LoRaWAN 915 Field Test Device

By Adeunis RF

PROVIDER Edition

User Guide Version 1.0

Document revision			
Version	Date	Author	Comment
		YRM	
		YRM	
1.0	05/10/2016	YRM	Initial release

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Information

Document information	
Title	LoRaWAN 915 Field Test Device by Adeunis RF
Subtitle	User Guide Version 1.0
Document type	User Guide
Document status	Beta

This document applies to the following products

Name	Reference	Firmware version
LoRaWAN 915 Field Test Device	ARF8124AA	V1.0

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Technical Support

Website

Our website contains much useful information: modules and stand-alone products information, user guides, configuration software and technical documents which can be accessed 24 hours a day.

Email

If you have technical problems or cannot find the required information in the provided documents, contact our Technical Support by email. Use our dedicated email address (arf@adeunis-rf.com) rather than any personal email address of our staff. This makes sure that your request is processed as soon as possible.

Helpful Information when Contacting Technical Support

When contacting Technical Support please have the following information ready:

- Product type (e.g. Wireless M-Bus),
- Firmware version (e.g. V3.03)
- Clear description of your question or the problem
- A short description of the application
- Your complete contact details

Declaration of conformity CE

We ADEUNIS RF,
283 rue LOUIS NEEL, 38920 CROLLES, FRANCE

Declare under our own responsibility that the products

Name LoRaWAN 868 FTD
Reference(s) ARF8123AA

to which this declaration refers conform with the relevant standards or other standardising documents

- EN 300 220-1 (v2.4.1) (2012)
- EN 60950-1 (2006 + A1)
  (2010 + A2)
  (2013 + A11)
  (2009 +A12)
  2011
- EN 301 489-1 (v1.9.2) (2011)
- EN 301 489-3 (v1.6.1) (2013)
- EN 62479 (2010)

According to the RTTE Directive 99/5/EC

Notes:
- Conformity has been evaluated according to the procedure described in Annex III of the RTTE directive
- Receiver class (if applicable): 3

Crolles, 2016

MONNET Emmanuel, Certification Manager

Environmental recommendations

All superfluous packaging materials have been eliminated. We have done everything possible to make it easy to separate the packaging into three types of materials: cardboard (box), expanded polystyrene (filler material) and polyethylene (packets, foam protective sheets). Your device is composed of materials that can be recycled and reused if it is dismantled by a specialist company. Please observe local regulations concerning the manner in which waste packaging material, used batteries and your obsolete equipment are disposed of.

Warnings

Valid for the following product: ARF8123AA

Read the instructions in the manual

The safety of this product is only guaranteed when it is used in accordance with its purpose. Maintenance should only be carried out by qualified persons.

Please note, do not install the equipment close to a heat source or in damp conditions.

Warning: Do not open the product, risk of electric shock.

Please note: for you own safety, you must ensure that equipment is switched off before carrying out any work on it.

Recommendations regarding use

- Before using the system, check that the power supply voltage shown in the user manual corresponds to your supply. If it doesn't, please consult your supplier.
- Place the device against a flat, firm and stable surface.
- The device must be installed in a location that is sufficiently ventilated so that there is no risk of internal heating and it must not be covered with objects such as newspapers, cloths, curtains, etc.
- The device's aerial must be free and at least 10 cm away from any conducting material.
- The device must never be exposed to heat sources such as heating equipment.
- Do not place the device close to objects with naked flames such as lit candles, blowtorches, etc.
- The device must not be exposed to aggressive chemical agents or solvents likely to damage the plastic or corrode the metal parts.
- Install your device close to its DC power supply.

Disposal of waste by users in private households within the European Union

This symbol on the product or on its packaging indicates that this product must not be disposed off with your other household waste. Instead, it is your responsibility to dispose of your waste by taking it to a collection point designated for the recycling of electrical and electronic appliances. Separate collection and recycling of your waste at the time of disposal will contribute to conserving natural resources and guarantee recycling that respects the environment and human health. For further information concerning your nearest recycling centre, please contact your nearest local authority/town hall offices, your household waste collection company or the shop where you bought the product.

Attention: There is a risk of explosion if the battery is replaced by an incorrect type. Throw away the used batteries according to instructions. When changing batteries, reassembled correctly and completely the product.

Switzerland IMPORTANT: Annex 4.10 of SR 814.013 standard is applicable to batteries

HAFTUNGSAUSSCHLUSS

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Hinweise zum Umweltschutz

Alle überflüssigen Verpackungsmaterialien wurden vermieden. Wir haben auch alles getan, was uns möglich ist, damit die Verpackung ohne Weiteres in drei Typen von Werkstoffen getrennt werden kann : Karton (die Schachtel), geschäumtes Polystyrol (Dämmmaterial) und Polyäthylen (Beutel, Schaumfolie zum Schutz). Ihr Gerät besteht aus Werkstoffen, die recycelt und weiterverwendet werden können, wenn es von einem darauf spezialisierten Unternehmen demontiert wird. Beachten Sie bitte die jeweils geltenden örtlichen Vorschriften zur Entsorgung der Verpackungsmaterialien, der verbrauchten Batterien und Ihres ausgemusterten Gerätes.

