RFD900x Peer-to-peer firmware User Manual

Configuration and usage guide
Flash Programmer User Manual

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

Last update 06/12/2016

Table of contents

1 Introduction

The RFD900x radio modem can be loaded with three official firmware releases to achieve different communication architectures and node topologies. So far, the available firmware versions are:

- Peer-to-peer (P2P) (SiK/MPSiK)
- Multipoint network
- Asynchronous non-hopping mesh

This document describes the configuration of the peer-to-peer release. The RFD900x comes with this version loaded by default, and it requires no further configuration to work. Figure 1-1 pictures a P2P network diagram.

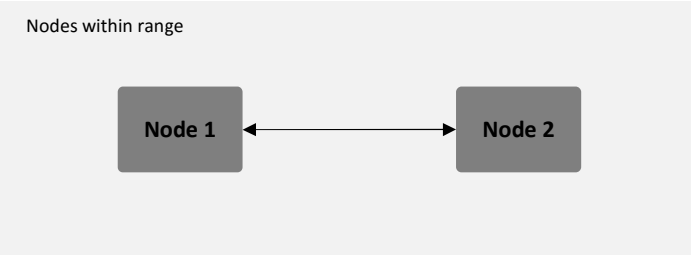

Figure 1-1: Peer-to-peer network architecture

2 Software/GCS Support

The software solution (see “Useful Links”) is an open source development which is called “SiK” and was created by Mike Smith and improved on by Andrew Tridgell and RFDesign.

The RFD900x modem features a boot loader which allows for the uploading of the various modem firmware via the serial port. This firmware upload is supported using the RFD900x Flash Programmer tool, current version of Mission Planner.

The RFD900x 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, GPIO pins etc.

Integrated support for configuring the RFD900x 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 RFD900x Radio Modem has many software features including:

- 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 real-time
- Automatic duty cycle throttling based on radio temperature in order to avoid overheating
- PPM (R/C signal) pass through (Control vehicle across radio).

3 AT commands

The RFD900x modem can support the Hayes 'AT' modem command set for configuration. The AT command mode can be entered by using the '+++' sequence in a serial terminal connected to the radio. When doing this, you must allow at least 1 second after any data is sent to be able to 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 RFD900x modem will stop displaying incoming data from the remote modem. Whilst in command mode, you can use the AT commands to control the local RFD900x modem or the RT commands to control the remote modem.

To set certain registers to a 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 save the new values to the RFD900x modem.
3. Use the command ATZ to reboot the RFD900x modem for changes to take effect.

Table 3-1 shows a 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 and their values
ATI5?	Shows all user settable EEPROM parameters and their possible range
ATI6	Displays TDM timing report
ATI7	Displays RSSI signal report
ATI8	Display Device 64-bit unique ID
ATI9	Display node ID [multipoint only]
ATO	Exits AT command mode
ATSn?	Displays radio 'S' parameter number 'n'
ATSn=X	Sets radio 'S' parameter number 'n' to 'X'
ATRn?	Displays radio 'R' parameter number 'n'
ATRn=X	Sets radio 'R' parameter number 'n' to 'X'
ATZ	Reboots the radio
AT&F	Resets all parameters to factory defaults
AT&W	Writes current parameters to EEPROM
AT&UPDATE	Reset and enter boot mode
AT&P	Change TDM phase (debug only)
AT&R	Record default PPM stream for PPM output (vehicle side)
AT&T	Disables debugging report
AT&T=RSSI	Enables RSSI debugging report
AT&T=TDM	Enables TDM debugging report
AT&E=X	Set new encryption key (128 bit AES in 16 hex bytes 5A02D5BB...)
AT&E?	Shows current encryption key
ATPP	Shows GPIO configuration and state
ATPO=X	Sets GPIO X to output

ATPI=X	Sets GPIO X to input
ATPM=X	Sets input GPIO pin to mirror on remote radio (local GPIO must be set to input and remote GPIO pin must be set to output)
ATPR=X	Shows GPIO input state
ATPC=X,S	Sets output GPIO X to state S

Table 3-1: AT Commands and their description

Comment [JD1]: I LOVE this feature!

