AN4967
Application note

Examples of AT commands on I-CUBE-LRWAN

Introduction

I-CUBE-LRWAN is a LoRaWAN™ software Expansion Package for STM32Cube™,. consisting in a set of libraries and application examples for microcontrollers of the STM32L0, STM32L1 and STM32L4 Series acting as end devices.

The I-CUBE-LRWAN main features are:

- Easy add-on of the low-power LoRa® solution
- Extremely low CPU load
- No latency requirements
- Small STM32L0 Series memory footprint

This application note describes the set of AT commands for the B-L072Z-LRWAN1 Discovery board embedding the CMWX1ZZABZ-091 LoRa® module.

This document explains how to interface with the LoRaWAN™ to manage the LoRa® wireless link using AT commands.

For more information on the LoRa® embedded Expansion Package (I-CUBE-LRWAN) implementation on the STM32Lx Series, refer to the user manual *STM32 LoRa® software expansion for STM32Cube*™ (UM2073), available at www.st.com.

Contents

1 Acronyms 8

2 Reference documents 9

3 Overview 10

4 AT commands 11

4.1 General commands 13

4.1.1 AT: attention 13

4.1.2 AT?: short help 14

4.1.3 ATZ: MCU reset 14

4.2 Keys, IDs and EUIs management 15

4.2.1 AT+APPEUI: application identifier 15

4.2.2 AT+APPKEY: application key 15

4.2.3 AT+APPSKEY: application session key 16

4.2.4 AT+DADDR: device address 16

4.2.5 AT+DEUI: device EUI 17

4.2.6 AT+NWKID: network ID 17

4.2.7 AT+NWKSKEY: network session key 18

4.3 Joining and sending data on LoRa® network 18

4.3.1 AT+CFM: confirm mode 18

4.3.2 AT+CFS: confirm status 18

4.3.3 AT+JOIN: join LoRa® network 19

4.3.4 AT+NJM: LoRa® network join mode 19

4.3.5 AT+NJS: LoRa® network join status 20

4.3.6 AT+RECV: last received text data 20

4.3.7 AT+RECVB: last received binary data 21

4.3.8 AT+SEND: send text data 21

4.3.9 AT+SENB: send binary data 21

4.4 LoRa® network management 22

4.4.1 AT+ADR: adaptive rate 22

4.4.2 AT+CLASS: LoRa® class 23

4.4.3 AT+DCS: duty cycle settings 23

4.4.4 AT+DR: data rate 24

4.4.5 AT+JN1DL: join delay on RX window 1 . . . 24
4.4.6 AT+JN2DL: join delay on RX window 2 . . . 25
4.4.7 AT+PNM: public network mode . . . 25
4.4.8 AT+RX1DL: delay of the received window 1 . . . 26
4.4.9 AT+RX2DL: delay of the received window 2 . . . 26
4.4.10 AT+RX2DR: data rate of the received window 2 . . . 27
4.4.11 AT+RX2FQ: frequency of the received window 2 . . . 27
4.4.12 AT+TXP: transmit power . . . 28
4.5 Class B mode . . . 28
4.5.1 AT+PGSLOT . . . 28
4.5.2 AT+BFREQ . . . 29
4.5.3 AT+BTIME . . . 29
4.5.4 AT+BGW . . . 29
4.5.5 AT+LTIME . . . 30
4.6 Asynchronous events . . . 30
4.7 Information . . . 31
4.7.1 AT+BAT: battery level . . . 31
4.7.2 AT+RSSI: RSSI on reception . . . 31
4.7.3 AT+SNR: signal noise ratio . . . 31
4.7.4 AT+VER: version of the firmware . . . 32
4.8 RF tests . . . 32
4.8.1 AT+TRSSI: Start radio frequency RSSI tone test . . . 32
4.8.2 AT+TTONE: Start radio frequency tone test . . . 32
4.8.3 AT+TTLRA: Start RF Tx LoRa® test . . . 33
4.8.4 AT+TRLRA: Start RF Rx LoRa® test . . . 33
4.8.5 AT+TCONF: Config LoRa® RF test . . . 33
4.8.6 AT+TOFF: Stop ongoing radio frequency test . . . 34
4.8.7 AT+CERTIF: Set the module in LoRaWAN™ Certification mode . . . 34

5 Examples . . . 35
5.1 Join and send . . . 35
5.2 Confirmation . . . 35
5.3 Receiving data . . . 36
5.4 Class B enable request . . . 37

6 Embedded software description . . . 39

6.1 Firmware overview 39
6.2 LPUART 39
6.3 Compilation switches 39
6.3.1 Debug switches 40
6.4 Footprint 40

7 Revision history 41

List of tables

Table 1. List of acronyms . . . 8
Table 2. Link check command . . . 13
Table 3. Short help command . . . 14
Table 4. MCU reset command . . . 14
Table 5. Application identifier command . . . 15
Table 6. Application key command . . . 15
Table 7. Application session key command . . . 16
Table 8. Device address command . . . 16
Table 9. Device EUI command . . . 17
Table 10. Network ID command . . . 17
Table 11. Network session key command . . . 18
Table 12. Confirm mode command . . . 18
Table 13. Confirm status command . . . 19
Table 14. Join LoRa® network command . . . 19
Table 15. LoRa® network join mode command . . . 19
Table 16. LoRa® network join status command . . . 20
Table 17. Last received text data command . . . 20
Table 18. Last received binary data command . . . 21
Table 19. Send text data command . . . 21
Table 20. Send binary data command . . . 22
Table 21. Adaptive rate command . . . 22
Table 22. LoRa® class command . . . 23
Table 23. Duty cycle settings command . . . 23
Table 24. Data rate command . . . 24
Table 25. Join delay on RX window 1 command . . . 24
Table 26. Join delay on RX window 2 command . . . 25
Table 27. Public network mode command . . . 25
Table 28. Delay of the received window 1 command . . . 26
Table 29. Delay of the received window 2 command . . . 26
Table 30. Data rate of the received window 2 command . . . 27
Table 31. Frequency of the received window 2 command . . . 27
Table 32. Transmit power command . . . 28
Table 33. Slot periodicity command . . . 28
Table 34. Beacon frequency command . . . 29
Table 35. Beacon frequency command . . . 29
Table 36. GW GPS coordinate command . . . 29
Table 37. Local time command . . . 30
Table 38. Asynchronous events . . . 30
Table 39. Battery level command . . . 31
Table 40. RSSI on reception command . . . 31
Table 41. Signal noise ratio command . . . 31
Table 42. Version of the firmware command . . . 32
Table 43. Start radio frequency RSSI tone command . . . 32
Table 44. Start radio frequency tone test command . . . 32
Table 45. Start RF Tx LoRa® test command . . . 33
Table 46. Start RF Rx LoRa® test command . . . 33
Table 47. Config LoRa® RF test command . . . 33
Table 48. Stop radio frequency test command . . . 34

Table 49. Set the module in LoRaWAN™ Certification mode command 34
Table 50. Compilation switch options 40
Table 51. AT_slave footprint 40
Table 52. Document revision history 41

List of figures

Figure 1. Terminal emulation mode 11
Figure 2. AT master mode 11
Figure 3. Tera Term port setup example 12
Figure 4. Tera Term terminal setup example 12

1 Acronyms

Table 1. List of acronyms

Acronym	Definition
LoRa®	Long range radio technology
LoRaWAN™	LoRa® wide-area network
RF	Radio frequency
RSSI	Received signal strength indicator
SNR	Signal to noise ratio
OTAA	Over-the-air activation
ABP	Activation by personalization
ETSI	European telecommunications standards institute

2 Reference documents

1. LoRaWAN™ Specification by LoRa Alliance™ (Version 1.0.3, March 2018, Final, Released), available at www.lora-alliance.org
2. *STM32 LoRa software expansion for STM32Cube* (UM2073), available at *www.st.com*

3 Overview

The B-L072Z-LRWAN1 Discovery board embeds the CMWX1ZZABZ-091 LoRa® firmware.

