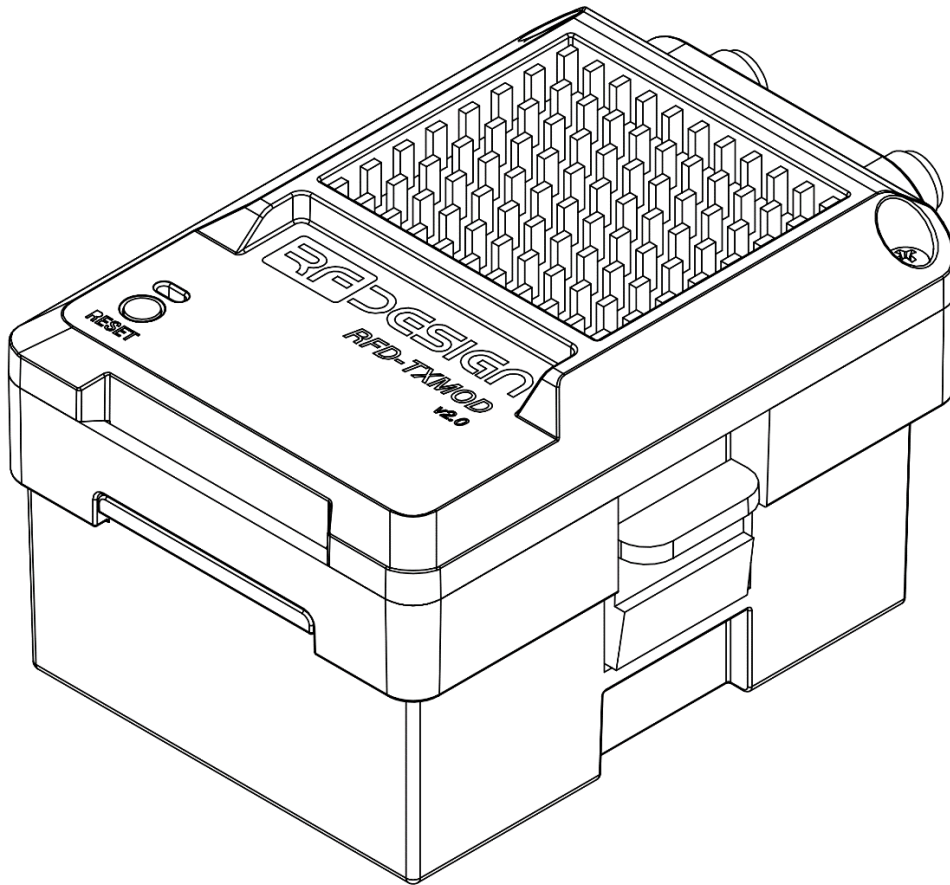




RFD TXMOD

Technical Datasheet



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1 Key Features

Key features for the TXMOD Radio Module include:

- Compatible with most JR-style expansion bay.
- Extended radio control transmission range using RFD modems.
- MAVLink data packet support.
- Wi-Fi telemetry and configuration.
- S.PORT telemetry on supported radio controllers using Yaapu's LUA script.
- Easy configuration with First run wizard.
- Hardware accelerated AES encryption with up to 256-bit key.
- Two antenna ports with automatic diversity by default.
- Operating temperature range of -20 to +80 deg. C.
- Automatic thermal throttling.
- Dimensions approximately 72x48.5x38.5mm
- Weight approximately 65g

2 Overview

The RFD TXMOD is an ABS plastic housing and electronics assembly designed to fit the long-range telemetry module expansion of some models of remote-control units. The module is designed to greatly improve the range of control for remotely operated vehicles and additionally provide telemetry data link for ground control station monitoring.

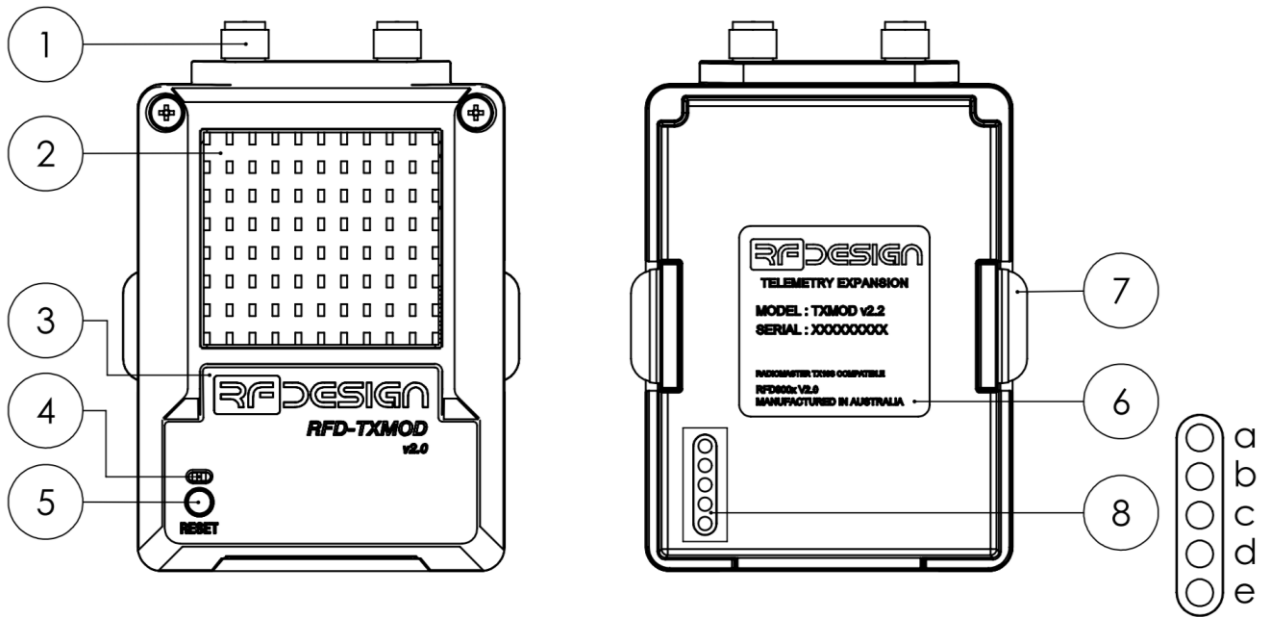


Figure 1: TXMOD feature diagram

Diagram Feature	Part
1	RF connectors 50ohm female RP-SMA
2	Heatsink
3	Top label
4	Indicator LEDs
5	Button
6	Bottom label
7	Locking tabs
8	Electrical interface (6-pin connector socket 0.1-inch/2.54mm pitch)

2.1 RF Connectors

The RFD TXMOD uses an internal x series modem fitted with two 50 Ohm reverse polarity sub-miniature A (RP-SMA) connectors. These are designed to provide robust and repeatable connection to compatible antennas or RF coaxial extension leads.

NOTE: The mechanical strength of these ports is limited and that hanging excessively large antennas from these ports or subjecting them to repeated mechanical/vibrational stresses can damage the ports, solder joints and PCB of the modem in the TXMOD.

2.2 Heatsink

This provides cooling to keep the modem within its operating temperatures. The cooling requirement will vary depending on the RF output power settings and the firmware that is loaded. It is possible for this to become hot during extended operation especially when used in limited airflow conditions.

2.3 Indicator LEDs

A green and red LED. They provide information on behaviour of the TXMOD. The exact functions are dependent on the firmware version that is loaded and is covered in the user manual.

2.4 Top Label

Product label.

2.5 Button

Triggers certain functions of the TXMOD such as factory reset.

2.6 Bottom Label

Gives the product serial number, model and version of TXMOD telemetry expansion.

2.7 Locking Tabs

Designed to provide mechanical retention of the TXMOD when installed in compatible remote control expansion bays.

2.8 Electrical interface

This socket provides for connection to the data and power pins of the compatible expansion bay. The functions of the individual pin functions are expanded in a later section of this document.

