Specification for Rust Industries RFM UHF Transceiver Module

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Document Change History

Issue	Amendment Details	Date of Issue	By
A	First Draft	6/02/05	AJR
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Table of Contents

Definitions

ADC	Analog to Digital Converter
CRC	Cyclic Redundancy Check
CTS	Clear to Send
dBm	Decibel referenced to 1mW
FHSS	Frequency Hopping Spread Spectrum
FSK	Frequency Shift Keying
IF	Intermediate Frequency
IIP3	Third Order Intercept Point
ISM	Industrial Scientific and Medical Frequency Band
LNA	Low Noise Amplifier
LO	Local Oscillator
MAN	Manchester Encoding
NRZ	Non Return to Zero
OEM	Original Equipment Manufacturer
PLL	Phase Locked Loop
PPM	Parts per Million
RF	Radio Frequency
RSSI	Receive Signal Strength Indication
RTS	Request to Send
TX / RX	Transmit / Receive
SAW	Surface Acoustic Wave
SRD	Short Range Device
VCO	Voltage Controlled Oscillator

Introduction

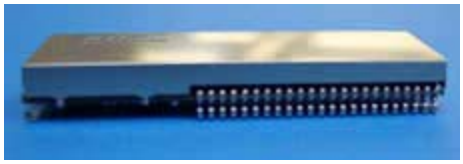
The RFM is a highly integrated, user programmable wireless UHF transceiver module with synthesized channels from 400 to 480MHz, and 800 to 950MHz. It typically operates in the unlicensed 434, 868 and 915MHz ISM Bands, using half duplex FSK modulation.

It has been conceived and designed as a *no-compromise product,* offering double conversion superheterodyne technology, a front end SAW filter and LNA, a –40ºC to +85ºC industrial temperature range, high output power and high receiver sensitivity (7km range attained at 434MHz and 3km range attained at 868MHz), serial RS232 communication, error free addressable data packeting, and exceptionally small size.

If this were not sufficient the user can program many parameters and features from a PC using supplied comprehensive software, including operating frequency to 200Hz resolution, output power, receive gain, squelch levels, frequency deviation, over-air baud rate, user baud rate, NRZ or Manchester encoding, and a range of data packeting options.

The RFM is available in through hole or surface mount versions.

Smd Version



Through Hole Version

The above photographs show the product full size.

Factory options include wide (up to 64kbps) or narrow (up to 14.4kbps) band variants in 434, 868 and 915 MHz bands, and removal of the normally fitted SAW filter.

Custom application software is a specialty. Forthcoming unique power saving and wake-up modes allow operation on a single AA cell for over 5 years.

Applications cover low cost telemetry, automatic meter reading, remote data acquisition, environmental monitoring, wireless modems, and a very wide range of OEM products. It is now affordable to enhance most of these systems with bi-directional error free communications.

Technology

Many of today's RF transceiver products may look fine on the surface, but dig a little deeper and the weaknesses become all too apparent. The RFM has excellent RF performance and reliability, and does not rely on AM, on-off keying, SAW transmitters, direct conversion receivers, etc.

The RF receiver uses the traditional high-end dual conversion FM superheterodyne approach, as used for decades by the public services such as fire, police and ambulance, as this gives the highest performance in terms of rejection of interference and unwanted signals.

The transmitter is derived from patented advanced frequency synthesis techniques, and is capable of FHSS with a high output power that is constant over temperature, supply voltage and production spreads.

Latest technology is used to produce exceptional receiver sensitivity and hence range, whilst minimizing current consumption. Its industrial temperatures and robust design ensures that it is not susceptible to harsh physical or electrical environments.

These features establish the RFM at the leading edge of UHF transceiver designs with features rarely found in competing products, and at a very competitive price.

It is our belief that in today's crowded frequency bands the use of such advanced technology is essential for high reliability. In the coming years the frequency bands will become even more crowded and the problems will only become worse. In Europe the 418 and 434MHz ISM bands are already quite full, and the introduction of a new digital public radio service called Tetra is causing even more interference in these bands. Simpler products that work today, may not work as well tomorrow. In fact they may not work at all.

Technical Specification

General

A RISC based microprocessor with in-circuit flash memory and E2rom, controls the RF circuitry. The transmitter derives its output frequency from a phase locked loop (PLL) synthesizer in steps of 200Hz. In the receive mode the antenna is fed via a TX / RX switch to a 50 ohm SAW filter which removes the image frequency and minimizes local high powered blocking signals. It is then fed via two 50 ohm LNA's and is mixed down, filtered and amplified at 2 intermediate frequencies before demodulation, base band low pass filtering, data slicing and data recovery. A digital Received Signal Strength Indication (RSSI) completes the receiver chain.