This firmware Implements the AT_Slave module (see document 2) that supports a set of AT commands to drive the LoRaWAN™ communications and the LoRa® RF test.

It applies to microcontrollers of the STM32L0, STM32L1 and STM32L4 Series, all based on Arm®(a) cores.

The following sections contain the Interface description, the AT commands definition, and the description of some use cases and of the embedded software.

a. Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

4 AT commands

The AT command set is a standard developed by “Hayes” to control modems. AT stands for attention.

The command set consists of a series of short text strings providing operations such as joining, data exchange and parameters setting.

In a context of LoRa® modem, the Hayes command set is a variation of the standard AT Hayes commands.

The AT commands are used to drive the LoRa® module and to send data (refer to document *1*). The AT commands are sent through the UART.

As described in document *2*, the LoRa® modem can be controlled either through a terminal emulation like Tera Term or PuTTY (see *Figure 1*), or through an embedded AT master module (see *Figure 2*).

Figure 1. Terminal emulation mode

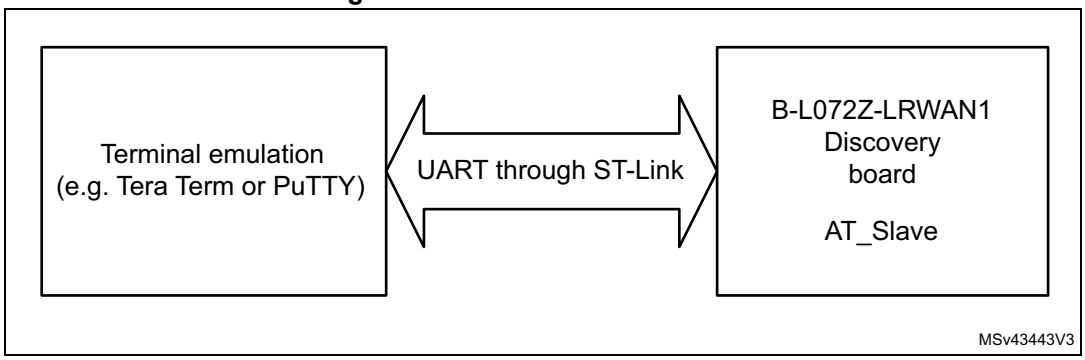
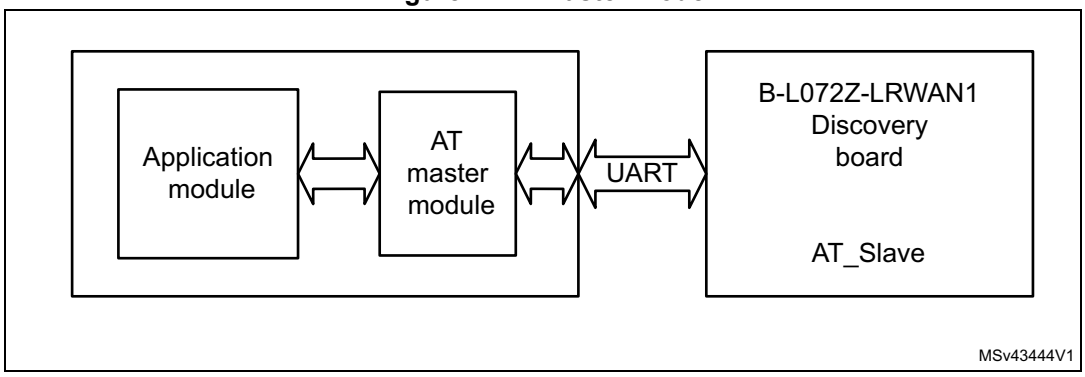


Figure 2. AT master mode



For illustration purposes, the rest of the document is based on the relation “terminal emulation” with the B-L072Z-LRWAN1 Discovery board.

An UART over ST-Link can then be used with standard Windows® software such as Tera Term or PuTTY. The chosen software has to be configured with the following parameters:

- Baud rate: 9600
- Data: 8 bit
- Parity: none
- Stop: 1 bit
- Flow control: none

Figure 3 and *Figure 4* show the standard configuration for Tera Term to use the UART over the ST-LINK.

Figure 3. Tera Term port setup example

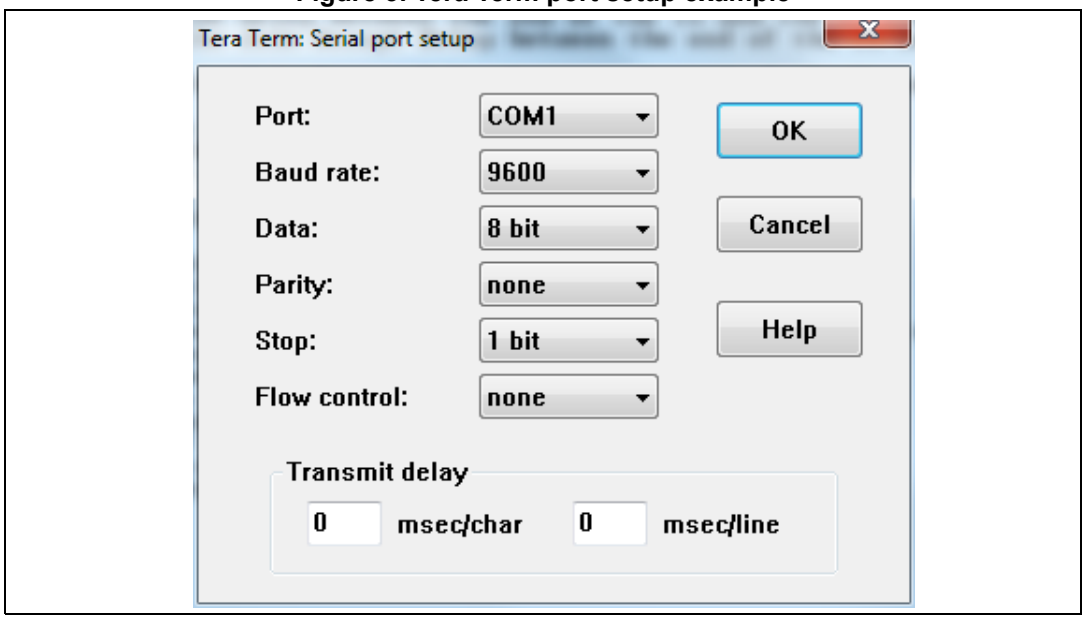
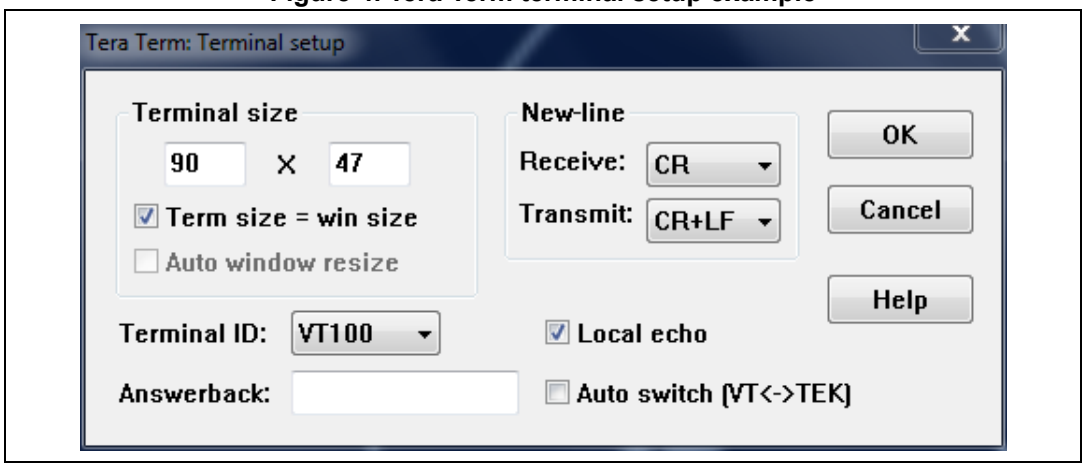