Warnhinweise

Gültig für das Produkt ARF8123AA

Lesen Sie die Anleitungen dieses Handbuches

Die durch dieses Produkt gewährte Sicherheit kann nur bei einer Anwendung entsprechend dem vorgesehenen Einsatzzweck gewähr-leistet werden.

Vorsicht, installieren Sie das Gerät nicht in der Nähe einer Wärmequelle oder in der Nähe einer Quelle von Feuchtigkeit.

Warnung: Öffnen Sie das Produkt nicht, die Gefahr eines elektrischen Schlags.

Bitte beachten Sie: für Sie Sicherheit besitzen, müssen Sie das Gerät gewährleistet ist, vor der Durchführung von Arbeiten an sie ausgeschaltet.

Empfehlungen zur Verwendung

• Bevor Sie das System verwenden, prüfen Sie, dass die Stromversorgungsspannung in der Bedienungsanleitung gezeigt zu Ihrem Angebot entspricht. Wenn dies nicht der Fall, wenden Sie sich bitte an Ihren Lieferanten.
• Stellen Sie das Gerät auf eine ebene, feste und stabile Oberfläche.
• Das Gerät muss an einem Ort installiert werden, der ausreichend so belüftet ist, dass es kein Risiko einer internen Heizung und es darf nicht mit Gegenständen wie Zeitungen, Tücher, Vorhänge cove¬red werden, usw.
• Das Gerät ist Antenne muss aus jedem leitenden Material frei und mindestens 10 cm entfernt sein.
• Das Gerät darf nie zu Wärmequellen wie Heizungsanlagen ausgesetzt werden.
• Stellen Sie das Gerät in der Nähe Objekte mit offener Flamme nicht platzieren wie brennende Kerzen, Fackeln usw.
• Das Gerät darf nicht mit aggressiven Chemikalien oder Lösungsmitteln ausgesetzt werden wahrscheinlich den Kunststoff zu beschädigen oder die Metallteile korrodieren.

Entsorgung der Abfälle von Betreibern in Privathaushalten innerhalb der Europäischen Union

Dieses Symbol auf dem Produkt oder auf seiner Verpackung weist darauf hin, dass dieses Produkt nicht gemeinsam mit Ihrem anderen Haushaltsmüll entsorgt werden darf. Stattdessen haben Sie dafür Sorge zu tragen, Ihre Abfälle bei einer Erfassungsstelle zu entsorgen, die auf das Recycling elektrischer und elektronischer Geräte spezialisiert ist. Die gesonderte Erfassung und das Recycling ihrer Abfälle bei der Entsorgung tragen dazu bei, die natürlichen Ressourcen zu bewahren und ein Recycling zu gewährleisten, das dem Schutz der Umwelt und der menschlichen Gesundheit dient. Für weitere Informationen zu der Ihrer Wohnung am nächsten gelegene Recyclingstelle wenden Sie sich bitte an die örtliche Gemeindeverwaltung, an die zuständige Dienststelle für die Müllabfuhr oder an das Geschäft, in dem sie das Gerät gekauft haben

Achtung: Es besteht die Gefahr einer Explosion, wenn die Batterie durch einen falschen type.Throwing ersetzt wird entfernt, die verbrauchte Batterien gemäß den Anweisungen. Wenn Batteriewechsel wieder zusammen korrekt und vollständig das Produkt.

