

Project Name: BIRDS-2 PROJECT

Satellite Name: MAYA-1 (Philippines), BHUTAN-1 (Bhutan), UiTMSAT-1 (Malaysia)

Link Budget for: APRS-DP and S&F User Uplink

Version: 5

Date of Last Revision: 2018-02-04

Changes:

-Elevation angle set to 30°.

-Added Eb/No method for link budget calculation

PARAMETERS	VALUES	UNITS
Frequency:	145.825 (requested)	MHz
Emission Type:	F2D	
Modulation:	AFSK/FM	
Data Rate:	1200	bps
Protocol:	AX.25	

USER RADIO

Ground Station Transmitter Power Output:	5.0	watts
In dBW:	7.0	dBW
In dBm:	37.0	dBm
Ground Stn. Total Transmission Line Losses:	0.3	dB
Antenna Gain:	12.0	dBi
Ground Station EIRP:	18.7	dBW
Ground Station Antenna Pointing Loss:	1.8	dB
Gnd-to-S/C Antenna Polarization Losses:	3.0	dB

PATH

Orbit Altitude:	400	km
Elevation Angle:	30	°
Slant Range:	739.4	km
Path Loss:	133.1	dB
Atmospheric Losses:	0.4	dB
Ionospheric Losses:	0.7	dB
Rain Losses:	0	dB
Isotropic Signal Level at Spacecraft:	-120.3	dBW

SPACECRAFT (Eb/No Method)

Spacecraft Antenna Pointing Loss:	1.5	dB
Spacecraft Antenna Gain:	1.5	dBi
Spacecraft Total Transmission Line Losses:	1.6	dB
Spacecraft Effective Noise Temperature:	900.0	K
Spacecraft Figure of Merit (G/T):	-29.7	dB/K
Spacecraft Signal-to-Noise Power Density (S/No):	77.1	dBHz
System Desired Data Rate:	1200	bps
	30.8	dBHz
System Eb/No for Uplink:	46.3	dB
Demodulation Method Selected:	AFSK/FM	
Forward Error Correction Coding Used:	None	
System Allowed or Specified Bit-Error-Rate:	1.0E-04	
Demodulator Implementation Loss:	0	dB

Eb/No Threshold:	21	dB
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System Link Margin	25.3	dB
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SPACECRAFT (SNR Method)

Spacecraft Antenna Pointing Loss:	1.5	dB
Spacecraft Antenna Gain:	1.5	dB
Spacecraft Total Transmission Line Losses:	1.6	dB
Spacecraft Effective Noise Temperature:	900.0	K
Spacecraft Figure of Merit (G/T):	-29.7	dB/K
Signal Power at Spacecraft LNA Input:	-122.0	dBW
Spacecraft Receiver Bandwidth:	12000.0	Hz
Spacecraft Receiver Noise Power (Pn = kTB)	-158.3	dBW
Signal-to-Noise Power Ratio at G.S. Rcvr:	36.3	dB
Analog or Digital System Required S/N:	21.0	dB

System Link Margin	15.3	dB
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Project Name: BIRDS-2 PROJECT

Satellite Name: MAYA-1 (Philippines), BHUTAN-1 (Bhutan), UiTMSAT-1 (Malaysia)

Link Budget for: APRS-DP and S&F User Downlink

Version: 5

Date of Last Revision: 2018-02-04

Changes:

-Elevation angle set to 30°.

-Added Eb/No method for link budget calculation

PARAMETERS	VALUES	UNITS
Frequency:	145.825 (requested)	MHz
Emission Type:	F2D	
Modulation:	AFSK/FM	
Data Rate:	1200	bps
Protocol:	AX.25	

SPACECRAFT

Spacecraft Transmitter Power Output:	0.5	watts
In dBW:	-3.0	dBW
In dBm:	27.0	dBm
Spacecraft Total Transmission Line Losses:	0.5	dB
Spacecraft Antenna Gain:	1.5	dBi
Spacecraft EIRP:	-2.0	dBW
Spacecraft Antenna Pointing Loss:	1.5	dB
S/C-to-Ground Antenna Polarization Loss:	3.0	dB

PATH

Orbit Altitude:	400	km
Elevation Angle:	30	°
Slant Range:	739.4	km
Path Loss:	133.1	dB
Atmospheric Losses:	0.4	dB
Ionospheric Losses:	0.7	dB
Rain Losses:	0	dB
Isotropic Signal Level at Ground Station:	-140.8	dBW

USER RADIO (Eb/No Method)

