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# DOCUMENT INFO

This document provides information about the specifications of all blocks that will compose the system in package.

# REVISION

|  |  |  |  |
| --- | --- | --- | --- |
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| 00 | - Initial draft | 02/12/2021 | Christian R Lehmen |
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# APPROVAL

|  |  |  |  |
| --- | --- | --- | --- |
| Position | Name | Date | Remarks |
|  |  |  |  |
|  |  |  |  |

# 

# Introduction

This application has the objective of making the first contact with the HTLRBL32L’s LoRaWAN® capabilities quick and easy using AT commands through a UART interface. The LoRaWAN version used on this application is [LoRaWAN 1.0.2rb](https://lora-alliance.org/resource_hub/lorawan-regional-parameters-v1-0-2rb/) and has all the features required to run on any LoRaWAN® network.

## **Serial Terminal Setup**

The UART interface can be used by connecting the pins TX(PA9) and RX(PA8) to a USB-Serial converter and connecting to a computer or simply connecting it to another microcontroller with a UART interface.

UART configuration required to connect:

* Baud rate: 115200
* Data bits: 8
* Stop bits: 1
* Parity: none
* Flow Control: none
* Transmitted text: Append LF

## **Termite Setup**

**One of the most widely used software for UART communication using a computer is** [Termite](https://www.compuphase.com/software_termite.htm)**.** Figure 1 – Termite setup **displays the configuration required to connect to the HTLRBL32L.**

Graphical user interface

Description automatically generated

Figure 1 – Termite setup

# AT command syntax

|  |  |
| --- | --- |
| **Command** | **Description** |
| AT+CMD=? | Read the parameter value |
| AT+CMD | Executes a command |
| AT+CMD=<parameters> | Executes a command with parameters |

# General COmmands

Returns the value input by the user. Command useful for UART connectivity tests.

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+ECHO =<param> | Any string value | Returns the input parameter |

# Device configuration

This section has all the commands necessary to configure the device.

## **Key Configuration**

Commands related to LoRaWAN ABP/OTAA key configuration.

### **General Command**

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+DEVEUI=<param> | 16 charactere hexadecimal | Sets the DevEUI |
| AT+DEVEUI? |  | Returns current DevEUI |

### **ABP Keys Commands**

ABP keys configuration is not required when using OTAA activation mode.

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+DEVADDR=<param> | 8 charactere hexadecimal | Sets the DevAddr |
| AT+DEVADDR? |  | Returns current DevAddr |
| AT+APPSKEY=<param> | 32 charactere hexadecimal | Sets the AppSKey |
| AT+APPSKEY? |  | Returns current AppSKey |
| AT+NWKSKEY=<param> | 32 charactere hexadecimal | Sets the NwkSKey |
| AT+NWKSKEY? |  | Returns current NwkSKey |

### **OTAA Keys Commands**

OTAAkeys configuration is not required when using ABP activation mode.

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+APPEUI=<param> | 16 charactere hexadecimal | Sets the AppEUI |
| AT+APPEUI? |  | Returns current AppEUI |
| AT+ APPKEY =<param> | 32 charactere hexadecimal | Sets the AppKey |
| AT+APPKEY? |  | Returns current AppKey |

## **Region**

Sets the region of operation of the device. Regions set as RED are disabled in this version.

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+REGION=<param> | AS923 = 0  AU915 = 1  CN470 = 2  CN779 = 3  EU433 = 4  EU868 = 5  KR920 = 6  IN865 = 7  US915 = 8  RU864 = 9 | Sets the LoRaWAN Region |
| AT+ REGION? |  | Returns current Region |

## **Activation Mode**

Sets the join type (ABP/OTAA)

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+JOINCFG=<param> | ABP=0 OTAA=1 | Sets the join procedure type |
| AT+JOINCFG? |  | Returns the current join procedure type |

## **ADR**

Sets the ADR bit.

Note: Default Tx Datarate is ignored when the ADR bit is active

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+ADR=<param> | Off=0 On=1 | Sets the ADR bit |
| AT+ADR? |  | Returns current ADR config |

## **Default TX Datarate**

Default datarate is not used when ADR is activated.

