RFD900ux/-SMT and RFD868ux/-SMT Radio Modem Datasheet

Long-range radio data modem operating in the 902-928MHz or 868-870MHz frequency band

RFD900ux/RFD868ux

RFD900ux-SMT/RFD868ux-SMT

Features

- Out of the box RF communications.
- Air data rate speeds of up to 224kbps
- Diversity antenna support
- Weight of 8g (ux) or 3.5g (SMT)
- Outdoor RF line-of-site range of 40km or more depending on antenna configuration
- USART interface
- Status LED

Applications

- Telemetry link
- UAV control
- Remote weather station
- House automation
- Long range RC
- Industrial and machine to machine communication

Operational

- Operating voltage: 5V, I/O Voltage (3.3V)
- Temperature range: -40°C to +85°C
- SMT Dimensions of 21 x 29 x 4.2mm
- ux Dimensions of 21 x 33 x 10.65mm
- Current consumption:
  TX mode: 1A peak at +30dBm,
  RX mode: 45mA (typical))

RFDesign Pty Ltd
7/1 Stockwell Place
Archerfield, QLD 4108
rfdesign.com.au

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1 Key features

RFD900/868ux modem family provides compact and yet powerful data communication. The key features are:

- No configuration required for out of the box RF communications.
- Operating frequency range of 902 – 928MHz or 865 - 870MHz
- Outdoor RF line-of-site range of 40km or more depending on antennas and conditions
- Air data rate speeds of up to 224kbps
- Automatic antenna port diversity
- Operating temperature of -40 to +85 degrees Celsius

Compliances and Worldwide Acceptances:

The RFD900ux(-SMT) modem is compliant to AS4268:2012, NZ GURL 2017, FCC 15.247 and RSS-247 Issue 2. Only the region locked versions of the modems are compliant.

The RFD868ux(-SMT) modem is compliant to EN300220, EN301489, and EN62311. Only the region locked versions of the modems are compliant.

Modem Variants	
Model	**Country Code Suffix**
RFD900ux and RFD900ux-SMT	None: Unlocked fully user configurable version for the 902-928 MHz band
	AU: Restricted settings and compliance for Australia
	NZ: Restricted settings and compliance for New Zealand
	US: Restricted settings and compliance for the United States of America and Canada
RFD868ux and RFD868ux-SMT	None: Unlocked fully user configurable version for the 865-868 MHz band
	EU: Restricted settings and compliance for the European Union
	IN: Restricted settings and compliance for India

Table 1- 1: Variant code table

2 Specifications

Performance	
Supported RF Data Rates	12, 56, 64, 100, 125, 200, 224, 500[1] and 750kbps[1]
Indoor Range	500m – 1km
Line-Of-Sight Range	40km or more depending on antennas
Transmit Power	0 to 30dBm in 1dBm steps
Receiver Sensitivity	108dBm @ 10^{-5} BER 12Kbps

Table 2- 1: Basic performance data

Features				
Serial Data Interface	+3.3V nominal, +3.5V ABS Max			
Configuration Method	AT Commands, APM Planner, RFD Configuration Tool			
Frequency Band[2]	Modem Type	Frequency band	Number of bands	Max power (dBm)
	900ux/-SMT Unlocked	902MHz - 928MHz	N/a	30
	AU locked	915MHz - 928MHz	2	30
	NZ locked	920.75MHz -927.25MHz	N/a	30
	US locked	902MHz - 915MHz	2	30
	868ux/-SMT Unlocked	865MHz -870MHz	N/a	30
	EU locked	869.525MHz or 869.85MHz	2	27
	IN locked	865MHz - 867MHz	N/a	30
Interference Immunity	FHSS (Frequency Hopping Spread Spectrum)			
Serial Interface Data Rate	2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400, 460800, 1000000 bps			
Antenna Connection	2 x u.FL (ux) or castellated pads (SMT) for diversity switched ports			
GPIO	1 pin (ux) 6 pads (SMT) (Digital IO, 1 settable as PPM/SBus capable)			
Compliance Standards	FCC Part 15.247, AS/NZS 4268:2012			

Table 2- 2: Basic feature summary

Networking and Security		
Addressing Options	Network ID: 0 –255	
Band Configuration	Modem Type	Number of Channels
	900ux(SMT) Unlocked	User settable
	AU locked	23
	NZ locked	25
	US locked	51
	868ux(SMT) Unlocked	User settable
	EU locked	2
	IN locked	7
Supported Network Topologies	Point-to-point, multipoint[3], and asynchronous non-forwarding mesh[3]	
Encryption	AES 128 bit with user settable key	

Table 2- 3: Network options

Power Requirements	
Supply Voltage	+5V nominal (+5V min, +5.5V Max, +6V ABS Max),
Transmit Current	1A peak at 30dBm
Receive/Standby Current	45mA typical

Table 2- 4: Power ratings and requirements

[1] High RF data rates are for experimental purposes only

[2] Locked modems may have further restrictions on RF power levels, duty cycle and RF data rates and other settings depending on country

[3] Only available in separate firmware versions available on RF design website (see useful links) and not compatible with locked versions

3 Output power levels

Many countries have different legal power levels. Be sure to operate within the legal power limits of the country that you are operating in. The RDF900/868ux modem modem can support the power levels between 0dBm and 30dBm in 1dBm steps. Formula 3-1 can be used to convert the power in dBm into milliwatts.

$$P_{mW} = 10^{(P_{dBm}/10)}$$

Formula: 3-1

To calculate Effective Isotropic Radiated Power (EIRP) of the whole system including antennas you can use the formula 3-2 below:

$$EIRP(dBm) = Transmitpower(dBm) – Cableloss(dB) + AntennaGain(dBi)$$

Formula: 3-2

The user is responsible for adhering to local limits for frequency and power of the modems. Local rules may vary.

