

CW BEACON

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|--------------------------------|----------|
| DESIGNATION OF EMISSION | 400HA1A |
| PROTOCOL | CW |
| DIRECTION | Downlink |

| Satellite Side (Transmitting) Parameter | |
|---|--------|
| Model | RFM96W |
| Modulation | CW |
| BR (kbps) | 0.2 |
| Bandwidth (kHz) | 0.4 |

| GS Side (Receiving) Parameter | |
|-------------------------------|---------------|
| Model | R820T RTL-SDR |
| Modulation | CW |
| BR (kbps) | 0.2 |
| Bandwidth (kHz) | 0.4 |

| ORBIT | | 5° | 10° | 15° | 20° | 40° | 60° | 80° |
|--|-----------|---------|---------|---------|---------|---------|---------|---------|
| Frequency | (MHz) | 437.425 | 437.425 | 437.425 | 437.425 | 437.425 | 437.425 | 437.425 |
| Orbit altitude | (km) | 550 | 550 | 550 | 550 | 550 | 550 | 550 |
| Elevation Angle | (Deg) | 5 | 10 | 15 | 20 | 40 | 60 | 80 |
| Slant Range | (km) | 2205.9 | 1815.7 | 1518.4 | 1293.8 | 812.1 | 626.9 | 557.8 |
| SATELLITE | | | | | | | | |
| Transmit Output Power | (W) | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Transmit Output Power | (dBm) | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Transmit Output Power (Max peak power) | (dBW) | -10 | -10 | -10 | -10 | -10 | -10 | -10 |
| Maximum Power Density | (dBW/Hz) | -36.0 | -36.0 | -36.0 | -36.0 | -36.0 | -36.0 | -36.0 |
| Antenna Gain | (dBi) | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Transmission Line Loss | (dB) | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 |
| Effective Isotropic Radiated Power | (dBW) | -9.8 | -9.8 | -9.8 | -9.8 | -9.8 | -9.8 | -9.8 |
| DOWNLINK PATH | | | | | | | | |
| SAT Antenna Pointing Loss | (dB) | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Antenna Polarization Loss | (dB) | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Atmospheric Loss | (dB) | 2.1 | 1.1 | 0.8 | 0.6 | 0.4 | 0.2 | 0.1 |
| Ionospheric Loss | (dB) | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Free Space Path Loss | (dB) | 152.1 | 150.4 | 148.9 | 147.5 | 143.5 | 141.2 | 140.2 |
| Power at the Ground Station | (dBW) | -167.5 | -164.8 | -163.0 | -161.4 | -157.2 | -154.7 | -153.6 |
| GROUND STATION | | | | | | | | |
| GS Antenna Pointing Loss | (dB) | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Antenna Gain | (dB) | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Transmission Line Loss | (dB) | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 |
| System Noise Temperature (Ts) | (K) | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| Figure of Merit (Gr/Ts) | (dB/K) | -8.8 | -8.8 | -8.8 | -8.8 | -8.8 | -8.8 | -8.8 |
| Boltzman's Constant | (dBW/HzK) | -228.6 | -228.6 | -228.6 | -228.6 | -228.6 | -228.6 | -228.6 |
| Data rate | (dBHz) | 23.0 | 23.0 | 23.0 | 23.0 | 23.0 | 23.0 | 23.0 |
| Carrier to Interference Required (C/I req) | (dB) | 31.9 | 34.6 | 36.4 | 38.0 | 42.3 | 44.7 | 45.8 |
| Carrier to Noise Power Ratio C/N | (dB) | 19.7 | 22.4 | 24.2 | 25.8 | 30.1 | 32.5 | 33.6 |
| Carrier to Noise Density Ratio C/No | (dB) | 45.7 | 48.4 | 50.2 | 51.8 | 56.1 | 58.5 | 59.6 |
| Eb/No (or SNR) | (dB) | 22.7 | 25.4 | 27.2 | 28.8 | 33.1 | 35.5 | 36.6 |
| BER | | - | - | - | - | - | - | - |
| Required SNR | (dB) | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Link Margin | (dB) | 12.7 | 15.4 | 17.2 | 18.8 | 23.1 | 25.5 | 26.6 |

