RN2903 LoRa™ Technology Module Command Reference User's Guide

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ISBN: 978-1-63277-690-7

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RN2903 LoRa™ TECHNOLOGY MODULE COMMAND REFERENCE USER'S GUIDE

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Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXXXXA", where "XXXXXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB IDE online help. Select the Help menu, and then Topics to open a list of available online help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the RN2903 module. Topics discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Web Site
- Development Systems Customer Change Notification Service
- Customer Support
- Revision History

DOCUMENT LAYOUT

This command reference user's guide provides information for configuring the RN2903 low-power long-range LoRa™ technology transceiver module, including a description of communication and command references. The document is organized as follows:

- **Chapter 1. "Introduction"** – This chapter introduces the RN2903 module and provides a brief overview of its features.
- **Chapter 2. "Command Reference"** – This chapter provides information on the commands used to configure the RN2903 module with examples.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *`file`* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void) { ... }`

RECOMMENDED READING

This command reference user's guide describes how to configure the RN2903 module. The module-specific data sheet contains current information on the module specifications. Other useful documents are listed below. The following documents are available and recommended as supplemental reference resources:

RN2903 Low-Power Long-Range LoRa™ Technology Transceiver Module Data Sheet (DS50002390)

This data sheet provides detailed specifications for the RN2903 module.

LoRa™ Alliance: LoRaWAN™ Specification

This document describes the LoRaWAN™ protocol, which is optimized for battery-powered end devices. This specification is available from the LoRa Alliance at www.lora-alliance.org.

To obtain any of Microchip's documents, visit the Microchip web site at www.microchip.com.

THE MICROCHIP WEB SITE

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- **Emulators** – The latest information on Microchip in-circuit emulators.This includes the MPLAB REAL ICE™ and MPLAB ICE 2000 in-circuit emulators.
- **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debuggers. This includes MPLAB ICD 3 in-circuit debuggers and PICkit™ 3 debug express.
- **MPLAB® IDE** – The latest information on Microchip MPLAB IDE, the Windows® Integrated Development Environment for development systems tools. This list is focused on the MPLAB IDE, MPLAB IDE Project Manager, MPLAB Editor and MPLAB SIM simulator, as well as general editing and debugging features.
- **Programmers** – The latest information on Microchip programmers. These include production programmers such as MPLAB REAL ICE in-circuit emulator, MPLAB ICD 3 in-circuit debugger and MPLAB PM3 device programmers. Also included are nonproduction development programmers such as PICSTART® Plus and PICkit 2 and 3.

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- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

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Technical support is available through the web site at:

http://www.microchip.com/support.

REVISION HISTORY

Revision A (August 2015)

Initial release of the document.

Chapter 1. Introduction

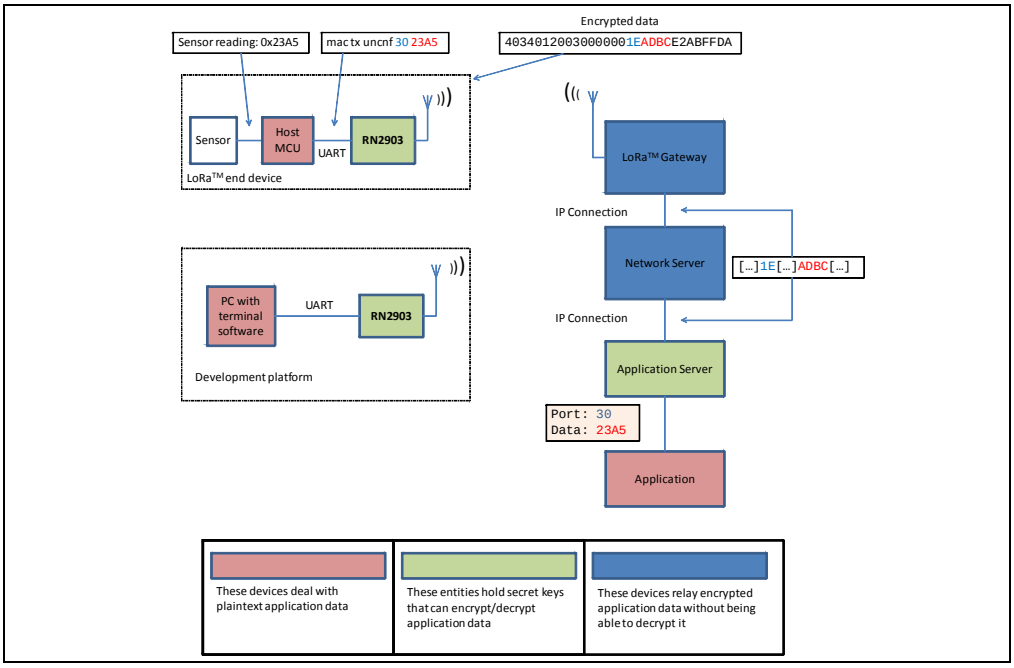
1.1 OVERVIEW

The Microchip RN2903 module provides LoRaWAN™ protocol connectivity using a simple UART interface. This module handles the LoRaWAN protocol and provides an optimized text command/response interface to the host system. This document is intended to describe an implementation of the LoRaWAN protocol. LoRaWAN protocol terms are described in more detail in the *LoRaWAN Specification* available from the LoRa Alliance (www.lora-alliance.org). Thus, it is recommended to review the *LoRaWAN Specification* before using the RN2903 module.

The required configuration for accessing a LoRa™ technology network is minimal and can be stored in the module's EEPROM, allowing for factory configuration of these parameters, lowering the requirements for the host system while also increasing system security. The module also features GPIO pins that can be configured through the UART interface.

A simple use case is described in Figure 1-1 where an end device, containing a host MCU which reads a sensor, commands the RN2903 to transmit the sensor reading over the LoRa network. Data are encrypted by the RN2903 and the radio packet is received by one or multiple gateways which forward it to the network server. The network server sends the data to the application server which has the key to decrypt the application data. Similarly, a development platform may consist of an RN2903 directly connected over UART to a PC, which becomes the host system in this case. Users can then type commands into the module using a terminal program.

FIGURE 1-1: SIMPLE LoRaWAN™ NETWORK DIAGRAM



The flow of data can be followed as it gets generated by an end device and transported on the network.

1.2 FEATURES

- LoRaWAN protocol compliance
- Integrated FSK, GFSK and LoRa technology transceiver allowing the user to transmit custom packets using these protocols
- Globally unique 64-bit identifier (EUI-64™)
- Configurable GPIOs
- Intelligent Low-Power mode with programmable/on-demand wake-up
- Bootloader for firmware upgrade
- All configuration and control done over UART using simple ASCII commands

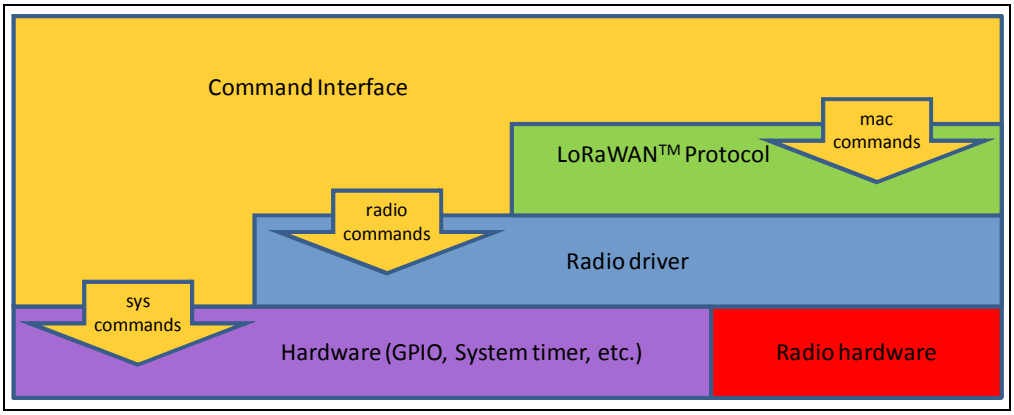
Refer to the *RN2903 Low-Power Long-Range LoRa™ Technology Transceiver Module Data Sheet* (DS50002390) for details on the hardware specifications of the module.

1.3 CONFIGURATION

The RN2903 module's architecture is described in Figure 1-2 from the command interface point of view. There are three types of commands that can be used, and each allows access to different module functions:

- LoRaWAN configuration and control, using the `mac` group of commands
- Radio configuration and control, using the `radio` group of commands
- Other module functions, using the `sys` group of commands

FIGURE 1-2: RN2903 COMMAND INTERFACE (YELLOW) AND ITS RELATIONSHIP TO THE MODULE'S INTERNAL COMPONENTS



The available commands can be used to configure and control the LoRaWAN protocol layer, the radio driver and some system peripherals.