3 RC Compatibility

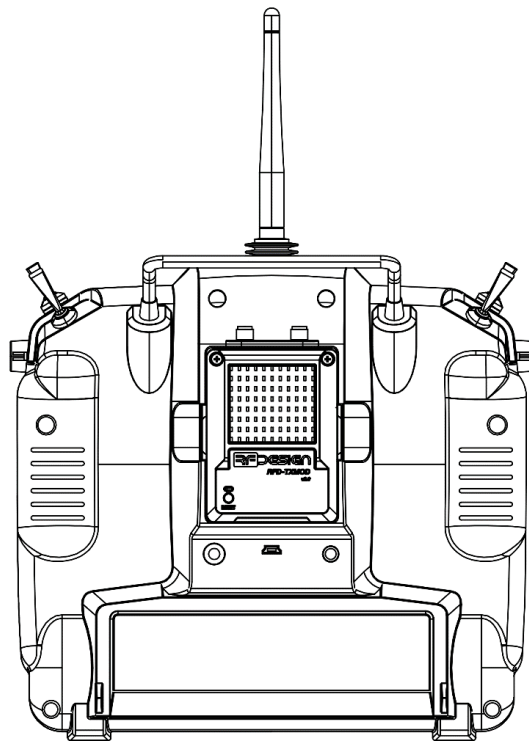
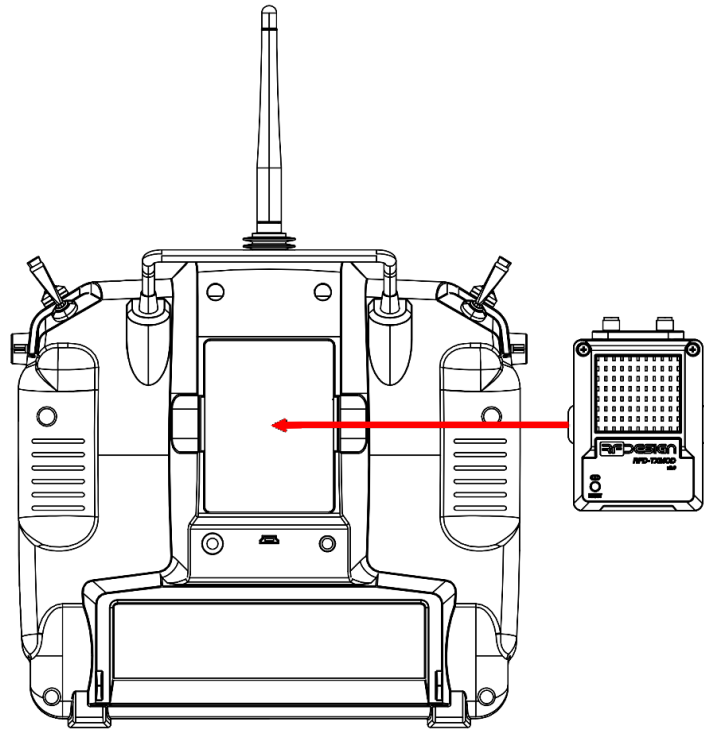


Figure 2: TXMOD mounted in compatible remote control external RF module slot

The TXMOD has been designed to fit into the rear expansion bay of an FrSky Taranis X9D Plus. And tested in the following models:

- FrSky Taranis X9D Plus
- Turnigy TR9X
- Radiomaster TX16s

It may also be compatible with other RC models that feature a JR-style bay and matching electrical and signalling connections.

NOTE: Ultimately it is up to the user to identify the compatibility of their RC with this external module slot and software, or scripts associated with the correct use of the TXMOD.

4 Hardware Versions

4.1 Hardware Versions

V1 TXMOD will not have any version number on the top label. V2 TXMOD will have v2.0 on the top label.

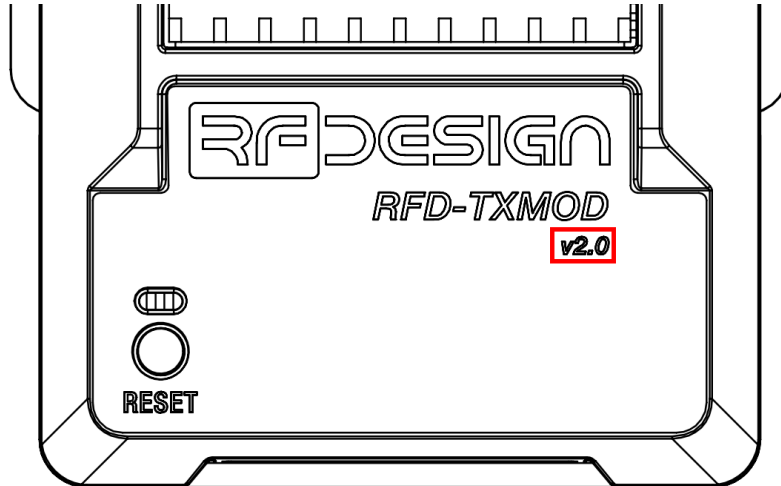


Figure 3: TXMOD v2.0 version on top label

The major and minor revision can be identified by the text on the bottom label which will have a v1.# or v2.# after the model indicating V1 or V2 hardware. The # is the minor revision. The firmware for V1 and V2 hardware is different.

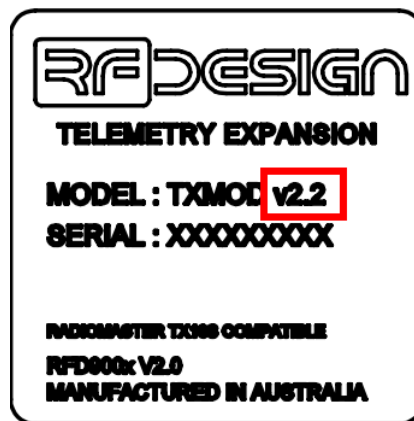


Figure 4: TXMOD bottom label version code

NOTE: Loading the incorrect firmware can irreparably corrupt the modem module.

NOTE: Early V1.0 hardware may lack the hardware connection for S.PORT functionality. Such units will require the user to make a modification that involves some soldering to provide support for this function. Later hardware does not require this modification. If in any doubt about the procedure or which model you have, please contact support@rfdesign.com.au before undertaking any modifications.

4.2 Regional Variants

It is possible to interface the TXMOD with a region locked receiver modem.

NOTE: Currently pairing with a region locked modem is incompatible with quick start wizard and will require manual configuration. For further information please see the TXMOD user manual.

Modems that feature a product code with a dash and letter code, e.g. RFD900x-AU, are region locked variants. The letters after the dash indicating the region to which that modem is locked.

NOTE: Locked modem variants may impose restrictions to the parameters/settings that can be modified or the values to which those parameters may be set.

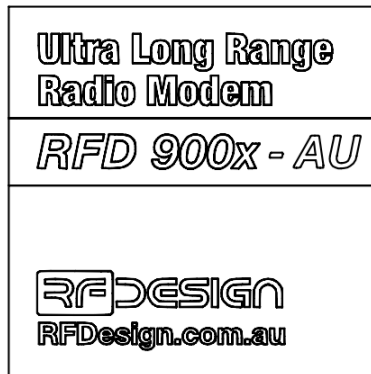


Figure 5: Example of Australia region locked modem label

These codes are:

- AU: Restricted settings and compliance for Australia
- EU: Restricted settings and compliance for European Union
- IND: Restricted settings and compliance for India
- NZ: Restricted settings and compliance for New Zealand
- US: Restricted settings and compliance for United States of America and Canada

NOTE: Not all country compliant variants are available for all modem models.

NOTE: Regional variants may satisfy regulations in other areas, for instance the US modem is also compliant with regulations in Canada.

NOTE: Ultimately it is up to the user to identify the radio frequency regulations applicable to their areas of operation and ensure their modems parameters are set correctly.

