RFD900x Multipoint firmware User Manual

Configuration and usage guide
Flash Programmer User Manual

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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)
- Multipoint network
- Asynchronous mesh

This document describes the configuration of the Multipoint network release. This firmware version is not loaded in the RFD900x radio modem by default. This means, you must download it from the website and flash it to the radio. The download link can be found in section “Useful links”.

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”)

Figure 1-1 pictures a generic multipoint network. The network requires that one of the devices assumes a *master* role to control the timeslot distribution of the surrounding radios.

Commented [S1]: If one the nodes is out of the base’s range, communication is still possible if the parameter *SyncAny* is properly set. (Is syncany actually working on this firmware?)

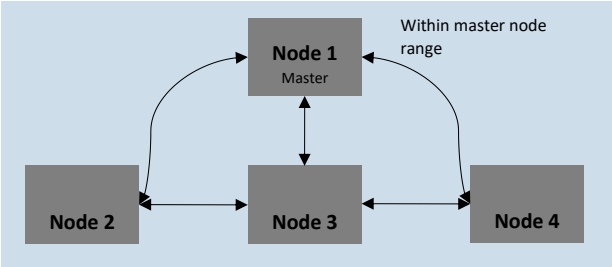

Figure 1-1: Multipoint network architecture

As depicted in Figure 1-1, the multipoint network allows each node to be addressed individually. However, after receiving data it is not possible to identify which node it came from.

Note: Due to the limited number of channels available on the 868 MHz band this firmware may not operate as intended and is not recommended for 868X modems or reduced band settings less than 915-928MHz on 900X modems

Note: For more reliable operation use of flow control is recommended.

2 Software/GCS Support

The Multipoint network firmware is currently only configurable using AT Commands support for managing settings using the RFD tools may be added later.

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 to avoid overheating

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 ensure the request for command mode is not 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&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)

Commented [S2]: Add AT&M and other new commands to the list

ATPR=X	Shows GPIO input state
ATPC=X,S	Sets output GPIO X to state S
AT&M?	Current master node settings
AT&MX=A,B	Describes the network configuration. Only set this on master node(NETID=0, NODEID=1). X is the network number (note must start with 0 as this is the synchronising network). A is the start channel ID of the network (this also starts at 0 and can have values 0,7 or 13). B is the nodecount of the network (i.e. the number of nodes on the network including the master)

Table 3-1: AT Commands and their description

Commented [S3]: Is this correct?

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 10-2 lists the RT commands and their respective descriptions.

RT 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 and their values
RTI5?,[x]	Shows all user settable EEPROM parameters and their possible range
RTI6,[x]	Displays TDM timing report
RTI7,[x]	Displays RSSI signal report
RTI8,[x]	Display Device 64-bit unique ID
RTI9,[x]	Display node ID [multipoint only]
RTO,[x]	Exits AT command mode
RTSn?,[x]	Displays radio 'S' parameter number 'n'
RTSn=X,[x]	Sets radio 'S' parameter number 'n' to 'X'
RTRn?,[x]	Displays radio 'R' parameter number 'n'
RTRn=X,[x]	Sets radio 'R' parameter number 'n' to 'X'
RTZ,[x]	Reboots the radio
RT&F,[x]	Resets all parameters to factory defaults
RT&W,[x]	Writes current parameters to EEPROM
RT&UPDATE,[x]	Reset and enter boot mode
RT&P,[x]	Change TDM phase (debug only)
RT&T,[x]	Disables debugging report
RT&T=RSSI,[x]	Enables RSSI debugging report
RT&T=TDM,[x]	Enables TDM debugging report
RT&E=X,[x]	Set new encryption key (128-bit AES in 16 hex bytes e.g. 5A02D5BB...)
RT&E?,[x]	Shows current encryption key
RTPP,[x]	Shows GPIO configuration and state
RTPO=X,[x]	Sets GPIO X to output
RTPI=X,[x]	Sets GPIO X to input
RTPM=X,[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,[x]	Shows GPIO input state
RTPC=X,S,[x]	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 node in a peer-to-peer configuration, which if 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.

RT commands on multipoint network will solicit a response from all available nodes on the network unless addressed to an individual node. This can be done by setting the destination ID of the sending node to match the desired node or by appending ,[x] to the RT command as per the examples below.