RT commands are terminal commands that take effect on a remote node. They allow the user to set or get a remote node's parameter, for instance, as if they were being set locally. Table 3-2 lists the RT commands and their respective descriptions.

RT Command	Description
RTI	Shows the radio version
RTI2	Shows the board type
RTI3	Shows board frequency
RTI4	Shows board version
RTI5	Shows all user settable EEPROM parameters and their values
RTI5?	Shows all user settable EEPROM parameters and their possible range
RTI6	Displays TDM timing report
RTI7	Displays RSSI signal report
RTI8	Display Device 64-bit unique ID
RTI9	Display node ID [multipoint only]
RTO	Exits AT command mode
RTSn?	Displays radio 'S' parameter number 'n'
RTSn=X	Sets radio 'S' parameter number 'n' to 'X'
RTRn?	Displays radio 'R' parameter number 'n'
RTRn=X	Sets radio 'R' parameter number 'n' to 'X'
RTZ	Reboots the radio
RT&F	Resets all parameters to factory defaults
RT&W	Writes current parameters to EEPROM
RT&UPDATE	Reset and enter boot mode
RT&P	Change TDM phase (debug only)
RT&R	Record default PPM stream for PPM output (vehicle side)
RT&T	Disables debugging report
RT&T=RSSI	Enables RSSI debugging report
RT&T=TDM	Enables TDM debugging report
RT&E=X	Set new encryption key (128 bit AES in 16 hex bytes 5A02D5BB...)
RT&E?	Shows current encryption key
RTPP	Shows GPIO configuration and state
RTPO=X	Sets GPIO X to output
RTPI=X	Sets GPIO X to input
RTPM=X	Sets input GPIO pin to mirror on remote radio (local GPIO must be set to input and remote GPIO pin must be set to output)
RTPR=X	Shows GPIO input state
RTPC=X,S	Sets output GPIO X to state S

Figure 3-2: RT Commands and their description

Issuing a RT command will take effect only in the remote mode in a peer-to-peer configuration, which is a very useful feature if you have a remote node that is hard to access. Just make sure to keep the parameters compatible, whenever changing a parameter in the remote node. The above command will return the remote radio's version string.

```
RTI
```

Table 3-3 shows more details about the parameters that can be set in the RFD900x modem.

Reg #	S Register Description	Default Value	Maximum Value	Minimum Value	Must be the same at both ends of the link?
S0	**FORMAT** This is for EEPROM version, it should not be changed	Firmware dependant	N/A	N/A	No
S1	**SERIAL_SPEED** Serial speed in 'one byte form'	57	460	1	No
S2	**AIR_SPEED** Air data rate in one byte form	64	500	4	Yes
S3	**NETID** Network ID. It should be the same on both modems	25	255	0	Yes
S4	**TXPOWER** Transmit power in dBm. Maximum is 30dBm	30	30	0	No
S5	**ECC**[1] Enables or disables the Golay error correcting code. When enabled, it doubles the over-the-air data usage	0	1	0	Yes
S6	**MAVLINK**[2] Enables or disables the MAVLink framing and reporting	1	1	0	No
S7	**OP_RESEND**[3] Deprecated. Has no effect.	0	0	0	No
S8	**MIN_FREQ** Min frequency in KHz	915000	927000	902000	Yes
S9	**MAX_FREQ** Max frequency in KHz	928000	928000	903000	Yes
S10	**NUM_CHANNELS** Number of frequency hopping channels	50	50	5	Yes
S11	**DUTY_CYCLE** The percentage of time to allow transmit	100	100	10	No
S12	**LBT_RSSI** Listen before talk threshold	0	220	25	Yes

	(This parameter shouldn't be changed)				
S13	**RTSCTS** Ready-to-send and Clear-to-send.	0	1	0	No
S14	**Max Window** Max transit window size, used to limit max time/latency if required otherwise will be set automatically	131	400	20	Yes
S15	**Encryption Level** Encryption level 0=off, 1=128bit	0	1	0	Yes
S16	**R/C input GPIO1.1** Set GPIO 1.1 as R/C(PPM) input	0	1	0	No
S17	**R/C output GPIO1.1** Set GPIO 1.1 as R/C(PPM) output	0	1	0	No
R0	**TARGET_RSSI** Optimal RSSI value to try to sustain (off = 255)	255	50	255	No
R1	**HYSTERESIS_RSSI** Amount of change before power levels altered	50	20	50	No

Table 3-3: RFD900x parameters

Notes:
[1] ECC - Software Detection and correction, extra packet information, twice the packet length, is sent to allow the recovery of corrupted packets.
[2] Injects RSSI packet when MAVLink protocol used and heartbeat packet detected.
[3] *Opportunistic resend* allows the node to resend packets if it has spare bandwidth.