Modems without these country codes are fully user configurable and are often referred to as unlocked.

The RFD900 TXMOD is compatible with the following receiver modems:

RFD900x
RFD900x-AU
RFD900x-NZ
RFD900x-US
RFD900ux
RFD900ux-US

The RFD868 TXMOD is compatible with the following receiver modems:

RFD868x
RFD868x-EU
RFD868ux
RFD868ux-EU
RFD868ux-IND

4.3 Compliance and Acceptance

The RFD 900x modems and variants are designed for conformity to:

- AS4268:2012
- NZ GURL 2017
- FCC 15.247
- RSS-247 Issue2

The RFD 868x modems and variants are designed for conformity to:

- Directive 2014/53/EU on radio equipment
- EN300220
- EN301489
- IEC 62368-1:2014
- EN62311
- Equipment type approval of the 865-867MHz band in India

The Wi-Fi module is designed for conformity to:

- CISPR22-10
- FCC PART 15 SUBPART B:2018
- ICES-003 Issue 6 : 2017
- RSSGEN

NOTE: Only the region locked versions of the modems are represented to be compliant in their respective regions. The TXMOD is not available in a region locked variant but may be configured to interoperate with region locked receiver modems.

NOTE: Interoperable configuration to pair with a region locked modem does not convey a representation of regional compliance to the TXMOD itself.

4.4 Compatibility

The receiver modem does not need to be of the same hardware version as the modem installed in the TXMOD but must have the same firmware version.

NOTE: Compatibility is only guaranteed and tested between modems operating the same firmware version. Backward and forward compatibility of firmware is not assured.

5 Firmware Support

The TXMOD has a device firmware and a modem firmware. These are managed by the firmware and SPIFFS files respectively.

The currently installed version of both the device and modem firmware can be found on the TXMOD home webpage (192.168.4.1). These are the "Software Version" and "Internal Modem Version" respectively.

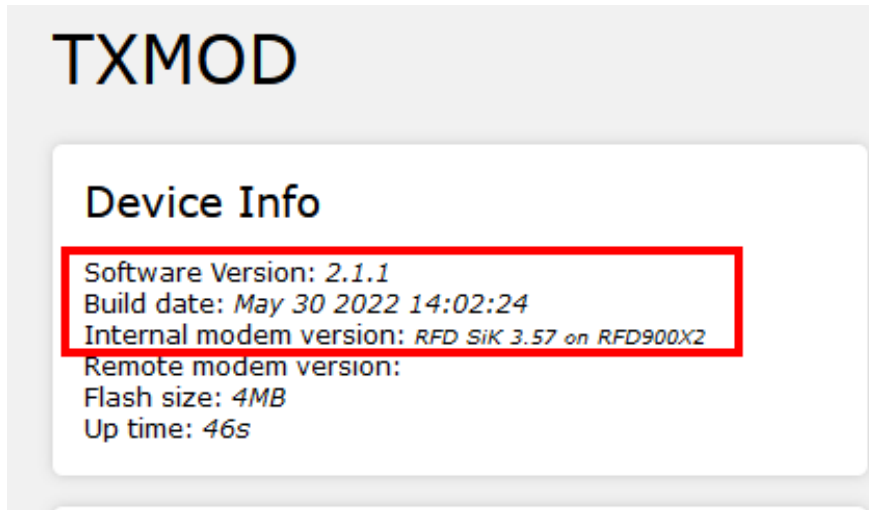


Figure 6: Software Version (device firmware) and Internal Modem Version (modem firmware and hardware version) on TXMOD home page.

NOTE: If your TXMOD has an "Internal Modem Version" that ends with X2, it is V2 modem hardware and requires the appropriate V2 firmware.



Figure 7: Internal modem hardware version identifier

5.1 Device Firmware

The device firmware controls the web interface, S.PORT and Wi-Fi functions of the TXMOD.

NOTE: Care must be taken to ensure that the firmware uploaded is correct for the hardware version.

NOTE: Factory defaulting the TXMOD will reset all Wi-Fi and other settings back to default values.

NOTE: Device firmware update may cause settings to be changed. The user must verify that Wi-Fi, S.PORT settings etc. are still correct after updating.

5.2 Modem Firmware

A copy of the appropriate modem firmware is contained in the SPIFFS file whose version matches the device firmware file. It is advisable to update both files to the latest versions at the same time as the device firmware may perform certain actions that are dependent on having the expected version of modem firmware installed.

If the firmware version of the modem differs from the one in the SPIFFS file, the TXMOD will update the modem.

Performing a factory default will cause the TXMOD to reinstall the firmware of the modem to the version in the SPIFFS file.

NOTE: Modem firmware update may cause settings to be changed. The user must verify that the receiver modem still pairs correctly with the TXMOD and all the required functions such as RC passthrough, fail safe streams etc. continue to function correctly.

NOTE: If the wrong hardware version of this file is loaded it may irreparably corrupt the modem by attempting to load an incompatible firmware into the modem.

NOTE: Separate programming of the modem to a different firmware version other than that supplied in the SPIFFS file is not supported.

NOTE: The Multipoint (MP) and Asynchronous modem firmware do not support RC signal passthrough and are not ultimately compatible with the TXMOD.

5.2.1 SiK (Point-to-point) Modem Firmware

- Factory default firmware.
- MAV telemetry data support.
- PPM or SBUS signals remote control pass through.
- Hardware accelerated AES encryption.

This firmware is the standard for RFD modems. It is installed on all new modems and configured for ready use as a MAV telemetry link out of the box. The [SiK firmware user manual](#) covers the various settings and uses of this firmware.

6 Loading firmware

6.1 TXMOD Device Firmware

The TXMOD has two firmware components; one to manage the device firmware and one for the managing the RFD modem that provides the long-range telemetry and RC link. Both files are supplied as binary (.bin) files. It is important that the correct version of both files be used. It must match the version of the modem hardware used in the device. Loading the wrong files can corrupt the modem irreparably.

The "Update firmware button under "Advanced Options" on the home page will load the firmware management page.

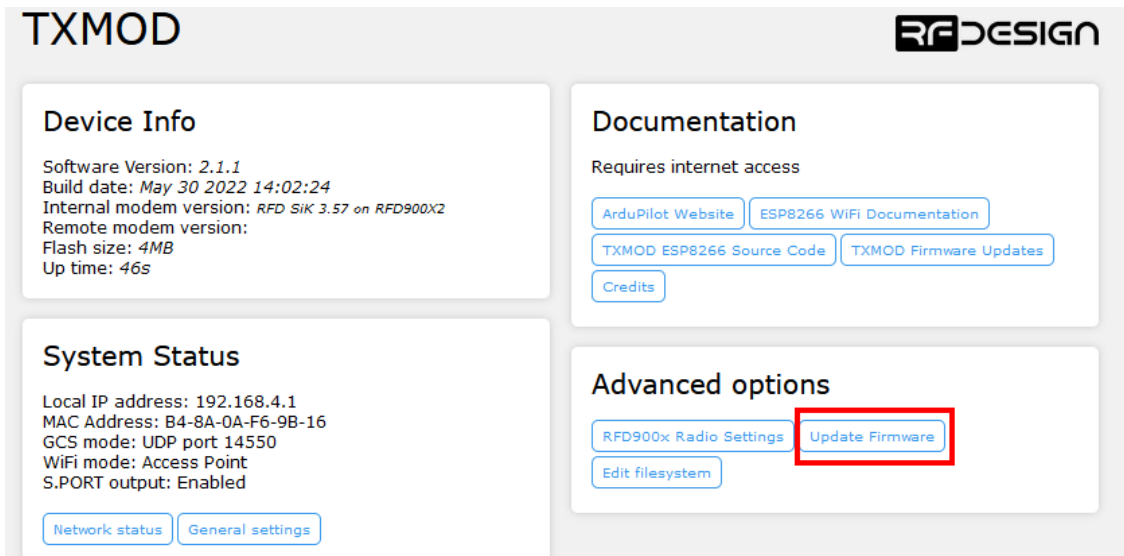


Figure 8: Update firmware location on the home page

The device firmware also called the "Main Controller" needs to be loaded first. The "Choose firmware.bin" button will open a dialog box to allow the user to choose the firmware file to upload.