Frequency of operation:	400 to 480MHz 800 to 950MHz PLL, crystal controlled
Common ISM bands:	433 to 435MHz 868 to 870MHz 902 to 928MHz
Frequency resolution:	Digital tuning in approximately 200Hz steps
Frequency Stability:	+/- 6ppm
Frequency shifts:	< 50us for 100kHz shift
Maximum RF output power:	+14dBm (25mW) at 434MHz (worst case +10dBm) +12dBm (15mW) at 868MHz (worst case +10dBm) +10dBm (10mW) at 915MHz (worst case + 8dBm) Regulated over supply voltage and temperature Output protected over the full range of VSWR
Minimum RF output power:	12dB below the maximum power output Controlled by user accessible software in 8 levels
Modulation / Demodulation:	True dc coupled FSK to 64kbps Low speed AM is possible
Maximum Over air data rate:	Narrowband 434MHz: 14.4kbps half duplex NRZ Narrowband 868MHz: 9.6kbps half duplex NRZ Narrowband 915MHz: 9.6kbps half duplex NRZ Wideband variants: 64kbps half duplex NRZ
Receive / transmit time:	< 200us
SAW RF filter:	Image rejection > 40dB
Channel spacing:	Narrowband variant: 50kHz Wideband variant: 200kHz

First IF filter:	10.7MHz, ceramic, 230kHz bandwidth at 6dB points
Second IF filter:	455kHz ceramic, 35kHz bandwidth at 6dB points
Receive sensitivity:	Narrowband variant: -112 dBm at 4.8kbps & 10dB S/N Wideband variant: - 100 dBm at 64kbps & 10dB S/N A 3 to 4dB increase in sensitivity is possible by removing the SAW filter, at the expense of poorer image rejection and blocking by strong local signals See separate section on Range and Receiver Sensitivity
Receiver high / low gain:	6dB gain reduction, software selectable
RSSI:	A digital Received Signal Strength Indicator output with limit thresholds defined in software is available with a 50dB dynamic range
Antenna:	50 ohm impedance, unbalanced
Analogue Inputs :	2 user specific 10 bit ADC inputs, for data logging, etc
Digital Interface :	2 user specific digital inputs and / or outputs, for user command and control, etc. Logic levels are equal to the supply voltage
Serial data with RS232 conventions:	TXD input, RXD output, CTS flow control Logic levels are equal to the supply voltage
Digital Output Drive Capability:	Sink or source 500uA
Data Transfer modes:	1. Transparent mode 2. 16 bit CRC error corrected / data packeted mode
Supply voltage:	2.7V to 3.6V Ripple less than 10mV peak to peak
Supply current (at 3V):	Reception: 36 mA Transmission: 55 mA Sleep: 1 mA
Standard variants:	433 - 435MHz wide band 433 - 435MHz narrow band 868 - 870MHz wide band 868 - 870MHz narrow band 914 – 916MHz wide band 914 – 916MHz narrow band Factory fitted LNA Factory fitted front end SAW filter Other options and custom available

Configuration Software:	The user can set up all parameters including frequency, output power, RSSI thresholds, error free protocols using 16bit CRC's, etc via an easy to use Windows program
Operating temperature:	-20ºC to +75ºC narrowband variant -40ºC to +85ºC wideband variant
Storage temperature:	-40ºC to +85ºC
Compliance:	EN 300-220-3 EN 301 489 EMC Immunity > 5V/m It is the responsibility of RFM's customers to ensure that the final product incorporating the RFM complies with the R&TTE essential requirements
Dimensions:	49mm x 16mm x 7mm Top metal cover Pins on 1.27mm pitch See below:

Range and Receiver Sensitivity

Range is very difficult to predict and depends on environmental conditions, reflections, fading, error correction algorithms, the data rate, and the antennas, just to name a few. In free line-of-sight tests the following ranges have been obtained in error correcting mode using simple ¼ wave end fed antennas in an electrically quiet environment:

434MHz: 7km
869MHz: 3km
915MHz: 2km

The receiver sensitivity depends on many factors, including:

LNA Gain and Noise Figure
IF Bandwidths
Presence of Front End SAW filter
Frequency Deviation
On-Air Data Rate

The default LNA gain is set to maximum. This can be reduced during set up by 6dB, which can have the effect of improving the IIP3, and increasing performance in the presence of interfering signals.

