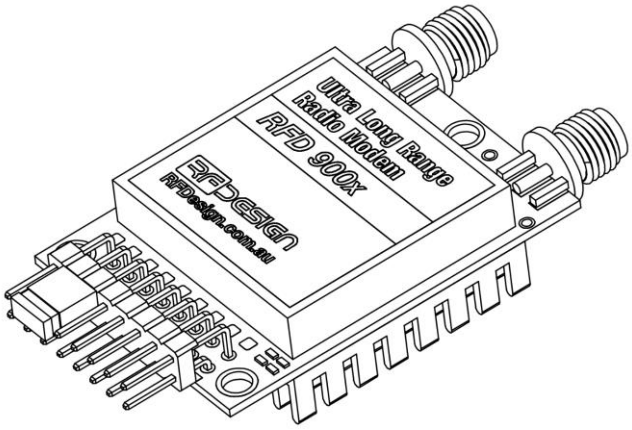
Point-to-Point/SIK Firmware User Manual

SiK V3.64+ for use on the RFD x and ux series modems





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

1 Key Features....3
2 General Cautions and Operating Considerations....4
2.1 General Cautions....4
2.2 When used in the US - FCC Caution....4
2.3 When used in Canada - ISED Caution....4
2.4 When used in Brazil....5
2.5 EIRP and Antenna Limits....5
3 Functions and Features....6
3.1 Feature overview....6
3.2 Point-to-point radio link....6
3.3 Bootloader....6
4 Peer-to-Peer Network....8
4.1 Network Layout:....8
4.2 Multiple Modem Pairs or Other Signals in RF Range:....8
5 Hardware and Regional Versions....10
5.1 Hardware Versions:....10
5.2 Regional Version:....11
5.3 Compliance and Acceptance:....12
6 Parameters and Configuration....13
6.1 GUI....13
6.2 AT Commands....15
6.3 S Parameters Table....17
6.4 S Parameter Details....19
6.5 AT Commands Examples....23
7 Reset to Factory Settings....26
7.1 AT Command....26
7.2 Override Firmware When Unable to Connect....26
8 Useful Links....27
9 Glossary....28
10 Regional Compatibility Settings for Unlocked Modems....29
10.1 900MHz Modems....29
10.2 868MHz Modems....34
11 Revision History....37

1 Key Features

- Default settings are ready to use for point-to-point (P2P) communication.
- Outdoor RF line-of-site range of 40km or more depending on configuration and antennas.
- MAVLink data packet support.
- Air data rate speeds of up to 1000 kbits/s. (Settable rates depend on variant)
- Hardware accelerated AES encryption with up to 256 bit keys.
- Support for PPM and SBUS remote control signal pass through.
- Digital pin mirroring
- Two antenna ports with automatic diversity.

2 General Cautions and Operating Considerations

2.1 General Cautions

During operation there must be a separation distance of 20cm between all persons and the antenna.

Ensure that all used RF connectors are secure

Unused RF connectors may be terminated with an open circuit or covered with a plastic dust cover. Ports should not be terminated with shorts or RF loads as this may damage componentry or cause failure of features such as the automatic diversity mode.

If used in proximity to other RF devices with transmission power exceeding 5W, devices such as ADSB transponders, radar etc., it is recommended that external filters are added between the antenna and modem to protect the receiver of the modem from damage. The Shireen BPF-915C is an example of such an external filter for the 902-928MHz band.

If used in environments with high chance of static discharge, such as dry dusty conditions, additional protection against static discharge into the device from the antennas/RF ports may be required to prevent damage.

2.2 When used in the US - FCC Caution

Caution: The user is cautioned that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.
Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
—Reorient or relocate the receiving antenna.
—Increase the separation between the equipment and receiver.
—Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
—Consult the dealer or an experienced radio/TV technician for help.

This equipment complies with FCC’s RF radiation exposure limits set forth for an uncontrolled environment. The antenna(s) used for this transmitter must be installed and operated to provide a separation distance of at least 20 cm from all persons and must not be collocated or operating in conjunction with any other antenna or transmitter. Installers must ensure that 20cm separation distance will be maintained between the device (excluding its handset) and users.

2.3 When used in Canada - ISED Caution

This device complies with RSS 210 of the Industry Canada Rules. Operation is subject to the following two conditions:
(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :
(1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.
This equipment complies with Canada radiation exposure limits set forth for uncontrolled environments. This equipment should be installed and operated with a minimum distance of 20cm （may be adjusted according to actual calculation result） between the radiator and your body.
This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.
Déclaration d'IC sur l'exposition aux radiations:
Cet équipement est conforme aux limites d'exposition aux radiations définies par le Canada pour des environnements non contrôlés. Cet équipement doit être installé et utilisé à une distance minimum de 20 cm entre l'antenne et votre corps.
Cet émetteur ne doit pas être installé au même endroit ni utilisé avec une autre antenne ou un autre émetteur.

2.4 When used in Brazil

Este equipamento não tem direito à proteção contra interferência prejudicial e não pode causar interferência em sistemas devidamente autorizados. Para maiores informações, consulte o site da ANATEL – www.anatel.gov.br".

2.5 EIRP and Antenna Limits

Where applicable this device has been tested and certified to operate with 3dBi dipole antennas. Other antenna types with directional radiation patterns or those with gain greater than 3dBi may require the user to compensate by reducing the maximum device output power in accordance with Effective Isotropic Radiated Power (EIRP) requirements of local radio authority.

3 Functions and Features

This firmware is a development of the open source project "SiK" created by Mike Smith, it has been further developed and modified by Andrew Tridgell, and by RFDesign. RFDesign's implementation and modifications are closed source and proprietary, source code will not be released or published.

3.1 Feature overview

The Point-to-Point/SiK firmware has many software features including:

- Frequency Hopping Spread Spectrum (FHSS): for interference minimisation. (When the radio is configured for more than a single channel)
- Transparent Serial Link: data is not manipulated or changed by the modem during transmission. (When configured for 'RAW' data framing.)

Note that certain settings can affect maximum frame size and may cause data to be sent in multiple smaller packets.

- Configuration by AT/RT commands for local and remote radios. User configuration includes serial data rates, air data rates, AES hardware encryption, data framing protocols, radio status reporting, antenna diversity switching, and others.
- PPM or SBUS (R/C signal) pass through.
- Overtemperature protection by automatic duty cycle throttling.

3.2 Point-to-point radio link

The firmware is designed to operate as a serial bridge, allowing serial data links to be formed wirelessly between two systems that have a radio frequency line of sight. The default modem configuration allows the modem to link on power up with a second modem operating the same firmware.

3.3 Bootloader

The modems feature a boot loader to facilitate upgrade of the modem firmware via the serial port. The RFD Modem tools provide a GUI to perform a firmware update (see "Useful links"), otherwise the bootloader can be triggered manually by entering the AT&UPDATE command from within the firmware command mode, or by external trigger pad. (See instructions in the relevant modem technical datasheet for specific steps to manually force bootloader mode for your modem if required.)

When the device LED is solid red, the modem is in bootloader mode.

The bootloader defaults to serial settings of:

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

On entering bootloader mode, the modem will print an identifier statement to the serial port. This statement identifies the hardware configuration of the modem, bootloader revision, and hardware ID.

e.g. RFD900xSub:2:MainV1.12.03 ChipID: XXXXXXXXXXXXXXXX

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

Default serial port settings are as follows:

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

The AT command mode is entered by sending +++ on the serial port. The modem will respond with an OK when entering AT command mode.

Note that the serial port can sometimes fail to recognise this command if the symbols are sent too close together, therefore it is sometimes necessary to add some delay, e.g. 50ms, between each symbol send to microcontroller or PC code for correct modem response.

