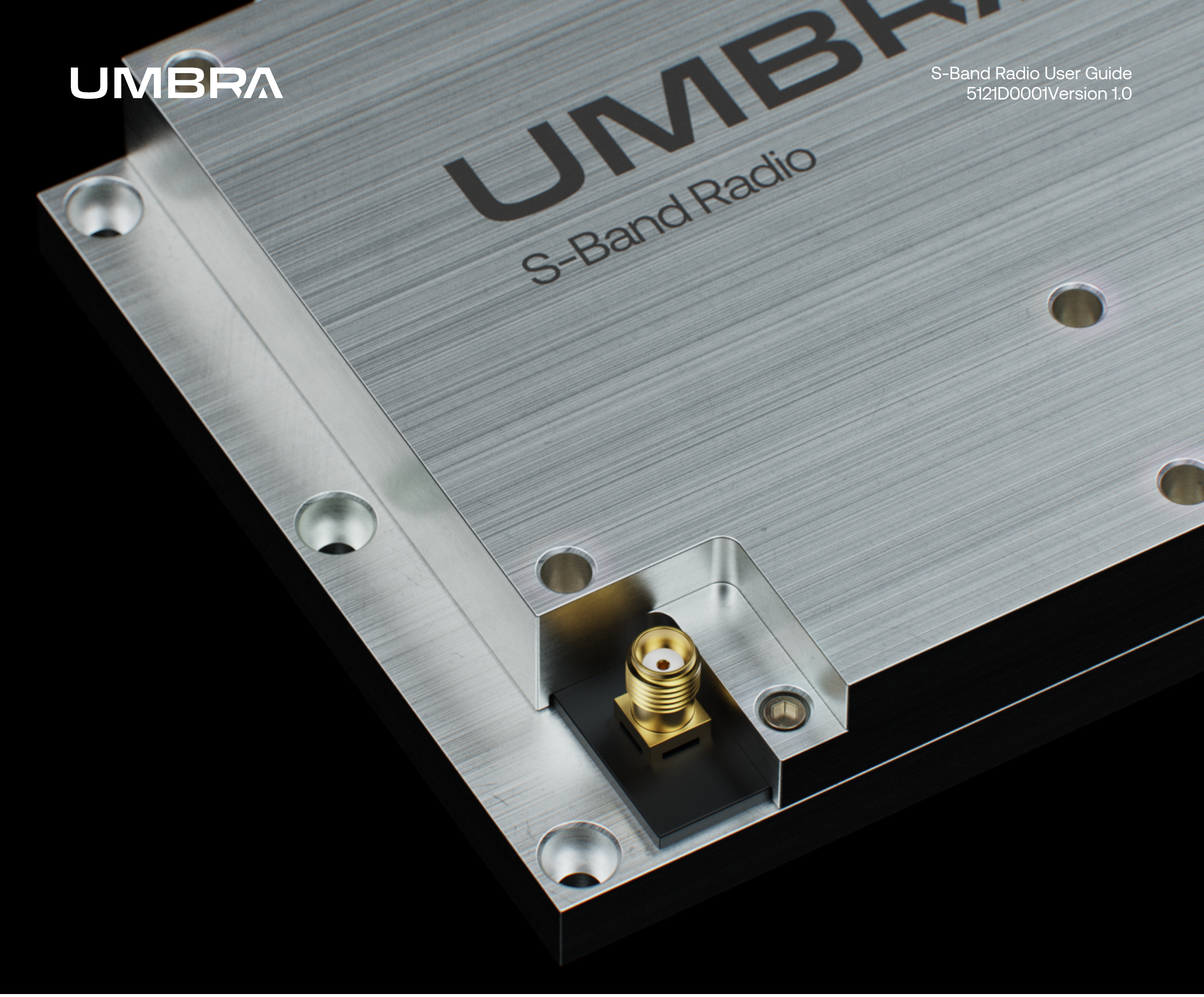
UMBRA



S-Band Radio User Guide

Distribution Statement

No Restrictions

Export Control

No US Export Control Information

Table of Contents

Figures

Tables

1.0 Objective

This document provides user guidance for the integration of the Umbra S-Band Radio.

Umbra’s S-Band Radio (SBR) product is intended to be used to command space vehicles and receive telemetry with a low data-rate connection over the unified S-Band spectrum.

2.0 Document References

This section contains the document number and description for documents that are referenced herein.

2.1 Umbra Documents

5111H20000	S-BAND RADIO MICD

2.2 Standard Documents

AS22759	WIRE, ELECTRICAL, FLUOROPOLYMER-INSULATED, COPPER or COPPER ALLOY
GSFC-STD-7000	GENERAL ENVIRONMENTAL VERIFICATION STANDARD (GEVS)
MIL-STD-461	MILITARY STANDARD: ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS REQUIREMENTS FOR EQUIPMENT
SAE-AS50881	WIRING, AEROSPACE VEHICLE

3.0 Document Authority

In the case of a conflict between any dimensional, mounting pattern, or pinout information defined within this document and other information sources, the released mechanical and electrical drawings in Appendix B shall supersede this document.