MISSION & TELEMETRY DATA

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|--------------------------------|----------|
| DESIGNATION OF EMISSION | 10K0F1D |
| PROTOCOL | AX.25 |
| DIRECTION | Downlink |

| GS Side (Transmitting) Parameter | |
|----------------------------------|--------|
| Model | RFM96W |
| Modulation | GFSK |
| FDA (kHz) | 5 |
| BR (kbps) | 1.2 |
| Bandwidth (kHz) | 10 |

| Satellite Side (Receiving) Parameter | |
|--------------------------------------|--------|
| Model | RFM96W |
| Modulation | GFSK |
| FDA (kHz) | 5 |
| BR (kbps) | 1.2 |
| Bandwidth (kHz) | 10 |

| ORBIT | | 5° | 10° | 15° | 20° | 40° | 60° | 80° |
|--|-----------|---------|---------|---------|---------|---------|---------|---------|
| Frequency | (MHz) | 437.425 | 437.425 | 437.425 | 437.425 | 437.425 | 437.425 | 437.425 |
| Orbit altitude | (km) | 550 | 550 | 550 | 550 | 550 | 550 | 550 |
| Elevation Angle | (Deg) | 5 | 10 | 15 | 20 | 40 | 60 | 80 |
| Slant Range | (km) | 2205.9 | 1815.7 | 1518.4 | 1293.8 | 812.1 | 626.9 | 557.8 |
| SATELLITE | | | | | | | | |
| Transmit Output Power | (W) | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Transmit Output Power | (dBm) | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Transmit Output Power (Max peak power) | (dBW) | -10 | -10 | -10 | -10 | -10 | -10 | -10 |
| Maximum Power Density | (dBW/Hz) | -50 | -50 | -50 | -50 | -50 | -50 | -50 |
| Antenna Gain | (dBi) | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Transmission Line Loss | (dB) | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 |
| Effective Isotropic Radiated Power | (dBW) | -9.8 | -9.8 | -9.8 | -9.8 | -9.8 | -9.8 | -9.8 |
| DOWNLINK PATH | | | | | | | | |
| SAT Antenna Pointing Loss | (dB) | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Antenna Polarization Loss | (dB) | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Atmospheric Loss | (dB) | 2.1 | 1.1 | 0.8 | 0.6 | 0.4 | 0.2 | 0.1 |
| Ionospheric Loss | (dB) | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Free Space Path Loss | (dB) | 152.1 | 150.4 | 148.9 | 147.5 | 143.5 | 141.2 | 140.2 |
| Power at the Ground Station | (dBW) | -167.5 | -164.8 | -163.0 | -161.4 | -157.2 | -154.7 | -153.6 |
| GROUND STATION | | | | | | | | |
| GS Antenna Pointing Loss | (dB) | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Antenna Gain | (dB) | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Transmission Line Loss | (dB) | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 |
| System Noise Temperature (Ts) | (K) | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| Figure of Merit (Gr/Ts) | (dB/K) | -8.8 | -8.8 | -8.8 | -8.8 | -8.8 | -8.8 | -8.8 |
| Boltzman's Constant | (dBW/HzK) | -228.6 | -228.6 | -228.6 | -228.6 | -228.6 | -228.6 | -228.6 |
| Data rate | (dBHz) | 30.8 | 30.8 | 30.8 | 30.8 | 30.8 | 30.8 | 30.8 |
| Carrier to Interference Required (C/I req) | (dB) | 17.9 | 20.6 | 22.4 | 24.0 | 28.3 | 30.7 | 31.8 |
| Carrier to Noise Power Ratio C/N | (dB) | 5.7 | 8.4 | 10.2 | 11.8 | 16.1 | 18.5 | 19.6 |
| Carrier to Noise Density Ratio C/No | (dB) | 45.7 | 48.4 | 50.2 | 51.8 | 56.1 | 58.5 | 59.6 |
| Eb/No (or SNR) | (dB) | 14.9 | 17.6 | 19.5 | 21.0 | 25.3 | 27.7 | 28.8 |
| BER | | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Required SNR | (dB) | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Link Margin | (dB) | 2.9 | 5.6 | 7.5 | 9.0 | 13.3 | 15.7 | 16.8 |

