Astro 331 Prelab 3: Radio Communication

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Documentation:

- DFAS writing guide (I used to write these instructions—you should read it but don't need to list it in your documentation statement)
- Cite references as necessary, but don't include course notes, course text (SMAD), or these instructions as documentation
- Don't forget to update your own documentation statement when you write your prelab report!

Overview

You will use an XBee radio on FlatSat to communicate with another XBee radio connected to the laptop (acting as your ground station). You will develop a model (equations) to predict the performance of FlatSAT's communication link during ground test and in orbit. Both radios (ground station and FlatSAT) will use an external stick antenna (see PulseLARSEN datasheet in appendix).

During the lab you will capture the RSSI value (received signal strength indicator) from the radio at various distances (500 mm–5 m) to validate your model and ensure that the radio will meet performance requirements on-orbit.

Format

Include the sections required in a Short Summary Report from the USAFA/DFAS writing guide, with the addition of a Nomenclature section. Do not include a cover sheet for prelabs.

- Objectives
- Nomenclature
- Approach
- Assumptions
- Math Technique
- Theoretical Predictions
- Experimental Setup
- Discussion
- Conclusion and Recommendations
- Appendices

This assignment will be no more than three typed pages. This assignment is individual effort, but you may use websites and textbooks provided that you cite all sources used (see the References section in the DFAS Writing Guide).

Content

For each distance, calculate your predictions for received signal strength, which can be calculated using a simplified version of the link budget equation. Assume free space path loss is the only loss term. Link margin is a simplified version of the E_b/N_0 equation we used in class—a positive value (in dB) is good. (The previous sentence should not appear in your prelab report.) Calculate the performance of this communications subsystem if the FlatSat were launched into a circular orbit with a 500 km altitude. Comment on your results. If the link margin you calculate at $S_{\max}$ is less than 9 dB, describe and calculate at least two possible design changes you could make to the design bring the link margin up to 9 dB.

Be sure to explain each equation, define all variables and include units, and state any assumptions you made in order to use those equations. You must show all work to arrive at your answers, though this work may be either in the main body of the prelab or attached as an appendix. Work may be hand-written, or solved with a computer, so long as it is clear to the reader how you arrived at your answers. This prelab should be a stand-alone document that any engineer without prior exposure to this course could read and understand. At a minimum, you will need the following equations:

Received signal strength (dB):

$$RSSI = P + G_t + G_r + L_s \tag{1}$$

Free space path loss (unitless):

$$L_s = \left(\frac{\lambda}{4\pi S}\right)^2 \tag{2}$$

*Don't forget to convert free space path loss to decibels before using it in the equation for RSSI!

Link Margin (dB):

$$LinkMargin = RSSI - ReceiverSensitivity \tag{3}$$

Receiver Sensitivity indicates the capability of the receiver to extract information from a weak signal, quantified as the lowest signal that is able to be received. Use the attached data sheets to find the radio transmission frequency, transmitter power, gain of the transmitter and receiver (same antenna for both), and receiver sensitivity. For your on-orbit predictions, you may assume a minimum elevation angle of 10 degrees.

In your theoretical predictions section, present the table below with your calculations and an appropriate title.

Table 1 Link Values

	integral RSSI (dB)	integral Link Margin (dB)	external RSSI (dB)	external Link Margin (dB)
0.5 m				
1 m				
2 m				
5 m				
best case orbital (indicate distance)				
worst case orbital				

Note: dBi indicates that the gain is isotropic. It is equivalent to dB.

Appendix A: Specifications

Use the performance specifications for the XBee 3 (not 3-PRO).

Note: dBm corresponds to power in mW (you will need to convert dBm to dB)

Performance specifications

The following table describes the performance specifications for the devices.

Specification	XBee 3	XBee 3-PRO
Indoor/urban range	Up to 60 m (200 ft)	Up to 90 m (300 ft)
Outdoor RF line-of-sight range	Up to 1200 m (4000 ft)	Up to 3200 m (2 mi)
RF Transmit power output (maximum)	6.3 mW (+8 dBm)	79 mW (+19 dBm)
BLE power output	6.3 mW (+8 dBm)	6.3 mW (+8 dBm)
RF data rate	250,000 b/s	
Receiver sensitivity	-103 dBm	

Note Range figure estimates are based on free-air terrain with limited sources of interference. Actual range will vary based on transmitting power, orientation of transmitter and receiver, height of transmitting antenna, height of receiving antenna, weather conditions, interference sources in the area, and terrain between receiver and transmitter, including indoor and outdoor structures such as walls, trees, buildings, hills, and mountains.

Part number	Type (description)	Gain (dBi)
Integral antennas		
29000294	Integral PCB antenna (through-hole only)	-0.5 dBi

Pulse LARSEN Antennas

Series: Stick Antenna

TECHNICAL DATA SHEET

Description: Wireless External Antenna for 2.4 GHz Applications

PART NUMBER: W1038x

Features:

- High gain performance, 3.8dBi
- For WLAN devices using WiFi (802.11b/g), Bluetooth® and ZigBeeTM
- Omni-directional radiation pattern provides broad 360° coverage
- One-quarter wavelength dipole configuration, length 196.2mm
- Connection and color options easily integrate with OEM designs
- **W1038** Black; **W1038W** White; **W1038G** Gray

Applications:

- Omni-directional antennas provide a uniform, donut-shaped, 360° radiation pattern. The omni-directional pattern is suitable for point-to-multipoint broadcasting in all directions. The antenna is primarily used for WLAN applications. However, it can also be used for a variety of other applications within the specified frequency range. When used as an access point, the antenna is ideally located at the center of the coverage

Issue: 1821

In the effort to improve our products, we reserve the right to make changes judged to be necessary.

RoHS COMPLIANT

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