For example the FCC limit for EIRP is 4 Watts, or 36dBm for frequency hopping radios in the ISM 900 MHz band and the Australian EIRP limit is 30dBm as defined by ACMA.

4 Performance characteristics

Figure 4-1 shows how the output power of the RDF900/868ux modem varies with supply voltage when the output power is set to +30dBm.

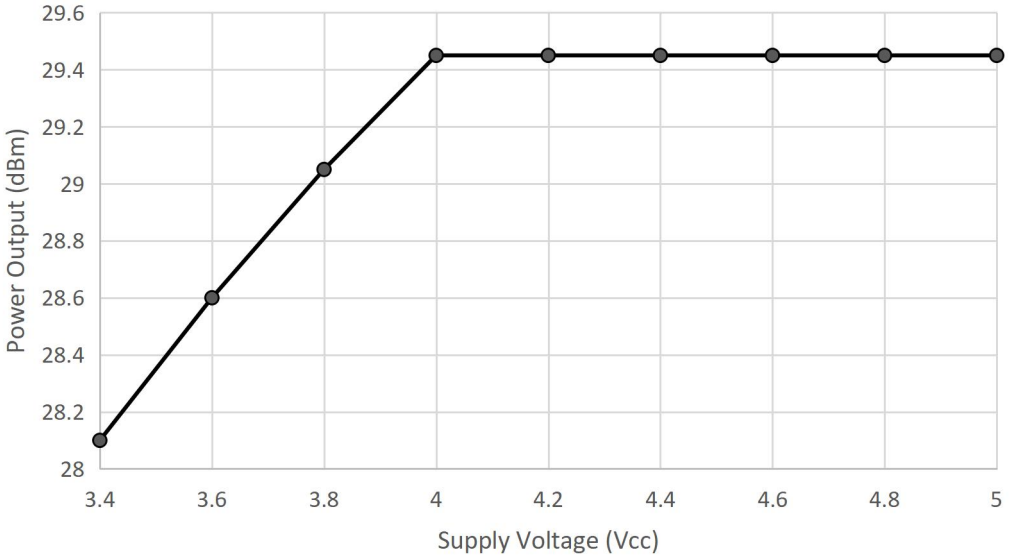


Figure 4- 1: Output power vs. input supply voltage

Figure 4-2 shows how the current consumption of the RDF900/868ux modem varies with the transmit power level.

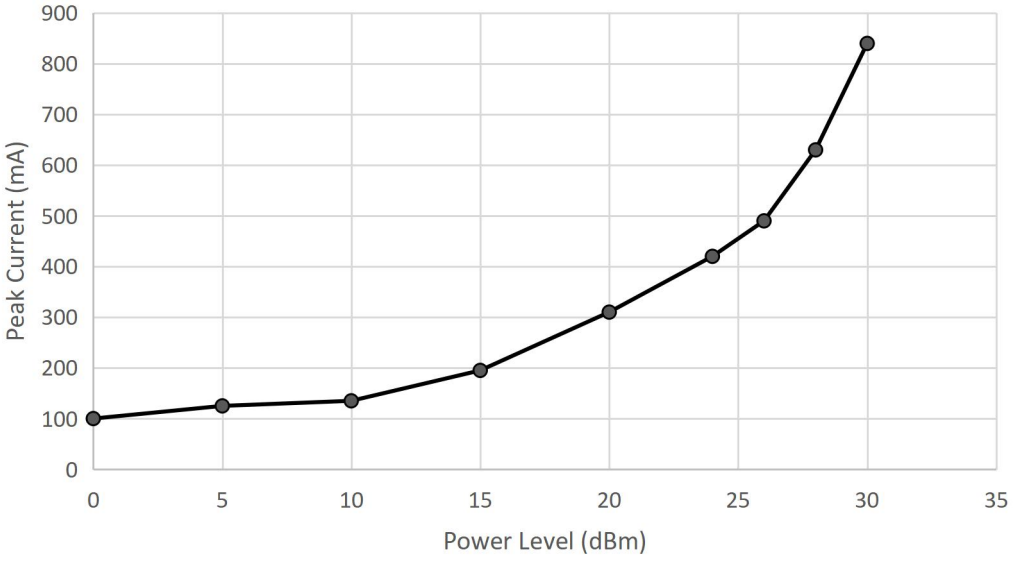


Figure 4- 2: Current consumption vs. TX power level

The table below is used to determine the sensitivity of the RDF900ux(-SMT)/868ux(-SMT) modem according to the selected air data rate. The link budget is directly affected by the sensitivity, and therefore the communication range also varies. The sensitivity values in the table are based on a 10^{-5} BER.

Air data rate	Sensitivity @ 10-5 BER
12 kbps	-108 dBm
56 kbps	-105 dBm
64 kbps	-103 dBm
100 kbps	-100 dBm
125 kbps	-102 dBm
200 kbps	-97 dBm
224 kbps	-93 dBm

Table 4- 1: Receiver sensitivity vs Air data rate

Received power levels can be estimated from the modem's RSSI figure. RSSI values may be converted back to received dBm by formula 4-1. Systems approaching the limits found in table 4-1 may experience interruption in link or increased data error.

$$\mathrm{dBm} = \mathrm{N}/2 - 152$$

Where N is the RSSI value given by AT&T=RSSI command or by the modem tools RSSI graph

