USER MANUAL

UHF Transceiver Type II

UHF TRANSCEIVER TYPE II

USER MANUAL

This user manual details the applications, features and operation of EnduroSat's UHF Transceiver Type II module.

Please read this manual before unpacking and using the module to ensure safe and proper use.

Figure 1 – UHF transceiver type II module

1 CHANGE LOG

Date	Version	Note
02/11/2017	Rev 1	
02/04/2018	Rev 1.2	Detailed antenna release connector pinout
24/04/2018	Rev 1.3	Changes in text
15/06/2018	Rev 1.4	Pinout changes
21/11/2018	Rev 1.5	Technical writing enhancements.

2 ACRONYMS LIST

AX.25	Amateur X.25 data link layer protocol
AFC	Automatic Frequency Correction
CAN	Controller Area Network
ECSS	European Cooperation for Space Standardization
EMI	Electromagnetic interference
ESD	Electrostatic Discharge
FRAM	Ferroelectric Random-Access Memory
FSK	Frequency-Shift Keying
GEVS	General Environmental Verification Standard
GFSK	Gaussian Frequency Shift Keying
GMSK	Gaussian Minimum Shift Keying
GND	Ground
IC	Integrated Circuit
I^2C	Inter-Integrated Circuit
LNA	Low-Noise Amplifier
MCU	Microcontroller Unit
MMCX	Micro-miniature Coaxial
NF	Noise Figure
OBC	On-Board Computer
OOK	On-Off Keying
PA	Power Amplifier
PCB	Printed Circuit Board
PER	Packet Error Ratio
RF	Radio Frequency
Rx	Receive
SNR	Signal-to-noise ratio
SPI	Serial Peripheral Interface
Tx	Transmit
Tx/Rx	Transmit and Receive
UART	Universal Asynchronous Receiver/Transmitter
UHF	Ultra-High Frequency
USB	Universal Serial Bus
VCP	Virtual Com Port

3 SYSTEM OVERVIEW

EnduroSat's UHF Transceiver Type II module operates in the commercial frequency band 400 to 403 MHz (Tx/Rx), and the amateur frequency band 430 to 440 MHz (Tx/Rx). Furthermore, it features configurable data rates, which can be changed whilst the satellite is in orbit.

The output power can also be tuned in order to maximize the link budget depending on the orbital altitude, ground station performance and desired minimum elevation angle for communication. The typical output power is 1W (30dBm) but the system allows the power to be boosted up to 2W (33dBm).

The system has a USB (virtual COM port) which allows the connection of EnduroSat's PC Software or Terminal Program for monitoring and configuring. The module is designed to fit within a CubeSat, but a second module can also be integrated in to a ground station to easily create a complete uplink and downlink communication solution. The module uses the popular AX.25 data protocol.

The UHF transceiver is fully encapsulated in an aluminum box which is designed to dissipate the heat from the power amplifier, reduce EMI and EMC, and protect the electronics from particle radiation.

4 HIGHLIGHTED FEATURES

- Frequency range (Tx/Rx): 400 to 403 MHz, and 430 to 440 MHz
- Modulation: OOK, GMSK, 2FSK, 4FSK and 4GFSK are optional, 2GFSK (by default)
- Automatic Frequency Correction
- Configurable AX.25 telemetry beacon broadcast
- Morse code
- Audio beacon
- Protocols: transparent, AX.25
- Maximum transmit power: 1 W (customizable up to 2 W)
- Power supply: 3.3 V (customizable to 5 V)
- Ultra-low power MCU with FRAM
- External FRAM
- Typical current consumption during receive mode (idle mode) (Rx): 25mA @ 3.3V
- Frequency stability: +/- 2.5 ppm
- Data rate in the air: up to 19.2kbps (optional up to 100 kbps)
- Sensitivity: up to -121 dBm
- Communication interfaces: UART / I^2C / USB (VCP) / RS485 (opt.) / CAN (opt.)
- Local and remote (in-flight) secured application firmware update

- Type: Half-duplex
- Weight: 94g

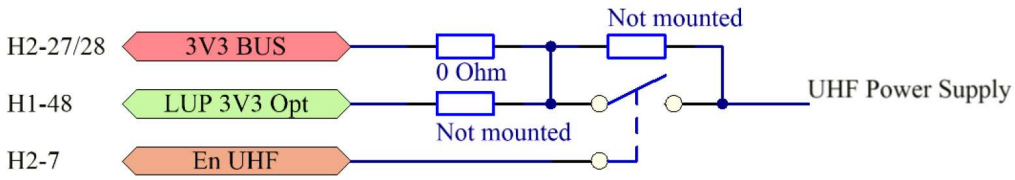
5 SYSTEM DESCRIPTION

The UHF Transceiver Type II works in the frequency range 400 to 403 MHz, and 430 to 440 MHz. Different modulation schemes are available, among them 2FSK, 4FSK, the spectrum efficient 2GFSK, 4GFSK, GMSK, and OOK as well.

The power supply block diagram is shown in figure 2.

