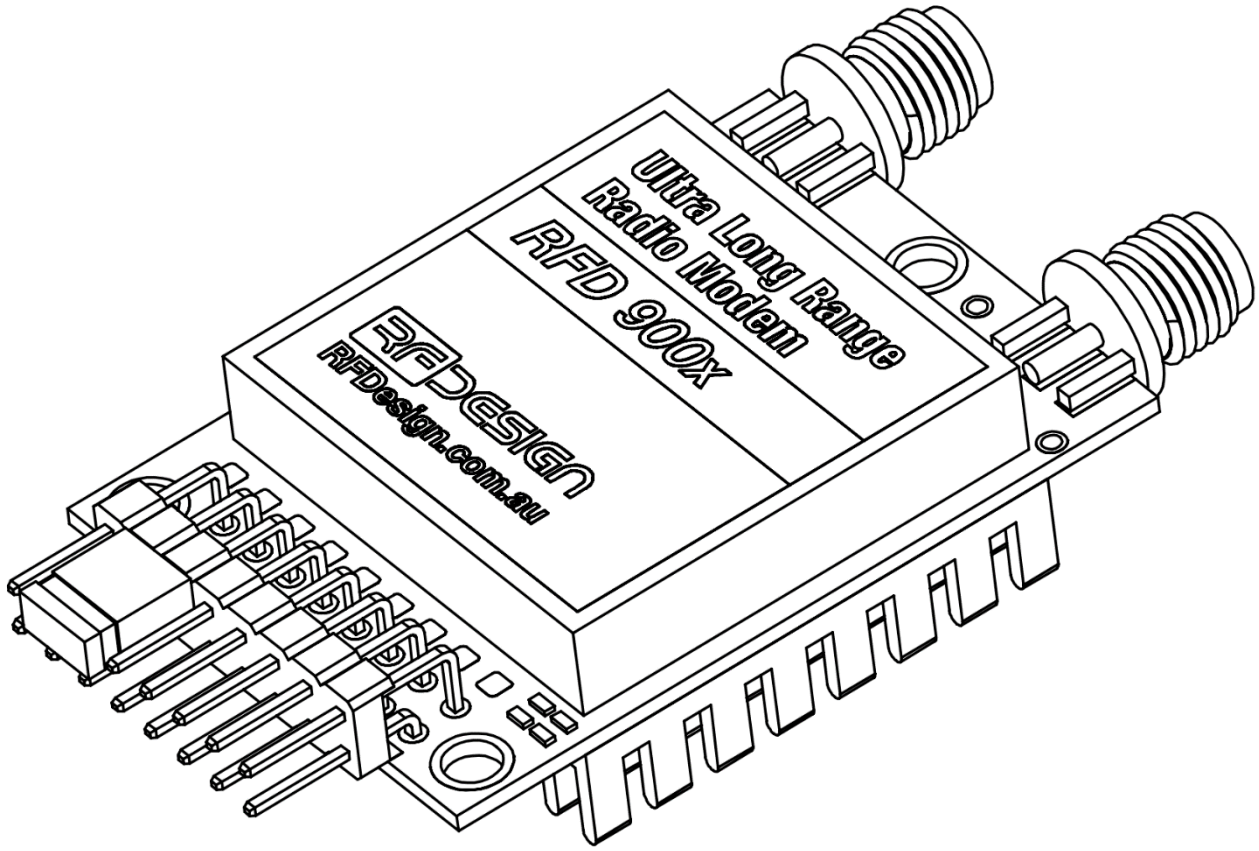
RFD x Series Radio Data Modem
Technical Datasheet



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Contents

1 Key Features

- Supplied with SiK firmware, ready to use in point to point communication.
- Outdoor RF line-of-site range of 40km or more depending on configuration and antennas.
- MAVLink data packet support.
- Air data rate speeds of up to 224kbits/s.
- Support for PPM and SBUS remote control signal passthrough (SiK firmware only).
- Hardware accelerated AES encryption with up to 256-bit key.
- Two antenna ports with automatic diversity by default.
- Operating temperature range of -40 to +85 deg. C.
- Automatic thermal throttling.
- Dimensions of 30mm x 57mm x 12.8mm
- Weight, 14g (7g bare variants)

2 General Cautions and Operating Considerations

2.1 General Cautions

During operation there must be a separation distance of 20cm between all persons and the antenna.

Ensure that all used RF connectors are secure

Unused RF connectors may be terminated with an open circuit or covered with a plastic dust cover. Ports should not be terminated with shorts or RF loads as this may damage componentry or cause failure of features such as the automatic diversity mode.

If used in proximity to other RF devices with transmission power exceeding 5W, devices such as ADSB transponders, radar etc., it is recommended that external filters are added between the antenna and modem to protect the receiver of the modem from damage. The Shireen BPF-915C is an example of such an external filter for the 902-928MHz band.

If used in environments with high chance of static discharge, such as dry dusty conditions, additional protection against static discharge into the device from the antennas/RF ports may be required to prevent damage.

2.2 When used in the US - FCC Caution

Caution: The user is cautioned that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.
Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
—Reorient or relocate the receiving antenna.
—Increase the separation between the equipment and receiver.
—Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
—Consult the dealer or an experienced radio/TV technician for help.

This equipment complies with FCC’s RF radiation exposure limits set forth for an uncontrolled environment. The antenna(s) used for this transmitter must be installed and operated to provide a separation distance of at least 20 cm from all persons and must not be collocated or operating in conjunction with any other antenna or transmitter. Installers must ensure that 20cm separation distance will be maintained between the device (excluding its handset) and users.

2.3 When used in Canada - ISED Caution

This device complies with RSS 210 of the Industry Canada Rules. Operation is subject to the following two conditions:
(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :
(1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.
This equipment complies with Canada radiation exposure limits set forth for uncontrolled environments. This equipment should be installed and operated with a minimum distance of 20cm （may be adjusted according to actual calculation result） between the radiator and your body.
This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.
Déclaration d'IC sur l'exposition aux radiations:
Cet équipement est conforme aux limites d'exposition aux radiations définies par le Canada pour des environnements non contrôlés. Cet équipement doit être installé et utilisé à une distance minimum de 20 cm entre l'antenne et votre corps.
Cet émetteur ne doit pas être installé au même endroit ni utilisé avec une autre antenne ou un autre émetteur.

2.4 When used in Brazil

Este equipamento não tem direito à proteção contra interferência prejudicial e não pode causar interferência em sistemas devidamente autorizados. Para maiores informações, consulte o site da ANATEL – www.anatel.gov.br".

2.5 EIRP and Antenna Limits

Where applicable this device has been tested and certified to operate with 3dBi dipole antennas. Other antenna types with directional radiation patterns or those with gain greater than 3dBi may require the user to compensate by reducing the maximum device output power in accordance with Effective Isotropic Radiated Power (EIRP) requirements of local radio authority.

3 Overview

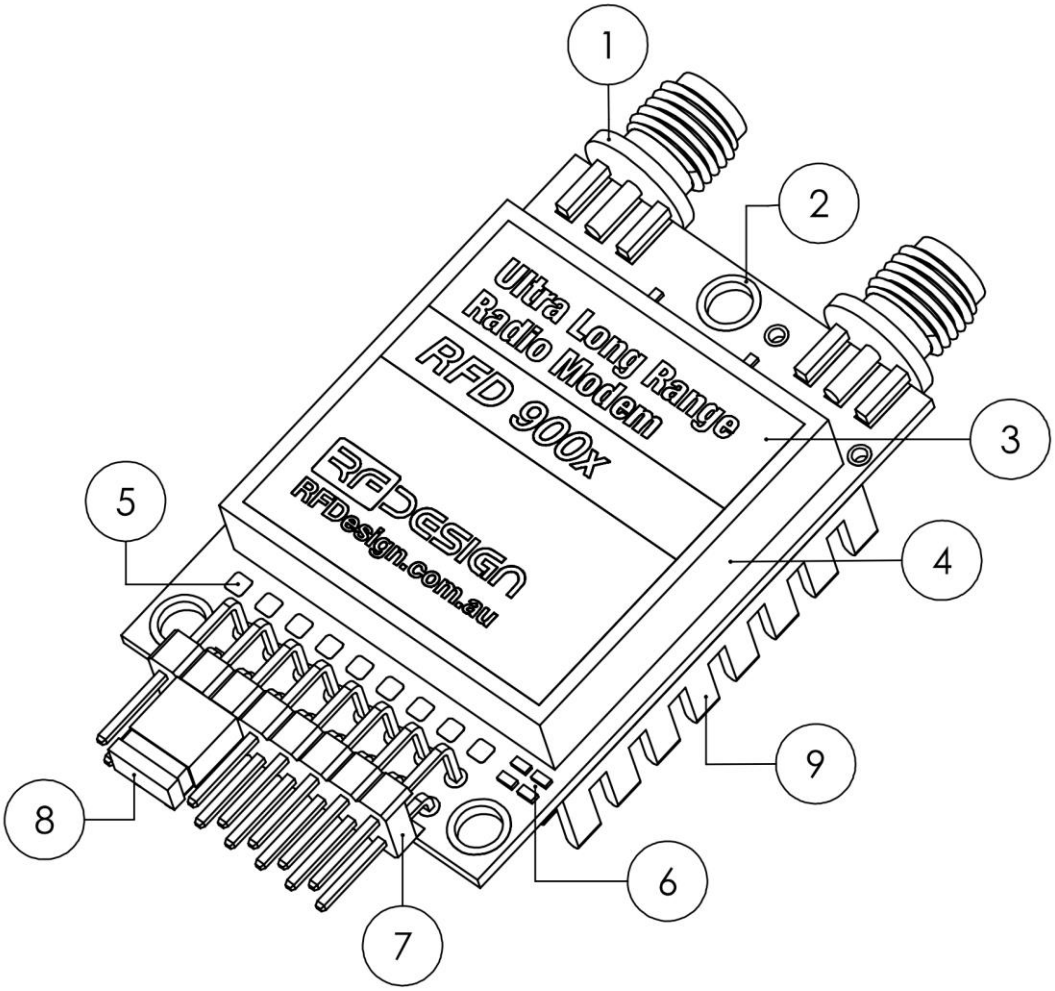

Figure 1: RFD x series modem feature diagram

Diagram Feature	Part
1	RF connectors 50ohm female RP-SMA (not fitted to bare models)
2	Mounting holes (3.1mm diameter)
3	Modem label
4	RF shield
5	Contact pads x 9
6	Indicator LEDs
7	0.1 inch (2.54mm) pitch 8x2 pin header (not fitted to bare models)
8	Power supply pin jumper
9	Heatsink (not fitted to bare models)

3.1 RF Connectors

The RFD x series modems are fitted with two 50 Ohm reverse polarity subminiture A (RP-SMA) connectors. These are designed to provide robust and repeatable connection to compatible antennas or RF coaxial extension leads.