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+DR=<param> | 0-7 | Sets the default datarate |
| AT+DR? |  | Returns default datarate |

Table 1 – Datarate Configurations displays the relation of Datarate with Spreading Factor and Bandwidth.

|  |  |  |  |
| --- | --- | --- | --- |
| **DR** | **AU915** | **US915** | **EU868** |
| 0 | SF12BW125 | SF10BW125 | SF12BW125 |
| 1 | SF11BW125 | SF9BW125 | SF11BW125 |
| 2 | SF10BW125 | SF8BW125 | SF10BW125 |
| 3 | SF9BW125 | SF7BW125 | SF9BW125 |
| 4 | SF8BW125 | SF8BW500 | SF8BW125 |
| 5 | SF7BW125 | Invalid | SF7BW125 |
| 6 | SF8BW500 | Invalid | SF7BW250 |
| 7 | Invalid | Invalid | FSK |

Table 1 – Datarate Configurations

## **Join Delay**

Delay between Tx and opening the Rx1 and Rx2 windows during activation (used by OTAA activation mode)

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+JOINDELAYRX1=<param> | Time in microssecond | Sets the join delay on the RX1 |
| AT+JOINDELAYRX1? |  | Returns the join delay on the RX1 |
| AT+JOINDELAYRX2=<param> | Time in microssecond | Sets the join delay on the RX2 |
| AT+JOINDELAYRX2? |  | Returns the join delay on the RX2 |

## **RX Window Delay**

Delay between Tx and opening the Rx1 and Rx2 windows during regular execution.

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+DELAYRX1=<param> | Time in microssecond | Sets the delay on the RX1 |
| AT+DELAYRX1? |  | Returns the delay on the RX1 |
| AT+DELAYRX2=<param> | Time in microssecond | Sets the delay on the RX2 |
| AT+DELAYRX2? |  | Returns the delay on the RX2 |

## **RX Window Duration**

Sets the duration in which the Rx windows stay open (regular and join procedure RX windows). This rule must be respected when setting Rx window delays: **(Rx2Delay-Rx1Delay) >= (RxDuration** **+100).**

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+RXDURATION=<param> | Time in microssecond | Sets the duration RX stays open |
| AT+RXDURATION? |  | Returns the set duration |

## **TX Power**

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+POWER=<param> | 0-15 | Sets the TX power level |
| AT+POWER? |  | Returns current TX power |

Tx power can be limited by regional specification, please refer to RP002-1.0.2 LoRaWAN Regional Parameters Document for more information.

## **Add Channels**

Command compatible with US915 and AU915 regions only.

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+CHMASK=<param> | param1:param2:param3...\* | Adds channels to the channel mask |
| AT+CHMASK? |  | Returns current channel mask |

\*Maximum of 8 channels per command (e.g: AT+CHMASK=1:2:3:4:5:10:25:8)

The frequency each channel represents in the device is depicted on Table 2 – Channel Configuration.

