

# RFD900 Radio Modem Data Sheet

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**RFD900 Product Specifications and Performance**

**RFD900 Configuration**

**RFD900 Modem Tools User Manual**

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## **1. Key Features**

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RFD900 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
- Outdoor RF line-of-site range of 40km or more depending on antennas
- Air data rate speeds of up to 250kbps
- Diversity antenna support
- Operating temperature of -40 to +85 degrees Celsius
- Dimensions of 30mm x 57mm x 12.8mm
- Weight of 14.5g

Compliances and Worldwide Acceptances:

The RFD900 is designed to be compliant to AS4268:2012, and FCC 15.247. It has not been certified as a standalone modem and should be compliance tested in the final product.

## 2. Specifications

Performance	
Supported RF Data Rates	4, 8, 16, 19, 24, 32, 48, 64, 96, 128, 192 and 250
Indoor Range	500m – 1km
Line-Of-Sight Range	40km or more depending on antennas
Transmit Power	0 to 30dBm in 1dBm steps
Receiver Sensitivity	>121dBm at low data rates, >TBA at high data rates
Low Noise Amplifier	>20dB

Features	
Serial Data Interface	+3.3V nominal, 5V tolerant
Configuration Method	AT Commands, APM Planner, Customised Configuration Tool
Frequency Band	902MHz - 928MHz
Interference Immunity	FHSS (Frequency Hopping Spread Spectrum)
Serial Interface Data Rate	2400, 4800, 9600, 19200, 38400, 57600, 115200 baud
Antenna Options	Yagi, ½ Wave Dipole, ¼ Wave Monopole Antenna
GPIO	6 pins (Digital, ADC, PWM capable)
Compliance Standards	FCC Part 15.247, AS/NZS 4268:2008

Networking and Security	
Addressing Options	Network ID: 0 –499
Channels	Up to 50 Frequency Hopping Channels
Supported Network Topologies	Point to point, Multipoint <sup>1</sup>

<sup>1</sup> Only available in firmware version 2.x and later

Power Requirements	
Supply Voltage	+5V nominal (+4V min, +5.5V max),
Transmit Current	~1 A peak at max power
Receive Current	~60mA

## 3. 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 RFD900 modem can support the power levels between 0dBm and 30dBm in 1dBm steps. Formula (1) can be used to convert the power in dBm into milliwatts.

$$P_{mW} = 10^{(P_{dBm}/10)} \quad (1)$$

To calculate Effective Isotropic Radiated Power (EIRP) you can use the equation (2) below:

$$EIRP(dBm) = Transmit\ power\ (dBm) - Cable\ loss(dB) + Antenna\ Gain\ (dBi) \quad (2)$$

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

## 4. Performance Characteristics

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Figure 4.1 shows how the output power of the RFD900 varies with supply voltage.

