

## RL78/G23, RL78/G14

### LoRaWAN® Stack Sample Application

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#### Introduction

This document describes a sample software to use LoRaWAN® stack. This application operates the LoRaWAN stack by user with some commands from a Host PC.

#### Notes on release

Features described with **gray background** are currently unsupported.

#### Target Devices

MCU: Renesas RL78/G23 (R7F100GLG) or RL78/G14 (R5F104ML)  
Transceiver: Semtech SX1261 or SX1262

## Contents

<b>1. Overview</b> .....	<b>4</b>
1.1 Environment .....	4
1.2 Software diagram .....	4
1.3 Related Documentation .....	4
1.4 Directories .....	5
1.5 Interface configuration .....	6
<b>2. AT command syntax</b> .....	<b>7</b>
2.1 Command syntax .....	7
2.1.1 Basic command syntax .....	7
2.1.2 Extended command syntax .....	8
2.2 Response syntax .....	9
2.2.1 Basic response .....	9
2.2.2 Extended response syntax .....	9
<b>3. AT command sets</b> .....	<b>11</b>
3.1 Basic AT command sets .....	11
3.1.1 Basic AT command list .....	11
3.2 Basic AT command reference .....	11
3.2.1 AT .....	11
3.2.2 ATE .....	11
3.2.3 ATV .....	11
3.3 Extended AT command sets .....	12
3.3.1 Extended AT command list .....	12
3.4 Extended AT command reference .....	13
3.4.1 AT+VER .....	13
3.4.2 AT+SAVE .....	13
3.4.3 AT+LOAD .....	13
3.4.4 AT+REGION .....	13
3.4.5 AT+DEVEUI .....	14
3.4.6 AT+CLASS .....	14
3.4.7 AT+DEVADDR .....	14
3.4.8 AT+NETID .....	15
3.4.9 AT+APPEUI .....	15
3.4.10 AT+NWKSKEY .....	15
3.4.11 AT+APPSKEY .....	15
3.4.12 AT+APPKEY .....	16
3.4.13 AT+ACTMODE .....	16
3.4.14 AT+MTYPE .....	16
3.4.15 AT+JOIN .....	17

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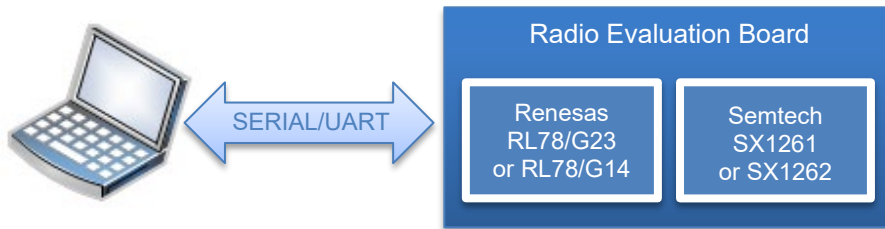
3.4.16	AT+SEND .....	17
3.4.17	AT+SENDHEX .....	18
3.4.18	AT+ADR .....	18
3.4.19	AT+RSSI .....	18
3.4.20	AT+RX1DELAY .....	19
3.4.21	AT+LINKCHK .....	19
3.4.22	AT+FPORT .....	19
3.4.23	AT+DCYCLE .....	20
3.4.24	AT+DR .....	20
3.4.25	AT+DEVTIME .....	20
3.4.26	AT+BCONACQ .....	21
3.4.27	AT+PNGSLPERIOD .....	21
3.4.28	AT+PNGSLINFO .....	22
3.4.29	+RCVD .....	22
3.4.30	+RSSI .....	22
3.4.31	+BCONRCVD .....	23
3.4.32	+BCONNORCVD .....	23
3.4.33	+BCONLOST .....	23
4.	Sample operations .....	24
4.1	Initial setting for ABP (Activation By Personalization) .....	24
4.2	Initial setting for OTAA (Over The Air Activation) .....	25
4.3	Activation .....	26
4.4	Switching to Class B .....	26
4.5	Send unconfirmed data of character string .....	27
4.6	Send confirmed data of character string .....	28
4.7	Send confirmed data of hexadecimal value .....	28
4.8	Display RSSI on receiving a data message .....	29

## 1. Overview

This document describes the APIs for operating the LoRaWAN stack sample application program. This application can be operated by the AT command sets.

### 1.1 Environment

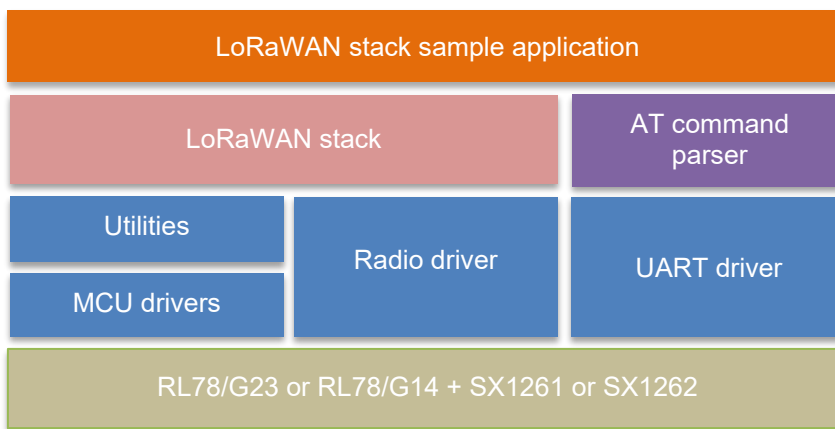
The figure below indicates the environment to use this sample application. This sample application can be operated with the AT command sets from a Host PC via a serial interface.