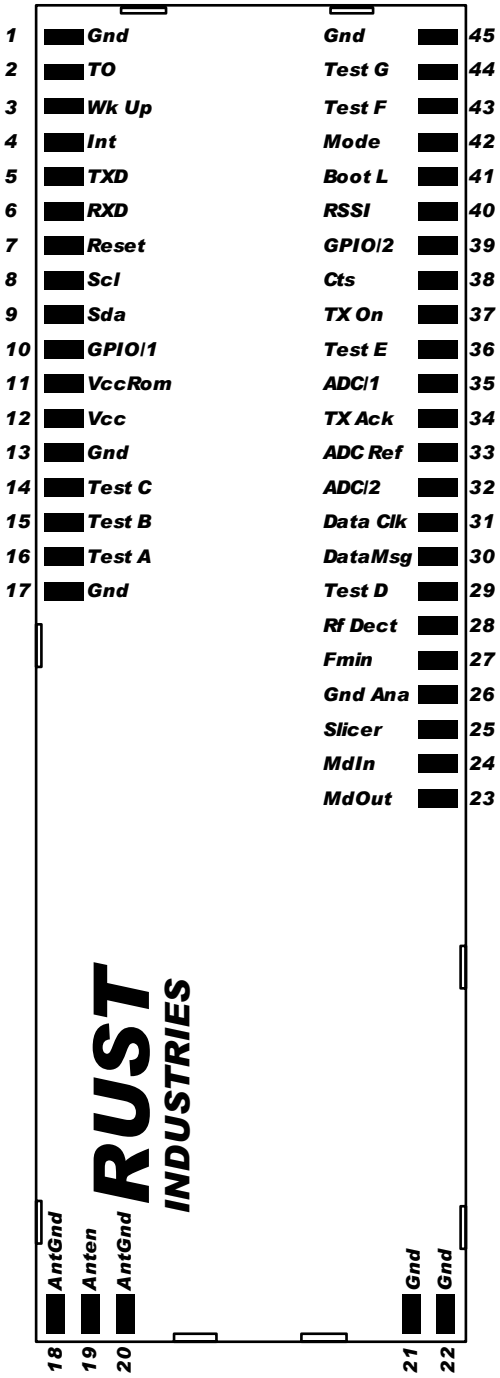
Narrow band modules have around 12dB more receive sensitivity than wide band modules, owing to the former having narrow IF bandwidths.

Removing filters (or increasing bandwidths) increases the probability to loose the RF link from time to time, depending on the external environment. The error correcting software overcomes these problems in many situations.

For a given bit error rate (BER) the receiver sensitivity is increased if the frequency deviation is large and the data rate is low. Thus it follows the maximum receiver sensitivity and range occurs with narrow band modules having maximum LNA gain, with a +/-10kHz frequency deviation, and a low data rate of, say, 1.2kbps

Optimizing the low pass filter on the output of the receiver demodulator can also add 1 or 2 dB to the receive sensitivity.

PIN Out RFM


1 Gnd
2 TO
3 Wk Up
4 Int
5 TXD
6 RXD
7 Reset
8 Scl
9 Sda
10 GPIO/1
11 VccRom
12 Vcc
13 Gnd
14 Test C
15 Test B
16 Test A
17 Gnd
Gnd 45
Test G 44
Test F 43
Mode 42
Boot L 41
RSSI 40
GPIO/2 39
Cts 38
TX On 37
Test E 36
ADC/1 35
TX Ack 34
ADC Ref 33
ADC/2 32
Data Clk 31
DataMsg 30
Test D 29
Rf Dect 28
Fmin 27
Gnd Ana 26
Slicer 25
MdIn 24
MdOut 23
RUST
INDUSTRIES
AntGnd
Anten
AntGnd
Gnd
Gnd
18
19
20
21
22