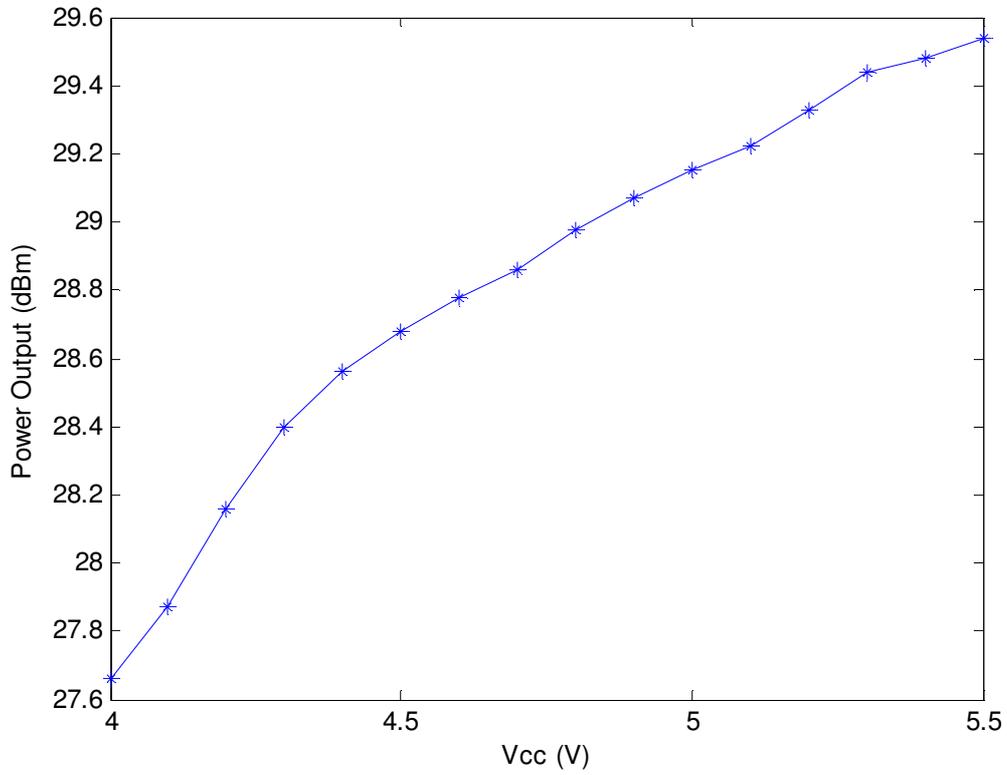


Figure 4.1: Output Power of RFD900 vs. Input Supply Voltage to the RFD900

Figure 4.2 shows how the current through the RFD900 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.

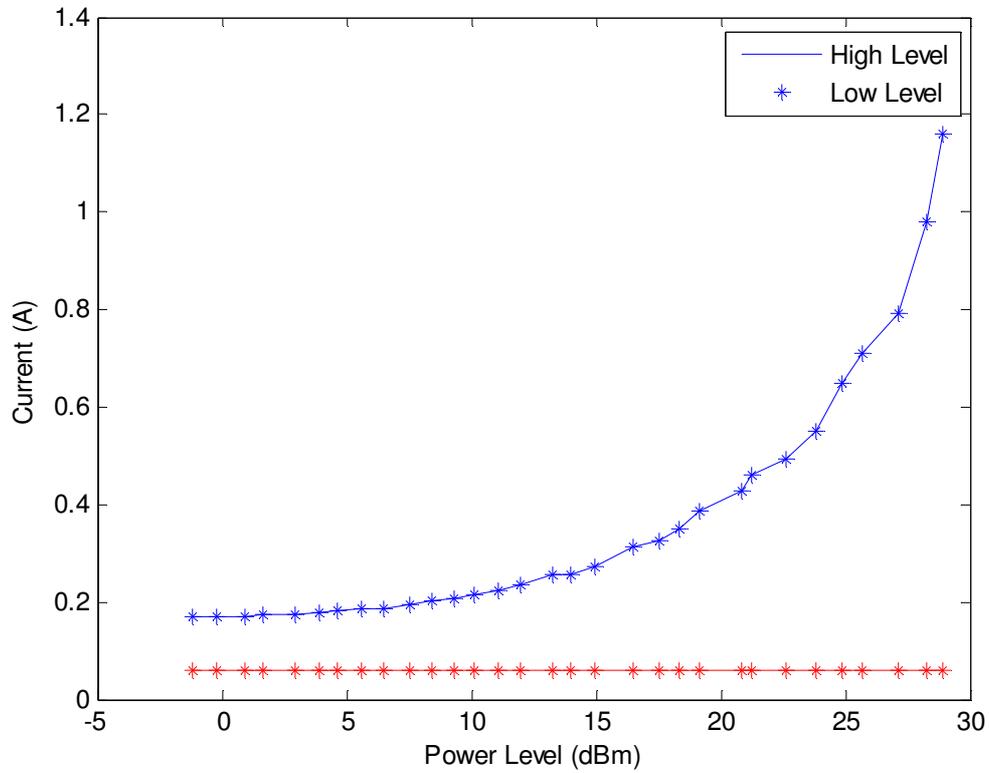


Figure 4.2: Current consumption of the RFD900 modem vs. TX power level

Figure 4.3 shows the occupied bandwidth (-20dB points) against the air data rate.