In order to communicate with a LoRa network, a specific number of parameters need to be configured. Since two distinctive methods are offered for a device to become part of the network, each of these requires different parameters:

- Over-the-Air Activation (OTAA), where a device negotiates network encryption keys at the time it joins the network. For this, the device EUI, application EUI and application key need to be configured and then the OTAA procedure can start.
- Activation by Personalization (ABP) where the device already contains the network keys and can directly start communication with the network. Configuring the device address, network session key and application session key is sufficient for this type of initialization.

For increased security, these parameters can be configured and stored in the module's EEPROM during manufacturing of devices requiring LoRaWAN connectivity. Thus, the keys do not need to be sent over the UART interface by the host system every time the device powers up.

1.4 UART INTERFACE

All of the RN2903 module's settings and commands are transmitted over UART using the ASCII interface.

All commands need to be terminated with <CR><LF> and any replies they generate will also be terminated by the same sequence.

The default settings for the UART interface are 57600 bps, 8 bits, no parity, 1 Stop bit, no flow control. The baud rate can be changed by triggering the auto-baud detection sequence of the module. To do this, the host system needs to transmit to the module a break condition followed by a 0x55 character at the new baud rate. The auto-baud detection mechanism can also be triggered during Sleep to wake the module up before the predetermined time has expired.

Note: A break condition is signaled to the module by keeping the UART_RX pin low for longer than the time to transmit a complete character. For example, at the default baud rate of 57600 bps, keeping the UART_RX pin low for 938 μs is a valid break condition, whereas at 9600 bps, this would be interpreted as a 0x00 character. Thus, the break condition needs to be long enough to still be interpreted as such at the baud rate that is currently in use.

Chapter 2. Command Reference

The RN2903 LoRa technology module supports a variety of commands for configuration. This section describes these commands in detail and provides examples.

2.1 COMMAND SYNTAX

To issue commands to the RN2903 module, the user sends keywords followed by optional parameters. Commands (keywords) are case sensitive, and spaces must not be used in parameters. Hex input data can be uppercase or lowercase. String text data, such as `0TAA` used for the join procedure, is case-insensitive.

The use of shorthand for parameters is *NOT* supported.

Depending on the command, the parameter may expect values in either decimal or hexadecimal form; refer to the command description for the expected form. For example, when configuring the frequency, the command expects a decimal value in Hertz such as `923300000` (923.3 MHz). Alternatively, when configuring the LoRaWAN device address, the hex value is entered into the parameter as `aabbccdd`. To enter a number in hex form, use the value directly. For example, the hex value 0xFF would be entered as FF.

2.2 COMMAND ORGANIZATION

There are three general command categories, as shown in Table 2-1.

TABLE 2-1: COMMAND TYPES

Command Type	Keyword	Description
System	`<sys>`	Issues system level behavior actions, gathers status information on the firmware and hardware version, or accesses the module user EEPROM memory.
LoRaWAN™ Protocol	`<mac>`	Issues LoRaWAN protocol network communication behaviors, actions and configurations commands.
Transceiver commands	`<radio>`	Issues radio specific configurations, directly accessing and updating the transceiver setup.

Once the LoRaWAN protocol configuration is complete, the user must save the settings to store the configuration data, otherwise it will not take effect upon reboot or Reset.

Note: Upon successful reception of commands, the module will respond with one of the following:

- `ok`
- `invalid_param`
- Requested Information
- Descriptive Error Message

Note: To facilitate the sharing of the radio between user custom applications and the LoRaWAN MAC, please refer to the `mac pause` and `mac resume` commands. Since no sharing exists between `sys` and other types of commands, there is no need for additional `pause` commands.

2.3 SYSTEM COMMANDS

System commands begin with the system keyword `<sys>` and include the categories shown in Table 2-2, Table 2-3 and Table 2-4.

TABLE 2-2: SYSTEM COMMANDS

Parameter	Description
`sleep`	Puts the system in Sleep for a finite number of milliseconds.
`reset`	Resets and restarts the RN2903 module.
`eraseFW`	Deletes the current RN2903 module application firmware and prepares it for firmware upgrade. The RN2903 module bootloader is ready to receive new firmware.
`factoryRESET`	Resets the RN2903 module's configuration data and user EEPROM to factory default values and restarts the RN2903 module.
`set`(1)	Sets specified system parameter values.
`get`(1)	Gets specified system parameter values.

Note 1: Refer to Table 2-3 for system `<set>` and Table 2-4 for system `<get>` command summaries.

2.3.1 sys sleep <length>

`<length>`: decimal number representing the number of milliseconds the system is put to Sleep, from 100 to 4294967296.

Response: `ok` after the system gets back from Sleep mode

`invalid_param` if the length is not valid

This command puts the system to Sleep for the specified number of milliseconds. The module can be forced to exit from Sleep by sending a break condition followed by a `0x55` character at the new baud rate.

Example: **`sys sleep 120`** // Puts the system to Sleep for 120 ms.

2.3.2 sys reset

Response: `RN2903 X.Y.Z MMM DD YYYY HH:MM:SS`, where X.Y.Z is the firmware version, MMM is month, DD is day, HH:MM:SS is hour, minutes, seconds (format: [HW] [FW] [Date] [Time]). [Date] and [Time] refer to the release of the firmware.

This command resets and restarts the RN2903 module; stored internal configurations will be loaded automatically upon reboot.

Example: **`sys reset`** // Resets and restarts the RN2903 module.

2.3.3 sys eraseFW

Response: no response

This command deletes the current RN2903 module application firmware and prepares it for firmware upgrade. The RN2903 module bootloader is ready to receive new firmware.

Example: **`sys eraseFW`** // Deletes the current RN2903 module application firmware.

2.3.4 sys factoryRESET

Response: RN2903 X.Y.Z MMM DD YYYY HH:MM:SS, where X.Y.Z is the firmware version, MMM is month, DD is day, HH:MM:SS is hour, minutes, seconds (format: [HW] [FW] [Date] [Time]). [Date] and [Time] refer to the release of the firmware.

This command resets the module's configuration data and user EEPROM to factory default values and restarts the module. After factoryRESET, the RN2903 module will automatically reset and all configuration parameters are restored to factory default values.

Example: **sys factoryRESET** // Restores factory default values.

2.3.5 System Set Commands

TABLE 2-3: SYSTEM SET COMMANDS

Parameter	Description
nvm	Stores <data> to a location <address> of user EEPROM.
pindig	Allows user to set and clear available digital pins.
pinmode	Allows the user to set the state of the pins as digital output, digital input or analog.

2.3.5.1 sys set nvm <address> <data>

<address>: hexadecimal number representing user EEPROM address, from 300 to 3FF

<data>: hexadecimal number representing data, from 00 to FF

Response: ok if the parameters (address and data) are valid

invalid_param if the parameters (address and data) are not valid

This command allows the user to modify the user EEPROM at <address> with the value supplied by <data>. Both <address> and <data> must be entered as hex values. The user EEPROM memory is located inside the MCU on the module.

Example: **sys set nvm 300 A5** // Stores the value 0xA5 at user EEPROM address 0x300.

2.3.5.2 sys set pindig <pinname> <pinstate>

<pinname>: string representing the pin. Parameter values can be: GPIO0-GPIO13, UART_CTS, UART_RTS, TEST0, TEST1

<pinstate>: decimal number representing the state. Parameter values can be: 0 or 1.

Response: ok if the parameters (<pinname>, <pinstate>) are valid

invalid_param if the parameters (<pinname>, <pinstate>) are not valid

This command allows the user to modify the unused pins available for use by the module. The selected <pinname> is driven high or low depending on the desired <pinstate>.

Default: GPIO0-GPIO13, UART_CTS, UART_RTS, TEST0 and TEST1 are driven low (value 0).

Example: **sys set pindig GPIO5 1** // Drives GPIO5 high 1, VDD.

2.3.5.3 sys set pinmode <pinname> <pinmode>

<pinname>: string representing the pin. Parameter values can be: GPIO0-GPIO13, UART_CTS, UART_RTS, TEST0, TEST1

<pinmode>: string representing the mode. It can be: digout, digin, ana

Response: ok if the parameters (<pinname>, <pinmode>) are valid

invalid_param if the parameters (<pinname>, <pinmode>) are not valid.

This command allows the user to modify the unused pins available for use by the module and set them as digital output, digital input or analog.

Default: GPIO0-GPIO14, UART_CTS, UART_RTS, TEST0 and TEST1 are output pins, driven low (value 0).

Example: **sys set pinmode GPIO5 ana** //Sets pin GPIO5 as analog pin

Note: Only the GPIO0-3, GPIO5-GPIO13 pins can be configured as analog pins.

2.3.6 System Get Commands

TABLE 2-4: SYSTEM GET COMMANDS

Parameter	Description
ver	Returns the information on hardware platform, firmware version, release date.
nvm	Returns data from the requested user EEPROM <address>.
vdd	Returns measured voltage in mV.
hweui	Returns the preprogrammed EUI node address.
pindig	Returns the state of the pin, either low ('0') or high ('1').