4 Peer-to-Peer Network

4.1 Network Layout:

The peer-to-peer firmware offers straight forward data communication between two configured nodes. Whenever two nodes with compatible parameters and are within RF signal range, they will automatically negotiate pairing and begin communication.

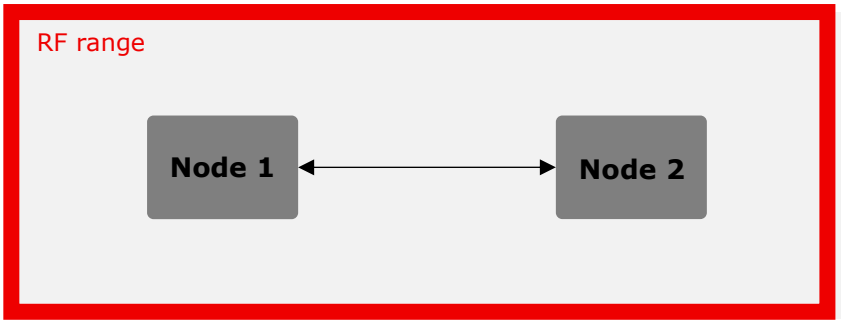


Figure 1: Pair of RFD modems in P2P communication

4.2 Multiple Modem Pairs or Other Signals in RF Range:

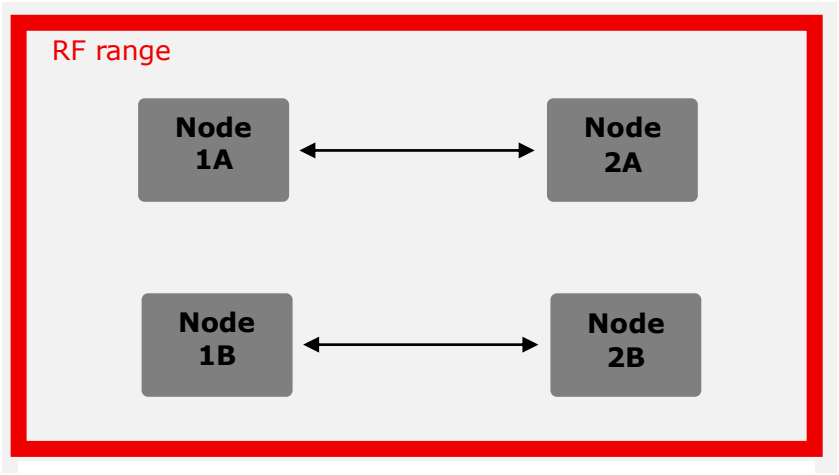


Figure 2: Multiple modem pairs in P2P mode, and in RF signal range of each other.

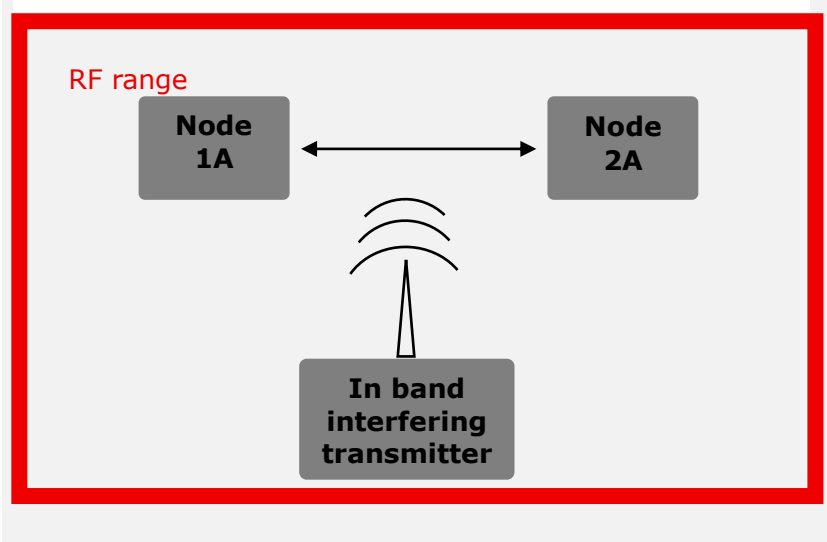


Figure 3: Pair of RFD modems in P2P communication with interfering signal

If operating in an area with other RFD modems, or other communication devices, on the same frequency band, it is possible that the communications link of the RFD modems will suffer from interference. There are a few mitigations that you can employ to minimise the impact of in band interference:

- When possible, set the different pairs on different frequencies or sub bands, and where possible include a 1MHz buffer. e.g. in the Australian frequency band of 915-928MHz set pair 'A' of modems to use 915-921MHz and pair 'B' can use 922-928MHz.
- Separate modem antennas from other transmitters. The minimum separation will be dependent on operating frequency and power of the transmitter, and antenna gain. For example, separation of two RFD modems with 3dBi antennas should be at least 5 metres when operating at 30dBm transmit power. This avoids overloading the modem receiver which can cause the modem to soft reboot and temporarily lose synchronisation, and data link.
- Set different 'Network ID' parameter values for each pair to filter multiple P2P links from each other.

5 Hardware and Regional Versions

5.1 Hardware Versions:

The RFD x and ux series modems currently have two major hardware revisions these can be identified by the text on the PCB between the antenna ports, see figures below. This will read V1.# for V1 type hardware and V2.# V2 type hardware. Where # can be any number and is indicative of a minor revision.

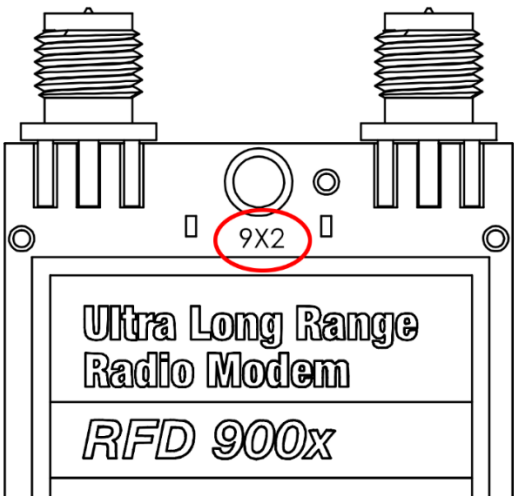


Figure 4: x series modem hardware version label

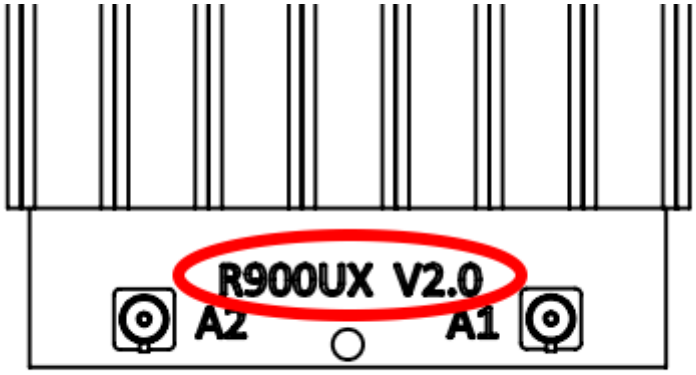


Figure 5: ux series modem hardware version label

Note the different hardware versions are generally compatible with each other when using the same version of SiK firmware. Older hardware versions are not guaranteed to receive ports of recent SiK firmware versions and as such may not have all the latest features available.