Note that these connectors are not fitted to bare variants.

Note that 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.

3.2 Mounting Holes

These holes provide locations for the RFD x series modems to be mounted to enclosures, such as the RFD x series enclosure or custom PCBs by means of M3 or M2.5 hardware. The exposed pad around these holes are electrically connected to ground.

Note that care should be taken to ensure that any mounting hardware does not pose a risk of creating an electrical short to pins, pads or tracks on the modem as this may result in undesired behaviour or damage to the electronic components.

Note care should be taken to not to over tighten the fasteners used to secure the modem as this risks damaging the PCB or components nearby.

3.3 Modem Label

This label indicates the model of modem including, where applicable, the country code designation.

3.4 RF Shield

This metal shield is connected to the modem ground rail. It ensures the modems comply with radiated electromagnetic energy and interference requirements under the various certifications, it also provides protection to the main electronic components from physical damage.

Note the shield is made of a thin gauge of metal and can support limited mechanical strain before deformation. Be careful not to bend or depress the lid excessively as it could contact and electrically short circuit the underlying electronic components causing damage.

3.5 Contact Pads

These pads are on the top and bottom of the PCB and provide various functions during manufacturing. The only pin to provide a user feature is pad 9. This pad can be connected to ground during power up to force the modem to start in bootloader mode.

Note that care should be taken not to short any of these pads with anything conductive during installation or integration into custom applications. This may be particularly important when installing bare modems by soldering into place.

3.6 Indicator LEDs

A green and red LED. They provide information on behaviour of the modems. The exact functions are dependent on the firmware that is loaded and is outlined in the respective firmware manuals.

3.7 8x2 pin 0.1” (2.54mm) Pitch Header

The main connection to the modem used to supply power, serial and various I/O functions depending on the firmware that is loaded. Compatible with DuPont style plug connectors.

Note that this connector is not fitted to bare variants.

3.8 Power Supply Jumper

When fitted between pins 4 and 6 of the header this connects the power supplied on pin 5 of the header to the modem’s regulator. When removed positive supply can be connected directly pin 4 to supply the regulator.

3.9 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.

Note that this is not fitted to bare variants.

4 Hardware and Regional Versions

4.1 Hardware Versions

The x series modems currently have two major hardware revisions these can be identified by the text on the PCB between the antenna ports, see figure 1. This will read '9X' for V1 type hardware and '9X2' for V2 type hardware.

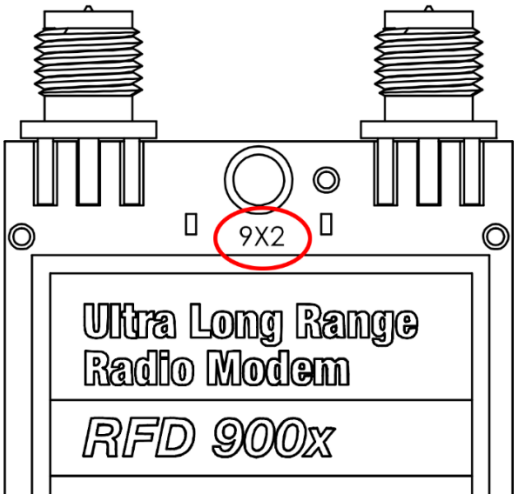

Figure 2: RFD x series modem hardware revision label

Note the different hardware versions are generally compatible with each other except for networks using the asynchronous firmware. See the compatibility tables below.

Hardware compatiblity
Peer to Peer (SiK)
and Multipoint

Modem	X (V1)	uX(V1)	X (V2)	uX(V2)
X (V1)				
uX(V1)				
X (V2)				
uX(V2)				

Hardware compatiblity
Ascynchronous

Modem	X (V1)	uX(V1)	X (V2)	uX(V2)
X (V1)				
uX(V1)				
X (V2)				
uX(V2)				

Figure 3: Hardware revision compatibility for different firmware types

4.2 Bare Modem

For customers seeking to integrate the RFD x series modems into custom electronics and hardware systems the modems can be supplied in a bare configuration. This does not have the RF RP-SMA connectors, pin header or heatsink fitted.

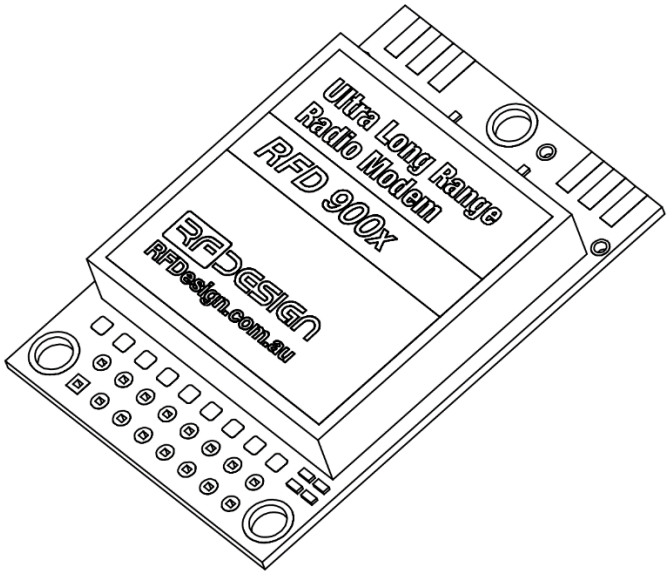

Figure 4: RFD x series modem in bare configuration

4.3 Regional Variants

Modems that feature a product code with a dash and letter code on the label are region locked variants. These modems may impose limitations on accepted values for S parameter values in accordance with the relevant regulatory guidelines. The letters after the dash indicating the region to which that modem is locked.

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

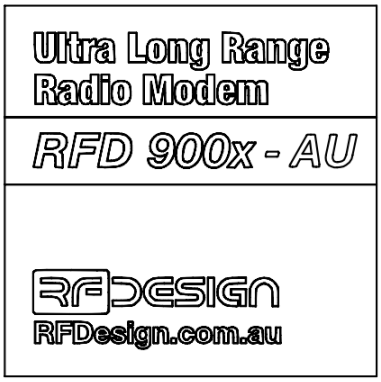

Figure 5: Example of Australia region locked modem label

The current regional modems are:

Modem Model Name	Country/Region of Compliance	Modular Certification ID
RFD900x2-AU	Australia	N/a
RFD900x2-BR	Brazil	Pending
RFD900x2-US	Canada and the United States of America	FCC: 2ADLE-900X IC: 24610-00UX2
RFD900x2-NZ	New Zealand	N/a
RFD868x2-EU	European Union	N/a

Note that not all country compliant variants are available for all modem models.

Note that regional variants may satisfy regulations in other areas, for instance the US modem may also suit the regulation 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.

4.4 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
- ANATEL Res 680 and Act 14448

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

Only the region locked versions of the modems are represented to be compliant in their respective regions.

4.5 Compatibility

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

Note Asynchronous firmware will not interoperate between V1 and V2 hardware. All other firmware types will interoperate between V1 and V2 hardware, provided that firmware version match.

The following table shows modem models which can be configured to interoperate with each other.

Modem	900X	900X-AU	900X-US	900X-NZ	868X	868X-EU	900uX	900uX-US	868uX	868uX-EU
900X										
900X-AU										
900X-US										
900X-NZ										
868X										
868X-EU										
900uX										
900uX-US										
868uX										
868uX-EU										
868uX-IND										

Figure 6: Modem interoperability configurability table.

Interoperable configuration does not convey regional compliance for an unlocked modem.

4.6 Firmware

Due to bandwidth constraints some versions of the RFD x series modems are not endorsed for use with some firmware types.

Note the Multipoint (MP) and Asynchronous firmware may be unsuitable for or have limited functionality on 868x/ux and region locked versions thereof.

5 Firmware Support

There are currently three firmware types developed by RF Design.

5.1 SiK (Point to point)

- 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.

5.2 Multipoint Mesh (MP)

A firmware designed for mesh networks of modems.

- Coordinated transmission to minimises interference and collision and maximises data throughput.
- Support for MAV telemetry and SAS binary data.
- Support for up to approximately 20 nodes. Depending on the available frequency bandwidth and airspeed.
- Hardware accelerated AES encryption.

