Wireless Extended Life Sensor

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MAKE WAVES.

Abstract

WELS monitors temperature, humidity, and light level and transmits data wirelessly though a building's Sub-GHz IEEE 15.4 network to feed a control system.

Additionally, this IoT sensor uses a solar panel and rectenna for light and radio frequency energy harvesting.

Ambient RF signals in the 2.4GHz ISM band stimulate a current on the rectenna, which is then rectified to a DC current to charge the removable battery. Ideally, WELS will be able to operate for multiple years without service.

Background

The purpose of this research was to investigate RF energy harvesting to extend the life of a battery powered IoT sensor.

My implementation focuses on micro power for small form factor devices. Wireless power transmission has been widely used for charging cell phones and smart watches, which is a signal for the success of wireless power transmission at distance as an upcoming power delivery platform as electronics require less power. Our proposed device receives exponentially smaller amounts of energy for much lower demand applications.

The goal of our design project was to combine the antenna development with an application that could have market demand.

References

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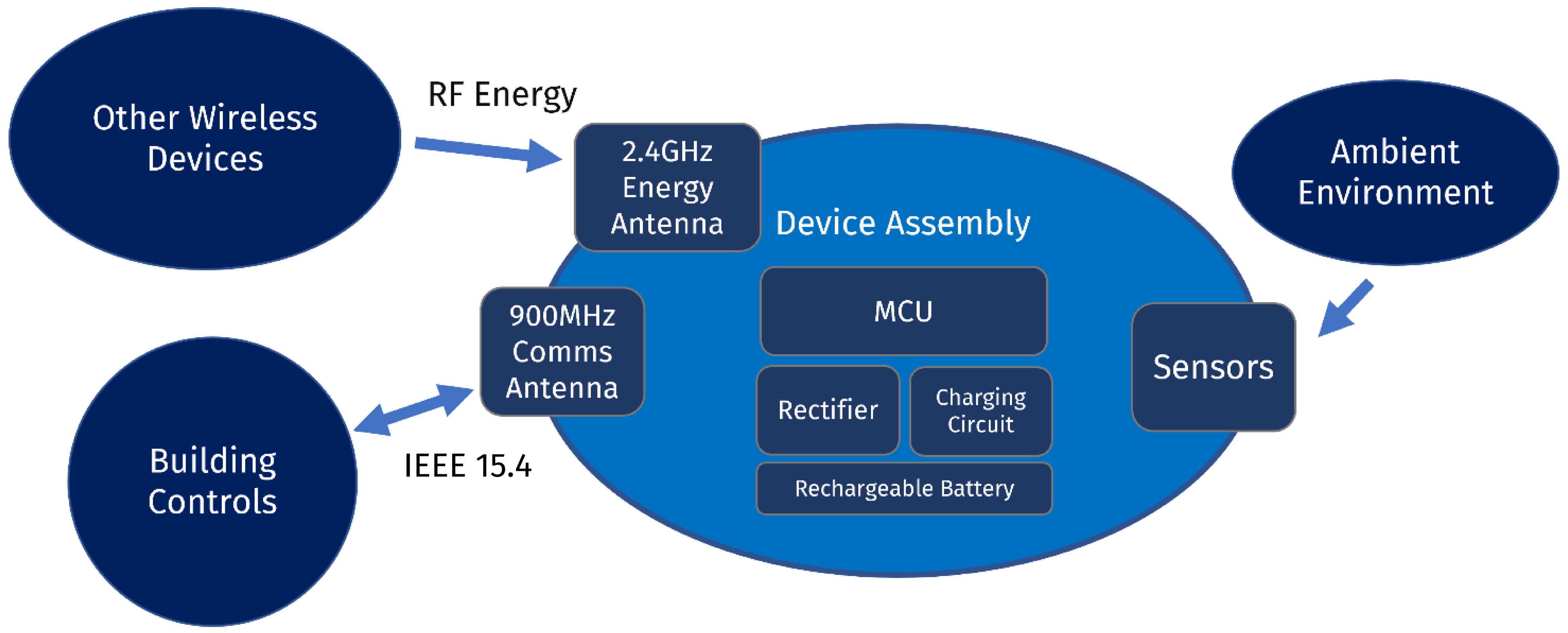
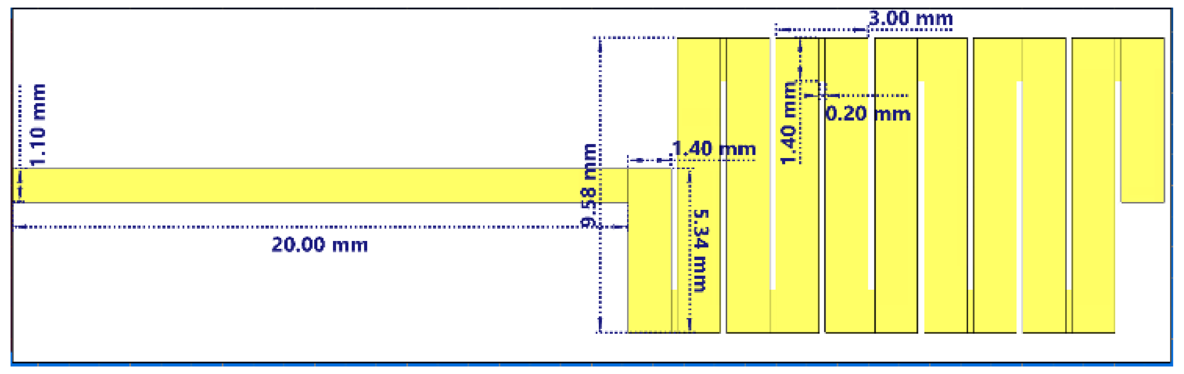
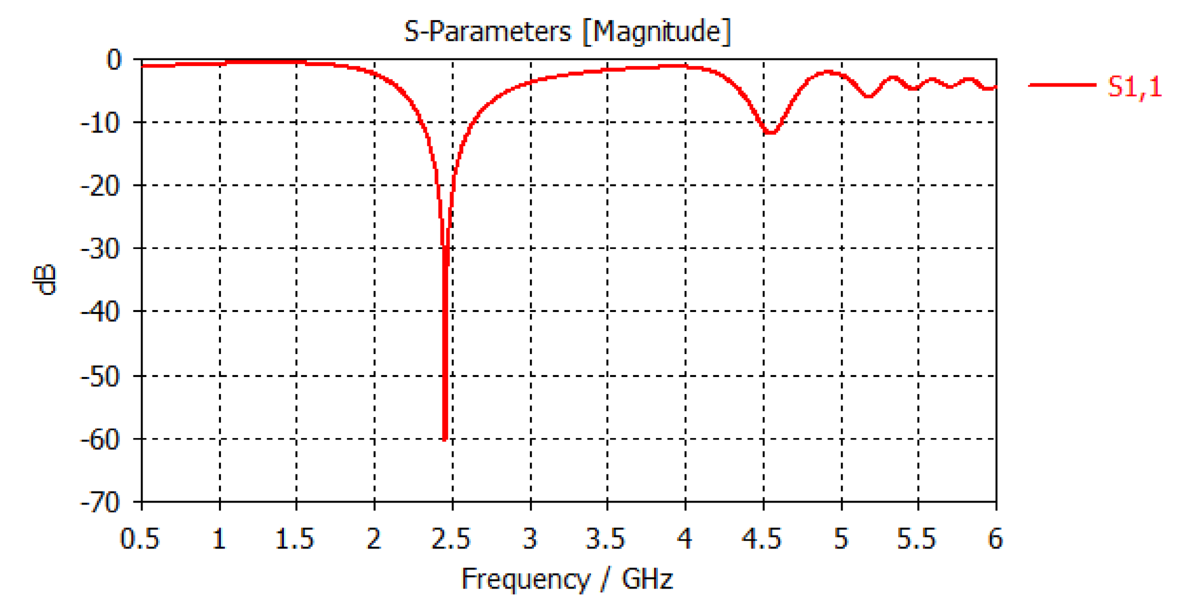
Methods and Materials

Antenna development was done in CST Microwave Studio, and test versions of antenna designs were then built in KiCad. After fabrication, antennas were tested with MegIQ-VNA. Embedded software developed in TI CCS studio, and circuit design developed from the TI CC1352 LaunchPad, and sensor tag kit. Used TI CC1352R1 processor, HDC2080 temperature and humidity sensor, OPT3001 light level sensor, and BQ25570 micro energy management IC to regulate battery charge, and output voltage.