Pinout Descriptions

Pin	Signal	Description	Direction
P1	0Vper	Recommended to leave this pin unconnected	
P2	T0	Connect externally to DATAMSG, P30	
P3	WAKEUP	Wakes up RFM	Digital Input
P4	INT	Connect externally to DATACLK, P31	
P5	TXD	Transmitted serial data in RS232 format	Digital Output
P6	RXD	Received serial data in RS232 format	Digital Input
P7	RESET	Reset to microcontroller. Normally do not connect	Digital Input
P8	SCL	I^2C serial bus for future expansion	Digital Output
P9	SDA	I^2C serial bus for future expansion	Bi-directional
P10	GPIO#1 ADC#3	General Purpose Digital Input / Output or 10 bit ADC Input	Bi-directional Analog Input
P11	VCCrom	Connect externally to VCC, pin 12	Supply Input
P12	VCC	+2.7 to +3.6V power input	Supply Input
P13	0V	0V power input	Supply Gnd
P14	Test C	Test pin. Do not connect to this pin	
P15	Test B	Test pin. Do not connect to this pin	
P16	Test A	Test pin. Do not connect to this pin	
P17	0Vper	Recommended to leave this pin unconnected	
P18	ANTgnd	Antenna ground	Antenna Gnd
P19	ANT	50 ohm antenna feed	Bi-directional
P20	ANTgnd	Antenna ground	Antenna Gnd
P21	0Vper	Recommended to leave this pin unconnected	
P22	0Vper	Recommended to leave this pin unconnected	
P23	MDOUT	Connect externally to Mdin, P24	Analog Output
P24	MDIN	Connect capacitor C1 between P24 & P26	Analog Input
P25	SLICER	Connect capacitor C2 between P25 & P26	Analog Output
P26	0Van	Ground reference for C1 and C2	Analog Gnd
P27	FMIN	Do not connect to this pin	
P28	RFDETECT	Sleep wakeup. Connect externally to WU, pin 3	Open Drain Out
P29	Test D	Test pin. Do not connect to this pin	
P30	DATAMSG	Transmit and Receive Raw data	Bi-directional
P31	DATACLK	Recovered Receive Clock in Transparent Mode	Digital Output
P32	ADC#2	10 bit ADC Input	Analog Input
P33	ADCREF	External ADC analog reference	Analog Input
P34	TXACK	Turns on during packet transmission	Digital Output
P35	ADC#1	10 bit ADC Input	Analog Input
P36	Test E	Test pin. Do not connect to this pin	
P37	TXON	In Transparent Mode, Low for TX, high for RX	Digital Input
P38	CTS	Flow control for serial data	Digital Output
P39	GPIO#2	General Purpose Digital Input / Output	Bi-directional
P40	RSSI	Digital Received Signal Strength Indicator	Digital Output
P41	BOOTL	Selects Bootloader or normal operation	Digital Input
P42	MODE	Selects Transparent or Data Packeting or Pings	Digital Input
P43	Test F	Test pin. Do not connect to this pin	
P44	Test G	Test pin. Do not connect to this pin	
P45	0Vper	Recommended to leave this pin unconnected	

Pinout Definitions

RESET: 1 = Reset off
0 = Reset on

WAKEUP: 1 = RFM asleep
0 = Module active

DATACLK: Recovered clock when in Transparent Mode

DATAMSG: Bi-directional half duplex data when in Transparent Mode
Transmit input when TXON = 0
Receive output when TXON = 1

TXON: 1 = Receive in Transparent Mode
1 = Transmit in Transparent Mode

RSSI: When in Transparent Receive Mode, the signal strength from the receiver is polled every 100ms. If this is above the squelch threshold set by the user interface software, RSSI = 1

In Data Packet Mode, RSSI indicates a valid packet reception
1 = On
0 = Off

TXACK: Active high signal that turns on during a Packet Transmission
1 = On
0 = Off

BOOTL: If held low (= 0) during RESET, the RFM enters the user set up mode, otherwise normal operation occurs

MODE: If held low (= 0) during RESET, sets Transparent Mode
If held high (= 1) during RESET, sets Data Packet Mode

Generates Ping Packets every 3 seconds in Addressed Acknowledged Mode, if MODE is taken low (= 0) when the RFM has completed RESET and is in normal operation
1 = Pings off
0 = Pings on

CTS: Clear to Send output flow controls RXD into the RFM
1 = On (CTS is on when the TX input buffer is not full)
0 = Off (CTS is always on)

Capacitor C1: For optimum receive sensitivity set the value of C1 as follows:

On air baud rate	C1 (+/- 10%)
64k	47p
28.8k	100p
10k	300p
2.4k	1n2

Other values of C1 can be found by interpolation

Capacitor C2: This capacitor stores charge when using the external data slicer. A value of 10n +/-10% is suitable for most applications

Antenna: The RFM has an internal switch, so only a single antenna is required for TX and RX. The antenna can be whip, a helical, a yagi, a PCB strip or a PCB loop. To meet approval requirements it may be necessary to reduce the power output with some types of antenna.

Simple ¼ wave end fed dipoles are simple and low cost

At 915MHz a ¼ wave end fed dipole is 7.9cm long in air
At 868MHz a ¼ wave end fed dipole is 8.3cm long in air
At 434MHz a ¼ wave end fed dipole is 16.6cm long in air

Decoupling: It should not be necessary to add external decoupling capacitors if a clean power source is utilized. However it is a good policy to add a 100n ceramic + 10u tantalum close to pins 12 and 13, and not fit them if found unnecessary. Low ripple is required for full performance.

