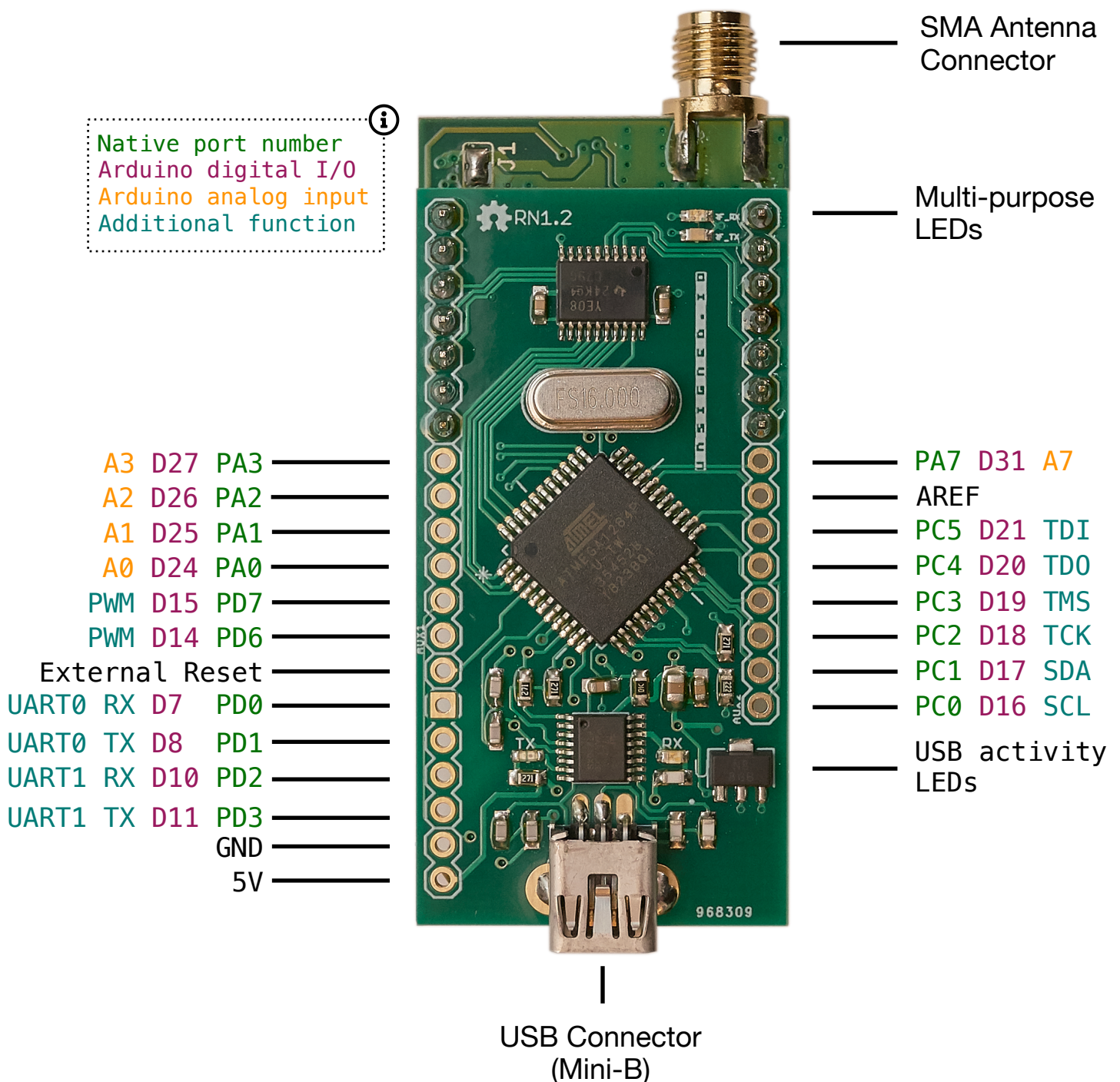


RNode User Manual

Thank you very much for buying this product! If you have any questions, suggestions, criticisms or good ideas, I'd love to hear from you! This guide provides a few pointers on getting started with RNode, how to connect to the board, and how configure it.

Device Overview

Please have a look at the following chart and familiarise yourself with the different ports, connectors and indicators on your RNode.



Cautions

- Never operate the device without a **connected antenna!** Doing so can **damage the radio.**
- Always ensure a **regulated 5V DC supply of correct polarity** is used to power the device. Supplying the device with incorrect voltage or polarity will damage the device.
- Always observe your **local laws and regulations** regarding RF emissions. This device is capable of operating in a wide range of frequency bands and emission modes, some of which may be illegal in your jurisdiction. It is your responsibility to ensure you are operating this device in a lawful way.