This example describes how to get the radio version of the remote node 1 in a multipoint network (append,[x] where x is desired node to RTI command):

```
RTI,1
```

If the local parameter NODEDESTINATION (refer to table 3-3 for parameter usage and description) is already set to 1, the following RT command will also retrieve the remote node's version number:

```
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	69	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, 460,1000 corresponding to 1200bps, 2400bps, 4800bps, 9600bps, 19200bps, 38400bps, 57600bps, 115200bps, 230400bps, 460800bps, and 1000000bps respectively.	57	460	1	No
S2	**AIR_SPEED** Air data rate in one-byte form	64	250	12	Yes
S3	**NETID** Network ID. It should be the same on all modems of the network	0	7,13[1]	0	Yes
S4	**TXPOWER** Transmit power in dBm. Maximum is 30dBm	27	30	0	No
S5	**ECC[2]** Enables or disables the Golay error correcting code. When enabled, it doubles the over-the-air data usage	0	1	0	Yes
S6	**RXFRAME** Sets the data type for the modem. 0=Raw, 1=Mavlink[3], 2 = SAS	1	2	0	No
S7	**OP_RESEND[4]** Deprecated. Has no effect.	0	0	0	No

Commented [S4]: Max setting from ATI5? Is 20 not 30. Serialbreakms10 also has max listed as 20 is this correct?

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. Do not change as this will affect the spectrum separation of the nodes	21	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.	0	1	0	No
S14	**Max Window** Max transit window size used to limit max time/latency if required otherwise will be set automatically	80	400	20	Yes
S15	**Encryption Level** Encryption level 0=off, 1=128bit	0	1	0	Yes
S16	**ANT Mode** Set antenna port function. 0= Diversity, 1=A1 only, 2=A2 only, 3= A1 TX and A2 RX	0	3	0	No
S17	**STATUS GPIO1.3** Set GPIO 1.3 to behave the same as the status LED allowing link lock status to read from the I/O pin	0	1	0	No
S18	**NODEID** Node ID. One node must be acting as a master (NODEID 1, NETID 0) for a multipoint environment to work.	2	15	1	N/A
S19	**NODEDESTINATION** Remote node ID to communicate with. Set the value to 255 to broadcast to all nodes. Cannot be the same as NODEID.	255	255	1	No
S20	**NETCOUNT** The total number of networks on the one master node. Not applicable to non-master nodes.	1	10^5	1	Yes
S21	**SERBREAKDETECTMS10** x10 to give time in ms units for break detection. Set to 0 to turn this feature off	0	20	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] To ensure the correct channel separation between networks this should only take the values 0,7 or 13
[2] ECC - Software Detection and correction, extra packet information, twice the packet length, is sent to allow the recovery of corrupted packets. This increases the data usage of the link.
[3] Injects RSSI packet when MAVLink protocol used and heartbeat packet detected.
[4] *Opportunistic resend* allows the node to resend packets if it has spare bandwidth.
[5] *Not recommended to use more then 3 networks as there may not be enough channel separation to prevent interference between modems*

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 allow for 3 networks of 4 nodes. 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 and the number of nodes that can be supported will also decrease. If set higher the greater throughput allows for more nodes but reduces range.

The air data rate is chosen depending on:

- The range that you need
- How many nodes you want on each network
- 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 a 250kbps air data rate, for instance, enter command mode and issue:

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

4 Multipoint Network

The multipoint mode requires the 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. After flashing the device, you are required to choose a *master* node that will control the radio timeslot allocations.

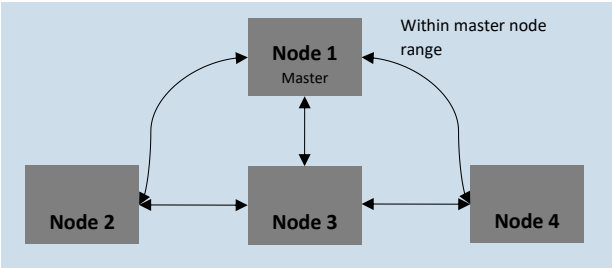

Figure 4-2: multipoint network diagram example

At this time the multipoint firmware settings are not supported by the RFD modem tools. Therefore, all settings must be made by AT commands via a terminal programme. The list of AT commands can be found in section three of this manual.

To set up the multipoint network, each device must be assigned a unique Node ID on its network. A device set as master is also mandatory.

By default, the nodes are configured to address all the other nodes in broadcast mode. To address a specific node, you must set the Node Destination parameter. For example, to address the data to node 1, you must send the following commands in command mode:

