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# AI Analysis & Processing Results

\*\*Bring-Up Test Plan for LoRa Car Radio Evaluation Board\*\*

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\*\*1. SCOPE\*\*

This document outlines the bring-up test procedures for the LoRa Car Radio Evaluation Board designed by the Clemson Senior design team. The purpose of these tests is to verify the hardware functionality and initial software operation, ensuring the board meets its specified hardware and software requirements to facilitate research into LoRa mesh networks for utilization on trains for various signaling and data monitoring applications.

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\*\*2. Referenced Documents\*\*

\* \*\*AE104193-001, Revision: V2:\*\* LoRa Evaluation Board Hardware Specification  
\* \*\*AE304194-001, Revision: -:\*\* LoRa Evaluation Board Software Specification  
\* \*\*AE304195-001:\*\* LoRa Car Radio Programming Procedure (referenced in Firmware Programming)  
\* \*\*IPC-610 Standard:\*\* Acceptability of Electronic Assemblies (referenced in Visual Inspection)

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\*\*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.

| Item | Description |  
| :--- | :---------------------- |  
| 1 | DC Power Supply |  
| 2 | Multimeter |  
| 3 | Input Power Cable |  
| 4 | JTAG Programmer |  
| 5 | Test PC |  
| 6 | USB to TTL Serial Cable |  
| 7 | Oscilloscope |  
| 8 | LoRa Antenna (SMA) |  
| 9 | GPS Antenna (SMA) |  
| 10 | Battery Pack |

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\*\*4. Procedure\*\*

\*\*4.1. Visual Inspection\*\*

1. Visually inspect the PCBA to the IPC-610 standard and class specified in the drawing (AE104077-001).  
2. Verify the presence and correct orientation of all components.  
3. Verify the integrity of solder joints and absence of shorts or opens.  
4. Verify the barrel-type connector for +5VDC input (AER-LORA-HW).  
5. Verify the presence of the 2-row 100mil header for external IO (AER-LORA-HW).  
6. Verify the presence of SMA interfaces for LoRa and GPS antennas (AER-LORA-HW).

\*\*4.2. Voltage Rail Checks\*\*

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)  
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:  
 \* J3 pin 1 (PWR\_JACK)  
 \* U6 pins 14-16 (+5V)  
 \* P2 pin 2 (+3V3)  
 \* U12 pin 1 (+3V3\_RF)  
5. Place 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 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)  
7. Disconnect any connected output power cables from the DC power supply (Item 1). Power on the supply without enabling output.  
8. Set the DC power supply (Item 1) to output 5V and set the current limit to 200mA.  
9. 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.  
 \* \*\*(WARNING: If the UUT draws too much current, be prepared to turn off power supply quickly to reduce damage to the UUT)\*\*  
10. Enable the power supply.  
 \* \*\*(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.\*\*  
11. 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:  
 \* Table - Voltage Rails to Check (Reference Table 4-1 from original procedure if available, otherwise specify expected rails like +5V, +3.3V, +3.3V\_RF, etc.)  
12. Power on and set up the Oscilloscope (Item 7) with the following settings on channel 1: 1V/div, 5us/div, measurement frequency channel 1.  
13. Probe Y1 pin 1 with the channel 1 probe. Verify that the clock signal is 16MHz.  
14. Probe Y2 pin 1 with the channel 1 probe. Verify that the clock signal is 32MHz.  
15. Power off the UUT.

\*\*4.3. 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.  
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:  
 \* [Insert specific pinout details for P2 if available]  
4. Program the UUT according to AE304195-001 LoRa Car Radio Programming Procedure.  
5. Verify programming is successful. (This also verifies programming updates via USB port - AER-LORA-HW).