|  |  |  |
| --- | --- | --- |
| **Channel n°** | **AU915** | **US915** |
| 1 | 915200000 | 902300000 |
| 2 | 915400000 | 902500000 |
| 3 | 915600000 | 902700000 |
| 4 | 915800000 | 902900000 |
| 5 | 916000000 | 903100000 |
| 6 | 916200000 | 903300000 |
| 7 | 916400000 | 903500000 |
| 8 | 916600000 | 903700000 |
| 9 | 916800000 | 903900000 |
| 10 | 917000000 | 904100000 |
| 11 | 917200000 | 904300000 |
| 12 | 917400000 | 904500000 |
| 13 | 917600000 | 904700000 |
| 14 | 917800000 | 904900000 |
| 15 | 918000000 | 905100000 |
| 16 | 918200000 | 905300000 |
| 17 | 918400000 | 905500000 |
| 18 | 918600000 | 905700000 |
| 19 | 918800000 | 905900000 |
| 20 | 919000000 | 906100000 |
| 21 | 919200000 | 906300000 |
| 22 | 919400000 | 906500000 |
| 23 | 919600000 | 906700000 |
| 24 | 919800000 | 906900000 |
| 25 | 920000000 | 907100000 |
| 26 | 920200000 | 907300000 |
| 27 | 920400000 | 907500000 |
| 28 | 920600000 | 907700000 |
| 29 | 920800000 | 907900000 |
| 30 | 921000000 | 908100000 |
| 31 | 921200000 | 908300000 |
| 32 | 921400000 | 908500000 |
| 33 | 921600000 | 908700000 |
| 34 | 921800000 | 908900000 |
| 35 | 922000000 | 909100000 |
| 36 | 922200000 | 909300000 |
| 37 | 922400000 | 909500000 |
| 38 | 922600000 | 909700000 |
| 39 | 922800000 | 909900000 |
| 40 | 923000000 | 910100000 |
| 41 | 923200000 | 910300000 |
| 42 | 923400000 | 910500000 |
| 43 | 923600000 | 910700000 |
| 44 | 923800000 | 910900000 |
| 45 | 924000000 | 911100000 |
| 46 | 924200000 | 911300000 |
| 47 | 924400000 | 911500000 |
| 48 | 924600000 | 911700000 |
| 49 | 924800000 | 911900000 |
| 50 | 925000000 | 912100000 |
| 51 | 925200000 | 912300000 |
| 52 | 925400000 | 912500000 |
| 53 | 925600000 | 912700000 |
| 54 | 925800000 | 912900000 |
| 55 | 926000000 | 913100000 |
| 56 | 926200000 | 913300000 |
| 57 | 926400000 | 913500000 |
| 58 | 926600000 | 913700000 |
| 59 | 926800000 | 913900000 |
| 60 | 927000000 | 914100000 |
| 61 | 927200000 | 914300000 |
| 62 | 927400000 | 914500000 |
| 63 | 927600000 | 914700000 |
| 64 | 927800000 | 914900000 |
| 65 | 915900000 | 903000000 |
| 66 | 917500000 | 904600000 |
| 67 | 919100000 | 906200000 |
| 68 | 920700000 | 907800000 |
| 69 | 922300000 | 909400000 |
| 70 | 923900000 | 911000000 |
| 71 | 925500000 | 912600000 |
| 72 | 927100000 | 914200000 |

Table 2 – Channel Configuration

Channels 65-72 are used by exclusively on DR6(AU915) and DR4(US915).

## **Remove Channels**

Command compatible with US915 and AU915 regions only.

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+RMVCHMASK=<param> | param1:param2:param3...\* | Removes channels from the channel mask |
| AT+CHMASK? |  | Returns current channel mask |

\*Maximum of 8 channels per command (e.g: AT+RMVCHMASK=1:2:3:4:5:10:25:8)

\*Sending a “AT+RMVCHMASK=0” command revert the channel mask to its default state.

## **Network Mode**

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+NWKMODE=<param> | 0: private mode  1: public mode | Sets network mode |
| AT+NWKMODE? |  | Returns current network mode |

# Packet send/receive

## **Join Procedure**

Performs the join procedure, exchanging keys required to communicate with the network server. Command is **required** to be used once before sending a payload if Network Join Type is OTAA.

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+JOIN=<param> |  | Sends a join request |
| AT+JOIN? |  | Return join status |

## 

## **Send Payload (String)**

Sends an uplink to the network server containing a user payload. Automatically opens both RX windows to expect a downlink.

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+SEND=<param> | 1-242 bytes payload\* | Sends a packet |

\*Payload size is dependent on current Datarate, refer to item 7 (Max Payload) for the appropriate values.

## **Send Payload (Hexadecimal)**

Sends an uplink to the network server containing a hexadecimal user payload. Automatically opens both RX windows to expect a downlink.

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+SENDHEX=<param> | 1-242 bytes payload\* | Sends a packet |

\*Payload size is dependent on current Datarate, refer to item 7 (Max Payload) for the appropriate values.

## **Receive Payload**

Returns the last application payload received by downlink. If there is no payload received or it has already been read an error is reported. Only payload addressed to LoRaWAN port 2 are returned.