Ground Plane: It is a wise precaution to have a ground plane under the RFM on the PCB.

Modes of Operation

There are 2 modes of operation, Transparent and Data Packet:

Transparent Mode (MODE = 0)

The internal microcontroller is used to configure (via the user interface software) and monitor the RF chip. User data is not passed through to the microcontroller, but is available via the DATAMSG pin. Encoding may be NRZ or Manchester, with internal or external data slicing, so long as the demodulation criteria (discussed elsewhere) is obeyed.

At power up the RFM is in the mode set by TXON, assuming WAKEUP is high. If WAKEUP is low, the RFM will be in sleep mode, and will not respond to any inputs.

Data can be transmitted and received via DATAMSG

The RSSI level and hysteresis is set by the User Interface Software and is used to squelch data and control the RSSI pin. In receive mode, if the RSSI bits are not zero, the RFM is polled every 100ms. If the RSSI is greater than the threshold then the RSSI pin is set high. Note if hysteresis is set on the RSSI, then this also will be used to determine whether the RSSI pin is on or off. If the RSSI level is set to zero, the RFM will not be polled.

Data Packet Mode (MODE = 1)

The internal microcontroller is used to configure (via the user interface software) and monitor the RF chip. The DATAMSG Pin is not used in this mode. User data is now transferred between the host and RFM as an asynchronous serial data stream. The internal microcontroller is responsible for packeting and encoding the data before it is transmitted to air, and performing the reverse at the receiver. The Module may be powered up in transparent mode if required when the module has been set up for packet mode. This is accomplished by holding the MODE pin low at RESET. This facility is useful for checking the transmit frequency.

At power up the RFM is in receive mode, assuming WAKEUP is high. If WAKEUP is low, the RFM will be in sleep mode, and will not respond to any inputs.

Packet Format

Data is transmitted in packets with the following format.

Preamble: Alternating 1 and 0 to allow Rx Synchronization

Sync Word: 1 byte. 0x8e Marks the beginning of the packet

Address: 1 byte. Module address

Packet Type: 1 byte. Defines type of packet & sequence number for data packets
ppppnnnn
pppp Indicates packet type
1000 = Ping
1001 = Data
0010 = Ack
nnnn Sequence Number 0 -15 for data packets
Prevents data being output more than once if Ack is not received.

Data:	0-64bytes.	User Data for data packets maximum 64bytes
CRC:	2 bytes.	CRC16
Sync Word:	1 byte.	0x8e Marks the end of the packet

Protocol Addressing

Address 0 is always accepted by the receiver. If the transmitter is programmed for address 0 it will accept packets from any address. This means that if one module is programmed to address 0 it will be able to talk to another module in point to point mode whatever its address. In operation it is recommended to change the address to a non zero value.

Acknowledged

Acknowledged mode is suitable for point to point operation. In this mode each module in a pair that are to communicate must be configured with the same 8 bit address. Only packets with the correct Address will be output to the host at the receive end. If a packet is not acknowledged it is re-sent until an ack is received or the retry count is reached. If more than one packet with the same sequence number is received due to an ACK not being detected the packet will not be output again.

Unacknowledged

This is suitable for point to point, broadcast operation. All modules with the same address as the transmitter will output data to the host at the receiver. If any acknowledgements are required these must be handled by a host level protocol.

Ping packets will not be replied to in this mode.

Configuration

Below is list of configurable parameters for data packeting. These are in addition to the Transparent mode configurable parameters. They can be set via the User Interface Software.

Retries:

Used in Addressed Acknowledged mode to limit the number of times a packet is sent without receiving an acknowledgement.

1 byte
1 – 63

Default 3

DATA Timeout:

Data transmission timeout. A timer is started when the 1st byte is received. Data is transmitted when the timeout occurs or when Tx buffer is full.

1 byte
10- 255 *(10ms)

Default 500ms

ACKs:

Used to determine whether ACKs are used.

I byte

0 ACKs are not returned (Unacknowledged mode)
1 ACKs returned (Acknowledged Mode)

Throughput:

Used to control the utilization of the channel by setting a minimum inter-packet delay time. This can be set as follows.

1 byte

0 = 100%
1 = 50%
2 = 20%
3 = 10%
4 = 5%
5 = 1%
6 = 0.1%

Narrow band Module On Air Baud Rate:

600 – 19,200bps
Default 9,600bps

Wide Band Module On Air Baud Rate:

600 – 64,000bps
Default 38,400bps

1 byte

600 - 115200 stored as n * 600bps
1 = 600bps 192 = 115.2

User Baud Rate:

Defines the baud rate between the host and the RFM. This should usually be faster than the on air baud rate, to avoid overflowing the Rx Buffer.