Figure 4. Tera Term terminal setup example



The AT commands have the standard format “AT+XXX”, with XXX denoting the command.

There are four available command behaviors:

- **AT+XXX?** provides a short help of the given command, for example **AT+DEUI?**
- **AT+XXX** is used to run a command, such as **AT+JOIN**
- **AT+XXX=?** is used to get the value of a given command, for example **AT+CFS=?**
- **AT+XXX=<value>** is used to provide a value to a command, for example **AT+SEND=2:Hello**

The output of the commands is provided on the UART. The output format is as below:

`<value><CR><LF>`

`<CR><LF><Status<CR><LF>`

Note: <CR> stands for “carriage return” and <LF> stands for “line feed”

The <value><CR><LF> output is returned whenever the “help AT+XXX?” or the “get AT+XXX=?” commands are run.

When no value is returned, the <value><CR><LF> output is not returned at all.

Every command (except for ATZ used for MCU reset) returns a status string, which is preceded and followed by <CR><LF> in a .”`<CR><LF><Status<CR><LF>”` format. The possible status are:

- OK: command run correctly without error.
- AT_ERROR: generic error
- AT_PARAM_ERROR: a parameter of the command is wrong
- AT_BUSY_ERROR: the LoRa® network is busy, so the command has not been completed
- AT_TEST_PARAM_OVERFLOW: the parameter is too long
- AT_NO_CLASSB_ENABLE: End-node has not yet switched in Class B
- AT_NO_NETWORK_JOINED: the LoRa® network has not been joined yet
- AT_RX_ERROR: error detection during the reception of the command

More details on each command description and examples are given in the remainder of this section. Note that each command preceded by # is provided by the host to the module. Then the return of the module is printed.

4.1 General commands

This section describes the commands related to “attention” help list, link control and CPU AT_Slave reset.

4.1.1 AT: attention

This command is used to check that the link is working properly (refer to *Table 2* for details).

Table 2. Link check command

Command	Input parameter	Return value	Return code
AT	-	-	OK

4.1.2 AT?: short help

This command provides short help for all the supported commands (refer to *Table 3* for details).

Table 3. Short help command

Command	Input parameter	Return value	Return code
AT?	-	AT+<CMD>?: help on <CMD AT+<CMD>: run <CMD> AT+<CMD>=<value>: set the value AT+<CMD>=?: get the value <followed by the help of all commands>	OK

4.1.3 ATZ: MCU reset

This command is used to trig a CPU reset of the B-L072Z-LRWAN1 Discovery board (refer to *Table 4* for details).

Table 4. MCU reset command

Command	Input parameter	Return value	Return code
ATZ?	-	ATZ: triggers a reset of the MCU	OK
ATZ	-	No return value and return code. The MCU is reset.	Void

4.2 Keys, IDs and EUIs management

This section describes the commands related to the activation of the end device.

4.2.1 AT+APPEUI: application identifier

This command allows the user to access the global application identifier (refer to *Table 5* for details).

Table 5. Application identifier command

Command	Input parameter	Return value	Return code
AT+APPEUI?	-	AT+APPEUI: get or set the application EUI	OK
AT+APPEUI=?	-	<8 hexa separated by:>	OK
AT+APPEUI= <Param>	<8 hexa separated by:>	-	OK / AT_PARAM_ERROR(1)
Example AT+APPEUI=	01:2:a:FB:A1:CD:4D:20:01 :02:30:40:5a:6b:7f:88	-	OK
Example AT+APPEUI=	01:2:a:FB:A1:CD:4D:20:01 :02:30:40:5a:6b:7f	-	AT_PARAM_ERROR(1)
Example AT+APPEUI=?	-	01:02:03:04:05:06:07:08	OK

1. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.2.2 AT+APPKEY: application key

This command allows the user to access the application session key (refer to *Table 6* for details).

Table 6. Application key command

Command	Input parameter	Return value	Return code
AT+APPKEY?	-	AT+APPKEY: get or set the application key	OK
AT+APPKEY=?	-	<16 hexa separated by:>	OK
AT+APPKEY= <Param>	<16 hexa separated by:>	void	OK / AT_PARAM_ERROR(1)
Example AT+APPKEY=	01:2:a:FB:A1:CD:4D:20: 01:02:30:40:5a:6b:7f:88	-	OK
Example AT+APPKEY=	01:2:a:FB:A1:CD:4D:20: 01:02:30:40:5a:6b:7f	-	AT_PARAM_ERROR(1)
Example AT+APPKEY=?	-	2b:7e:15:16:28:ae:d2:a6: ab:f7:15:88:09:cf:4f:3c	OK

1. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.2.3 AT+APPSKEY: application session key

This command allows the user to set the application session key (refer to *Table 7* for details).

Table 7. Application session key command

Command	Input parameter	Return value	Return code
AT+APPSKEY?	-	AT+APPSKEY: set the application session key	OK
AT+APPSKEY=<Param>	<16 hexa separated by:>	void	OK / AT_PARAM_ERROR(1)
Example AT+APPSKEY=	01:2:a:FB:A1:CD:4D:20:01:02:30:40:5a:6b:7f:88	-	OK
Example AT+APPSKEY=	01:2:a:FB:A1:CD:4D:20:01:02:30:40:5a:6b:7f:	-	AT_PARAM_ERROR(1)

1. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.2.4 AT+DADDR: device address

This command allows the user to access the device address (refer to *Table 8* for details).

Table 8. Device address command

Command	Input parameter	Return value	Return code
AT+DADDR?	-	AT+DADDR: get or set the device address	OK
AT+DADDR=?	-	<4 hexa separated by:>	OK
AT+DADDR=<Param>	<4 hexa separated by:>	-	OK / AT_PARAM_ERROR(1)
Example AT+DADDR=	01:2:a:FB:A1:CD:4D:20:01:02:30:40:5a:6b:7f:88	-	OK
Example AT+DADDR=?	11:22:33:44	11:22:33:44	OK

1. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.2.5 AT+DEUI: device EUI

This command allows the user to access the global end-device ID (refer to *Table 9* for details).