```
ATS19=1
AT&W
ATZ
```

A few notes on the multipoint network (see Figure 1-2):

- Based on the topology depicted in Figure 1-2, for Node 3 to communicate with Node 2, Node 1 (the base) and Node 2 must be within the RF range, and
- More nodes will reduce the bandwidth.

4.1 Example network configurations

This section will cover the modem settings for some of the network types that may be desired. As a general rule lower airspeed will allow for more range but limit the amount of data that can be transferred.

64kbps Airspeed Networks

Single network (Maximum 3 non-master nodes)

Parrameter	Value
S1	57
S2	64
S3	0
S4	30*
S5	0
S6	1**
S7	0
S8	915000
S9	928000
S10	21
S11	100
S12	0
S13	1
S14	80
S15	0
S16	0
S17	0
S18	x
S19	y***
S20	1****
S21	0

* Dependent on range and power requirements. Lower power generally lowers range.
** For sending mavlink data
*** Depends on the network structure. Master node (1) must be set to broadcast (255). Most commonly nodes will address the master (1)
**** Master node only. This value is not applicable to the network nodes
x = the node number starting with the master (1) with a maximum in this case of (4) in a three node one master configuration

Master node specific settings

Parrameter	Value
S20	1

AT&M0= 0, Z where Z is the maximum NodeID used e.g. (4) in a three node one master configuration.

Single network with relay node

Example network path. Note that the master node has been set as the relay node as all nodes must be able to see the master and that Vehicle1 will always send messages via the relay even if it is in range to receive them direct from the GCS

Node name	NodeID
Vehicle1 → Relay → GCS	3 → 1 → 2
GCS → Relay → Vehicle1	2 → 1 → 3

GCS → Vehicle1	2 ->3 (When in range)
Vehicle2 → GCS	4 → 2
GCS → Vehicle2	2 → 4

Settings as for single network with the following exceptions

NodeID 1 (aka Relay)

Parrameter	Value
S19	255
S13	0

NodeID 2 (aka GCS)

Parrameter	Value
S19	255

NodeID 3 (aka Vehicle1)

Parrameter	Value
S19	1

NodeID 4 (aka Vehicle2)

Parrameter	Value
S19	2

Note that for the master (aka relay) only the flow control is disabled. This node also requires that the RX and TX pin of the UART (aka pin 7 and 9) must be wired together.

128kbps Airspeed Networks

Single network (Maximum 7 non-master nodes)

Parrameter	Value
S1	115
S2	125
S3	0
S4	30*
S5	0
S6	1**
S7	0
S8	915000
S9	928000
S10	21
S11	100
S12	0
S13	1
S14	40
S15	0
S16	0
S17	0
S18	x
S19	y***

S20	1****
S21	0

* Dependent on range and power requirements. Lower power generally lowers range.
** For sending mavlink data
*** Depends on the network structure. Master node (1) must be set to broadcast (255). Most commonly nodes will address the master (1)
**** Master node only. This value is not applicable to the network nodes
x = the node number starting with the master (1) with a maximum in this case of (8) in a seven node one master configuration.

Master node specific settings

Parrameter	Value
S20	1

AT&M0= 0, Z where Z is the maximum NodeID used e.g. (8) in a seven node one master configuration.

Multiple Networks

It is possible to run up to three networks of the same configuration at the same time to enable support for more nodes. There will still only be one master node (network 0, node 1) and all nodes will need to be in range of the master for synchronisation. Node 1 on network 7 or 13 will act as normal nodes. Nodes will only see other nodes on the same NetworkID.

The valid NetworkID values are 0,7 and 13

The following settings will be needed for the master node.

Parrameter	Value	
S20	A	Where A is the number of networks

AT&M0= 0, Z0 where Z0 is the maximum NodeID used in NetworkID 0
AT&M1= 7, Z1 where Z1 is the maximum NodeID used in NetworkID 7
AT&M2= 13, Z2 where Z2 is the maximum NodeID used in NetworkID 13

5 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.

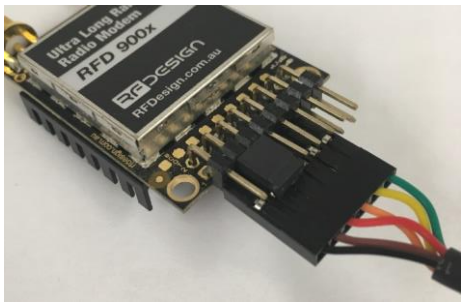

Figure 5-2: An FTDI cable connected to the RFD900x modem

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.

I upgraded to multipoint 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.

6 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

1 Document revision history

Version	Date	Changes
1.0	20/08/18	Release document