By default, the transceiver works in half-duplex mode with configurable data rate and modulation index (m). It has the option to transmit a beacon signal with predefined information. The default data and command interfaces are UART and I^2C. Optionally, RS485 and CAN could be used. Additionally, it has a USB (Virtual COM Port) for configuration by EnduroSat's PC Software or Terminal Program. The module can also be used in a UHF ground station so that the AX.25 modem, receiver and transmitter sections can be used for communication purposes. All communication interfaces have dedicated hardware buffers for protection and when the **Enable UHF = OFF** (see fig. 2) then the interfaces of the module go high impedance.

The module can be powered either with 3.3V or 3.3V with latch-up protection with the corresponding enable pin pulled up in high state. Custom versions of the UHF transceiver can be powered from the 5V bus.



Enable UHF:

ON 1V – 5.5V

OFF 0V – 0.3V

Figure 2: Power Supply Diagram

At the core of the RF section there is a high performance transceiver IC. In the transmitter part of the device, there is a high efficiency RF power amplifier which by default is powered with 3.3V giving an output power up to 1W. If a 5V bus is used the output power can be boosted up to 2W in specific versions of the device. In the receiver part, a low noise amplifier with a maximum Noise Figure (NF) of 0.9dB improves the overall receiver performance in terms of sensitivity which is specified down to -121dBm.

The device uses a PC-104 connector which is suitable for stackable configurations of other satellite modules. The RF connector to the antenna is an MMCX.

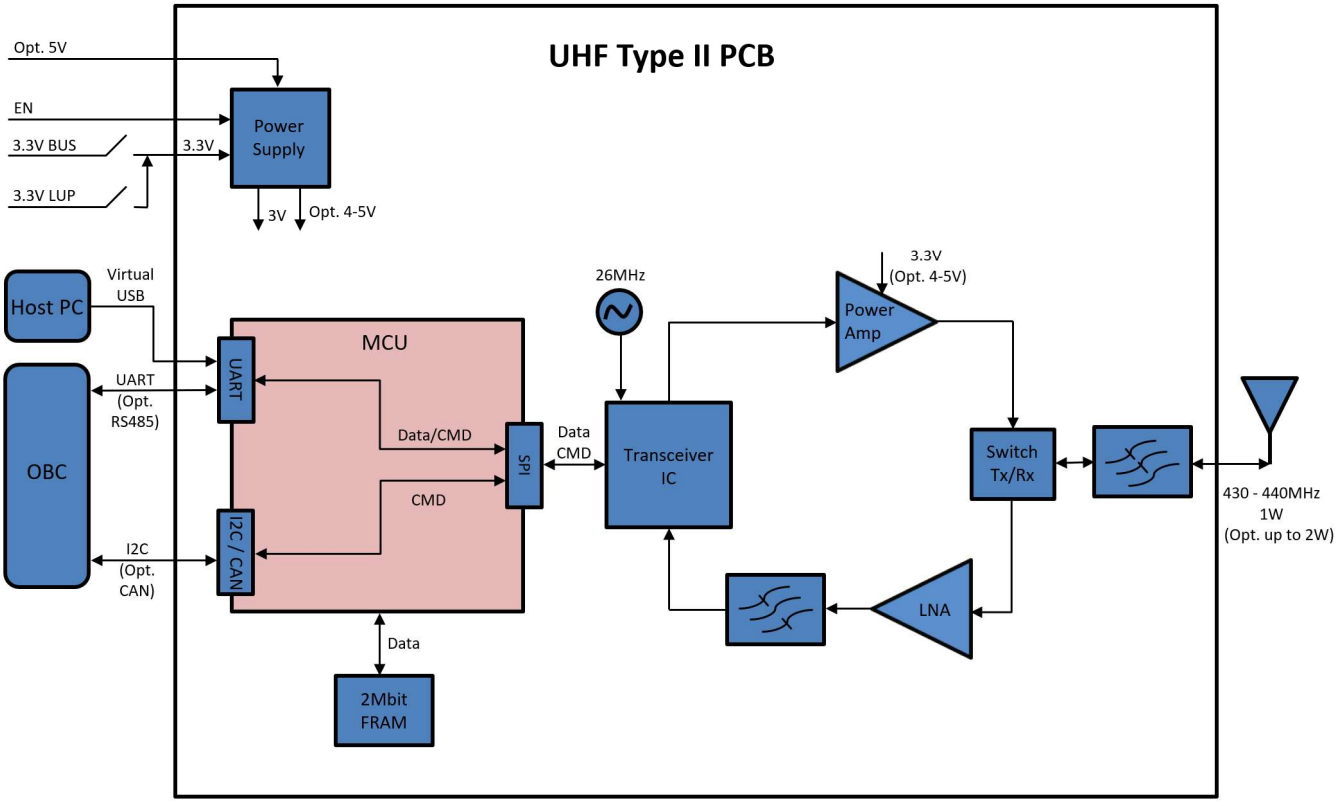


Figure 3: Functional Block Diagram of the UHF Transceiver Type II

6 RF CHARACTERISTICS

6.1 Transmitter

Parameter	Unit	Min	Typical value	Max
Freq. Range	MHz		400 to 403 435 to 438	
Output Power	W		1	2
Spurious level	dBc	60		
Baud Rate in The Air	bps	1200		19200