2.3.6.1 sys get ver

Response: RN2903 X.Y.Z MMM DD YYYY HH:MM:SS, where X.Y.Z is the firmware version, MMM is month, DD is day, HH:MM:SS is hour, minutes, seconds (format: [HW] [FW] [Date] [Time]). [Date] and [Time] refer to the release of the firmware.

This command returns the information related to the hardware platform, firmware version, release date and time-stamp on firmware creation.

Example: **sys get ver** // Returns version-related information.

2.3.6.2 sys get nvm <address>

<address>: hexadecimal number representing user EEPROM address, from 300 to 3FF

Response: 00–FF (hexadecimal value from 00 to FF) if the address is valid

invalid_param if the address is not valid

This command returns the data stored in the user EEPROM of the RN2903 module at the requested <address> location.

Example: **sys get nvm 300** // Returns the 8-bit hex value stored at 300.

2.3.6.3 `sys get vdd`

Response: 0–3600 (decimal value from 0 to 3600)

This command requires the RN2903 module to do an ADC conversion on the VDD. The measurement is converted and returned as a voltage (mV).

Example: **`sys get vdd`** // Returns mV measured on the VDD module.

> **Note:** The upper limit is given for consideration only, considering the module's maximum supply voltage. Should the module's maximum supply voltage be exceeded, the response to this command will reflect the true supply voltage (i.e., will be higher than 3600).

2.3.6.4 `sys get hweui`

Response: hexadecimal number representing the preprogrammed EUI node address

This command reads the preprogrammed EUI node address from the RN2903 module. The value returned by this command is a globally unique number provided by Microchip.

Example: **`sys get hweui`** // Reads the preprogrammed EUI node address.

> **Note:** The preprogrammed EUI node address is a read-only value and cannot be changed or erased. This value can be used to configure the device EUI using the `mac set deveui` command (see Section 2.4.8.2).

2.3.6.5 `sys get pindig <pinname>`

`<pinname>`: string representing the pin. Parameter values can be: `GPIO0-GPIO13`, `UART_CTS`, `UART_RTS`, `TEST0`, `TEST1`

Response: a bit representing the state of the pin, either '`0`' (low) or '`1`' (high), if `<pinname>` is valid
`invalid_param` if `<pinname>` is not valid

This command returns the state of the queried pin, either '`0`' (low) or '`1`' (high).

Example: **`sys get pindig GPIO5`** // Returns the state of GPIO5.

2.3.6.6 `sys get pinana <pinname>`

`<pinname>`: string representing the pin. Parameter values can be: `GPIO0-GPIO3`, `GPIO5-GPIO13`

Response: decimal number representing the 10-bit analog value, from 0 to 1023, if `<pinname>` is valid, and `invalid_param` if `<pinname>` is not valid

This command returns a 10-bit analog value for the queried pin, where 0 represents 0V and 1023 represents VDD. An ADC conversion on the VDD pin can be performed by using the command `sys get vdd`.

Example: **`sys get pinana GPIO0`** // Returns the state of GPIO0.

2.4 MEDIA ACCESS CONTROLLER (MAC) COMMANDS

LoRaWAN protocol commands begin with the system keyword `mac` and include the categories shown in Table 2-5 through Table 2-9.

TABLE 2-5: MAC COMMANDS

Parameter	Description
`reset`	Resets the RN2903 module and sets default values for most of the LoRaWAN parameters.
`tx`	Sends the data string on a specified port number.
`join`	Informs the RN2903 module to join the configured network.
`save`	Saves LoRaWAN configuration parameters to the user EEPROM.
`forceENABLE`	Enables the RN2903 module after the LoRaWAN network server commanded the end device to become silent immediately.
`pause`	Pauses LoRaWAN stack functionality to allow transceiver (radio) configuration.
`resume`	Restores the LoRaWAN stack functionality.
`set`	Accesses and modifies specific MAC related parameters.
`get`	Reads back current MAC related parameters from the module.

2.4.1 `mac reset`

Response: `ok`

This command will automatically reset the software LoRaWAN stack and initialize it with the parameters for the selected band.

Example: **`mac reset`**

Note:	This command will set default values for most of the LoRaWAN™ parameters. Everything set prior to this command will lose its set value, being reinitialized to the default value, including setting the cryptographic keys to 0.

2.4.2 mac tx <type> <portno> <data>

<type>: string representing the uplink payload type, either cnf or uncnf (cnf – confirmed, uncnf – unconfirmed)

<portno>: decimal number representing the port number, from 1 to 223

<data>: hexadecimal value. The length of <data> bytes capable of being transmitted are dependent upon the set data rate (please refer to the *LoRaWAN™ Specification* for further details).

Response: this command may reply with two responses. The first response will be received immediately after entering the command. In case the command is valid (ok reply received), a second reply will be received after the end of the data transfer. Please refer to the *LoRaWAN™ Specification* for further details.

Response after entering the command:

- ok – if parameters and configurations are valid and the packet was forwarded to the radio transceiver for transmission
- invalid_param – if parameters (<type> <portno> <data>) are not valid
- not_joined – if the network is not joined
- no_free_ch – no channels are available
- silent – if the module is in a Silent Immediately state
- frame_counter_err_rejoin_needed – if the frame counter rolled over
- busy – if MAC state is not in an Idle state
- mac_paused – if MAC was paused and not resumed back
- invalid_data_len if application payload length is greater than the maximum application payload length corresponding to the current data rate

Response after the uplink transmission:

- mac_tx_ok if uplink transmission was successful and no downlink data was received back from the server;
- mac_rx <portno> <data> if transmission was successful, <portno>: port number, from 1 to 223; <data>: hexadecimal value that was received from the server;
- mac_err if transmission was unsuccessful, ACK not received back from the server
- invalid_data_len if application payload length is greater than the maximum application payload length corresponding to the current data rate

A confirmed message will expect an acknowledgment from the server; otherwise, the message will be retransmitted by the number indicated by the command mac set retx <value>, whereas an unconfirmed message will not expect any acknowledgment back from the server. Please refer to the *LoRaWAN™ Specification* for further details.

The port number allows multiplexing multiple data streams on the same link. For example, the end device may send measurements on one port number and configuration data on another. The server application can then distinguish the two types of data based on the port number.

Example: **mac tx cnf 4 5A5B5B** // Sends a confirmed frame on port 4 with application payload 5A5B5B.

If the automatic reply feature is enabled and the server sets the Frame Pending bit or initiates downlink confirmed transmissions, multiple responses will be displayed after each downlink packet is received by the module. A typical scenario for this case would be (prerequisites: free LoRaWAN channels available and automatic reply enabled):

- The module sends a packet on port 4 with application payload 0xAB
- Radio transmission is successful and the module will display the first response: `ok`
- The server needs to send two separate downlink confirmed packets back on port 1 with the following data: 0xAC, then 0xAF. First it will transmit the first one (0xAC) and will set the Frame Pending bit. The module will display the second response `mac_rx 1 AC`
- The module will initiate an automatic uplink unconfirmed transmission with no application payload because the Frame Pending bit was set in the downlink transmission
- The server will send back the second confirmed packet (0xAF). The module will display a third response `mac_rx 1 AF`
- The module will initiate an automatic unconfirmed transmission with no application payload because the last downlink transmission was confirmed, so the server needs an ACK
- If no reply is received back from the server, the module will display the fourth response after the end of the second Receive window: `mac_tx_ok`
- After this scenario, the user is allowed to send packets when at least one enabled channel is free

Based on this scenario, the following responses will be displayed by the module after running the `mac tx cnf 4 AB` command:

- `ok`
- `mac_rx 1 AC`
- `mac_rx 1 AF`
- `mac_tx_ok`

2.4.3 `mac join <mode>`

<mode>: string representing the join procedure type (case-insensitive), either `otaa` or `abp` (`otaa` – over-the-air activation, `abp` – activation by personalization).

Response: this command may reply with two responses. The first response will be received immediately after entering the command. In case the command is valid (`ok` reply received) a second reply will be received after the end of the join procedure. Please refer to the *LoRaWAN™ Specification* for further details.

Response after entering the command:

- `ok` – if parameters and configurations are valid and the join request packet was forwarded to the radio transceiver for transmission
- `invalid_param` – if <mode> is not valid
- `keys_not_init` – if the keys corresponding to the Join mode (`otaa` or `abp`) were not configured
- `no_free_ch` – no channels are available
- `silent` – if the device is in a Silent Immediately state
- `busy` – if MAC state is not in an Idle state
- `mac_paused` – if MAC was paused and not resumed back

Response after the join procedure:

- `denied` if the join procedure was unsuccessful (the module attempted to join the network, but was rejected);
- `accepted` if the join procedure was successful;

This command informs the RN2903 module it should attempt to join the configured network. Module activation type is selected with `<mode>`. Parameter values can be `otaa` (over-the-air activation) or `abp` (activation by personalization). The `<mode>` parameter is not case sensitive. Before joining the network, the specific parameters for each activation type should be configured (for over the air activation: device EUI, application EUI, application key; for activation by personalization: device address, network session key, application session key).