\*\*4.4. Functional Test\*\*

1. Open a serial terminal to the UUT on the test PC (Item 5) using the following parameters (AER-LORA-SW):  
 \* Baud Rate: 115200  
 \* Parity: None  
 \* Stop Bits: 1  
2. Reset the UUT by pressing SW1.  
3. Verify the welcome screen prints to the console.  
4. Enter command “bit.lora” into the console. Verify built-in test shows as Pass. (Verifies SX1276 chipset - AER-LORA-HW, AER-LORA-SW)  
5. Enter command “bit.gps” into the console. Verify built-in test shows as Pass. (Verifies Ublox M8/M10 chipset - AER-LORA-HW)  
6. Enter command “bit.imu” into the console. Verify built-in test shows as Pass. (Verifies 6/9 axis IMU sensing - AER-LORA-HW)  
7. Enter command “bit.i2c” into the console. Verify built-in test shows as Pass. (Verifies I2C interface functionality)  
8. \*\*Processor Verification:\*\* Confirm the MCU is an STM32L4 series chip (AER-LORA-HW, AER-LORA-SW). This might be done by a specific `bit` command or boot-up message.  
9. \*\*Memory Verification:\*\* If possible via CLI, verify the presence of at least 64MBytes of external Flash memory (AER-LORA-HW).  
10. \*\*RF Input Verification:\*\* Connect LoRa Antenna (Item 8) to the LoRa SMA interface.  
11. \*\*Radio Band Verification:\*\* If a command exists, verify the radio can be configured to operate within the US unlicensed radio band (902.0 - 928.0 MHz) (AER-LORA-SW).  
12. \*\*GPIO Braking Test:\*\*  
 \* Enter a command (e.g., "set.braking 50") to set braking percentage to 50. Verify the GPIO output for braking reflects this (e.g., measure voltage/PWM on the relevant GPIO pin, if accessible).  
 \* Enter a command (e.g., "set.braking 0") to set braking percentage to 0. Verify the GPIO output.  
 \* Enter a command (e.g., "set.braking 100") to set braking percentage to 100. Verify the GPIO output. (AER-LORA-SW)  
13. \*\*Shared Messaging Protocol:\*\* Verify the ability to send and receive test messages based on the agreed-upon command message protocol (AER-LORA-SW). This might involve interaction with a simulated Base Station if available.  
14. \*\*Power Monitoring:\*\* If a command exists, query the UUT for its current power draw from the primary power input source and verify it is reporting correctly (AER-LORA-HW).

\*\*4.5. External IO Verification\*\*

1. Using the serial debug interface, send commands to cycle/toggle each of the 8x GPIO signals on the external header (AER-LORA-HW). Verify their states with a multimeter or oscilloscope.  
2. Send commands to output specific voltages on the 2x DAC signals. Verify output voltages with a multimeter (AER-LORA-HW).  
3. Connect known voltage sources to the 2x ADC signals. Send commands to read ADC values and verify accuracy (AER-LORA-HW).  
4. Verify functionality of 1x UART, 1x I2C, and 1x SPI serial interfaces by sending/receiving test data (AER-LORA-HW).  
5. Verify the +3.3V Power pins on the header provide the correct voltage (AER-LORA-HW).  
6. Verify all pins on the external IO header are tolerant to voltage levels from 0V to +3.3VDC by applying test signals within this range and monitoring for unexpected behavior (AER-LORA-HW).

\*\*4.6. GPS Subsystem Verification\*\*

1. Connect GPS Antenna (Item 9) to the GPS SMA interface.  
2. Verify the GPS module can acquire a fix and report location data via the serial debug interface.  
3. If accessible, verify the 1PPS output signal from the GPS module is present and accurate (AER-LORA-HW).

\*\*4.7. IMU Subsystem Verification\*\*

1. Initiate IMU data acquisition via serial debug commands.  
2. Physically move the UUT and verify that the IMU reports changes in motion/orientation (AER-LORA-HW).  
3. \*\*Wake-From-Low-Power (Secondary):\*\* If implemented, put the UUT into a low-power state and verify it wakes up upon detecting motion from the IMU (AER-LORA-SW).