Ground Station Antenna Pointing Loss:	1.8	dB
Ground Station Antenna Gain:	12.0	dBi
Ground Station Total Transmission Line Losses:	0.5	dB
Ground Station Effective Noise Temperature:	900.0	K
Ground Station Figure of Merit (G/T):	-18.0	dB/K
Ground Station Signal-to-Noise Power Density (S/No):	68.0	dBHz
System Desired Data Rate:	1200	bps
	30.8	dBHz
System Eb/No for Downlink:	37.2	dB
Demodulation Method Selected:	AFSK/FM	
Forward Error Correction Coding Used:	None	
System Allowed or Specified Bit-Error-Rate:	1.0E-04	
Demodulator Implementation Loss:	0	dB

Eb/No Threshold:	21	dB
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System Link Margin	16.2	dB
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USER RADIO (SNR Method)

Ground Station Antenna Pointing Loss:	1.8	dB
Ground Station Antenna Gain:	12	dB
Ground Station Total Transmission Line Losses:	0.5	dB
Ground Station Effective Noise Temperature:	900	K
Ground Station Figure of Merit (G/T):	-18	dB/K
Signal Power at Ground Station LNA Input:	-131.1	dBW
Ground Station Receiver Bandwidth (B):	12000	Hz
G.S. Receiver Noise Power (Pn = kTB)	-158.3	dBW
Signal-to-Noise Power Ratio at G.S. Rcvr:	27.2	dB
Analog or Digital System Required S/N:	21.0	dB

System Link Margin	6.2	dB
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Project Name: BIRDS-2 PROJECT

Satellite Name: MAYA-1 (Philippines), BHUTAN-1 (Bhutan), UiTMSAT-1 (Malaysia)

Link Budget for: UHF Command Uplink

Version: 5

Date of Last Revision: 2018-02-04

Changes:

-Ground station transmit power output changed from 5W to 14 W

-Elevation angle set to 10°.

-Required S/N changed from 9.6 dB to 14 dB

-Added Eb/No method for link budget calculation

PARAMETERS	VALUES	UNITS
Frequency:	UHF band	MHz
Emission Type:	F1D	
Modulation:	GMSK	
Data Rate:	9600	bps
Protocol:	AX.25	

GROUND STATION

Ground Station Transmitter Power Output:	14	watts
In dBW:	11.5	dBW
In dBm:	41.5	dBm
Ground Stn. Total Transmission Line Losses:	3.0	dB
Antenna Gain:	16.0	dBi
Ground Station EIRP:	24.5	dBW
Ground Station Antenna Pointing Loss:	1.0	dB
Gnd-to-S/C Antenna Polarization Losses:	3.0	dB

PATH

Orbit Altitude:	400	km
Elevation Angle:	10	°
Slant Range:	1439.8	km
Path Loss:	148.4	dB
Atmospheric Losses:	1.1	dB
Ionospheric Losses:	0.4	dB
Rain Losses:	0	dB
Isotropic Signal Level at Spacecraft:	-129.4	dBW

SPACECRAFT (Eb/No Method)

Spacecraft Antenna Pointing Loss:	3.1	dB
Spacecraft Antenna Gain:	0.5	dBi
Spacecraft Total Transmission Line Losses:	1.7	dB
Spacecraft Effective Noise Temperature:	900.0	K
Spacecraft Figure of Merit (G/T):	-30.7	dB/K
Spacecraft Signal-to-Noise Power Density (S/No):	65.4	dBHz
System Desired Data Rate:	9600	bps
	39.8	dBHz
System Eb/No for Uplink:	25.6	dB
Demodulation Method Selected:	GMSK	

Forward Error Correction Coding Used:	None	
System Allowed or Specified Bit-Error-Rate:	1.0E-05	
Demodulator Implementation Loss:	0	dB
Eb/No Threshold:	14	dB

System Link Margin **11.6** **dB**

SPACECRAFT (SNR Method)

Spacecraft Antenna Pointing Loss:	3.1	dB
Spacecraft Antenna Gain:	0.5	dB
Spacecraft Total Transmission Line Losses:	1.7	dB
Spacecraft Effective Noise Temperature:	900.0	K
Spacecraft Figure of Merit (G/T):	-30.7	dB/K
Signal Power at Spacecraft LNA Input:	-133.6	dBW
Spacecraft Receiver Bandwidth:	15000.0	Hz
Spacecraft Receiver Noise Power (Pn = kTB)	-157.3	dBW
Signal-to-Noise Power Ratio at G.S. Rcvr:	23.7	dB
Analog or Digital System Required S/N:	14.0	dB

System Link Margin **9.7** **dB**

Project Name: BIRDS-2 PROJECT

Satellite Name: MAYA-1 (Philippines), BHUTAN-1 (Bhutan), UiTMSAT-1 (Malaysia)

Link Budget for: UHF Telemetry & Mission Downlink

Version: 5

Date of Last Revision: 2018-02-04

Changes:

-Elevation angle set to 10°.