Table 9. Device EUI command

Command	Input parameter	Return value	Return code
AT+DEUI?	-	AT+DEUI: get or set the device EUI	OK
AT+DEUI=?	-	<8 hexa separated by:>	OK
AT+DEUI= <Param>	<8 hexa separated by:>	-	OK / AT_PARAM_ ERROR(1)
Example AT+DEUI=?	-	11:22:33:44:55:66:77:88	OK
Example AT+DEUI=	11:22:33:44:55:66:77:88	-	OK

1. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.2.6 AT+NWKID: network ID

This command allows the user to access the network identifier (refer to *Table 10* for details).

Table 10. Network ID command

Command	Input parameter	Return value	Return code
AT+NWKID?	-	AT+NWKID: get or set the network ID	OK
AT+NWKID=?	-	<4 hexa separated by:>	OK
AT+DEUI=<Par am>	<4 hexa separated by:>	-	OK / AT_PARAM_ ERROR(1)
Example AT+DEUI=?	-	11:22:33:44:55:66:77:88	OK
Example AT+DEUI=	11:22:33:44:55:66:77:88	-	OK

1. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.2.7 AT+NWKSKEY: network session key

This command allows the user to set the network session key (refer to *Table 11* for details).

Table 11. Network session key command

Command	Input parameter	Return value	Return code
AT+NWKSKEY?	-	AT+NWKSKEY: set the network session key	OK
AT+NWKSKEY=<Param>	<16 hexa separated by:>	-	OK / AT_PARAM_ERROR(1)
Example AT+NWKSKEY=	0:1:2:3:4:5:6:7:8:9:A:B:C:D:E:F	-	OK

1. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.3 Joining and sending data on LoRa® network

This section gives description of the commands related to the join procedure and to the data path.

4.3.1 AT+CFM: confirm mode

This command allows the user to access the notification on received data coming from network (refer to *Table 12* for details).

Table 12. Confirm mode command

Command	Input parameter or Parmeter	Return value	Return code
AT+CFM?	-	AT+CFM: get or set the confirm mode (0-1)	OK
AT+CFM=?	-	0 or 1	OK
AT+CFM=<Param>	0 or 1	-	OK / AT_PARAM_ERROR(1)
Example AT+CFM=	1	-	OK
Example AT+CFM=?(2)	-	1	OK

1. AT_PARAM_ERROR is returned when setting a wrong or malformed value.
2. When the confirmation mode is 1, each sent message must be confirmed. AT+CFS=? allows the user to know whether the last sent message has been confirmed or not.

4.3.2 AT+CFS: confirm status

This command allows the user to access the status of the last “SEND” command (refer to *Table 13* for details).

Table 13. Confirm status command

Command	Input parameter	Return value	Return code
AT+CFS?	-	AT+CFS: get the confirmation status of the last AT+SEND (0-1)	OK
AT+CFS=?	-	0 or 1	OK
Example AT+CFS=?	-	0	OK

4.3.3 AT+JOIN: join LoRa® network

This command does a join request to the network (refer to *Table 14* for details).

Table 14. Join LoRa® network command

Command	Input parameter	Return value	Return code
AT+JOIN?	-	AT+JOIN: join network	OK
AT+JOIN	Void	Void	OK/ AT_BUSY_ERROR(1)
Example AT+JOIN	-	-	OK

1. AT_BUSY_ERROR is returned when a joining process is already running.

This is an asynchronous command. OK means that the join is being run. The completion of the JOIN must be verified with AT+NJS=?.

4.3.4 AT+NJM: LoRa® network join mode

This command allows the user to access the network join mode (refer to *Table 15* for details).

Table 15. LoRa® network join mode command

Command	Input parameter	Return value	Return code
AT+NJM?	-	AT+NJM: get or set the network join mode (0 = ABP, 1 = OTAA)	OK
AT+NJM	-		OK/
AT+NJM=<Input>	0 or 1	-	OK/ AT_PARAM_ERROR(1)
Example AT+NJM=?	-	0	OK
Example AT+NJM=	1	-	OK
Example AT+NJM=	2	-	AT_PARAM_ERROR

1. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.3.5 AT+NJS: LoRa® network join status

This command allows the user to access the current status of the LoRa® link (refer to *Table 16* for details).

Table 16. LoRa® network join status command

Command	Input parameter	Return value	Return code
AT+NJS?	-	AT+NJS: get the join status	OK
AT+NJS=?	-	0 or 1	OK
Example AT+NJS=?	-	0 (network not joined)	OK
Example AT+NJS=?	-	1 (network joined)	OK

4.3.6 AT+RECV: last received text data

This command allows the user to access the last received text data in raw format (refer to *Table 17* for details).

Table 17. Last received text data command

Command	Input parameter	Return value	Return code
AT+RECV?	-	AT+RECV: print the last received data in raw format	OK
AT+RECV=?	-	Raw (string format)	OK
Example AT+RECV=?	-	45: hello world	OK

This command returns the last received data in a text form, along with the port on which it was received. The format of the output is:

```
<port>:<text data><CR><LF>
<CR><LF>OK<CR><LF>
```

When called twice, without new data received between the calls, the second AT+RECV=? returns an empty value as shown below:

```
45:<CR><LF>
<CR><LF>OK<CR><LF>
```

4.3.7 AT+RECVB: last received binary data

This command allows the user to access the last received text data in binary format (refer to *Table 18* for details). In *Table 18* the binary data is received on port 45.

Table 18. Last received binary data command

Command	Input parameter	Return value	Return code
AT+RECVB?	-	AT+RECVB: print the last received data in binary format (with hexadecimal values)	OK
AT+RECVB=?	-	<port>:<binary>,	OK
Example AT+RECVB=?	-	45:48656c6c6f20576f726c64	OK

4.3.8 AT+SEND: send text data

This command provides the way to send text data on a dedicated port number (refer to *Table 19* for details). In *Table 19* the text data is received on port 12.

Table 19. Send text data command

Command	Input parameter	Return value	Return code
AT+SEND?	-	AT+SEND: send text data along with the application port	OK
AT+SEND=<input>	port text	-	OK/ AT_PARAM_ERROR(1)/ AT_BUSY_ERROR(2)/ AT_NO_NETWORK_JOINED(3)
Example AT+SEND=	12: hello world	-	OK

1. AT_PARAM_ERROR is returned when the setting does not have the correct format <port>:<text>, with <port> being a decimal value.
2. AT_BUSY_ERROR is returned when the previous send is not complete (send waiting for duty cycle, rx window not consumed…).
3. AT_NO_NETWORK_JOINED is returned when the network is not yet joined.

4.3.9 AT+SENB: send binary data

This command provides the way to send text data in binary format on a dedicated port number (refer to *Table 20* for details).

Each byte of the binary data is provided as two characters denoting the value in hexadecimal. Hence, the length of the binary data is always even.

In the example of *Table 20*, 8 bytes are sent on port 12: 0xAB, 0xCD, 0xEF, 0x01 (note that the example passes “01”, passing only “1” would fail), 0x23, 0x45, 0x67 and 0x89.

Table 20. Send binary data command

Command	Input parameter	Return value	Return code
AT+SENDB?	-	AT+SENDB: send hexadecimal data along with the application port	OK
AT+SENDB=<input>	<port>:<binary>,	-	OK/ AT_PARAM_ERROR(1)/ AT_BUSY_ERROR(2)/ AT_NO_NETWORK_JOINED(3)
Example AT+SENDB=	12:abcdef0123456789	-	OK
Example AT+SENDB=	abcdef0123456789	-	AT_PARAM_ERROR

1. AT_PARAM_ERROR is returned when the setting has not the correct format <port>:<binary>, with <port> being a decimal value, and <binary> following hexadecimal format using two characters as described above.
2. AT_BUSY_ERROR is returned when the previous send is not complete (send waiting for duty cycle, rx window not consumed…).
3. AT_NO_NETWORK_JOINED is returned when the network is not joined yet.