Formula 4-1: Received power in dBm from RSSI value

5 Pin signals and layout

5.1 RFD900ux/RFD868ux

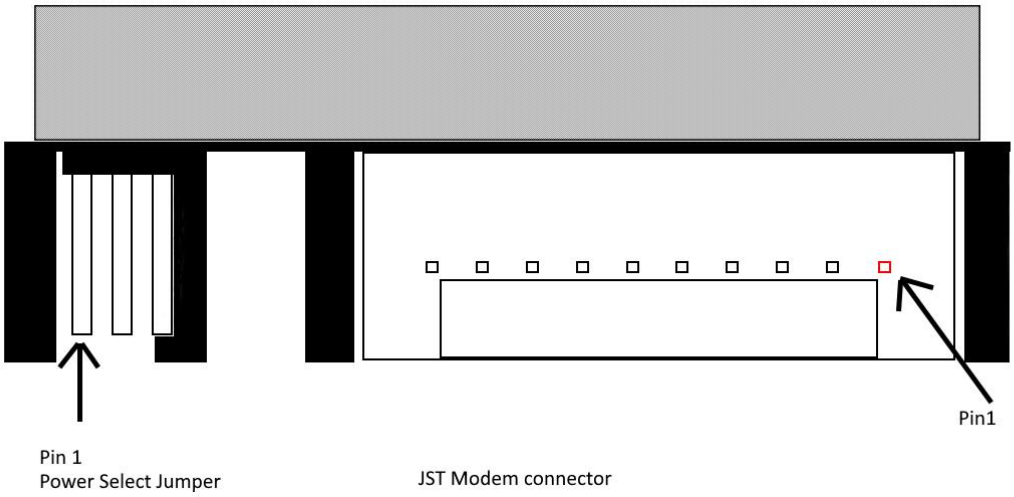


Figure 5-1 Connector diagram rear of ux modem

Pin #	Name	Description	Max Voltage
1	V External	External 5V supply, connected to pin 2 of JST connector.	5V
2	Supply	The supply pin for the modem	5V
3	V Standard	5V supply, connected to pin 5 of JST connector, for supply from a Pixhawk or FTDI	5V

Table 5-1: Pin functions for power jumper

Pin #	Name	Direction	Description	Max Voltage
1	GND	-	Ground	0V
2	V External	Input	External 5V supply	5V
3	GND	-	Ground	0V
4	GPIO1_EXT	I/O	Digital I/O, PPM I/O	3.3V
5	V Standard	INPUT	Pixhawk/FTDI 5V supply	5V
6	RX	Input	UART Data In	3.3V
7	TX	Output	UART Data Out	3.3V
8	RTS	Output	Request to send	3.3V
9	CTS	Input	UART Clear to send	3.3V
10	GND	-	Ground	0V

Table 5-2: Pin ux modem JST connector

Note: A jumper must be fitted between pin 1 and 2 (external supply) or pin 2 and 3 (Pixhawk/FTDI supply) of the power select in order to power the modem.

5.2 RFD900ux-SMT/RFD868ux-SMT

Figure 5- 2: Physical pin layout (top view) of the RDF900ux-SMT/868ux-SMT modem Radio Modem

Pin #	Name	Direction	Description	Max Voltage
1	VUSB	Input	Power supply from USB	5V
2	USB_DM	Input	USB Data - [1]	
3	USB_DP	Input	USB Data + [1]	
4	SWO	Output	SWD debug output	3.3V
5	P3.3	I/O	Digital I/O	3.3V
6	P3.4	I/O	Digital I/O	3.3V
7	P3.5	I/O	Digital I/O	3.3V
8	GND	-	Ground	0V
9	GND	-	Ground	0V
10	+3V3		LDO output	3.3V
11	GND	-	Ground	0V
12	GND	-	Ground	0V
13	ANT1	-	Antenna 1	-
14	GND	-	Ground	0V
15	GND	-	Ground	0V
16	ANT2	-	Antenna 2	-
17	GND	-	Ground	0V
18	GND	-	Ground	0V
19	+5V		Power Supply	5V
20	GND	-	Ground	0V
21	GPIO0	I/O	Digital I/O	3.3V
22	GPIO1	I/O	Digital I/O, PPM I/O	3.3V
23	GPIO2	I/O	Digital I/O	3.3V
24	GPIO3	I/O	Digital I/O	3.3V
25	RX	Input	UART Data In	3.3V

26	TX	Output	UART Data Out	3.3V
27	RTS	Output	Request to send	3.3V
28	CTS	Input	UART Clear to send	3.3V

Table 5-3: Pad functions for ux SMT modem

[1]The USB functionality will be available in future updates

In case there is a need to force the modem into boot mode:

On the ux short the pad on the top right rear of the modem to the shield during power up

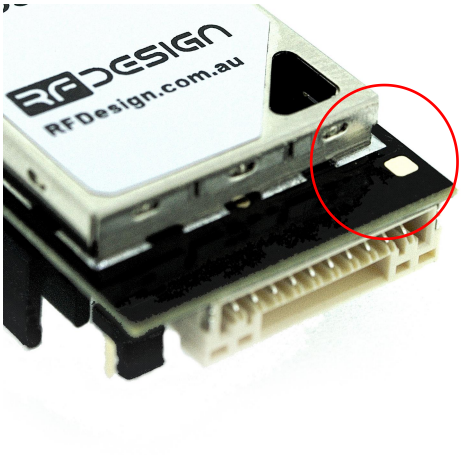


Figure 5- 3: Red circle highlighting the pad to short to shield on power up for bootloader

On the SMT, pull the SWO pad to the ground during power up.

The on-board LED will become solid red when in bootloader mode.

