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ASEN 5148 Telecommunications Homework

1. Perform the following calculations for a 2 meter diameter parabolic antenna with S Band (2.14 Ghz) or X Band (8.3 Ghz) signals:
a. What is the dimension of the wavelength (in meters)
b. What is the gain attainable for both conditions?
c. What is the beam width for both frequencies?

	S-Band	**X-Band**
Wavelength (cm)	14.0	3.61
Gain (dB)	24.7	36.5
Beamwidth (degrees)	4.57	1.18

2. For a 1 meter diameter parabolic antenna transmitting at S Band (2.14 Ghz), what is the maximum angle that the antenna can be off pointed from the target to not lose more than 3 dB of signal?

   9.14 degrees

3. What is the space loss in X Band (8.3 Ghz) transmitting to Earth for:
   a. A satellite in a 700 km Earth orbit? **168 dB @ zenith, 180 dB @ horizon**
   b. A satellite in a geostationary Earth orbit? **202 dB @ zenith, 203 dB @ horizon**
   c. A satellite in a 700 km altitude Mars orbit? **269 dB @ opposition, 282 dB @ conjunction (assuming no sun interference)**

4. What is the atmospheric loss for the S and X Band frequencies previously described?
   From Fig. 9.20:
   S-Band: 0.1 dB
   X-Band: 0.2 dB @ 5 degree elevation

5. What is the effective noise temperature for an antenna, cable, and receiver with the following properties:
   a. Antenna is pointing directly to space, perpendicular to the ground, with no physical objects in the field of view
   b. The cable temperature is 250 degrees Kelvin
   c. The cable loss is 1 dB
   d. The receiver figure of merit (F) is 2.2
   353 Kelvin

6. Select a spacecraft antenna (type and size), and prepare a budget for the downlink communication for a satellite in Earth orbit at 750 km altitude with the following parameters:

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Parameter	Value
Transmit Frequency	8.2 Ghz
Transmit RF power	3 Watts
Downlink BER	10^{-5}
Coding	Reed Solomon
Data Rate	50 kbits/sec
Ground Antenna Diameter	11 meter
Maximum ground antenna pointing error	0.1°
Polarization	RHC
Maximum Spacecraft Pointing Error	0.5°
Ground Antenna System Noise Temperature	80°K
Minimum link margin	3 dB

Using 0.25 m parabolic antenna:

Parameter	Value	Units
Range	3182.6875436	km
Transmitter Gain	4.7712125472	dB
Cable Loss	0	dB
Transmit Antenna Gain	24.035077221	dB
EIRP	28.806289768	dB
Spacecraft Pointing Loss	-0.032897372	dB
Space Loss	-180.7721571	dB
Atmospheric Loss	-0.2	dB
polarization	0	dB
Ground Antenna Gain	56.904130751	dB
Ground Antenna Pointing Loss	-2.532038561	dB
Total Received Power (Eb)	-97.82667255	dB
System Noise (No)	-209.5691001	dB
Eb/No	64.170374204	dB
Eb/No Required	5.5	dB
Link Margin	58.670374204	dB

7. For the system above (Problem 6) calculate the link margin for the uplink with the following additional parameters:

Ground Transmitter RF Power	300 Watts
Transmit Symbol Rate	100 bps

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Spacecraft receiver system noise temperature	1200° K

Parameter	Value	Units
Range	3182.6875436	km
Transmitter Gain	24.771212547	dB
Cable Loss	0	dB
Transmit Antenna Gain	56.904130751	dB
EIRP	81.675343298	dB
Spacecraft Pointing Loss	-0.032897372	dB
Space Loss	-180.7721571	dB
Atmospheric Loss	-0.2	dB
polarization	0	dB
Ground Antenna Gain	24.035077221	dB
Ground Antenna Pointing Loss	-2.532038561	dB
Total Received Power (Eb)	-44.95761902	dB
System Noise (No)	-197.8081875	dB
Eb/No	132.26821519	dB
Eb/No Required	5.5	dB
Link Margin	126.76821519	dB

8. In problem 6. If the spacecraft had a low gain antenna (1dB), what would be the maximum symbol transmission rate to maintain 10 dB of margin?
20500

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Parameter	Value	Units
Transmit Frequency	8.2	Ghz
Transmit RF power	3	Watts
Downlink BER	10^{-5}	
Coding	1.1434978	Reed Solomo
Data Rate	50	kbits/sec
Ground Antenna Diameter	11	m
Maximum ground antenna pointing error	0.1	deg
Polarization	RHC	
Maximum Spacecraft Pointing Error	0.5	deg
Ground Antenna System Noise Temperature	80	K
Minimum link margin	3	dB
Range	3182.6875436	km
Transmitter Gain	4.7712125472	dB
Cable Loss	0	dB
Transmit Antenna Gain	1	dB
EIRP	5.7712125472	dB
Spacecraft Pointing Loss	-0.032897372	dB
Space Loss	-180.7721571	dB
Atmospheric Loss	-0.2	dB
polarization	0	dB
Ground Antenna Gain	56.904130751	dB
Ground Antenna Pointing Loss	-2.532038561	dB

9. When NASA's Galileo satellite was launched to Jupiter, there was an anomaly with the telecommunications system. In looking at the link budget equation, what terms would have been affected by the event?

The high-gain antenna did not fully deploy. This would affect the S/C antenna gain (thus EIRP) in the main lobe. It would affect the data rate of received data if the signal-to-noise ratio were affected enough (have to lower it).

10. Assuming that you are the spacecraft system engineer (and recognizing that your knowledge of a complete spacecraft may be limited after looking at only one subsystem in this class) I'm interested in your views of the information you would share with each of other spacecraft subsystem engineers about how the telecommunications design might influence the overall

design. Please list 3 items per subsystem that you see as important that they know about the telecom system.

Structure System (Mounting and orientation of components to survive launch and on-orbit forces)

1. **Unobstructed antenna**

2. **Antenna size**

3. **Transeiver size, cabling depending on location**

Thermal System (maintaining the spacecraft at within required temperatures)

1. Antenna size/Material (for radiating)

2. Transeiver required minimum temp to stay functioning

3. Transeiver heat production

Propulsion System (Orbit changing and modification)

1. **Location of antenna to avoid thruster plume.**

2. **Maximum range allowed in link budget**

3. **Required times for data link of science data, certain orbits can give more transmit/receive time.**

Attitude Control System (Responsible for knowledge of where the spacecraft is on orbit, and to point and control the spacecraft)

1. **The pointing requirement for the links**

2. **Mass properties of antenna**

3. **Flexibility of antenna structure, may require higher order control terms**

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Command and Data Handling System (the spacecraft brain – responsible for command decoding, data handling, computation, and packaging data for transmission)

1. **Data encoding**

2. **Data rate**

3. **Structure of data packets to ensure proper data routing**

Power System (generates, distributes and stores power for use by subsystems)

1. **Transeiver power**

2. **Power required for antenna deployment (motorized)**

3. **Power required for phased array antenna motors**