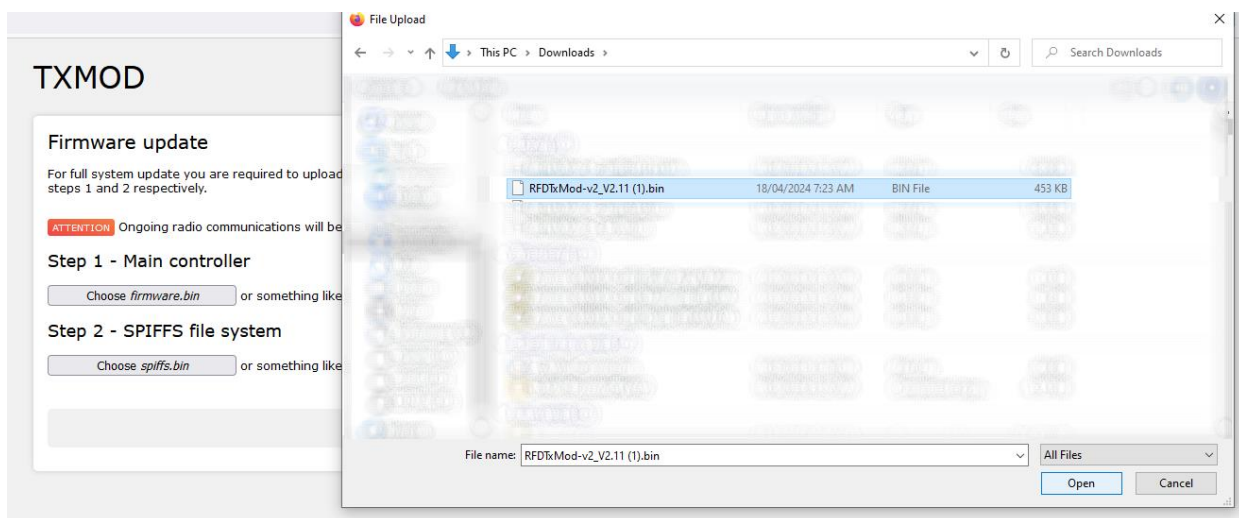


Figure 9: File upload dialog box

NOTE: Device firmware update may cause settings to be changed. The user must verify that Wi-Fi, SPORT settings etc. are still correct after updating.

6.2 TXMOD SPIFFS File

The second firmware file called the "SPIFFS" file is a .bin file that contains the firmware of the RFD modem.

This file can be uploaded on the same firmware update page as the device firmware.

It should be uploaded after the device firmware.

Once the SPIFFS file has been uploaded the device will automatically go to a reboot page. The device needs to reboot to finish the firmware update process of the modem.

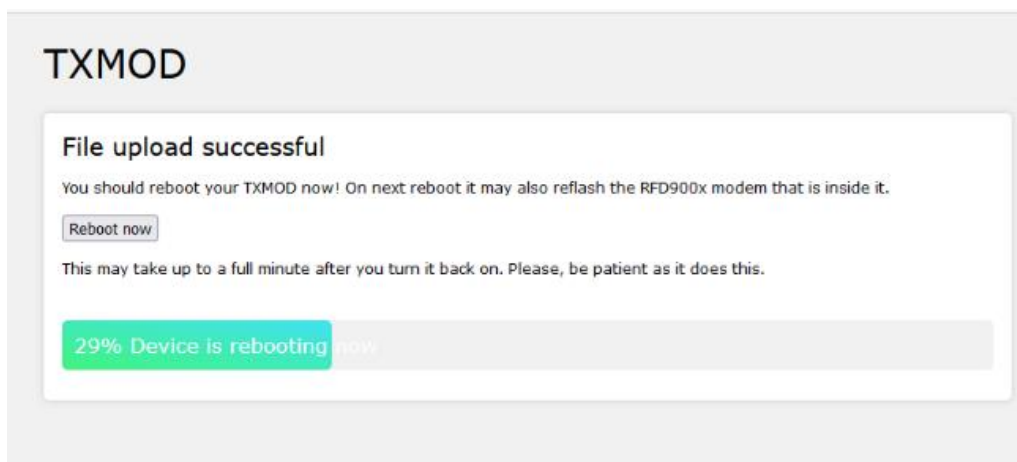


Figure 10: Successful firmware upload and reboot page

Once the device has rebooted the user may need to reconnect to the device wireless network.

NOTE: Modem firmware update may cause settings to be changed. The user must verify that the receiver modem still pairs correctly with the TXMOD and all the required functions such as RC passthrough, fail safe streams etc. continue to function correctly.

6.3 Receiver Modem Firmware

Compatible firmware can be loaded on to the receiver modem by means of:

- The RFD modem tools software.
- MissionPlanner software.

6.3.1 Programming with RFD modem tools

Requires the user to connect the modem to the PC by means of an FTDI cable. Then you can open the tools programme configure the serial port settings and connect to your modem.



Figure 11: RFD Tools COM port connection

Once connected to the tools select the upload firmware button. This will open a dialogue asking you to select the desired firmware. If you cannot select or upload a file to your modem check that you have selected the correct version for your hardware.

NOTE: The V1 and V2 modems use different firmware packages, the RFD tools will block you from loading the incorrect version.

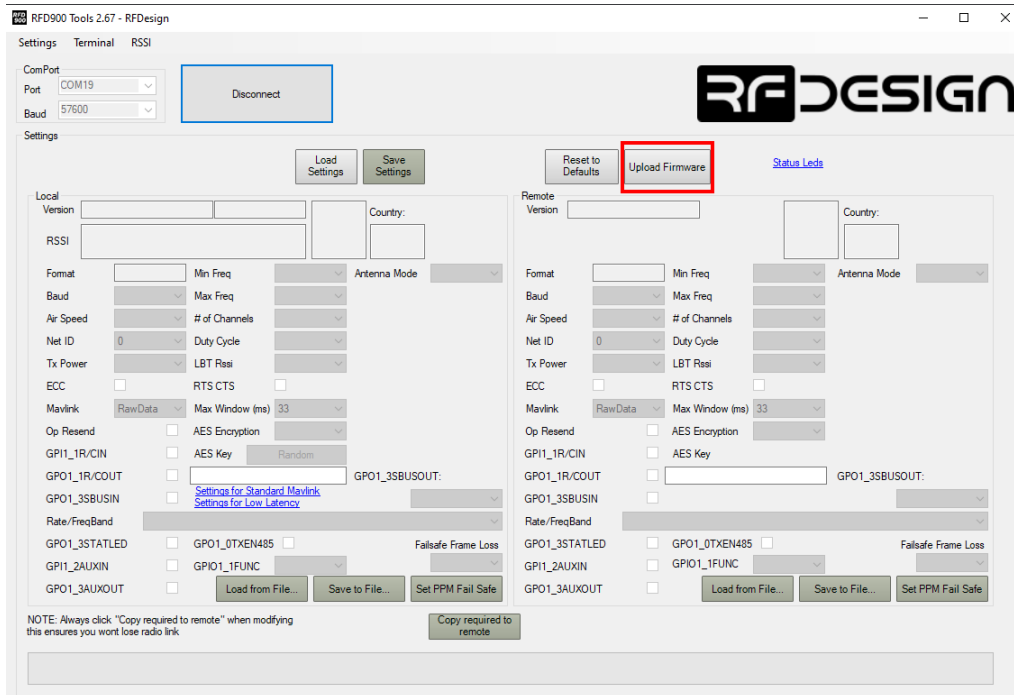


Figure 12: RFD Tools Upload Firmware button.

