RFD900x and RFD868x
Radio Modem Datasheet

Long-range radio data modem operating in the 902-928MHz or 865-870MHz frequency band

Features

- Out of the box RF communications.
- Air data rate speeds of up to 500kbps
- Diversity antenna support
- Weight of 14g
- Outdoor line-of-site range of up to 40km
- USART interface
- Status LEDs

Applications

- Telemetry data
- 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
- Dimensions of 30mm x 57.7mm x 12.8mm
- Current consumption:
  TX mode: ~1A peak at +30dBm,
  RX mode: 60mA (typical)

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1 Key features

RFD900x 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
- Air data rate speeds of up to 500kbps
- Diversity antenna support
- Operating temperature of -40 to +85 degrees Celsius
- Dimensions of 30mm x 57mm x 12.8mm
- Weight of 14g

Compliances and Worldwide Acceptances:

The RFD900x 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 RFD868x modem is compliant to EN300220, EN301489, and EN62311, 865-867MHz unlicensed band in India. Only the region locked versions of the modems are compliant.

Modem Variants	
Model	**Country Code Suffix**
RFD900x	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
RFD868x	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

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	-111dBm @ 10^{-5} BER 12Kbps

Air data rate	Sensitivity @ 10-5 BER
12 kbps	-111 dBm
56 kbps	-107 dBm
64 kbps	-105 dBm
100 kbps	-102 dBm
125 kbps	-104 dBm
200 kbps	-98 dBm
224 kbps	-94 dBm

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	1	30
	US locked	902MHz - 915MHz	2	30
	868ux/-SMT Unlocked	865MHz -870MHz	N/a	30
	EU locked	869.525MHz or 869.85MHz	2	27 or 7
	IN locked	865MHz - 867MHz	1	30
Interference Immunity	FHSS (Frequency Hopping Spread Spectrum)			

Features	
Serial Interface Data Rate	2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400, 460800, 1000000 bps
Antenna Connection	2 x RPSMA diversity switched ports
GPIO	6 pins (Digital, PPM capable)
Compliance Standards	AS/NZS 4268:2012, NZ GURL 2017, FCC 15.247 and RSS-247 Issue 2 EN300220, EN301489, and EN62311, 865-867MHz unlicensed band in India[4]

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 up to 256 bit with user settable key	

Power Requirements	
Supply Voltage	+5V nominal (+5V min, +5.5V Max, +6V ABS Max),
Transmit Current	1A peak at 30dBm
Receive/Standby Current	60mA typical

[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). Locked versions will remain locked across different firmware types and versions. Not all firmware types are suitable for all modem versions.

[4] Applicable only to the appropriate locked modem versions.

3 Performance characteristics

Figure 3-1 shows how the output power of the RFD900x varies with supply voltage when the output power is set to +30dBm.

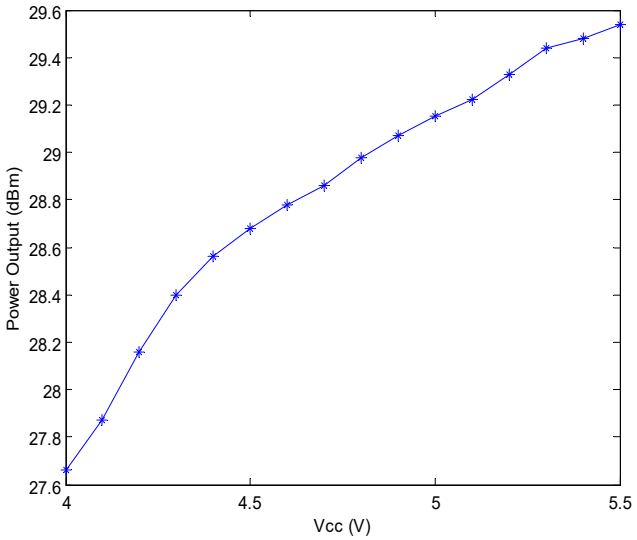

Figure 3- 1:Ouput power vs. input supply voltage

Figure 3-2 shows how the current through the RFD900x varies with the transmit power level. The current during transmission is shown by the 'High Level' plot and that during receive mode is shown by the 'Low Level' plot.