6 Recommended PCB Design for SMT Modems

6.1 Module Footprint

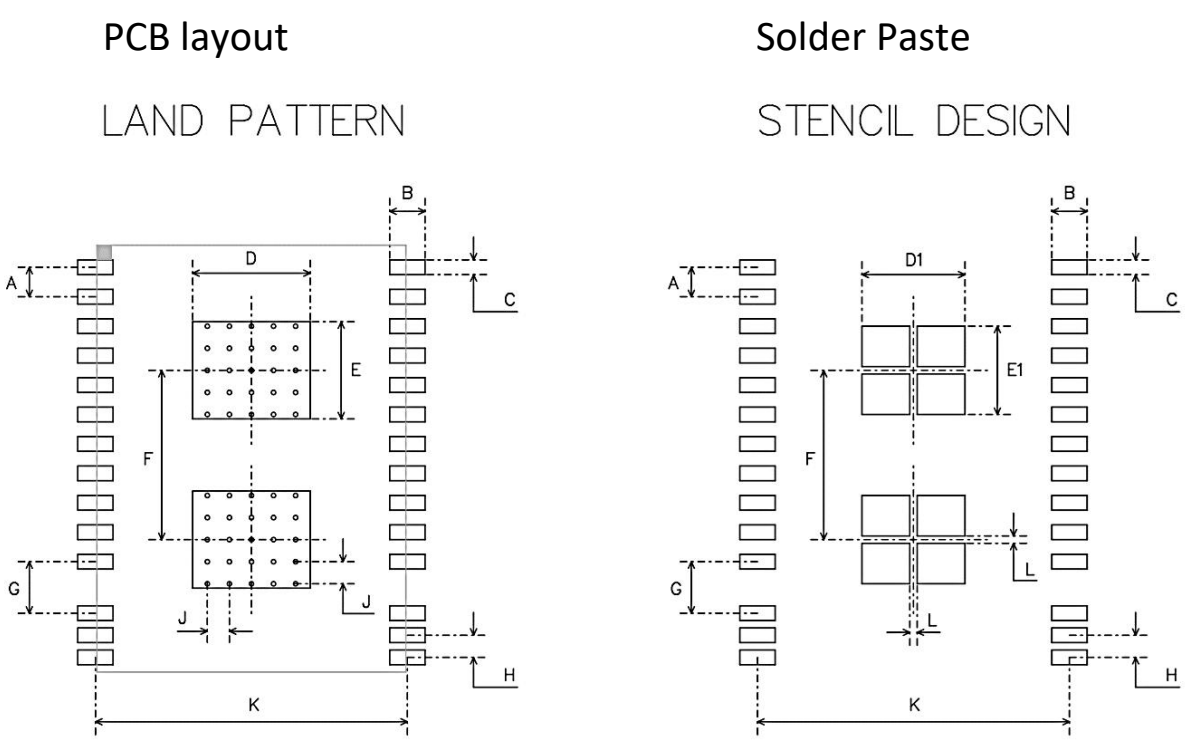


Figure 6-1: Pad functions for ux-SMT modem

Symbol	Dimension (mm)	Symbol	Dimension (mm)
A	2	F	11.5
B	2.4	G	3.5
C	1	H	1.5
D	8	J	1.5
D1	7	K	21.2
E	6.6	L	0.5
E1	6	Vertical A to E	7.0

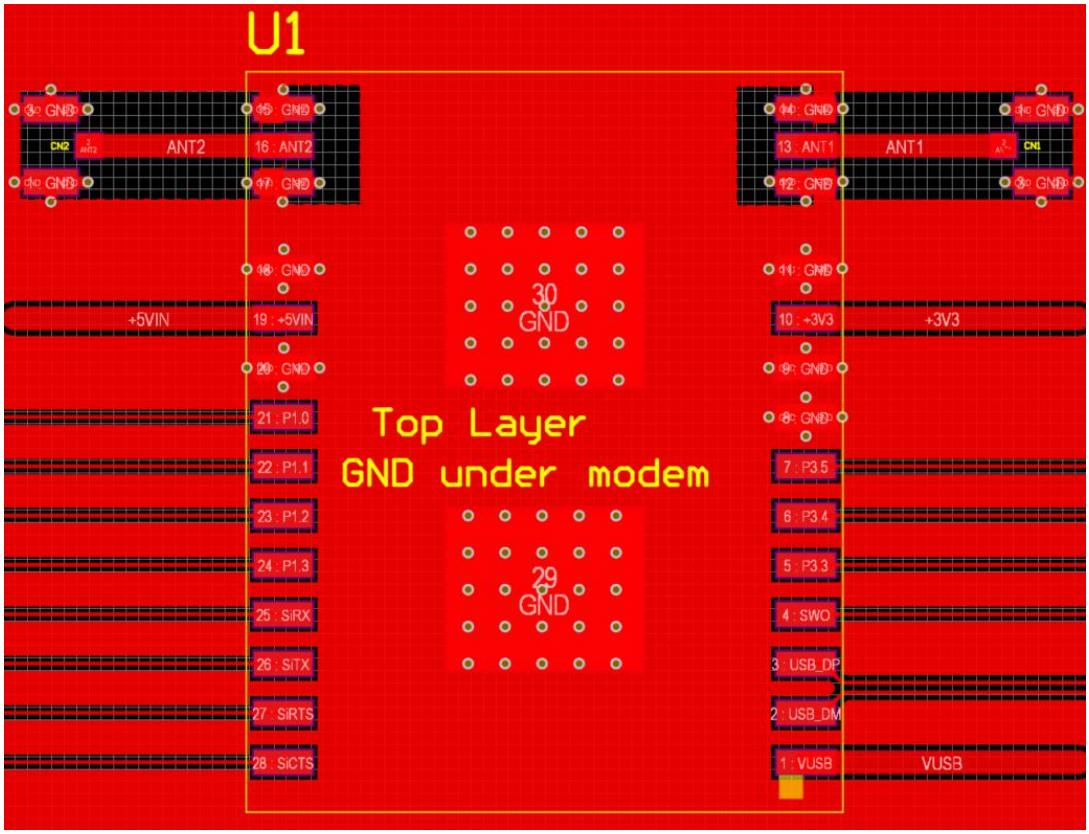
Table 6-1: Pad dimensions for ux-SMT modem

Note the two large central pads provide for thermal dissipation and should be electrically connected to ground

An Altium component is available on the RF Design website (see useful links)

6.2 PCB Layout Guidelines

Some guidelines should be followed as to ensure the PCB design meets the RDF900/868ux-SMT modem thermal dissipation and electromagnetic compatibility requirements. The proposed layout can be used as a starting point and it is not guaranteed to comply with EM immunity and emissions regulations as is. The PCB designer is expected to calculate the RF antenna track widths to match 50Ω impedance outputs. This will vary depending on the host PCB layer stack up and dielectric constant.