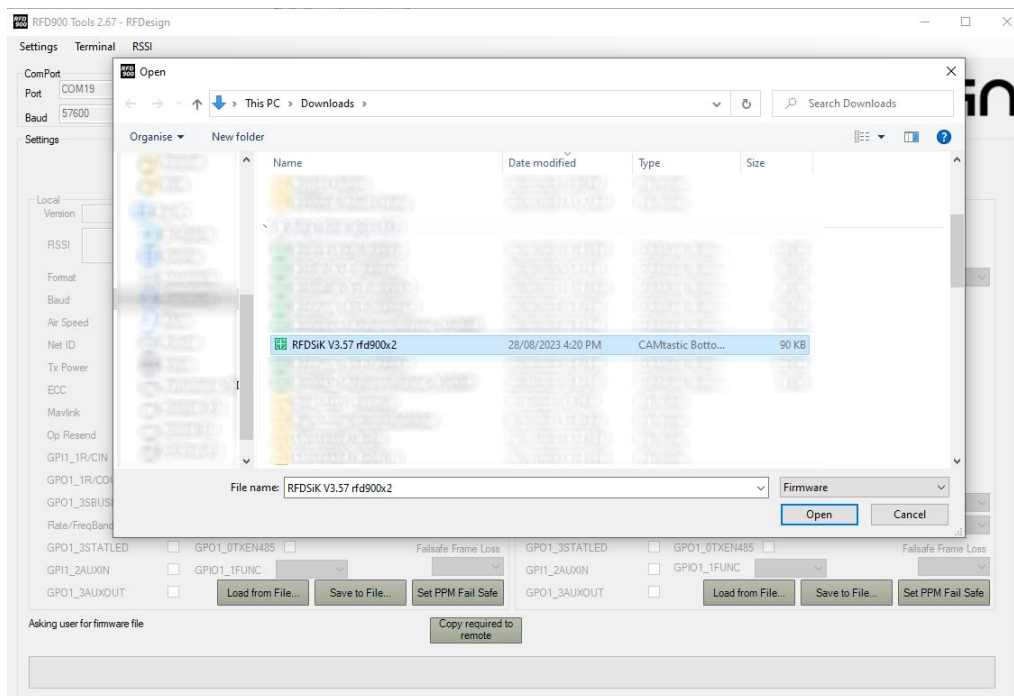


Figure 13: Firmware file selection dialogue box.

Once a file has been selected press open and the tools will begin to programme the modem with the firmware. Progress is indicated by the filling green progress bar at the bottom of the screen.

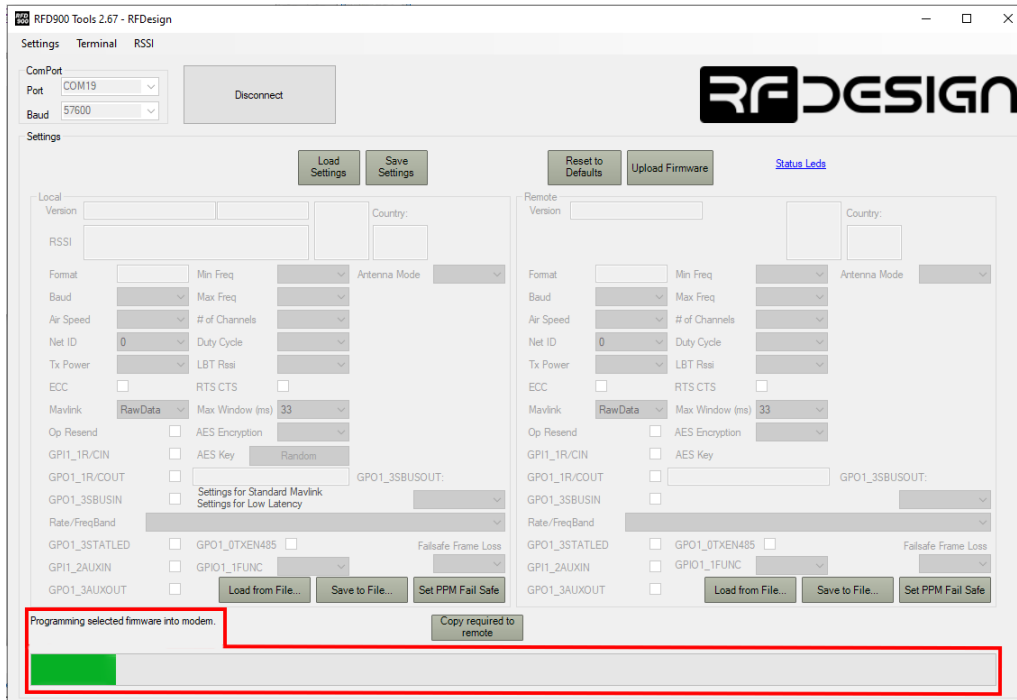


Figure 14: Programming progress bar of the RFD Tools

7 Pinout

The TXMOD electrical connections are outlined in the following section.

7.1 Pin Header

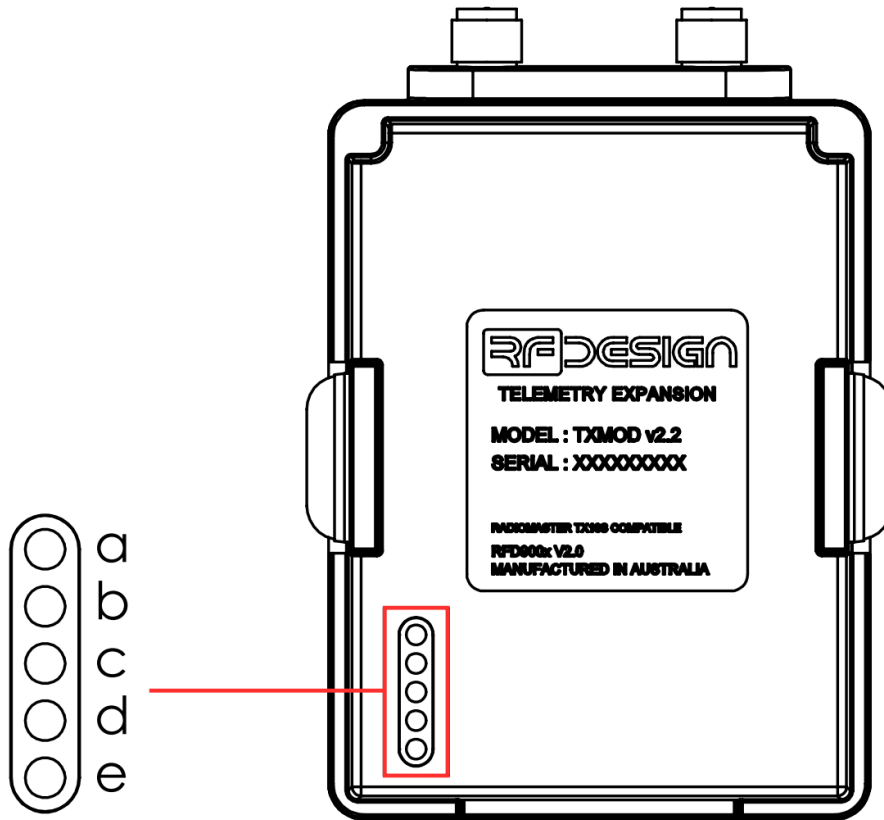


Figure 15: Modem 0.1" header pinout

Pin #	Name	Type	Description	Max. Voltage
a	RC	Input	PPM or SBUS format RC signal	3.6V
b	+6V	Power	Regulated 6V supply from the RC. (No internal connection, not used by the TXMOD)	N/A
c	+V _{BAT}	Input	Positive supply voltage from the RC battery	18V
d	GND	Ground	Ground	0V
e	S.PORT	Output	Sends reduced telemetry data to the RC for the Yaapu script functions	3.6V

7.2 Remote control signal

The TXMOD receives the external RC signals on from pin "a" of the electrical interface connector. This signal pin has Zener diode protection to limit signal voltages to safe levels. Both PPM and SBUS1 or 2 signals are supported as inputs to the TXMOD.