The target MCU and the target RF for this sample application are Renesas RL78/G23(R7F100GLG) or RL78/G14(R5F104ML), and Semtech SX1261 or SX1262.

### 1.2 Software diagram

The figure below indicates a block diagram of this sample application.



### 1.3 Related Documentation

Table 1. Related Documentation

	Document No.	Title	Author	Language
[1]	R11AN0228EJ	LoRaWAN® stack reference guide	Renesas Electronics	English
[2]	R11QS0033EJ	LoRa®-based Wireless Software Package Quick Start Guide	Renesas Electronics	English

## 1.4 Directories

Table 2 shows a folder structure and what kind of codes are included in each folder

**Table 2. Directories**

Directories	Description
apps/LoRaSample	LoRaWAN sample application
boards	Board specific codes
boards/mcu	MCU drivers
mac	LoRaWAN MAC stack
radio	Radio driver for LoRa®
peripherals	Security related codes
system	Utility codes
sytem/d_flash (*1)	EEPROM Emulation Library
sytem/rfd (*2)	Renesas Flash Driver

**CAUTION:**

(\*1) This folder contains the EEPROM Emulation Library and Data Flash Access Library to access Data Flash memory, which can be used for RL78/G14. The libraries for testing, 'EEPROM Emulation Library Pack02 Package Ver.2.00(for CA78K0R/CC-RL Compiler) for RL78 Family', are contained in advance. But when you start to develop a product, it is necessary to copy the newest library corresponding to your development environment to this folder.

The EEPROM Emulation Library and Data Flash Access Library are downloaded from Renesas website.

(\*2) This folder contains the 'Renesas Flash Driver (RFD) RL78 Type01 V1.00' for RL78/G23. The driver for testing is contained in advance. But when you start to develop a product, it is necessary to copy the newest driver corresponding to your development environment to this folder.

The driver is downloaded from Renesas website.

## 1.5 Interface configuration

The Serial/UART interface configuration of this sample application is as shown in Table 3.

**Table 3. Serial/UART interface configuration**

<b>Configuration Items</b>	<b>Value</b>
Baud rate	115200 bps
Data bit	8 bits
Parity bit	None
Stop bit	1 bit
Flow control	None
Local echo back	Yes
Line terminator	Transmission: CR+LF Reception: CR+LF

## 2. AT command syntax

### 2.1 Command syntax

A command line is made up of three elements: the prefix, the body, and the termination character. The body is made up of individual commands as specified later in this document.

Note: This sample application program supports up to 512 characters for input of the command line. If the number of input characters exceeds the limit, the exceeded characters are ignored except for <BS>.

**Table 4. General command syntax**

Prefix	Body	Termination
"AT"	Individual commands as specified	<CR><LF>

#### 2.1.1 Basic command syntax

The format of basic command syntax consists of <command>[<number>], where <command> is a single alphabetic character and where <number> may have a string of one or more characters from "0" to "9" decimal integer value.

**Table 5. Basic command syntax**

Prefix	Body	Termination	Description
"AT"	<command>[<number>]	<CR><LF>	Execute a command with number

### 2.1.2 Extended command syntax

There are two types of commands: action commands and parameter commands. Action commands are used to “execute” a particular function of the equipment. Parameter commands are used to “set” value(s) to parameter(s) or to “read” current value(s) of parameter(s).

**Table 6. Extended command syntax: Action command**

Prefix	Body (Subcommand)	Termination	Description
“AT”	+<name>	<CR><LF>	Execute an action command with no parameters
“AT”	+<name>=<value> <compound values>	<CR><LF>	Execute an action command with one or more parameters

**Table 7. Extended command syntax: Parameter command**

Prefix	Body (Subcommand)	Termination	Description
“AT”	+<name>=<value> <compound values>	<CR><LF>	Store a <value> or <compound values>
“AT”	+<name>?	<CR><LF>	Read the current value



## 2.2 Response syntax

Two types of response, the basic response and the extended response, are supported. The format used for these responses are shown in Table 8.

**Table 8. General response syntax**

Header	Information response	Trailer
<CR><LF>	Individual commands as specified	<CR><LF>

### 2.2.1 Basic response

The basic response returns a result code in the information response as a result of basic and extended commands. Table 9 and Table 10 show the syntax of the basic response and the result codes respectively.

**Table 9. Basic response syntax**

Header	Result code	Trailer
<CR><LF>	<result code>	<CR><LF>

**Table 10. Result codes**

Result code	Description
OK	Acknowledges execution of a command.
ERROR	Command not recognized, command line maximum length exceeded, parameter value invalid, or other problem with processing the command line.
BUSY	Other command is still running.