7 Physical dimensions

7.1 RFD900ux/RFD868ux

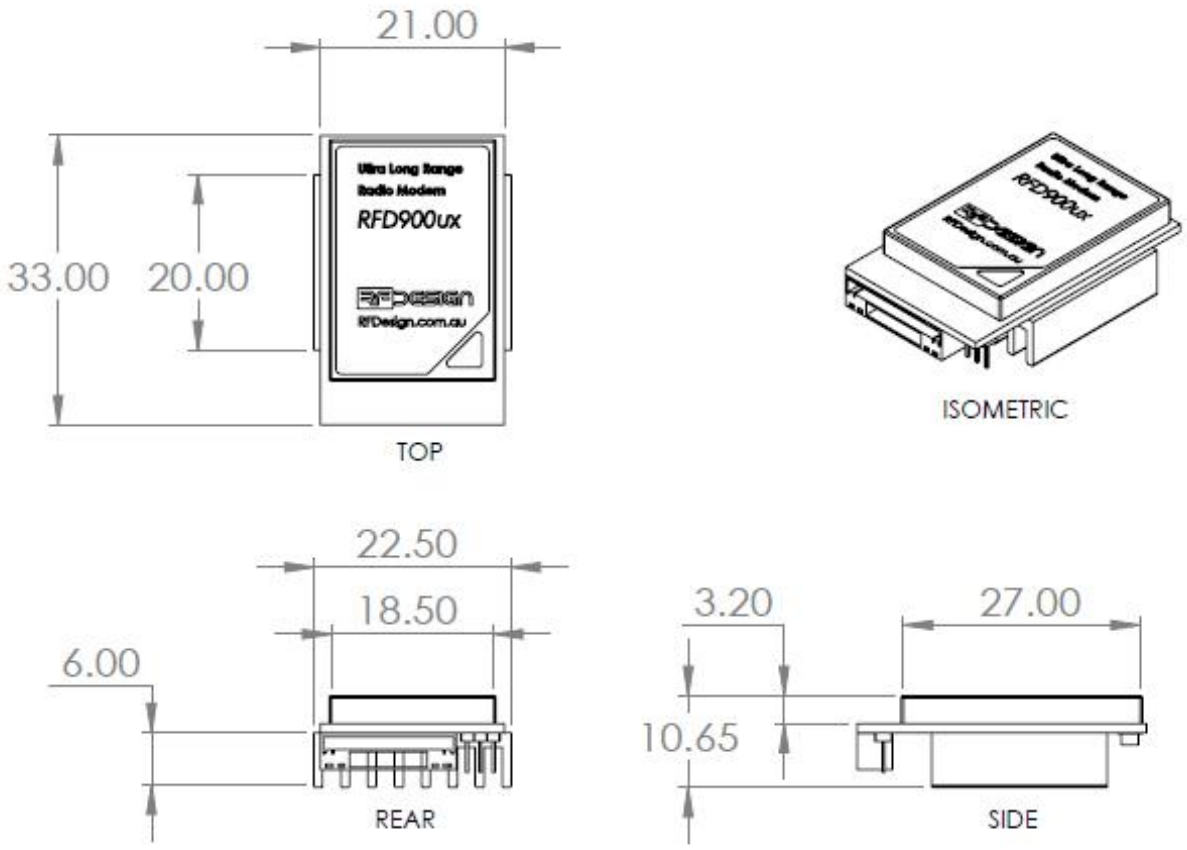


Figure 7-1 Dimensional drawing of RFD900ux/RD868ux modem

7.2 RFD900ux-SMT/RFD868ux-SMT

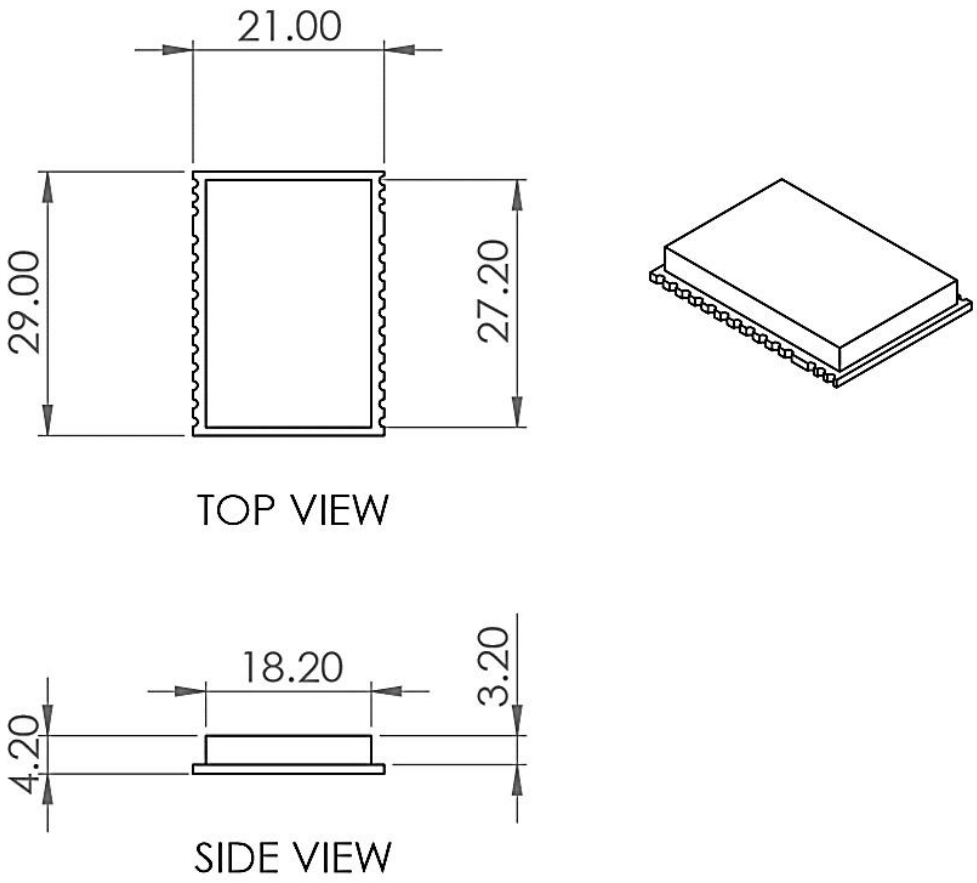


Figure 7-2 Dimensional drawing of RFD900ux-SMT/RFD868ux-SMT modem

8 Software/GCS Support

The software solution (see “Useful Links”) is a custom development, by RF Design, of the open source development called “SiK” that was created by Mike Smith and improved on by Andrew Tridgell.

A bootloader and the RFD Tools make it easy to change settings and upgrade modem firmware via the serial port. This functionality is also available in the current version of Mission Planner.

The Radio Modem is also settable via AT commands. These can be used to change parameters such as power levels, air data rates, serial speeds, GPIO pins etc. This requires a terminal programme such as Hyperterminal or Coolterm.

The default serial port settings of the standard SiK peer to peer firmware are as follows:

- 57600bps baudrate
- No parity
- 8 data bits
- 1 stop bit

The Radio Modem firmware features can be examined in more detail by reading the appropriate datasheets on the RF Design website (see useful links)

9 Accessories

A number of accessories and ancillary items are available to support different functions of the modems. These can be found on the RF Design store (see useful links)

9.1 Antennas and adapters