4.4 LoRa® network management

This section provides a set of commands for network management.

4.4.1 AT+ADR: adaptive rate

This command allows the user to access the adaptive data rate (refer to *Table 21* for details). The default value of the ADR is 1 (enabled).

Table 21. Adaptive rate command

Command	Input parameter	Return value	Return code
AT+ADR?	-	AT+ADR: get or set the adaptive data rate setting (0 = off, 1 = on)	OK
AT+ADR=?	-	0 or 1	OK
AT+ADR=<Input>	0 or 1	-	OK/ AT_PARAM_ERROR(1)
Example AT+ADR=	0	-	OK
Example AT+ADR=?	-	0	OK

1. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.4.2 AT+CLASS: LoRa® class

This command allows the user to access the LoRaWAN™ class (refer to *Table 22* for details).

Table 22. LoRa® class command

Command	Input parameter	Return value(1)	Return code
AT+CLASS?	-	AT+CLASS: get or set the device class	OK
AT+CLASS=?	-	A, B or C	OK
AT+CLASS=<Input>	A, B(2) or C	-	OK/ AT_PARAM_ERROR(3)
Example AT+CLASS=?	-	A	-

1. This release version supports the LoRaWAN V1.0.3 stack.
2. B, S0: Beacon searching
   B, S1: Beacon locked
   B, S2: Beacon failed
   B: Class B enabled
3. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.4.3 AT+DCS: duty cycle settings

This command allows the user to access the duty cycle parameter (refer to *Table 23* for details).

Table 23. Duty cycle settings command

Command	Input parameter	Return value	Return code
AT+DCS?	-	AT+DCS: get or set the ETSI duty cycle setting: – 0 = disable – 1 = enable - only for testing (refer to document *2*)	OK
AT+DCS?	-	0 or 1	OK
AT+DCS=<Input>	0 or 1	-	OK/ AT_PARAM_ERROR(1)
Example AT+DCS?	-	1	OK
Example AT+DCS=	1	-	OK

1. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.4.4 AT+DR: data rate

This command allows the user to access the data rate (refer to *Table 24* for details).

Table 24. Data rate command

Command	Input parameter	Return value	Return code
AT+DR?	-	AT+DR: get or set the data rate (0-7 corresponding to DR_X)	OK
AT+DR=?	-	[0,1,2,3,4,5,6,7]	OK
AT+DR=<Input>	[0,1,2,3,4,5,6,7]	-	OK/ AT_PARAM_ERROR(1)
Example AT+DR=?	-	3	OK
Example AT+DR=	2	-	OK

1. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.4.5 AT+JN1DL: join delay on RX window 1

This command allows the user to access the join delay on RX window 1 (refer to *Table 25* for details).

Table 25. Join delay on RX window 1 command

Command	Input parameter	Return value	Return code
AT+JN1DL?	-	AT+JN1Dl: get or set the joint accept delay between the end of the Tx and the join Rx window 1 in ms	OK
AT+JN1DL=?	-	<integer>	OK/ AT_BUSY_ERROR(1)
AT+JN1DL=<input>	<integer>	-	OK/ AT_PARAM_ERROR(2) AT_BUSY_ERROR(1)
Example AT+JN1DL=?	-	5000	OK
Example AT+JN1DL=	10000	-	OK

1. AT_BUSY_ERROR is returned when a join or a send is being processed.
2. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.4.6 AT+JN2DL: join delay on RX window 2

This command allows the user to access the join delay on RX window 2 (refer to *Table 26* for details).

Table 26. Join delay on RX window 2 command

Command	Input parameter	Return value	Return code
AT+JN2DL?	-	AT+JN2DL: get or set the joint accept delay between the end of the Tx and the join Rx window 2 in ms	OK
AT+JN2DL=?	-	<integer>	OK/ AT_BUSY_ERROR(1)
AT+JN2DL=<input>	<integer>	-	OK/ AT_PARAM_ERROR(2) AT_BUSY_ERROR(1)
Example AT+JN2DL=?	-	6000	OK
Example AT+JN2DL=	20000	-	OK

1. AT_BUSY_ERROR is returned when a join or a send is being processed.
2. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.4.7 AT+PNM: public network mode

This command allows the user to access the public network mode (refer to *Table 27* for details).

Table 27. Public network mode command

Command	Input parameter	Return value	Return code
AT+PNM?	-	AT+PNM: get or set the public network mode (0 = off, 1 = on)	OK
AT+PNM=?	-	0 or 1	OK
AT+PNM=<input>	0 or 1	-	OK/ AT_PARAM_ERROR(1)
Example AT+PNM=?	-	0	OK
Example AT+PNM=	1	-	OK
Example AT+PNM=	2	-	AT_PARAM_ERROR(1)

1. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.4.8 AT+RX1DL: delay of the received window 1

This command allows the user to access the delay of the received window 1 (refer to *Table 28* for details).

Table 28. Delay of the received window 1 command

Command	Input parameter	Return value	Return code
AT+RX1DL?	-	AT+RX1DL: get or set the delay between the end of the Tx and the Rx window 1 in ms	OK
AT+RX1DL=?	-	<integer>	OK/ AT_BUSY_ERROR(1)
AT+RX1DL=<input>	<integer>	-	OK/ AT_PARAM_ERROR(2) AT_BUSY_ERROR(1)
Example AT+RX1DL=?	-	1000	OK
Example AT+RX1DL=	1500	-	OK

1. AT_BUSY_ERROR is returned when a join or a send is being processed.
2. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.4.9 AT+RX2DL: delay of the received window 2

This command allows the user to access the delay of the received window 2 (refer to *Table 29* for details).

Table 29. Delay of the received window 2 command

Command	Input parameter	Return value	Return code
AT+RX2DL?	-	AT+RX2DL: get or set the delay between the end of the Tx and the Rx window 2 in ms	OK
AT+RX2DL=?	-	<integer>	OK/ AT_BUSY_ERROR(1)
AT+RX2DL=<input>	<integer>	-	OK/ AT_PARAM_ERROR(2) AT_BUSY_ERROR(1)
Example AT+RX2DL=?	-	2000	OK
Example AT+RX2DL=	2500	-	OK

1. AT_BUSY_ERROR is returned when a join or a send is being processed.
2. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.4.10 AT+RX2DR: data rate of the received window 2

This command allows the user to access the data rate of received window 2 (refer to *Table 30* for details).

Table 30. Data rate of the received window 2 command

Command	Input parameter	Return value	Return code
AT+RX2DR?	-	AT+RX2DR: get or set the Rx2 window data rate (0-7) corresponding to DR_X	OK
AT+RX2DR=?	-	[0,1,2,3,4,5,6,7]	OK/ AT_BUSY_ERROR(1)
AT+RX2DR=<input>	[0,1,2,3,4,5,6,7]	-	OK/ AT_PARAM_ERROR(1) AT_BUSY_ERROR(2)
Example AT+RX2DR=?	-	6	OK
Example AT+RX2DR=	5	-	OK

1. AT_BUSY_ERROR is returned when a join or a send is being processed.
2. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.4.11 AT+RX2FQ: frequency of the received window 2

This command allows the user to access the frequency of the received window 2 (refer to *Table 31* for details).