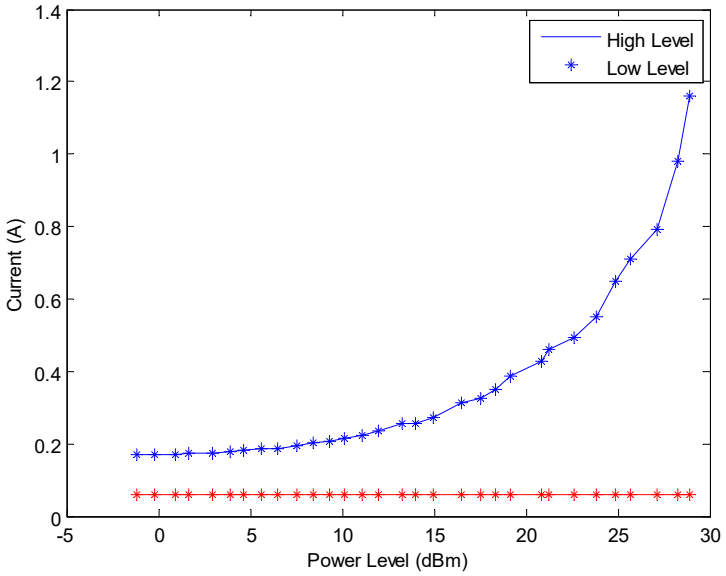

Figure 3- 2: Current consumption vs. TX power level

4 Pin signals and layout

Pin #	Name	Direction	Description	Max Voltage
1	GND	-	Ground	0V
2	GND	-	Ground	0V
3	CTS	Input	Clear to send	3.3V
4	Vcc	-	Power supply	5V
5	Vusb	-	Power supply from USB	5V
6	Vusb	-	Power supply from USB	5V
7	RX	Input	UART Data In	3.3V
8	GPIO5/P3.4	I/O	Digital I/O	3.3V
9	TX	Output	UART Data Out	3.3V
10	GPIO4/P3.3	I/O	Digital I/O	3.3V
11	RTS	Output	Request to send	3.3V
12	GPIO3/P1.3	I/O	Digital I/O	3.3V
13	GPIO0/P1.0	I/O	Digital I/O	3.3V
14	GPIO2/P1.2	I/O	Digital I/O	3.3V
15	GPIO1/P1.1	I/O	Digital I/O, PPM I/O	3.3V
16	GND	-	Ground	0V

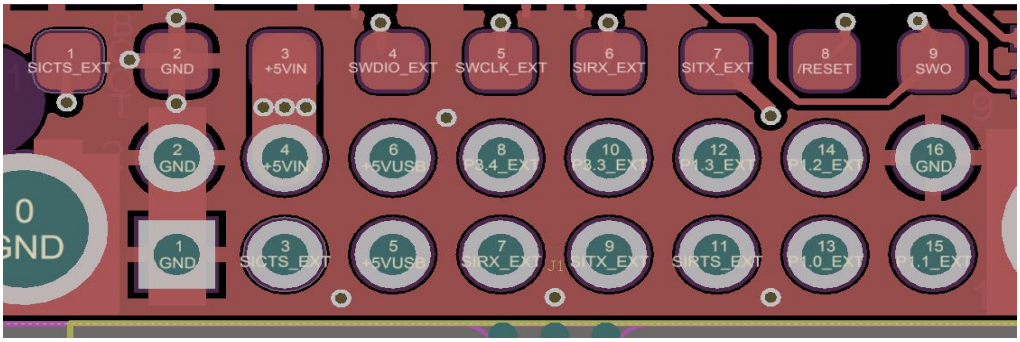

Figure 4-1: Physical pin layout of the RFD900x Radio Modem

GPIO pins will configure for 40kOhm pull down or pull up based on setting as input or output. They can sink or source approximately 5 mA each.

An FTDI cable (see “Useful Links”) is compatible with the RFD900x modem.

Note: Must be 3.3V logic and 5V supply.

Pin 1 of the FTDI cable (black wire) should connect to pin 1 of the RFD900x header, left most of the lower row. To power the modem from the +5V USB power, a jumper is needed to connect pins 4 and 6.

To power the modem from an external +5V supply, connect the power to pins 2 (GND) and 4 (+5V) the left most two pins of the upper row.

To force the modem into boot mode short pad 9, the right most of the row of pads in front of the pin header, to the shield or other ground on the modem as the modem is powered up. The on-board LED will become solid red when in boot mode at this point the short can be removed. The modem is then in a state ready to accept firmware.