3.1 Revision Notes

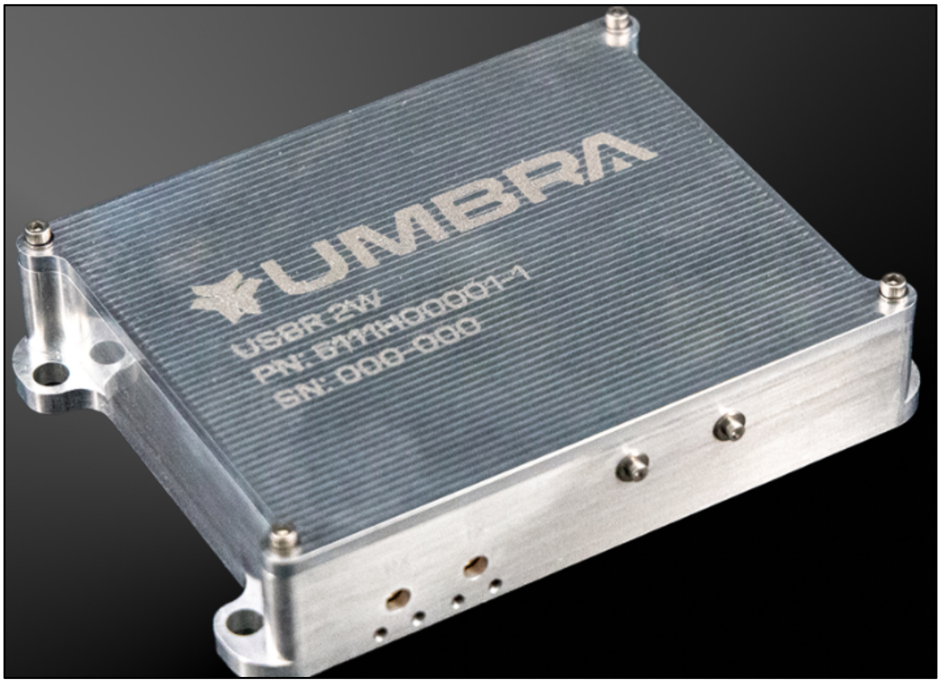
This document is Version 1.0.

3.2 Document Disclaimer

DISCLAIMER: This User Guide is intended to provide a brief summary of our knowledge and guidance regarding the use of this item. The information contained herein has been compiled from sources considered by Umbra Lab, Inc. to be dependable and is accurate to the best of Umbra's knowledge. It is not meant to be an all-inclusive document on worldwide hazard communication regulations. This information is offered in good faith. Each user of this material needs to evaluate the conditions of use and design the appropriate protective mechanisms to prevent employee exposure, personal injury, property damage or release to the environment of any hazardous substances. Umbra. assumes no responsibility for injury, damage, or loss sustained by the recipient or third persons or for any damage to any property resulting from misuse of the product. Purchase and use of the product(s) identified herein are governed by the terms of sale under which you purchase the product(s) from Umbra Lab, Inc.

4.0 Hardware Handling

Figure 1. Umbra S-Band Radio



4.1 Mechanical Handling

Contact Umbra if any Umbra S-Band Radio fails any procedure as described in this document. Do not continue use of any Umbra S-Band Radio with a suspected failure.
Ensure that any transportation of the Umbra S-Band Radio occurs in an environment described in the “Storage and Transport Environments” section.

Do not drop the Umbra S-Band Radio

Only lift the Umbra S-Band Radio by the chassis.

Do not disassemble the Umbra S-Band Radio.

Be sure to install SMA F/M dust caps on RF connections when transporting or when packaged.

4.1.1 Hazards

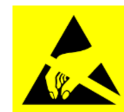
Ensure the Tx and Rx ports have an electrical 50 Ohm, 5W load or customer furnished coax harness terminated when operating the S-Band radio in order to prevent damage to the hardware. The Umbra S-Band Radio can radiate at 2W therefore ensure the RF interfaces are properly terminated to avoid radiation of personnel. It is recommended that a standard RF wand is used to ensure RF power levels are below industry maximum permissible exposure levels.

The Umbra S-Band Radio does not contain any hazardous materials subject to exposure during intended use.

4.1.2 ESD Sensitivity

The Umbra S-Band Radio is electrostatic discharge (ESD) sensitive.

An ESD ground strap shall be worn by the person(s) handling the hardware.



Failure to follow ESD requirements and recommendations may result in damage to components and/or personnel injury.

Follow ANSI/ESD S20.20 while handling ESD sensitive components.

4.1.3 Unpacking

- If applicable, check shock detection stickers
- Remove assembly from transportation container
- Perform visual inspection for damage
- Take pictures as received
- Inspect connections then re-apply protective dust caps

4.2 RBF/ Red Tag GSE

Items listed in Table 1 must be removed during hardware integration.

Table 1. RBF Items

Item	Critical/Optional	Notes
Connector Dust Cover	Critical	J4 Ethernet Link Dust Cover
Connector Dust Cover	Critical	J3 Tx SMA Dust Cover
Connector Dust Cover	Critical	J2 Rx SMA Dust Cover
Connector Dust Cover	Critical	J1 MD Connector

4.3 Electrical Mate/Demate

The assembly's connector and required mating harness connector are in Table 2.