Schweiz WICHTIG: Anhang 4.10 von SR 814.013 Norm gilt für Batterien

1 Device Overview

1.1 Device Description

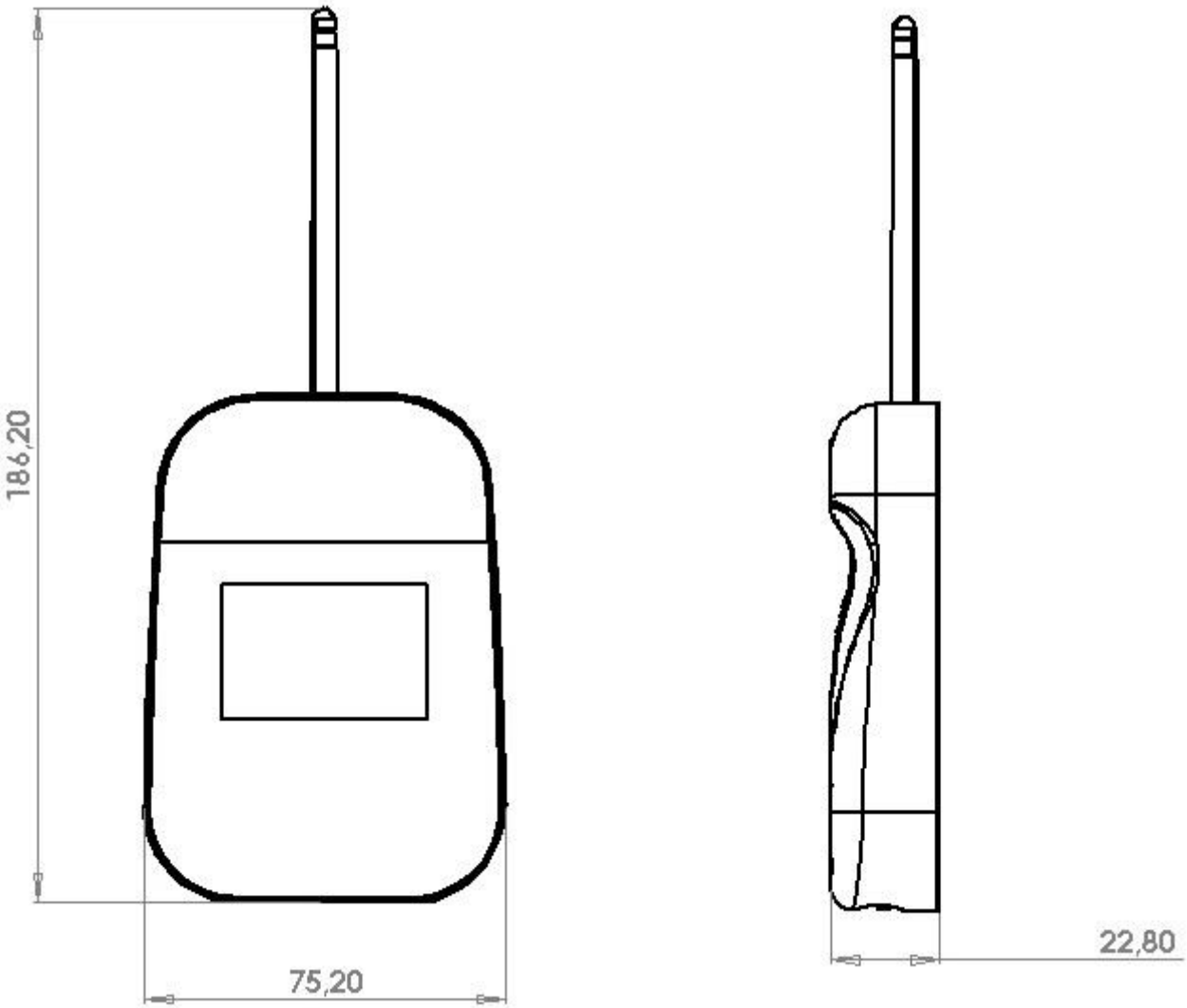
The LoRaWAN Field Test Device (FTD) by Adeunis RF is a LoRaWAN v1.0.1 Class A & C compliant device. It is NOT a point-to-point device and cannot be operated in such a way. It is meant to be paired to an operated network.

The **LoRaWAN Field Test Device by ADEUNIS RF** is a ready to use system, which provides connection to the any operated network using the LoRaWAN V1.0.1 protocol. It allows transmitting, receiving and instantly viewing the radio frames on the used network.
Equipped with a **large LCD screen**, you can check all operating information (GPS coordinates, temperature, battery ...) and use of the network (uplink, downlink, SF, Packet Error Rate ...). Its ultra-fast and precise GPS optimizes geolocation operations.

This Field Test Device is particularly suitable for the validation of applications like sensor networks, asset tracking, smart buildings, metering, security, or M2M.

With **built-in rechargeable battery**, this demonstrator allows for many hours of use and can be recharged with any type of mobile phone charger.

1.2 Mechanical description



1.3 Technical specifications

Technical specifications	
Communication	LoRaWAN protocol & LoRa Modulation
Module configuration	Through AT commands
Radio data rate	Variable
UART configuration	115.2 kbps/N/8/1
Frequency channels	ISM band 902-928
RF output power	20dBm (100mW)
Sensitivity	down to -140dBm in SF12/125kHz
Operating range (Line Of Sight)	Up to 15km
Operating temperature	-30°C / +70°C
Dimensions	186 x 75 x 23 mm
USB Port	Micro-USB – 5V – 500mA
Standard compliance	FCC part 15.247

1.4 Charging the FTD

The product contains a rechargeable battery. Upon connecting it to a computer via a micro-USB cable, it will automatically begin charging; even if the ON/OFF switch is on the OFF position (this behavior is similar to the one of mobile phones). The product can still be used while it's charging.