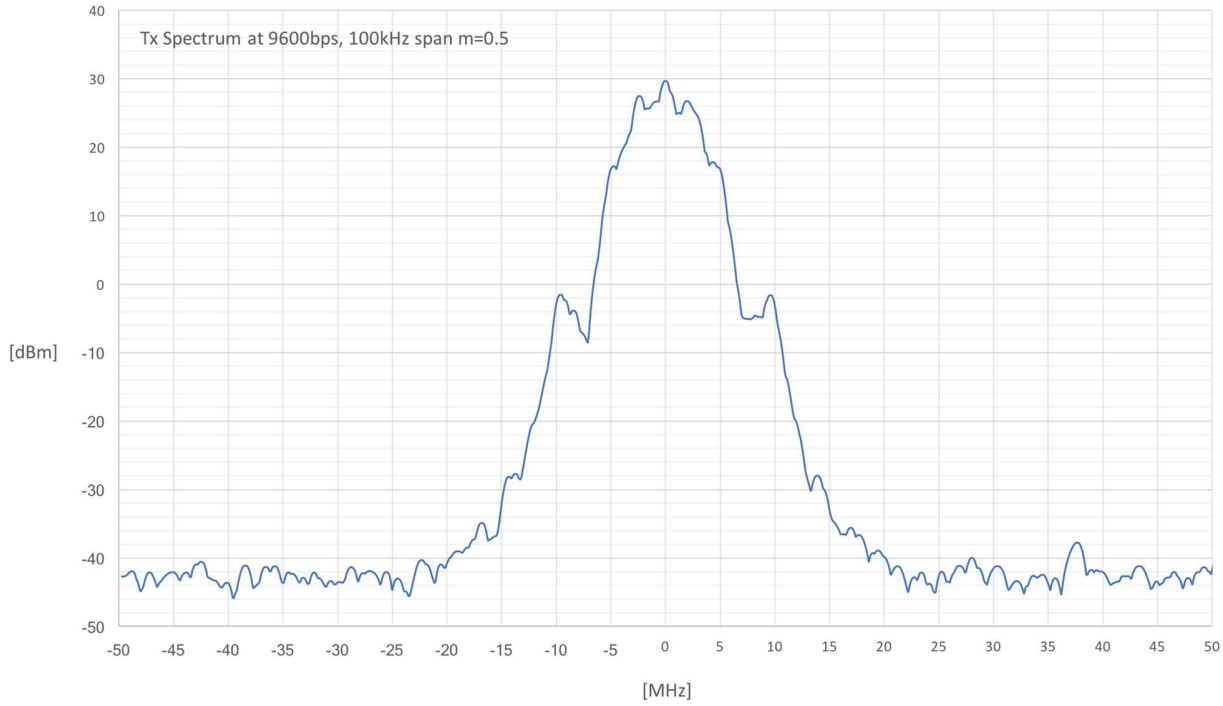


Figure 4: Tx Spectrum at 9600 bps, 100 kHz Span, m=0.5

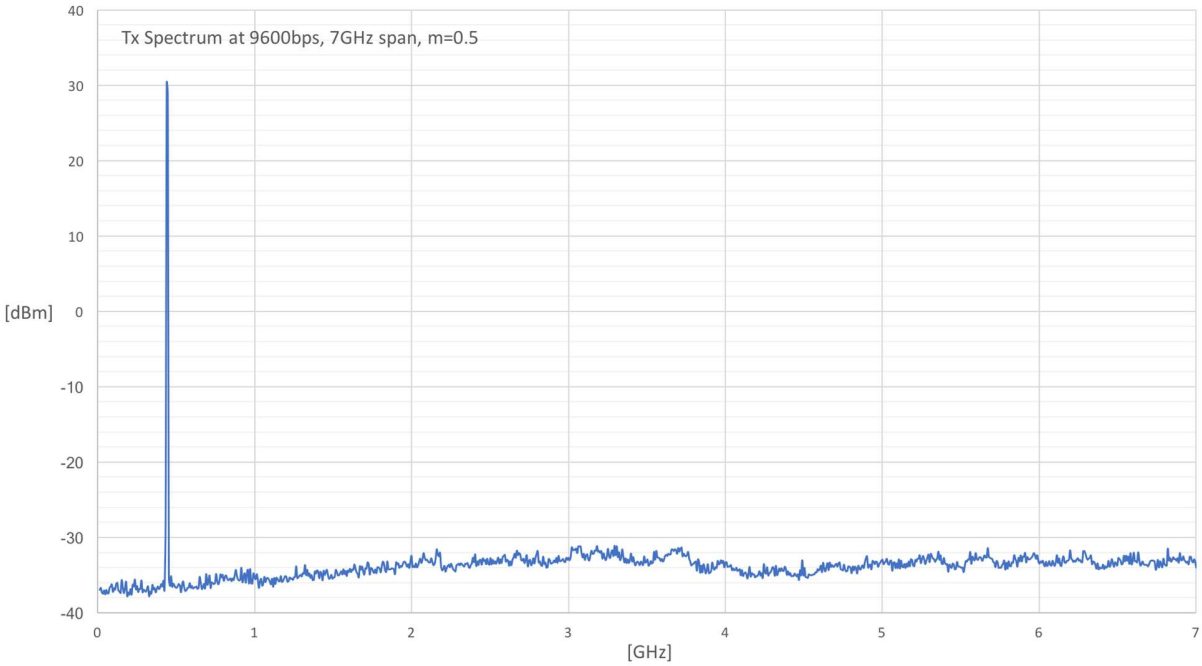


Figure 5: Tx Spectrum at 9600 bps, 7 GHz Span, m=0.5

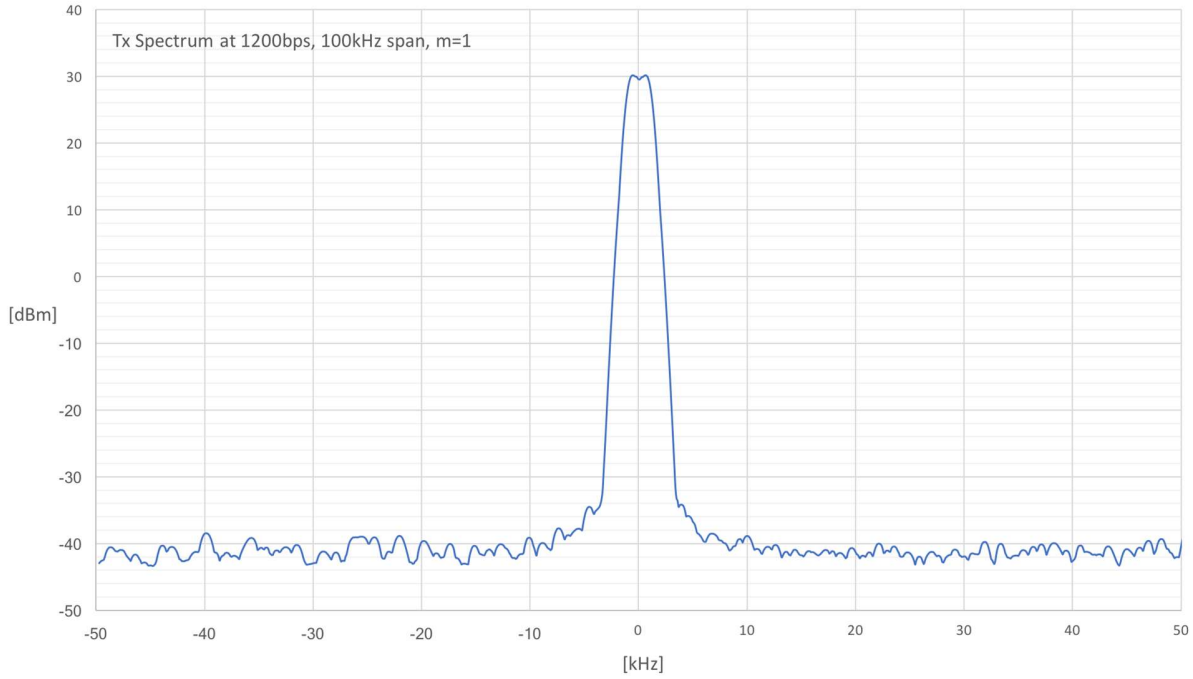


Figure 6: Tx Spectrum at 1200 bps, 100 kHz Span, m=1

