LoRa (requires a Car Radio to confirm reception).  
3. Simulate a status update from a Car Radio.  
 \* \*\*Verify:\*\* The web interface displays the status information about the connected nodes.

##### 4.6.10. Spectrum Scan (Base Station Only)

1. \*\*(Base Station Only - Secondary Priority)\*\* If implemented, enter the spectrum scan command (e.g., `lora.scan`) into the console.  
 \* \*\*Verify:\*\* The Base Station executes a spectrum scan and reports an acceptable RF channel.  
2. \*\*(Base Station Only - Secondary Priority)\*\* Enter a command to set all nodes to the newly found RF channel.  
 \* \*\*Verify:\*\* The command is processed and acknowledged.

#### 4.7. Final Power Off

1. Power off the UUT gracefully via software command, if available.  
2. Disconnect the DC power supply (Item 1) from the UUT.  
3. Disconnect all other test equipment.

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### Appendix A Test Datasheet

Record the results of each test in the datasheet below.

\*(Placeholder for a detailed datasheet table, which would include columns for Test Step #, Description, Expected Result, Actual Result, Pass/Fail, and Comments.)\*

# Document Information

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