Design Verification Tests

Finn Hittson

November 16th, 2023

1 Design Verification Tests

The following documents outlines a set of tests for each of the functional blocks that are included on Radio Tiny (RAT) that should be performed in order to determine whether RAT is working as it should. Each section corresponds to a specific block from the block diagram and includes a set of procedures to verify the hardware's functionality. In the tests described below, if a test point is not given, find the nearest leg.

2 Battery Management System

The battery management system is expecting a 3.7V battery input and should output 3.3V source and a 5V source. There should be communication between the fuel gauge and the microcontroller and the battery should charge when the board is connected via a micro-USB or a USB-C.

2.1 3.3V Regulator (U3)

U3 is expecting a voltage between 2.7V and 6.0V. The battery voltage should be maintained at 3.7V so we are well withing the range.

Tests

1. First measure the voltage of the battery and check that it is within the operating range of U3. If a battery is not available then connect a voltage source to the board.

2. Measure output voltage from the U3 and check that it is within the range of 3.3±0.3V. Use the 3V3 TP for this.

3. With a voltage source connected, check that 3.3±0.3V is still maintain at the edges of the voltage regulator (2.7V and 6.0V). Use the 3V3 TP for this.

2.2 5.0V Booster (U9)

U9 is expecting a voltage between 3.0V and 4.2V. The battery voltage should be maintained at 3.7V so we are well withing the range.

Tests

1. First measure the voltage of the battery and check that it is within the operating range of U9. If a battery is not available then connect a voltage source to the board.
2. Measure output voltage from the U9 and check that it is within the range of 5.0V at 300mA. Use the 5V TP for this.
3. With a voltage source connected, check that 5.0V at 300mA is still maintain at the edges of the voltage regulator (3.0V and 4.2V). Use the 5V TP for this.

2.3 Fuel Gauge (U8)

The fuel gauge is responsible for monitoring the conditions of the battery which charging and discharging.

Tests

1. With the battery charging and discharging through the board, communicate with U8 via its I2C communication lines and confirm that the battery is operating as it should be.

2.4 Battery Charger (e1)

The battery charger is responsible for handling VBUS voltage to charge the battery. It is expecting a voltage between 3.75V and 6.0V and should output a current to charge the battery between 10mA and 50mA.

Tests

1. First connect voltage source directly to e1 and tests the edge cases of the input voltage range (3.75V and 6.0V). Check that the output current is between 10mA and 50mA and that LED2 lights up.
2. Connect either the micro-USB or the USB-C and check that VBUS is within e1 input voltage operating range. Use VBUS TP for this. Should be around 5.0V for both types of connection.
3. Check that LED2 lights up when cables are connect.
4. Check that output current is between 10mA and 50mA and that battery is charging over time. Use VBAT TP for this.

3 Radio

The radio is responsible for receiving radio band waves and translating them into audio signals. There is a communication line between the radio component and the microcontroller for relaying tuning data and other related information and the output signals are sent to the amplifier and the aux port.

3.1 Crystal Oscillator (XTAL2)

The crystal oscillator provides and input oscillatory signal for the radio unit.

Tests

1. Test that the input voltage is approximately 3.3V. The oscillator accepts a voltage between 1.5V and 3.63V.

2. Probe the output with an oscilloscope and check that the output signal is a 32.768 kHz sine wave. Use XTAL TP for this.

3.2 Antenna

The FM and AM antenna should be converting radio waves into electric signals.

Tests

Connect both antenna and probe both outputs with an oscilloscope to see if they are detecting anything.

3.3 Radio IC (U1)

U1 is what receives and processes the signals from the antenna and transforms them into audio signals.

3.4 Tests

1. First check communication between U1 and the microcontroller via the I2C communication lines.

2. Test the communication between the microcontroller and the three GPIO pins on the U1 IC.

3. Measure the audio output signal from U1 and confirm that it is creating an analog audio signal. Plug in headphones to the aux port and test if signal is audible and if the signal is intelligible (if we can hear words or music).

4. With a DMM, test that the reset button for U1 is pulled low when pressed, and high when not pressed.

4 Audio Amplifier

The audio amplifier amplifies the audio for the speaker.

Tests

1. Check that input voltage source is 3.3V.
2. With a DMM, test that the middle lead of the potentiometer is actively changing as you turn the wiper.
3. With a DMM or oscilloscope, compare input and output signals from the amplifier (U6) and see if the output signal is that of the original only amplified. Max gain is 23dB.

5 Memory

The memory system on RAT consists of a 5V to 3.3V buffer that reduces the signals to 3.3V as to not damage the micro SD card and a micro SD card slot.

Tests

1. With a DMM, measure input voltages to buffer and micro SD card slot and check that both are 3.3V.
2. First test each of the four outputs from the buffer that they have been reduced to a 3.3V signal. Use MEM TP for this.
3. Test communication between the micro SD card and the microcontroller.
4. When reading or writing data, LED1 should light up.
5. Write data to the micro SD and check that it can be read.

6 Display

Display shows RAT related information, such as tuned frequency, volume, band, and battery.

Tests

1. Load a message onto the display from the microcontroller.
2. With a DMM, measure middle leg of potetiometer (RV1) and make sure its value changes and thus changes character brightness on screen.

7 Microcontroller (U2)

U2 connects all components of RAT together. It handles data being written and read to and from memory, changing frequency and band for the radio, what is display on the LCD, and speaks to the fuel gauge for battery health.

7.1 USB Receptacles

Both receptacles allow for communication between the microcontroller and a computer for programming and data transfer. These connections also charge the battery.

Tests

1. With USB-C plugged in, test that VBUS is supplying 5V. Use test point VBUS TP to make this measurement.

2. With micro-USB plugged in, check that VBUS is between 4.4V and 5V with a DMM. Use test point VBUS TP to make this measurement.

7.2 Frequency Adjuster (SW5) and Band Changing (Sw2)

SW5 changes the frequency that the radio is tuned into and SW2 changes from AM to FM.

Tests

1. Turn the knob either way and monitor the voltage changes with an oscilloscope at test points ROTA TP and ROTB TP to check that each knob click causes a difference in between pins A and B which can be translated into tuning up or tuning down.

2. With a DMM, check that pressing the button pulls the button's output low.

7.3 JTAG Connector

This connector allows us to load a bootloader onto the microcontroller.

Tests

1. Measure pin 1 and confirm that it is receiving 3.3V.

2. Attempt to load a boot loader onto the microcontroller.

7.4 Microcontroller

The microcontroller manages all data lines so testing comes down to whether each pin is configured correctly and receiving information from a component that we have already physically tested. Issues in this realm are now software ones.