All modems are designed for RF loads of 50 ohm impedance at the operating frequency. This should be considered when choosing suitable antennas. RF Design sells a number of suitable options on our web store (see useful links). The RFD900ux and RFD868ux modems feature two u.Fl connectors for RF output. There is a range of antennas options available for these modems. Models such as the standard 3dBi dipole will require the addition of a u.Fl to RPSMA adapter cable (figure 9-1). While the RFD Flex1 (figure 9-2) and Flex2 (figure 9-3) antennas are available in u.Fl variant. The antenna options for the RFD900ux-SMT and RFD868ux-SMT modems will be determined by the designer of the carrier PCB. There are also various options for extension coaxial cables.

Figure 9-1: u.Fl to RPSMA adapter cable

Figure 9-2: Flex1 with u.Fl

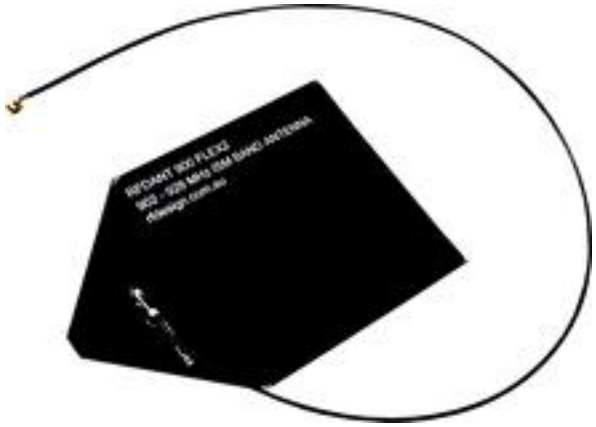


Figure 9-3: Flex2 antenna with u.Fl

9.2 Cables

The RFD900ux and RFD868ux modems feature a 10 pin JST locking connector for interfacing to breakout cables.

Available options include:

- PIXH2 to RFD900ux Telemetry cable: With 6 pin JST connector for Pixhawk 2 Telemetry port, Two pin connector for external power and Three pin servo connector for PPM signal. This is available in 150 mm and 300 mm length

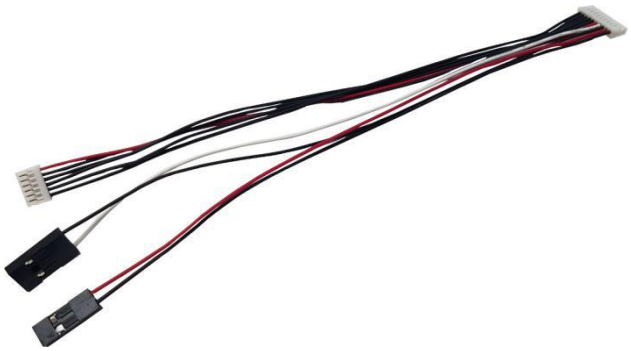


Figure 9-4: PIXH2 to RFD900ux Telemetry cable

- 900ux to 8 way socket cable: With 8 pin 0.1” pitch socket for interfacing with all but the external supply pins of the modem. Using the supplied pin header the cable can be used to interface to an FTDI lead by aligning with the red wires of both cables.

