DALHOUSIE UNIVERSITY
FACULTY OF ENGINEERING

ECED 4900 Group 6
Michelle Coleman Andrew Crutcher
Alexander MacDonald Logan Dempsey

Dalhousie Space Systems Lab

Department of Electrical and Computer Engineering

Low-Orbit Satellite Ground Station

Introduction

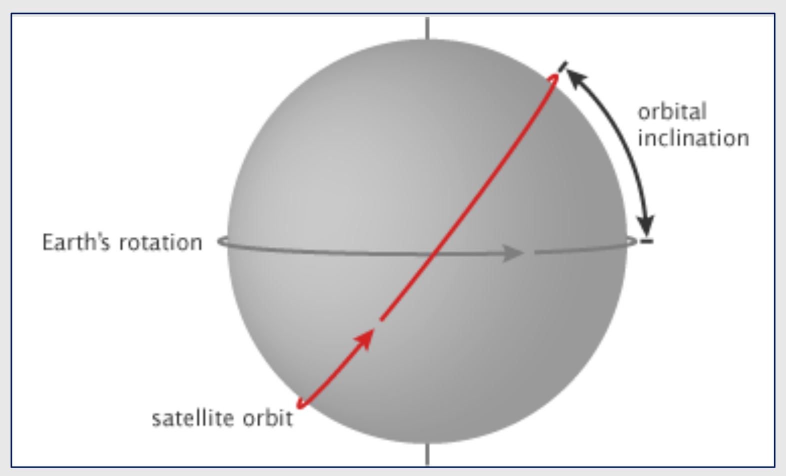
The Problem: The Dalhousie Space Systems Lab (DSS) is working to develop an experimental, low Earth orbit CubeSat satellite. The DSS requires a ground station in order to communicate with the satellite after it has been launched. The project scope involves designing, building and testing a ground station system that could communicate with the CubeSat satellite at low Earth orbit.

Design Requirements:

- Low Earth orbit (400km) communication link
- Software Defined Radio for transmitting and receiving
- Transmit/Receive in the ultra high frequency (UHF) band at 430 MHz
- Motorized antenna rotator system for tracking the satellite in the 51.6° orbital inclination.
- Antenna gain of 11dBi at a minimum
- Pass prediction software and GNU Radio programming
- Total system cost under $2000

Initial Conditions:

