RFDESIGN

RFD900x Peer-to-peer Firmware

User Manual

Configuration and usage guide
Flash Programmer User Manual

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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)

- Asynchronous mesh

- Multipoint network

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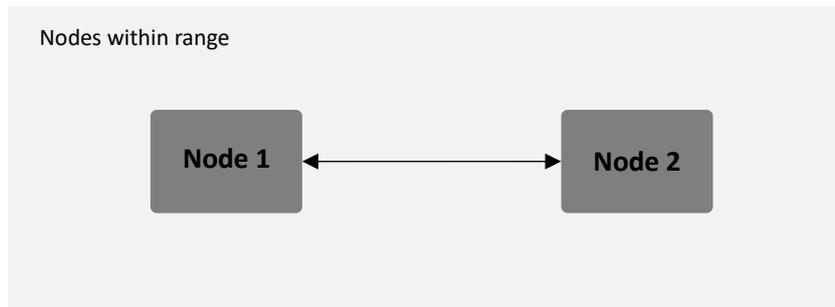
Figure 1-1: Peer-to-peer network architecture

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2   Software/GCS Support

This firmware (see "Useful Links") is a development of the open source project called "SiK" and was created by Mike Smith. It has been further developed and modified by Andrew Tridgell and RFDesign.

The modems feature a boot loader to facilitate field upgrade of the modem firmware via the serial port. This is most easily performed by using the latest version RFD Modem tools (see "Useful links")

Parameters such as power levels, air data rates, serial speeds, GPIO pins etc can all be custom set by the user using the AT Command set, the RFD Modem Tools V2 or later and APM Planner.

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 AT commands for local radio, RT commands for remote radio

• User configurable serial data rates and air data rates

• Error correction routines

• 128-bit AES hardware encryption with user settable key

• 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 to avoid overheating

• PPM (R/C signal) pass through (Control vehicle across radio).

• GIPO pin mirroring

3   AT commands

The RFD900x modem can supports an 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. You should allow at least one second after the sending of data before entering the sequence to ensure that the modem will correctly enter command mode.

If successful, an 'OK' prompt will be displayed on the screen and the RFD900x modem will stop displaying incoming data from the remote modem. 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 value to assign.

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.

By replacing A with R the settings of the remote modem can be changed. It is recommended that changes to remote settings be made first.

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

RF=DESIGN

AT&E=X	Set new encryption key (128-bit AES in 32 hex characters 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

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 e.g. 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 affect only in the remote node. After resetting the changes will take effect, link may be lost due to mismatch in parameter until local settings match the remote node.

An example that command will return the remote radio's version string.

```
RTI
```

Table 3-3 detailing the S-register parameters settings on the RFD x series 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. It is set by the firmware	Firmware dependant	N/A	N/A	No
S1	**SERIAL_SPEED** Serial speed in 'one-byte form'. Accepted values are 1, 2, 4, 9, 19, 38, 57, 115, 230, 460 corresponding to 1200bps, 2400bps, 4800bps, 9600bps, 19200bps, 38400bps, 57600bps, 115200bps, 230400bps, 460800bps and 1000000bps respectively.	57	1000^3	1	No
S2	**AIR_SPEED** Air data rate in 'one-byte form'. Accepted values are 4,64,125,250,500, 750 corresponding to 4000bps, 64000bps, 125000bps, 25000bps, 500000bps and 750000bps respectively.	64	750^3	4	Yes
S3	**NETID** Network ID. The same on both modems in the pair	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** Opportunistic resend allows the node to resend packets if it has spare bandwidth	0	1	0	No
S8	**MIN_FREQ** Min frequency in KHz	915000 /868000[4]	927000 /869000[4]	902000 /868000[4]	Yes

RFDESIGN

S9	MAX_FREQ Max frequency in KHz	928000 /869000[4]	928000 /870000[4]	903000 /869000[4]	Yes
S10	NUM_CHANNELS Number of frequency hopping channels	20	50	1	Yes
S11	DUTY_CYCLE The percentage of time to allow transmit	100	100	10	No
S12	LBT_RSSI Listen before talk threshold (This parameter shouldn't be changed)	0	220	25	Yes
S13	RTSCTS Ready-to-send and Clear-to-send flow control.	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 AES	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
S18[5]	ANT_MODE 0= Diversity, 1= Antenna 1 only, 2= Antenna 2 only, 3= Antenna 1 TX and antenna 2 RX	0	3	0	No
S19[5]	PKT_DROP_RSSI Sets a RSSI threshold below which the packet will be discarded. 0 disables the feature	0	255	0	No
R0	TARGET_RSSI Optimal RSSI value to try to sustain (255 disables the feature)	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] Maximum from version 2.60 onwards

[4] 868 modems

[5] Introduced in V2.55

RFDESIGN

3.1   Setting up data encryption

The 128-bit AES data encryption may be set, enabled and disabled using the AT commands (see Table 3.1). The encryption key can be any 32-character hexadecimal string.