### 2.2.2 Extended response syntax

The extended response returns a subcommand information response in the information response as a result of extended commands. Table 11 shows the syntax of the extended response. The subcommand information response returns a value or compound values. The compound values use a comma as a delimiter. The response of the subcommand information response may be different except the common format.

**Table 11. Extended response syntax**

Header	Subcommand information response	Trailer	Description
<CR><LF>	+<name>:<value> <compound values>	<CR><LF>	The body has the executed command name and the result value or compound values.

Some of the commands return what are referred to as an extended result code as extended response value. Following table shows the list of extended result codes a command can return.

**Table 12. List of Extended Result Code**

Extended Result Code	Description
OK	Success
BUSY	MAC is busy
ACK_RECEIVED	Received an ACK to a confirmed data message
NO_ACK	Did not receive an ACK to a confirmed data message
NO_RESPONSE	Did not receive a response to a MAC command sent
JOIN_ACCEPTED	Received Join Accept in response to Join Request
JOIN_FAILED	Did not receive Join Accept in response to Join Request
BEACON_NOT_FOUND	Could not receive a Class B beacon
SERVICE_UNKNOWN	Unknown MAC service
PARAMETER_INVALID	Invalid parameter is specified
FREQUENCY_INVALID	Invalid radio frequency is specified
DATARATE_INVALID	Invalid data rate is specified
NO_NETWORK_JOINED	Device is not activated
LENGTH_ERROR	Payload is too long
REGION_NOT_SUPPORTED	Specified region is not supported
SKIPPED_APP_DATA	Application data transmission is skipped
DUTYCYCLE_RESTRICTED	Transmission is under duty cycle restriction
NO_CHANNEL_FOUND	There is no channel to send data at current data rate
NO_FREE_CHANNEL_FOUND	Transmission channels are busy
BUSY_BEACON_RESERVED_TIME	Transmission aborted due to beacon reserved time
BUSY_PING_SLOT_WINDOW_TIME	Transmission aborted due to ping slot window
BUSY_UPLINK_COLLISION	Transmission aborted due to beacon time
MC_GROUP_UNDEFINED	Multicast group undefined
MAC_ERROR	MAC error
RADIO_FAIL	Radio driver error
RADIO_PARAMETER_INVALID	Radio parameter configuration invalid
UNKNOWN_STATUS	Unknown error

### 3. AT command sets

#### 3.1 Basic AT command sets

##### 3.1.1 Basic AT command list

Commands	Description
AT	Tests whether to accept AT commands.
ATE	Enables / disables Echo-back. Echo-back is enabled in the initial state.
ATV	Changes the response format of the result code and response information.

#### 3.2 Basic AT command reference

##### 3.2.1 AT

Command	The result code	Description
AT	- OK - ERROR	- Tests if the AT command interface is valid.

##### 3.2.2 ATE

Command	The result code	Description
ATE<value>  <value> 0: Echo-back is disabled (default) 1: Echo-back is enabled	- OK - ERROR	- Enables or disables the echo-back. - Echo-back is enabled by default

##### 3.2.3 ATV

Command	The result code	Description
ATV<value>  <value> 0: Delimiter before result code and response information is omitted (default) 1: Delimiter before result code and response information is added	- OK - ERROR	- Set the response format of the result code and response information

	ATV0	ATV1
Information response	<text><CR><LF>	<CR><LF> <text><CR><LF>
Result code	<text><CR><LF>	<CR><LF> <text><CR><LF>

### 3.3 Extended AT command sets

#### 3.3.1 Extended AT command list

Commands	Description
+VER	Show the version of this sample application
+SAVE	Save parameters to the data flash
+LOAD	Load parameters from the data flash
+REGION	Set/get Region
+DEVEUI	Set/get device EUI (DevEUI)
+NETID	Set/Get network identifier (NetID)
+CLASS	Set/get device class
+DEVADDR	Set/get device address (DevAddr)
+APPEUI	Set/get application identifier (AppEUI)
+NWKKEY	Set/get network session key (NwkSKey)
+APPSKEY	Set/get application session key (AppSKey)
+ACTMODE	Set/get activation mode
+MTYPE	Set/get message type (confirmed / unconfirmed) of data messages to be sent
+JOIN	Activate the device according to the activation mode
+SEND	Send data message of character string
+SENDHEX	Send data message of hexadecimal
+ADR	Enable/disable ADR mode
+RSSI	Enable/disable RSSI display
+RX1DELAY	Set the delay for Rx Window 1 in ms.
+LINKCHK	Send LinkCheckReq command
+FPORT	Set/get port number (FPort) of data messages to be sent
+DCYCLE	Enable/disable duty cycle control
+DR	Set/get default data rate in case ADR is disabled
+DEVTIME	Send DeviceTimeReq
+BCONACQ	Initiate beacon acquisition
+PNGSLPERIOD	Set/get PingSlot Periodicity
+PNGSLINFO	Send PingSlotInfoReq
+RCVD	(Notification) Received a data message
+BCONRCVD	(Notification) Successfully received a Class B beacon
+BCONNORCVD	(Notification) Failed to receive a Class B beacon at an expected time interval
+BCONLOST	(Notification) Lost synchronization with Class B beacons

### 3.4 Extended AT command reference

#### 3.4.1 AT+VER

Command	The result code	Description
+VER?	<version string> OK	Read firmware version