Figure 4-2: Boot mode pad

5 Physical dimensions

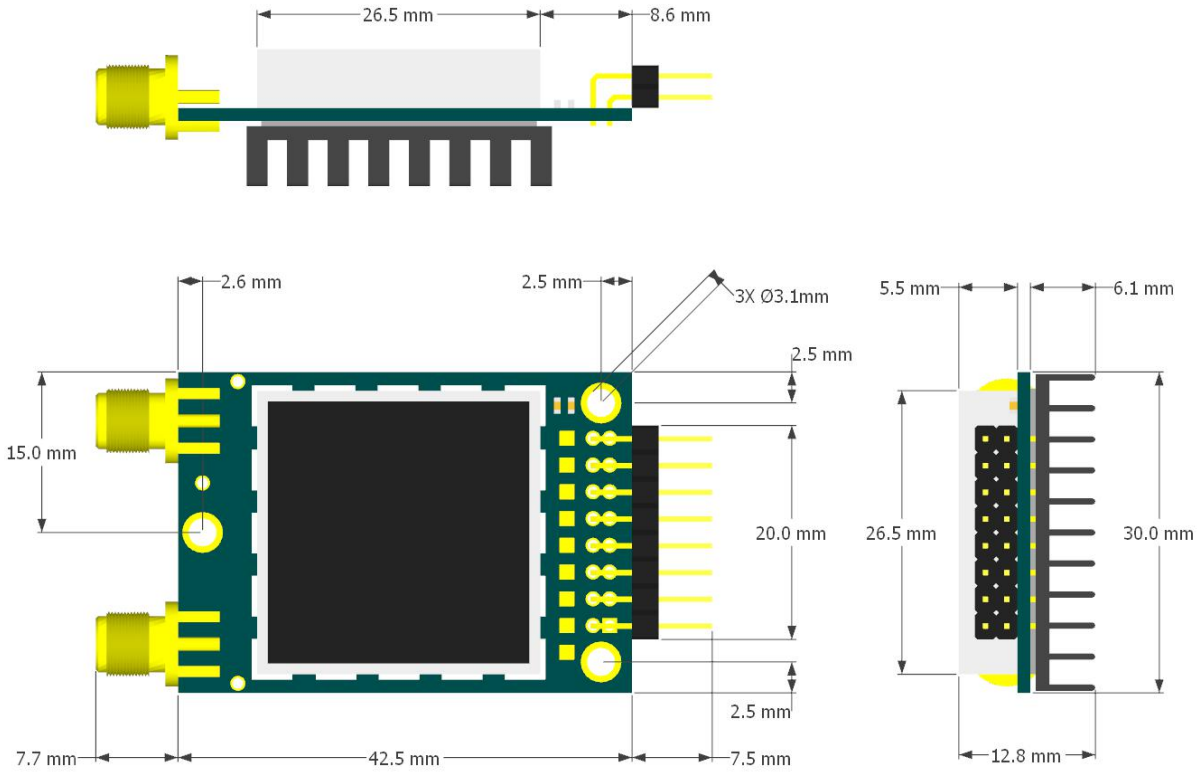

Figure 5-1: Modem dimension drawing

6 Output power levels and RSSI

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.

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

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

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

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.

Received power levels can be estimated from the modem's RSSI figure (ATI7 on Point-to-Point/SiK FW). 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.

$$dBm = \frac{N}{2} - 152$$

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

Note: Some firmware version have the option to switch RSSI to report in dBm

7 Software/GCS Support

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

The modem 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 modem is also configurable 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, Hterm or Coolterm.

The default serial port settings of the standard Point-to-Point/SiK firmware are as follows:

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

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

8 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)

8.1 Antennas and adapters

All RFD modems are designed for RF loads of 50 ohm impedance at the operating frequency. This should be considered when choosing suitable antennas from other suppliers. RF Design sells a number of antenna options on our web store (see useful links). There are also various options for extension coaxial cables.

Figure 8-1: 2 dBi right angle monopole antenna

Figure 8-2: Flex1 with 300mm cable and RP-SMA connector

Figure 8-3: 150mm RP-SMA extension cable with bulkhead connector

8.2 Cables

RF Design sells several cable versions with different lengths and connector configurations for interfacing with various flight controller systems.

Figure 8-4: 300mm PIXH2 to RFD900x telemetry cable

Figure 8-5: 150mm APM 2.X to RFD900x telemetry cable

9 Diversity

The RDF900x/868x modem has two antenna ports and firmware which supports diversity operation of antennas. When enabled, 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 by up to 8dB by employing a diversity scheme.

9.1 Spatial diversity

Spatial diversity is the case where the antennas are separated by some distance from one another. To be effective it is recommended that two antennas be separated by at least 25cm, more if possible.

9.2 Polarisation diversity

Polarisation diversity is the case where the antennas are perpendicular to each other. e.g. one vertical, and one horizontal. This is effective in reducing multipath effects which may 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.

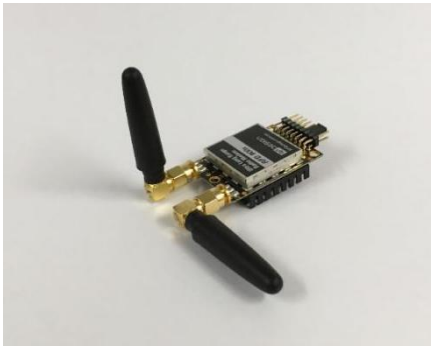

Figure 9-1: Polarisation diversity

10 Network options

The Radio Modems can be implemented in a Point-to-Point/SiK pair, a Multipoint synchronised network, or Asynchronous non-forwarding mesh. Firmware for the latter two options are available for download from the website (see “Useful Links”) but may not be suitable for all modem types.