Hardware compatiblity
Peer to Peer (SiK)
and Multipoint

Modem	X (V1)	uX(V1)	X (V2)	uX(V2)
X (V1)				
uX(V1)				
X (V2)				
uX(V2)				

Figure 6: Hardware revision compatibility for SiK firmware

5.2 Regional Version:

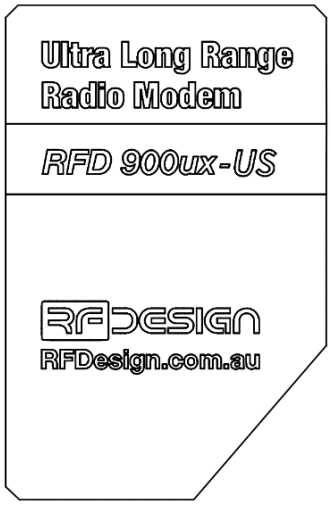


Figure 7: 900ux-US variant label

Modems that feature a product code with a dash and letter code, e.g. RFD900ux-US, are region locked variants. The letters after the dash indicating the region to which that modem is locked.

The current regional modems are:

x series

Modem Model Name	Country/Region of Compliance	Modular Certification ID
RFD900x2-AU	Australia	N/a
RFD900x2-BR	Brazil	ICC 11.148/2025-I
RFD900x2-US	Canada and the United States of America	FCC: 2ADLE-900X IC: 24610-00UX2
RFD900x2-NZ	New Zealand	N/a
RFD868x2-EU	European Union	N/a

ux series

Modem Model Name	Country/Region of Compliance	Modular Certification ID
RFD900ux2-US	Canada and the United States of America	FCC: 2ADLE-900UX2 IC: 24610-00UX2
RFD868ux-IND	India	N/a
RFD868ux2-EU	European Union	N/a

Note not all country complaint variants are available for all models.

Regional variants may satisfy regulations in other areas, for instance the US modem may also suite the regulation in Canada.

Note it is ultimately up to the user to identify the radio frequency regulations applicable to their areas of operation and ensure their modems parameters are set correctly.

Modems without these codes are fully user configurable.

5.3 Compliance and Acceptance:

The RFD 900x modems and variants are designed and may be tested for conformity to:

- AS4268:2012
- NZ GURL 2017
- FCC 15.247
- RSS-247 Issue2
- ANATEL Res 680 and Act 14448

The RFD 868x modems and variants are designed and may be tested for conformity to:

- Directive 2014/53/EU on radio equipment
- EN300220
- EN301489
- IEC 62368-1:2014
- EN62311

Equipment type approval of the 865-867MHz band in India

Note only the region locked versions of the modems are represented to be compliant in their respective regions.

Note that unlocked modems can be setup in an interoperable configuration with region locked variants, but this configuration does not convey regional compliance for an unlocked modem.

6 Parameters and Configuration

The SiK firmware can be configured in two main ways, by use of the RFDTools GUI, or by serial using AT/RT commands.
Some other software developments, such as Mission Planner do also offer tools which can make configuration changes to the RFD modem parameters with varying compatiblity.

6.1 GUI

The RFDTools available from the RFD website, see useful links, is designed to support graphical configuration of modem parameters regardless of the firmware loaded. This section will provide a very brief outline of the use of the RFDTools.

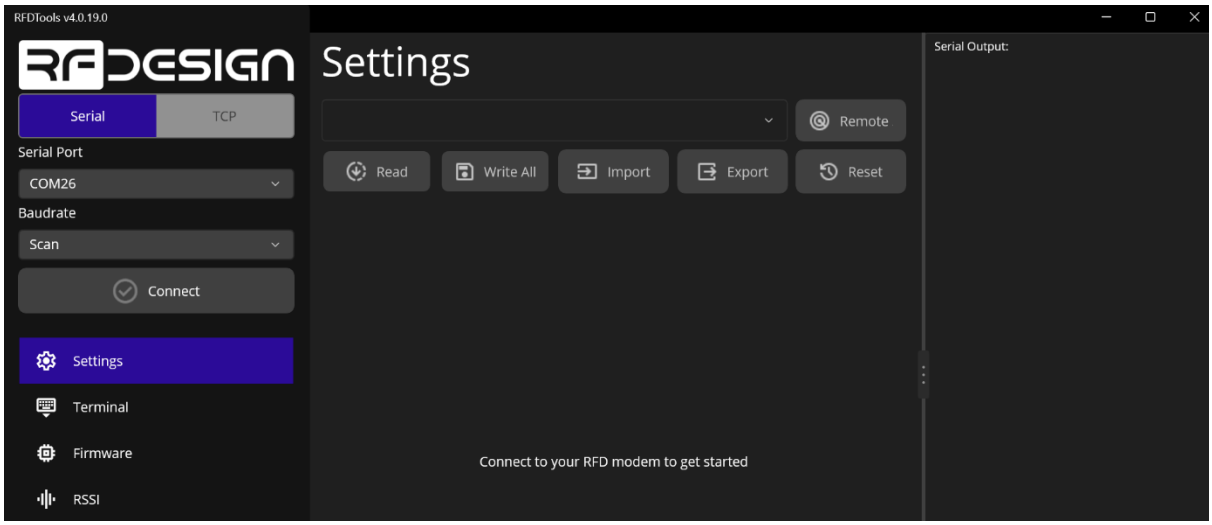


Figure 8: RFDTools GUI

The connection modem can be switched between “Serial” and “TCP” mode using the buttons in the top left under the RFDESIGN logo.

The port settings can then be selected below that. In serial mode if the baudrate is known it can be selected otherwise it can be left in “Scan” mode.

Pressing “Connect” opens the port.

Pressing “Read” will get current settings information from the modem and populate the screen below with those details.

When connected to a modem that is linked to others in the network the ‘Remote’ button will scan for other modem’s settings. The remote modem can be selected using the drop down menu under the “Settings” title.