This firmware is best suited to systems that require regular data transmission and do not have independent transmission coordination such as operating multiple unmanned vehicles simultaneously. The Multipoint firmware user manual covers the various settings and uses of this firmware.

Note that due to bandwidth limitations the Multipoint (MP) firmware is not considered suitable for 868x/ux and region locked versions thereof.

5.3 Asynchronous Mesh (Async)

A firmware designed for mesh networks of modems. There is no transmission coordination or synchronisation of the network.

- Modems will attempt to transmit data as soon as they receive anything from the serial port if an RF channel is free.
- Random back off time to minimise the chance of data collision.
- Optional retries can be used to maximise data integrity.
- Hardware accelerated AES encryption.
- Support for high node counts.

This firmware has a greater maximum number of nodes and no requirement for all nodes to be in range of a master, but generally has lower throughput. It is best suited to systems with independent coordination or low data polling rates and tolerance to data loss/errors, e.g. remotely deployed temperature sensor that reports every ten minutes. The Asynchronous firmware user manual covers the various settings and uses of this firmware.

Note regionally locked version of the modems may restrict or limit the performance and available parameter settings compared to the unlocked modems. Please refer to the appropriate firmware manuals for more details on the configuration and performance.

6 Bootloader

All RFD x series modems have a bootloader that manages the loading of firmware to the modem. This can be entered by:

- The AT&UPDATE command from within the firmware command mode.

Note that each bootloader and AT command alike need to be followed by an enter press or other method of sending a newline delimiter (\n).

Or

- By using a conductor such as a pin or straightened paperclip to connect the number 9 pad, located between pin 16 and the radio frequency shield of the modem, to a ground pin or the metal of the shield while powering up the modem, by for instance sliding the jumper into place on pins 4 and 6.

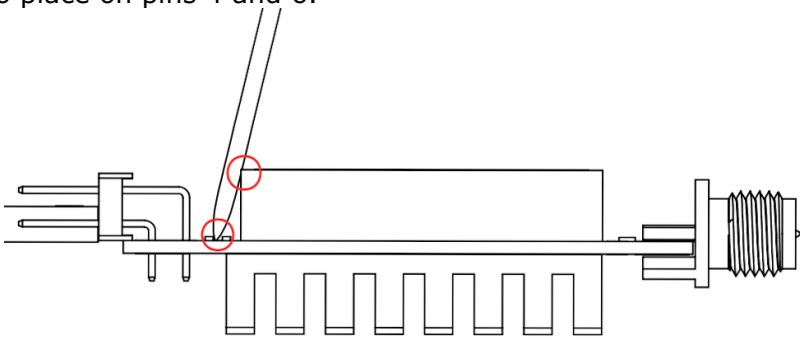

Figure 7: Pin making contact with pad 9 and RF shield to force bootloader mode

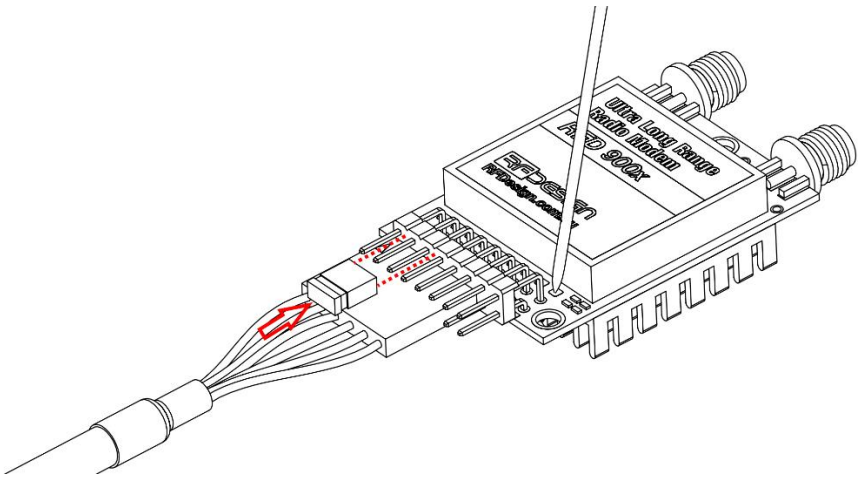

Figure 8: Pin connecting pad 9 and shield while powering up modem by adding jumper to pin 4 and 6

The modem signals that it is in bootloader mode by a solid red LED.

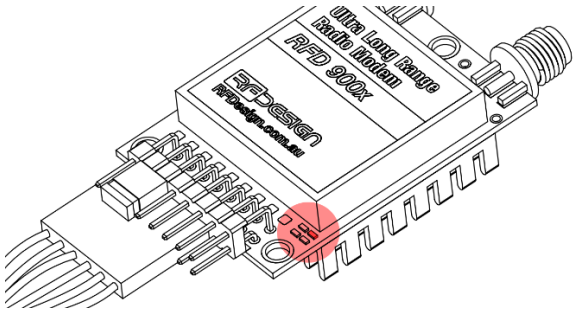

Figure 9: Solid red LED indicating modem in bootloader mode

When entering bootloader mode the serial port will print a string with the modem model, bootloader version and ChipID.

```
RFD900xSub:2:MainV1.12.03 ChipID: E8E07EFFFEFCBFE9
```

Figure 10: Example bootloader mode serial string

The serial port will be configured to the following defaults.

- 57600 Baud
- No parity bit
- 8 Data bits
- 1 Stop bit
- RTS/CTS flow control OFF

The bootloader has commands for performing basic functions. These commands are typed and followed by pressing the enter key or other method of sending newline delimiter (\n). The modem will reply with and 'OK' to indicate the command has been accepted. The bootloader commands are as follows:

BAUDHI This command switches the baud rate of the bootloader to 1200000.

Note this command is not available for some older modems that have an earlier version of the bootloader.

BAUDLO This command switches the baud rate of the bootloader to 57600.

Note this command is not available for some older modems that have an earlier version of the bootloader.

BOOTNEW This command reboots the modem to the loaded firmware.

UPLOAD This command tells the modem to expect XMODEM formatted firmware data to install on the modem. The modem will reply with 'Ready' and begin to periodically print 'C' as it waits for data. It will timeout if no data is received within about a minute.

```
UPLOAD
Ready
CCCCC
```

Figure 11: Example of UPLOAD command execution

7 Loading firmware

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

- The RFD modem tools software.
- MissionPlanner software.

7.1 Programming with RFD modem tools

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

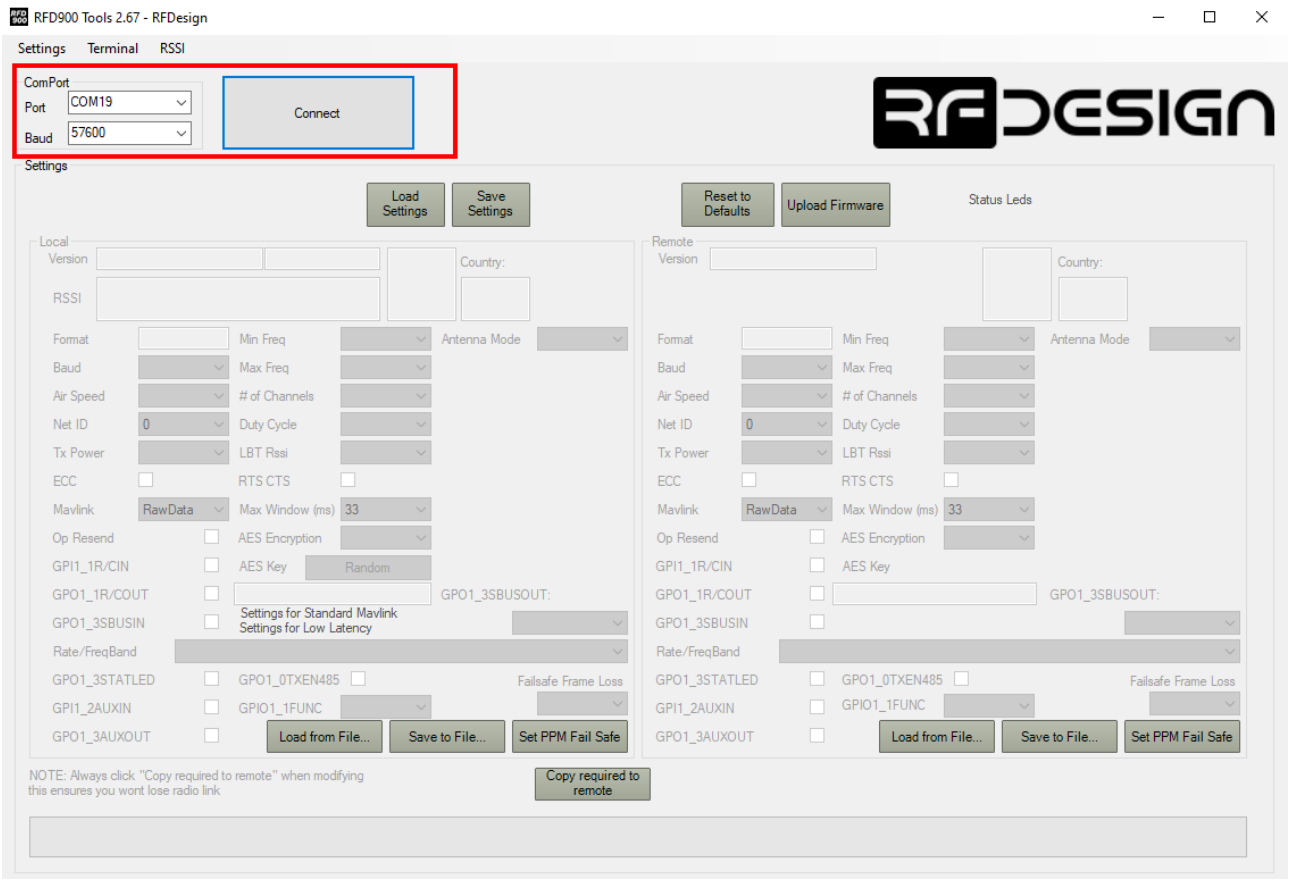

Figure 12: RFD Tools COM port connection

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 the correct version for your hardware.