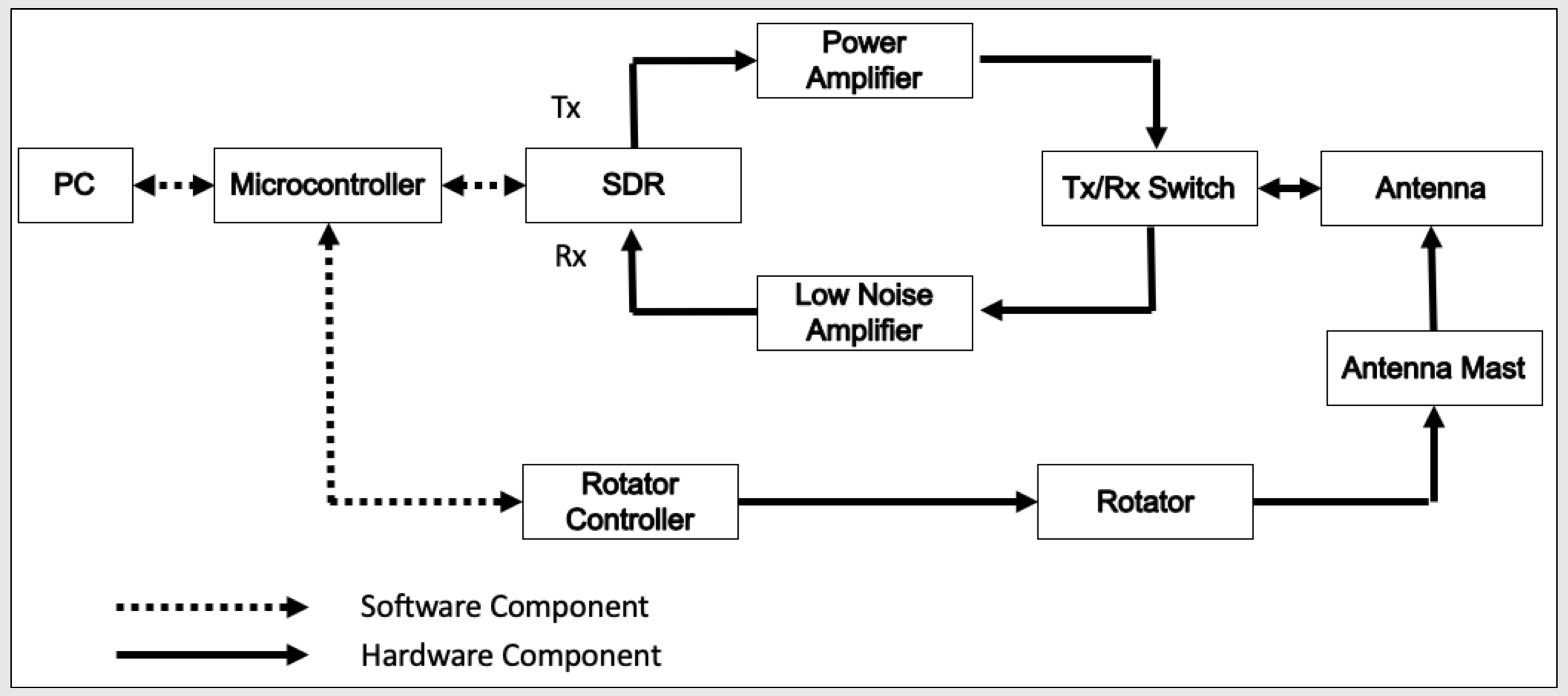
- Adalm-Pluto Software Defined Radio
- Completed Radio Link Budget
- Approaches and designs used in other ground stations



Design Details

- A ground station based on a single directional antenna system is proposed. The system can either transmit or receive at a given time. The system meets the design requirements and is within the budget.
- Power and low noise amplifiers are used to increase the transmitted and received signal power.
- Satellite tracking can be done with Gpredict software (PC) and the rotator controller.
- The Helical antenna and Yaesu rotator were selected from the available options.

Ground Station Block Diagram



Antenna Design Choices

Helical	Yagi
+ Great directivity + Easy and inexpensive to build + Circularly polarized - Not commercially available	+ Simple design + Commercially available - Not circularly polarized - Increased cost
	

Rotator Design Choices

SatNOGS v3	• ~$300 CAD • <1 deg precision • ~30 Nm • 3D printed parts • DIY solution • Time commitment	
Alfa Spid RAS 12V	• ~$2000 CAD • <1 deg precision • 255 Nm • Ideal solution aside from cost	
Yaesu G-5500	• ~$1000 CAD • ±4% precision • 58 Nm (Azimuth) • 137 Nm (elevation) • Open source controller design • Best option within budget	