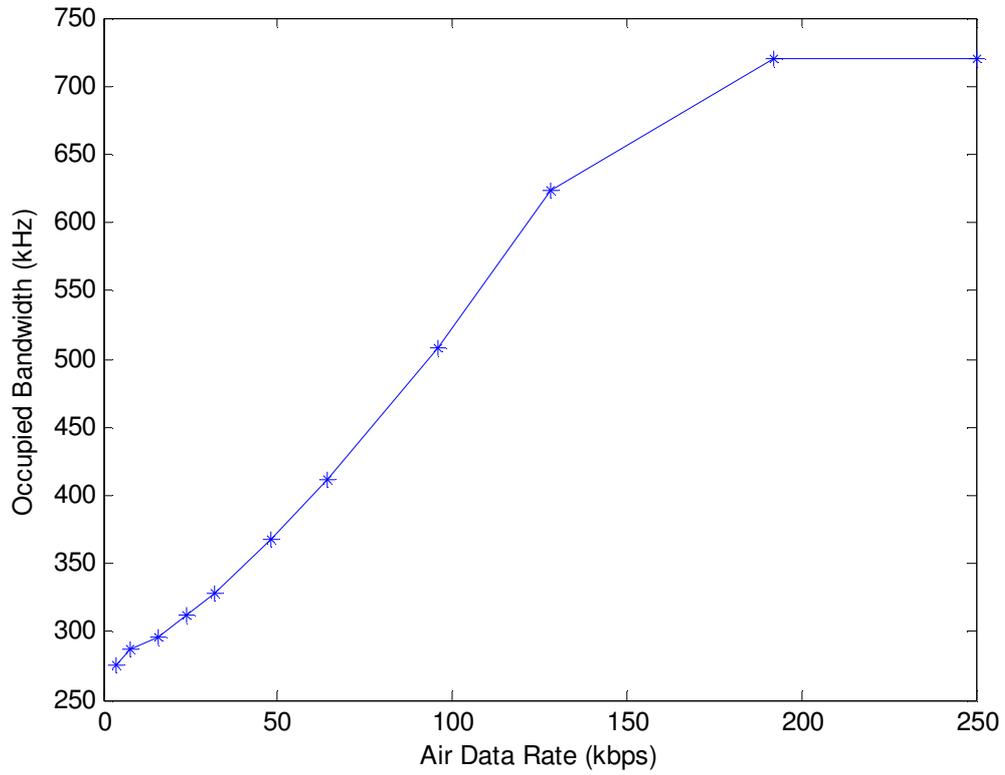


Figure 4.3: Occupied Bandwidth vs. Air Data Rate

## 5. Pin Signals and Layout

Pin #	Name	Direction	Description	Max Voltage
1	GND	-	Ground	0V
2	GND	-	Ground	0V
3	CTS	Either	Clear to send	5V
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	5V
8	P2.3	Either	Digital I/O	5V
9	TX	Output	UART Data Out	5V
10	P2.2	Either	Digital I/O	5V
11	RTS	Either	Request to send	5V
12	P2.1	Either	Digital I/O	5V
13	P0.1	Either	Digital I/O	5V
14	P2.0	Either	Digital I/O	5V
15	P2.6	Either	Digital I/O	5V
16	GND	-	Ground	0V