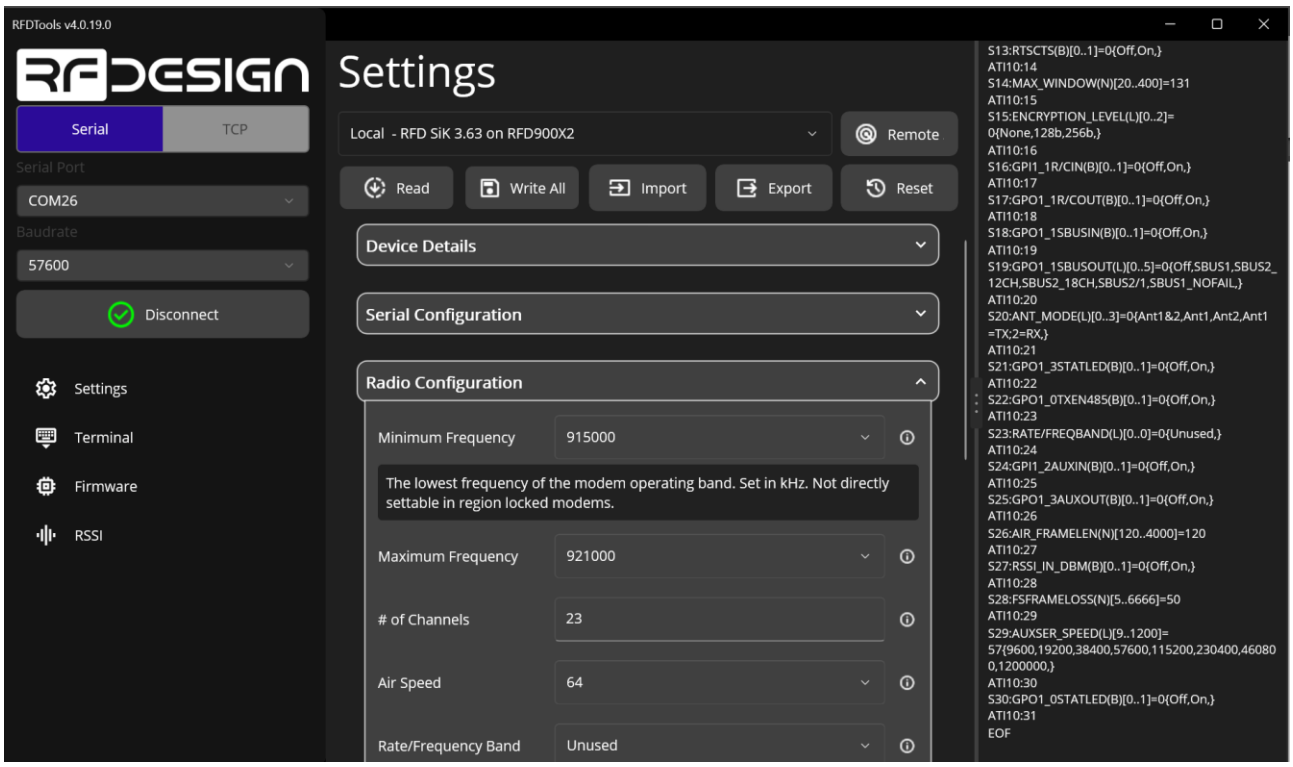


Figure 9: RFDTools modem settings example

Settings are grouped in various category tabs. They can be changed using the check and drop-down boxes.

Tips about various settings can be displayed by clicking on the information logo.



"Write All" saves changes made to the modem/s, where applicable changes will be made to remote modems first.

"Import" allows for modems settings matching previously saved configurations to be loaded automatically to the connected modem.

"Export" allows for the current modem settings to be recorded for future reference or for later reloading using "Import". This button will also trigger a pop up to optionally include device information. This is not required settings files but can be useful if contacting support@rfdesign.com.au for assistance with modems settings or behaviour.

"Reset" will return all settings to default values.

The "Terminal" tab on the left hand side, below the port details and the "Settings" tab, will open a direct terminal from which commands can be manually entered or data on the port monitored.

Note in "Settings" mode the right most panel will print the most recent serial activity.

The "Firmware" tab below "Terminal" will take the user to the programming mode.

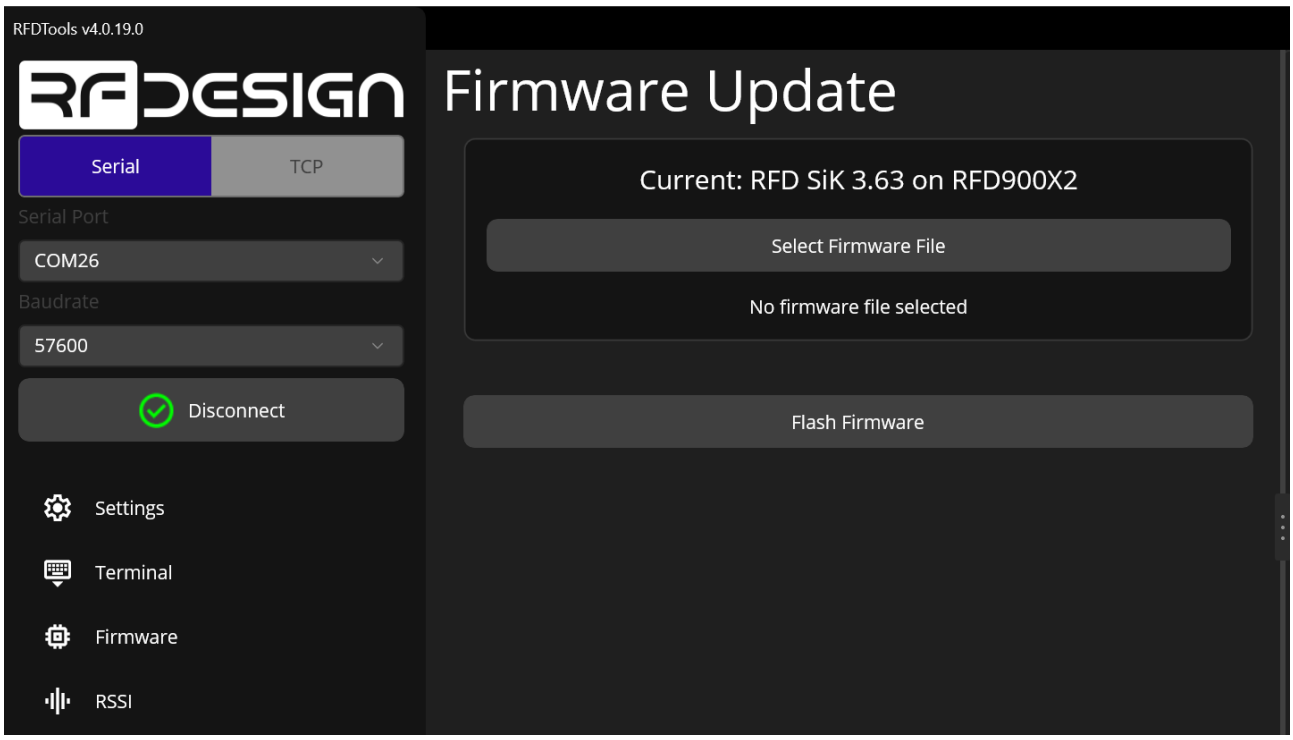


Figure 10: RFDTools Firmware Tab

The currently loaded firmware version is displayed towards the top of the window.

The "Select Firmware File" button will open a dialogue allowing the user to choose the desired file. Once done the details of the selected file will be displayed below the button.

"Flash Firmware" will load the selected firmware file onto the modem.

Note at the end of the firmware flashing process the tools will disconnect automatically as part of the modem reboot process. You will need to reconnect to read settings or change the firmware again. Also be aware that the update process may change the baudrate setting and this may need to be adjusted in the port configuration before the tools will reconnect.

6.2 AT Commands

The AT command mode can be entered by using the '+++', without quotes, sequence in a serial terminal connected to the radio.
If successful, an 'OK' prompt will be displayed on the screen, and the modem will stop displaying incoming data from the remote modem.

Note the serial port can sometimes fail to recognise this command if the symbols are sent too close together, therefore it is sometimes necessary to add some delay, e.g. 50ms, between each symbol send by microcontroller or PC code for correct modem response.

In command mode, you can use the AT commands to modify the local modem settings or the RT commands to modify the remote modem.
To set parameter 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.
    a. Repeat for all the settings that you wish to update.

Note that certain settings may only become available after other settings have been applied, including saving and rebooting. An example is setting the duty cycle value of an EU modem to a value higher than 10 is only possible after the low power mode has been enabled using the "S23:RATE/FREQBAND" parameter.

2. Use the command AT&W to save the new values to the x modem memory.

3. Use the command ATZ to software reboot the modem, required for some changes to take effect.

By replacing **A** with **R** in the command means that the settings of the remote modem can be changed.

Note it is recommended that changes to remote settings be made first as some of the changes can unlink the modems after being applied.