1 byte

600 – 38400bps stored as n * 600bps
1 = 600bps 0x40 = 38400bps
Default 9600

Address:

Packet Address used in addressed modes. Packet address 0 is always accepted by the receiver. If the transmitter is programmed for address 0 it will accept packets from any address.

I byte

0 -255
Default 0

Encoding:

Used to determine Coding method for on air data.

I byte

0 Manchester Encoding Off
1 Manchester Encoding On

Power Up Message:

Determines message output by the RFM at Power Up

0 No Message

1 Standard Message
Returns SW version, Serial Number, Frequency, Offset and Mode
e.g.
V1.4
4NABCD0000000025
REM434-9.6
433920000Hz
10000Hz
Packet Manchester
OK

User Interface Software

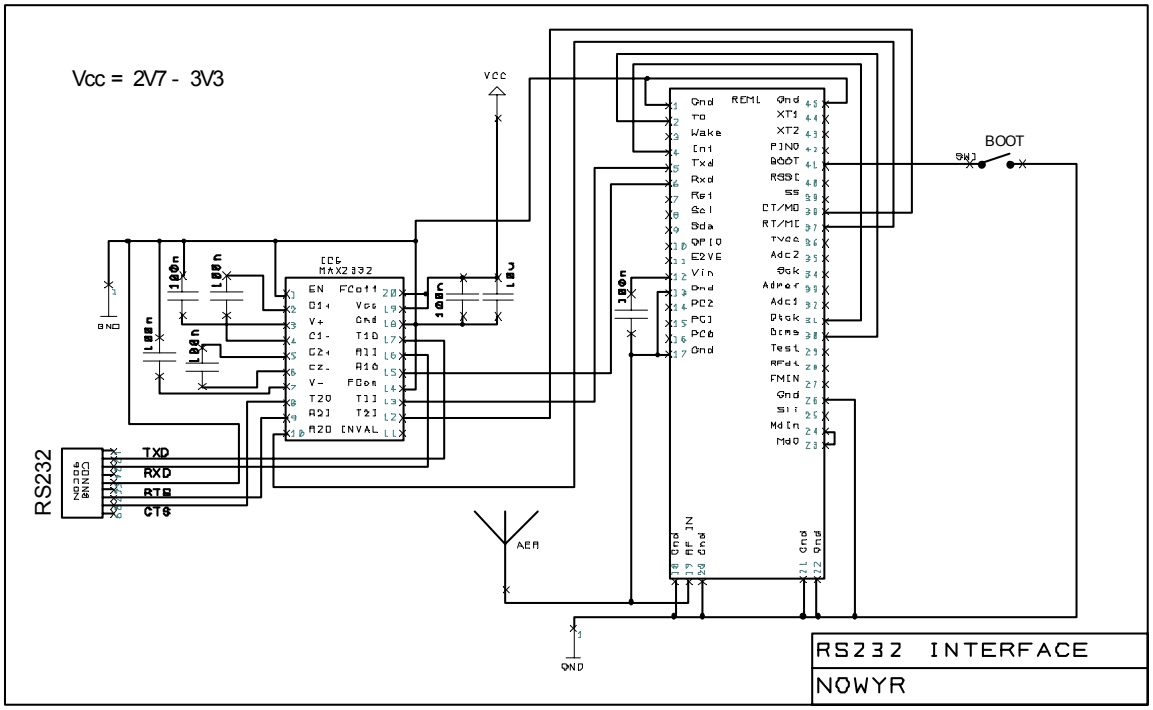
The user can program many features of the RFM over a simple RS232 serial connection from a PC, with supplied software. To enter this mode, switch the 'BOOT' switch to 0V before power up, and connect the TXD, RXD and 0V to a suitable COM port on the PC via a level shifting converter.

For simplified development it is recommended that a customer development kit is used, however it is possible to connect the module to a PC using a level shift arrangement as shown below. Reference the 'User Set-up' software manual will help detail the programming procedures.