COMMAND

| | |
|--------------------------------|---------|
| DESIGNATION OF EMISSION | 10K0F1D |
| PROTOCOL | AX.25 |
| DIRECTION | Uplink |

| GS Side (Transmitting) Parameter | |
|----------------------------------|--------|
| Model | RFM96W |
| Modulation | GFSK |
| FDA (kHz) | 5 |
| BR (kbps) | 1.2 |
| Bandwidth (kHz) | 10 |

| Satellite Side (Receiving) Parameter | |
|--------------------------------------|--------|
| Model | RFM96W |
| Modulation | GFSK |
| FDA (kHz) | 5 |
| BR (kbps) | 1.2 |
| Bandwidth (kHz) | 10 |

| ORBIT | | 5° | 10° | 15° | 20° | 40° | 60° | 80° |
|--|-----------|--------|--------|--------|--------|--------|--------|--------|
| Frequency | (MHz) | 437 | 437 | 437 | 437 | 437 | 437 | 437 |
| Orbit altitude | (km) | 550 | 550 | 550 | 550 | 550 | 550 | 550 |
| Elevation Angle | (Deg) | 5 | 10 | 15 | 20 | 40 | 60 | 80 |
| Slant Range | (km) | 2205.9 | 1815.7 | 1518.4 | 1293.8 | 812.1 | 626.9 | 557.8 |
| GROUND STATION | | | | | | | | |
| Transmit Output Power | (W) | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Transmit Output Power | (dBm) | 34.8 | 34.8 | 34.8 | 34.8 | 34.8 | 34.8 | 34.8 |
| Transmit Output Power (Max peak power) | (dBW) | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 |
| Maximum Power Density | (dBW/Hz) | -35.2 | -35.2 | -35.2 | -35.2 | -35.2 | -35.2 | -35.2 |
| Antenna Gain | (dBi) | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Transmission Line Loss | (dB) | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 |
| Effective Isotropic Radiated Power | (dBW) | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 |
| UPLINK PATH | | | | | | | | |
| GS Antenna Pointing Loss | (dB) | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Antenna Polarization Loss | (dB) | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Atmospheric Loss | (dB) | 2.1 | 1.1 | 0.8 | 0.6 | 0.4 | 0.2 | 0.1 |
| Ionospheric Loss | (dB) | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Free Space Path Loss | (dB) | 152.1 | 150.4 | 148.9 | 147.5 | 143.4 | 141.2 | 140.2 |
| Power at the Satellite | (dBW) | -140.6 | -137.9 | -136.0 | -134.4 | -130.2 | -127.7 | -126.6 |
| SATELLITE | | | | | | | | |
| SAT Antenna Pointing Loss | (dB) | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Antenna Gain | (dB) | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Transmission Line Loss | (dB) | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 |
| System Noise Temperature (Ts) | (K) | 1010 | 1010 | 1010 | 1010 | 1010 | 1010 | 1010 |
| Figure of Merit (Gr/Ts) | (dB/K) | -28.0 | -28.0 | -28.0 | -28.0 | -28.0 | -28.0 | -28.0 |
| Boltzman's Constant | (dBW/HzK) | -228.6 | -228.6 | -228.6 | -228.6 | -228.6 | -228.6 | -228.6 |
| Data rate | (dBHz) | 30.8 | 30.8 | 30.8 | 30.8 | 30.8 | 30.8 | 30.8 |
| Carrier to Interference Required (C/I req) | (dB) | 27.4 | 30.1 | 32.0 | 33.5 | 37.8 | 40.2 | 41.3 |
| Carrier to Noise Power Ratio C/N | (dB) | 15.2 | 17.9 | 19.8 | 21.3 | 25.6 | 28.0 | 29.1 |
| Carrier to Noise Density Ratio C/No | (dB) | 55.2 | 57.9 | 59.8 | 61.3 | 65.6 | 68.0 | 69.1 |
| Eb/No (or SNR) | (dB) | 24.4 | 27.1 | 29.0 | 30.5 | 34.8 | 37.2 | 38.4 |
| BER | | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Required SNR | (dB) | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Link Margin | (dB) | 12.4 | 15.1 | 17.0 | 18.5 | 22.8 | 25.2 | 26.4 |