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

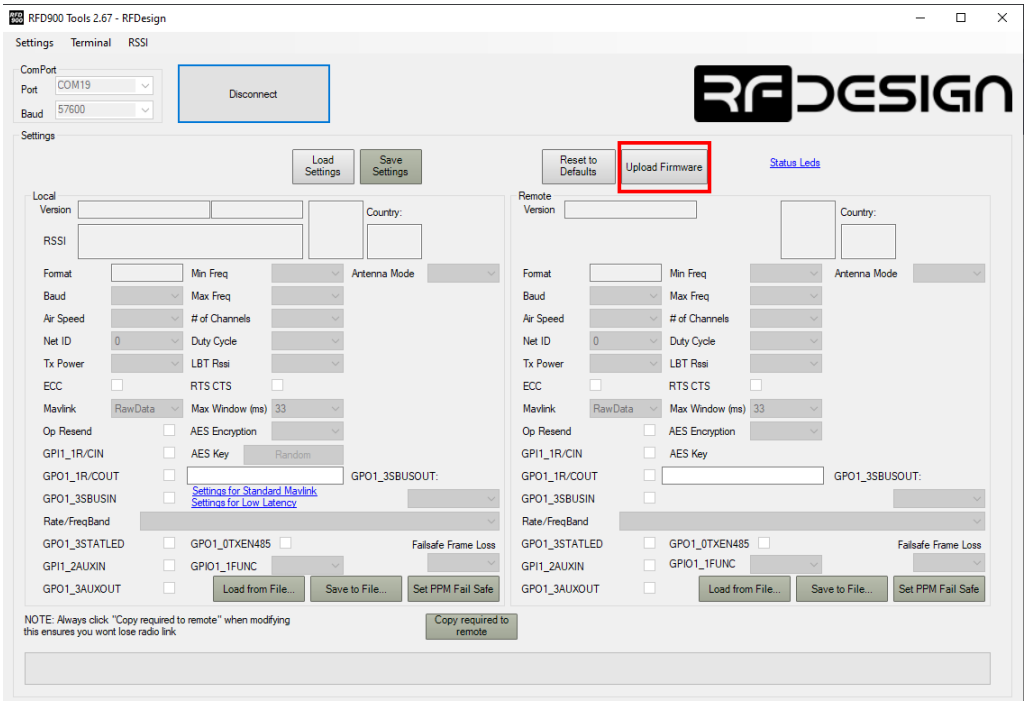

Figure 13: RFD Tools Upload Firmware button

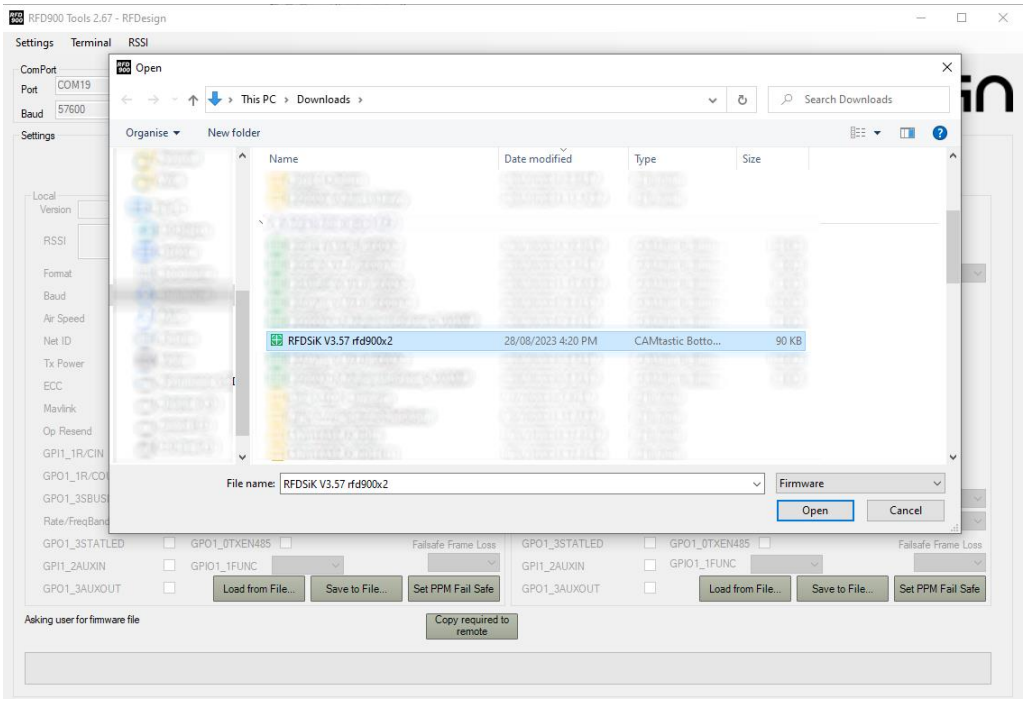

Figure 14: Firmware file selection dialogue box

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.

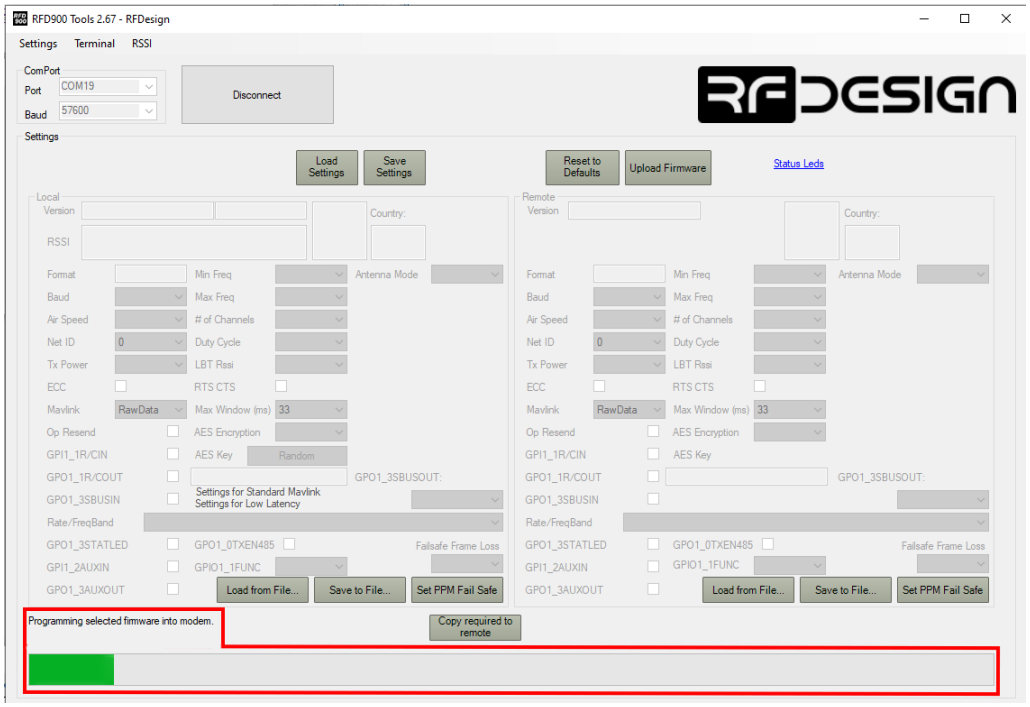

Figure 15: Programming progress bar of the RFD Tools

8 Pinout

The RFD x series modem electrical connections are outlined in the following section.