Table 2. Electrical Connectors

Connector Designator	Assembly Connector	Mating Flight Connector
J4	CONN MULTI-PURP RCPT 10P UPRIGHT R/A SMD TYPE A ETHERNET IX61G-A-10P	ND9-AP54-00
J3	TX SMA RECEPTACLE	Male SMA
J2	RX SMA RECEPTACLE	Male SMA
J1	FEMALE SOCKET	MMDP-015 (Micro-D 15 Pin)

Do not mate or demate electrical connections from the Umbra S-Band Radio while powered.

4.4 Connector Strain

It is recommended to secure all harnessing interfacing to the Umbra S-Band Radio per SAE-AS50881, which provides guidance on the installation of wiring harnesses.

4.5 Storage and Transport Environment

Follow the guidelines below for storage and environmental factors.

Do not store the Umbra S-Band Radio in such a way that damages part markings.

Keep dust covers on the connections of the Umbra S-Band Radio when in storage as called out in section 4.2

Do not store the Umbra S-Band Radio in direct sunlight.

Ensure that critical RBF is in place during all transport of the Umbra S-Band Radio.

Table 3. Recommended Storage Environment

Parameter	Value
Storage Temperature	5°C to 35°C
Humidity	< 50% Relative Humidity

4.6 Operating Environment

Table 4. Operating Environment

Parameter	Value
Operational Temperature	-30°C to +80°C

4.7 Survival Environment

The Umbra S-Band Radio is designed to survive in an on-orbit, powered state from -40C to 90C

Table 5. Survival Environment

Parameter	Value
Survival Temperature	-40°C to +90°C
Vibration	Qualified to 14.16 g RMS profile enveloping GEVS, Falcon 9, SpaceX Rideshare, and Electron levels.
Shock	Qualified to 1000 g peak profile enveloping GEVS, Falcon 9, SpaceX Rideshare, and Electron levels.
Minimum Survivable Total Ionizing Dose	Designed to withstand at least 30 krad TID

4.8 Mounting Information

See Appendix B for more information on mounting the Umbra S-Band radio.

5.0 Electrical Properties

Table 6. Electrical Properties

Property	Typical Value	Notes
Operating Voltage	28 VDC	+22 VDC to +32 VDC
Avg. Power	4.4 W	While Receiving
Peak Power	15.7 W	While Transmitting
Data Interface	100 Mbps or 1 Gbps	GigE over IX Connector
Backup Command and Telemetry Interface	Serial	LVDS or RS-422 at 921600 Baud
Operating Current Avg.	0.16 A	0.56 A Max

5.1 Connector Pinouts

See section 6.0 Software Properties for more information on signal packet structure.

See Section 5.0 for more information about provided power.

Figure 2. MMDS-015 Connector Mating Face View

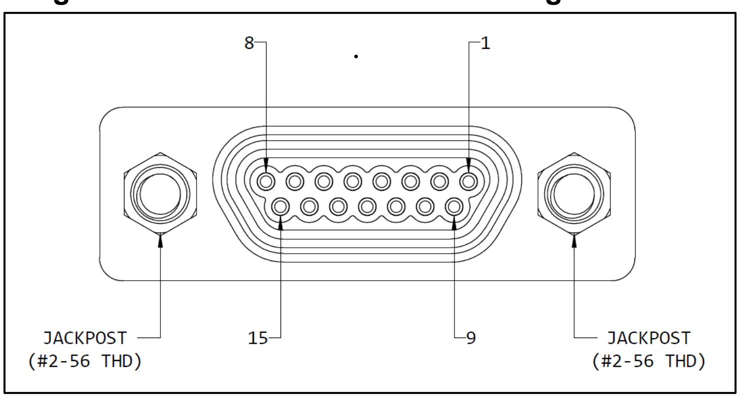


Table 7. Connector Pinout J1 28 V Power and Communication Interface

PIN	SIGNAL
1	COM RADIO TO FC P

PIN	SIGNAL
2	COM RADIO TO FC N
3	COM FC TO RADIO P
4	COM FC TO RADIO N
5	CLK RADIO TO FC P
6	CLK RADIO TO FC N
7	CLK FC TO RADIO P
8	CLK FC TO RADIO N
9	GND
10	GND
11	GND
12	GND
13	POWER 28 V
14	POWER 28 V
15	POWER 28 V

Figure 3. iX Ethernet Connector Mating Face View

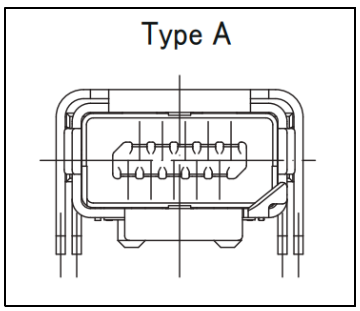


Table 8. Connector Pinout J4 Ethernet

PIN	SIGNAL (1000BASE-T)	SIGNAL (10BASE-T, 100BASE-TX)
1	BI_DA+	TX+
2	BI_DA-	TX-
3	No Connect	No Connect
4	BI_DC+	No Connect
5	BI_DC-	No Connect
6	BI_DB+	RX+
7	BI_DB-	RX-
8	No Connect	No Connect
9	BI_DD+	No Connect
10	BI_DD-	No Connect
SH	ETHERNET_SHIELD	ETHERNET_SHIELD