#### 3.4.2 AT+SAVE

Command	The result code	Description
+SAVE	OK	<ul style="list-style-type: none"> <li>- Save parameters to the data flash.</li> <li>- The parameters to save are region, device class, activation mode, AppKey, DevEUI, AppEUI, NwkSKey, AppSKey, DevAddr, NetID, message type, FPort, Rx Window 1 delay, duty cycle control, default data rate, ADR and RSSI settings.</li> </ul>

#### 3.4.3 AT+LOAD

Command	The result code	Description
+LOAD +LOAD=<option>  <option> 0: Load from the data flash (same as "+LOAD") 1: Load default parameters	OK	<ul style="list-style-type: none"> <li>- Load parameters from the data flash when the option is not specified or set to 0.</li> <li>- Set default values to parameters when the option is set to 1.</li> </ul>

#### 3.4.4 AT+REGION

Command	The result code	Description
+REGION=<region>  <region> Operation region 0: EU868 1: US915 6: AS923	- OK - ERROR	<ul style="list-style-type: none"> <li>- Set operation region to the device.</li> <li>- When the &lt;region&gt; is other than the value for supported region, this command returns ERROR.</li> </ul>
+REGION?	<region> OK	Read the operation region set in the device.

**3.4.5 AT+DEVEUI**

Command	The result code	Description
+DEVEUI=<deveui>  <deveui> Device EUI (DevEUI) in 8 bytes hexadecimal value (16 characters)	- OK - ERROR	- Set DevEUI to the device. - When the length of <deveui> less than 8 bytes, pad with 0x00 from MSB. - When the length of <deveui> exceeds 8 bytes, this command returns ERROR.
+DEVEUI?	<deveui> OK	Read the DevEUI set in the device.

**3.4.6 AT+CLASS**

Command	The result code	Description
+CLASS=<class>  <class> Device class 0: Class A (default) 1: Class B 2: Class C	- OK - ERROR	- Set the device class to the device. - When <class> is other than 0, 1 or 2, this command returns ERROR.
+CLASS?	<class> OK	Read the device class of the device.

Note: The device class shall be changed from A to B via AT+CLASS after the beacon acquisition is succeeded and the ping slot periodicity is set to the intended value.

**3.4.7 AT+DEVADDR**

Command	The result code	Description
+DEVADDR=<devaddr>  <devaddr> Device address (DevAddr) in 4bytes hexadecimal value (8 characters)	- OK - ERROR	- Set DevAddr to the device. - When the length of <devaddr> is less than 4bytes, pad with 0x00 from MSB. - When the length of <devaddr> exceeds 4 bytes, this command returns ERROR. - When activation of OTAA is succeeded, DevAddr is updated to a value assigned by a server.
+DEVADDR?	<devaddr> OK	Read the DevAddr set in the device.

**3.4.8 AT+NETID**

Command	The result code	Description
+NETID=<netid>  <netid> Network identifier (NetID) in 3 bytes hexadecimal value (6 characters)	- OK - ERROR	- Set NetID to the device. - When the length of <netid> is less than 3 bytes, pad with 0x00 from MSB. - When the length of <netid> exceeds 4 bytes, this command returns ERROR. - When activation of OTAA is succeeded, NetID is updated to a value assigned by a server.
+NETID?	<netid> OK	Read the NetID set in the device.

**3.4.9 AT+APPEUI**

Command	The result code	Description
+APPEUI=<appeui>  <appeui>: Application identifier (AppEUI) in 8 bytes hexadecimal value (16 characters).	- OK - ERROR	- Set AppEUI to the device. - When the length of <appeui> is less than 8 bytes, pad with 0x00 from MSB. - When the length of <appeui> exceeds 8 bytes, this command returns ERROR.
+APPEUI?	<appeui> OK	Read the AppEUI set in the device.

**3.4.10 AT+NWKSKEY**

Command	The result code	Description
+NWKSKEY=<nwkskey>  <nwkskey>: Network session key (NwkSKey) in 16 bytes hexadecimal value (32 characters).	- OK - ERROR	- Set NwkSKey to the device. - When the length of <nwkskey> is less than 16 bytes, pad with 0x00 from MSB. - When the length of <nwkskey> exceeds 16 bytes, this command returns ERROR.
+NWKSKEY?	<nwkskey> OK	Read the NwkSKey set in the device.

**3.4.11 AT+APPSKEY**

Command	The result code	Description
+APPSKEY=<appskey>  <appskey> Application session key (AppSKey) in 16 bytes hexadecimal value (32 characters).	- OK - ERROR	- Set AppSKey to the device. - When the length of <appskey> is less than 16 bytes, pad with 0x00 from MSB. - When the length of <appskey> exceeds 16 bytes, this command returns ERROR.
+APPSKEY?	<appskey> OK	Read the AppSKey set in the device.

**3.4.12 AT+APPKEY**

Command	The result code	Description
+APPKEY=<appkey>  <appkey> Application key (AppKey) in 16 bytes hexadecimal value (32 characters).	- OK - ERROR	- Set AppKey to the device. - When the length of <appkey> is less than 16 bytes, pad with 0x00 from MSB. - When the length of <appkey> exceeds 16 bytes, this command returns ERROR.
+APPKEY?	<appkey> OK	Read the AppKey set in the device.