8.1 Pinheader

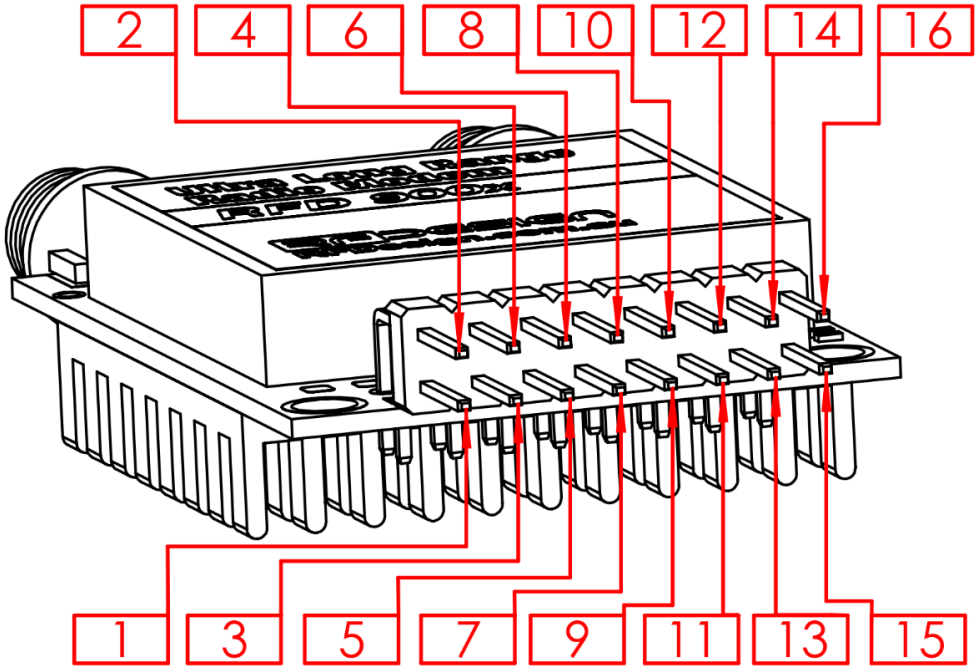

Figure 16: Modem 0.1" header pinout

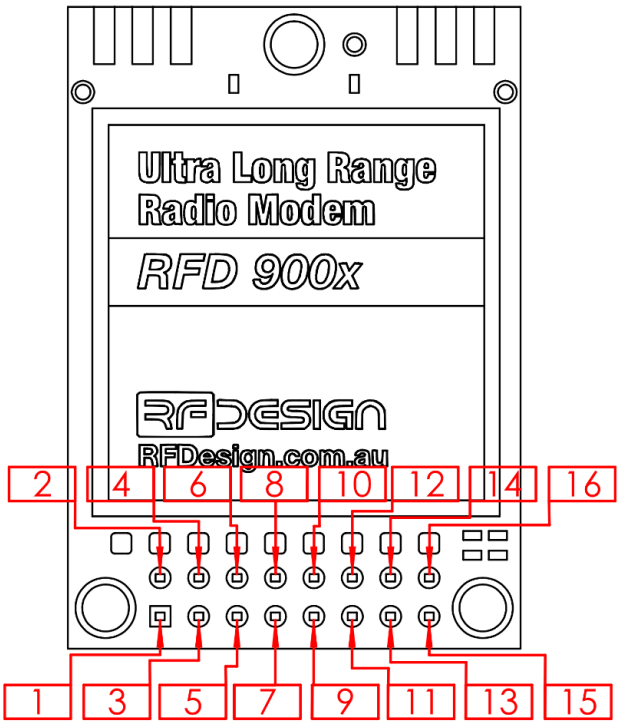

Figure 17: Bare modem pad numbering

Pin #	Name	Direction	Description	Max. Voltage
1	GND	—	Ground	0V
2	GND	—	Ground	0V
3	RTS	Output	Request to send flow control pin	3.3V
4	Vcc	Input	Positive supply voltage	5.5V
5	Vusb	Input	Positive supply voltage from USB	5.5V
6	Vusb	Input	Positive supply voltage from USB	5.5V
7	RX	Input	UART Data In	3.3V
8	GPIO5	I/O	Digital I/O	3.3V (5V input tolerant)
9	TX	Output	UART Data Out	3.3V
10	GPIO4	I/O	Digital I/O	3.3V (5V input tolerant)
11	CTS	Input	Clear to send flow control pin	3.3V
12	GPIO3	I/O	Digital I/O, Link status	3.3V
13	GPIO0	I/O	Digital I/O	3.3V
14	GPIO2	I/O	Digital I/O	3.3V (5V input tolerant)
15	GPIO1	I/O	Digital I/O, PPM I/O	3.3V
16	GND	—	Ground	0V

8.2 Pads

The modem has a row of pads found between the main pin header and RF shield. The functions of these supplemental electrical connections are outlined below.

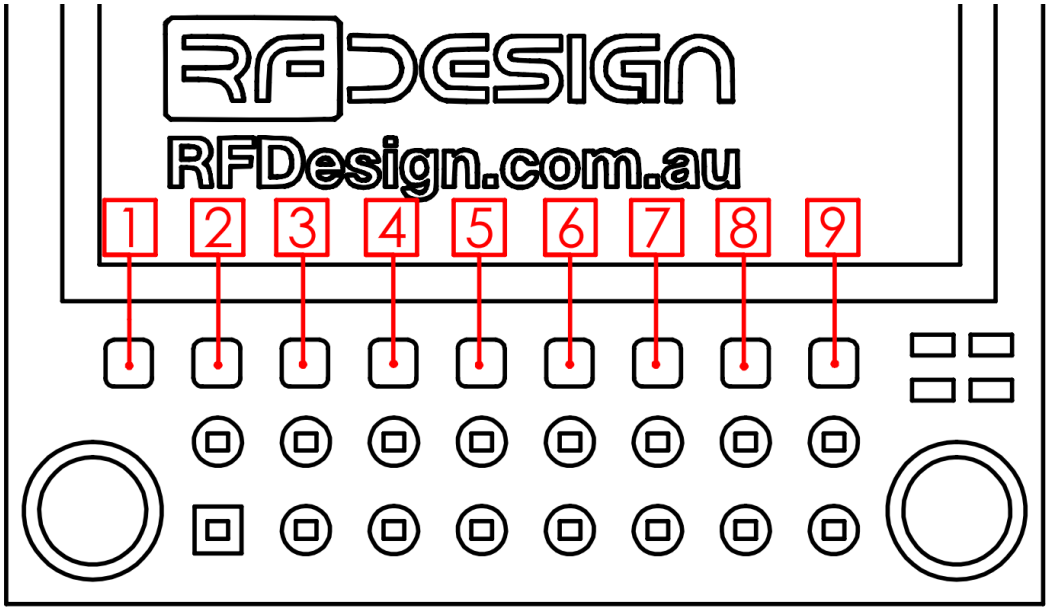

Figure 18: x series modem pad numbering

Pad #	Name	Direction	Description	Max. Voltage
1	N/A	—	Not applicable to user functions	3.3V
2	GND	—	Ground	0V
3	VIN	—	Supply voltage to the modem	5.5V
4	N/A	—	Not applicable to user functions	3.3V
5	N/A	—	Not applicable to user functions	3.3V
6	N/A	—	Not applicable to user functions	3.3V
7	N/A	—	Not applicable to user functions	3.3V
8	N/A	—	Not applicable to user functions	3.3V
9	Bootloader Trigger	Input	When connected to ground during power up this will trigger the modem to enter bootloader mode	3.3V

8.3 GPIO Functions

- GPIO pins may be configured as input or output.
- GPIO pins default to inputs.
- When configured as an output they can sink or source approximately 5 mA each.
- Please refer to the appropriate firmware manual for specific information.

Note that the function/s of each pin may vary depending on the firmware in use.

GPIO #	Possible functions (SiK firmware)
0	Digital I/O pin mirror
1	Digital I/O pin mirror, PPM/SBUS I/O
2	Digital I/O pin mirror
3	Digital I/O pin mirror, Link status
4	Digital I/O pin mirror
5	Digital I/O pin mirror

8.4 Serial connection

Note the RFD x series modems support 3.3 volt logic UART connections, higher voltage serial levels risk damaging the pins of the microcontroller. Where different voltage levels are used a level converter should be used to ensure correct operation.

The pin arrangement of the modem header is designed to be compatible with FTDI cables such as those supplied by RFD on our web store. Such a cable can be connected to pins 1,3,5,7,9 and 11 of the modem pin header. Cable pin one, as denoted by the arrow marker on the connector, corresponding with modem pin 1, bottom left pin of the modem pin header and denoted by the square solder pad and white '1' marking on the PCB.

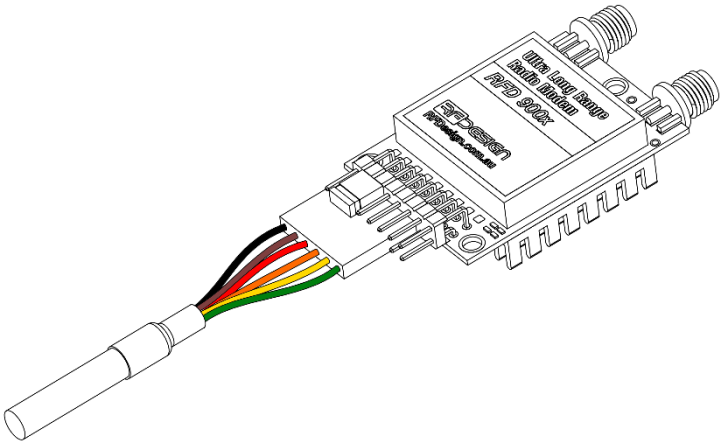

Figure 19: x series modem with FTDI Cable attached

The RFD x series has support for hardware flow control by use of the RTS and CTS pins. Default configuration of the modem's serial port with factory SiK firmware is:

- 57600 Baud
- No parity bit
- 8 Data bits
- 1 Stop bit
- RTS/CTS flow control OFF

8.5 Remote control signal

The SiK firmware, loaded on an RFD x series modems by default, can configure pin 15 (GPIO1) as either an input or output for remote control signal passthrough in PPM or SBUS1/2 formats. The modem can also convert the input format to a different format on the output.

Please see the SiK manual for the details of the supported formats and configurations.

9 Accessories

9.1 Cables and Harnesses:

An outline of some cables that support the integration for the RFD x series modems in various applications.

FTDI This cable acts as an interface between the 3.3V serial interface RFD x series modem and a PC or other similar system such as a Single Board Computer (SBC) via a USB port. RFD provides two options for such cables with either a USB type A connector or USB type C connector. When connecting to the FTDI cable should create a virtual COM port. If this port is not correctly established, there may be a requirement for the installation of an appropriate driver from FTDI.

Figure 20: USB type A connector FTDI cable

RFD900x multi cable This cable offers a 300mm breakout of the 16 pin header to three sperate connectors including:

- A JST GH series connector suitable for the TELEM port of the Pixhawk Cube standard carrier board.
- A two pin, 0.1” (2.54mm) pitch, DuPont style socket for connecting to external power supply.
- A three pin, 0.1” (2.54mm) pitch, DuPont style socket for connecting to RC signal.