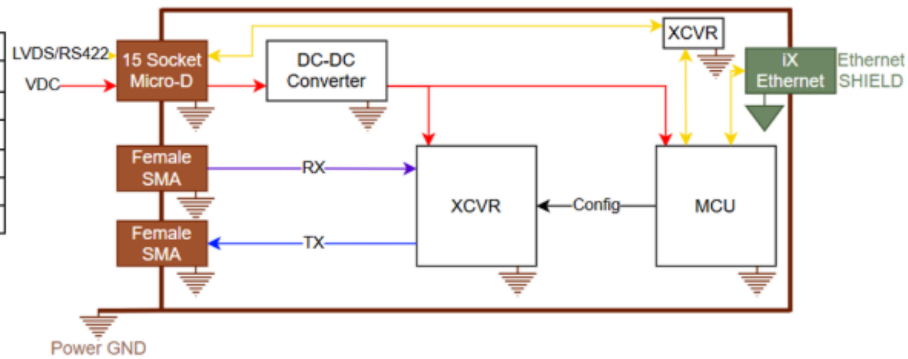
5.2 Harnessing Recommendations

Space-rated harnesses connecting to the Umbra S-Band Radio should use wire following SAE AS22759.

5.3 Grounding Block Diagram

Figure 4. Grounding Block Diagram

Color	Description
Red	Power
Green	Ethernet
Brown	GND
Purple	Rx
Blue	Tx
Yellow	RS-422/LVDS



5.4 EMI/EMC Properties

The Umbra S-Band radio is pending test of Electromagnetic Interference (EMI) / Electromagnetic Compatibility (EMC) testing complies with MIL-STD-461. Units have been verified to be self-compatible with X-band and L-band radios onboard a LEO spacecraft.

5.5 Material Properties

All Umbra products are manufactured from materials deemed space-rated based on low outgassing. See Appendix B for more information on material properties of the Umbra S-Band Radio.

6.0 Software Properties

6.1 Communication Parameters

6.1.1 Ethernet Communication Protocols

The Umbra S-Band radio standard communications protocol uses an Ethernet link at 100 Mbps or 1 Gbps utilizing the Remote Procedure Call (RPC) protocol.

RPC is a request – response type protocol where the host sends a request message to the client to retrieve data or take an action such as setting a parameter.

6.1.2 Serial Communication Protocols

A communications interface is available using RS-422 with a Baud of 921600.

The Umbra S-Band radio utilizes differential signaling available as RS-422 at 1Mbps or LVDS at 100MBps.

6.2 Downlink

6.2.1 Downlink Modulation

The S-Band radio utilizes Offset Quadrature Phase Shift Keying modulation (OQPSK).

6.2.2 Downlink Data Rate

1kbps to1Mbps in 1kbps increments.

6.2.3 Downlink Filtering Type

The Umbra S-Band radio can apply Root-Raised Cosine filtering.

6.2.4 Downlink Power

The Umbra S-Band radio can vary its output power level in 0.1 dBm increments from 0 dBm to 33 dBm.

6.2.5 Downlink Encoding

The Umbra S-Band radio can apply PCM, Convolutional, HDLC and Reed Solomon encoding.

6.2.6 Downlink Frequency

The Umbra S-Band radio downlink center frequency can be varied from 2200 – 2290 MHz

6.2.7 Downlink Symbol Rate

The symbol error rate is less than 50 ppm at a symbol rate of less than 500 ksps.

6.2.8 Downlink Packet Example

Telemetry data from the host is proceeded by the S-Band radio controller and converted to HDLC encoded blocks followed by Reed Soloman encoding in accordance per CCSDS 131.0-B-3-a.

HDLC encoded blocks are further discussed in section 0. The HDLC encoded blocks are input to the Reed-Soloman encoder.

The Reed Solomon block consists of 255 Bytes of which 223 bytes are HDLC data and preceded by a 4 byte sync marker and followed by 32 bytes of error correction data.

Table 9. Reed Solomon Block

Sync Marker	HDLC Bytes	Parity Bytes
4 Bytes	223 Bytes	32 Bytes

The Reed Solomon encoded blocks are then PCM encoded before being passed on to convolutional encoding in accordance with CCSDS 131.0.B-3 at a code rate of ½ with k=7.

G1 = 0b1111001 (171 octal) G2 = 0b1011011 (133 octal) shall be the connection vector

Following convolutional encoding the telemetry frame is OQPSK modulated. See table 10 for input logic and output phase shift mapping.

Table 10. Phase Shift Mapping

Logic Input	Phase Output
00	45 Deg
01	135 Deg
11	255 Deg
10	315 Deg

6.3 Uplink

6.3.1 Uplink RF

The Umbra S-Band radio remains on as to allow the ability to receive commands at any time.

6.3.1.1 Uplink RF Frequency

The Umbra S-Band radio can vary the Uplink center frequencies from 2025 MHz – 2110 MHz.

6.3.1.2 Uplink RF Decoding

The Umbra S-Band radio is capable of PCM decoding.

