RFD V4 BETA Firmware Mesh Network Application Note

RF Design Pty Ltd
7/1 Stockwell Place
Archerfield, QLD 4108 Australia
rfdesign.com.au

Contents

1 Key Features

- Support for Multipoint like behaviour
- Multiple networks with up to 63 nodes in each
- Raw, MAVLink and SAS data packet support
- Hardware accelerated AES encryption

2 Disclaimer and Limitations

The V4 BETA firmware is under active development, there may be significant changes to the operation between firmware releases. Known bugs and issues are listed in the firmware release notes. It is possible that further faults may be found during use. This firmware is to be considered experimental and should be used as such.

Any bugs, issues, general feedback or questions should be addressed to the team via email at beta@rfdesign.com.au

Note: The V4 BETA firmware is currently only configurable by AT Commands. It is not compatible with the modem tools GUI.

Note: The V4 BETA firmware is currently only compatible with the V2 hardware revision of the x series modem. See the x series modem datasheet for details on how to identify the modem hardware version if you are unsure.

3 AT Commands

The V4 BETA firmware is currently only configurable by AT Commands.

The AT command mode can be entered by sending '+++', without quotes, sequence in a serial terminal connected to the radio at the correct baud rate, 57600 by default.

If successful, an 'OK' prompt will be displayed on the screen and the modem will stop displaying incoming data from the remote modem, if any.

In command mode, you can use the AT commands to control the local modem settings.

Useful commands for this application note:

AT Command	Description
ATI	Shows the firmware version and country code and hardware revision
ATI5	Shows all user settable EEPROM parameters and their values
ATI5:x:y	An alternate ATI5 command that shows the parameters in the range x to y inclusive. Example usage ATI5:6:11 will print parameters S6 through S11
ATI9	Calibration validation test
ATI10:n	Displays radio S parameter number 'n' and valid settings range.
ATI11	Show information on RC data packets sent or received, if any, depending on if the node is an RC input or RC output.
ATO	Exits AT command mode
ATSn=X	Sets radio 'S' parameter number 'n' to 'X'
ATZ	Reboots the radio
AT&F	Resets all parameters to factory defaults
AT&R	Record default PPM stream for PPM output (vehicle side)

Note: Modem parameters are saved whenever changes are made but modems need to be rebooted after any settings have been modified to activate changes.

4 LED Behaviour

Green LED
This LED indicates the modem link status and has the following patterns:
A solid green indicates that the link has been established.
A master unit flashing approximately every two seconds indicates that the unit is unlocked.
A slave unit flashing approximately every second indicates that the unit is unlocked.
A slave unit flashing approximately every half second indicates that the unit currently locking/unlocking to/from the network.
A unit flashing for one second and off for three seconds indicates that the firmware has been installed on an unsupported modem.

Red LED
This LED indicates that data received, and bootloader functions and has the following patterns:

- Flashes indicate an RF data packet received by the modem.
- Solid red indicates that the modem has entered bootloader mode.

5 Application Configuration

5.1 Multipoint Mesh Overview

This mode is designed to function similarly to the RFD modem multipoint firmware. Groups of modems operate as a wireless serial links either between individual nodes or as a broadcast to all.

Multipoint operations depend on the configuration of the key parameters:

- P2PAUTO
- SLOTS
- SLOTIDS
- NODEID
- BITRATE
- TOTALUS
- NETWORKS
- DESTID

Note: It is the responsibility of the user to confirm the compatibility of this firmware with local regulation and operate accordingly.

The total slot size of a network, in terms of bytes of data is related to the settings of the TOTALUS and BITRATE parameters. Slot BYTES~=TOTALUS*BITRATE/8000

Note that the practical throughput is approximately 85% of the theoretical maximum as represented by the BITRATE parameter.

Note: The radio will not allow settings that result in slots smaller than ~300bytes and not larger than ~1000 bytes.

The highest NODEID available in any a single network is 62

5.2 Single Network

For small numbers of total nodes or scenarios where all nodes need to be able to intercommunicate, the single network mode is recommended.

The available bitrate is divided among the total number of nodes in the network. Likewise, the total TOTALUS transmission time is divided amongst the nodes of the network.

An example 10 node network is configured by the following settings:

Master

Setting	AT Command
BITRATE=125	ATS1=125
P2PAUTO=0	ATS6=0
TOTALUS=25000	ATS7=25000
SLOTS=10	ATS8=10
SLOTIDS=1	ATS9=1
NODEID=0	ATS10=0

Network node settings

Setting	AT Command
BITRATE=125	ATS1=125
P2PAUTO=0	ATS6=0
TOTALUS=25000	ATS7=25000
SLOTS=10	ATS8=10
SLOTIDS=2^N	ATS9=2^N
NODEID=N	ATS10=N

Where N is the node number from 1-9

Nodes can either be directed to broadcast to all nodes in the network or to direct data packets to a particular node in the network. This is controlled by the DESTID parameter as follows:

Broadcast

Setting	AT Command
DESTID=63	ATS14=63

Unicast

Setting	AT Command
DESTID=Target NODEID	ATS14=Target NODEID

5.3 Multiple Networks

Where a larger number of nodes, nodes with higher individual throughput, or improved RF sensitivity, and therefore maximum range, by use of lower bit rates are need multiple network mode is recommended.

The available bitrate is divided among the total number of nodes in the network. Likewise, the total TOTALUS transmission time is divided amongst the nodes of a network.