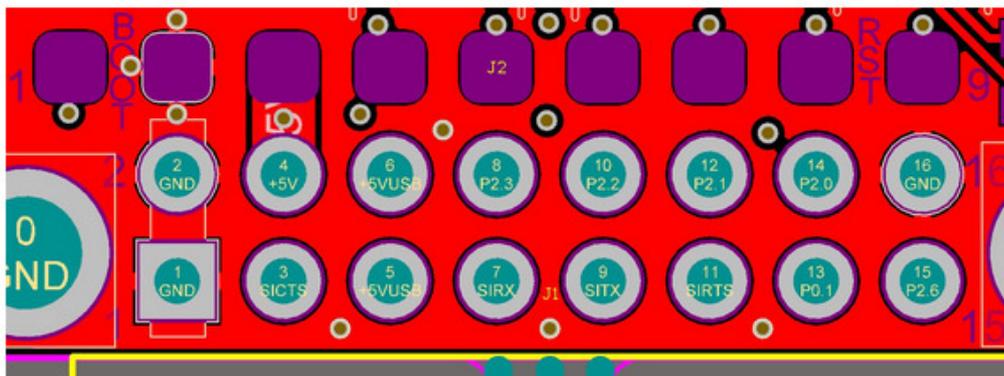


Figure 5.1: Physical Pin Layout of the RFD900 Radio Modem

The FTDI cable (see Useful Links) is compatible with the RFD900 modem.

Pin 1 of the FTDI cable (black wire) should connect to pin 1 of the RFD900 header. In order 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 and 4 as shown in figure 5.1.

In case there is need to force the modem into boot mode, short circuit pads 1 and 2 (labelled BOOT) on the 9 way test pads.

## **6. Software/GCS Support**

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The software solution (see Useful Links) is an open source development which is also compatible with RFD900 Modem Tools (see Useful Links) and the 3DR Radio Config (see Useful Links) from 3D Robotics. It is called "SiK" and was created by Mike Smith and improved on by Andrew Tridgell and RFDesign.

A boot loader and interface is available using RFD900 Modem Tools and field upgrade of the modem firmware via the serial port.

The RFD900 Radio Modem is compatible with many configuration methods like the AT Commands and APM Planner. The AT Commands can be used to change parameters such as power levels, air data rates, serial speeds etc.

Integrated support for configuring the RFD900 Radio Modem is supported by the APM Planner, with other GCS solutions in development. Its default serial port settings are as follows:

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

The RFD900 Radio Modem has many software features which include:

- Frequency Hopping Spread Spectrum
- Transparent Serial Link
- Configuration by simple AT commands for local radio, RT Commands for remote radio
- User configurable serial data rates and air data rates
- Error correction routines, Mavlink protocol framing (user selectable)
- Mavlink radio status reporting (Local RSSI, Remote RSSI, Local Noise, Remote Noise)
- Automatic antenna diversity switching on a packet basis in realtime
- Automatic duty cycle throttling based on radio temperature in order to avoid overheating

## 7. Antenna Connectivity

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### 7.1. Diversity

The RFD900 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. 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 in the order of 6-8dB by employing a diversity scheme.

- **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 RFD900 modem be separated by at least 25cm, more if possible.

- **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.

## 7.2. Types of Antennas

Below are some examples of antennas that can be used with the RFD900 modems.

- **Yagi Antenna**



Figure 7.1: 900MHz 6dBi Yagi Antenna

Yagi antennas are recommended for Ground-Station applications due to their size. They have approximately 6dBi gain and give significant link budget improvement when compared to standard dipole, or monopole antennas.

- **Quarter Wave Monopole Antenna**



Figure 7.2: 900MHz Quarter Wave Monopole Antenna

Quarter Wave Monopole Antennas are recommended for air-borne, or space constrained applications. They are required to be mounted on a ground plane of approx 20cm diameter or more to operate as intended. Using an RF extension cable with an RPSMA bulkhead connector will give good mounting options.

- **Half Wave Dipole Antenna**



**Figure 7.3: 900MHz Half Wave Dipole Antenna**

The half wave Dipole antenna has approx 3dBi gain with an omnidirectional radiation pattern. It is suited for ground station, or large airborne applications.

## 8. AT Commands

The RFD900 modem can support the Hayes 'AT' modem command set for configuration. The AT command mode can be entered by using the '+++' sequence. When doing this, you have to wait for 1 second before and after entering the command mode in order to prevent data being interpreted as data. When you are successfully in the AT command mode, an 'OK' prompt will be displayed on the screen and the RFD900 modem will stop displaying information from the other modem. Whilst in AT mode, you can use the AT commands to control the local RFD900 modem or the RT commands to control the remote modem.