7.3 +6V Supply

A regulated 6-volt supply from the host RC. Unused by the TXMOD this pin has no connection internally.

7.4 +V_{BAT} Supply

The positive of the unregulated battery supply. This is internally regulated to the required voltages for the various components of the TXMOD.

7.5 GND

Supply ground, the reference for all other voltages.

7.6 S.PORT

A single wire half-duplex serial data port. The TXMOD supplies a limited data set containing navigation metrics from the received MAVLink telemetry stream over this serial link to support the functions of software scripts such as Yaapu's LUA script running on the host remote control.

NOTE: This functionality was not built into the earliest V1.0 TXMOD hardware and will require the user to make a modification that involves some soldering to provide support for this function. Later hardware does not require this modification. If in any doubt about the procedure or which model you have, please contact support@rfdesign.com.au before undertaking any modifications.

8 Accessories

8.1 Antennas

- The RFD x series modems which are integrated in the TXMOD are designed for 50 Ohm impedance RF connections.
- The modems are fitted with reverse pole sub-miniature A (RP-SMA) connectors on both antenna ports.
- Operating without any antennas fitted will not damage the x series modem RF systems.
- Only a single antenna is required for long range operation.
- Different antenna modes available including:
 - Automatic diversity. (Default for SiK firmware.)
 - Single port. (Antenna port 1 or 2 depending on parameter setting)
 - Dedicated TX and RX ports.
- Settings will vary depending on the firmware installed.
- The Wi-Fi module in the TXMOD has an integrated PCB trace antenna. There is no port for external user antennas.

NOTE: The modem antenna ports should not be terminated with short circuits or RF loads, other than appropriate antennas, as this can cause RF signal problems and incorrect operation of the diversity feature.

Some important performance considerations regarding antennas and RFD modem integrated in the TXMOD:

- **Line of Sight (LOS):** The RFD modems are LOS devices with limited ability to get around obstacles. To this end operating with minimal obstructions, such as buildings, terrain, trees, etc. obscuring the LOS will improve the range achievable of the link.
- **Antenna polarity:** The polarity of the antennas can have a large impact on performance. To minimise losses the same type and direction of polarisation should be the same at both ends of the link. Most antennas are linearly polarised. Generally, the performance of the vertical orientation is best for the range of such antennas in the normal use cases of the x series modems.
- **The diversity setting** of the modem firmware can significantly improve performance when orientation of the antennas is variable, e.g. on manoeuvring aircraft. Provided that the two antennas in use are mounted at 90 degrees to each other in order to provide polarisation separation. The modem can automatically select the antenna which has the best signal strength for communication.
- **Elevation:** The modems are LOS devices and the elevation of the antennas at both ends affects the radio horizon distance and therefore the operational range that can be achieved. It can also help mitigate the problems caused by obstructions and reduce the effects of multipathing.
- **Antenna placement:** The placement of the antennas can have a large impact on performance. Antennas placed near to or against metal or carbon fibre can experience distortions to resonant frequency, gain, radiation pattern etc. which can impact performance or partially block signal.
- **Antenna separation** from other transmitters is required to minimise interference and/or receiver RF saturation. The required separation will depend on the RF power level as well as the antenna gains. As an example, using 3dBi dipole antennas and a 30dBm power level, a separation of at least 3m for like polarised antennas is recommended. Spatial separation can be reduced with polarity separation. The cross-polarisation isolation, between for example a horizontally and vertically polarised

antenna, is usually sufficient to protect against receiver saturation problems with a significantly smaller separation of antennas.

8.2 Recommended antennas from the RFD store

NOTE: All 900MHz band antennas supplied by RF Design for use with the x series modems are suitable for both the 900 and 868 MHz bands.

NOTE: The mechanical strength of the RPSMA connectors is limited and that hanging excessively large antennas from these ports or subjecting them to repeated mechanical/vibrational stresses can damage the ports, solder joints and PCB of the modem.

3dBi Dipole A half wave dipole antenna with a male RP-SMA connector. It has a flexible joint at the base that allows for right angle mounting if required. This is the recommended antenna for most applications of the TXMOD.



Figure 16: 3dBi dipole Antenna.

It can be easier to fit the antenna after the module has been mounted into the remote. This can prevent damage to the RF ports from bending or other impacts on antenna.