Note: The radio will not allow settings that result in slots smaller than ~300bytes and not larger than ~1000 bytes. BYTES~=TOTALUS*BITRATE/8000

An example 18 nodes across 3 networks of 6 nodes each is configured by the following settings:

Master

Setting	AT Command
BITRATE=64	ATS1=64
P2PAUTO=0	ATS6=0
TOTALUS=24000	ATS7=24000
SLOTS=6	ATS8=6
SLOTIDS=1	ATS9=1
NODEID=0	ATS10=0
NETWORKS=3	ATS12=3

Network 1 nodes settings

Setting	AT Command
BITRATE=64	ATS1=64

P2PAUTO=0	ATS6=0
TOTALUS=24000	ATS7=24000
SLOTS=6	ATS8=6
SLOTIDS=2^N	ATS9=2^N
NODEID=N	ATS10=N
NETWORKS=3	ATS12=3

Where N is the node number from 1-5

Network 2 node settings

Setting	AT Command
BITRATE=64	ATS1=64
P2PAUTO=0	ATS6=0
TOTALUS=24000	ATS7=24000
SLOTS=6	ATS8=6
SLOTIDS=2^N	ATS9=2^N
NODEID=N	ATS10=N
NETID=8	ATS11=8
NETWORKS=3	ATS12=3

Where N is the node number from 0-5

Network 3 node settings

Setting	AT Command
BITRATE=64	ATS1=64
P2PAUTO=0	ATS6=0
TOTALUS=24000	ATS7=24000
SLOTS=6	ATS8=6
SLOTIDS=2^N	ATS9=2^N
NODEID=N	ATS10=N
NETID=15	ATS11=15
NETWORKS=3	ATS12=3

Where N is the node number from 0-5

Nodes can either be directed to broadcast to all nodes in the network or to direct data packets to a particular node in the network. This is controlled by the DESTID parameter as follows:

Broadcast

Setting	AT Command
DESTID=63	ATS14=63

Unicast

Setting	AT Command
DESTID=Target NODEID	ATS14=Target NODEID

Note: There is also a limitation that nodes of different networks cannot be co-located, within 3 metres of each other, unless they never transmit whilst other collocated nodes are receiving. This is to avoid overloading the receiver electronics.

Synchronising the co-located node transmissions can mitigate the need for physical separation and can be achieved by using the following settings:
All Networks have the same number of SLOTS
Co-located nodes belong to different networks.
Co-located nodes have the same SLOTIDS
Co-Located nodes SLOTTXMODE is set to 1.

5.4 Encryption

The firmware supports hardware accelerated AES encryption with key lengths of 128 or 256 bits. To send and receive valid data all nodes need to have the same encryption level and key. All payload data is encrypted including RC passthrough signals.

Note: Despite being a hardware accelerated process there can be some small latency associated with the encryption and decryption process.

The encryption key (K) should be a string of 32 comma separated values each with a maximum value of 255 and a final trailing comma. This represents the 256 bits of the maximum key length.

Note: Even when only the 128 bit encryption is used the full 256 bit key is required when setting this parameter.

For example, the default key is:

6,61,235,16,21,202,113,190,43,115,174,240,133,125,119,129,31,53,44,7,59,97,8,215,45,152,16,163,9,20,223,244,

To enable encryption the following settings should be set:

Setting	AT Command
ENCRYPTLV=1 (128bit key), or 2 (256bit key)	ATS20=1 or 2
ENCRYPTKEY=K	ATS48=K

5.5 Multivehicle Operation Notes

- When operating multiple vehicles and/or ground control stations (GCS) on a multipoint network it is necessary to set unique SYSID for each vehicle.
- A programme, such as MAVPROXY, is required to coordinate or merge the messages between the different vehicles and GCS systems.

6 Useful Links

FTDI USB Drivers

https://ftdichip.com/drivers/

RFD Modem Firmware and documentation

https://rfdx.atlassian.net/wiki/spaces/TS/pages/452198432/RFD+x2+Family

RFD Store

https://store.rfdesign.com.au

MAVPROXY Documentation

https://ardupilot.org/mavproxy/

7 Glossary

Term	Description
Throughput	Measure of data transfer speed/rate.
RF	Radio Frequency. A term used to describe a portion of the electromagnetic spectrum. Commonly encompassing frequencies between a few tens of kilohertz and a couple of hundred gigahertz.
RF Sensitivity	A measure of the level of discrimination between signal and noise of an RF system.
AES	Advanced Encryption Standard. A data encryption protocol meeting the specifications established in the ISO/IEC 18033-3 standard.
Baud	Unit of measurement of symbol rate. This is an indication of data transfer speed of serial connections
FTDI	Future Technology Devices International, a supplier of electronic components synonymous with their UART to USB converter chips and the cables which use such components.
GPIO	General Purpose Input Output. A microcontroller pin that can be configured for various input and output functions
MAVLink	Micro Air Vehicle Link. A protocol for telemetry data exchange between compatible ground control software and autonomous vehicle controllers.
RFD	RF Design. The Australian company who designed, build and support the x series modems among other products.
RX	Receive/Receiver of data transfer from an external source.
SAS	A data protocol. This provides an alternative for users not sending MAV data.
Logic Level	The voltage level of digital logic signals.
GND (Ground)	The reference level for defining voltages of a circuit or system. May also be called 0 volts.
Latency	The time delay between signal input and output.
Serial	A protocol for sending and receiving data in a sequential manner.
TX	Transmit/Transmitter of data to a receiver.
UART	Universal Asychronous Receiver Transmitter. Hardware implementation of a serial data protocol.

8 Revision History

Version	Date	Changes
1.0	18/10/24	V4 BETA Initial Release Document