4. Evaluation

WiRAD was subjected to rigorous testing in order to ensure satisfaction of performance and safety constraints. This section is divided into test specifications and test certifications. Each of these sections is further subdivided into simulation testing, hardware testing, software testing, and system testing.

4.1 Test Specification

The tests specified in this section are designed to evaluate the satisfaction of the technical design constraints of Table I.

Table I: Technical Design Constraints

Name	Description
Decoding Quality	WiRAD is capable of decoding streaming audio encoded at bitrates of up to 128 kbit/s.
Transmission Rate	The 802.11b wireless link is capable of sustaining 1 Mbit/s transfer at an operating frequency of 2.4 GHz and range of 30m from a base-station.
Battery Life	The battery provides at least 3 hours continued usage before recharging.
Portability	WiRAD is less than 10 cm (W) x 15 cm (H) x 5 cm (D).
Audio Quality	WiRAD provides 20-bit stereo audio at 48 KHz.

4.1.1 Simulation

4.1.1.1 Antenna

[antenna simulation testing explanation will go here]

4.1.2 Hardware

4.1.2.1 Microcontroller

Proper microcontroller (MCU) operation was tested in two steps:

1. 16 MHz oscillation was measured on the MCU X1 and X2 clock pins.
2. A test program for flashing an LED was programmed to the MCU via the USB bootloader and verified to work.

The MCU is essential to basic WiRAD functionality and proper operation is implied in the technical design constraints of Table I. MCU operation is particularly relevant to the decoding quality and audio quality constraints. The MCU's 16 MHz clock indicates the availability of instruction cycles to process 128kbit/s and provide a mechanism for interrupts at a frequency of 48 KHz for the 20-bit stereo digital-to-analog converter.

4.1.2.2 WiFi Module

The WiFi module was powered on in isolation from the MCU at a distance of 30m from the WiFi access point in order to test operation. The module's on-chip application processor allows operation in a standalone mode independent of MCU control. In this mode, the module can host web pages and receive command-line interface (CLI) commands via telnet. Proper operation was tested by using a web browser and telnet to connect to the module and issue the "wl-status" command that causes the module to report its wireless status. This status information, along with the fact that a connection was achieved at all, was used to verify proper operation of the WiFi module.

The WiFi module is essential to basic WiRAD functionality and proper operation is implied in the technical design constraints of Table I. This testing was also necessary to ensure a minimum WiFi transmission rate of 1 Mbit/s.

4.1.2.3 Battery

To ensure adequate battery life as dictated by design constraints, charge/discharge testing was conducted. The battery was charged from initial depletion to full capacity through a standard USB port as illustrated in Figure ___.

[Picture here of charging battery].
Fig XXX.

It was then discharged through a resistor as illustrated in Figure ___.

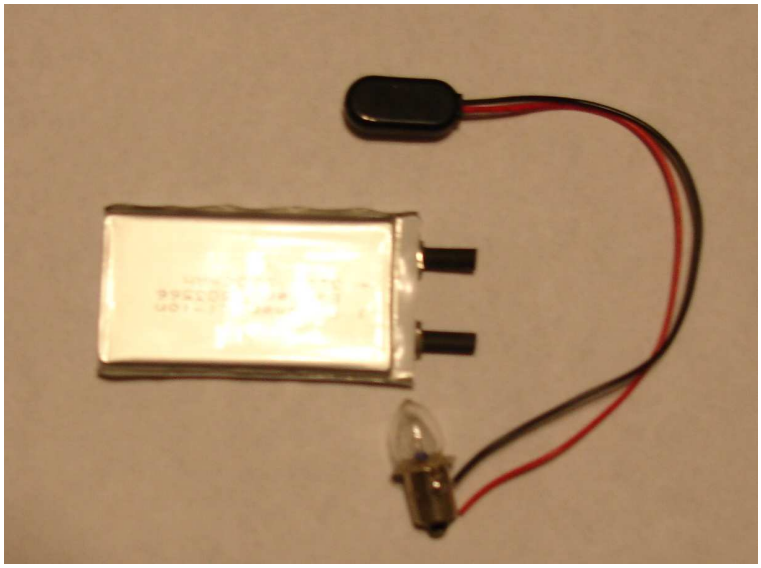

Fig. XXX

In both procedures, protection circuitry was utilized.

This testing provided the necessary data to evaluate satisfaction of WiRAD's battery-life constraint. It also yielded data on charge/discharge times.

4.1.2.4 Antenna

The power return loss of the WiFi module was tested in the bandwidth range of 2.4 GHz to 2.48 GHz using a network analyzer.

After ensuring the constructed antenna's effectiveness, the antenna was connected to the WiFi module (in standalone mode). Both were tested together by using telnet to access the WiFi module and validate the signal strength at a distance of 30m. In order to test the operational bandwidth of the antenna, the 802.11b wireless access point was manually set to operate at different frequencies by changing the channels of the router. Each channel was tested to ensure a functional bandwidth of 2.4 GHz to 2.48 GHz.