Figure 21: RFD900x Multi cable

Pixhawk 2 to RFD900 Telemetry Cable Available in 150, 300 and 750mm lengths this cable has a JST GH series connector suitable for the TELEM port of the Pixhawk Cube standard carrier board and a 6 pin, 0.1” (2.54mm) pitch, DuPont style socket for connecting to modem pins 1-11 to supply power and serial communication.

Figure 22: RFD900 to Pixhawk 2 Telemetry Cable

Pixhawk to RFD900 Telemetry Cable A 150mm cable with a DF13 6 pin connector suitable for the TELEM port of the Pixhawk 1 and a 6 pin, 0.1” (2.54mm) pitch, DuPont style socket for connecting to modem pins 1-11 to supply power and serial communication.

Figure 23: RFD900 to Pixhawk Telemetry Cable

APM2.x to RFD900 Telemetry Cable A 150mm cable with a DF13 5 pin connector suitable for the TELEM port of the Ardupilot Mega APM 2.5, 2.6, Autopilots and a 6 pin, 0.1” (2.54mm) pitch, DuPont style socket for connecting to modem pins 1-11 to supply power and serial communication.

Figure 24: RFD900 to Pixhawk Telemetry Cable

9.2 Antennas

- The RFD x series modems are designed for 50 Ohm impedance RF connections.
- All versions of the x series modems except the bare modem are fitted with reverse pole subminiture 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.

Note that 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/or incorrect operation of the diversity feature.

Some important performance considerations regarding antennas and RFD modems:

- 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 acheivable 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. The majority of 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 be 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: 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 3 for like polarised antennas is recommended. Spatial separation can be replaced with polarity separation. Where the cross polarisation loss between, for example a horizontally and vertically polarised antenna is usually sufficient to protect against problems.

9.3 Compatible antennas from the RFD store

Note that 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 that 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.

2dBi Monopole A quarter wave monopole antenna with a male RP-SMA connector. Available in a right angle and straight configuration. For optimal performance it should mounted above a suitably sized ground plane.

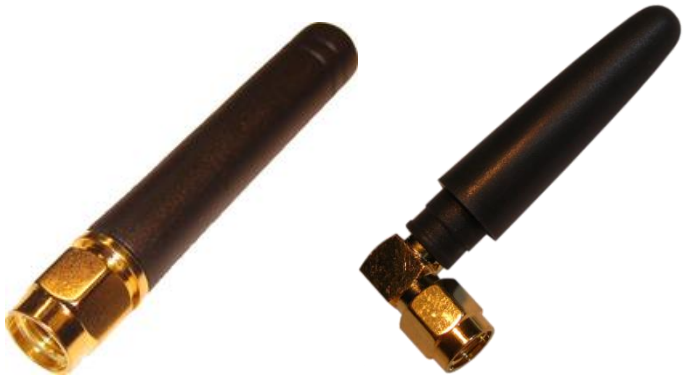

Figure 25: Straight and right angle monopole antennas

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.

Figure 26: 3dBi dipole antenna

Flex 1 An antenna built on a flexible substrate with an adhesive backing. The antenna performance is optimised for mounting to fibreglass and foam structures. It has a radiation pattern like that of the dipole antenna and a gain of approximately 2.7 dBi. The antenna is polarised along the length of the antenna. It is available with a coaxial cable of 300 and 500mm with a male RP-SMA connector. It can also be supplied without a cable.

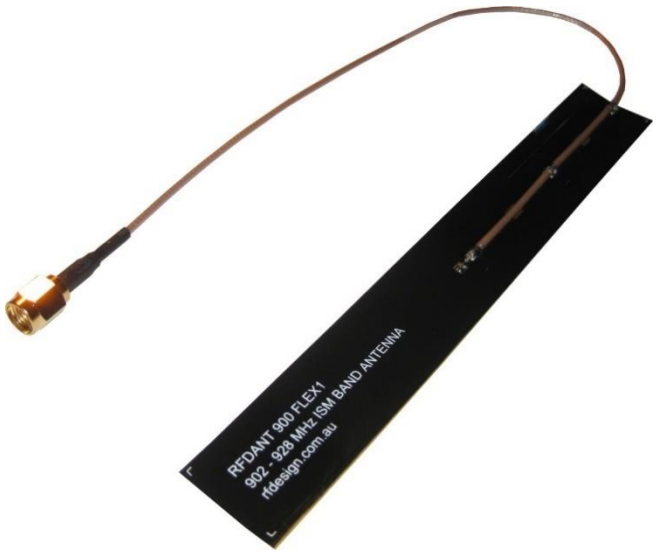

Figure 27: RFD Flex1 antenna with 300mm cable

Flex 2 An antenna built on a flexible substrate with an adhesive backing. The antenna performance is optimised for mounting to fibreglass and foam structures. It has a radiation pattern like that of the dipole antenna and a gain of approximately 2.4 dBi. The antenna is polarised along the width of the antenna. It is available with a coaxial cable of 500 and 1000mm with a male RP-SMA connector. It can also be supplied without a cable.

Figure 28: RFD Flex2 antenna with 500mm cable

High Gain Dipoles Dipole antennas available with gains of 5dBi and 8dBi with a male RP-SMA connector or N-type connector with adaptor.

Figure 29: 5dBi dipole antenna

6dBi Yagi A Yagi type directional antenna with a peak gain of 6dBi. Has an N-Type connector and is supplied with an adaptor to suit the RFD x series modems.

Figure 30: Yagi antenna

9.4 Coaxial cables and adaptors from the RFD store

Coaxial extension cables and RF connector adaptors increase the mounting, routing and antenna options available when using the x series modems.

Some important performance considerations regarding coaxial extension cables and RF connector adaptors, and RFD modems:

- RF Signal Loss: Adaptors and coaxial extension cables create some losses in radio frequency power. As such a minimal amount/number should be used to maximise the radio performance.
- Low loss cable variants: For cable runs of more than 1m but less than approximately 10m a minimum specification of LMR195 coaxial cable is recommended. If coaxial cables of more than this distance are required, then even higher performance grades of cable such as LMR400 should be considered. As the weight of such long cables can be substantial sufficient strain relief should be provided to ensure that the RF port of the modems are not damaged be the mechanical strain.
- Damaged, knotted pinched or crushed cables: Such cables may have performance loss due to open/short circuits, or impedance mismatch.
- Impedance: As with the antenna selection RF coaxial cables and/or adaptors need to be chosen to match the modem's RF port impedance of 50 Ohm.

RP-SMA Extension An RG316 type coaxial cable with male and female RP-SMA connectors. The female connector has a locking nut and spring washer to allow panel mounting. Available in lengths of 150mm, 500mm and 1000mm. A 150mm cable with right angle connectors and 500mm male to male RP-SMA connector version of the cable are also available.

Figure 31: 150mm RP-SMA coaxial extension cable

Right angle RP-SMA male to N-type female: An RG316 type coaxial cable with an RP-SMA male and N-type female connector. The female connector has a locking nut and spring washer to allow panel mounting.

Figure 32: RP-SMA to N-type coaxial extension cable

RP-SMA Female to N-type male RF connector adaptor: An RF connector adaptor turning a female RP-SMA to and male N-type. Useful for matching antennas with N-type connectors such as the Yagi and high gain 6dBi dipole to the RP-SMA type connector of the RFD x series modems. Such a setup will require the male to male RP-SMA extension cable as well.

Figure 33: RP-SMA to N-type adaptor

9.5 Modem Enclosure

RFD x-series Modem Enclosure is an injection moulded plastic housing that provides some additional mechanical support for the antenna ports, as well as strain relief for fitted cables such as the FTDI cable. It also provides mechanical mounting points for fitting the enclosed modem in vehicles or ground station setups.

Figure 34: Modem enclosure kit and example with fitted modem and FTDI cable

10 Electrical Characteristics

Parameter	Minimum	Typical	Maximum
Operating temperature	-40°C	—	+85°C
Supply Voltage	+5V	+5V	+5.5V (Continuous) +6V(Absolute)
Supply Current (30dBm transmit)	—	—	1.2A
Receive/Standby Current	—	60mA	—
Voltage on I/O pin (Ref. to GND)	-0.3	—	+3.6V
Input Voltage Low	—	—	+1V
Input Voltage High	+2.3V	—	—
Output Voltage Low (sink 5mA)	—	—	+0.7V
Output Voltage High (source 5mA)	+2.5V	—	—
DC current on I/O pin	—	—	5mA
I/O pull up/down resistance	30 kOhm	40 kOhm	65 kOhm
SBUS/SBUS2 channels	—	—	18Ch
PPM channels	2Ch	—	16Ch
PPM Frame Length	—	—	36ms
Channel levels	1000 counts (1ms)	—	2000 counts (2ms)
RF output power	+0 dBm	—	+30 dBm
RF input power	—	—	+20 dBm
RF port impedance (RP-SMA)	—	50 Ohm	—
RF connector torque (RP-SMA)	0.3 Nm	0.5 Nm	0.5 Nm
RF connector rated number of connections (RP-SMA)	—	—	500