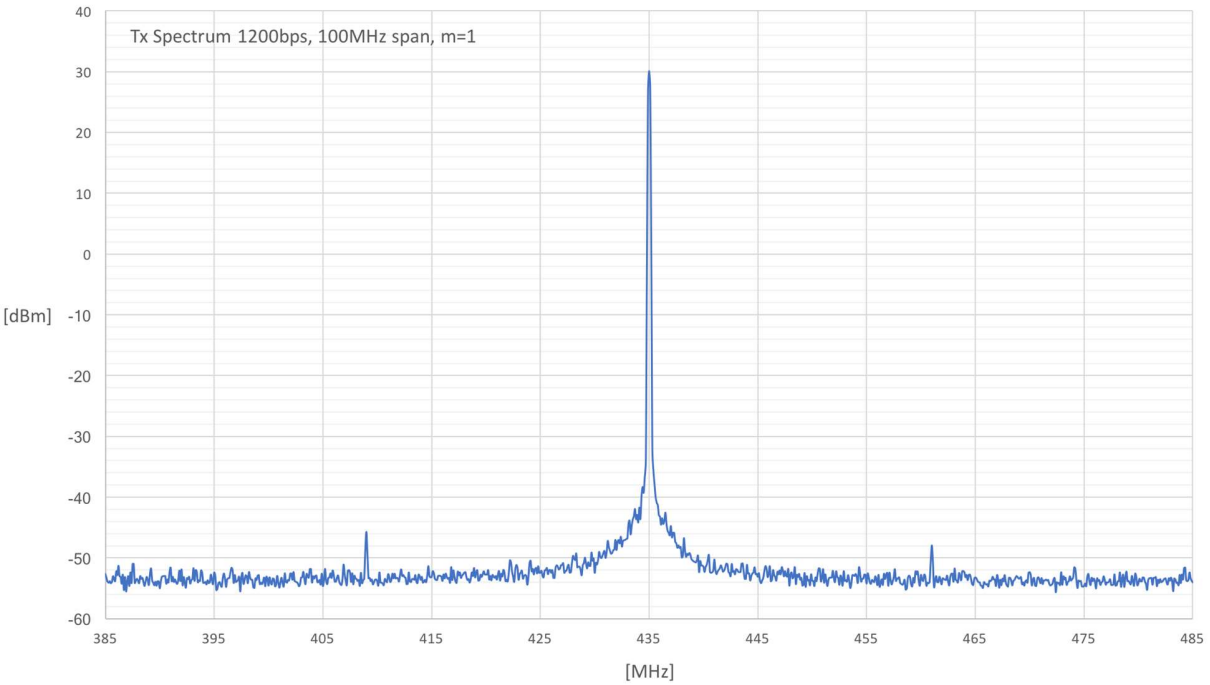


Figure 7: Tx Spectrum at 1200 bps, 100 MHz Span, m=1

6.2 Receiver

Parameter	Condition	Unit	Min	Typical value	Max
Freq. Range		MHz		400÷403, 435÷438	
Baud Rate In The Air		bps	1200		19200
SNR	PER<1% @9600bps	dB		14	
Input Power		dBm			10