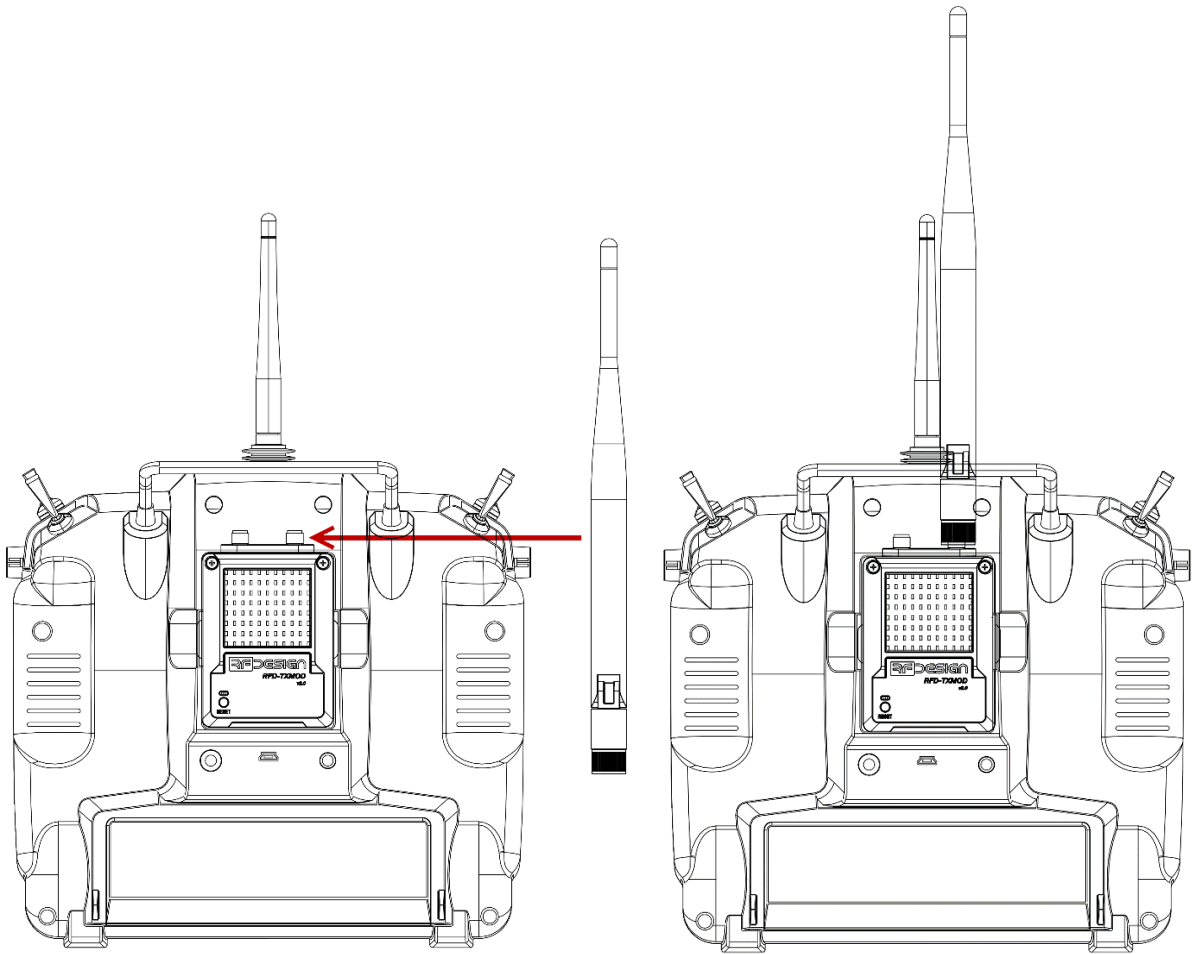


Figure 17: Fitting of 3dBi dipole antenna to TXMOD

9 Electrical Characteristics

Parameter	Minimum	Typical	Maximum
Operating temperature	-20°C	—	+65°C
Supply Voltage	+6V	—	+18V
Peak Supply Current @ 6V (30dBm transmit)	—	—	1.2A
Voltage on I/O pin (Ref. to GND)	-0.3	—	+3.6V
Input Voltage Low	-0.3V	—	+0.825V
Input Voltage High	+2.5V	—	+3.6V
Output Voltage Low (sink 5mA)	—	—	+0.33V
Output Voltage High (source 5mA)	+2.65V	—	3.6V
DC current on I/O pin	—	—	12mA
I/O pull up/down resistance	40 kOhm	—	65 kOhm
SBUS/SBUS2 channels	—	—	18Ch
PPM channels	2Ch	—	16Ch
PPM Frame Length	—	—	36ms
PPM/SBUS control signal latency (default link settings)	—	45ms	80ms
Channel levels	1000 counts (1ms)	—	2000 counts (2ms)
RFD modem RF output power	+0 dBm	—	+30 dBm
RFD modem RF input power	—	—	+20 dBm
RFD modem RF port impedance (RP-SMA)	—	50 Ohm	—
RFD modem RF connector torque (RP-SMA)	0.3 Nm	0.5 Nm	0.5 Nm
RFD modem RF connector rated number of connections (RP-SMA)	—	—	500
Wi-Fi RF output power 72.2Mbps	+15.5 dBm	+16.5 dBm	+17.5 dBm
Wi-Fi RF output power 11b mode	+19.5 dBm	+20.5 dBm	+21.5 dBm

10 Performance Characteristics

10.1 Internal RFD x Series Modem

Feature	Implementation or Performance		
RF Data Rates	12, 56, 64, 100, 125, 188, 200, 224, 430 kbits/sec ¹		
Obstructed Line of Sight Range	0.5 – 1 km ²		
Line of Sight Range	40+km ³		
Serial Interface Data Rate	2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400, 460800 and 1200000 baud ⁴		
Modulation	2GFSK, 4GFSK ⁵		
Interference Mitigation	Frequency Hopping Spread Spectrum, FHSS		
	Modem Variant	Frequency Bands	Number of Channels
	RFD900x Unlocked	902 – 928 MHz	User settable (51 Max)
	RFD868x Unlocked	865 – 868 MHz	User settable (7 Max)
Receiver sensitivity	Air data rate		Sensitivity @ 10-5 BER
	12 kbits/s		-102 dBm
	56 kbits/s		-102 dBm
	64 kbits/s		-101 dBm
	100 kbits/s		-89 dBm
	125 kbits/s		-101 dBm
	188 kbits/s		-97 dBm
	200 kbits/s		-96 dBm
224 kbits/s		-93 dBm	
Encryption	Hardware accelerated advanced encryption standard, AES, up to 256-bit user-settable key		
Error detection	Cyclic redundancy check, CRC		

¹ Available air rates depend on modem variant and firmware

² Depending on antenna and radio configuration

³ Depending on antenna and radio configuration

⁴ Available baud rates depend on modem variant and firmware

⁵ Dependent on selected air rate

10.2 Wi-Fi

Feature	Implementation or Performance	
Certificates	FCC/CE/ROSH	
Wireless Protocols	802.11 b/g/n	
Wi-Fi Modes	Station, Soft AP and Soft AP + Station	
Network Protocols	TCP and UDP via IPv4	
Line of Sight Range	25 meters ⁶	
Frequency Range	2412 – 2483.5MHz	
Modulation	DSSS, CCK, BPSK, QAM, H20, OFDM MCS0 and MCS7	
Receiver sensitivity	Encoding and data rate	Sensitivity @ 10 ⁻⁵ BER
	DSSS (1 Mbps)	-98 dBm
	CCK (11 Mbps)	-91 dBm
	1/2 BPSK (6Mbps)	-93 dBm
	3/4 64-QAM (54Mbps)	-75 dBm
	H20/MCS7 (65/72.2 Mbps)	-72 dBm
Adjacent Channel Rejection	Encoding and data rate	Rejection
	OFDM (6 Mbps)	37 dBm
	OFDM (54 Mbps)	21 dBm
	HT20/MCS0	37 dBm
	H20/MCS7	20 dBm
Encryption	WEP/TKIP/AES	

10.3 Power Supply

Figure 18 outlines the peak and average current draw of the TXMOD vs the supply voltage.

The voltage range of some common battery chemistries are represented by the shaded areas:

- Blue, approximately 6-8.4V, for six cells in series nickel metal hydride (NiMH).
- Yellow, approximately 7.5-10.8V, for three cells in series lithium iron phosphate (LiFePO4)
- Red, approximately 9.6-12.6V, for three cells in series lithium polymer (LiPo)

NOTE: The user should ensure that the battery used can supply sufficient current for both the remote control and the TXMOD telemetry module.

⁶ Line of Sight indicative range. Obstructions may greatly impact Wi-Fi range

NOTE: The user should be aware that the extra current requirements of powering the TXMOD can significantly reduce the battery life of the RC and this should be factored into planning to ensure safe flight operations.

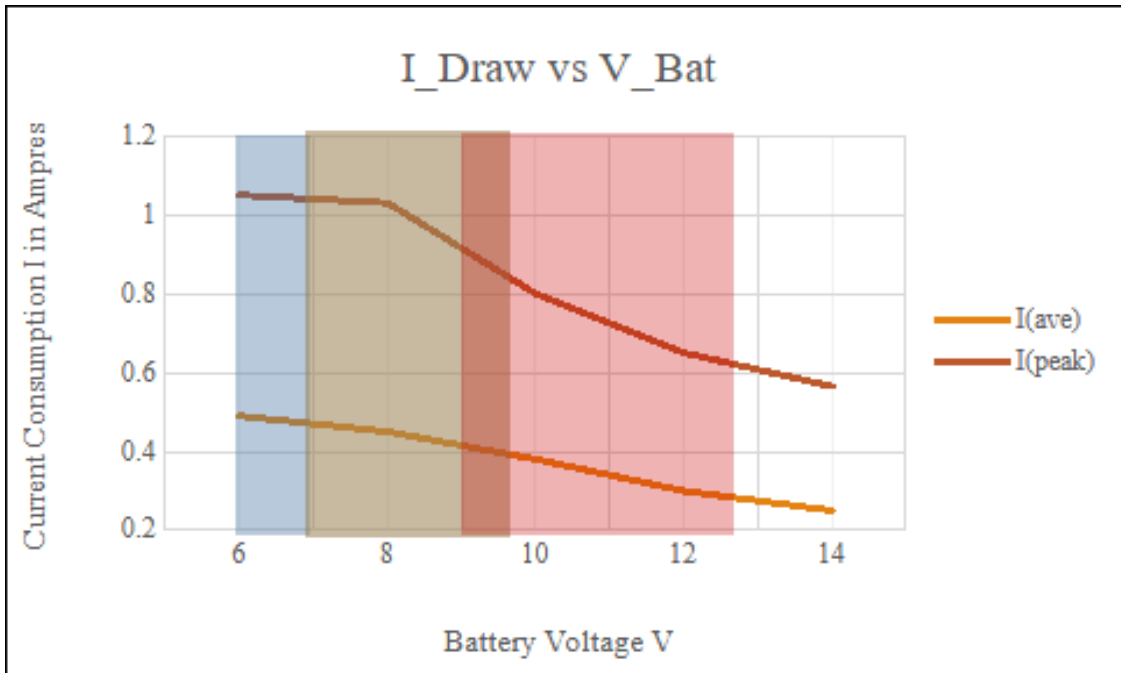


Figure 18: TXMOD supply current vs supply voltage

10.4 Thermal Management

RFD x series modem installed in the TXMOD is supplied with a heatsink to improve the cooling of the module. The modems may generate substantial heat whilst operating at full transmitter power. It is not advisable to block or limit airflow so that the device is able to dissipate this heat effectively.