AT/RT Command	Description
ATI / RTI	Shows the firmware version and country code
ATI1 / RTI1	Shows the firmware version number
ATI2 / RTI2	Shows the board type
ATI3 / RTI3	Shows board frequency
ATI4 / RTI4	Shows board version
ATI5 / RTI5	Shows all user settable EEPROM parameters and their values
ATI5? / RTI5?	Shows all user settable EEPROM parameters and their possible range
ATI6 / RTI6	Displays TDM timing report
ATI7/ RTI7	Displays RSSI signal report
ATI8 / RTI8	Display Device 64-bit unique ID
ATI9 / RTI9	Calibration validation test
ATI10:X / RTI10:X	Prints the detailed information for S parameter X
ATI11 / RTI11	RC signal statistics
ATI13 / RTI13	Auxiliary serial port statistics
ATI14 / RTI14	Chip configuration data
ATO / RTO	Exits AT command mode
ATSn? / RTSn?	Displays radio 'S' parameter number 'n'
ATSn=X / RTSn=X	Sets radio 'S' parameter number 'n' to 'X'
ATRn? / RTRn?	Displays radio 'R' parameter number 'n'
ATRn=X / RTRn=X	Sets radio 'R' parameter number 'n' to 'X'
ATZ / RTZ	Reboots the radio
AT&F / RT&F	Resets all parameters to factory defaults
AT&W / RT&W	Writes current parameters to EEPROM
AT&UPDATE	Reset and enter boot mode
AT&R	Record failsafe RC PPM/SBUS stream for (vehicle side) failsafe output
AT&R=0	Reset the failsafe RC PPM/SBUS stream to default
AT&T	Disables debugging report
AT&T=RSSI	Enables RSSI debugging report
AT&T=TDM	Enables TDM debugging report

AT&E=X / RT&E=X	Set new encryption key 'X' expressed in hexadecimal characters (e.g. 5A02D5BB...)
AT Command	**Description**
AT&E? / RT&E?	Shows current encryption key
ATPP / RTPP	Shows GPIO configuration and state
ATPO=X / RTPO=X	Sets GPIO X to output
ATPI=X / RTPI=X	Sets GPIO X to input
ATPM=X / RTPM=X	Designates GPIO pin X input state to be mirrored as the value output on the corresponding pin of the paired radio. Note the mirror state messages have lowest priority in radio messages behind, RC control signals and serial data. Latency of this feature is not fixed and may vary due to radio settings, data throughput, and other factors. It is not intended for data and/or critical signals.
ATPU=X / RTPU=X	Remove the pin mirror from GPIO pin X
ATPR=X / RTPR=X	Shows GPIO input state
ATPC=X,Q / RTPC=X,Q	Sets output GPIO X to state Q. Note if applied to a mirrored output the commanded value will be overwritten by the next state transition of the mirror input state.

An example command to return the local modem's firmware version string.

Command

ATI (or RTI for a remote modem)

Response

RFD SiK 3.64 on RFD900X2-AU # On a region locked modem

RFD SiK 3.64 on RFD900X2 # On an unlocked modem

6.3 S Parameters Table

Note some parameters must be the same on both modems in the pair for correct operation. There are labelled **Link** below.

Note that not all values in the ranges listed below will be applicable to all modem models. For instance, regional variants will not allow arbitrary frequency settings, and the physically available pins of the ux models may prevent some GPIO functions from being available to the user.

Reg	Register Name	Default 900/868	Maximum	Minimum	Link
S0	FORMAT	Firmware dependant	N/A	N/A	Yes
S1	SERIAL_SPEED	57	3000	1	No
S2	AIR_SPEED	64/200	1000	12	Yes
S3	NETID	25	255	0	Yes
S4	TXPOWER	30	30	0	No
S5	RSVD	0	0	0	No
S6	MAVLINK	1	2	0	No
S7	OPRESEND	0	1	0	No
S8	MIN_FREQ	915000 /868000	928000 /870000	902000 /865000	Yes
S9	MAX_FREQ	928000 /870000	928000 /870000	902000 /865000	Yes
S10	NUM_CHANNELS	20/1	51/8	1	Yes
S11	DUTY_CYCLE	100	100	10	No
S12	LBT_RSSI	0	220	25	Yes
S13	RTSCTS	0	1	0	No
S14	MAX_WINDOW	131	400	20	Yes
S15	ENCRYPTION_LEVEL	0	2	0	Yes
S16	GPI1_1R/CIN	0	1	0	No
S17	GPO1_1R/COUT	0	1	0	No
S18	GPI1_1SBUSIN	0	1	0	No
S19	GPO1_1SBUSOUT	0	5	0	No
S20	ANT_MODE	0	3	0	No
S21	GPO1_3STATLED	0	1	0	No
S22	GPO1_0TXEN485	0	1	0	No
S23	RATE/FREQBAND	0	3	0	Yes
S24	GPI1_2AUXIN	0	1	0	No
S25	GPO_1.3AUXOUT	0	1	0	No
S26	AIR_FRAMELEN	120	120	4000	Yes
S27	RSSI_IN_DBM	0	0	1	N/A
S28	FSFRAMELOSS	50	5	50	No
S29	AUXSER_SPEED	9	57	1200	No
S30	GPO1_0STATLED	0	0	1	No
S31	SBUS_PPM_FSAFE_CFG	0	1	0	No
R0	TARGET_RSSI_dBm	0	110	0	No
R1	HYSTERESIS_RSSI	5	15	2	No

6.4 S Parameter Details

FORMAT – Packet Format
The packet format identifier used to signify details about the data formats used by the firmware.

> Note that generally firmware which has the same Format value should interoperate, it is however best practice to ensure that exactly matching firmware versions are installed on both modems in the link for best performance.

SERIAL_SPEED – Primary Serial Baudrate
This configures the baudrate of the main serial port. Accepted values are 1, 2, 4, 9, 19, 38, 57, 115, 230, 460, 1200, and 3000. These correspond to buadrates of 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400, 460800, 1200000, and 3000000 respectively. Typically, this is set at a rate similar to but, below the AIRSPEED data rate.

AIRSPEED – RF Data rate in Kilobits per Second (kbps)
Radio link data rate in kilobits per second. Accepted values are 12, 56, 64, 80, 100, 125, 188, 200, 224, 430 and 1000 corresponding 12000, 56000, 64000, 80000, 100000, 125000, 188000, 200000, 224000, 430000 and 1000000.

> Note this is a theoretical rate which does not represent the data throughput of the link. There are various overheads that occupy some of the radio packet reducing effective data throughput.

When practical the AIRSPEED should be set to a value higher than the SERIAL_SPEED to avoid data backing up in the input buffer. When both serial ports are sending data the AIRSPEED may need to be further increased to accommodate the combined data throughput requirement.

NETID – Network Identifier
This is used to separate modem pairs which may otherwise try to link due to shared radio settings into prescribed networks.

> Note that separation by unique NETID only controls modem pair linking. It does not prevent possible interference and data loss from other modems with shared radio settings.

TXPOWER – RF Transmit Power
Sets the target transmit power for the radio system in dBm.

MAVLINK – Data Framing
Enables or disables the MAVLink framing and reporting.

0 – Raw data mode

1 – MAV1 framing

2 – MAV2 framing

Supports MAV1 and MAV2 framing. When enabled the modem will reconstruct the MAVLink framing of the serial data stream and adds radio status messages to the stream as appropriate. When disabled the serial data is transmitted in a raw mode without framing.

OPRESEND – Opportunistic Resend

When enabled the system will resend data packets if it has spare bandwidth. This can be used to increase the chances of correctly receiving data through redundancy. Should be considered when operating around other transmitters in the frequency band which may interfere with signals for example.

MIN_FREQUENCY – Minimum Frequency
Specifies the minimum operating frequency, in kHz, which the radio signals will occupy.

MAX_FREQUENCY – Maximum Frequency
Specifies the maximum operating frequency, in kHz, which the radio signals will occupy.

NUM_CHANNELS – Number of Radio Frequency Channels
The number of RF channels to use within the frequency band defined by MIN_FREQUENCY and MAX_FREQUENCY. This will define the channel spacing as follows.

ChannelSpacing = (FREQMAX – FREQMIN) / (NUMCHANS + 1).

The number of channels **must be** set such that the channel spacing is **at least**:
500kHz – For 1000kbs and 430kbps air rates.
250kHz – For all other lower air rates.

Note that if only a single channel is set its frequency will be in the middle of the FREQMIN and FREQMAX parameters.