\*\*4.8. Battery Power Subsystem Verification (Car Radio Only)\*\*

1. Ensure the UUT is powered by the DC power supply (Item 1).  
2. Connect the Battery Pack (Item 10) to the UUT.  
3. Disconnect the DC power supply (Item 1). Verify the UUT remains operational without interruption, now running on battery power (Hot Swapping - AER-LORA-HW).  
4. Reconnect the DC power supply (Item 1). Verify the UUT switches back to primary power without interruption (Hot Swapping - AER-LORA-HW).  
5. Monitor the battery charging status via serial debug commands. Verify the battery begins charging when primary power is applied (AER-LORA-HW).  
6. Allow the battery to charge fully. Verify the unit transitions to trickle charge mode to prevent overcharge (AER-LORA-HW). This may require extended observation.  
7. Disconnect the DC power supply (Item 1) and operate on battery. Monitor and verify the UUT can report accurate battery levels (AER-LORA-HW).

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\*\*5. Appendix A Test Datasheet\*\*

Record the results of each test in the datasheet below.

| Section | Step | Description | Actual Result | Pass/Fail/N/A | Comments |  
| :------ | :--- | :----------------------------------------------- | :------------ | :------------ | :------- |  
| 4.1 | 1 | Visual inspection to IPC-610 standard | | | |  
| 4.1 | 2 | Component presence and orientation | | | |  
| ... | ... | ... | | | |  
| 4.2 | 1 | Multimeter in diode check mode | | | |  
| ... | ... | ... | | | |  
| 4.3 | 1 | JTAG programmer connected to PC | | | |  
| ... | ... | ... | | | |  
| 4.4 | 1 | Serial terminal opened with correct parameters | | | |  
| 4.4 | 2 | UUT reset via SW1 | | | |  
| 4.4 | 3 | Welcome screen prints to console | | | |  
| 4.4 | 4 | "bit.lora" shows Pass | | | |  
| 4.4 | 5 | "bit.gps" shows Pass | | | |  
| 4.4 | 6 | "bit.imu" shows Pass | | | |  
| 4.4 | 7 | "bit.i2c" shows Pass | | | |  
| 4.4 | 8 | Processor verified as STM32L4 series | | | |  
| 4.4 | 9 | External Flash memory >= 64MBytes verified | | | |  
| 4.4 | 10 | LoRa Antenna connected to SMA interface | | | |  
| 4.4 | 11 | Radio band configured to 902.0 - 928.0 MHz | | | |  
| 4.4 | 12a | GPIO braking set to 50% verified | | | |  
| 4.4 | 12b | GPIO braking set to 0% verified | | | |  
| 4.4 | 12c | GPIO braking set to 100% verified | | | |  
| 4.4 | 13 | Shared messaging protocol tested | | | |  
| 4.4 | 14 | Power monitoring reports correctly | | | |  
| 4.5 | 1 | 8x GPIO signals verified | | | |  
| 4.5 | 2 | 2x DAC signals output verified | | | |  
| 4.5 | 3 | 2x ADC signals input verified | | | |  
| 4.5 | 4 | UART, I2C, SPI interfaces verified | | | |  
| 4.5 | 5 | +3.3V Power pins verified | | | |  
| 4.5 | 6 | External IO pins 0-3.3VDC tolerant | | | |  
| 4.6 | 1 | GPS Antenna connected to SMA interface | | | |  
| 4.6 | 2 | GPS fix and location data reported | | | |  
| 4.6 | 3 | 1PPS output from GPS verified | | | |  
| 4.7 | 1 | IMU data acquisition verified | | | |  
| 4.7 | 2 | IMU motion/orientation changes reported | | | |  
| 4.7 | 3 | Wake-from-low-power via IMU verified (Secondary) | | | |  
| 4.8 | 1 | UUT powered by DC supply | | | |  
| 4.8 | 2 | Battery Pack connected | | | |  
| 4.8 | 3 | Hot swapping to battery verified | | | |  
| 4.8 | 4 | Hot swapping to primary power verified | | | |  
| 4.8 | 5 | Battery charging initiated | | | |  
| 4.8 | 6 | Trickle charge verified | | | |  
| 4.8 | 7 | Battery level monitoring verified | | | |

# Document Information

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