Table 31. Frequency of the received window 2 command

Command	Input parameter	Return value	Return code
AT+RX2FQ?	-	AT+RX2FQ: get or set the Rx2 window frequency	OK
AT+RX2FQ=?	-	Frequency in Hz	OK/ AT_BUSY_ERROR(1)
AT+RX2FQ=869535000	Frequency in Hz	-	OK/ AT_PARAM_ERROR(2) AT_BUSY_ERROR(1)
Example AT+RX2FQ=?	-	869535000	OK
Example AT+RX2FQ=	869535000	-	OK

1. AT_BUSY_ERROR is returned when a join or a send is being processed.
2. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.4.12 AT+TXP: transmit power

This command allows the user to access the transmit power (refer to *Table 32* for details).

Table 32. Transmit power command

Command	Input parameter	Return value	Return code
AT+TXP?	-	AT+TXP: get or set the transmit power (0-5)	OK
AT+TXP=?	-	[0,1,2,3,4,5]	OK AT_PARAM_ERROR(1)
AT+TXP=<input>	[0,1,2,3,4,5]	-	OK AT_PARAM_ERROR(1)
Example AT+TXP=?	-	1	OK
Example AT+TXP=	4	-	OK

1. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.5 Class B mode

This section provides a set of commands for Class B mode management.

4.5.1 AT+PGSLOT

This command allows the user to set or to get the unicast ping slot periodicity.

Table 33. Slot periodicity command

Command	Input parameter	Return value	Return code
AT+PGSLOT?	-	PS: periodicity, DRx, psfreq(1)	OK
AT+PGSLOT=<input>	[0,1,2,3,4,5,6,7]	-	OK AT_PARAM_ERROR(2)
Example AT+PGSLOT=?	-	PS: 2, 3, 869.525	OK
Example AT+PGSLOT=	1	-	OK

1. Default value for EU868 SF9/125 MHz. Periodicity (see 2).
2. AT_PARAM_ERROR is returned when setting a wrong or malformed value.

4.5.2 AT+BFREQ

This command allows the user to access the current beacon (default broadcast) frequency.

Table 34. Beacon frequency command

Command	Input parameter	Return value	Return code
AT+BFREQ?	-	AT+BFREQ: “Get the Beacon frequency”	OK
AT+BFREQ=?	-	BCON: DRx, psfreq(1)	
Example AT+BFREQ=?	-	BCON: 3, 869.525	OK

1. Default value for EU868 SF9 / 125 MHz.

4.5.3 AT+BTIME

This command(a) allows the user to access the current beacon time(b).

Table 35. Beacon frequency command

Command	Input parameter	Return value	Return code
AT+BTIME?	-	BTIME: “Get the Beacon Time (GPS Epoch time)”	OK
AT+BTIME=?	-	BTIME: “GPS epoch time”	OK
Example AT+BTIME=?	-	BTIME: 1226592311	OK

4.5.4 AT+BGW

This command(a) allows the user to access the GW GPS coordinate, NetID and GwID.

Table 36. GW GPS coordinate command

Command	Input parameter	Return value	Return code
AT+BGW?	-	AT+BGW: Get the Gateway GPS coordinate, NetID and GwID	OK
AT+BGW=?	-	BGW: INFO(1), netid, gwid, longitude, latitude	OK
Example AT+BGW=?	-	BGW: 3, “NetID”, “GwID”, “N/A”, “N/A”	OK

1. For a single omnidirectional antenna gateway the INFO value is 0 with GPS coordinates. For a site featuring three sectored antennas, for example, the first antenna INFO equals 0 with GPS coordinates, the second antenna INFO equals 1 with GPS coordinate, etc. In this case netid and gwid are not relevant. When INFO = 3, the content of network NetID plus a freely allocated gateway gwid and longitude and latitude are not relevant.

a. Only applicable when the end-node is in “beacon locked” state.

b. Time in seconds since January 6, 1980 00:00:00 UTC (start of the GPS epoch) modulo 2^{32}.

4.5.5 AT+LTIME

This command[a] allows the user to access the local time in a UTC format.

Table 37. Local time command

Command	Input parameter	Return value	Return code
AT+LTIME?	-	AT+LTIME: Get the local time in UTC format	OK
AT+LTIME=?	-	LTIME: YYYY-MM-DD	OK
Example AT+LTIME=?	-	LTIME: 2018-11-14	OK

4.6 Asynchronous events

Table 38 lists the possible events sent from the B-L072Z-LRWAN1 Discovery board to host serial port actively. Host parser may need to handle this event at any time.

Table 38. Asynchronous events

Event		Parameter	Description
Beacon acquisition process	+BC:	<status>	FAILED: if beacon not found during Class B switching mode process.
			ACQ: the beacon acquisition process is ongoing.
			REACQ: missed a beacon, need to update the beacon time. Reacquisition is needed.
			LOST: beacon lost, modem does a Beacon Reacquisition.
			LOCKED: beacon found. The modem is synchronized.
Pingslot process	+PS:	<status>	DONE: at this time, ping slots will be opened periodically. The modem is now in Class B mode.
Class B downlink	+EVT:	<status>	UNICAST: lets host know that the Rx is in unicast Class B mode.
			PortNumber: “12345678”: received binary data on PortNumber.
			RX3, RSSI -110, SNR 5: indicates that data has been received on pingslot received window.
Class A/C downlink	+EVT:	<status>	PortNumber: “binary or string format”: received binary data or raw string format data on PortNumber.

a. Only relevant after the end-node has received from the network the answer of the “DeviceTimeReq” request.

4.7 Information

This section provides a set of commands for battery level, RF signal quality and FW version.

4.7.1 AT+BAT: battery level

This command allows the user to access the battery level of the end-device (refer to *Table 39* for details).

Table 39. Battery level command

Command	Input parameter	Return value(1)	Return code
AT+BAT?	-	AT+BAT: get the battery level	OK
AT+BAT=?	-	[1 ... 254]	OK
Example AT+BAT=?	-	254	OK

1. Battery level is from 1 to 254, 254 meaning fully charged.

4.7.2 AT+RSSI: RSSI on reception

This command allows the user to access the RSSI on reception (refer to *Table 40* for details).

Table 40. RSSI on reception command

Command(1)	Input parameter	Return value	Return code
AT+RSSI?	-	AT+RSSI: get the RSSI of the last received packet	OK
AT+RSSI=?	-	Integer	OK
Example AT+RSSI=?	-	-31	OK

1. AT+RSSI=? provides a value in dBm.

4.7.3 AT+SNR: signal noise ratio

This command allows the user to access the SNR of the last received packet (refer to *Table 41* for details).

Table 41. Signal noise ratio command

Command(1)	Input parameter	Return value	Return code
AT+SNR?	-	AT+SNR: get the SNR of the last received packet	OK
AT+SNR=?	-	Integer	OK
Example AT+SNR=?	-	32	OK

1. AT+SNR=? provides a value in dBm.

4.7.4 AT+VER: version of the firmware

This command allows the user to access the version of the B-L072Z-LRWAN1 Discovery board firmware (refer to *Table 42* for details).

Table 42. Version of the firmware command

Command	Input parameter	Return value	Return code
AT+VER?	-	AT+VER: get the version of the AT_iSlave FW	OK
AT+VER=?	-	V.x.y	OK
Example AT+VER=?	-	1.0.0	OK

4.8 RF tests

This section provides a set of commands for the RF test management.