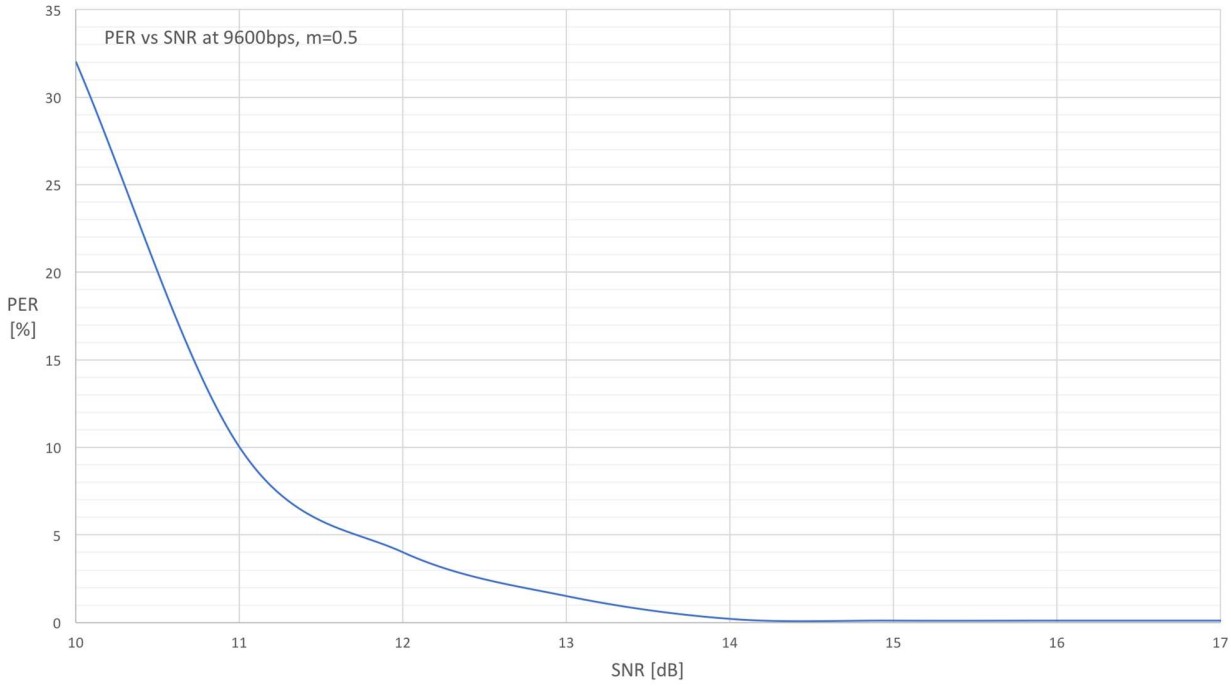


Figure 8 - PER vs SNR at 9600 bps, m=0.5

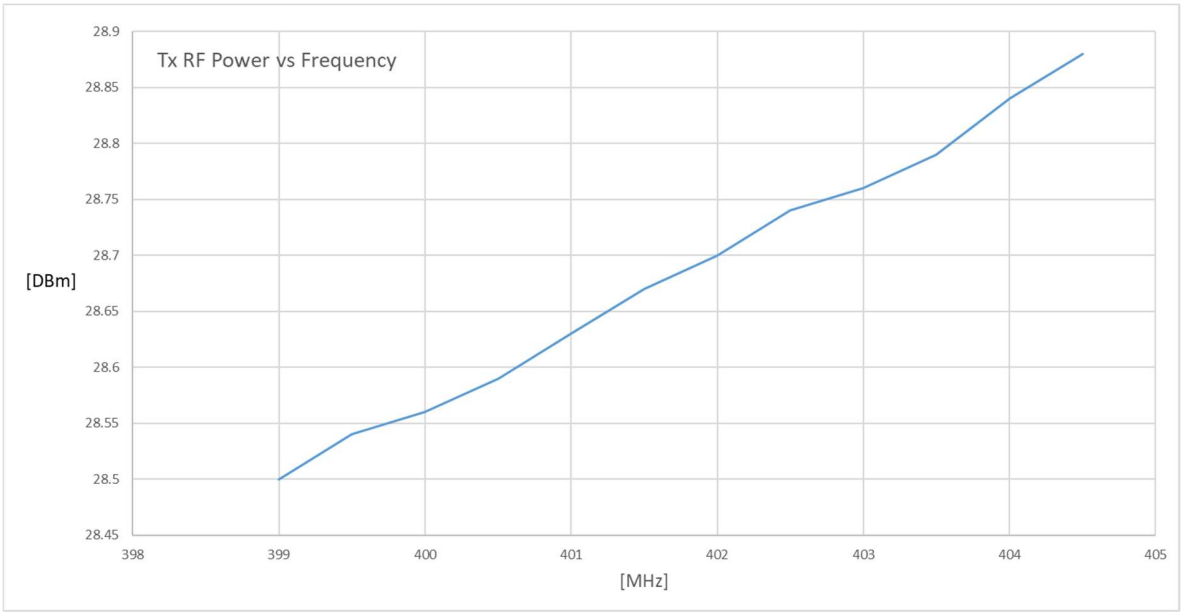


Figure 9: Tx RF Power vs Frequency [399 to 404 MHz] at 3.3Vdc, 24°C

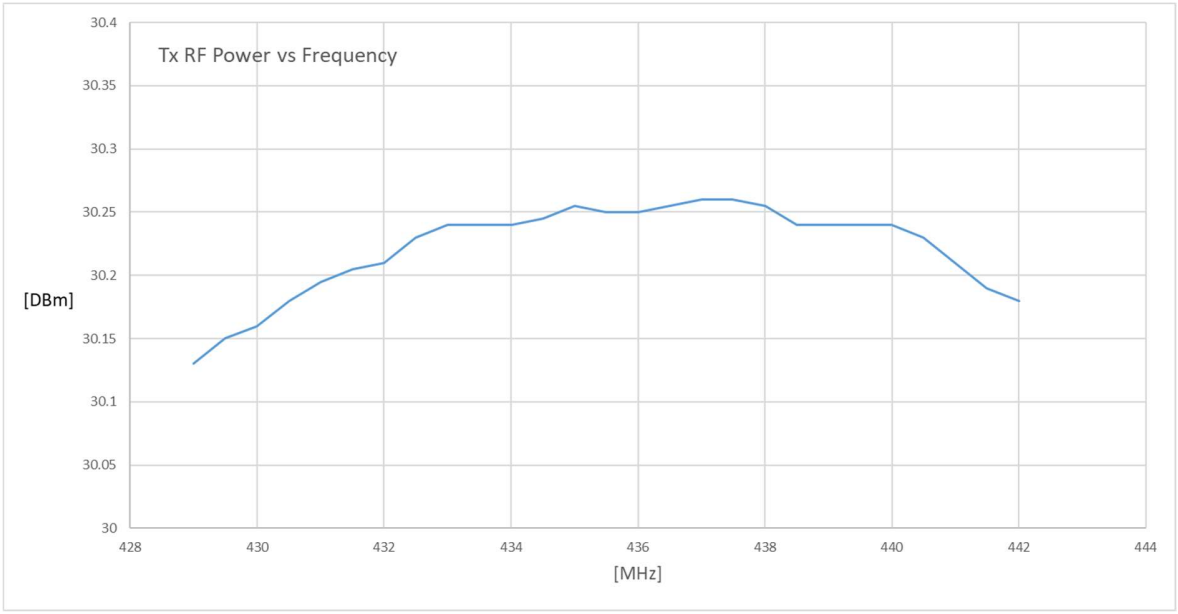


Figure 10: Tx RF Power vs Frequency [429÷442Mhz] at 3.3Vdc, 24°C

7 CONNECTOR PINOUT

7.1 Connector Location

Figure 11: Main Stack Connector Location

Figure 12: MMCX and Mini-USB Connector Location

Figure 13 – Antenna Release Connector and Jumper Location

7.2 H1 - Stack Connector

Pin	Mnemonic	Description
H1-1	CAN L	CAN communication Low (3.3V)
H1-3	CAN H	CAN communication High (3.3V)
H1-22	RS485A	RS-485 Driver output or receiver input (complementary to B)
H1-24	RS485B	RS-485 Driver output or receiver input (complementary to A)
H1-33	RxD	UART receive data
H1-35	TxD	UART transmit data
H1-41	I^2C SDA	I2C data
H1-43	I^2C SCL	I2C clock
H1-48	LUP 3V3	Latch-up protected 3.3V power bus (input)

7.3 H2 - Stack Connector

Pin	Mnemonic	Description
H2-5	En UHF Opt.	UHF power enable pin (optional)[1]
H2-7	En UHF	UHF power enable pin
H2-25	+5V	+5V BUS Power supply (optional)
H2-26	+5V	+5V BUS Power supply (optional)
H2-27	+3V3	+3.3V BUS Power supply
H2-28	+3V3	+3.3V BUS Power supply
H2-29	GND	Ground
H2-30	GND	Ground
H2-31	GND	Ground
H2-32	GND	Ground

