ANTHONY KRUPA

[Abstract]

Ground Station

On-Earth System for Communication and Control of the Satellite

Revision: 1.0.0



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# 1 Introduction

Follow this guide: <http://www.mhhe.com/mayfieldpub/tsw/introduc.htm>

There is no need to include background on what a CubeSat is. The main CougSat-1 documentation covers this.

# 2 Theory

Follow this guide: <http://www.mhhe.com/mayfieldpub/tsw/theory.htm>

Use sections if applicable

## 2.1 Physics

Lorem ipsum dolor sit amet, consectetur adipiscing elit.

## 2.1 Electrical components

Lorem ipsum dolor sit amet, consectetur adipiscing elit.

# 3 Design Criteria

This system should do this be successful. Follow this guide: <http://www.mhhe.com/mayfieldpub/tsw/designcr.htm>

# 4 Design Considerations

Explain the relevant design considerations for the project

# 5 Detailed Description

Include all relevant hardware this project is made of. Use sections is appropriate.

## 5.1 Functional Block Diagram

This diagram shows how our system works

## 5.1 Hardware

This chip does \_\_\_\_\_\_\_, we choose it because it is \_\_\_\_\_

We did/did not use \_\_\_\_\_ because they do \_\_\_\_\_\_ in space

## 5.3 Software

Our software controls \_\_\_\_\_\_ because \_\_\_\_\_\_\_

# 6 Testing

## *6.1 Basic Receive Test*

The first receive test is designed to determine if the antenna can successfully receive signals near 435 MHz. The antenna has passed this test if the received signal strength is constant over all test distances at 435 MHz. Although this test is highly qualitative, it allows determination of the antenna’s basic capability to receive.

## 6.1.1 Testing Apparatuses

The RTL-SDR receiver was connected to the computer via USB. The application SDRSharp was then configured to receive narrowband FM (NFM) with a filter bandwidth of 12.5 kHz. All noise reduction and AGC was disabled for this test. The software-defined receiver was tuned to the test frequency.

To the SDR dongle was connected the antenna cable (through a BNC to microSMA adapter. The antenna was placed at one end of the hallway, along with the laptop running SDRSharp. The transmitting radio was then configured to transmit 1 watt of NFM (2.5 kHz deviation) at the test frequency.

The test frequencies were 430 MHz, 435 MHz, 440 MHz, 445 MHz, and 450 MHz Five distances from the antenna were marked in the test area: 1 meter, 5 meters, 10 meters, and 20 meters. Distance was measured from the most anterior point of the antenna.

The transmitting radio was held upright, transmitting spoken voice. The antenna was placed on nonconducting supports, pointing towards the transmitting radio.

The procedure was performed with no antenna connected to the SDR (control), and then with the antenna connected. For each distance from the antenna, the received signal was recorded for all test frequencies, sequentially.

The approximate received signal strength (in dBm) was recorded for each of five frequencies per distance point.

## 6.1.2 Results

The results were added to an Excel sheet, to allow determination of antenna performance at each frequency. Tables 1 and 2 show the test results for the control and the antenna, respectively.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Control** |  |  |  |  |  | **Antenna** |  |  |  |
| Distance (m) | | Frequency (MHz) | | RSS (dBm) |  | Distance (m) | | Frequency (MHz) | | RSS (dBm) |
| 1 |  | 430 |  | -18 |  | 1 |  | 430 |  | 0 |
| 1 |  | 435 |  | -20 |  | 1 |  | 435 |  | 0 |
| 1 |  | 440 |  | -35 |  | 1 |  | 440 |  | 0 |
| 1 |  | 445 |  | -25 |  | 1 |  | 445 |  | 0 |
| 1 |  | 450 |  | -20 |  | 1 |  | 450 |  | 0 |
| 5 |  | 430 |  | -30 |  | 5 |  | 430 |  | 0 |
| 5 |  | 435 |  | -19 |  | 5 |  | 435 |  | 0 |
| 5 |  | 440 |  | -19 |  | 5 |  | 440 |  | 0 |
| 5 |  | 445 |  | -21 |  | 5 |  | 445 |  | 0 |
| 5 |  | 450 |  | -25 |  | 5 |  | 450 |  | 0 |
| 10 |  | 430 |  | -29 |  | 10 |  | 430 |  | 0 |
| 10 |  | 435 |  | -30 |  | 10 |  | 435 |  | 0 |
| 10 |  | 440 |  | -28 |  | 10 |  | 440 |  | 0 |
| 10 |  | 445 |  | -26 |  | 10 |  | 445 |  | 0 |
| 10 |  | 450 |  | -28 |  | 10 |  | 450 |  | 0 |
| 20 |  | 430 |  | -38 |  | 20 |  | 430 |  | 0 |
| 20 |  | 435 |  | -31 |  | 20 |  | 435 |  | 0 |
| 20 |  | 440 |  | -30 |  | 20 |  | 440 |  | 0 |
| 20 |  | 445 |  | -30 |  | 20 |  | 445 |  | 0 |
| 20 |  | 450 |  | -30 |  | 20 |  | 450 |  | 0 |