**3.4.13 AT+ACTMODE**

Command	The result code	Description
+ACTMODE=<mode>  <mode> Activation mode 0: ABP 1: OTAA (default)	- OK - ERROR	- Set activation mode to the device - When <mode> is other than 0 and 1, this command returns ERROR
+ACTMODE?	<mode> OK	Read activation mode set in the device

**3.4.14 AT+MTYPE**

Command	The result code	Description
+MTYPE=<mtype>  <mtype> Message type of data message 0: Unconfirmed data (default) 1: Confirmed data	OK ERROR	Set the message type of data messages to be sent, unconfirmed or confirmed.
+MTYPE?	<mtype> OK	Read the message type.



**3.4.15 AT+JOIN**

Command	The result code	Description
+JOIN	<ul style="list-style-type: none"> <li>- OK</li> <li>- ERROR</li> <li>- +JOIN: JOIN_ACCEPTED</li> <li>- +JOIN: JOIN_FAILED</li> </ul>	<ul style="list-style-type: none"> <li>- Request to activate the device according to the activation mode setting (ABP or OTAA).</li> <li>- In case of ABP mode, the device is activated if the result code "OK" is received.</li> <li>- In case of OTAA, the device is activated if the result code "OK" and "+JOIN: JOIN_ACCEPTED" are received.</li> <li>- In other cases, the device failed to be activated.</li> </ul>
Extended result codes		
	JOIN_ACCEPTED	Succeeded to receive Join-Accept message in case of OTAA mode.
	JOIN_FAILED	Failed to receive Join-Accept message in case OTAA mode.

Note: AT+JOIN shall not be issued when the LoRaWAN stack operates in class B.

**3.4.16 AT+SEND**

Command	The result code	Description
+SEND="<data>"  <data> Data of character string	<ul style="list-style-type: none"> <li>- OK</li> <li>- ERROR</li> <li>- +SEND: OK</li> <li>- +SEND:NO_NETWORK_JOINED</li> <li>- +SEND: LENGTH_ERROR</li> <li>- +SEND: ACK_RECEIVED-</li> <li>- +SEND: NO_ACK</li> <li>- +SEND: SKIPPED_APP_DATA</li> </ul>	<ul style="list-style-type: none"> <li>- Request to send a data message of character string.</li> <li>- Only visible characters, except space (0x20) and double quote (0x22) and comma (0x2c), are permitted for the character string.</li> <li>- Message type, unconfirmed data or confirmed data, can be specified by AT+MTYPE command.</li> <li>- Port number can be specified by AT+FPORT command.</li> </ul>
Extended result codes		
	OK	Sent unconfirmed data message
	ACK_RECEIVED	Sent confirmed data message and received ACK
	NO_ACK	Sent confirmed data message and failed to receive ACK
	NO_NETWORK_JOINED	The device has not been activated
	LENGTH_ERROR	Too long data message length
	SKIPPED_APP_DATA	Sent MAC commands only. Need to retry sending data message.

**3.4.17 AT+SENDHEX**

Command	The result code	Description
+SENDHEX=<data>  <data> Data of hexadecimal value	- OK - ERROR - +SEND: OK - +SEND: NO_NETWORK_JOINED - +SEND: LENGTH_ERROR - +SEND: ACK_RECEIVED - +SEND: NO_ACK - +SEND: SKIPPED_APP_DATA	- Request to send a data message of hexadecimal value. - Message type, unconfirmed data or confirmed data, can be specified by AT+MTYPE command. - Port number can be specified by AT+FPORT command.
		Extended result codes
		OK Sent unconfirmed data message
		ACK_RECEIVED Sent confirmed data message and received ACK
		NO_ACK Sent confirmed data message and failed to receive ACK
		NO_NETWORK_JOINED The device has not been activated
		LENGTH_ERROR Too long data message length
		SKIPPED_APP_DATA Sent MAC commands only. Need to retry sending data message.

**3.4.18 AT+ADR**

Command	The result code	Description
+ADR=<mode>  <mode> ADR mode 0: OFF 1: ON (default)	- OK - ERROR	- Set ADR mode to the device - When <mode> is other than 0 or 1, this command returns ERROR
+ADR?	<mode> OK	Read ADR mode set in the device

**3.4.19 AT+RSSI**

Command	The result code	Description
+RSSI=<mode>  <mode> RSSI display mode 0: OFF (default) 1: ON	- OK - ERROR	- Set RSSI display mode to the device - When RSSI display mode is ON, RSSI and SNR values will be displayed on reception of messages. - When <mode> is other than 0 or 1, this command returns ERROR
+RSSI?	<mode> OK	Read RSSI display mode set in the device

**3.4.20 AT+RX1DELAY**

Command	The result code	Description
+RX1DELAY=<delay>  <delay> Delay for Rx Window 1 in decimal [msec]. Range: 500 – 50000 Default: 1000	- OK - ERROR	- Set <delay> [msec] to the delay for Rx Window 1 and '<delay> + 1000' [msec] to the delay for Rx Window 2. - Default value is 1000. - When <delay> is out of range, this command returns ERROR
+RX1DELAY?	<duration> OK	Read the delay for Rx Window 1 in ms.