MISSION DATA

| | |
|--------------------------------|---------|
| DESIGNATION OF EMISSION | 31K3F1D |
| PROTOCOL | LoRa |
| DIRECTION | Uplink |

| Satellite Side (Receiving) Parameter | |
|--------------------------------------|--------|
| Model | RFM96W |
| Modulation | CSS |
| Bandwidth (kHz) | 31.25 |
| Spreading Factor | 10 |
| BR (kbps) | 0.146 |

| ORBIT | | 5° | 10° | 15° | 20° | 40° | 60° | 80° |
|---|--|---------|---------|---------|---------|---------|---------|---------|
| Frequency (MHz) | | 437 | 437 | 437 | 437 | 437 | 437 | 437 |
| Orbit altitude (km) | | 550 | 550 | 550 | 550 | 550 | 550 | 550 |
| Elevation Angle (Deg) | | 5 | 10 | 15 | 20 | 40 | 60 | 80 |
| Slant Range (km) | | 2205.9 | 1815.7 | 1518.4 | 1293.8 | 812.1 | 626.9 | 557.8 |
| GROUND STATION | | | | | | | | |
| Transmit Output Power (W) | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Transmit Output Power (dBm) | | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Transmit Output Power (Max peak power) (dBW) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum Power Density (dBW/Hz) | | -44.9 | -44.9 | -44.9 | -44.9 | -44.9 | -44.9 | -44.9 |
| Antenna Gain (dBi) | | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Transmission Line Loss (dB) | | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 |
| Effective Isotropic Radiated Power (dBW) | | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| UPLINK PATH | | | | | | | | |
| GS Antenna Pointing Loss (dB) | | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Antenna Polarization Loss (dB) | | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Atmospheric Loss (dB) | | 2.1 | 1.1 | 0.8 | 0.6 | 0.4 | 0.2 | 0.1 |
| Ionospheric Loss (dB) | | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Free Space Path Loss (dB) | | 152.1 | 150.4 | 148.9 | 147.5 | 143.4 | 141.2 | 140.2 |
| Power at the Satellite (dBW) | | -157.3 | -154.6 | -152.8 | -151.2 | -146.9 | -144.5 | -143.4 |
| SATELLITE | | | | | | | | |
| SAT Antenna Pointing Loss (dB) | | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Antenna Gain (dB) | | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Transmission Line Loss (dB) | | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 |
| System Noise Temperature (Ts) (K) | | 1010 | 1010 | 1010 | 1010 | 1010 | 1010 | 1010 |
| Figure of Merit (Gr/Ts) (dB/K) | | -28.0 | -28.0 | -28.0 | -28.0 | -28.0 | -28.0 | -28.0 |
| Boltzman's Constant (dBW/HzK) | | -228.6 | -228.6 | -228.6 | -228.6 | -228.6 | -228.6 | -228.6 |
| Data rate (dBHz) | | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 |
| Carrier to Interference Required (C/I req) (dB) | | 10.5 | 13.2 | 15.0 | 16.6 | 20.8 | 23.3 | 24.4 |
| Carrier to Noise Power Ratio C/N (dB) | | -1.7 | 1.0 | 2.8 | 4.4 | 8.6 | 11.1 | 12.2 |
| Carrier to Noise Density Ratio C/No (dB) | | 38.4 | 41.1 | 43.0 | 44.6 | 48.8 | 51.3 | 52.4 |
| Eb/No (or SNR) (dB) | | 16.8 | 19.5 | 21.3 | 22.9 | 27.2 | 29.6 | 30.7 |
| BER | | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 |
| Required SNR (dB) | | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Link Margin (dB) | | 10.8 | 13.5 | 15.3 | 16.9 | 21.2 | 23.6 | 24.7 |