3.1 Setting up data encryption

The 128-bit AES data encryption may be set, enabled and disabled using the AT commands (see Table 2.1). The encryption key can be any 32-character hexadecimal string. Data encryption is essential for the separation of different networks.

To encrypt a device, the encryption mode must first be enabled by typing 'ATS15=1' in the command terminal. Once the encryption mode is active, an encryption key may be set after typing 'AT&E' into the command terminal. The encryption key may be of any 32-character hexadecimal string of the users choosing. Any devices with different encryption settings will not communicate.

After entering command mode, send the following commands to set encryption on using an arbitrary 16-byte key:

```
ATS15=1
AT&E=5AEEF103125C0AA233678909160111CA
AT&W
ATZ
```

3.2 Setting the air data rate

An air speed of 64kps will give a range of about 40km in open space 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 4, 64, 125 (can be set as 128), and 500.

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

It is important to note that the board's data rate must be set to a higher value then the air data rate (when flow control is enabled) to prevent bottlenecking and data loss.

To set to the highest air data rate, for instance, enter command mode and issue:

```
ATS2=250
AT&W
ATZ
```

4 Peer-to-peer Network

The peer-to-peer firmware offers a straight forward communication option that allows the user to quickly transmit and receive data across a great distance between two nodes. Figure 4-2 depicts this very simple communication topology. Whenever two nodes have compatible parameters and are within range, communication will succeed after they synchronize. A solid green LED state indicates synchronisation has been successful and the nodes can effectively communicate.

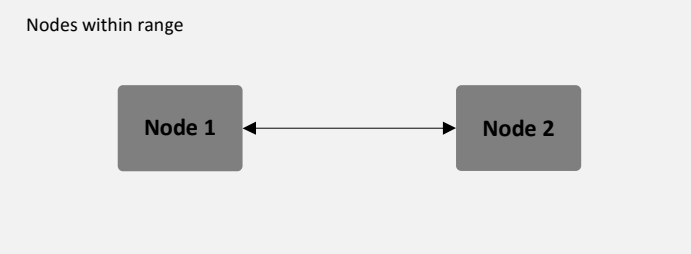

Figure 4-2: Simple pair mode

If your setup requires more than one pair of radios within the same physical space, you are required to set different network ID's to each pair. This prevents packet collision and communication instability. To set up the network ID, get into command mode using the serial terminal and issue the ATS3 command. In the following example, the node is set to network id 5:

```
ATS3=5
AT&W
ATZ
```

5 RFD900x Flash Programmer tool

5.1 Introduction

The update tool is a user-friendly tool for programming new firmware into the RFD900x. It relies on the XMODEM protocol to safely transfer the new binary.

5.2 Requirements for end user

Download the Flash Programmer tool and the new firmware from the RFDesign website (see "Useful Links"). Be sure to download the latest firmware version for your device.

5.3 Flashing new firmware

To communicate with the modem, make sure you connect it to the computer using an FTDI cable. Open the Flash Programmer application and use the Serial Port drop-down box to choose the correct COM port to which the modem is connected. Press *Connect* to put the modem into boot mode.

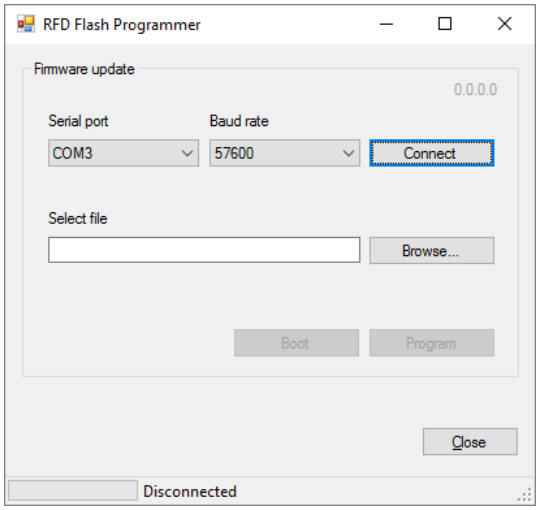

Figure 12-5-1: Flash programmer screen. Press Connect to continue.