To set certain registers to a particular value, follow these steps:

1. Use the command ATSn=X where n is the register number and X is the actual value.
2. Use the command AT&W to write the new values to the RFD900 modem.
3. Use the command ATZ to reboot the RFD900 modem.

Figure 8.1 shows a table that gives a list of AT commands and their description.

AT Command	Description
ATI	Shows the radio version
ATI2	Shows the board type
ATI3	Shows board frequency
ATI4	Shows board version
ATI5	Shows all user settable EEPROM parameters
ATI6	Displays TDM timing report
ATI7	Displays RSSI signal report
ATO	Exits AT command mode
ATSn?	Displays radio parameter number 'n'
ATSn=X	Sets radio parameter number 'n' to 'X'
ATZ	Reboots the radio
AT&W	Writes current parameters to EEPROM
AT&F	Resets all parameters to factory defaults
AT&T=RSSI	Enables RSSI debugging report
AT&T=TDM	Enables TDM debugging report
AT&T	Disables debugging report

Figure 8.1: AT Commands and their description

Figure 8.2 shows a table that gives a list of RT commands and their description. The x parameter is optional where x is the node ID. For example: use RTI,1 to get RTI value for node 1 or simply use RTI to get the RTI value for the node set in the local NODEDESTINATION (see RFD900 Parameters in figure 8.3).

AT Command	Description
RTI[,x]	Shows the radio version.
RTI2[,x]	Shows the board type
RTI3[,x]	Shows board frequency
RTI4[,x]	Shows board version
RTI5[,x]	Shows all user settable EEPROM parameters
RTI6[,x]	Displays TDM timing report
RTI7[,x]	Displays RSSI signal report

RT0[,x]	Exits AT command mode on the remote node
RTSn? [,x]	Displays radio parameter number 'n'
RTSn=X[,x]	Sets radio parameter number 'n' to 'X'
RTZ[,x]	Reboots the radio
RT&W[,x]	Writes current parameters to EEPROM
RT&F[,x]	Resets all parameters to factory defaults
RT&T=RSSI[,x]	Enables RSSI debugging report
RT&T=TDM[,x]	Enables TDM debugging report
RT&T[,x]	Disables debugging report

Figure 8.2: RT Commands and their description

Figure 8.3 shows a table with more details about the parameters that can be set in the RFD900 modem.

S Reg #	S Register	Description	Default Val	Max Val	Min Val	Should be the same at both ends of the link for successful communication ?
0	FORMAT	This is for EEPROM version, it should not be changed	Firmware dependant	N/A	N/A	No
1	SERIAL_SPEED	Serial speed in 'one byte form'	57	115	2	No
2	AIR_SPEED	Air data rate in one byte form	64, 128 <sup>1</sup>	250	2	Yes
3	NETID	Network ID. It should be the same on both modems	25	499	0	Yes
4	TXPOWER	Transmit power in dBm. Maximum is 30dBm	20, 27 <sup>1</sup>	30	0	No
5	ECC <sup>3</sup>	Enables or disables the golay error correcting code	1, 0 <sup>1</sup>	1	0	Yes
6	MAVLINK <sup>4</sup>	Enables or disables the MAVLink framing and reporting	1, 0 <sup>1</sup>	1	0	No
7	OP_RESEND <sup>5</sup>	OpportunisticResend	1, 0 <sup>1</sup>	1	0	No
8	MIN_FREQ	Min freq in KHz	915,000	927,000	902,000	Yes
9	MAX_FREQ	Max freq in KHz	928,000	928,000	903,000	Yes
10	NUM_CHANNELS	Number of frequency hopping channels	50, 20 <sup>1</sup>	50	5	Yes
11	DUTY_CYCLE	The percentage of time to allow transmit	100	100	10	No
12	LBT_RSSI	Listen before talk threshold (This parameter shouldn't be changed)	0	1	0	Yes
13	MANCHESTER	Manchester encoding (This parameter shouldn't be changed)	0	1	0	Yes
14	RTSCTS	Ready To Send and Clear To Send (This parameter shouldn't be changed)	0	1	0	No
15	NODEID <sup>2</sup>	Node ID. Base node ID is 0. One node must be acting as a base for a multipoint environment to work. NODECOUNT must be updated first before updating this parameter with bigger number.	2 <sup>1</sup>	29	0	N/A
16	NODEDESTINATION <sup>2</sup>	Remote node ID to communicate with.	65535 <sup>1</sup>	29	0	No