Example: **`mac join otaa`** // Attempts to join the network using over-the-air activation.

2.4.4 `mac save`

Response: `ok`

The `mac save` command must be issued after configuration parameters have been appropriately entered from the `mac set <cmd>` commands. This command will save LoRaWAN protocol configuration parameters to EEPROM. Upon the next system reset the LoRaWAN protocol configuration will be initialized with the last saved parameters. The system may reset by power cycling or a pulse on the $\overline{\text{MCLR}}$ pin as well as by using `sys reset`.

The LoRaWAN protocol configuration savable parameters are:

- `deveui`: End-Device Identifier
- `appeui`: Application Identifier
- `appkey`: Application Key
- `nwkskey`: Network Session Key
- `appskey`: Application Session Key
- `devaddr`: End Device Address
- `ch`: Channel Parameter
  - `drrange`: Data Rate Range
  - `status`: Status
- `upctr`: Uplink Counter
- `dnctr`: Downlink Counter
- `adr:` ADR state
- `rx2:` RX Window 2 parameters

Example: **`mac save`** // Saves the LoRaWAN protocol configuration parameters to the user EEPROM.

2.4.5 `mac forceENABLE`

Response: `ok`

The network can issue a certain command (Duty Cycle Request frame with parameter 255) that would require the RN2903 module to go silent immediately. This mechanism disables any further communication of the module, effectively isolating it from the network. Using `mac forceENABLE`, after this network command has been received, restores the module's connectivity by allowing it to send data.

Example: **`mac forceENABLE`** // Disables the Silent Immediately state.

2.4.6 mac pause

Response: 0 – 4294967295 (decimal number representing the number of milliseconds the mac can be paused)

This command pauses the LoRaWAN stack functionality to allow transceiver (radio) configuration. Through the use of `mac pause`, radio commands can be generated between a LoRaWAN protocol uplink application (`mac tx` command), and the LoRaWAN protocol Receive windows (second response for the `mac tx` command). This command will reply with the time interval in milliseconds that the transceiver can be used without affecting the LoRaWAN functionality. The maximum value (4294967295) is returned whenever the LoRaWAN stack functionality is in Idle state and the transceiver can be used without restrictions. '`0`' is returned when the LoRaWAN stack functionality cannot be paused. After the radio configuration is complete, the `mac resume` command should be used to return to LoRaWAN protocol commands.

Example: **`mac pause`** // Pauses the LoRaWAN stack functionality if the response is different from 0.

Note:	If already joined to a network, this command *MUST* be called *BEFORE* configuring the radio parameters, initiating radio reception, or transmission.

2.4.7 mac resume

Response: `ok`

This command resumes LoRaWAN stack functionality, in order to continue normal functionality after being paused.

Example: **`mac resume`** // Resumes the LoRaWAN stack functionality.

Note:	This command *MUST* be called *AFTER* all radio commands have been issued and all the corresponding asynchronous messages have been replied.

2.4.8 MAC Set Commands

TABLE 2-6: MAC SET COMMANDS

Parameter	Description
devaddr	Sets the unique network device address for RN2903 module.
deveui	Sets the globally unique identifier for the RN2903 module.
appeui	Sets the application identifier for the RN2903 module.
nwkskey	Sets the network session key for the RN2903 module.
appskey	Sets the application session key for the RN2903 module.
appkey	Sets the application key for the RN2903 module.
pwridx	Sets the output power to be used on the next transmissions.
dr	Sets the data rate to be used for the next transmissions.
adr	Sets if the adaptive data rate is to be enabled, or disabled.
bat	Sets the battery level needed for Device Status Answer frame command response.
retx	Sets the number of retransmissions to be used for an uplink confirmed packet.
linkchk	Sets the time interval for the link check process to be triggered.
rxdelay1	Sets the value used for the first Receive window delay.
ar	Sets the state of the automatic reply.
rx2	Sets the data rate and frequency used for the second Receive window.
sync	Sets the current synchronization word.
upctr	Sets the current uplink counter.
dnctr	Sets the current downlink counter.
ch	Allows modification of channel related parameters.

2.4.8.1 mac set devaddr <address>

<address>: 4-byte hexadecimal number representing the device address, from 00000000 – FFFFFFFF

Response: ok if address is valid

invalid_param if address is not valid

This command configures the module with a 4-byte unique network device address <address>. The <address> *MUST* be *UNIQUE* to the current network. This must be directly set solely for activation by personalization devices. This parameter must not be set before attempting to join using over-the-air activation because it will be overwritten once the join process is over.

Example: **mac set devaddr ABCDEF01**

Note: If this parameter had previously been saved to user EEPROM by issuing the mac save command, after modifying its value, the mac save command should be called again.

2.4.8.2 mac set deveui <devEUI>

<devEUI>: 8-byte hexadecimal number representing the device EUI

Response: ok if address is valid

invalid_param if address is not valid

This command sets the globally unique device identifier for the module. The identifier must be set by the host MCU. The module contains a pre-programmed unique EUI that can be retrieved using the sys get hweui command (see Section 2.3.6.4). Alternatively, a user provided EUI can be configured using the mac set deveui command.

Example: **mac set deveui 0004A30B001A55ED**

> **Note:** If this parameter was previously saved to user EEPROM by issuing the mac save command, after modifying its value, the mac save command should be called again.

2.4.8.3 mac set appeui <appEUI>

<appEUI>: 8-byte hexadecimal number representing the application EUI

Response: ok if address is valid

invalid_param if address is not valid

This command sets the application identifier for the module. The application identifier should be used to identify device types (sensor device, lighting device, etc.) within the network.

Example: **mac set appeui FEDCBA9876543210**

> **Note:** If this parameter was previously saved to user EEPROM by issuing the mac save command, after modifying its value, the mac save command should be called again.

2.4.8.4 mac set nwkskey <nwksesskey>

<nwkSessKey>: 16-byte hexadecimal number representing the network session key

Response: ok if address is valid

invalid_param if address is not valid

This command sets the network session key for the module. This key is 16 bytes in length, and should be modified with each session between the module and network. The key should remain the same until the communication session between devices is terminated.

Example: **mac set nwkskey 1029384756AFBECD5647382910DACFEB**

> **Note:** If this parameter was previously saved to user EEPROM by issuing the mac save command, after modifying its value, the mac save command should be called again.

2.4.8.5 `mac set appskey <appSesskey>`

<appSessKey>: 16-byte hexadecimal number representing the application session key

Response: `ok` if address is valid

`invalid_param` if address is not valid

This command sets the application session key for the module. This key is unique, created for each occurrence of communication, when the network requests an action taken by the application.

Example: **`mac set appskey AFBECD56473829100192837465FAEBDC`**

> **Note:** If this parameter was previously saved to user EEPROM by issuing the `mac save` command, after modifying its value, the `mac save` command should be called again.

2.4.8.6 `mac set appkey <appKey>`

<appKey>: 16-byte hexadecimal number representing the application key

Response: `ok` if address is valid

`invalid_param` if address is not valid

This command sets the application key for the module. The application key is used to identify a grouping over module units which perform the same or similar task.

Example: **`mac set appkey 00112233445566778899AABBCCDDEEFF`**

> **Note:** If this parameter was previously saved to user EEPROM by issuing the `mac save` command, after modifying its value, the `mac save` command should be called again.

2.4.8.7 `mac set pwridx <pwrIndex>`

<pwrIndex>: decimal number representing the index value for the output power. Valid values are: 5, 7, 8, 9 or 10.

Response: `ok` if power index is valid

`invalid_param` if power index is not valid

This command sets the output power to be used on the next transmissions. Refer to the *LoRaWAN™ Specification* for the output power corresponding to the <pwrIndex> and also to the *RN2903 Low-Power Long-Range LoRa™ Technology Transceiver Module Data Sheet* (DS50002390) for the actual radio power capabilities.

Example: **`mac set pwridx 10`** // Sets the TX output power to index 10 (refer to the *LoRaWAN™ Specification* for the output power corresponding to the index).

2.4.8.8 `mac set dr <dataRate>`

`<dataRate>`: decimal number representing the data rate, from 0 and 4, but within the limits of the data rate range for the defined channels.

Response: `ok` if data rate is valid

`invalid_param` if data rate is not valid

This command sets the data rate to be used for the next transmission. Please refer to the *LoRaWAN™ Specification* for the description of data rates and the corresponding spreading factors.

Example: **`mac set dr 0`**

2.4.8.9 `mac set adr <state>`

`<state>`: string value representing the state, either `on` or `off`.

Response: `ok` if state is valid

`invalid_param` if state is not valid

This command sets if the adaptive data rate (ADR) is to be enabled or disabled. The server is informed about the status of the module's ADR in every uplink frame it receives from the ADR field in uplink data packet. If ADR is enabled, the server will optimize the data rate and the transmission power of the module based on the information collected from the network.

Example: **`mac set adr on`** // This will enable the ADR mechanism.