10.1 Point-to-Point/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.

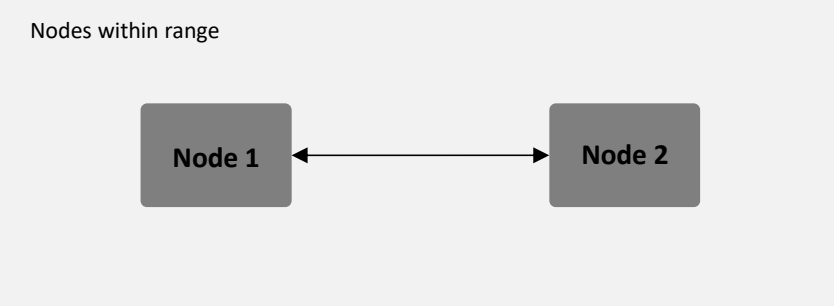

Figure 10-1: Peer-to-peer network diagram

10.2 Multipoint network

This mode requires the Multipoint firmware to be loaded into all radios on the network and several configuration steps to correctly link the modems. Check the “Useful links” section for the download link and refer to section “RFD Modem Tools” for flashing firmware to the modem. Refer to the “Multipoint user manual” for setup and usage instructions.

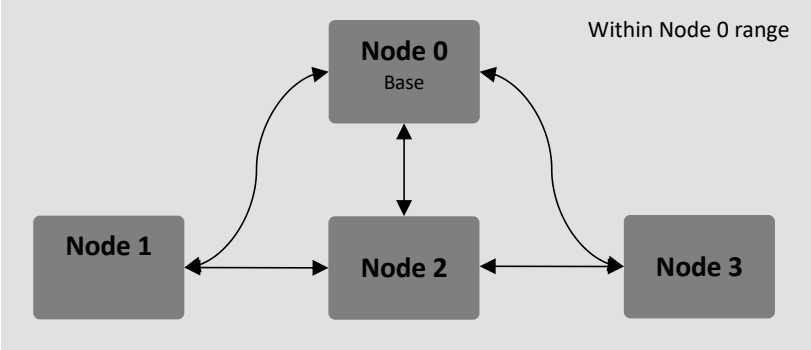

Figure 10-2: Multipoint network diagram

10.3 Asynchronous non-forwarding mesh

The asynchronous non-forwarding mesh firmware offers a communication option that allows the user to transmit and receive data across distances and between two or more nodes. Figure 10-3 depicts this communication topology. As long as all the nodes are within range and have compatible parameters, communication can occur.

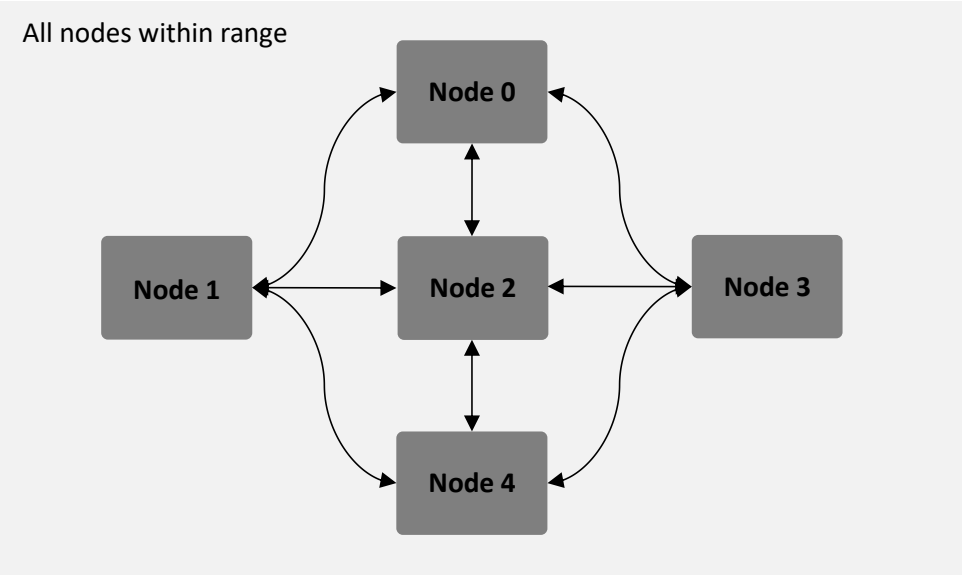

Figure 10-3: Asynchronous network diagram

11 Useful links

RDF900x/RFD868x modem Firmware
The firmware is the same for both the 868x/900x modems and can be found at.
http://files.rfdesign.com.au/firmware/

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

Documentation (including FAQ)
http://files.rfdesign.com.au/docs/

Store
http://store.rfdesign.com.au

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

12 Document 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