		Set the value to 65535 to broadcast to all nodes. Cannot be the same as NODEID. NODECOUNT must be updated first before updating this parameter with bigger number.				
17	SYNCANY <sup>2</sup>	If set to 1, allows the modem to send data to all non-base nodes without finding the base. It is strongly recommended to set the value to 0 to avoid unwanted data communication confusion on a multipoint environment.	0 <sup>1</sup>	1	0	No
18	NODECOUNT <sup>2</sup>	The total number of nodes.	3 <sup>1</sup>	30	2	Yes

Figure 8.3: RFD900 parameters

**Notes:**

<sup>1</sup>Defaults for firmware version 2.\* and later

<sup>2</sup>Available only for firmware version 2.\* and later

<sup>3</sup>ECC - Software Detection and correction, extra packet information (twice the packet length) is sent to allow the recovery of corrupted packets.

<sup>4</sup>Injects RSSI packet when Mavlink protocol used and heartbeat packet detected.

<sup>5</sup>Opportunicesend allows the node to resend packets if it has spare bandwidth.

## 9. Air Data Rate

An air speed of 64kps will give a range of about 40km depending on antenna. If the air speed is set to be lower, the range of the wireless link increases but the amount of data that you can send will be limited. Therefore one has to compromise between range and data rate. The data rates that you can choose are only limited to 2, 4, 8, 16, 19, 24, 32, 48, 64, 96, 128, 192 and 250.

The air data rate is chosen depending on:

- the range that you need
- the data rate that you will be sending
- whether you send data in one direction or both
- whether you have enabled ECC or not
- whether you have APM firmware with adaptive flow control

## 10. Network Options

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RFD900 can be implemented in either simple pair (V1.x, V2.x) or multipoint network (V2.x Only).

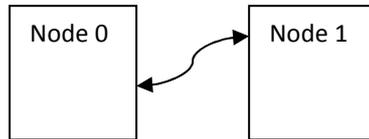


Figure 10.1: Two-node Network Setup

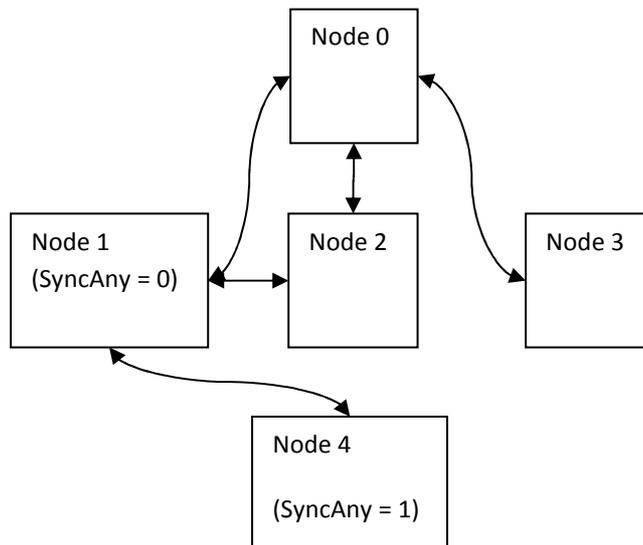


Figure 10.2: Five-node Network Setup

A few notes on the multipoint network (see Figure 10.2):

- In order for Node 1 to communicate with Node 2, it has to be able to see Node 0 (the base) and Node 2
- If Node 4 cannot see Node 0, to communicate with Node 1, it has to be able to see Node 1 and set the SyncAny parameter to 1 (refer to Figure 8.3: RFD900 parameters).
- Please note that there is a maximum number of one node which can have SyncAny = 1 parameter in a network to avoid data corruption.
- More nodes will reduce the bandwidth.