2.4.8.10 `mac set bat <level>`

`<level>`: decimal number representing the level of the battery, from 0 to 255. 0 means external power, 1 means low level, 254 means high level, 255 means the end device was not able to measure the battery level.

Response: `ok` if the battery level is valid

`invalid_param` if the battery level is not valid

This command sets the battery level required for Device Status Answer frame in use with the LoRaWAN protocol.

Example: **`mac set bat 127`** // Battery is set to ~50%.

2.4.8.11 `mac set retx <reTxNb>`

`<reTxNb>`: decimal number representing the number of retransmissions for an uplink confirmed packet, from 0 to 255.

Response: `ok` if `<retx>` is valid

`invalid_param` if `<retx>` is not valid

This command sets the number of retransmissions to be used for an uplink confirmed packet, if no downlink acknowledgment is received from the server.

Example: **`mac set retx 5`** // The number of retransmissions made for an uplink confirmed packet is set to 5.

2.4.8.12 `mac set linkchk <linkCheck>`

`<linkCheck>`: decimal number that sets the time interval in seconds for the link check process, from 0 to 65535

Response: `ok` if the time interval is valid

`invalid_param` if the time interval is not valid

This command sets the time interval for the link check process to be triggered periodically. A `<value>` of '`0`' will disable the link check process. When the time interval expires, the next application packet that will be sent to the server will include a link check MAC command. Please refer to the *LoRaWAN™ Specification* for more information on the link check MAC command.

Example: **`mac set linkchk 600`** // The module will attempt a link check process at 600-second intervals.

Note: If the command `mac reset` is issued, the link check process will be set as disabled.

2.4.8.13 `mac set rxdelay1 <rxDelay>`

`<rxDelay>`: decimal number representing the delay between the transmission and the first Reception window in milliseconds, from 0 to 65535.

Response: `ok` if `<rxDelay>` is valid

`invalid_param` if `<rxDelay>` is not valid

This command will set the delay between the transmission and the first Reception window to the `<rxDelay>` in milliseconds. The delay between the transmission and the second Reception window is calculated in software as the delay between the transmission and the first Reception window + 1000 (ms).

Example: **`mac set rxdelay1 1000`** // Set the delay between the transmission and the first Receive window to 1000 ms.

2.4.8.14 `mac set ar <state>`

`<state>`: string value representing the state, either `on` or `off`.

Response: `ok` if state is valid

`invalid_param` if state is not valid

This command sets the state of the automatic reply. By enabling the automatic reply, the module will transmit a packet without a payload immediately after a confirmed downlink is received, or when the Frame Pending bit has been set by the server. If set to OFF, no automatic reply will be transmitted.

Example: **`mac set ar on`** // Enables the automatic reply process inside the module.

Note: The RN2903 module implementation will initiate automatic transmissions with no application payload if the automatic reply feature is enabled and the server sets the Frame Pending bit or initiates a confirmed downlink transmission. The user will not be able to initiate uplink transmissions until the automatic transmissions are done.

2.4.8.15 `mac set rx2 <dataRate> <frequency>`

`<dataRate>`: decimal number representing the data rate, from 8 to 13.

`<frequency>`: decimal number representing the frequency, from 923300000 to 927500000 in Hz.

Response: `ok` if parameters are valid

`invalid_param` if parameters are not valid

This command sets the data rate and frequency used for the second Receive window. The configuration of the Receive window parameters should be in concordance with the server configuration.

Example: **`mac set rx2 10 923300000`** // Receive window 2 is configured with SF10/500 kHz data rate with a center frequency of 923 MHz.

2.4.8.16 `mac set sync <syncWord>`

`<syncWord>`: hexadecimal number representing the synchronization word, from 0x00 to 0xFF.

Response: `ok` if `<syncWord>` is valid

`invalid_param` if `<syncWord>` is not valid

This command sets the current synchronization word used during the communication.

Example: **`mac set sync 34`** // Sets the current synchronization word to `0x34`.

2.4.8.17 `mac set upctr <uplinkCounter>`

`<uplinkCounter>`: decimal number representing the uplink counter, from 0 to 4294967295

Response: `ok` if `<uplinkCounter>` is valid

`invalid_param` if `<uplinkCounter>` is not valid

This command sets the current uplink counter used during the communication. This may be used to synchronize the uplink counter with the value stored by the server (as it may be needed by activation by personalization).

Example: **`mac set upctr 22`** // Sets the current uplink counter to 22

> **Note:** If this parameter was previously saved to user EEPROM by issuing the `mac save` command, after modifying its value, the `mac save` command should be called again.

2.4.8.18 `mac set dnctr <downlinkCounter>`

`<downlinkCounter>`: decimal number representing the downlink counter, from 0 to 4294967295

Response: `ok` if `<downlinkCounter>` is valid

`invalid_param` if `<downlinkCounter>` is not valid

This command sets the current downlink counter used during the communication. This may be used to synchronize the downlink counter with the value stored by the server (as it may be needed by activation by personalization).

Example: **`mac set dnctr 20`** // Sets the current downlink counter to 20

> **Note:** If this parameter was previously saved to user EEPROM by issuing the `mac save` command, after modifying its value, the `mac save` command should be called again.

2.4.8.19 MAC SET CHANNEL COMMANDS

TABLE 2-7: MAC SET CHANNEL COMMANDS

Parameter	Description
drrange	Sets the module allowed data rate range (min.- max.) allowed on a given channel ID.
status	Sets the use of the specified channel ID.

2.4.8.19.1 `mac set ch drrange <channelID> <minRange> <maxRange>`

<channelId>: decimal number representing the channel number, from 0 to 63

<minRange>: decimal number representing the minimum data rate range, from 0 to 3

<maxRange>: decimal number representing the maximum data rate range, from 0 to 3

Response: ok if parameters are valid

invalid_param if parameters are not valid

This command sets the operating data rate range, min. to max., for the given <channelId>. By doing this the module can vary data rates between the <minRange> and <maxRange> on the specified <channelId>. Please refer to the *LoRaWAN™ Specification* for the actual values of the data rates and the corresponding spreading factors (SF).

Example: **`mac set ch drrange 13 0 2`** // On channel 13 the data rate can range from 0 (SF10/125 kHz) to (SF8/125 kHz) as required.

Note: If this parameter was previously saved to user EEPROM by issuing the `mac save` command, after modifying its value, the `mac save` command should be called again.

2.4.8.19.2 `mac set ch status <channel ID> <status>`

<channelId>: decimal number representing the channel number, from 0 to 71.

<status>: string value representing the state, either on or off.

Response: ok if parameters are valid

invalid_param if parameters are not valid

This command sets the operation of the given <channelId>.

Example: **`mac set ch status 4 off`** // Channel ID 4 is disabled from use.

Note: If this parameter was previously saved to user EEPROM by issuing the `mac save` command, after modifying its value, the `mac save` command should be called again.

2.4.9 MAC Get Commands

TABLE 2-8: MAC GET COMMANDS

Parameter	Description
devaddr	Gets the current stored unique network device address for that specific end device.
deveui	Gets the current stored globally unique identifier for that specific end device.
appeui	Gets the application identifier for the end device.
dr	Gets the data rate to be used for the next transmission.
pwridx	Gets the output power index value.
adr	Gets the state of adaptive data rate for the device.
retx	Gets the number of retransmissions to be used for an uplink confirmed packet.
rxdelay1	Gets the interval value stored for rxdelay1.
rxdelay2	Gets the interval value stored for rxdelay2.
ar	Gets the state of the automatic reply.
rx2	Gets the data rate and frequency used for the second Receive window.
dcycleps	Gets the duty cycle prescaler which can only be configured by the server.
mrgn	Gets the demodulation margin as received in the last Link Check Answer frame.
gwnb	Gets the number of gateways that successfully received the last Link Check Request frame.
status	Gets the current status of the RN2903 module.
sync	Returns the current synchronization word.
upctr	Returns the current uplink counter.
dnctr	Returns the current downlink counter.
ch	Gets parameters related information which pertains to channel operation and behaviors.

2.4.9.1 mac get devaddr

Response: 4-byte hexadecimal number representing the device address, from 00000000 to FFFFFFFF.

This command will return the current end-device address of the module.

Default: 00000000

Example: **mac get devaddr**

2.4.9.2 mac get deveui

Response: 8-byte hexadecimal number representing the device EUI.

This command returns the globally unique end-device identifier, as set in the module.

Default: 0000000000000000

Example: **mac get deveui**

2.4.9.3 mac get appeui

Response: 8-byte hexadecimal number representing the application EUI.

This command will return the application identifier for the module. The application identifier is a value given to the device by the network.

Default: 0000000000000000

Example: **mac get appeui**

2.4.9.4 mac get dr

Response: decimal number representing the current data rate.

This command will return the current data rate.

Default: 3

Example: **mac get dr**

2.4.9.5 mac get pwridx

Response: decimal number representing the current output power index value. Return values can be: 5, 7, 8, 9 or 10.