[1] can be used to control a secondary UHF Module

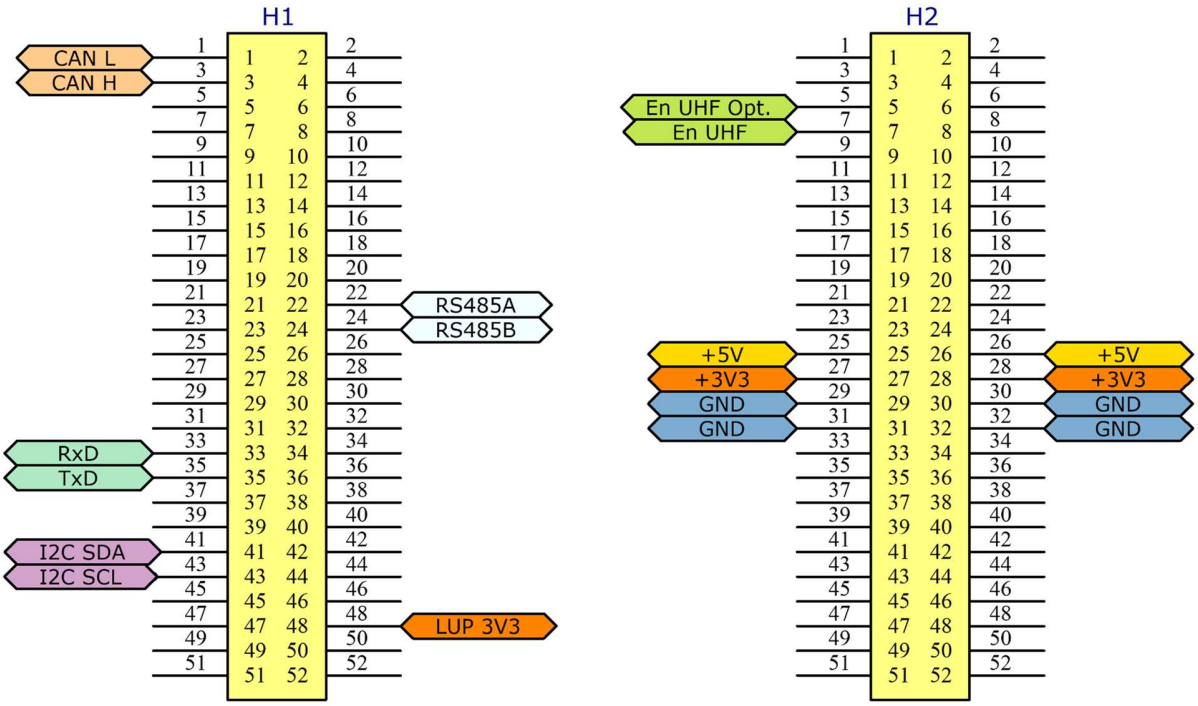


Figure 14: Headers Pinout

7.4 Antenna Release Connector

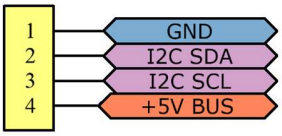


Figure 15: Antenna release connector pinout

Pin	Mnemonic	Description
1	Ground	Ground
2	I2C SDA	I²C data pin
3	I2C SCL	I²C clock pin
4	+5V	+5V BUS

All pins of the antenna release connector are directly connected to the H1&H2 stack connectors.

7.5 Jumper

As shown in figure 13, there is a 2 pin jumper on the side of the module. When the jumper is mounted, the UHF module starts immediately to transmit Morse code followed by the audio beacon.

7.6 Mini USB

The Mini-B USB shown in figure 12 enables the device to be monitored and configured by EnduroSat's software or third-party software. The module can be used as an AX.25 receiver.

8 ELECTRICAL CHARACTERISTICS

Parameter	Condition	Min	Typical value	Max
Supply Voltage [V]		3.2	3.3[1]	5V Opt.
Current Consumption [mA]	Receive mode (Idle mode)	20	25[2]	30
	Transmit mode		413[3]	
	Continuous wave mode	700	780[4]	800
Operating temperature [°C]		-35		80

[1] This voltage directly supplies the internal power amplifier. Changes in the supply voltage will reflect in the output transmit power.

[2] Typical current consumption at 3.3Vdc power supply using only the UART and I²C interfaces (CAN and RS485 are turned off).

[3] Typical current consumption depends on the ratio of transmit vs receive mode duration. For 50% Tx / 50%, then the consumption would be as follows: 0.5*800 mA (Tx CW) + 0.5*25 mA (Rx) = 413 mA @ 3.3 V.

[4] Typical current consumption at 3.3Vdc and 435MHz working frequency

9 LED INDICATORS

As shown in Figure 16, the system has LED indicators to give information about its status.

- Blinking of the blue LEDs (left side) – USB communication
- Blinking of the green LED (right side) – transmitting;
- Blinking of the orange LED (right side) – receiving.

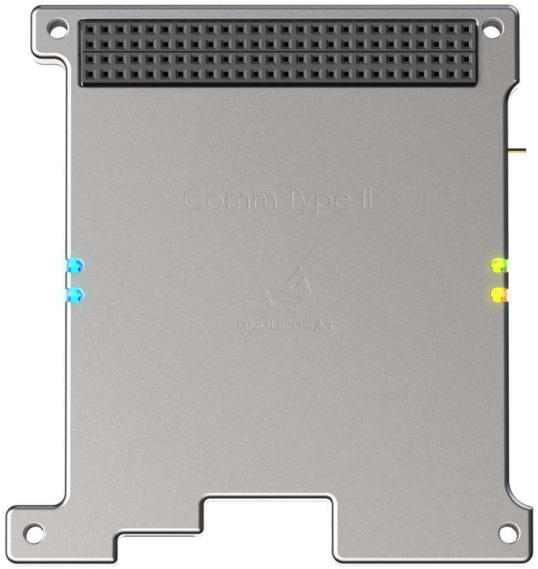


Figure 16: LED indicators

10 MECHANICAL DRAWING

The following pictures show the external dimensions of the UHF Transceiver Type II module.