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 32 hexadecimal character key. For example:

```
ATS15=1

AT&E=5AEEF103125C0AA233678909160111CA

AT&W

ATZ
```

3.2   Setting the air data rate

An air speed of 64kps will give a maximum range of about 40km in open space depending on antenna configurations, terrain and weather. Reducing the air speed can help to increase the range and link quality limits the data throughput.

Considerations for the air speed setting:

- The desired range

- The amount of data across the link

- Whether you send data in one direction or both

- Whether you have enabled ECC or not

- Whether you have adaptive flow control

It is important to note that the air rate should be set to a higher value then the baud rate to prevent bottlenecking and data loss.

Example of changing air data rate:

```
ATS2=250

AT&W

ATZ
```

RFDESIGN

3.3   Setting up PPM

To enable PPM control signal passthrough on a modem link it is necessary to set the ground station modem to PPM input and the receiver modem to PPM output. This is enabled using the S registers 16 or 17. The PPM stream can then be injected/retrieved from GPIO1 (aka P1.1 or pin 15) the right most pin on the bottom row of the header.

```
(INPUT SIDE)
ATS16=1
AT&W
ATZ
(OUTPUT SIDE)
ATPO=1
ATS17=1
AT&W
ATZ
```

To record a failsafe PPM stream first connect the PPM generator to the ground station modem. Then power up the receiving modem. Connect the ground station modem using the FTDI cable. After the modems have established a link set the desired PPM failsafe stream using the generator and connect to the ground station modem. Then send the following command to set the failsafe on the receiver modem.

```
RT&R
RT&W
RTZ
```

This could alternatively be done by powering up the ground station and sending the PPM while connected to the receive modem via the FTDI cable in which case the command would be.

```
AT&R
AT&W
ATZ
```

Please note that it is the modem that receiver modem that must record the failsafe mode.

4   Peer-to-peer Network

The peer-to-peer firmware offers straight forward data communication between two nodes. Figure 4-2 depicts this very simple communication topology. Whenever two nodes have compatible parameters and are within range, communication will be established after the units synchronise. A solid green LED state indicates synchronisation has been successful.

Nodes within range

Node 1 ↔ **Node 2**
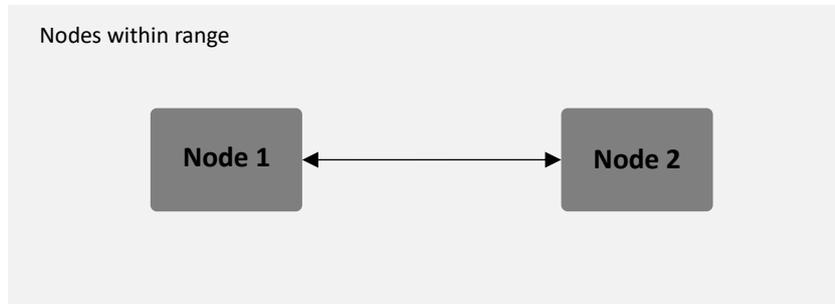
Figure 4-2: Simple pair mode

If operating with other RFD modems on the same band, you will need to set different network ID's to each pair to distinguish the networks from each other. It is also advisable when possible to set the different pairs on different frequencies. This prevents packet collision, communication instability and other interference that may reduce the effectiveness of the links.

Example of using the AT commands to set to network id 5:

```
ATS3=5

AT&W

ATZ
```

5   Frequently asked questions (FAQ)

5.1   How many antennas do I need to use?
One is the minimum. Two is recommended.

5.2   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 6-2.
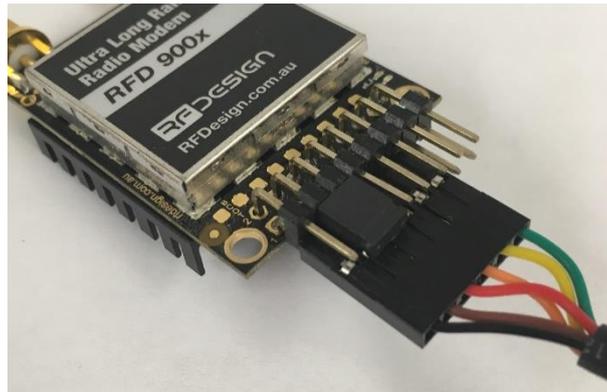
Figure 6-2: An FTDI cable connected to the RFD900x modem

5.3   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").

6   Useful links

RFD900x Firmware

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

RFD SiK firmware is standard SiK (open source)

RFD Asynchronous firmware

RFD900x Modem Tools

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

FTDI Cable documentation

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

7   Document revision history

Version	Date	Changes
1.0	22/09/17	Release document
1.1	22/05/18	Updated settings, values and information for current firmware versions