This command returns the current output power index value.

Default: 8

Example: **mac get pwridx**

2.4.9.6 mac get adr

Response: string representing the state of the adaptive data rate mechanism, either on or off.

This command will return the state of the adaptive data rate mechanism. It will reflect if the ADR is on or off on the requested device.

Default: off

Example: **mac get adr**

2.4.9.7 mac get retx

Response: decimal number representing the number of retransmissions, from 0 to 255.

This command will return the currently configured number of retransmissions which are attempted for a confirmed uplink communication when no downlink response has been received.

Default: 7

Example: **mac get retx**

2.4.9.8 mac get rxdelay1

Response: decimal number representing the interval in milliseconds for `rxdelay1`, from 0 to 65535.

This command will return the interval in milliseconds for `rxdelay1`.

Default: 1000

Example: **mac get rxdelay1**

2.4.9.9 mac get rxdelay2

Response: decimal number representing the interval in milliseconds for `rxdelay2`, from 0 to 65535.

This command will return the interval in milliseconds for `rxdelay2`.

Default: 2000

Example: **mac get rxdelay2**

2.4.9.10 mac get ar

Response: string representing the state of the automatic reply, either `on` or `off`.

This command will return the current state for the automatic reply (AR) parameter. The response will indicate if the AR is on or off.

Default: `off`

Example: **mac get ar**

2.4.9.11 mac get rx2

Response: decimal number representing the data rate configured for the second Receive window, from 8 to 13 and a decimal number for the frequency configured for the second Receive window, from 923300000 to 927500000 in Hz.

This command will return the current data rate and frequency configured to be used during the second Receive window.

Default: 8 923300000

Example: **mac get rx2**

2.4.9.12 mac get dcycleps

Response: decimal number representing the prescaler value, from 0 to 65535.

This command returns the duty cycle prescaler. The value of the prescaler can be configured *ONLY* by the *SERVER* through use of the Duty Cycle Request frame. Upon reception of this command from the server, the duty cycle prescaler is changed for all enabled channels.

Default: 1

Example: **mac get dcycleps**

2.4.9.13 mac get mrgn

Response: decimal number representing the demodulation margin, from 0 to 255.

This command will return the demodulation margin as received in the last Link Check Answer frame. Please refer to the *LoRaWAN™ Specification* for the description of the values.

Default: 255

Example: **mac get mrgn**

2.4.9.14 mac get gwnb

Response: decimal number representing the number of gateways, from 0 to 255.

This command will return the number of gateways that successfully received the last Link Check Request frame command, as received in the last Link Check Answer.

Default: 0

Example: **mac get gwnb**

2.4.9.15 mac get status

Response: 2-byte hexadecimal number representing the current status of the module.

This command will return the current status of the module. The value returned is a bit mask represented in hexadecimal form. Please refer to Figure 2-1 for the significance of the bit mask.

Default: 0000

Example: **mac get status**

2.4.9.16 mac get sync

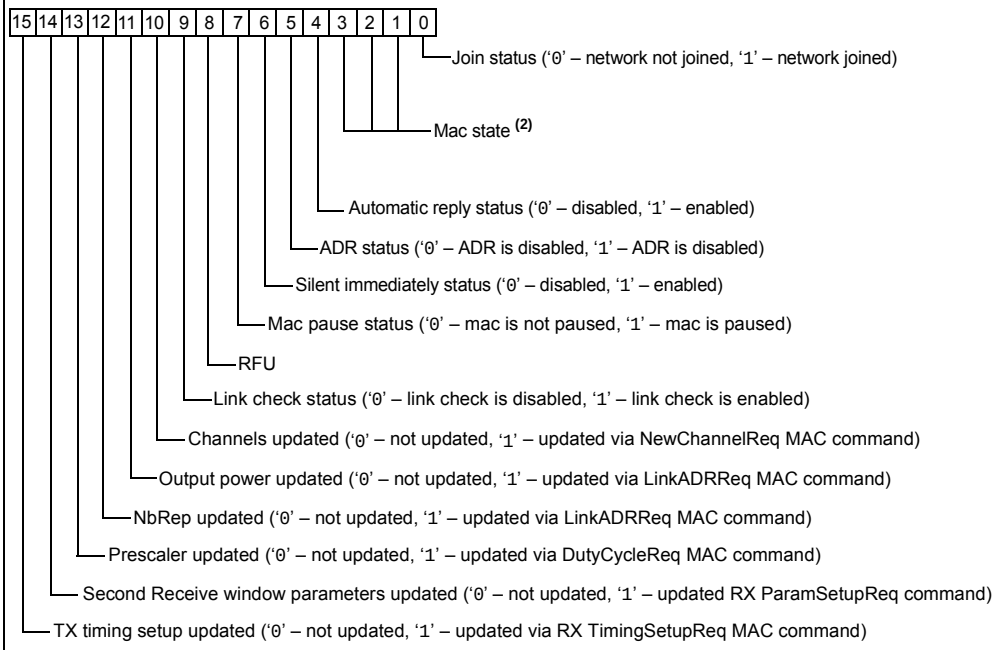
Response: hexadecimal number representing the current synchronization word, from 0x00 to 0xFF.

This command returns the current synchronization word.

Default: 34

Example: **mac get sync**

FIGURE 2-1: MAC STATUS BIT-MAPPED REGISTER (1)



Note 1: Bits 10 (Channels updated), 11 (Output power updated), 12 (NbRep updated), 13 (Prescaler updated), 14 (Second Receive window parameters updated) and 15 (TX timing setup updated) are cleared after issuing a "`mac get status`" command.

2: Mac state:

0 – Idle (transmissions are possible)

1 – Transmission occurring

2 – Before the opening of Receive window 1

3 – Receive window 1 is open

4 – Between Receive window 1 and Receive window 2

5 – Receive window 2 is open

6 – Ack_timeout (Ack_timeout is described in more detail in the *LoRaWAN™ specification*)

3: NbRep is the number of repetitions for unconfirmed packets (please refer to the *LoRaWAN™ Specification* for more details).

2.4.9.17 `mac get upctr`

Response: decimal number representing the downlink counter, from 0 to 4294967295

This command will return the current uplink counter of the module.

Default: 0

Example: **`mac get upctr`** // Returns the current uplink counter

2.4.9.18 `mac get dnctr`

Response: decimal number representing the downlink counter, from 0 to 4294967295

This command will return the current downlink counter of the module.

Default: 0

Example: **`mac get dnctr`** // Returns the current downlink counter

2.4.9.19 MAC GET CHANNEL COMMANDS

TABLE 2-9: MAC GET CHANNEL COMMANDS

Parameter	Description
`freq`	Gets the module operation frequency for the specified channel ID.
`drrange`	Gets the valid data rate range (min. to max.) allowed for the module on the specified channel ID.
`status`	Gets the status for the specified channel ID to indicate if it is enabled for use.

TABLE 2-10: DEFAULT PARAMETERS FOR CHANNELS

Channel Number	Parameters	Default Values
Channel 0-63	Frequency (Hz)	902300000 + 200000 * `channelIndex`
	Data rate range (min. - max.)	0 - 3
	Status	ON
Channel 64-71	Frequency (Hz)	903000000 + 1600000 * `channelIndex`
	Data rate range (min. - max.)	4 - 4
	Status	ON

2.4.9.19.1 `mac get ch freq <ChannelId>`

`<channelId>`: decimal number representing the channel number, from 0 to 71.

Response: decimal number representing the frequency of the channel, from 923300000 to 914900000 in Hz.

This command returns the frequency on the requested `<channelId>`, entered in decimal form.

Default: see Table 2-10

Example: **`mac get ch freq 0`**

2.4.9.19.2 `mac get ch drrange <channelId>`

`<channelId>`: decimal number representing the channel number, from 0 to 71.

Response: decimal number representing the minimum data rate of the channel, from 0 to 4 and a decimal number representing the maximum data rate of the channel, from 0 to 4.

This command returns the allowed data rate index range on the requested `<channelId>`, entered in decimal form. The `<minRate>` and `<maxRate>` index values are returned in decimal form and reflect index values. Please refer to the *LoRaWAN™ Specification* for the description of data rates and the corresponding spreading factors.

Default: see Table 2-10

Example: **`mac get ch drrange 0`**

2.4.9.19.3 `mac get ch status <channelId>`

`<channelId>`: decimal number representing the channel number, from 0 to 71.

Response: string representing the state of the channel, either `on` or `off`.

This command returns if `<channelId>` is currently enabled for use. `<channelId>` is entered in decimal form and the response will be `on` or `off` reflecting the channel is enabled or disabled appropriately.

Default: see Table 2-10

Example: **`mac get ch status 2`**

2.5 RADIO COMMANDS

TABLE 2-11: RADIO COMMANDS(1)

Parameter	Description
rx	This command configures the radio to receive simple radio packets according to prior configuration settings.
tx	This command configures a simple radio packet transmission according to prior configuration settings.
cw	This command will put the module into a Continuous Wave (cw) Transmission for system tuning or certification use.
set	This command allows modification to the radio setting directly. This command allows for the user to change the method of radio operation within module type band limits.
get	This command grants the ability to read out radio settings as they are currently configured.