Preliminary Results

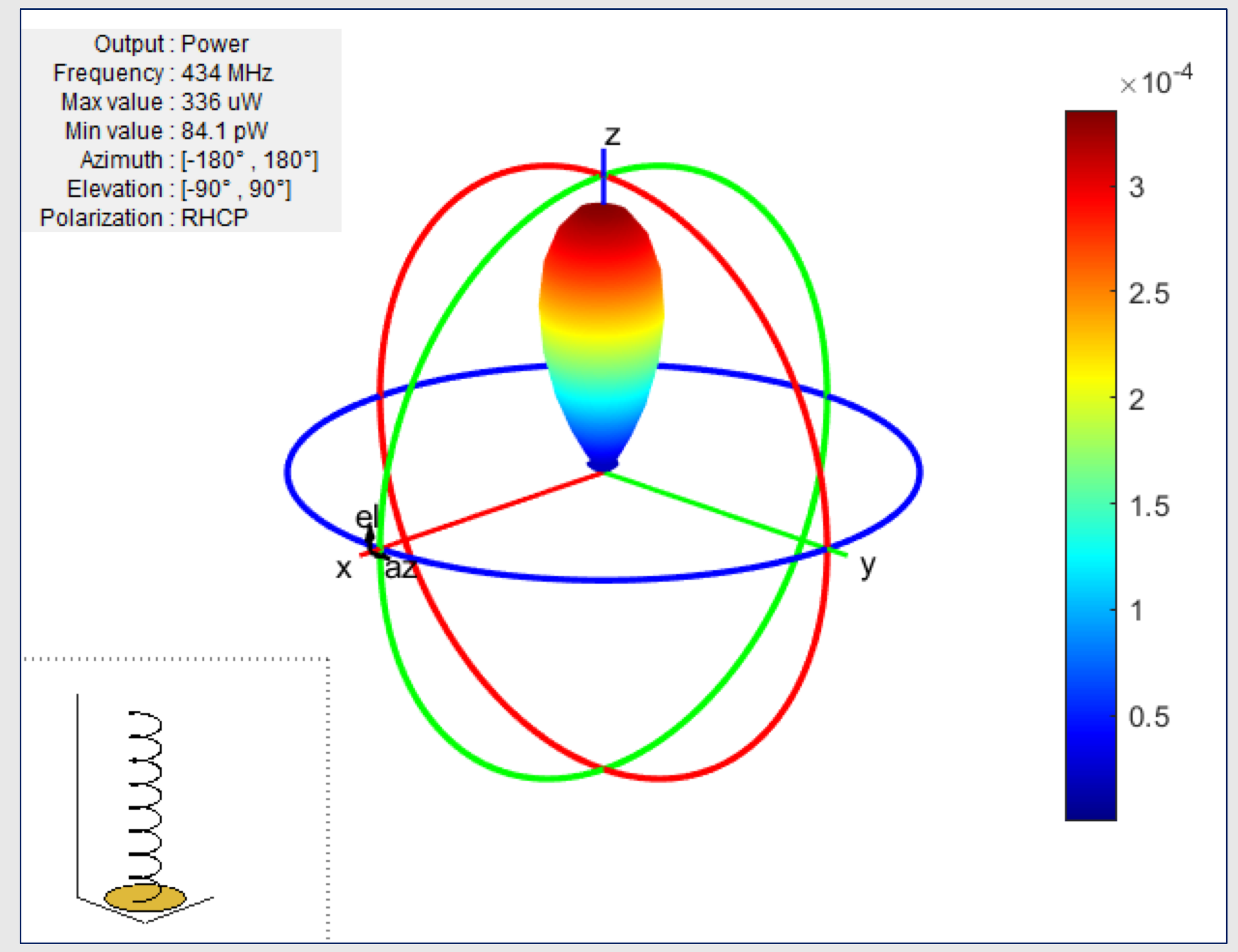
Antenna Simulation in MATLAB

- Verified hand calculations using MATLAB.
- Estimated antenna gain value will meet the gain requirement.
- Estimated antenna beam width to be 50˚. This means that the antenna does not have to be perfectly pointed at the satellite to communicate.

Revised Communication Link Budget

- A low noise amplifier can be used to reduce the total system noise figure.
- Estimated that by reducing the noise figure to 0.6dB, the receive link margin is increased from 1.56dB to 9.8dB.

Antenna Simulation



Design Process

Defining client requirements and researching for commercially available components aids in developing system architecture.

Preliminary Design Choices:

- Antenna type –> Directivity, polarization, gain and cost attributes
- Rotator –> Precision, durability and cost attributes

Definition → Research → Evaluation → Selection

Initial Conclusions and Further Work

- Preliminary results from the antenna MATLAB simulation and hand-calculations have estimated that the helical antenna will meet the gain requirements. Furthermore, by including a low noise amplifier in the design the receive link margin could be increased.
- Immediate next steps are to fabricate the antenna and verify the actual gain using the RF Lab Anechoic Chamber, procure the remaining hardware components and develop modulation and demodulation programming for the Pluto software defined radio.
- After this, unit testing to verify the performance of individual components, including the rotator, controller, antenna and software defined radio.
- Once the ground station is operating, the ground station will be tested by trying to transmit and receive a signal with an satellite in operation.

References

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