**3.4.21 AT+LINKCHK**

Command	The result code	Description
+LINKCHK	- OK - ERROR - +LINKCHK: <Margin>,<GwCnt> - +LINKCHK: NO_NETWORK_JOINED - +LINKCHK: NO_RESPONSE  <Margin> Link margin in dB <GwCnt> Number of gateways that received the LinkCheckReq command	- Request to send LinkCheckReq command. - If LinkCheckAns is received in response to LinkCheckReq command, <Margin> and <GwCnt> are notified.
		Extended result codes
		NO_NETWORK_JOINED The device has not been activated
		NO_RESPONSE Failed to receive LinkCheckAns command

**3.4.22 AT+FPORT**

Command	The result code	Description
+FPORT=<port>  <port> Port number (FPort) in decimal Range: 1 - 224 Default: 1	OK ERROR	- Set the FPort of data messages to be sent. - When <port> is other than 1 to 224, this command returns ERROR.
+FPORT?	<port> OK	Read the FPort of data messages to be sent.

**3.4.23 AT+DCYCLE**

Command	The result code	Description
+DCYCLE=<mode>  <mode> Duty cycle mode 0: OFF 1: ON (default)	OK ERROR	- Set duty cycle operation mode to the device - When duty cycle operation mode is ON, message send is controlled by duty cycle limitation. - When <mode> is other than 0 or 1, this command returns ERROR
+DCYCLE?	<mode> OK	Read the duty cycle operation mode.

**3.4.24 AT+DR**

Command	The result code	Description
+DR=<dr>  <dr> Default data rate Range: 0 - 15	OK ERROR +DR: DATARATE_INVALID	- Set the default data rate of data messages to be sent when ADR is off. - When <dr> is out of regional specification, this command returns ERROR. - This data rate is just a request to the stack. The actual data rate used to send messages could be changed by the stack.
		Extended result codes
		DATARATE_INVALID   Data rate is out of regional specification
+DR?	<dr> OK	Read the default data rate of data messages to be sent when ADR is off.

**3.4.25 AT+DEVTIME**

Command	The result code	Description
+DEVTIME	- OK - ERROR - +DEVTIME: OK - +DEVTIME: NO_RESPONSE	- Requests to send DeviceTimeReq
		Extended result codes
	OK	Received DeviceTimeAns in response to DeviceTimeReq
	NO_RESPONSE	Failed to receive DeviceTimeAns command

Note 1: AT+DEVTIME shall not be issued when the LoRaWAN stack operates in class B.

**3.4.26 AT+BCONACQ**

Command	The result code	Description	
+BCONACQ	- OK - ERROR - +BCONACQ: OK - +BCONACQ: BEACON_NOT_FOUND	- Initiates Class B beacon acquisition - Result of beacon acquisition attempt is displayed up to 128 seconds after initiation of beacon acquisition. - If this command is not following a successful execution of AT+DEVTIME, the device can stay in the reception state up to 128 seconds	
		Extended result codes	
		OK	Successfully received a Class B beacon
		BEACON_NOT_FOUND	Could not receive a Class B beacon

Note 1: AT+BCONACQ shall not be issued when the LoRaWAN stack operates in class B.

Note 2: If GPS time is received via AT+DEVTIME, AT+BCONACQ makes the LoRaWAN stack open a receive window to acquire a beacon frame around the calculated beacon frame reception timing. If not, AT+BCONACQ makes the LoRaWAN stack open a receive window to acquire a beacon frame up to 128 seconds.

**3.4.27 AT+PNGSLPERIOD**

Command	The result code	Description
+PNGSLPERIOD =<Periodicity>  <Periodicity> Periodicity of Class B unicast ping slots. Range: 4 to 7 Default: 7	- OK - ERROR	- Sets periodicity of unicast ping slots - Returns ERROR if <Periodicity> is not in the valid range of 0 to 7
+PNGSLPERIOD?	<Periodicity> OK	Reads current periodicity configuration

Note 1: AT+PNGSLPERIOD shall not be issued when the LoRaWAN stack operates in class B.

**3.4.28 AT+PNGSLINFO**

Command	The result code	Description	
+PNGSLINFO	- OK - ERROR - +PNGSLINFO: OK - +PNGSLINFO: NO_RESPONSE	- Requests to send the PingSlotInfoReq command - Parameter "Periodicity" of PingSlotInfoReq can be set by AT+PNGSLPERIOD - Returns ERROR if <Periodicity> is not in the valid range of 0 to 7	
		Extended result codes	
		OK	Received PingSlotInfoAns in response to PingSlotInfoReq
		NO_RESPONSE	Did not receive PingSlotInfoAns command

Note: AT+PNGSLINFO shall not be issued when the LoRaWAN stack operates in class B.