Note 1: The `mac pause` command must be called before any radio transmission or reception, even if no MAC operations have been initiated before.

TABLE 2-12: RADIO PARAMETERS AVAILABILITY FOR DIFFERENT OPERATIONS

Command	`radio get`	`radio set`	Availability for LoRa™ Modulation	Availability for FSK Modulation
bt	√	√	—	√
mod	√	√	√	√
freq	√	√	√	√
pwr	√	√	√	√
sf	√	√	√	—
afcbw	√	√	—	√
rxbw	√	√	—	√
bitrate	√	√	—	√
fdev	√	√	—	√
prlen	√	√	—	√
crc	√	√	√	√
iqi	√	√	√	—
cr	√	√	√	—
wdt	√	√	√	√
sync	√	√	√	√
bw	√	√	√	—
snr	√	—	√	—

2.5.1 radio rx <rxWindowSize>

<rxWindowSize>: decimal number representing the number of symbols (for LoRa modulation) or time out in milliseconds (for FSK modulation) that the receiver will be opened, from 0 to 65535. Set <rxWindowSize> to '0' in order to enable the Continuous Reception mode. Continuous Reception mode will be exited once a valid packet is received.

Response: this command may reply with two responses. The first response will be received immediately after entering the command. If the command is valid (ok reply is received), a second reply will be received after the reception of a packet or after the time out occurred.

Response after entering the command:

- ok – if parameter is valid and the transceiver is configured in Receive mode
- invalid_param – if parameter is not valid
- busy – if the transceiver is currently busy

Response after the receive process:

- radio_rx <data> – if reception was successful, <data>: hexadecimal value that was received;
- radio_err – if reception was not successful, reception time-out occurred

Example: **radio rx 0** // Puts the radio into continuous Receive mode.

Note:	Ensure the radio Watchdog Timer time-out is higher than the Receive window size.

Note:	The mac pause command must be called before any radio transmission or reception, even if no MAC operations have been initiated before.

2.5.2 radio tx <data>

<data>: hexadecimal value representing the data to be transmitted, from 0 to 255 bytes for LoRa modulation and from 0 to 64 bytes for FSK modulation.

Response: this command may reply with two responses. The first response will be received immediately after entering the command. If the command is valid (ok reply received), a second reply will be received after the effective transmission.

Response after entering the command:

- ok – if parameter is valid and the transceiver is configured in Transmit mode
- invalid_param – if parameter is not valid
- busy – if the transceiver is currently busy

Response after the effective transmission:

- radio_tx_ok – if transmission was successful
- radio_err – if transmission was unsuccessful (interrupted by radio Watchdog Timer time-out)

This command transmits the <data> passed.

Example: **radio tx 48656c6C6F** // Transmits a packet of [0x48][0x65][0x6c][0x6C][0x6F]; Hello.

Note:	The mac pause command must be called before any radio transmission or reception, even if no MAC operations have been initiated before.

2.5.3 radio cw <state>

<state>: string representing the state of the Continuous Wave (CW) mode, either on or off.

Response: ok if state is on

RN2903 X.Y.Z MMM DD YYYY HH:MM:SS, where X.Y.Z is the firmware version, MMM is month, DD is day, HH:MM:SS is hour, minutes, seconds (format: [HW] [FW] [Date] [Time]). [Date] and [Time] refer to the firmware release; if state is off.

invalid_param if state is not valid

This command will enable or disable the CW mode on the module. CW mode allows the user to put the transceiver into Transmission mode to observe the generated signal. By altering the radio settings the user can observe the changes in transmissions levels.

Example: **radio cw on**

Note: Please note that using radio cw off resets the module, this command being semantically identical to sys reset.

2.5.4 Radio Set Commands

TABLE 2-13: RADIO SET COMMANDS

Parameter	Description
bt	Set the data shaping for frequency shift keying (FSK) modulation type.
mod	Set the module Modulation mode.
freq	Set the current operation frequency for the radio.
pwr	Set the output power level used by the radio during transmission.
sf	Set the requested spreading factor (SF) to be used during transmission.
afcbw	Set the value used by the automatic frequency correction bandwidth.
rxbw	Set the operational receive bandwidth.
bitrate	Set the frequency shift keying (FSK) bit rate.
fdev	Set the frequency deviation allowed by the end device.
prlen	Set the preamble length used during transmissions.
crc	Set if a CRC header is to be used.
iqi	Set if IQ inversion is used.
cr	Set the coding rate used by the radio.
wdt	Set the time-out limit for the radio Watchdog Timer.
sync	Set the sync word used.
bw	Set the value used for the radio bandwidth.

2.5.4.1 radio set bt <gfBT>

<gfBT>: string representing the Gaussian baseband data shaping, enabling GFSK modulation. Parameter values can be: none, 1.0, 0.5, 0.3.

Response: ok if the data shaping is valid

invalid_param if the data shaping is not valid

This command modifies the data shaping applied to FSK transmissions. Entering any <gfBT> other than none will result in a Gaussian Filter BT being applied to transmissions in FSK mode.

Example: **radio set bt none** // Data shaping in FSK mode is disabled or null.

2.5.4.2 radio set mod <mode>

<mode>: string representing the modulation method, either lora or fsk.

Response: ok if the modulation is valid

invalid_param if the modulation is not valid

This command changes the modulation method being used by the module. Altering the mode of operation does not affect previously set parameters, variables or registers. FSK mode also allows GFSK transmissions when data shaping is enabled.

Example: **radio set mod lora**

2.5.4.3 radio set freq <frequency>

<frequency>: decimal representing the frequency, from 902000000 to 928000000 in Hz.

Response: ok if the frequency is valid

invalid_param if the frequency is not valid

This command changes the communication frequency of the radio transceiver.

Example: **radio set freq 923300000**

2.5.4.4 radio set pwr <pwrout>

<pwrOut>: signed decimal number representing the transceiver output power, from 2 to 20.

Response: ok if the output power is valid

invalid_param if the output power is not valid

This command changes the transceiver output power. It is possible to set the output power above the regulatory limits. This power setting allows some compensation on the cable or transmission line loss. For more details on output power please check the *RN2903 Low-Power Long-Range LoRa™ Technology Transceiver Module Data Sheet* (DS50002390).

The actual radio power capabilities are from 2 to 17 dBm or 20 dBm.

Example: **radio set pwr 14**

2.5.4.5 radio set sf <spreadingFactor>

<spreadingFactor>: string representing the spreading factor. Parameter values can be: sf7, sf8, sf9, sf10, sf11 or sf12.

Response: ok if the spreading factor is valid

invalid_param if the spreading factor is not valid

This command sets the spreading factor used during transmission.

Example: **radio set sf sf7**

2.5.4.6 radio set afcbw <autoFreqBand>

<autoFreqBand>: float representing the automatic frequency correction in kHz. Parameter values can be: 250, 125, 62.5, 31.3, 15.6, 7.8, 3.9, 200, 100, 50, 25, 12.5, 6.3, 3.1, 166.7, 83.3, 41.7, 20.8, 10.4, 5.2, 2.6.

Response: ok if the automatic frequency correction is valid

invalid_param if the automatic frequency correction is not valid

This command modifies the automatic frequency correction bandwidth for receiving/transmitting.

Example: **radio set afcbw 125**

2.5.4.7 `radio set rxbw <rxbandwidth>`

`<rxBandwidth>`: float representing the signal bandwidth in kHz. Parameter values can be: 250, 125, 62.5, 31.3, 15.6, 7.8, 3.9, 200, 100, 50, 25, 12.5, 6.3, 3.1, 166.7, 83.3, 41.7, 20.8, 10.4, 5.2, 2.6.

Response: `ok` if the signal bandwidth is valid

`invalid_param` if signal bandwidth is not valid

This command sets the signal bandwidth when receiving.

Example: **`radio set rxbw 250`** // Signal bandwidth for receiving is 250 kHz.

2.5.4.8 `radio set bitrate <fskBitRate>`

`<fskBitRate>`: decimal number representing the FSK bit rate value, from 1 to 300000.

Response: `ok` if the bit rate value is valid

`invalid_param` if the bit rate value is not valid

This command sets the FSK bit rate value.

Example: **`radio set bitrate 5000`** // FSK bit rate is set to 5 kb/s.

2.5.4.9 `radio set fdev <freqdev>`

`<freqDev>`: decimal number representing the frequency deviation, from 0 to 200000.

Response: `ok` if the frequency deviation is valid

`invalid_param` if frequency deviation is not valid

This command sets the frequency deviation during operation.

Example: **`radio set fdev 5000`** // Frequency deviation is 5 kHz.

2.5.4.10 `radio set prlen <preamble>`

`<preamble>`: decimal number representing the preamble length, from 0 to 65535.