2D CAD rendering of 2.45GHz Rectenna

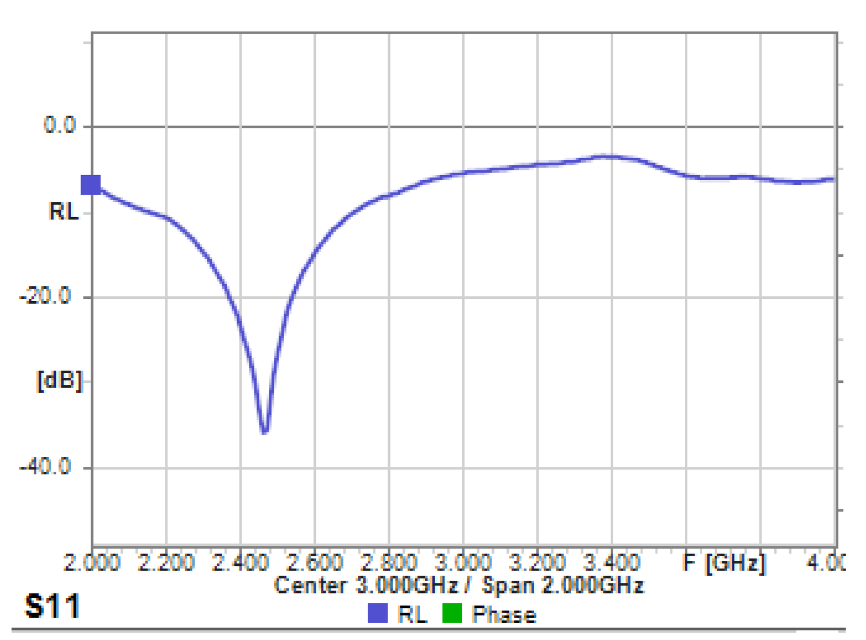


Simulation result of 2.45GHz rectifier antenna (isolated)

Results

Initially, the measured results of the antennas did not follow the designed frequency response. After re-simulating accounting for both antennas placement on the modeled PCB together, adjustments were made and another version of the PCB was fabricated.

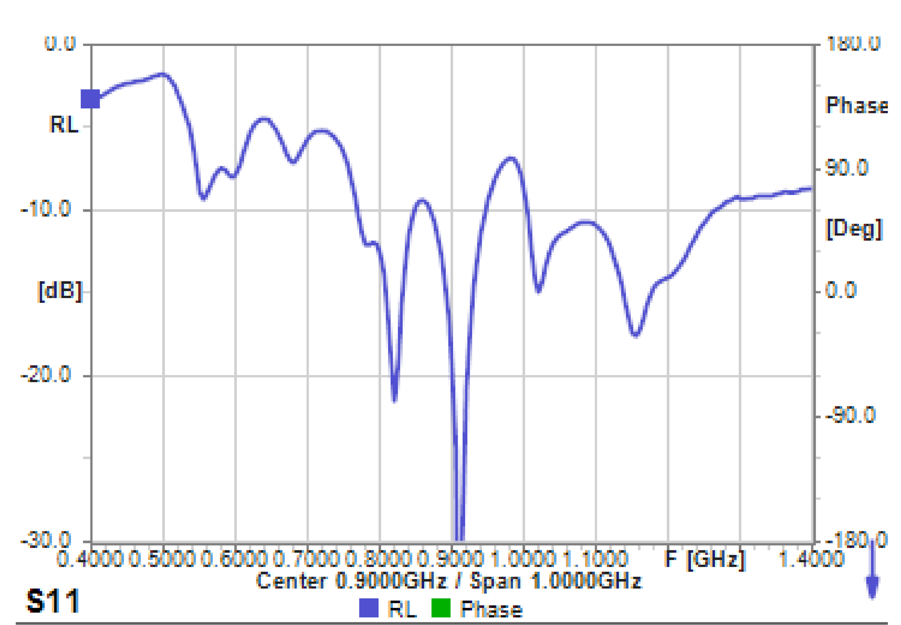
While both antennas were simulated together in CST in their positions on my PCB model, real measurements taken in the lab with the VNA showed the rectenna resonated well at 2.4GHz even with both antennas on the PCB at once with the system operating.