**3.4.29 +RCVD**

Command	Description												
+RCVD: <data>,<port>,<slinfo>	- Notify reception of a data message - This command is notified only when the data message is received without an error.												
<data> Hexadecimal data	<slinfo> indication code <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%; text-align: center;">0</td> <td>Unicast data received in the first receive window (RX1) following uplink</td> </tr> <tr> <td style="text-align: center;">1</td> <td>Unicast data received in the second receive window (RX2) following uplink</td> </tr> <tr> <td style="text-align: center;">2</td> <td>Unicast data received in continuously open receive window of Class C</td> </tr> <tr> <td style="text-align: center;">3</td> <td>Multicast data received in the continuously open receive window of Class C</td> </tr> <tr> <td style="text-align: center;">4</td> <td>Unicast data received in a ping slot of Class B</td> </tr> <tr> <td style="text-align: center;">5</td> <td>Multicast data received in a multicast ping slot of Class B.</td> </tr> </table>	0	Unicast data received in the first receive window (RX1) following uplink	1	Unicast data received in the second receive window (RX2) following uplink	2	Unicast data received in continuously open receive window of Class C	3	Multicast data received in the continuously open receive window of Class C	4	Unicast data received in a ping slot of Class B	5	Multicast data received in a multicast ping slot of Class B.
0		Unicast data received in the first receive window (RX1) following uplink											
1		Unicast data received in the second receive window (RX2) following uplink											
2		Unicast data received in continuously open receive window of Class C											
3		Multicast data received in the continuously open receive window of Class C											
4		Unicast data received in a ping slot of Class B											
5		Multicast data received in a multicast ping slot of Class B.											
<port> Port number in decimal													
<slinfo> Reception information (window type, multicast/unicast). See indication code list on the right.													

**3.4.30 +RSSI**

Command	Description
+RSSI: <rssi>,<snr>	- Notify RSSI and SNR values of received data message and beacon when RSSI display mode is ON. - See AT+RSSI (3.4.19) about RSSI display mode.
<rssi> RSSI value	
<snr> SNR value	

**3.4.31 +BCONRCVD**

Command	Description
+BCONRCVD:<Time>,<InfoDesc>,<Info[6]>  <Time> Timestamp in millisecond (ms) since January 6, 1980 00:00:00 UTC. <InfoDesc> "Information descriptor" in the GwSpecific field of the received beacon frame. <Info[6]> 6-byte "Information" in the GwSpecific field of the received beacon frame.	<ul style="list-style-type: none"> <li>- Class B beacon reception notification</li> <li>- Notifies a successful Class B beacon reception</li> <li>- Unsuccessful beacon reception at an expected time interval is notified with +BCONNORCVD (See 3.4.32)</li> <li>- If GwSpecific field in beacon is invalid (CRC for the optional part is incorrect), &lt;infoDesc&gt; and &lt;Info[6]&gt; are not notified.</li> </ul>

**3.4.32 +BCONNORCVD**

Command	Description
+BCONNORCVD	<ul style="list-style-type: none"> <li>- Notification</li> <li>- Notifies that the device could not receive a beacon frame at an expected time interval</li> </ul>

**3.4.33 +BCONLOST**

Command	Description
+BCONLOST	<ul style="list-style-type: none"> <li>- Notification</li> <li>- Notified that the device lost synchronization with Class B beacons. This indicates MAC layer fails to receive a beacon for 120 minutes.</li> </ul>

## 4. Sample operations

### 4.1 Initial setting for ABP (Activation By Personalization)

The following command sequence is an example to initialize the device setting for ABP. Parameter values for each command are just samples and need to be modified according to application program specifications. This example sets following parameters, region, device class, activation mode, device EUI (DevEUI), device address (DevAddr), network session key (NwkSKey) and application session key (AppSKey). A Class B device needs to start as Class A and later switch to Class B. Each read command is optional (ex. AT+REGION?) and can be omitted. Optionally parameters can be saved to the data flash after the settings.

```
AT+REGION=6
OK
AT+REGION?
+REGION: 6:AS923
OK
AT+CLASS=0
OK
AT+CLASS?
+CLASS: 0:CLASS_A
OK
AT+ACTMODE=0
OK
AT+ACTMODE?
+ACTMODE: 0:ABP
OK
AT+DEVEUI=910
OK
AT+DEVEUI?
+DEVEUI: 00000000000000910
OK
AT+DEVADDR=01020304
OK
AT+DEVADDR?
+DEVADDR: 01020304
OK
AT+NWKSKEY=30F
OK
AT+NWKSKEY?
+NWKSKEY: 000000000000000000000000000030F
OK
AT+APPSKEY=40E
```



```
OK
AT+APPSKEY?

+APPSKEY: 0000000000000000000000000000040E

OK
AT+SAVE

OK
```

## 4.2 Initial setting for OTAA (Over The Air Activation)

The following command sequence is an example to initialize the device setting for OTAA. Parameters for each command are just samples and need to be modified according to application program specifications. This example sets following parameters, region, device class, activation mode, device EUI (DevEUI), application identifier (AppEUI) and application key (AppKey). A Class B device needs to start as Class A and later switch to Class B. Each read command (ex. AT+REGION?) is optional and can be omitted. Optionally parameters can be saved to the data flash after the settings.

```
AT+REGION=6

OK
AT+REGION?

+REGION: 6:AS923

OK
AT+CLASS=0

OK
AT+CLASS?

+CLASS: 0:CLASS_A

OK
AT+ACTMODE=1

OK
AT+ACTMODE?

+ACTMODE: 1:OTAA

OK
AT+DEVEUI=90F

OK
AT+DEVEUI?

+DEVEUI: 0000000000000090F

OK
AT+APPEUI=10E

OK
AT+APPEUI?
```

```
+APPEUI: 000000000000010E
OK
AT+APPKEY=F0E
OK
AT+APPKEY?
+APPKEY: 0000000000000000000000000000F0E
OK
AT+SAVE
OK
```

### 4.3 Activation

The following command sequence is an example to activate the device according to the activation mode setting (ABP or OTAA).