Response: `ok` if the preamble length is valid

`invalid_param` if the preamble length is not valid

This command sets the preamble length for transmit/receive.

Example: **`radio set prlen 8`** // Preamble length is 8.

2.5.4.11 `radio set crc < crcHeader >`

`<crcHeader>`: string representing the state of the CRC header, either `on` or `off`.

Response: `ok` if the state is valid

`invalid_param` if the state is not valid

This command enables or disables the CRC header for communications.

Example: **`radio set crc on`** // Enables the CRC header.

2.5.4.12 `radio set iqi <iqInvert>`

`<iqInvert>`: string representing the state of the invert IQ, either `on` or `off`.

Response: `ok` if the state is valid

`invalid_param` if the state is not valid

This command enables or disables the Invert IQ for communications.

Example: **`radio set iqi on`** // Invert IQ is enabled.

2.5.4.13 `radio set cr <codingRate>`

`<codingRate>`: string representing the coding rate. Parameter values can be: `4/5`, `4/6`, `4/7`, `4/8`.

Response: `ok` if the coding rate is valid

`invalid_param` if the coding rate is not valid

This command modifies the coding rate currently being used by the radio.

Example: `radio set cr 4/7` // The coding rate is set to 4/7.

2.5.4.14 `radio set wdt <watchDog>`

`<watchDog>`: decimal number representing the time-out length for the Watchdog Timer, from 0 to 4294967295. Set to '`0`' to disable this functionality.

Response: `ok` if the Watchdog time-out is valid

`invalid_param` if the Watchdog time-out is not valid

This command updates the time-out length in milliseconds applied, to the radio Watchdog Timer. If this functionality is enabled, then the Watchdog Timer is started for every transceiver reception or transmission. The Watchdog Timer is stopped when the operation in progress in finished.

Example: **`radio set wdt 2000`** // The Watchdog Timer is configured for 2000 ms.

> **Note:** Ensure the value configured for the Watchdog Timer matches the radio configurations. For example, set the `<watchDog>` value to '`0`' in order to disable this functionality during the radio continuous reception.

2.5.4.15 `radio set sync <syncWord>`

`<syncWord>`: hexadecimal value representing the Sync word used during communication. For LoRa modulation one byte is used, for FSK up to eight bytes can be entered.

Response: `ok` if the sync word is valid

`invalid_param` if the sync word is not valid

This command configures the sync word used during communication.

Example: **`radio set sync 12`** // LoRa modulation in use.

2.5.4.16 `radio set bw <bandWidth>`

`<bandWidth>`: decimal representing the operating radio bandwidth in kHz. Parameter values can be: 125, 250, 500.

Response: `ok` if the bandwidth is valid

`invalid_param` if the bandwidth is not valid

This command sets the operating radio bandwidth for LoRa operation.

Example: **`radio set bw 250`** // The operating bandwidth is 250 kHz.

2.5.5 Radio Get Commands

TABLE 2-14: RADIO GET COMMANDS

Parameter	Description
bt	Get the data shaping for frequency shift keying (FSK) modulation type.
mod	Get the module Modulation mode.
freq	Get the current operation frequency for the radio.
pwr	Get the output power level used by the radio during transmission.
sf	Get the requested spreading factor (SF) to be used during transmission.
afcbw	Get the value used by the automatic frequency correction bandwidth.
rxbw	Get the operational receive bandwidth.
bitrate	Get the frequency shift keying (FSK) bit rate.
fdev	Get the frequency deviation allowed by the end device.
prlen	Get the preamble length used during transmissions.
crc	Get if a CRC header is to be used.
iqi	Get if IQ inversion is used.
cr	Get the coding rate used by the radio.
wdt	Get the time-out limit for the Watchdog Timer.
bw	Get the value used for the radio bandwidth.
snr	Get the signal noise ratio (SNR) of the last received packet.
sync	Returns the current synchronization word for the radio.

2.5.5.1 radio get bt

Response: string representing the configuration for data shaping. Parameter values can be: none, 1.0, 0.5, 0.3.

This command reads back the current configuration for data shaping applied to FSK transmissions.

Default: 0.5

Example: **radio get bt** // Reads the current data shaping FSK configuration.

2.5.5.2 radio get mod

Response: string representing the current mode of operation of the module, either lora or fsk.

This command reads back the current mode of operation of the module.

Default: lora

Example: **radio get mod** // Reads if module is modulating in LoRa or FSK.

2.5.5.3 radio get freq

Response: decimal number representing the frequency, from 902000000 to 928000000 in Hz.

This command reads back the current operation frequency of the module.

Default: 923300000

Example: **radio get freq** // Reads back the current frequency the transceiver communicates on.

2.5.5.4 radio get pwr

Response: signed decimal representing the current power level, from 2 to 20.

This command reads back the current power level settings used in operation.

Default: 2

Example: **radio get pwr** // Reads back the current transmit output power.

2.5.5.5 radio get sf

Response: string representing the current spreading factor.

This command reads back the current spreading factor being used by the transceiver. Parameter values can be: sf7, sf8, sf9, sf10, sf11, sf12

Default: sf12

Example: **radio get sf** // Reads back the current spreading factor settings.

2.5.5.6 radio get afcbw

Response: float representing the automatic frequency correction band in kHz. Parameter values can be: 250, 125, 62.5, 31.3, 15.6, 7.8, 3.9, 200, 100, 50, 25, 12.5, 6.3, 3.1, 166.7, 83.3, 41.7, 20.8, 10.4, 5.2, 2.6.

This command reads back the status of the Automatic Frequency Correction Bandwidth.

Default: 41.7

Example: **radio get afcbw** // Reads back the current automatic frequency correction bandwidth.

2.5.5.7 radio get rxbw

Response: float representing the signal bandwidth in kHz. Parameter values can be: 250, 125, 62.5, 31.3, 15.6, 7.8, 3.9, 200, 100, 50, 25, 12.5, 6.3, 3.1, 166.7, 83.3, 41.7, 20.8, 10.4, 5.2, 2.6.

This command reads back the signal bandwidth used for receiving.

Default: 25

Example: **radio get rxbw** // Reads back the receive signal bandwidth.

2.5.5.8 radio get bitrate

Response: signed decimal representing the configured bit rate, from 1 to 300000.

This command reads back the configured bit rate for FSK communications.

Default: 50000

Example: **radio get bitrate** // Reads back the current FSK bit rate setting.

2.5.5.9 radio get fdev

Response: signed decimal representing the frequency deviation setting, from 0 to 200000.

This command reads frequency deviation setting on the transceiver.

Default: 25000

Example: **radio get fdev** // Reads back current configured frequency deviation setting.

2.5.5.10 radio get prlen

Response: signed decimal representing the preamble length, from 0 to 65535.

This command reads the current preamble length used for communication.

Default: 8

Example: **radio get prlen** // Reads back the preamble length used by the transceiver.

2.5.5.11 radio get crc

Response: string representing the status of the CRC header, either on or off

This command reads back the status of the CRC header, to determine if it is to be included during operation.

Default: on

Example: **radio get crc** // Reads back if the CRC header is enabled for use.

2.5.5.12 radio get iqi

Response: string representing the status of the Invert IQ functionality, either on or off.

This command reads back the status of the Invert IQ functionality.

Default: off

Example: **radio get iqi** // Reads back the status of the Invert IQ functionality.

2.5.5.13 radio get cr

Response: string representing the current value settings used for the coding rate. Parameter values can be: 4/5, 4/6, 4/7, 4/8.

This command reads back the current value settings used for the coding rate during communication.

Default: 4/5

Example: **radio get cr** // Reads back the current coding rate transceiver settings.

2.5.5.14 radio get wdt

Response: decimal number representing the length used for the Watchdog time-out, from 0 to 4294967295.

This command reads back in milliseconds, the length used for the Watchdog time-out.

Default: 15000

Example: **radio get wdt** // Reads back the current time-out value applied to the Watchdog Timer

2.5.5.15 radio get bw

Response: decimal representing the current operating radio bandwidth in kHz. Parameter values can be: 125, 250 or 500.

This command reads back the current operating radio bandwidth used by the transceiver.

Default: 125

Example: **radio get bw** // Reads back the current operational bandwidth applied to transmissions.

2.5.5.16 radio get snr

Response: signed decimal number representing the signal to noise ratio (SNR), from -128 to 127.

This command reads back the Signal Noise Radio (SNR) for the last received packet.

Default: -128

Example: **radio get snr** // Reads back the measured SNR for the previously packet reception.

2.5.5.17 radio get sync

Response: up to 8-byte hexadecimal number representing the synchronization word.

This command reads back the current synchronization word for the radio, depending on the modulation method set by the `radio set mod <mode>` command.

Default: 34

Example: **radio get sync** // Reads back the current synchronization word.

NOTES:

Appendix A. Current Firmware Features and Fixes

Please check the product web page for the current RN2903 firmware version at www.microchip.com/lora.

A.1. Version TBD

Initial release of the firmware.

NOTES:

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