11 Performance Characteristics

<table>
<tr><th>Feature</th><th colspan="3">Implementation or Performance</th></tr>
<tr><td>RF Data Rates</td><td colspan="3">12, 56, 64, 100, 125, 188, 200, 224 kbits/sec
(Available rates depend on modem variant and firmware)</td></tr>
<tr><td>Obstructed Line of Sight Range</td><td colspan="3">0.5 – 1 km (depending on antennas, and settings)</td></tr>
<tr><td>Line of Sight Range</td><td colspan="3">40+km (depending on antennas, and settings)</td></tr>
<tr><td>Serial Interface Data Rate</td><td colspan="3">2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400, 460800 and 1200000 baud</td></tr>
<tr><td>Modulation</td><td colspan="3">2GFSK/4GFSK (dependent on air data rate)</td></tr>
<tr><td rowspan="8">Interference Mitigation</td><td colspan="3">Frequency Hopping Spread Spectrum, FHSS, (except RFD868x-EU)</td></tr>
<tr><td>Modem Variant</td><td>Frequency Band/s</td><td>Number of Channels</td></tr>
<tr><td>RFD900x Unlocked</td><td>902 – 928 MHz</td><td>User settable (51 Max)</td></tr>
<tr><td>RFD900x-AU locked</td><td>915 – 921MHz and
922 – 928MHz</td><td>23</td></tr>
<tr><td>RFD900x-NZ locked</td><td>920.75 – 927.25 MHz</td><td>25</td></tr>
<tr><td>RFD900x-US locked</td><td>902 – 915MHz and
915 – 928MHz</td><td>51</td></tr>
<tr><td>RFD868x Unlocked</td><td>865 – 868 MHz</td><td>User settable (7 Max)</td></tr>
<tr><td>RFD868x-EU locked</td><td>869.525MHz and 869.85MHz</td><td>1</td></tr>
</table>

Feature	Implementation or Performance	
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	

11.1 Power Supply

Supply voltage fluctuations can cause the modem RF output power to deviate from calibrated levels. Many flight controller telemetry ports are not rated for sufficient current to supply the x series modems, in such cases a separate supply should be used. This is done by removing the jumper from pins 4 and 6 of the header and connecting the external supply ground to pin 2 and the positive voltage to pin 4.

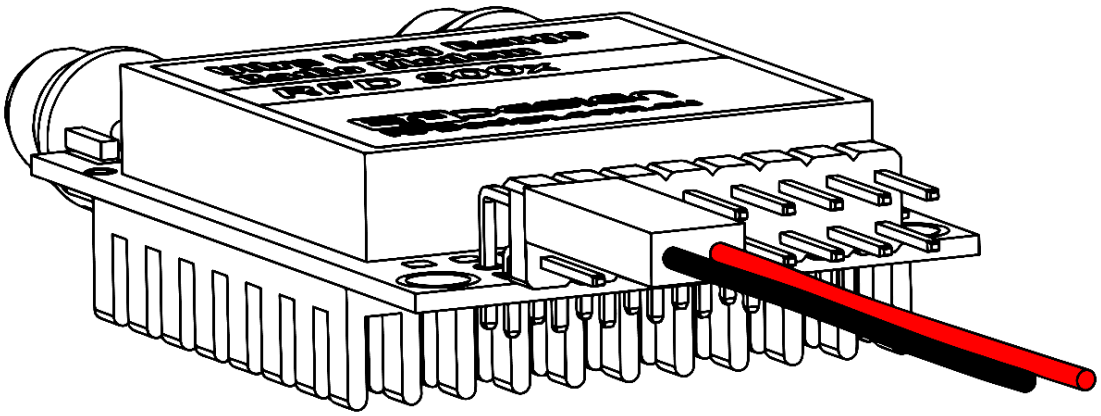

Figure 35:External power supply connection to the modem

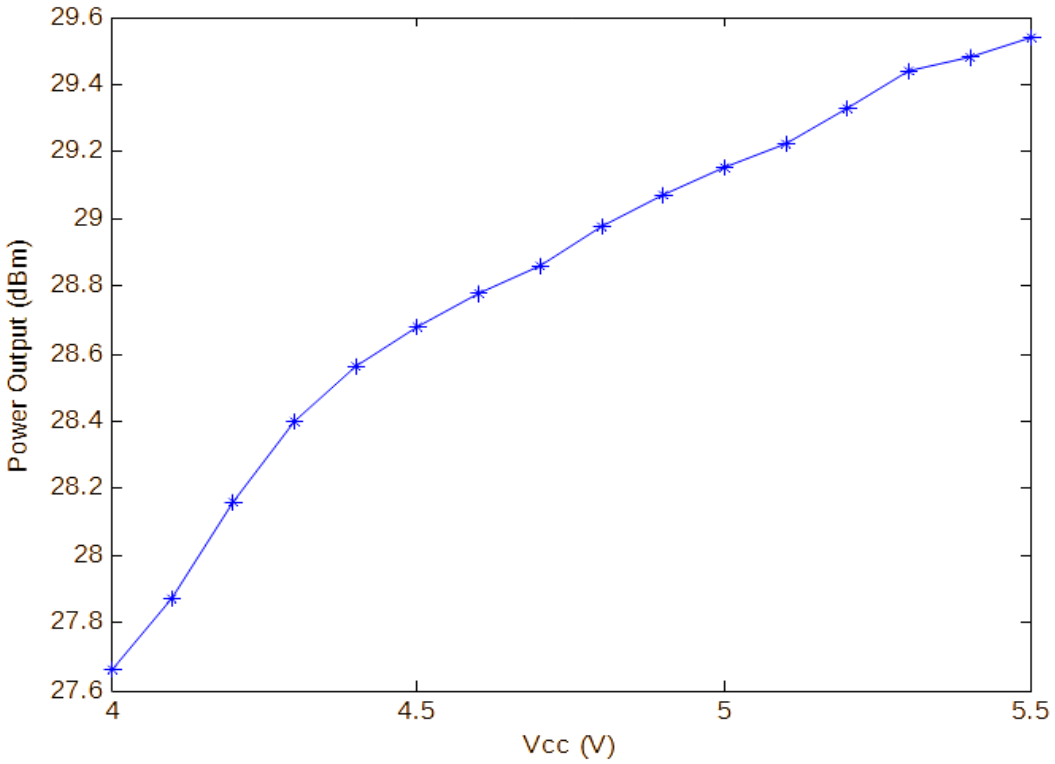

Figure 36: RF output power variation verse input voltage

It should be noted that long power cables, particularly made of thin gauge wire, can cause voltage drop particularly during high current draw. This voltage drop can negatively affect the modem output power and in extreme cases cause brown out events and resets. Users are encouraged to check/calculate the voltage drop in the cables that they are using. It is important that the modem be connected to a supply capable of maintaining 5V under load.

Note supply current requirement varies with the RF output power setting but a guideline minimum of a 1A supply current limit is recommended when operating the modem at 30dBm transmit power.

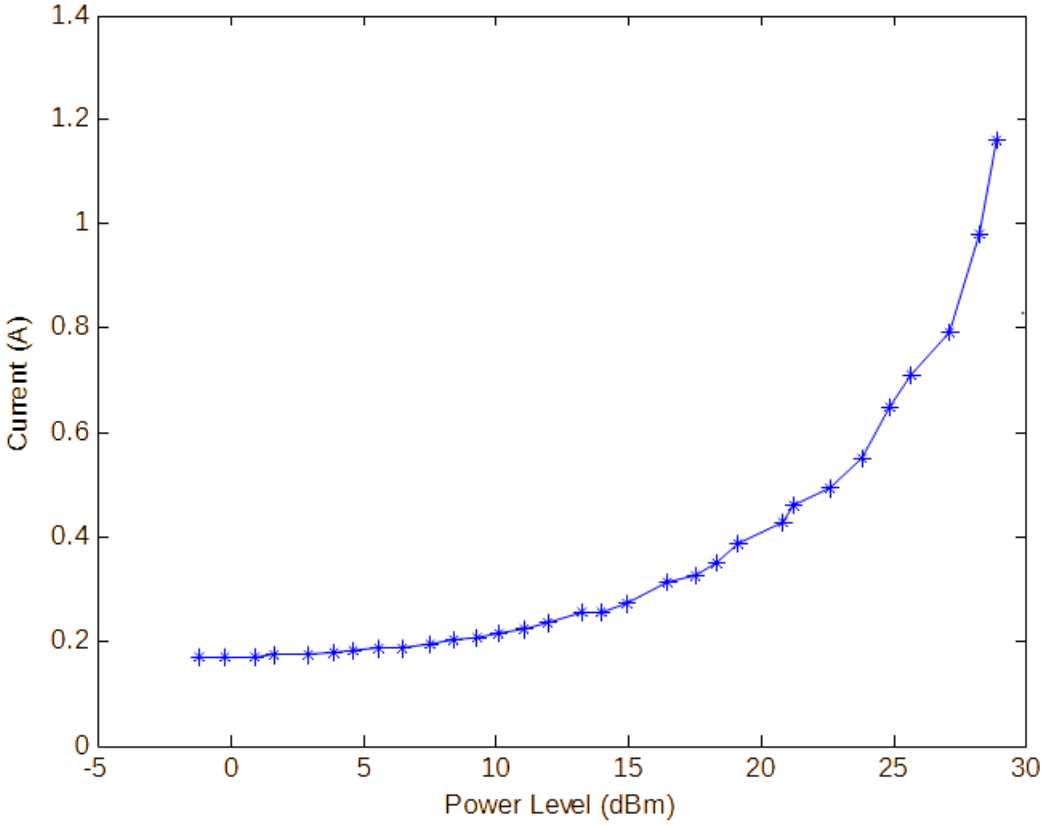

Figure 37: Current draw from 5V supply verses RF transmit power level

11.2 Thermal Management

RFD x series modems, except for bare variants, are 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 advisable to mount the modems in a location where airflow is able to dissipate this heat from the modem.

Note that 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 that the reduction in duty cycle associated with the thermal protection will cause a decrease in transmission throughput of the affected modem.