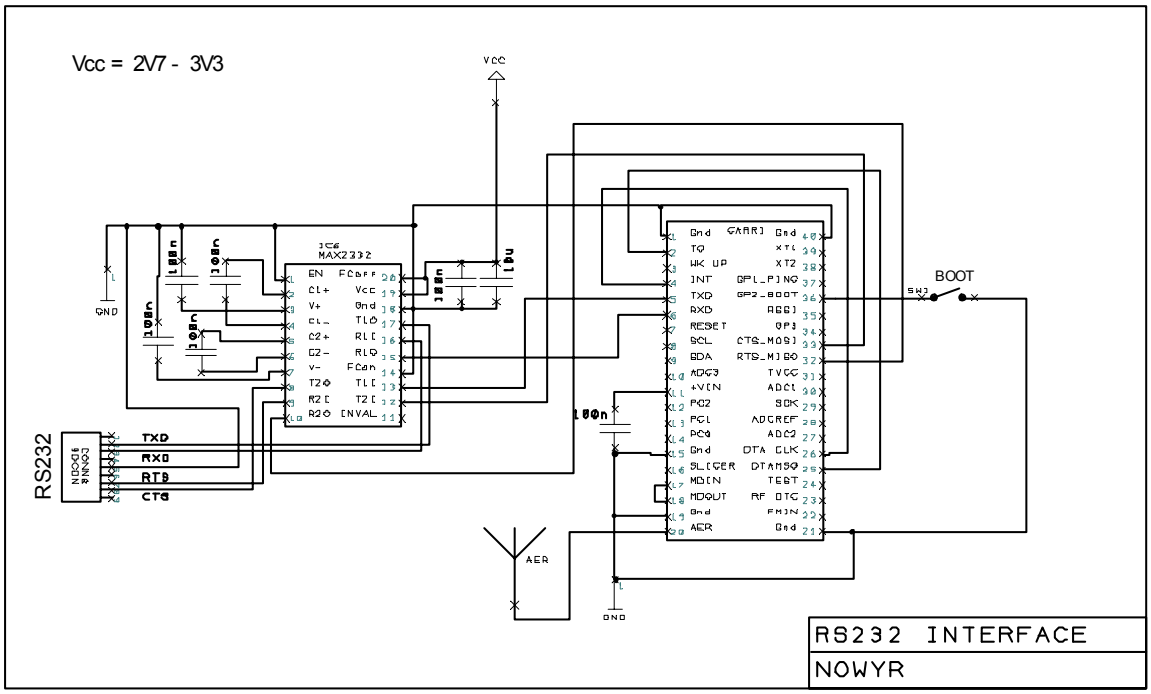
The type of level shifter IC that is shown can generate undesirable EMC if not implemented using appropriate tracking and standard precautions, this could adversely affect the RF performance of the module.

The module can be purchased on a carrier board in order the make the handling and connection to the module more convenient, the two schematics show connection for the 'pin outs' for both a basic module and a module mounted on a carrier board.

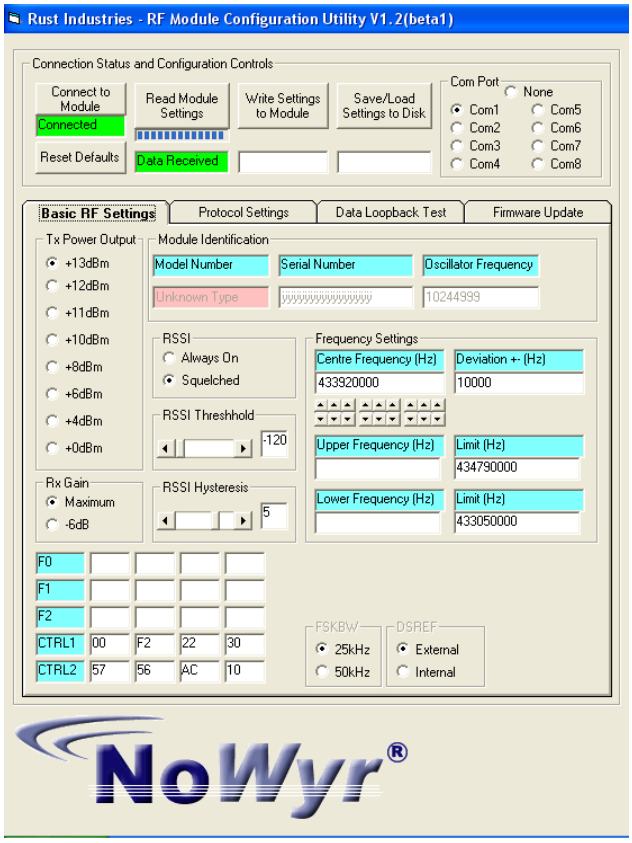
RS232 connection to basic module



RS232 connection to module on carrier.