STEP files can be provided upon request. All dimensions are in mm.

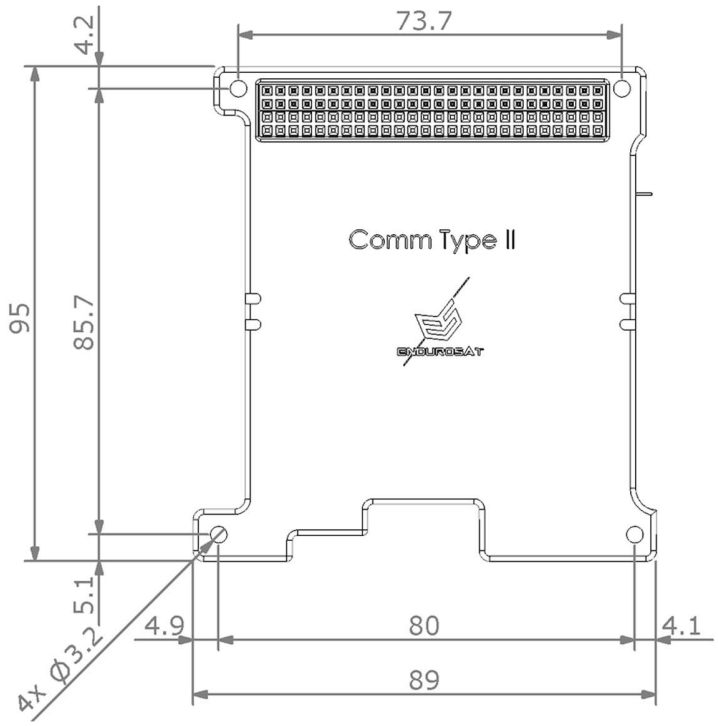


Figure 17: UHF transceiver Type II - Top View

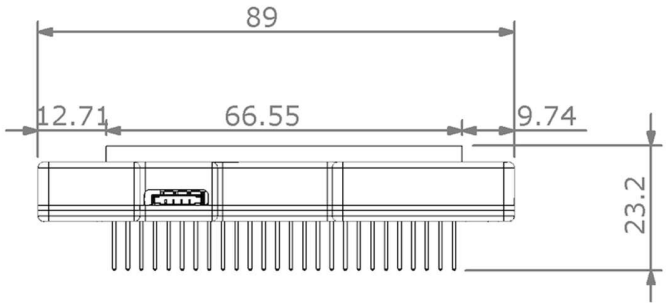


Figure 18: UHF Transceiver Type II - Side View

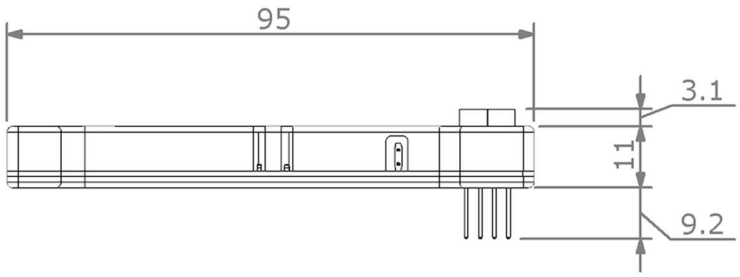


Figure 19: UHF Transceiver Type II - Side View

11 ENVIRONMENTAL AND MECHANICAL TESTING

A full campaign of tests at qualification level was performed on the qualification engineering model. Qualification tests level and duration follow the GEVS standard: GSFC-STD-7000A. Test performed:

- Random Vibration
- Sinusoidal Vibration
- Pyroshock Test
- Thermal Cycling
- Thermal Vacuum
- Total Ionizing Dose

12 MATERIALS AND PROCESSES

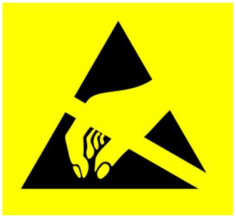
- Surface mount technology component placement
- Standard: IPC-A-610E Class 3
- Aluminum 6061 T651 box
- Visually inspected
- X-ray checked
- Functionally verified

13 HANDLING AND STORAGE

Particular attention shall be paid to the avoidance of damage of the communication module during handling, storage and preservation. The handling of the communication module should be performed in compliance with the following instructions:

- Handle using PVC, latex, cotton (lint free) or nylon gloves.
- The environment where the device will be handled shall meet the requirements for a class environment 100,000, free of contaminants such dust, oil, grease, fumes and smoke from any source.
- Store in such a manner as to preclude stress and prevent damage.
- To prevent the deterioration of the module, then the module shall be stored in a controlled environment (i.e. the temperature and humidity levels shall be maintained within the proper ranges):
    - Ideal storage temperature range: 15ºC to 27ºC
    - Ideal storage humidity range: 30% to 60% relative humidity (RH)

14 WARNINGS



This product uses semiconductors that can be damaged by electrostatic discharge (ESD). Observe precautions for handling.

Sensitive Electronic device. Do not ship or store near strong electrostatic, electromagnetic, magnetic or radioactive fields.

Communication module. Do not transmit without antenna or attenuator. Be mindful of RF interference issues.