6.3.1.3 Uplink RF Demodulation

The Umbra S-Band radio is capable of demodulating Binary Phase Key Shifting (BPSK).

6.3.1.4 Uplink RF Data Rate

The Umbra S-Band radio is capable of a data rate of 1kbps to 1Mbps

6.3.2 Uplink Packet Format

Demodulation and decoding of uplink data occurs with the RF signal being BPSK demodulated, per CCSDS 401.0.B-29, before being sent to the PCM decoder. The bitstream from demodulator is then PCM decoded to avoid polarity ambiguity.

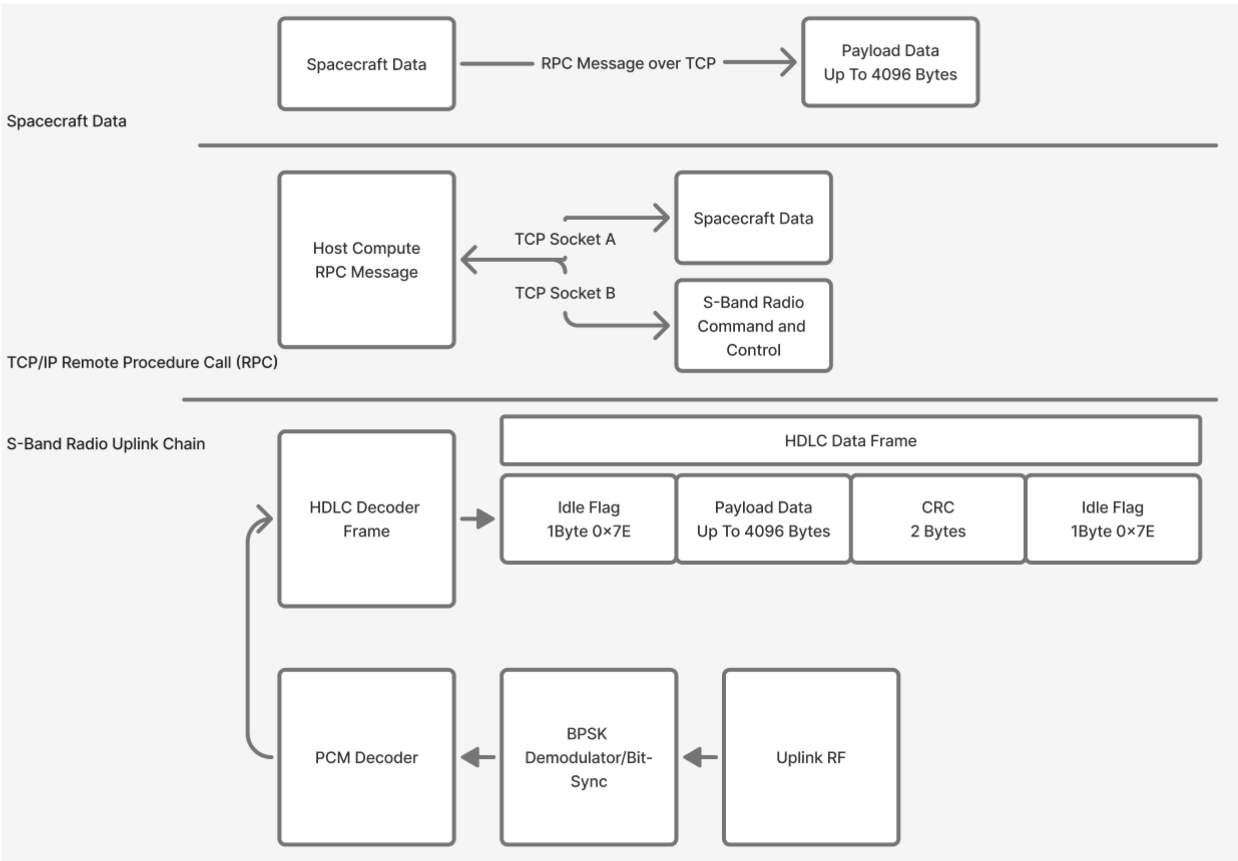
The output of the PCM decoder is in the form of HDLC data blocks and idle flags as seen below.

Table 11. Uplink HDLC Block

Idle Flag	Payload Data	CRC	Idle Flag
1Byte: 0x7E	Up to 4096	2 Bytes	1Byte: 0x7E

HDLC decoded blocks of data are then processed by the radio controller and are provided to the host over ethernet using the standard Remote Procedure Call messaging protocol.

Figure 5. Decoding Process Flow



6.3.3 Field Types

N/A

6.3.4 Uplink Commanding

Uplink command processing time is 50ms.

Uplink commands may be processed within 2 mins of power being applied to the S-Band radio.

6.4 S-Band Radio Control and Spacecraft Data

This section will cover the radio control interface to configure and read data from the radio itself. The data interface to the host used to communicate ground commands to the spacecraft will be described here as well.