-Added Eb/No method for link budget calculation

PARAMETERS	VALUES	UNITS
Frequency:	437.375	MHz
Emission Type:	F1D	
Modulation:	GMSK	
Data Rate:	9600	bps
Protocol:	AX.25	

SPACECRAFT

Spacecraft Transmitter Power Output:	0.8	watts
In dBW:	-1.0	dBW
In dBm:	29.0	dBm
Spacecraft Total Transmission Line Losses:	0.1	dB
Spacecraft Antenna Gain:	0.5	dBi
Spacecraft EIRP:	-0.5	dBW
Spacecraft Antenna Pointing Loss:	3.1	dB
S/C-to-Ground Antenna Polarization Loss:	3.0	dB

PATH

Orbit Altitude:	400	km
Elevation Angle:	10	°
Slant Range:	1439.8	km
Path Loss:	148.4	dB
Atmospheric Losses:	1.1	dB
Ionospheric Losses:	0.4	dB
Rain Losses:	0	dB
Isotropic Signal Level at Ground Station:	-156.5	dBW

GROUND STATION (Eb/No Method)

Ground Station Antenna Pointing Loss:	1.0	dB
Ground Station Antenna Gain:	16.0	dBi
Ground Station Total Transmission Line Losses:	1.3	dB
Ground Station Effective Noise Temperature:	900.0	K
Ground Station Figure of Merit (G/T):	-14.8	dB/K
Ground Station Signal-to-Noise Power Density (S/No):	56.2	dBHz
System Desired Data Rate:	9600	bps
	39.8	dBHz
System Eb/No for Downlink:	16.4	dB
Demodulation Method Selected:	GMSK	
Forward Error Correction Coding Used:	None	
System Allowed or Specified Bit-Error-Rate:	1.0E-05	

Demodulator Implementation Loss:	0	dB
Eb/No Threshold:	9.6	dB

System Link Margin **6.8** **dB**

GROUND STATION (SNR Method)

Ground Station Antenna Pointing Loss:	1.0	dB
Ground Station Antenna Gain:	16.0	dB
Ground Station Total Transmission Line Losses:	1.3	dB
Ground Station Effective Noise Temperature:	900.0	K
Ground Station Figure of Merit (G/T):	-14.8	dB/K
Signal Power at Ground Station LNA Input:	-142.8	dBW
Ground Station Receiver Bandwidth (B):	15000.0	Hz
G.S. Receiver Noise Power (Pn = kTB)	-157.3	dBW
Signal-to-Noise Power Ratio at G.S. Rcvr:	14.5	dB
Analog or Digital System Required S/N:	9.6	dB

System Link Margin **4.9** **dB**

Project Name: BIRDS-2 PROJECT

Satellite Name: MAYA-1 (Philippines), BHUTAN-1 (Bhutan), UiTMSAT-1 (Malaysia)

Link Budget for: UHF CW Beacon

Version: 5

Date of Last Revision: 2018-02-04

Changes:

PARAMETERS	VALUES	UNITS
Frequency:	437.375	MHz
Emission Type:	A1A	
Modulation:	Morse Code	
Data Rate:	20	words/min
Protocol:	-	

SPACECRAFT

Spacecraft Transmitter Power Output:	0.1	watts
In dBW:	-10	dBW
In dBm:	20	dBm
Spacecraft Total Transmission Line Losses:	0.05	dB
Spacecraft Antenna Gain:	0.5	dBi
Spacecraft EIRP:	-9.6	dBW
Spacecraft Antenna Pointing Loss:	3.1	dB
S/C-to-Ground Antenna Polarization Loss:	3.0	dB

PATH

Orbit Altitude:	400	km
Elevation Angle:	10	°
Slant Range:	1439.8	km
Path Loss:	148.4	dB
Atmospheric Losses:	1.1	dB
Ionospheric Losses:	0.4	dB
Rain Losses:	0	dB
Isotropic Signal Level at Ground Station:	-165.6	dBW

GROUND STATION (SNR Method)

Ground Station Antenna Pointing Loss:	1.0	dB
Ground Station Antenna Gain:	16.0	dBi
Ground Station Total Transmission Line Losses:	1.3	dB
Ground Station Effective Noise Temperature:	900.0	K
Ground Station Figure of Merit (G/T):	-14.8	dB/K
Signal Power at Ground Station LNA Input:	-151.9	dBW
Ground Station Receiver Bandwidth (B):	500.0	Hz
G.S. Receiver Noise Power (Pn = kTB)	-172.1	dBW
Signal-to-Noise Power Ratio at G.S. Rcvr:	20.2	dB
Analog or Digital System Required S/N:	11.0	dB

System Link Margin

9.2

dB