Specifications

- High-quality LoRa module with genuine **Semtech SX1276** chip
- Powered by an **ATmega1284p** MCU clocked at **16 MHz**
- **128 kilobytes** of flash
- **16 kilobytes** of RAM
- Large payloads with a packet **MTU** of **500 bytes**
- Max **17 dBm** continuous TX output in the **820-1020 MHz** band
- Max **14 dBm** continuous TX output in the **410-525 MHz** band
- Sensitivity down to **-139 dBm**
- Data rates ranging from **20 bps** to **21.88 kbps**
- **Mini-USB** connector
- **SMA** antenna connector
- Fully **programmable**
- **Arduino** compatible
- **Open source** firmware and config util
- **17 multi-purpose IO ports** available
- Operating temperature range: **-20°C** to **60°C** (in non-condensing humidity)
- **23.3 mA** idle power consumption

Connecting RNode to Host Equipment

RNode can be connected to any host supporting USB or serial UART connections. The board uses an FTDI USB-to-serial converter, so drivers should already be included in most operating systems. You can use either the **USB port**, or connect directly to the **UART0 RX** and **UART0 TX** ports.

The default firmware uses **115200 baud**, **8N1**. No UART flow control is used. RTS line is connected to **External Reset**. Toggling RTS will reset the board.

If you wish to prevent the USB host from being able to reset the board, connect an **80Ω** resistor between the pins **5V** and **External Reset**.

Operating Modes

RNode can operate in two modes, host-controlled (default) and TNC mode:

- When RNode is in host-controlled mode, it will stay in standby when powered on, until the host specifies frequency, bandwidth, transmit power and other required parameters. In host-controlled mode, promiscuous mode can be activated to sniff any LoRa frames.
- When RNode is in TNC mode, it will configure itself on power-up and enable the radio immediately. This mode can be enabled by using the configuration utility.

Configuring RNode

The device is useable out of the box, but can be further configured to your needs by using the RNode Configuration Utility. Please visit the RNode page at <https://unsigned.io/rnode> for the latest version of the config utility.

Multi-purpose LEDs

RNode is equipped with two multi-purpose LEDs close to the antenna port. The LEDs are used to signify a variety of device states and events.

| Pattern | Description |
|---|--|
| After powering the device: Blue LED is pulsing slowly | Device is in standby and all health checks and device verification succeeded. |
| After powering the device: Orange LED is pulsing slowly | Device verification failed, and operation was halted. Possible radio or EEPROM damage. |
| When radio is on: Blue LED is on | Device is receiving data, or a data carrier was detected on the channel |
| When radio is on: Orange LED is on | Device is transmitting data |
| Blue and orange LEDs alternatingly blinks for 3 seconds | Hardware error. Possibly invalid radio parameters were supplied. |
| Blue and orange LEDs alternatingly blinks for more than 3 seconds | EEPROM is about to be formatted. Power down device within 7 seconds to cancel. |
| Blue LED emits 3 short blinks | Radio powered on and ready |
| Orange LED emits 3 short blinks | Warning indicator. Check error codes sent. |

Updating the Firmware

You can easily update the device firmware to the latest version by using the RNode Config Utility. Alternatively, you can manually download specific firmware versions from https://github.com/markqvist/RNode_Firmware and flash it manually with `avrdude` or similar programs.

Programming

The easiest way to program RNode is probably from within the Arduino IDE. Even the entire default RNode firmware can be edited and compiled directly from the Arduino environment. For adding RNode to your Arduino IDE, please see <https://unsigned.io/board-support-in-arduino-ide/>. It is also possible to work with any other toolchain that supports the ATmega1284p that powers RNode, like `avr-gcc` or similar.

If you want to make your own firmware for RNode, it can be a good idea to use the default firmware as a starting point, since a lot of the setup required to use RNode, such as initialising the LoRa transceiver, is already done for you. The source code for the firmware is available under an MIT license, and can be found here: https://github.com/markqvist/RNode_Firmware.

See the pinout in the beginning of this manual for Arduino pin mappings.

A Few Notes on the EEPROM

As a completely open device, RNode does not block you from modifying the EEPROM contents, which specifies things like radio parameters, serial number, manufacture date and similar. But please be aware that doing so might render the device inoperable or burn out the radio.

Before making any modifications, please make sure to create a backup of the EEPROM. RNode includes a cryptographic signature of the EEPROM contents, which validates all the information stored within it. You will not be able to re-create a valid signature if you erase it! Without this signature, the board will still function, but warranty will be void.

If you upload your own programs or alternative firmwares to RNode, you should make sure that they don't write to the last 200 bytes of EEPROM. You can back up your EEPROM with the config utility.

Interfacing with RNode

You can interface directly with the device using the protocol specified later in this manual, or to get started easily, use one of the available **libraries**. To download libraries and examples, please have a look at: https://github.com/markqvist/RNode_Firmware/tree/master/Libraries.