The radio is configurable via ground commands from the RF section over the J4 ethernet link socket to the host or via the backup RS-422 or differential LVDS Data and Clock interface. Both the radio control socket and the spacecraft data sockets are hosted on the J4 ethernet connector and use the standard Remote Procedure Call request-response protocol. Messages are sent by the spacecraft client to the S-Band radio to execute a specific action with supplied parameters (such as a status response or the setting of a parameter). The server responds to the client with the response and the process continues.

6.4.1 S-Band Radio Control

6.4.1.1 S-Band Radio RPC Control Blocks

Following receipt and processing of control commands from the ground, the S-Band radio control information is processed through the uplink chain where HDLC encoded blocks are sent to the S-Band radio controller and then on to the host via the Remote Procedure Call messaging protocol over the provided ethernet link. The HDLC frame employs a one byte idle flag followed by up to 4096 bytes of payload data, a 2 byte CRC and bit-stuffing.

Table 12. HDLC Block

Idle Flag	Payload Data	16bit CRC	Idle Flag
1 Byte 0x7E	Up to 4096 Bytes	2 Bytes	1 Byte 0x7E

The radio generates a continuous stream of bytes regardless of whether HDLC frames are being transmitted. Idle Flag bytes are inserted between HDLC Frames when no data is available to transmit.

The host spacecraft computer will request data from the radio via Remote Procedure Call protocol messages.

6.4.1.2 S-Band Radio Available Controls

The following parameters are provided to controllable the S-Band radio. These control commands are sent structured in the HDLC frame protocol described above.

Table 13. S-Band Radio Controls

Name	Description	Data Type	Range
set_tx_center_frequency	Set center frequency for TX upconversion	float Hz	2200 to 2290 MHz
set_rx_center_frequency	Set center frequency for RX downconversion	float Hz	2025 to 2110 MHz
set_sampling_frequency	Set sampling rate for analog front end	float sps	2083333 - 61440000
set_tx_bandwidth	Set BW of TX spectrum	float Hz	200 KHz – 4MHz
set_rx_bandwidth	Set BW of RX spectrum	float Hz	200 KHz – 5.6 MHz

Name	Description	Data Type	Range
set_tx_hardware_gain	Set the gain of the TX signal	float dB	-89.750000 0.250000 0.000000
set_rx_hardware_gain	Set the receive gain	TBD	-3 - 71
set_rx_gain_mode	Set the gain mode of the AGC on RX	String: fast or slow	String: fast or slow
set_config	TBD	TBD	TBD
save_config	Save the current configuration file	TBD	TBD
enable_tx	Enable the radio for transmission	N/A	N/A
key_tx_up	Turn the transmitter On for a specified amount of time	u32 sec	TBD
key_tx_down	Turn the transmitter Off	N/A	TBD
set_rx_symbol_rate	Set the symbol rate of the RX signal for demodulation	Float sps	Float sps
set_expected_rx_symbol_rate	Set the expected symbol rate of the RX signal	Float sps	Float sps
set_tx_symbol_rate	Set the symbol rate of the TX signal for modulation	Float sps	Float sps
set_rx_alpha	Set the loop filter proportional gain	U32	16 bits
set_rx_beta	Set the loop filter integrator gain	U32	16 bits
set_rx_threshold_a	Set the upper threshold for RX demodulation lock	U32	24 bits
set_rx_threshold_b	Set the lower threshold for RX demodulation lock	U32	24 bits
set_rx_decoding	Set the decoding scheme used in RX	U8	PCM: 0 -> NRZ-L; 1 -> NRZ-M; 2 -> NRZ-S
set_tx_encoding	Set the encoding scheme used in TX	U8	u8 PCM: 0 -> NRZ-L; 1 -> NRZ-M; 2 -> NRZ-S

6.4.2 S-Band Radio Telemetry

The following S-Band radio telemetry is available to the host to determine S-Band radio state of health.

Table 14. S-Band Radio Telemetry

Name	Type	Units	Description	Memory	Default Value
Firmware Version	uint32_t	N/A	Firmware Version	Persistent	Current Version
Hardware version	uint32_t	N/A	Version of the hardware	Persistent	Current Version
Software version	uint32_t	N/A	Software version	Persistent	Current Version
Rx center frequency	float	MHz	Center frequency of the Rx	Persistent	2080
Tx center frequency	Float	MHz	Center frequency of the Tx	Persistent	2254
Rx Sample Rate	Float	Msps	Sample Rate of the AFE ADC	Persistent	40
RX Bandwidth	Float	MHz	The set bandwidth for the receiver	Persistent	10
TX Bandwidth	Float	MHz	The set bandwidth for the transmitter	Persistent	10
TX Attenuation	Float	dB	Amount of digital attenuation applied to the Tx signal	Persistent	0
Rx RSSI	Float	dBm	Amount of power measured on Rx	Volatile	-200
Rx Demodulation Lock	Bool	N/A	1 -> RX demod lock; 0 -> searching	Volatile	0
Tx Enable	Bool	N/A	1 -> TX front end is enabled; 0 -> disabled	Volatile	0