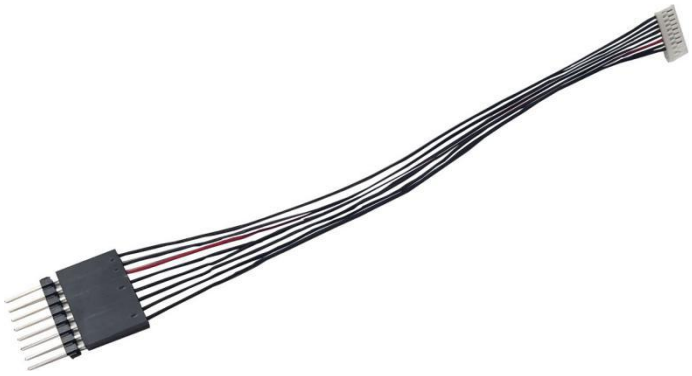


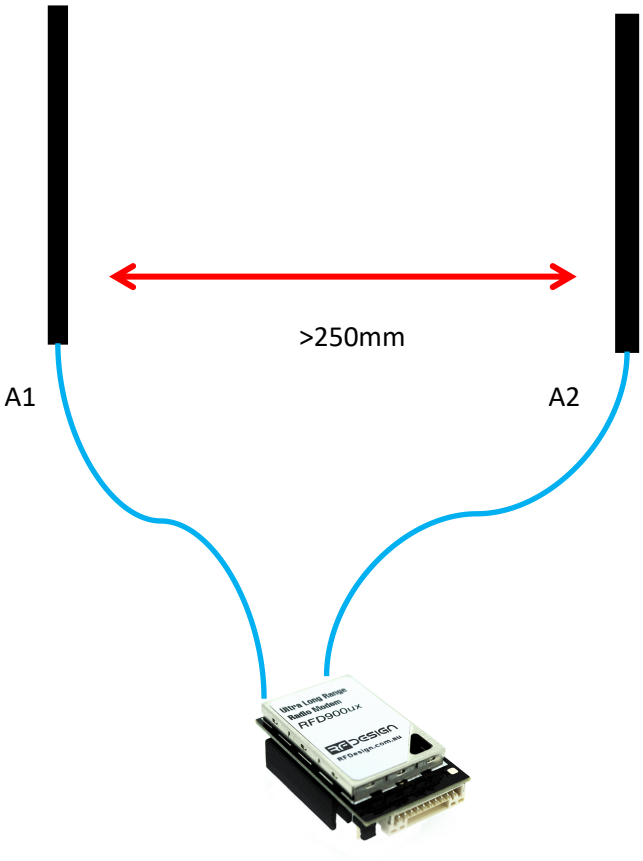
Figure 9-5: RFD900ux to 8 way socket cable

10 Diversity

The RDF900ux(-SMT)/868ux(-SMT) modem has two antenna ports and firmware which supports diversity operation of antennas. During the receive sequence the modem will check both antennas and select the antenna with the best receive signal. The antenna selected during receive is then also used for subsequent transmission. In the case of only one antenna connected, it will automatically select the port with the antenna connected. Testing by Silicon Labs has shown that link budgets can be improved up to the order of 8dB by employing a diversity scheme.

10.1 Spatial diversity

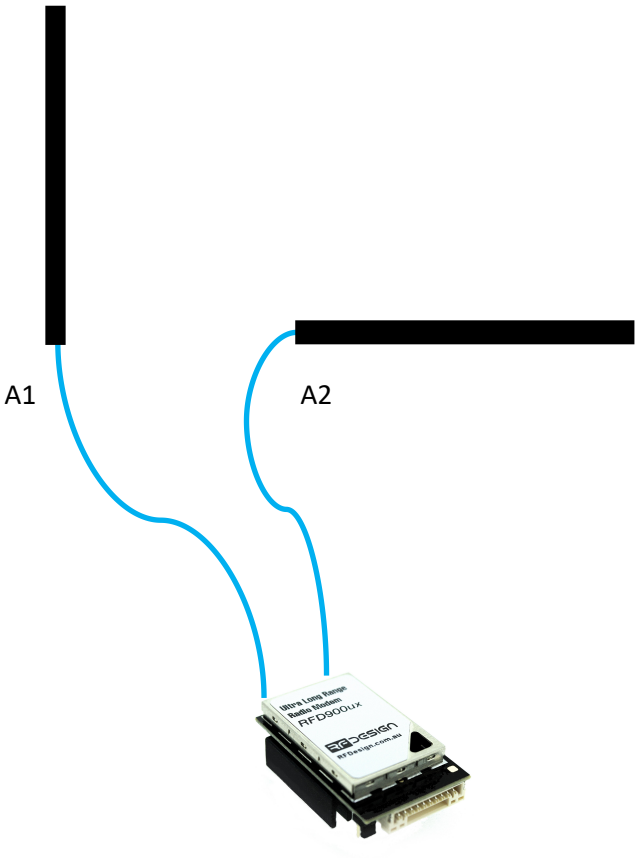
Spatial diversity is the case where the antennas are separated by some distance from one another. It is recommended that two antennas connected to the RDF900/868ux modem modem be separated by at least 25cm, more if possible.



Modem

10.2 Polarisation diversity

Polarisation diversity is the case where the antennas are perpendicular to each other. i.e. one vertical, and one horizontal. This is effective in reducing multipath effects which affect one or the other polarisation. This scheme also helps to maintain the link between non-static objects such as aircraft performing acrobatics by increasing the likelihood that one antenna will maintain the same polarisation as an antenna on the other side of the link.



Modem

11 Network options

The Radio Modems can be implemented in either simple pair (peer to peer SiK), multipoint network (MP Firmware Only), or asynchronous non-forwarding mesh. Firmware for the latter two options are available for download in the website (see “Useful Links”).

11.1 Simple pair aka peer to peer SiK (factory default)

The out-of-the-box firmware of the radio modem is set to work in simple pair mode. If you purchased a bundle, you are only required to connect the antennas and power supply to initiate the link. As soon as the pair synchronises, the on-board LED will become solid green.