In case of ABP mode, the device is activated if the result code “OK” is received.

In case of OTAA, the device is activated if the result code “OK” and “+JOIN: JOIN\_ACCEPTED” are received.

In other cases, the device failed to be activated.

(In case of ABP mode)

```
AT+JOIN
OK
```

(In case of OTTA mode)

```
AT+JOIN
OK
+JOIN: JOIN_ACCEPTED
```

### 4.4 Switching to Class B

The following example command sequence shows device class transition to Class B. In this example, the device switches to Class B after DeviceTimeReq/DeviceTimeAns command exchange and beacon acquisition.

```
AT+JOIN
OK
AT+DEVTIME
OK
+DEVTIME: OK
AT+BCONACQ
```

```
OK

+BCONACQ: OK

+BCONRCVD: 1234567890000,00,000000000000
AT+PNGSLPERIOD=5

OK
AT+CLASS=1

OK
AT+CLASS?

+CLASS: 1:CLASS_B

OK
AT+LINKCHK ; Notifies LoRaWAN server that currently it is operating in Class B
; LinkCheckReq command which requests response is used for example.

OK
+LINKCHK: OK
```

#### 4.5 Send unconfirmed data of character string

The following command sequence is an example to send an unconfirmed data message. This example sends an unconfirmed data message of 'HELLO', and receives data of 0xAA, 0x00, 0xBB, 0x11 and port number of 123 sent from a server.

```
AT+MTYPE=0

OK
AT+MTYPE?

+MTYPE: 0:UNCONFIRMED_DATA

OK
AT+SEND="HELLO"

OK

+SEND: OK

+RCVD: AA00BB11,123,0
```

#### 4.6 Send confirmed data of character string

The following command sequence is an example to send a confirmed data message. This example sends a confirmed data with payload 'HELLO', and receives an ACK for the confirmed data message, data of 0xAA, 0x00, 0xBB, 0x11 and port number of 1, sent from a server.

```
AT+MTYPE=1
OK
AT+MTYPE?
+MTYPE: 1:CONFIRMED_DATA
OK
AT+SEND="HELLO"
OK
+SEND: ACK_RECEIVED
+RCVD: AA00BB11,1,0
```

#### 4.7 Send confirmed data of hexadecimal value

The following command sequence is an example to send a data message of hexadecimal data sequence. This example sends a confirmed data message of 0xAA, 0x00, 0xBB and receives an ACK for the confirmed data sent from a server.

```
AT+MTYPE=1
OK
AT+MTYPE?
+MTYPE: 1:CONFIRMED_DATA
OK
AT+SENDHEX=AA00BB
OK
+SENDHEX: ACK_RECEIVED
```

#### 4.8 Display RSSI on receiving a data message

The following command sequence is an example to display RSSI. This example sends a confirmed data message of 'HELLO', and receives an ACK for the confirmed data, and RSSI and SNR on receiving it.

```
AT+RSSI=1
OK
AT+RSSI?
+RSSI: 1:RSSI_ENABLED
OK
AT+MTYPE=1
OK
AT+MTYPE?
+MTYPE: 1:CONFIRMED_DATA
OK
AT+SEND="HELLO"
OK
+SEND: ACK_RECEIVED
+RSSI: -59,10
```

**Revision History**

Rev.	Date	Description	
		Section	Summary
01.00	Jan. 31, 2019	-	First official release
01.10	Nov. 29, 2019	-	Changed target device from 'RL78/G14 (R5F104JJ)' to 'RL78/G14 (R5F104ML)'
		2.2.2	Added table for 'List of Extended Result Code'.
		3.4.1.19 4.7	Added SNR value when to display RSSI value
02.10	July. 10, 2020	-	Supported Class B related commands and extended result codes
		1.3	Changed setting of local echo back to 'Yes'.
		2.1	Changed 127 characters to 512 characters for input of the command line
		3.2.2	Disabled echo back as default
		3.2.3	Omitted delimiter before result code and response information as default
		4.4	Added sample operation for Class B
03.00	Mar. 26, 2021	-	Supported RL78/G23 (R7F100GLG) as a target device
		1.3, 1.4	Added section 1.3 and 1.4 to describe related documentation and directories
03.01	June 10, 2021	5	Use official Renesas Flash Driver (RFD) RL78 Type01 V1.00. No functional changes.

# General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

## 1. Precaution against Electrostatic Discharge (ESD)

A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

## 2. Processing at power-on

The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

## 3. Input of signal during power-off state

Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

## 4. Handling of unused pins

Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

## 5. Clock signals

After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

## 6. Voltage application waveform at input pin

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between  $V_{IL}$  (Max.) and  $V_{IH}$  (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between  $V_{IL}$  (Max.) and  $V_{IH}$  (Min.).

## 7. Prohibition of access to reserved addresses

Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

## 8. Differences between products

Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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