Name	Type	Units	Description	Memory	Default Value
RX Symbol Rate	Float	Ksps	Symbol rate of received data	Persistent	100
Expected RX Symbol Rate	Float	Ksps	Expected symbol rate of received data	Persistent	100
TX Symbol Rate	Float	Ksps	Symbol rate of transmitted data	Persistent	100
RX Alpha	uint32_t	N/A	Loop filter proportional Gain	Persistent	TBD
RX Beta	uint32_t	N/A	Loop filter integrator gain	Persistent	TBD
RX Threshold A	uint32_t	TBD	TBD	Persistent	TBD
RX Threshold B	uint32_t	TBD	TBD	Persistent	TBD
RX Threshold Lock	uint32_t	TBD	TBD	Persistent	TBD
RX Threshold Unlock	uint32_t	TBD	TBD	Persistent	TBD
RX PCM Decoding	uint8_t	N/A	0 -> NRZ-L; 1 -> NRZ-M; 2 -> NRZ-S	Persistent	1
RX Valid Frame Counter	uint32_t	N/A	Counter that shows number of CRC Passes	Volatile	0
RX Invalid Frame Counter	uint32_t	N/A	Counter that shows number of CRC Fails	Volatile	0
TX PCM Encoding	uint8_t	N/A	0 -> NRZ-L; 1 -> NRZ-M; 2 -> NRZ-S	Persistent	1
TX Packet Counter	uint32_t	N/A	Counter that shows number of TX packets sent	Volatile	0
RX Doppler Correction	Float	KHz	Amount of doppler shift	Volatile	0

Name	Type	Units	Description	Memory	Default Value
			that is being corrected		
TX Baudcount	uint32_t	N/A	The baudcount for the OQPSK modulator for TX	Persistent	1
Tx On	uint32_t	N/A	This telemetry point is the swtich for TX amps	Persistent	0
AFE PHY Voltage	Float	V	AFE PHY Voltage	Volatile	0
AFE PHY Temp	Float	C	AFE PHY Temperature	Volatile	0
FPGA System Voltage 1	Float	V	TBD	Volatile	0
FPGA System Voltage 2	Float	V	TBD	Volatile	0
FPGA System Voltage 3	Float	V	TBD	Volatile	0
FPGA System Voltage 4	Float	V	TBD	Volatile	0
FPGA System Voltage 5	Float	V	TBD	Volatile	0
FPGA System Voltage 6	Float	V	TBD	Volatile	0
FPGA System Voltage 7	Float	V	TBD	Volatile	0
FPGA System Voltage 8	Float	V	TBD	Volatile	0
FPGA System Voltage 9	Float	V	TBD	Volatile	0

Name	Type	Units	Description	Memory	Default Value
FPGA System Voltage 10	Float	V	TBD	Volatile	0
FPGA System Voltage 11	Float	V	TBD	Volatile	0
FPGA System Voltage 12	Float	V	TBD	Volatile	0
FPGA System Voltage 12	Float	V	TBD	Volatile	0
FPGA System Voltage 14	Float	V	TBD	Volatile	0
FPGA System Voltage 15	Float	V	TBD	Volatile	0
FPGA System Voltage 16	Float	V	TBD	Volatile	0
FPGA System Voltage 17	Float	V	TBD	Volatile	0
FPGA System Voltage 18	Float	V	TBD	Volatile	0
FPGA System Voltage 19	Float	V	TBD	Volatile	0
FPGA System Voltage 20	Float	V	TBD	Volatile	0
FPGA System Voltage 21	Float	V	TBD	Volatile	0
FPGA System Voltage 22	Float	V	TBD	Volatile	0
FPGA System Voltage 23	Float	V	TBD	Volatile	0
FPGA System Voltage 24	Float	V	TBD	Volatile	0

Name	Type	Units	Description	Memory	Default Value
FPGA System Voltage 25	Float	V	TBD	Volatile	0
FPGA System Voltage 26	Float	V	TBD	Volatile	0
FPGA System Voltage 27	Float	V	TBD	Volatile	0
FPGA System Temp 1	Float	C	TBD	Volatile	0
FPGA System Temp 2	Float	C	TBD	Volatile	0
FPGA System Temp 3	Float	C	TBD	Volatile	0
Telemetry ADC Temp	Float	C	TBD	Volatile	0
28V CS	Float	A	TBD	Volatile	0
5V CS	Float	A	TBD	Volatile	0
3V3 CS	Float	A	TBD	Volatile	0
1V8 CS	Float	A	TBD	Volatile	0
6V CS	Float	A	TBD	Volatile	0
AFE Temp Sensor	Float	C	TBD	Volatile	0
Load Switch Temp Sensor	Float	C	TBD	Volatile	0
4V CS	Float	A	TBD	Volatile	0

6.4.3 Spacecraft Data

Spacecraft command and control data is received and processed by the S-Band radio and sent to the host via a socket in the J4 ethernet connector in standard Remote Procedure Call messaging protocol (a server, client request and response type of protocol).

The host will interpret the data from the S-Band radio and will process the spacecraft commands. Spacecraft data is sent to the S-Band radio over the data socket on the J4 ethernet connector to be processed and transmitted to the ground.

The S-Band radio can be configured to utilize the serial port for spacecraft data if so desired. The serial interface will utilize a RS-422 (Baud of 921600) or an available differential LVDS Data and Clock interface. Point-to-Point Protocol is used as the communications protocol on the serial link.