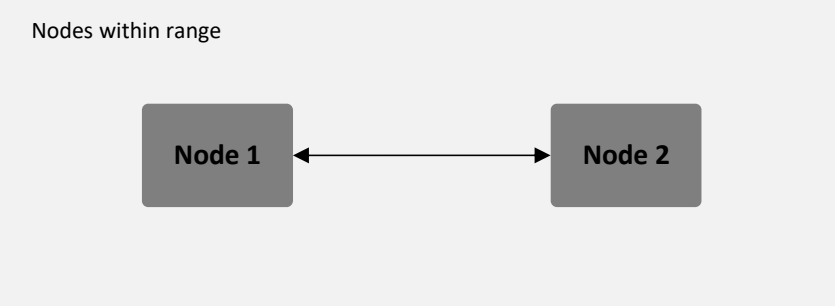


Figure 9- 1:Simple pair mode

11.2 Multipoint network

This mode requires the Multipoint firmware to be loaded into the all network radios. Check section “Useful links” for the download link and refer to section “RFD900x Flash Programmer tool” to flash the multipoint firmware. Refer to the “Multipoint user manual” for setup and usage instructions.

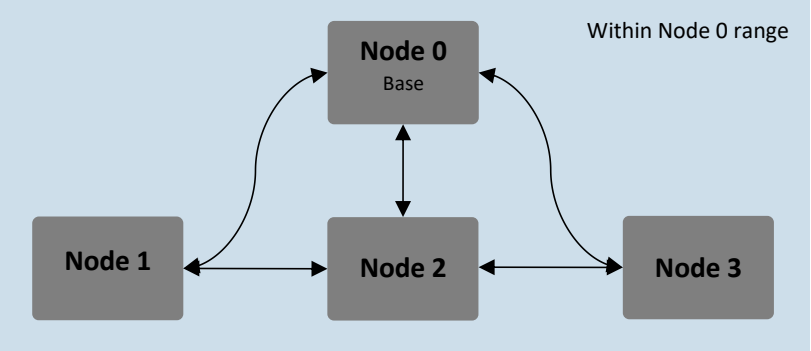


Figure 9- 2: example of multipoint network diagram

11.3 Asynchronous non-forwarding mesh

The asynchronous non-forwarding mesh firmware offers a straightforward communication option that allows the user to quickly transmit and receive data across a great distance between two nodes

or more. Figure 4-2 depicts this communication topology. As long as all the nodes are within range and have compatible parameters, communication between them will succeed.

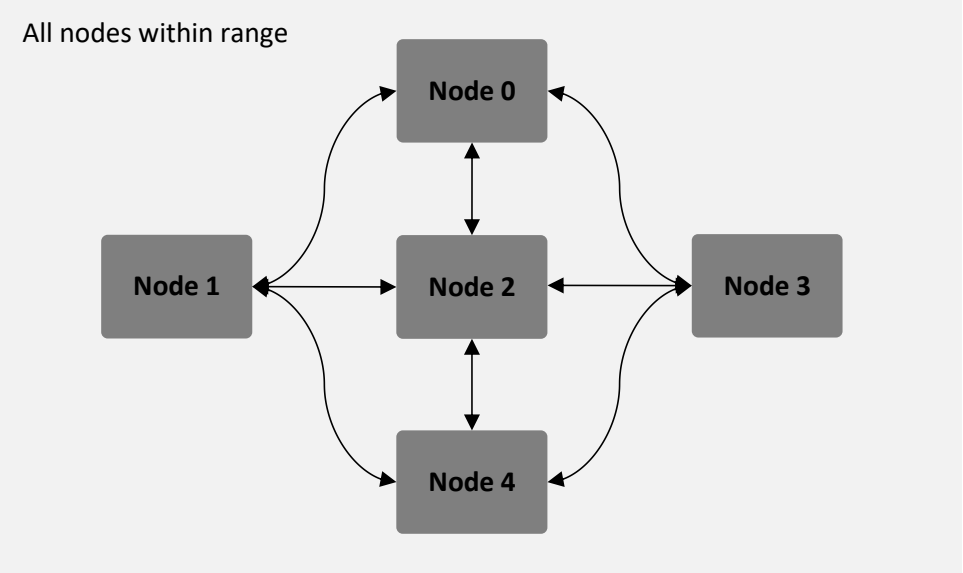


Figure 9- 3: Asynchronous non-forwarding mesh topology

12 Frequently asked questions (FAQ)

How many antennas do I need to use?

One is the minimum. Two is recommended.

What do I need to upload the firmware or to change the modem configuration?

Download the latest firmware (see “Useful Links”). Download the RFD900x Modem Tools (see “Useful Links”). Connect the FTDI cable to the modem and to a computer. Use the RFD900x Modem Tools to upload the latest firmware or to change the modem configuration (see “RFD900x Modem Tools User Manual”).

What should I do if the Tools keep displaying error messages?

- Make sure to connect the FTDI cable firmly into the modem.
- Make sure you choose the correct COM port from the COM dropdown box and the correct baud rate.
- Try at least twice moreand if it still doesn’t work, disconnect and reconnect the modem.
- Should it still fail, open a terminal programme and perform a loop back test on the cable.
  Short the orange and yellow pins of the FTDI cable with something like a paper clip.
  Then using the terminal programme connect to the COM of the cable then type some text if this text is not returned then it indicates there is likely a fault with the FTDI cable where possible retry the upload process with a new cable.

Other Problems

Consult the Modem Support FAQ in the useful links section

13 Useful links

RDF900ux(-SMT)/RFD868ux(-SMT) modem Firmware

The firmware is the same for stand-alone and SMT Radio Modems and can be found at.

http://files.rfdesign.com.au/firmware/

RFD TOOLS

http://files.rfdesign.com.au/tools/

Documentation

http://files.rfdesign.com.au/docs/

FAQ

http://files.rfdesign.com.au/Files/documents/Modem%20Support%20FAQs%20V1.1.pdf

Store

http://store.rfdesign.com.au

FTDI Cable documentation

http://www.ftdichip.com/Support/Documents/DataSheets/Cables/DS_TTL-232R_CABLES.pdf

14 Document revision history

Version	Date	Changes
1.0	20/08/2019	Release document
1.1	12/09/2019	Amended VBUS pin voltage
1.2	19/03/2020	Updated for ux-SMT and compliant versions