## **11. RFD900 Modem Tools User Manual**

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### **11.1. Introduction**

This GUI is for changing RFD900 modem parameters as well as for uploading firmware.

### **11.2. Requirements – for End Users**

Download and copy two files from RFDesign website (see Useful Links) and put them in the same folder:

1. RFD900ModemTools.exe
2. RFD900ModemTools.glade

### 11.3. User Interface

- **Configuration Tab**

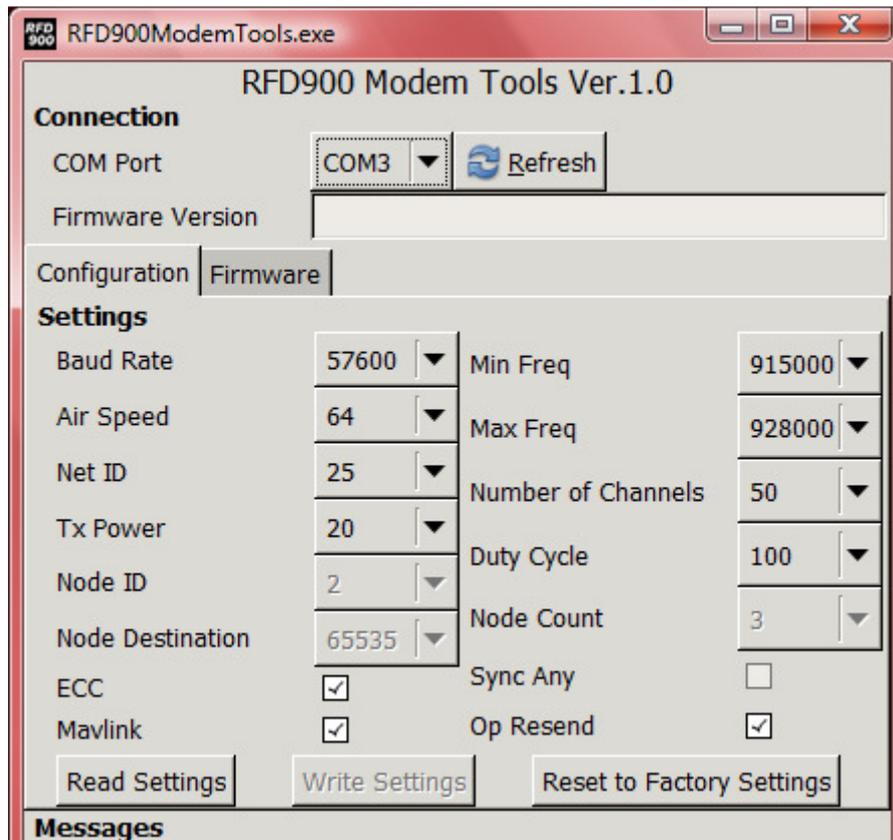


Figure 11.1: Configuration Tab – Modem Tools

To communicate with the modem, make sure you connect the modem to the computer using FTDI cable. Use the COM Port combobox to choose the correct COM port to which the modem is connected.

Use the Refresh button to refresh the COM combobox list after connecting/disconnecting a modem.

Set Node Destination to 65535 to send data to all nodes.

All other comboboxes and checkbuttons are self-explanatory.

Use Update Settings button to write setting changes to the modem. Initially, this button is disabled and will be enabled once the Load Settings button is clicked.

Use the Load Settings button to load settings from the modem.

Use Reset Factory Settings button to reset the current modem settings to the factory settings.