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+RCV |  | Returns the last received payload |

## 

## **Rx Stats**

Returns the last received packet stats (RSSI/SNR) on this format: <RSSI> <SNR>.

|  |  |  |
| --- | --- | --- |
| **Command** | **Parameter** | **Description** |
| AT+STATS? |  | Returns RSSI and SNR of the last packet received |

# Max Payload

Table 3 – Maximum payload displays the maximum payload allowed for each datarate of each region (value in bytes).

|  |  |  |  |
| --- | --- | --- | --- |
| **Datarate** | **AU915** | **EU868** | **US915** |
| 0 | 51 | 51 | 11 |
| 1 | 51 | 51 | 53 |
| 2 | 51 | 51 | 125 |
| 3 | 115 | 115 | 242 |
| 4 | 242 | 242 | 242 |
| 5 | 242 | 242 | Invalid |
| 6 | 242 | 242 | Invalid |
| 7 | Invalid | 242 | Invalid |

Table 3 – Maximum payload

# Default parameter state

When the system is initialized/reset all parameters go to their default state, depicted on the Table 4 – Default parameters.

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| DevEUI | 0xDEADBEEFBEEFDEAD |
| DevAddr | 0xDEADBEEF |
| AppSkey | 0x11111111111111111111111111111111 |
| NwkSkey | 0x11111111111111111111111111111111 |
| AppEUI | 0x1111111111111111 |
| AppKey | 0x11111111111111111111111111111111 |
| Active Channels | 9-16 |
| Join Configuration | ABP |
| ADR | 0 |
| Network Mode | 1 |
| Default Datarate | 0 |
| Join Delay Rx1 | 5000 |
| Join Delay Rx2 | 6000 |
| Delay Rx1 | 1000 |
| Delay Rx2 | 2000 |
| Rx Window Size | 850 |
| Tx Power | 14 |
| Region | US915 |

Table 4 – Default parameters

# ERROR codes

After every command and during special events the system will return a hexadecimal 4-byte error code referring to possible errors during the execution, using this format:

[00][00][00][00]

Reserved

CMD

LORA

UART

## **Command Error codes**

The first byte is related to command syntax and parameter validations.

|  |  |
| --- | --- |
| **Code** | **Description** |
| 0x00 | No errors |
| 0x01 | Invalid command |
| 0x02 | Parameter missing |
| 0x03 | Parameter overflow |
| 0x04 | Invalid command header |
| 0x05 | Expected hexadecimal value |

Table 5 – Command error codes

## **UART Error codes**

The second byte is related to possible UART errors.

|  |  |
| --- | --- |
| **Code** | **Description** |
| 0x00 | No errors |
| 0x01 | Command max size violated |
| 0x02 | Empty command |

Table 6 – UART error codes

## **LORA Error codes**

The third byte refers to LoRa errors.

|  |  |
| --- | --- |
| **Code** | **Description** |
| 0x00 | No errors |
| 0x01 | Invalid region |
| 0x02 | Invalid Rx Window configuration¹ |
| 0x03 | Network already joined |
| 0x04 | Invalid payload size |
| 0x05 | Invalid payload+FOPTS size² |
| 0x06 | No new Rx Data |
| 0x07 | LoRaWAN stack error³ |
| 0x08 | Tx Timeout |

Table 7 – LoRa error codes

¹ - (Rx2 Window Delay - Rx1 Window Delay) must be greater than (Rx Window size + 100).

Eg:   
Rx2Delay = 1000.

Rx1Delay = 2000.

RxDuration = 850.

(Rx2Delay-Rx1Delay) >= (RxDuration +100) **OK**

Eg:   
Rx2Delay = 1000.

Rx1Delay = 2000.

RxDuration = 1500.

(Rx2Delay-Rx1Delay) >= (RxDuration +100) **ERROR**

² - Application Payload plus LoRaWAN configuration commands exceeds max payload size. This error can be reported dynamically during execution. When this error happens, the packet is sent without the application payload.

³ - Internal LoRaWAN stack error. After this error the stack is reset (user configuration is maintained)