DUTY_CYCLE – Radio transmission duty cycle percentage
Sets the proportion of transmit time that the radio can use. As this setting is reduced so is the effective throughput of the link. Depending on data requirements, and message frequency latency may increase as duty cycle increases.

LBT_RSSI – Listen before transmission signal level threshold
The RSSI (Received Signal Strength Indication) level that will prevent a modem from trying to transmit. Intended to prevent packet loss due to potentially interfering signals. Experimental feature not fully tested.

RTSCTS – RTS CTS hardware flow control signals

Hardware flow control signals for the primary serial port. Helpful for preventing data loss due to input buffer overwrite. Especially recommended when the duty cycle is reduced or airspeed is set below the serial baudrate.

MAX_WINDOW – Transmission period in milliseconds

Sets the maximum radio window period. Reducing the value can decrease latency but may reduce the effective throughput of the link as it reduces the data that can fit into a single transmission.

ENCYRPTION_LEVEL – Bit depth of AES encryption applied to data

Controls the hardware accelerated AES encryption:

0 – Disables data encryption

1 – Data encryption with a 128bit key

2 – Data encryption with a 256bit key

GPI1.1R/CIN – GPIO 1 pin function as PPM signal input

Sets the GPIO 1 as an input for externally generated PPM control signals with 3.3V logic.

GPO1.1R/COUT – GPIO 1 pin function as PPM signal output

Sets the GPIO 1 as an output for transmitted PPM control signals with 3.3V logic.

GPI1.1SBUS input – GPIO 1 pin function as SBUS signal input

Sets the GPIO 1 as an input for externally generated SBUS control signals with 3.3V logic.

GPO1.1SBUS output– GPIO 1 pin function as SBUS signal output

Sets the GPIO 1 as an input for transmitted SBUS control signals with 3.3V logic.

ANT_MODE – Antenna port behaviours

The two RF ports of the modem may be configured to operate in several ways:

0 – Automatic antenna diversity. The modem will monitor both ports for received signals and lock on to the strongest signal. The port with the best signal will be used for the subsequent transmission.

1 – Exclusively use antenna port 1 for both receive and transmit.

2 – Exclusively use antenna port 2 for both receive and transmit.

3 – Exclusively use antenna port 1 for receive, and port 2 for transmit.

Note that automatic diversity does not work correctly for 12k airspeed settings and it is recommended that another mode be selected if using this airspeed.

GPO1.3STATLED – GPIO 3 pin function as green status LED mirror

Sets the GPIO 3 as an output mirroring the status LED signals with 3.3V logic.

Note that this output is configured as a current sink so if driving an LED 3.3V indicates the LED off and 0V indicates the LED on.

GPO1.0485 – GPIO 0 pin function as control signal for RS485 interface

Sets the GPIO 0 pin as an output intended for controlling the data direction signal of an RS485 converter IC used in some RFD designs.

RATE/FREQBAND – Region locked modem band or rate selection

Controls settings such as frequency, number of channels, duty cycle and/or transmit power as applicable for the available configuration options of regionally locked modem variants. The exact settings available are dependent on the variant in use.

GPI1_2AUXIN – GPIO pin 2 as auxiliary serial RX

Sets the GPIO 1 as an input for the auxiliary serial RX signal with 3.3V logic.

GPO_1.3AUXOUT – GPIO pin 3 as auxiliary serial TX

Sets the GPIO 1 as an output for the auxiliary serial TX signal with 3.3V logic.

AIR_FRAMELEN – Maximum size in bytes of the data frame

Set the maximum radio data size of the data frame in bytes.

Note the default setting is designed for compatibility with V1 hardware. If the network contains only V2 hardware, then this should be increased to 4000 for best performance.

RSSI_IN_DBM – Received signal strength measurement displayed in dBm

Converts the RSSI figure from counts to dBm.

Note that due to the structure of the radio status message these values are given as positive numbers when actual measurements will be negative. This can give the false impression that the noise is higher than the signal when in its in fact more negative.

FSFRAMELOSS – Number of lost RC signal frames to trigger failsafe output

Sets the number of RC signal frames to trigger the prerecorded failsafe output.

AUXSER_SPEED – Auxiliary serial baudrate

This configures the baudrate of the main serial port. Accepted values are 9, 19, 38, 57, 115, 230, 460, and 1200. These correspond to baudrates of 9600, 19200, 38400, 57600, 115200, 230400, 460800, and 1200000 respectively.

GPO1_0STATLED – GPIO 0 pin function as green status LED mirror

Sets the GPIO 0 as an output mirroring the status LED signals with 3.3V logic.

Note that this output is configured as a current sink and the LED should be connected to a 3.3V power supply with suitable current limiting resistor, max current 5mA. In this configuration a high output of the modem pin corresponds to the LED being off.

SBUS_PPM_FSAFE_CFG – Selects the failsafe output used after RC input or radio link loss

When set to 0, the receiving modem outputs the recorded failsafe if the transmitting modem loses its RC input. If the radio link between the modems is lost, the receiving modem instead continues to output the last received RC frame. When set to 1, the receiving modem outputs the recorded failsafe after either RC input loss or radio link loss.

TARGET_RSSI_dBm – Received signal strength for transmit power automatic scaling

An experimental feature for scaling the transmit power used by the modem depending on the received signal strength indicated value. When the value is below the target by the hysteresis amount power will be increased, and equally, when above the target by the hysteresis amount the power will be decreased.

HYSTERESIS_RSSI – Received signal margin for transmit power automatic scaling

6.5 AT Commands Examples

Setting Encryption

AES data encryption may be disabled, set to 128 bit, or 256 bit mode using the AT commands (see Table 4.1). When enabled the corresponding encryption key can of a 32, or 64 character hexadecimal string can be set with the 'AT&E' command.
First enter AT command mode by typing '+++' and waiting for an 'OK' response from the modem. Then to activate encryption on a device, the encryption mode must be set first using 'ATS15=x' in the command terminal. Once the encryption mode is active, an encryption key may be set after typing 'AT&E=xyz' into the command terminal.

Note that the encryption level and key for connected devices must match or they will not be able to properly share data.

```
ATS15=1

OK

AT&E=5AEEF103125C0AA233678909160111CA

OK

AT&W

OK

ATZ

Note blue text are user commands

Note green text are modem response
```

Setting Airdata Rate

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 flow control on the serial link

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. If this is not possible then flow control should be strongly considered to prevent data corruption or loss due to buffer overwrite.

Example of changing air data rate:

```
ATS2=224
OK
AT&W
OK
ATZ
```

Setting Up RC Signals

To enable PPM control signal pass through on a modem link it is necessary to set the RC transmitting 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 of the x series).

Input modem configuration:

```
ATPI=1
OK
ATS16=1
OK
AT&W
OK
ATZ
```

Output modem configuration:

```
ATPO=1
OK
ATS17=1
OK
AT&W
OK
```

```
ATZ
```

To record a failsafe PPM stream:

- Connect the PPM generator to the signal transmitter modem.
- Power up the receiving modem.
- Connect the transmitting modem using the FTDI cable.
- After the modems have established a link set the desired PPM failsafe stream using the generator.
- Send the following command to set the failsafe on the output modem.

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

Alternatively connected to receiver modem via the FTDI cable in which case the command would be.

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

Note it is the RC output modem that must record the failsafe.

Note that different RC signal types can be inter-converted by the modem. e.g SBUS input can be output as PPM etc.

7 Reset to Factory Settings

7.1 AT Command

The modems can be returned to the default factory settings by use of the following AT commands.

```
AT&F

OK

AT&W

OK

ATZ

Note blue text are user commands

Note green text are modem response
```

7.2 Override Firmware When Unable to Connect

If the modem is an unknown state and serial connection is not possible the following procedure will force the system to return to default settings.