4.8.1 AT+TRSSI: Start radio frequency RSSI tone test

This command allows the user to start the RF RSSI tone test (refer to *Table 43* for details).

Table 43. Start radio frequency RSSI tone command

Command	Input parameter	Return value	Return code
AT+TRSSI?	-	AT+TRSSI: start RF RSSI tone test	OK
AT+TRSSI	Void	Void	OK AT_BUSY_ERROR
Example AT+TRSSI	-	-	OK

4.8.2 AT+TTONE: Start radio frequency tone test

This command allows the user to start the RF tone test (refer to *Table 44* for details).

Table 44. Start radio frequency tone test command

Command	Input parameter	Return value	Return code
AT+TTONE?	-	AT+TTONE: start RF tone test	OK
AT+TTONEI	Void	Void	OK AT_BUSY_ERROR
Example AT+TTONE	-	-	OK

4.8.3 AT+TTLRA: Start RF Tx LoRa® test

This command allows the user to start the RF Tx LoRa® test (refer to *Table 45* for details).

Table 45. Start RF Tx LoRa® test command

Command	Input parameter	Return value	Return code
AT+TTLRA?	-	AT+TTLRA: starts Tx LoRa® test	OK
AT+TTLRA	Void	Void	OK AT_BUSY_ERROR
Example AT+TTLRA	-	-	OK

4.8.4 AT+TRLRA: Start RF Rx LoRa® test

This command allows the user to start the RF Rx LoRa® test (refer to *Table 46* for details).

Table 46. Start RF Rx LoRa® test command

Command	Input parameter	Return value	Return code
AT+TRLRA?	-	AT+TRLRA: starts Rx LoRa® test	OK
AT+TRLRA	Void	Void	OK AT_BUSY_ERROR
Example AT+TRLRA	-	-	OK

4.8.5 AT+TCONF: Config LoRa® RF test

This command allows the user to access the LoRa® configuration test (refer to *Table 47* for details).

Table 47. Config LoRa® RF test command

Command	Input parameter	Return value	Return code
AT+TCONF?	-	AT+TCONF: configure LoRa® RF test	OK
AT+TCONF=?	Void	Void	OK AT_ERROR
AT+TCONF=<param>	Void	Void	OK AT_PARAM_ERROR
Example AT+TCONF?	-	Freq = 868 MHz Power = 14 dbm Bandwidth = 125 KHz SF = 12 CR = 4 / 8 LNA State = 0 PA boost state = 0	OK

Table 47. Config LoRa® RF test command (continued)

Command	Input parameter	Return value	Return code
Example AT+TCONF=	868:12:125:12:4 /8:0:0	-	OK
Example AT+TCONF=	868:12:**300**:12:4 /8:0:0	-	AT_PARAM_ERROR (error on bandwidth setting)

AT_PARAM_ERROR is returned when the setting does not have the correct format (being a decimal value), or when it is outside the required set:

- Bandwidth = {125, 250, 500};
- SF = {7, 8, 9, 10, 11, 12};
- CR = {4/5, 4/6, 4/7, 4/8}.

4.8.6 AT+TOFF: Stop ongoing radio frequency test

This command allows the user to stop the ongoing RF test (refer to *Table 48* for details).

Table 48. Stop radio frequency test command

Command	Input parameter	Return value	Return code
AT+TOFF?	-	AT+TOFF: stop ongoing RF test	OK
AT+TOFF	Void	Void	OK

4.8.7 AT+CERTIF: Set the module in LoRaWAN™ Certification mode

This command allows the user to start the RF Rx LoRa test (refer to *Table 49* for details).

Table 49. Set the module in LoRaWAN™ Certification mode command

Command	Input parameter	Return value	Return code
AT+CERTIF?	-	AT+CERTIF: set the module in LoraWAN™ Certification mode	OK
AT+CERTIF	Void	Void	OK AT_BUSY_ERROR

AT+CERTIF puts the timer to handler data transmission equal to 5 s.

5 Examples

This section provides examples of join and send, receiving and confirmation of data.

5.1 Join and send

This example shows the complete join procedure and the way to send data on the LoRa® link.

```
# AT
<CR><LF>OK<CR><LF>
# AT+JOIN
<CR><LF>OK<CR><LF>
# AT+NJS=?
0<CR><LF>/* Network is not joined yet */
<CR><LF>OK<CR><LF>
/* wait for few seconds to wait for join to complete */
# AT+NJS=?
1<CR><LF>/* Network is now joined */
<CR><LF>OK<CR><LF>
/* now the network is joined, data can be sent */
# AT+SEND=50:Hello World/* Send text to port 50 */
<CR><LF>OK<CR><LF>
# AT+SENDB=60:0123 /* Send data (2 bytes: 0x01 and 0x23) on port 60 */
<CR><LF>OK<CR><LF>
/* Note that the result could be AT_BUSY_ERROR in case the previous send is
not completed, because of the duty cycle restriction, or because RX windows
are not completed */
```

5.2 Confirmation

This example shows how to transmit data on the LoRa® link. This example assumes that the network is already joined.

```
# AT+NJS=?
1<CR><LF>/* Network is already joined */
<CR><LF>OK<CR><LF>
# AT+CFM=?
0<CR><LF>/* Unconfirmed data */
<CR><LF>OK<CR><LF>
# AT+CFM=1
<CR><LF>OK<CR><LF>
# AT+CFM=?
0<CR><LF>/* Confirmed data */
<CR><LF>OK<CR><LF>
# AT+SEND=50:Hello World/* Send text to port 50 */
```

```
<CR><LF>OK<CR><LF>
# AT+CFS=?
0<CR><LF>/* Message is not confirmed yet */
<CR><LF>OK<CR><LF>
/* wait for few seconds to wait for the confirmation */
# AT+CFS=?
# AT+NJS=?
1<CR><LF>/* Network is already joined */
<CR><LF>OK<CR><LF>
# AT+CFM=?
0<CR><LF>/* Unconfirmed data */
<CR><LF>OK<CR><LF>
# AT+CFM=1
<CR><LF>OK<CR><LF>
# AT+CFM=?
0<CR><LF>/* Confirmed data */
<CR><LF>OK<CR><LF>
# AT+SEND=50:Hello World/* Send text to port 50 */
<CR><LF>OK<CR><LF>
# AT+CFS=?
0<CR><LF>/* Message is not confirmed yet */
<CR><LF>OK<CR><LF>
/* wait for few seconds to wait for the confirmation */
# AT+CFS=?
```

5.3 Receiving data

This example shows how to receive data on the LoRa® link, with the assumption that the network is already joined.

```
# AT+NJS=?
1<CR><LF>/* Network is already joined */
<CR><LF>OK<CR><LF>
# AT+RECV=?
0:<CR><LF>/* Nothing has been received */
<CR><LF>OK<CR><LF>
/* Server is sending Binary Data 0x01 0xA0 0x23 on port 20
   Need to send data to receive the one from the server */
# AT+SENDB=2:ab
<CR><LF>OK<CR><LF>
# AT+RECVB=?
0:<CR><LF>/* Nothing has been received yet */
<CR><LF>OK<CR><LF>
/* wait the received windows to complete */
# AT+RECVB=?
20:01a023<CR><LF> /* Message is now received */
```

```
<CR><LF>OK<CR><LF>
# AT+RECVB=?
20:<CR><LF>/* No new message received */
<CR><LF>OK<CR><LF>
```