Note that it is not advised to rapidly cool a hot modem with water, alcohol, electronics freeze spray etc. as this could cause damage to solder joints and other components due to thermal shock.

12 Physical dimensions

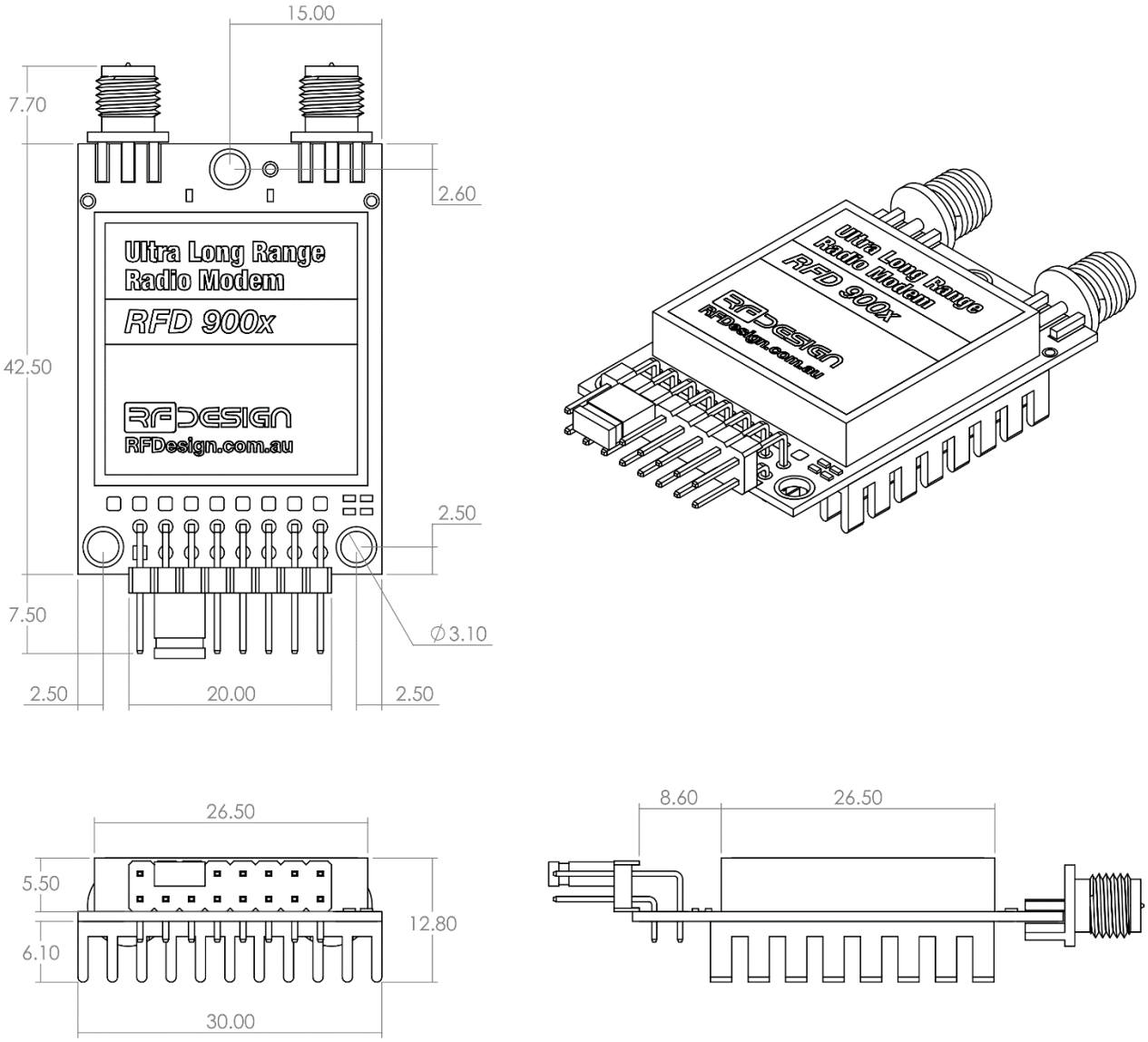

Figure 38: x series modem dimension drawing

Note all dimensions have a +/- 0.1mm tolerance.

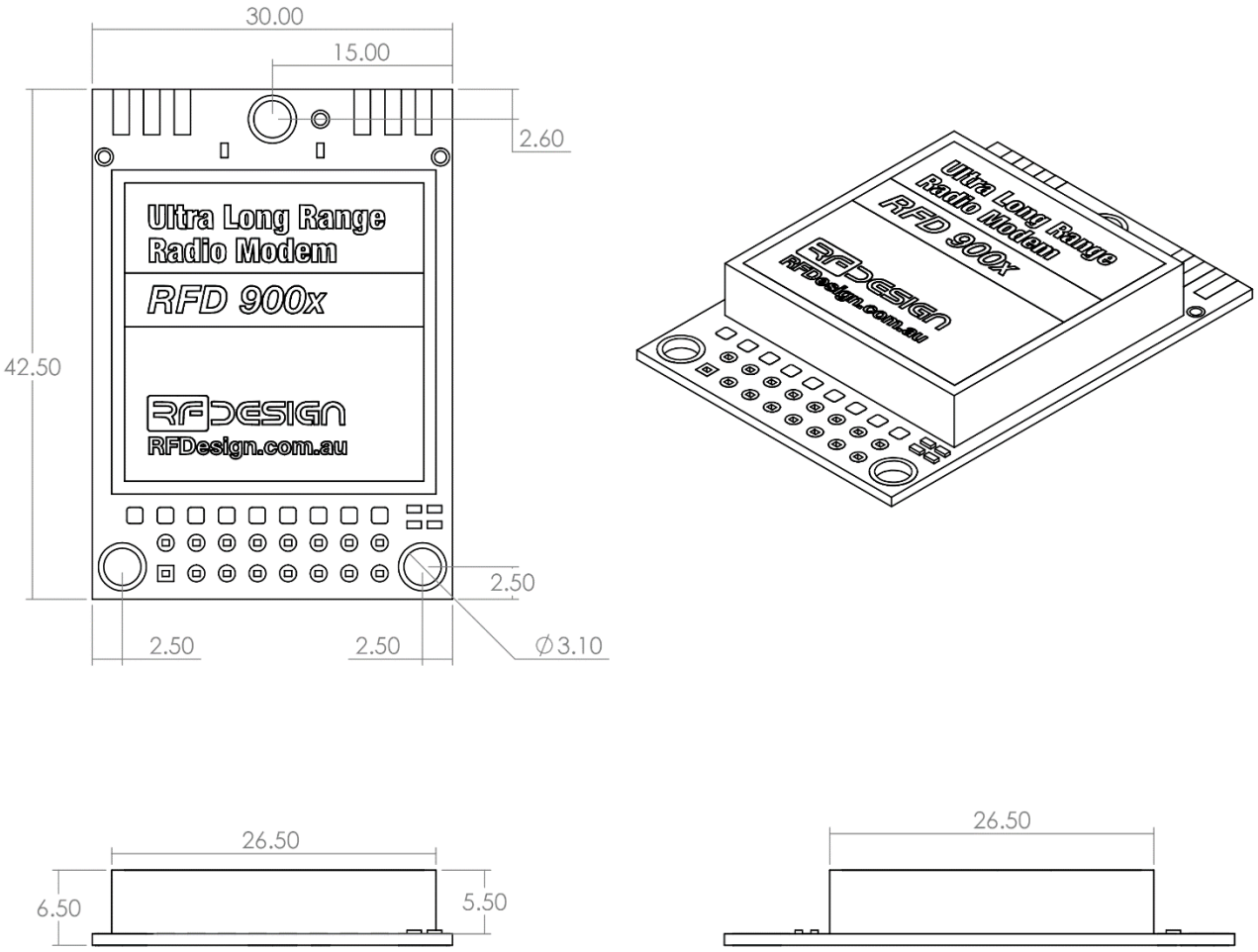

Figure 39: x series bare modem dimensions

Note all dimensions have a +/- 0.1mm tolerance.

Modem Model	Weight
x	14g (+/- 0.5g)
x bare	7g (+/- 0.5g)

13 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

14 Glossary

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 (aka LoS): Line of Sight. This refers to the distance that a radio signal can reach uninterrupted by obstructions or the radio horizon.
PPM: Pulse Position Modulation. This is an encoding standard used by radio controller to send data about the position of multiple servo motors.
SBUS: Serial Bus protocol created by Futaba. This is an encoding standard used by radio controller to send data about the position of multiple servo motors.
AES: Advanced Encryption Standard. A data encryption protocol meeting the specifications established in the ISO/IEC 18033-3 standard.
RP-SMA: Reverse Pole Subminature type A. A common form of RF connector on consumer electronics. It offers 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. This is an indication of 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.
RTS: Request to Send. UART hardware flow control flag.
CTS: Clear to Send. UART hardware flow control flag.
UART: Universal Asynchronous Receive Transmit. Hardware that manages serial data transfer between connected devices.
XMODEM: An older standard of file transfer protocol which is relatively simple to implement.
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 synonymous with 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 minimise interference. An RF spectrum allocation into narrow RF channels and the system then hops through those channels.
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 extra data to mathematically determine the correctness of a decoded signal.
RFD: RF Design. The Australian company who designed, build and support the x series modems among other products.

15 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	09/04/24	Major revision and update to reflect changes in hardware and software behaviours and provide more technical details.
2.1	08/01/26	Updated regulatory compliance standards to include new BR variant and added “General Cautions” section