Open the application and you should see the following screen:

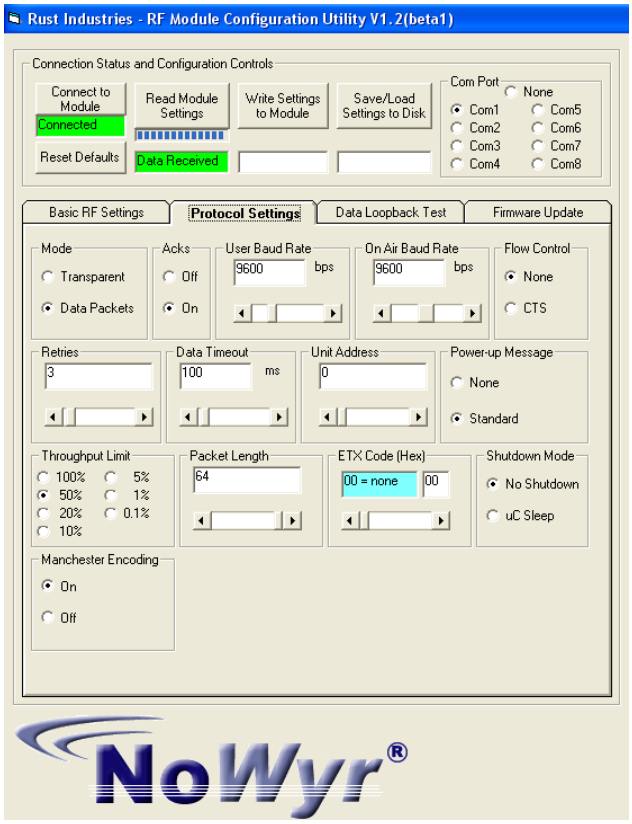


Select the COM port and click on “Connect to Module”, when the connection has been established, the red ‘Not Connected’ box will be replaced with a green ‘Connected’ box

Various default parameters will appear, including model number, serial number, centre frequency, deviation, etc.

The user can then adjust any of these settings, and store them in the RFM by clicking “Write Data to Module”.

Clicking on “Config. Protocol Settings” opens the following screen:



In a similar manner the user can adjust any of these settings, and store them in the RFM by clicking “Write Configuration to Module”.

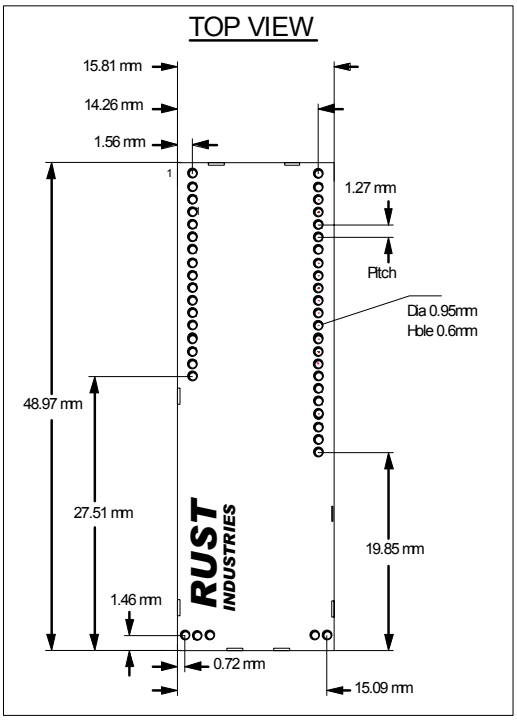
Customisation

The module has been designed with many useful functions, however if the user requires functionality that is not currently available, it may be possible to have the firmware customised for specific requirements.

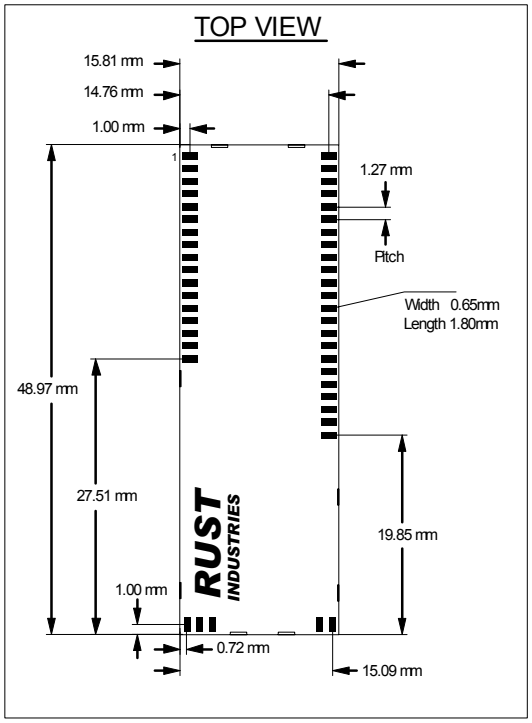
If customization is required please or you require any further assistance please contact us at ‘nowyr.co.uk’.

PCB Land Patterns

Through Hole



SMD



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