NOTE: Unless transmissions are infrequent, or transmission power levels are low, it is not recommended to operate the x series modems without a heatsink. Likewise, it is not advisable put the modems in environments where the heat from other components may unduly affect the modems.

The modems have an internal silicon temperature sensor. This sensor is not fully calibrated and therefore could vary by a few degrees from the actual temperature. The temperature reading can be found in the ATI7 RSSI report. If this exceeds a safe operating temperature the modem will reduce the operating duty cycle in order to reduce the heat produced by the system and thus help to protect the components against suffering a thermal failure. Once below a normal operating temperature the system will return to normal function.

NOTE: The reduction in duty cycle associated with the thermal protection will cause a decrease in transmission throughput of the affected modem.

NOTE: It is not advised to rapidly cool a hot component with water, alcohol, electronics freeze spray etc. as this could cause damage to solder joints and other components due to thermal shock.

11 Physical dimensions

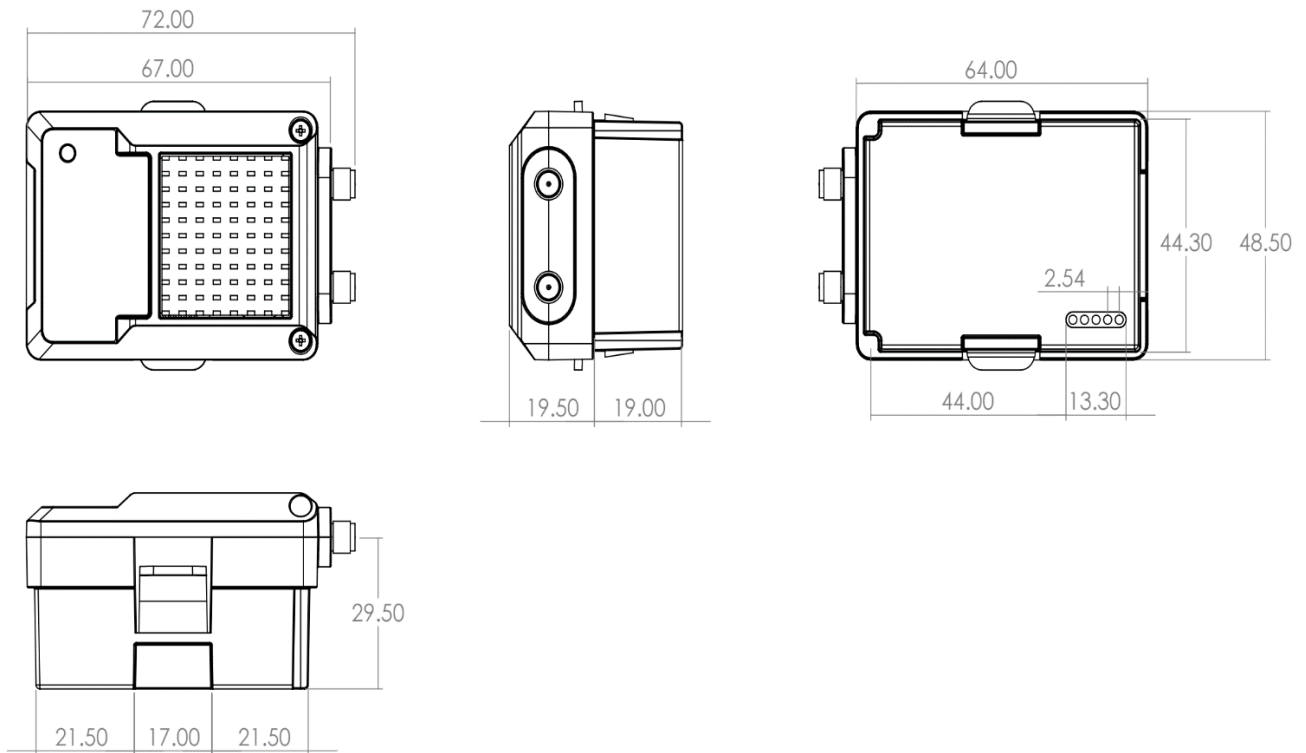


Figure 19: TXMOD dimensions

NOTE: All dimensions have a +/- 0.1mm tolerance.

The TXMOD has a weight of approximately 65g +/- 3g

12 Useful Links

FTDI

<https://ftdichip.com/drivers/>

RFD Modem Firmware

<https://files.rfdesign.com.au/firmware>

RFD Tools

<https://get.support.rfdesign.com.au/servicedesk/customer/portal/1/article/242712577>

RFD Store

<https://store.rfdesign.com.au>

RFD Documentation

<https://files.rfdesign.com.au/docs>

13 Glossary

Acronym	Definition
RC	Radio Control. A device, usually having two analogue sticks and several buttons and sliders for user input, that generates control signals used to direct the movements/behavior of a vehicle.
RF	Radio Frequency. A term used to describe a portion of the electromagnetic spectrum, commonly encompassing frequencies between a few tens of kilohertz and a couple of hundred gigahertz.
LOS	Line of Sight. Refers to the distance that a radio signal can reach uninterrupted by obstructions or the radio horizon.
PPM	Pulse Position Modulation. An encoding standard used by radio controllers to send data about the position of multiple servo motors.
SBUS	Serial Bus protocol created by Futaba. An encoding standard used by radio controllers to send data about the position of multiple servo motors.
S.PORT	A one-wire half-duplex serial signal for data exchange. As implemented on the TXMOD, this is an output only.
AES	Advanced Encryption Standard. A data encryption protocol meeting the specifications established in the ISO/IEC 18033-3 standard.
RP-SMA	Reverse Pole Subminiature type A. A common form of RF connector on consumer electronics, offering a reasonable compromise between overall size and rated connection cycles.
MAVLink	Micro Air Vehicle Link. A protocol for telemetry data exchange between compatible ground control software and autonomous vehicle controllers.
LED	Light Emitting Diode. A semiconductor device that converts electrical power to light.
Baud	Unit of measurement of symbol rate, indicating the data transfer speed of serial/UART connections.
Serial	A synonym of UART, a protocol for sending and receiving data in a sequential manner.
TX	Transmit.
RX	Receive.
GPIO	General Purpose Input Output. A microcontroller pin that can be configured for various input and output functions.
FTDI	Future Technology Devices International, a supplier of electronic components known for their UART to USB converter chips and the cables which use such components.
USB	Universal Serial Bus. An industry standard for data communication and power delivery between devices, most commonly found in type A and C connectors.
FHSS	Frequency Hopping Spread Spectrum. A radio technique used to minimize interference by dividing the RF spectrum into narrow RF channels and hopping through those channels.

Acronym	Definition
GFSK	Gaussian Frequency Shift Keying. A form of modulating data onto a carrier frequency by controlling frequency shifts.
CRC	Cyclic Redundancy Check. An error-detecting code that uses a small piece of extra data to mathematically determine the correctness of a decoded signal.
RFD	RFDdesign. The Australian company that designed, built, and supports the x series modems among other products.

14 Revision History

Version	Date	Changes
1.0	22/09/17	Release document
1.1	22/05/18	Updated to correct typos, mistakes and changes in new versions
1.2	17/12/20	Updated to reflect changes in compliance and firmware
2.0	24/05/24	Major revision and update to reflect changes in hardware and software behaviours and provide more technical details.