- **Firmware Tab**

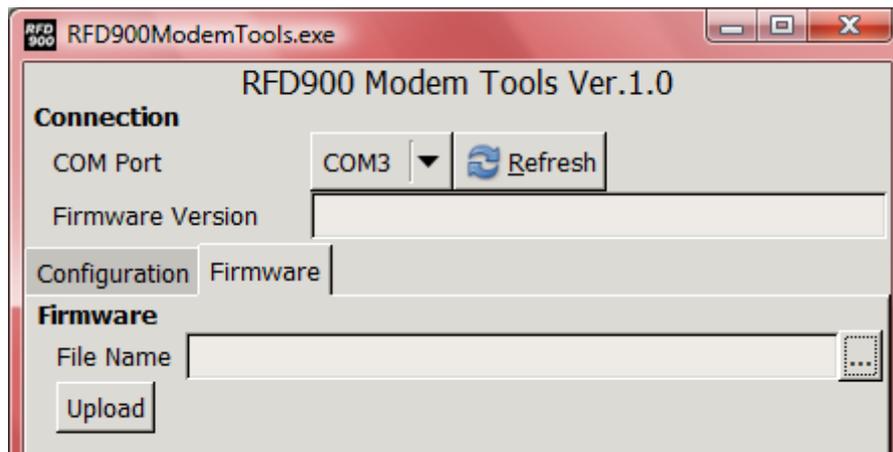


Figure 11.2: Configuration Tab – Modem Tools

Use the COM Port combobox to choose the correct COM port to which the modem is connected.

Use the Refresh button to refresh the COM combobox list after connecting/disconnecting a modem.

Download the firmware from the RFDDesign website (see Useful Links) and put the file on the same folder as this RFD900 Modem Tools application. Browse for the file using the “...” button then click the Upload button to upload the new firmware to the modem.

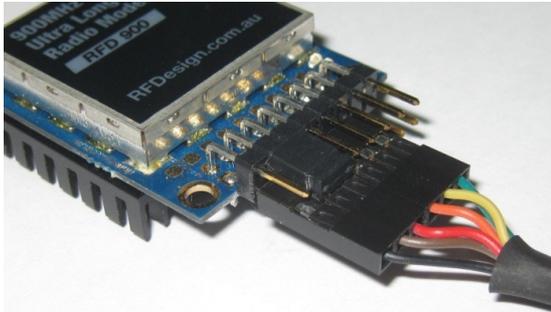
## 12. Frequently Asked Questions (FAQ)

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### How many antennas do I need to use?

One is the minimum. Two is recommended.

### How do I connect the FTDI cable to the modem?



The black cable of the FTDI (pin 1) should connect to pin 1 on the modem (see above)

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

Download the latest firmware (see Useful Links). Download the RFD900 Modem Tools (see Useful Links). Connect the FTDI cable to the modem and to a computer. Use the RFD900 Modem Tools to upload the latest firmware or to change the modem configuration (see RFD900 Modem Tools User Manual).

### What should I do if the RFD900 Modem Tools application keeps giving me back 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 for two more trials and if it still doesn't work, disconnect and reconnect the modem.

### I upgraded to V2.x firmware and the modems don't connect anymore?

The default setting for a modem is to have a NODEID set to 1. A network must have one node set to 0 to be the base. The base node defines the synchronisation for the whole network of nodes.

### How do I configure 2 base stations and one Airborne platform with 3 modems?

Set the Airborne platform as follows:

```
NODEID = 0  
NODEDESTINATION = 65535  
MAVLINK = 1
```

Set the ground station as follows:

```
NODEID = 1 or 2  
NODEDESTINATION = 0  
MAVLINK = 1
```

This will allow the airborne modem to handover to multiple ground stations as it flies from the coverage area of one ground station, to another. Both ground stations can be connected and can control the Airborne platform simultaneously. (APM Planner using Mavlink)

## 13. Useful Links

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### **RFD900 Firmware**

<http://rfdesign.com.au/firmware/>

V1.x firmware is standard SiK (open source)

V2.x firmware is multipoint SiK (MP SiK)

### **RFD900 Modem Tools**

<http://rfdesign.com.au/downloads/>

### **FTDI Cable**

[http://www.ftdichip.com/Support/Documents/DataSheets/Cables/DS\\_TTL-232R\\_CABLES.pdf](http://www.ftdichip.com/Support/Documents/DataSheets/Cables/DS_TTL-232R_CABLES.pdf)

### **Software Solution Sik V1.x**

<https://github.com/RFDesign/SiK>

### **3DR Radio Configuration Tool**

<http://vps.oborne.me/3drradioconfig.zip>