While the primary motivations for custom-designing an antenna were size and cost, the above functional tests were necessary to ensure that antenna quality was not degraded to the point where transmission rate

and decoding quality constraints could not be satisfied.

4.1.3 Software

4.1.3.1 Device Firmware

The device firmware was evaluated on the basis of usability in accordance with the use cases and state flowcharts enumerated in 3.3.

4.1.3.2 Desktop Client Software

4.1.3.2.1 Saving and Loading Configurations

The WiRAD desktop client application is designed to manage profiles of station presets. The client application allows for this interaction with the simple Save, Save As, Load commands located in the File Menu as seen in Figure ____.

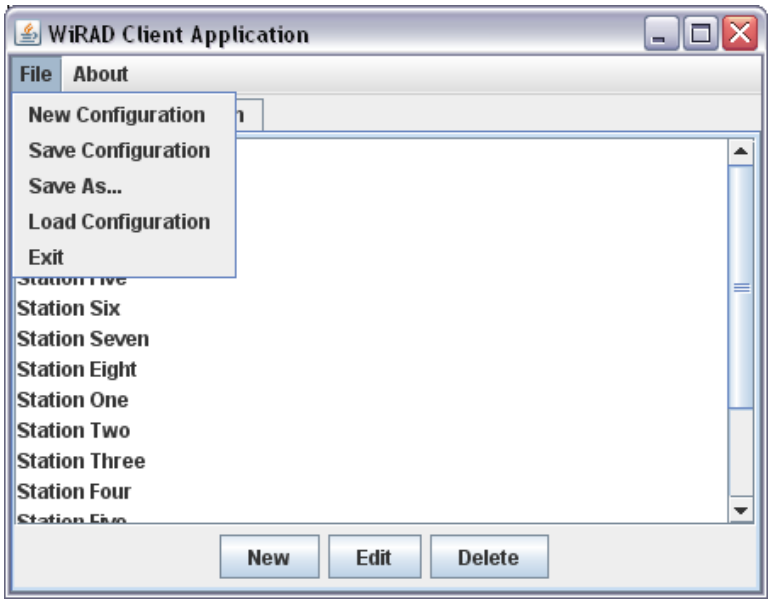

Figure X. Profile Management Options

To test this process, a new profile was created using the option from the File menu. A number of stations were then created using the New button at the bottom of the menu. After population, this profile was saved using the Save Configuration option. To test the integrity of the saved file, the application was closed and reopened and the previously saved profile was loaded using the Load Configuration option. The original profile was recorded and then compared to the profile that appeared after the load operation.

4.1.3.2.2 Station Editor

The Station Editor is used to create a new preset station or edit an existing preset station. To test the Station Editor, a new profile was created and then the New button was pressed, causing an information-less Station Editor to appear as illustrated in in Figure ___.

Figure XX. Blank Station Editor Window

From here, a station name and preset number were chosen. Also, a number of potential relays were associated with the station. To verify that the station list was updated correctly, the Apply option at the bottom of the window was selected and it was verified that the appropriate station information changed in the main station window.

The next step tested the Station Editor's ability to edit an existing station. A station was created and data was recorded; this station was then edited by pressing Edit in the main station window. It was then verified that the Station Editor appeared with existing information as illustrated in Figure ____.

Figure XXX. Station Editor Opening an Existing Station

4.1.3.2.3 Application Interoperability

To verify that the application worked properly on Java-enabled platforms, the application was tested on multiple Windows and Linux machines with the Java Runtime Environment (JRE) installed. All glitches and errors were recorded to verify that the WiRAD client application provided an identical user experience on any operating system.

4.1.4 System

4.1.4.1 Audio Throughput

WiRAD audio throughput was tested in conjunction with device firmware by attempting to receive progressively higher resolution MP3 streams at various distances.

4.1.4.2 Configuration with Desktop Client

4.1.4.2.1 USB Connection

The first step to testing the WiRAD/PC system was to verify that the USB connection between the two was valid. To do this, a USB cable was used to connect the USB port of WiRAD to that of the PC. The LED indicator for the wireless module was then verified to be off. This metric was used because the MCU, upon achieving a USB connection, shuts down the WiFi module so as not to draw too much current from the USB port and allow the battery to recharge.

4.1.4.2.2 USB Communication

When both WiRAD and the testing PC were running, a USB connection was establish between the two via USB cable. The WiRAD desktop client application was opened and a profile loaded. The preset order of each station was then recorded. The program tab was then selected so as to show the application's programming options. The program was then verified to have detected the WiRAD, as illustrated in Figure ___.