USB and Serial Protocol

Communications to and from the device uses KISS framing with a custom command set. RNode also does **not** use HDLC ports in the command byte, and as such uses the full 8 bits of the command byte is available for the actual command. Please see table below for supported commands.

| Command | Byte | Description |
|------------------|------|--|
| Data frame | 0x00 | A data frame to or from the device |
| Frequency | 0x01 | Sets or queries the frequency |
| Bandwidth | 0x02 | Sets or queries the bandwidth |
| TX Power | 0x03 | Sets or queries the TX power |
| Spreading Factor | 0x04 | Sets or queries the spreading factor |
| Coding Rate | 0x05 | Sets or queries the coding rate |
| Radio State | 0x06 | Sets or queries radio state |
| Radio Lock | 0x07 | Sets or queries the radio lock |
| Device Detect | 0x08 | Probe command for device detection |
| Promiscuous | 0x0E | Sets or queries promiscuous mode |
| Ready | 0x0F | Flow control command indicating ready for TX |
| RX Stats | 0x21 | Queries received bytes |
| TX Stats | 0x22 | Queries transmitted bytes |
| Last RSSI | 0x23 | Indicates RSSI of last packet received |
| Blink | 0x30 | Blinks LEDs |
| Random | 0x40 | Queries for a random number |
| Firmware Version | 0x50 | Queries for installed firmware version |
| ROM Read | 0x51 | Read EEPROM byte |
| ROM Write | 0x52 | Write EEPROM byte |
| TNC Mode | 0x53 | Enables TNC mode |
| Normal Mode | 0x54 | Enables host-controlled mode |
| ROM Erase | 0x59 | Completely erases EEPROM |
| Error | 0x90 | Indicates an error |

Error Codes

If an error occurs on the device, it will be signalled to the host using the error command, which will include an error code as command payload. As an example, if the radio could not be initialised, the device will send `0xc09001c0` to the host. The error codes are defined as follows.

| Command | Byte | Description |
|----------------------|------|--|
| Radio Init | 0x01 | Radio module could not be started |
| Transmission Failure | 0x02 | Transmission failed due to a hardware error |
| EEPROM Locked | 0x03 | EEPROM write failed due to EEPROM lock |
| Queue Full | 0x04 | Data frame dropped because the queue is full |

Flow Control and Packet Buffer

When sending data frames for transmission to the device, RNode employs a simple mechanism of flow control to ensure no packets are dropped due to congestion. When a data frame is received from the host, the device will put the frame into a queue. By default, the queue can hold up to 24 frames (12 kilobytes of data). If the channel is free, the frame will be transmitted immediately. If there is already activity on the channel, the device will wait until the channel is free, and then send all frames in its queue. RNode can receive and queue frames from the host while it is waiting for the channel to become free.

Every time a frame is received from the host, RNode will send a **Ready** command back to the host (`0xc00F01c0`), if it is ready for more data. If the queue is full, a **Ready** command will not be sent. As soon as more space is available in the queue, a **Ready** command will be sent to the host. If the host sends a data frame when the queue is full, the frame will be dropped, and RNode will send an **Error - Queue Full** command to the host (`0xc09004c0`).

Receiving Packets and RSSI

When the device is powered up and configured by a host, or operating in TNC mode, it will be listening for packets on the specified frequency. Once a packet has been demodulated, it will be sent as a data frame to the host.

Just before sending the data frame, the device will signal the average RSSI of the packet by sending an RSSI command. Subtract 157 from the received command payload to obtain the RSSI in dBm. As an example, let us assume the command `0xC0233FC0` is received from the device. The command payload is `3F`, which is equal to 63. We obtain the RSSI by subtracting the offset: $63 - 157 = -94\text{dBm}$.

Packet Format and MTU

RNode allows large packets with a max payload of 500 bytes. Standard LoRa packets can only carry a payload of 255 bytes, so RNode achieves the larger MTU by directly stringing together two standard LoRa packets.

At the physical layer, a one-byte header is employed, which includes a random **sequence number** in the most-significant 4 bits, and a **split packet** flag in the least significant bit. Bits 3, 2 and 1 are reserved for future uses.

This physical layer format is transparent to the host, and 500 byte packets are sent and delivered in exactly the same way as a small packet would.

If you do not need large packet support, but want compatibility with standard LoRa networks, this feature can be turned off, see the next section.

Promiscuous Mode

RNode can be put into **promiscuous mode** to perform packet capture and packet injection on standard LoRa networks. In promiscuous mode, all demodulated LoRa frames will be dumped raw to the host. Raw LoRa frames can also be injected by sending data frames to the device. Standard 255 byte LoRa MTU applies in promiscuous mode.

RNode will demodulate and dump packets with any LoRa coding rate, no matter what coding rate the device itself has been configured to use.

For a ready-to-use LoRa packet sniffer program, have a look at LoRaMon here: <https://github.com/markqvist/LoRaMon>.

Getting Help

If you have any questions regarding RNode, please do not hesitate to send me an email at mark@unsigned.io. You can also register for the forums at unsigned.io where other users might offer pointers and advice.