6.5 Memory

The S-Band radio utilizes non-volatile memory configuration storage. The Umbra S-Band Radio memory architecture does not include any memory allocation for logs.

6.6 Error Mitigation

The Umbra S-Band Radio includes two Built in Self-Tests to discern the health of the radio. The first Built in Self-Test applies to the transmit section of the Umbra S-Band Radio. This test will detect the Tx Power level to confirm the health of the amplifiers within the radio.

The second Built in Self-Test applies to the receive section of the radio. In this scenario the S-Band Radio takes noise figure measurements to determine the states of health of the Rx chain.

Both tests can be enabled by the user via a ground command and will save the values to non-volatile memory where they are available to downlink.

As a general note, should the user encounter data integrity issues then it is advisable to lower the S-Band Radio symbol rate via the "set_expected_rx_symbol_rate" or the set_tx_symbol_rate command.

7.0 Performance Specifications

Table 15. Performance Specifications

Property	Value
RF Output Power	2W
Data Rate	100KHz to 1Mbps
Doppler Correction	100Khz to 10KHz/s
Sensitivity @ 100KBps	-100 dBm
Transmit Modulation	OQPSK, HDLC, NRZ-L/M/S, Convolutional Encoding (k=7, ½, G2 inverted, Reed Solomon (255,223)
Receive Demodulation	BPSK, HDLC, NRZ-L/M/S

7.1 Performance Verification

Customer recommended checkout and qualification testing is described in this document in the Section 8.0 Operational Procedures

8.0 Operational Procedures

Follow all requirements and recommendations in 4.1 Mechanical Handling while carrying out any and all procedures in this section. Umbra S-Band radio may be damaged by carrying out any procedure listed in this section if mechanical handling requirements and recommendations are not followed.

8.1 Ground Support Equipment

Not applicable.

8.2 First Use Procedure

The following must be completed before any other procedures in this user guide are carried out.

8.2.1 Assembly

The Umbra S-Band radio arrives fully assembled.

8.2.2 Checkouts

- Verify TX chain through downlink power measurement
- Verify RX chain through uplink noise figure measurements
- Verify full functionality of Radio uplink and downlink through TX and RX data loopback

8.2.3 Initial Configuration

The Umbra S-Band radio is ready to be configured for the customer use case upon boot up.

8.3 Sample Procedure

Not applicable.

8.3.1 Success Criteria

Not applicable.

8.3.2 Configuration and Equipment

Not applicable.

8.3.3 Test Procedure

Not applicable.

8.4 On-Orbit Checkout

Expectation is that the list of default values is set and verified at initial power on.

On-Orbit checkout will confirm that the S-Band radio booted up to its default state. Parameters that should be verified are RF transmit power level, receive power and command processing. The thermal profile at hot and cold should also be documented and together with the first two telemetry points to give an overall state of health of the S-Band radio in both environments.

8.4.1 Command Processing Check

The Umbra S-Band radio receive section is on by default. At first contact the customer should send an S-Band radio command to request S-Band radio configuration information such as “Firmware Version” and then compare actual results to expected values.

8.4.2 Configure Downlink

Set the S-Band Radio Downlink by sending the following commands to set the transmit attenuation, to set the frequency and to enable the downlink.

- set_tx_center_frequency
- set_tx_hardware_gain
- set_tx_encoding
- enable_tx

8.4.3 Verify Telemetry

The following telemetry is to be verified to confirm the default state of health of the Umbra S-Band radio.

Table 16. Telemetry Verification

Name	Description	Default
RX Center Frequency	Center Frequency of RX	User Defined
RX RSSI	Amount of power measured on RX	
TX Attenuation	Amount of digital attenuation applied to TX signal	
Telemetry ADC Temp	TBD	TBD
28V CS	TBD	TBD
5V CS	TBD	TBD
3V3 CS	TBD	TBD
1V8 CS	TBD	TBD
6V CS	TBD	TBD
AFE Temp Sensor	AFE Temperature Sensor	TBD
Load Switch Temp Sensor	Load Switch Temperature Sensor	TBD
4V CS	TBD	TBD

Appendix A

Acronyms and Abbreviations

A.1 Acronyms and Abbreviations

AFE	Analog Front End
BPSK	Binary Phase Shift Keying
CCSDS	Consultative Committee for Space Data Systems
CRC	Cyclic Redundancy Check
ESD	Electro-Static Discharge
FOD	Foreign Object Debris
GEVS	General Environmental Verification Standard
HDLC	High Level Data Link Control
LEO	Low Earth Orbit
LNA	Low Noise Amplifier
LVDS	Low Voltage Differential Signal
NRZ	Non-Return to Zero
OQPSK	Offset Quadrature Phase-Shift Keying
TBD	To Be Determined
TBR	To Be Revised
TID	Total Ionizing Dose
PCM	Pulse Code Modulation
PPP	Point to Point Protocol
RBF	Remove Before Flight
RF	Radio Frequency
RPC	Remote Procedure Call

A.2 Units

dB	Decibel
dBm	Decibel Milliwatts
KHz	Kilohertz
krad	Kilorad
Mbps	Megabits per Second
m^2	Square Meters
W	Watts

Appendix B

Mechanical Interface Control Documentation