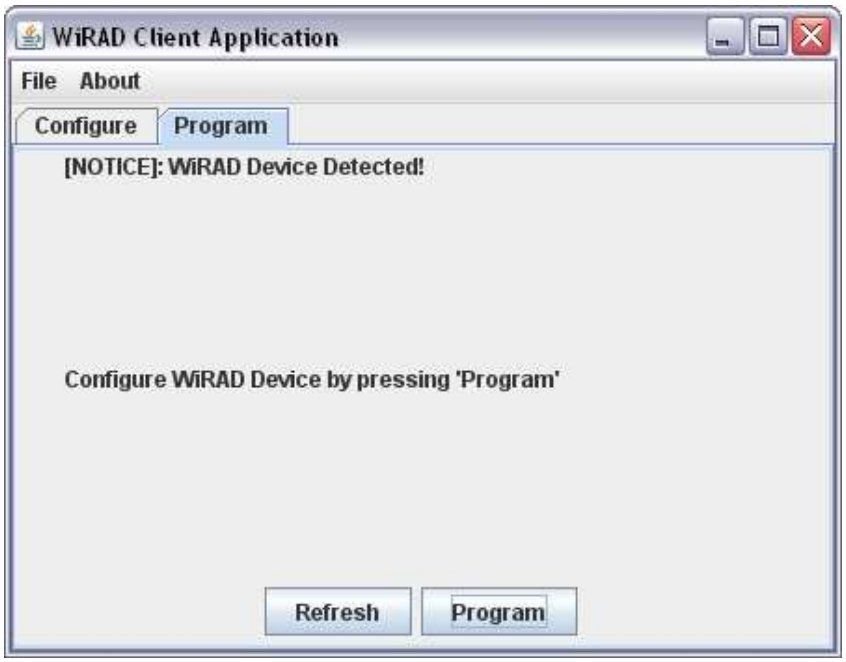

Figure XXXX. WiRAD Client Application Programming Window, WiRAD Detected

To verify that the application properly detected WiRAD, the WiRAD was next disconnected from the PC. Then, the "Refresh" button was selected and it was verified that the application responded as indicated in Figure ____.

Figure XXXXX. WiRAD Client Application Programming Window, WiRAD Not Detected

The USB cable was then reconnected to the PC and the Refresh option was selected once more.

To test the USB data transfer from the PC to WiRAD, the Program option was selected. This process transfers a text file from the PC to WiRAD via USB that represents the preset selections the user has made on the client application. To test that this data transfer was successful, after an allowable period of time had passed, the USB connection between WiRAD and the PC was removed and it was verified that WiRAD contained the configured presets.

4.2 Test Certification

4.2.1 Simulation

4.2.1.1 Antenna

[antenna simulation testing explanation will go here]

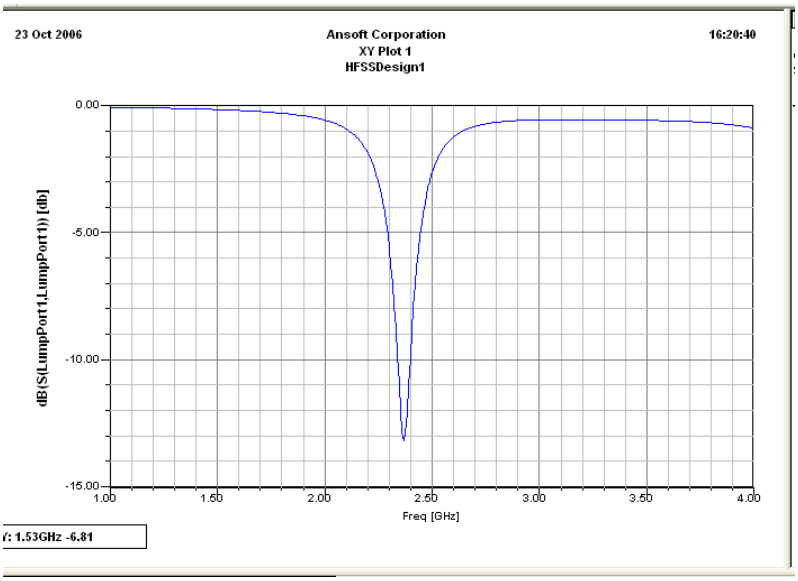

Fig. XXX

4.2.2 Hardware

4.2.2.1 Microcontroller
[put in o-scope picture when we have it of oscillator]
[say that test code worked]

4.2.2.2 WiFi Module
[put in screenshot of wl-status command showing 11Mbit/s connection]

4.2.2.3 Battery
[put in charge/discharge data]

4.2.2.4 Antenna
[put in pictures]

4.2.3 Software

4.2.3.1 Device Firmware
[talk about how interface worked]

4.2.3.2 Desktop Client Software

4.2.3.2.1 Saving and Loading Configurations
[say it worked]

4.2.3.2.2 Station Editor
[say it worked]

4.2.3.2.3 Application Interoperability
[say it worked]

4.2.4 System

4.2.4.1 Audio Throughput

Qualitative results of stream-quality by bitrate are recorded in Table ___.

Table XXX. Quality by bitrate

	Bitrate (kbps)							
	16	24	32	48	56	64	96	128
Clicks/Pops					X	X	X	X
Halts						X	X	X
Speed Distortion							X	X

4.2.4.2 Configuration with Desktop Client

4.2.4.2.1 USB Connection

[we will fill this in when we have it]

4.2.4.2.2 USB Communication

[we will fill this in when we have it]