*Table 1: Control Table 2: Antenna*

Analysis of results indicates that the received signal strength varied with neither distance nor frequency. Conversely, for the control setup, the received signal strength decreased significantly with distance and varied with frequency. This indicates that the test antenna markedly increased received signal strength. This is to be expected; the test antenna is a highly directional helical antenna. The antenna did not exhibit any noticeable imperfections or unexpected behaviors during the test. Although this test is qualitative by nature, results suggest that **the antenna works as intended**, and that more rigorous tests may be conducted.

## *6.2 “Real-World” (Satellite) Receive Test*

The “real-world” receive test will determine the antenna’s capability to receive signals from an already-orbiting satellite, which more closely reflects the ultimate use case of the ground station antenna for receiving. The goal is for the received signal strength of the antenna to meet the requirements of the link budget. Please note that the automatic azimuth/elevation tracker was not used for this test.

## 6.2.1 Testing Apparatuses

The **antenna array** was firstly brought to the test location. The array was held by one of the testers, to be pointed manually towards the satellite. The antenna cable was then connected to a **RTL-SDR dongle**, which was then connected to a **laptop** running **SDRSharp** receiving software. The receiving software was run with default settings, configured to receive narrowband (8 kHz bandwidth) FM, beginning at 435.840 MHz. The satellite tracking website provided frequency values compensated for Doppler shift, but the frequency was changed manually in SDRSharp as needed.

The satellite tracked was the Taurus-1, which broadcast an FM audio beacon at a nominal frequency of 435.840 MHz. The satellite’s azimuth ranged from 11 degrees north to 201 degrees south-southwest. The maximum elevation of the satellite was 75 degrees above the horizon.

The SDRSharp software was configured to record the received signal. At the time of the satellite’s ascendance above the horizon, the tester began tracking the satellite in accordance with the pass predictor values. The tester continued to track the satellite until it fell below the horizon again. Recording was then terminated, and the results were analyzed.

## 6.2.2 Results

The satellite’s periodically beeping audio beacon was heard at several points throughout the approximately 15-minute track. The audio was clear and consistent. This indicates that the antenna is able to receive satellite signals in the field. For future tests, the tracker will be installed and a quantitative procedure will be implemented. The manual antenna tracking procedure was a significant limitation in the procedure. Ultimately, both qualitative tests indicate that the antenna is able to receive in the field, and that a final, quantitative test is warranted. This will allow final determination of the antenna’s receive performance relative to design requirements.

# 7 Discussion

Were all requirements just met or came out better. Follow this guide: <http://www.mhhe.com/mayfieldpub/tsw/discuss.htm>

# 8 Conclusion

Summarize all relevant information. Follow this guide: <http://www.mhhe.com/mayfieldpub/tsw/conclusi.htm>

# 9 Recommendations

What to do next? What to improve? Follow this guide: <http://www.mhhe.com/mayfieldpub/tsw/recommen.htm>

# 10 Appendix

Include materials that are not essential to the document but give more information for those who want it. Follow this guide: <http://www.mhhe.com/mayfieldpub/tsw/appendix.htm>

If a drawing is not natively a portrait letter size, change that single page to make the drawing’s format. Follow this guide: <http://blogmines.com/blog/how-to-have-different-page-size-in-the-same-document-in-word-2010/>

## 10.1 Bill of Materials

Tables are cool

## 10.2 Mechanical Drawings

Measurements measure millimeters

## 10.3 Full Schematic

Wires