Measured return loss of 2.45GHz rectenna on PCB

Sensor data was successfully sent to the sub-GHz network receiver, but the device has to be within 2m to hold the connection. This is most likely due to poor impedance match between the 915MHz antenna and the radio, as the measured impedance was measured at 12 ohms, instead of the 50 required.

No significant voltage was measured at the output of the rectifier after one hour directly next to a 5dBm 2.45GHz source in our lab. Using a spectrum analyzer we measured reception of the signal at the antenna on the PCB, meaning the rectifier was too inefficient to charge the battery. Connecting the signal generator to the rectifier directly, 0.6V (cold start requirement) was able to be achieved up to 1.3GHz.

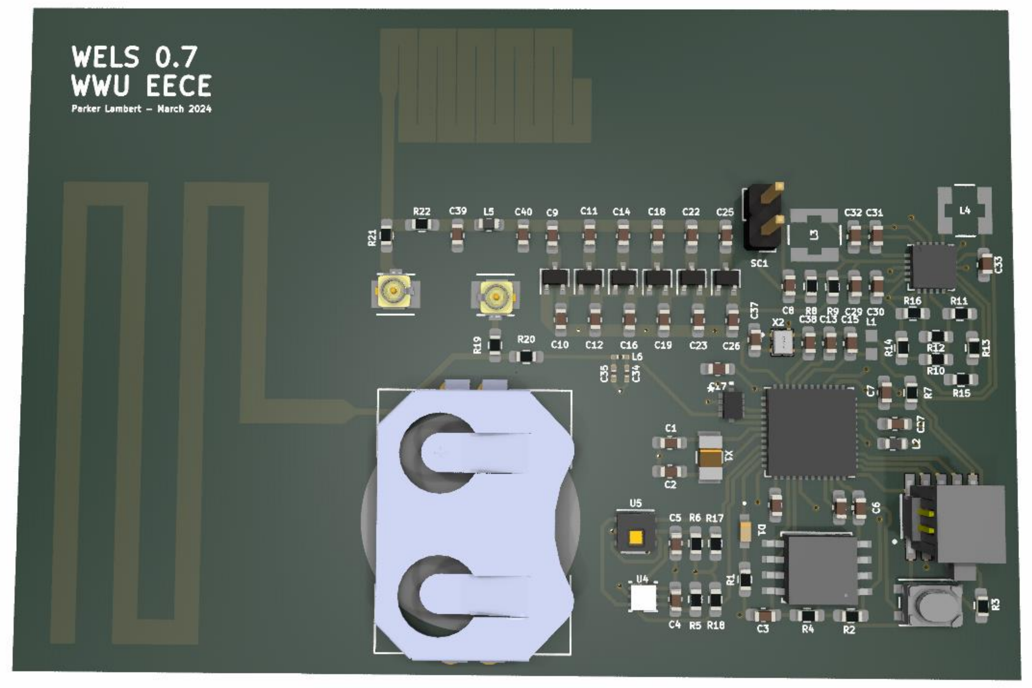


Measured return loss of 915MHz Comms Antenna on PCB

The solar cell was able to power the charging circuit, in the tested classroom environment successfully.

Future Direction

While the antennas and sensors worked, the rectenna design did not work at the desired frequency, and needs to be re-designed with properly matched microstrip transmission lines to correct the parasitics, impedance matching, and most importantly high frequency behavior.



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WWU

Capstone Project

Electrical & Computer Engineering Program