If the modem detection is successful it will display the Bootloader version and modem Chip ID. The RED led also turns on to indicate the modem has successfully entered the bootloader mode. Click *Browse* and select binary file to load. You will then click *Program* to start programming.

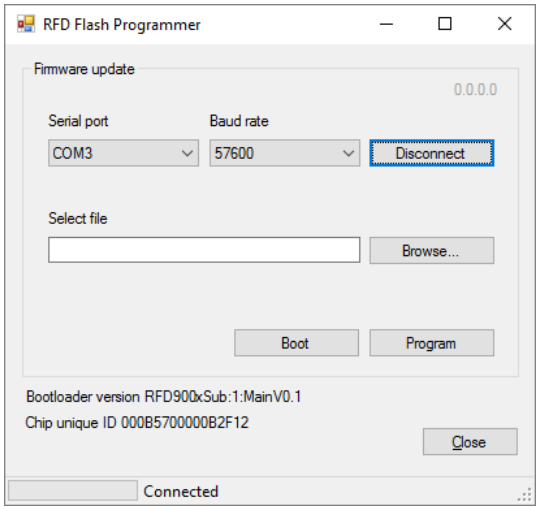

Figure 5-2: the RFD900x modem was successfully recognised. Select a file and click Program

If the firmware has been corrupted, it should go into bootloader automatically as soon as the modem is powered. If the bootloader has not entered correctly you can remove power, short pad 9 to pin 16 (ground pin) and apply power to force the boot mode. You are required to restart the flashing process by clicking *Connect* once again.

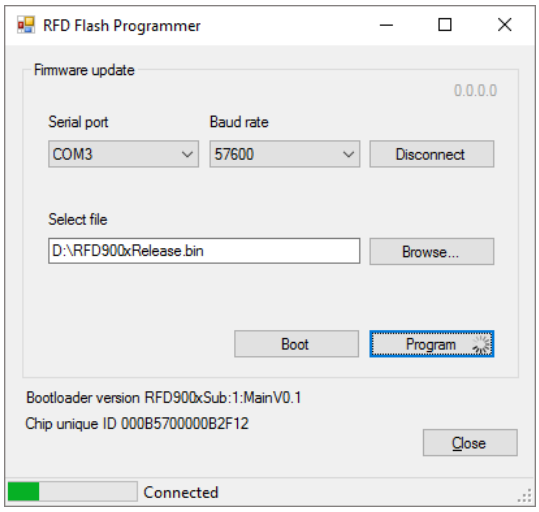

Figure 5-3: Screen showing the firmware flashing progress

After clicking the *Program* button, the programmer will proceed to flash the new firmware and a pop up window will indicate completion of programming. Click *Boot* to run the firmware you just downloaded.

6 Frequently asked questions (FAQ)

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 as shown in Figure 13-1.

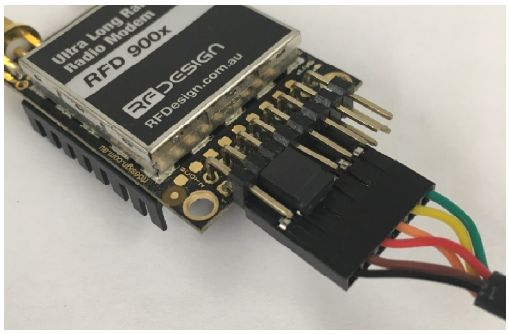

Figure 6-1: An FTDI cable connected to the RFD900x modem

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 Flash Programmer keeps 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 for two more trials and if it still doesn't work, disconnect and reconnect the modem.

7 Useful links

RFD900x Firmware

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

RFD SiK firmware is standard SiK (open source)

RFD Multipoint firmware is multipoint SiK (MP SiK)

RFD900x Flash Programmer

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

FTDI Cable documentation

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

8 Document revision history

Version	Date	Changes
1.0		Release document