- Download the desired firmware for your modem as well as a version from a separate branch, e.g. if SiK V3.64 is the desired firmware download this as well as a version of either the Asynchronous or MultiComm firmware. (See Useful Links)
- Force the modem into bootloader mode using the process outlined in the technical datasheet relevant to the model of modem that you are using.
- Connect to the modem using the modem tools and enter the firmware menu
- Upload the previously downloaded firmware from the alternative type. e.g. the Asynchronous or MultiComm firmware.
- Once the firmware has loaded connect to the modem again and load the settings.
- Change any setting in anyway and write the changes. (This will force the user settings memory to be overwritten and will reset when the desired firmware is reloaded.)
- Return to the firmware menu and load the desired firmware.
- Once the modem reboots you will be able to connect at the default 57600 baud rate and all settings will have been returned to default.

8 Useful Links

FTDI

https://ftdichip.com/drivers/

RFD Modem Firmware

https://rfdx.atlassian.net/servicedesk/customer/portal/1/article/252968986

RFD Tools

https://rfdx.atlassian.net/servicedesk/customer/portal/1/article/242712577

RFD Store

https://store.rfdesign.com.au

RFD Documentation

https://rfdx.atlassian.net/servicedesk/customer/portal/1/article/252968986

9 Glossary

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.

LOS (LoS): *Line of Sight*.
This refers to the distance that a radio signal can reach uninterrupted by obstructions or the radio horizon.

PPM: *Pulse Position Modulation*.
This is an encoding standard used by radio controller to send data about the position of multiple servo motors.

SBUS: *Serial Bus protocol created by Futaba*.
This is an encoding standard used by radio controller to send data about the position of multiple servo motors.

AES: *Advanced Encryption Standard*.
A data encryption protocol meeting the specifications established in the ISO/IEC 18033-3 standard.

MAVLink: *Micro Air Vehicle Link*.
A protocol for telemetry data exchange between compatible ground control software and autonomous vehicle controllers.

LED: *Light Emitting Diode*.
A semiconductor device that converts electrical power to light.

Baud: *Unit of measurement of symbol rate*.
This is an indication of data transfer speed of serial/UART connections.

Serial: *A synonym of UART*,
a protocol for sending and receiving data in a sequential manner.

TX: *Transmit*.
RX: *Receive*.

RTS: *Request to Send*.
UART hardware flow control flag.

CTS: *Clear to Send*.
UART hardware flow control flag.

UART: *Universal Asynchronous Receive Transmit*.
Hardware that manages serial data transfer between connected devices.

GPIO: *General Purpose Input Output*.
A microcontroller pin that can be configured for various input and output functions.

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.

USB: *Universal Serial Bus*.
An industry standard for data communication and power delivery between devices. Most commonly found in type A and C connectors.

FHSS: *Frequency Hopping Spread Spectrum*.
A radio technique used to minimise interference. An RF spectrum allocation into narrow RF channels and the system then hops through those channels.

GFSK: *Gaussian Frequency Shift Keying*.
A form of modulating data onto a carrier frequency by controlling frequency shifts.

CRC: *Cyclic Redundancy Check*.
An error detecting code that uses a small piece extra data to mathematically determine the correctness of a decoded signal.

RFD: *RF Design*.
The Australian company who designed, build and support the x series modems among other products.

10 Regional Compatibility Settings for Unlocked Modems

Applying these settings allows an unlocked modem to connect to regional variant modem that shares the same base frequency. There are settings for the different available rate/frequency modes, but they are otherwise default settings. If the modems will not link review the S Parameters Table to see the 'Link' parameters that must match for a link to be established. These settings are valid for SiK V3.64 firmware. There may be difference for other version of firmware

The information below has been formatted such that required settings can be copied from this document into an INI file for importing to a modem by the RFDTools.

Note it is ultimately up to the user to identify the radio frequency regulations applicable to their areas of operation and ensure their modems parameters are set correctly.

Note that unlocked modems can be setup in an interoperable configuration with region locked variants, but this configuration does not convey regional compliance for an unlocked modem.

10.1 900MHz Modems

-AU

Lower band (DEFAULT)

S0:FORMAT=63

S1:SERIAL_SPEED=57

S2:AIR_SPEED=64

S3:NETID=25

S4:TXPOWER=30

S5:RSVD=0

S6:MAVLINK=1

S7:OPPRESEND=0

S8:MIN_FREQ=915000

S9:MAX_FREQ=921000

S10:NUM_CHANNELS=23

S11:DUTY_CYCLE=100

S12:LBT_RSSI=0

S13:RTSCTS=0

S14:MAX_WINDOW=131

S15:ENCRYPTION_LEVEL=0

S16:GPI1_1R/CIN=0

S17:GPO1_1R/COUT=0

S18:GPO1_1SBUSIN=0

S19:GPO1_1SBUSOUT=0

S20:ANT_MODE=0
S21:GPO1_3STATLED=0
S22:GPO1_0TXEN485=0
S23:RATE/FREQBAND=0
S24:GPI1_2AUXIN=0
S25:GPO1_3AUXOUT=0
S26:AIR_FRAMELEN=120
S27:RSSI_IN_DBM=0
S28:FSFRAMELOSS=50
S29:AUXSER_SPEED=57
S30:GPO1_0STATLED=0
S31:SBUS_PPM_FSAFE_CFG=0
R0:TARGET_RSSI_dBm=0
R1:HYSTERESIS_RSSI_dBm=5

Upper Band

S0:FORMAT=63
S1:SERIAL_SPEED=57
S2:AIR_SPEED=64
S3:NETID=25
S4:TXPOWER=30
S5:RSVD=0
S6:MAVLINK=1
S7:OPPRESEND=0
S8:MIN_FREQ=922000
S9:MAX_FREQ=928000
S10:NUM_CHANNELS=23
S11:DUTY_CYCLE=100
S12:LBT_RSSI=0
S13:RTSCTS=0
S14:MAX_WINDOW=131
S15:ENCRYPTION_LEVEL=0
S16:GPI1_1R/CIN=0
S17:GPO1_1R/COUT=0
S18:GPO1_1SBUSIN=0
S19:GPO1_1SBUSOUT=0
S20:ANT_MODE=0
S21:GPO1_3STATLED=0

S22:GPO1_0TXEN485=0
S23:RATE/FREQBAND=1
S24:GPI1_2AUXIN=0
S25:GPO1_3AUXOUT=0
S26:AIR_FRAMELEN=120
S27:RSSI_IN_DBM=0
S28:FSFRAMELOSS=50
S29:AUXSER_SPEED=57
S30:GPO1_0STATLED=0
S31:SBUS_PPM_FSAFE_CFG=0
R0:TARGET_RSSI_dBm=0
R1:HYSTERESIS_RSSI_dBm=5

-US

Lower Band (DEFAULT)

S0:FORMAT=63
S1:SERIAL_SPEED=57
S2:AIR_SPEED=64
S3:NETID=25
S4:TXPOWER=30
S5:RSVD=0
S6:MAVLINK=1
S7:OPPRESEND=0
S8:MIN_FREQ=902000
S9:MAX_FREQ=915000
S10:NUM_CHANNELS=51
S11:DUTY_CYCLE=100
S12:LBT_RSSI=0
S13:RTSCTS=0
S14:MAX_WINDOW=131
S15:ENCRYPTION_LEVEL=0
S16:GPI1_1R/CIN=0
S17:GPO1_1R/COUT=0
S18:GPO1_1SBUSIN=0
S19:GPO1_1SBUSOUT=0
S20:ANT_MODE=0
S21:GPO1_3STATLED=0
S22:GPO1_0TXEN485=0