5.4 Class B enable request

This example shows how to do a Class B request through an AT command sequence.

```
#AT+JOIN
<CR><LF>OK<CR><LF>
/* wait for few seconds to have a join complete */
# AT+NJS=?
1<CR><LF>                    /* Network is now joined */
<CR><LF>OK<CR><LF>
/* now the network is joined, data can be sent */
/* --> A build in MAC message is sent to the network  to acquire the system
time "Device Time req"*/
AT+SEND=2:hello             /* Send data will allow to piggybacking the MAC
Device Time Req -could be a dummy message*/
<CR><LF>OK<CR><LF>
/* --> MAC Ping Device Time ANS is received by end-node in hidden way*/
AT+CLASS=B                   /* Request to switch to Class B "enable"*/
<CR><LF>OK<CR><LF>
AT+CLASS=?
B, S0<CR><LF>                /*Beacon Acquisition on-going*/
+BC: LOCKED<CR><LF>          /*Asynchronous event : End-Node locked on
Beacon*/
/* now the End-node is locked, Beacon Time can be requested */
AT+BTIME=?
BTIME: 1538759296<CR><LF>
<CR><LF>OK<CR><LF>
/* --> A build in MAC messages are sent to the network "link check req" and
"ping slot info req"*/
AT+SEND=2:hello         /* will allow to piggybacking the MAC messages */
<CR><LF>OK<CR><LF>
/* --> MAC Ping Slot Info ANS is received by end-node in hidden way*/
+PS: DONE<CR><LF>            /*Asynchronous event : pingslot will be opened
periodically*/
/* now the end-node is Class B "enable"*/
AT+CLASS=?
B<CR><LF>                    /*Class B "enable"*/
+BC: LOST<CR><LF>        /* Asynchronous event: Beacon lost, modem does a
Beacon Reacquisition:*/
+BC: REACQ<CR><LF>       /* Asynchronous event : Beacon Reacquisition:*/
+BC: LOCKED<CR><LF>      /* Asynchronous event : Beacon found. The modem is
synchronized
```

```
/* Since the End-node is locked, Local Time can be requested */
AT+LTIME=?
LTIME: 17h08m16s on 05/10/2018<CR><LF>
<CR><LF>OK<CR><LF>
```

6 Embedded software description

This section gives an overview of the firmware architecture of the B-L072Z-LRWAN1 Discovery board. To see the complete description of the software implementation in I-CUBE-LRWAN refer to document *2*.

6.1 Firmware overview

This overview refers to the software Expansion Package for STM32Cube™ (see document *2*) and not to the specific implementation of the LoRa® technology. For more details on how to proceed with the specific LoRa® technology case refer to document *2*).

The AT command processing is found in the source files listed below:

- command.c: contains the definition and handlers of all the commands
- at.c: contains AT driver functions (basic action to provide what to whom)

6.2 LPUART

The AT commands are sent through an UART carrier. In order to optimize the low power, the LPUART of the B-L072Z-LRWAN1 Discovery board is used.

The AT_slave module executes two different tasks:

- LoRa® tasks: it manages the received windows, and it sends data
- Receives commands from the master that schedules LoRa® tasks, and then sends back the requested value and the status of the command.

As the AT_slave is already executing the two tasks described above, the MCU is idle most of the time. The MCU remains waiting either for a command from the master or for a LoRa® task schedule.

So it is important to be in Stop mode in order to optimize the low-level power of the MCU. As commands are received through the UART, the low power UART (LPUART) is used, hence the communication transfer rate is limited to 9600 bauds.

The LPUART is initialized to be enabled in Stop mode, and the wakeup from Stop mode is performed on a Start bit detection. The LPUART handler (vcom_IRQHandler()) enables RXNE (RX not empty) IT, so that when RXNE IT is raised, the character is read and stored in an internal circular buffer.

The buffer of read characters is then processed in the normal thread (not in the IT thread). A command is recognized when the new character received is <CR> or <LF>.

6.3 Compilation switches

This section lists the compilation switches provided to the user to control the compilation process.

Table 50 provides a summary of the main options for the application configuration.

Table 50. Compilation switch options

Switch option		Definition	Location
LoRa® stack	LORAMAC _CLASSB_ENABLED	Compile the relevant code for Class B mode	Compiler option setting
	USE_DEVICE_TIMING	Include either “LORA_DeviceTimeReq()” or “LORA_BeaconTimeReq(void)”	lora.c
Bands	USE_BAND_868	Enable the EU band selection	Compiler option setting
	USE_BAND_433		
	USE_BAND_915		
Debug	DEBUG	Enable “Led on/off”	hw_conf.h
	VERBOSE_LEVEL	Enable the trace level	utilities_conf.h
Command	NO_HELP	Disable the short help on AT commands when using AT+<CMD>?	command.c

Note: Even if Class B mode cannot be activated by AT+CLASS command, the code is proposed in this release. It is up to the user to adapt the current AT command interface to support a Class B compatible application.

Note: When “printf” are enabled, the resulting commands may be interlaced with debug printf().

6.3.1 Debug switches

In \Projects\B-L072Z-LRWAN1\Applications\LoRa\AT_Slave\LoRaWAN\App\inc\hw_conf.h, the user can enable the debug mode and /or the trace mode by commenting out #define DEBUG.

The debug mode enables the DBG_GPIO_SET and DBG_GPIO_RST macros. This mode also enables the debugger mode even when the MCU goes in low power.

Note: To do a true low power the #define DEBUG must be commented out.

6.4 Footprint

The values in *Table 51* have been measured for the following configuration:

- Compiler: Keil®
  - Optimization: optimized for size level 3
  - Debug option: off

Table 51. AT_slave footprint

Footprint	Flash memory (bytes)	RAM (bytes)	Description
AT_Slave	6324	395	LoRa® finite state machine (Lora.c)
LoRa® stack	40800	4389	LoRa® stack
Total	47124	4784	Total memory

7 Revision history

Table 52. Document revision history

Date	Revision	Changes
10-Jan-2017	1	Initial release.
25-Aug-2017	2	Updated document title and *Section 3: Overview*. Added *Section 4.8: RF tests* and its subsections. Updated *Figure 1: Terminal emulation mode*. Updated *Table 1: List of acronyms*. Minor text edits across the whole document.
14-Dec-2017	3	Updated *Section 2: Reference documents* and *Section 3: Overview*.
11-Jul-2018	4	Updated *Section 2: Reference documents*, *Section 6.3: Compilation switches*, *Section 6.3.1: Debug switches* and *Section 6.4: Footprint*. Minor text edits across the whole document. Updated *Table 22: LoRa® class command* and its footnote *1*, *Table 50: Compilation switch options* and *Table 51: AT_slave footprint*. Removed former *Section 4.4.5: AT+FCD: frame counter downlink,* former *Section 4.4.6: AT+FCU: frame counter uplink*, former *Section 6.2: Low layer driver* and former *Note* in *Section 4.3.4: AT+NJM: LoRa® network join mode*.
17-Dec-2018	5	Updated *Section 4: AT commands*, *Section 4.2.3: AT+APPSKEY: application session key* and *Section 4.2.7: AT+NWKSKEY: network session key*. Added *Section 4.5: Class B mode*, *Section 4.6: Asynchronous events* with their subsections and tables, and *Section 5.4: Class B enable request*. Minor text edits across the whole document. Updated *Figure 1: Terminal emulation mode*. Updated *Table 7: Application session key command*, *Table 11: Network session key command*, *Table 22: LoRa® class command* and its footnotes.