S23:RATE/FREQBAND=0
S24:GPI1_2AUXIN=0
S25:GPO1_3AUXOUT=0
S26:AIR_FRAMELEN=120
S27:RSSI_IN_DBM=0
S28:FSFRAMELOSS=50
S29:AUXSER_SPEED=57
S30:GPO1_0STATLED=0
S31:SBUS_PPM_FSAFE_CFG=0
R0:TARGET_RSSI_dBm=0
R1:HYSTERESIS_RSSI_dBm=5

Upper Band

S0:FORMAT=63
S1:SERIAL_SPEED=57
S2:AIR_SPEED=64
S3:NETID=25
S4:TXPOWER=30
S5:RSVD=0
S6:MAVLINK=1
S7:OPPRESEND=0
S8:MIN_FREQ=915000
S9:MAX_FREQ=928000
S10:NUM_CHANNELS=51
S11:DUTY_CYCLE=100
S12:LBT_RSSI=0
S13:RTSCTS=0
S14:MAX_WINDOW=131
S15:ENCRYPTION_LEVEL=0
S16:GPI1_1R/CIN=0
S17:GPO1_1R/COUT=0
S18:GPO1_1SBUSIN=0
S19:GPO1_1SBUSOUT=0
S20:ANT_MODE=0
S21:GPO1_3STATLED=0
S22:GPO1_0TXEN485=0
S23:RATE/FREQBAND=1
S24:GPI1_2AUXIN=0

S25:GPO1_3AUXOUT=0
S26:AIR_FRAMELEN=120
S27:RSSI_IN_DBM=0
S28:FSFRAMELOSS=50
S29:AUXSER_SPEED=57
S30:GPO1_0STATLED=0
S31:SBUS_PPM_FSAFE_CFG=0
R0:TARGET_RSSI_dBm=0
R1:HYSTERESIS_RSSI_dBm=5

-NZ

S0:FORMAT=63
S1:SERIAL_SPEED=57
S2:AIR_SPEED=64
S3:NETID=25
S4:TXPOWER=30
S5:RSVD=0
S6:MAVLINK=1
S7:OPPRESEND=0
S8:MIN_FREQ=920750
S9:MAX_FREQ=927250
S10:NUM_CHANNELS=25
S11:DUTY_CYCLE=100
S12:LBT_RSSI=0
S13:RTSCTS=0
S14:MAX_WINDOW=300
S15:ENCRYPTION_LEVEL=0
S16:GPI1_1R/CIN=0
S17:GPO1_1R/COUT=0
S18:GPO1_1SBUSIN=0
S19:GPO1_1SBUSOUT=0
S20:ANT_MODE=0
S21:GPO1_3STATLED=0
S22:GPO1_0TXEN485=0
S23:RATE/FREQBAND=0
S24:GPI1_2AUXIN=0
S25:GPO1_3AUXOUT=0
S26:AIR_FRAMELEN=120

S27:RSSI_IN_DBM=0

S28:FSFRAMELOSS=50

S29:AUXSER_SPEED=57

S30:GPO1_0STATLED=0

S31:SBUS_PPM_FSAFE_CFG=0

10.2 868MHz Modems

-EU

Note Valid airspeeds = 12,56,100 and 200

High Power (DEFUALT)

S0:FORMAT=63

S1:SERIAL_SPEED=57

S2:AIR_SPEED=200

S3:NETID=25

S4:TXPOWER=27

S5:RSVD=0

S6:MAVLINK=1

S7:OPPRESEND=0

S8:MIN_FREQ=869400

S9:MAX_FREQ=869650

S10:NUM_CHANNELS=1

S11:DUTY_CYCLE=10

S12:LBT_RSSI=0

S13:RTSCTS=0

S14:MAX_WINDOW=131

S15:ENCRYPTION_LEVEL=0

S16:GPI1_1R/CIN=0

S17:GPO1_1R/COUT=0

S18:GPO1_1SBUSIN=0

S19:GPO1_1SBUSOUT=0

S20:ANT_MODE=0

S21:GPO1_3STATLED=0

S22:GPO1_0TXEN485=0

S23:RATE/FREQBAND=0

S24:GPI1_2AUXIN=0

S25:GPO1_3AUXOUT=0
S26:AIR_FRAMELEN=120
S27:RSSI_IN_DBM=0
S28:FSFRAMELOSS=50
S29:AUXSER_SPEED=57
S30:GPO1_0STATLED=0
S31:SBUS_PPM_FSAFE_CFG=0
R0:TARGET_RSSI_dBm=0
R1:HYSTERESIS_RSSI_dBm=5

Low power

S0:FORMAT=63
S1:SERIAL_SPEED=57
S2:AIR_SPEED=200
S3:NETID=25
S4:TXPOWER=7
S5:RSVD=0
S6:MAVLINK=1
S7:OPPRESEND=0
S8:MIN_FREQ=869700
S9:MAX_FREQ=870000
S10:NUM_CHANNELS=1
S11:DUTY_CYCLE=100
S12:LBT_RSSI=0
S13:RTSCTS=0
S14:MAX_WINDOW=131
S15:ENCRYPTION_LEVEL=0
S16:GPI1_1R/CIN=0
S17:GPO1_1R/COUT=0
S18:GPO1_1SBUSIN=0
S19:GPO1_1SBUSOUT=0
S20:ANT_MODE=0
S21:GPO1_3STATLED=0
S22:GPO1_0TXEN485=0
S23:RATE/FREQBAND=1
S24:GPI1_2AUXIN=0
S25:GPO1_3AUXOUT=0
S26:AIR_FRAMELEN=120

S27:RSSI_IN_DBM=0
S28:FSFRAMELOSS=50
S29:AUXSER_SPEED=57
R0:TARGET_RSSI_dBm=0
R1:HYSTERESIS_RSSI_dBm=5
S30:GPO1_0STATLED=0
S31:SBUS_PPM_FSAFE_CFG=0

-IND

S0:FORMAT=63
S1:SERIAL_SPEED=57
S2:AIR_SPEED=188
S3:NETID=25
S4:TXPOWER=30
S5:RSVD=0
S6:MAVLINK=1
S7:OPPRESEND=0
S8:MIN_FREQ=865000
S9:MAX_FREQ=867000
S10:NUM_CHANNELS=7
S11:DUTY_CYCLE=100
S12:LBT_RSSI=0
S13:RTSCTS=0
S14:MAX_WINDOW=131
S15:ENCRYPTION_LEVEL=0
S16:GPI1_1R/CIN=0
S17:GPO1_1R/COUT=0
S18:GPO1_1SBUSIN=0
S19:GPO1_1SBUSOUT=0
S20:ANT_MODE=0
S21:GPO1_3STATLED=0
S22:GPO1_0TXEN485=0
S23:RATE/FREQBAND=0
S24:GPI1_2AUXIN=0
S25:GPO1_3AUXOUT=0
S26:AIR_FRAMELEN=120
S27:RSSI_IN_DBM=0
S28:FSFRAMELOSS=50

S29:AUXSER_SPEED=57

S30:GPO1_0STATLED=0

S31:SBUS_PPM_FSAFE_CFG=0

R0:TARGET_RSSI_dBm=0

R1:HYSTERESIS_RSSI_dBm=5

11 Revision History

Version	Date	Changes
1.0	19/03/19	Release document
1.1	24/09/19	
1.2	16/03/20	Added section 3.4
1.3	03/04/20	Updated for changes in v3.15 firmware
1.4	17/12/20	Updated for changes in v3.20 firmware and general amendments
1.5	04/09/26	Reformatted and updated for changes in v3.64 firmware, and general amendments. Added cautions, hardware versions, and compatibility sections.