During the charging process, the charge state indicator is steady **red**. When charging is completed, the charge state indicator becomes steady **green.**

Figure 1: Product during charge

Figure 2: Product when charge is completed

If the battery is completely discharged, **it will need 6 hours** of charging time to get back to full charge.

2 Device operation

2.1 User interface

Figure 3: Front view

Figure 4: Bottom view

2.1.1 Button 1

BTN 1 is used to trigger RF transmissions manually

2.1.2 Button 2

BTN 2 is used to manage the LCD screen and has two functions:

1. 1st push activates LCD backlight
2. If LCD backlight is already activated, pushing BTN2 changes the LCD display

2.1.3 ON/OFF button

The ON/OFF button turns the device ON or OFF. Slide the button to the right to turn the device ON

2.1.4 Charge State Indicator

The CSI indicates the device's state of charge. See 1.4

2.1.5 USB connector

The USB connector can be used to charge (see 1.4) or configure (see 3) the device.

2.1.6 LCD screen description

The embedded LCD screen is divided in three pages: **Main screen, GPS screen & PER screen**

2.1.6.1 Main screen

The main screen displays the most important information:

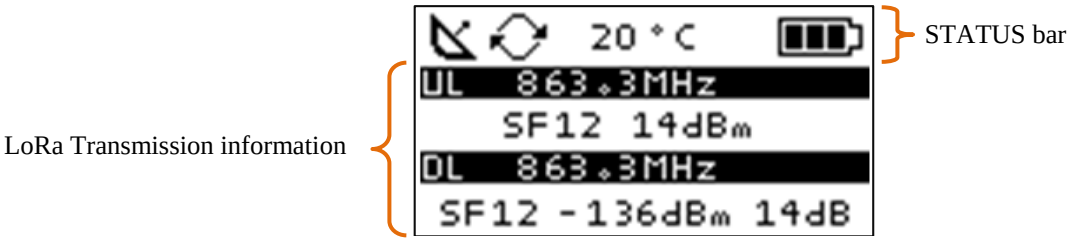
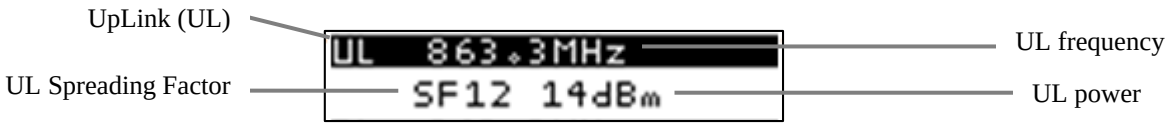


Figure 5: Main Screen

- The STATUS bar contains four different kinds of information:

Item	Icons	Description
GPS status	**No Icon**	GPS is deactivated
		GPS is not synchronized
		GPS is synchronized
RF status	**No Icon**	Product is Idle
		Device is trying to Join a network
		Manual transmission has been triggered
		Periodic transmission has been triggered
Temperature	**20°C**	Temperature in °C
Battery status		Battery level indicator

- The LoRa transmission information section gives information about the current uplink (UL) and resulting downlink (DL) (if there is any)



2.1.6.2 GPS Screen

The GPS screen gives detailed information about the GPS status

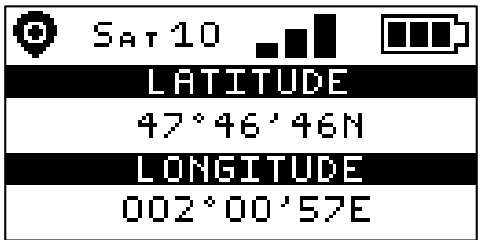
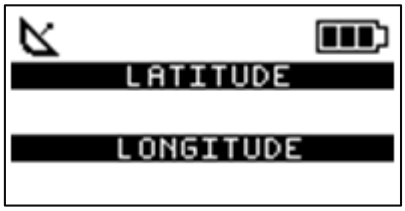


Figure 6: GPS screen

- In the STATUS bar, RF status and Temperature icons are replaced by GPS-related icons

Item	Icons	Description
Number of satellites	**No Icon**	GPS not synchronized
	SAT 10	Number of satellites that the GPS is tracking
Positioning Accuracy	**No Icon**	GPS not synchronized
		Indicates the positioning accuracy. 1 bar = poor accuracy 2 bars = medium accuracy 3 bars = good accuracy

- The rest of the screen indicates the Latitude and Longitude. If the GPS isn't synchronized the LAT and LON fields are left blank, and a satellite dish is displayed indicating that the GPS is attempting a fix



2.1.6.3 Packet Error Rate Screen

The packet error rate screen is dedicated to radio testing, for evaluating the quality of the radio link between the device and a gateway.

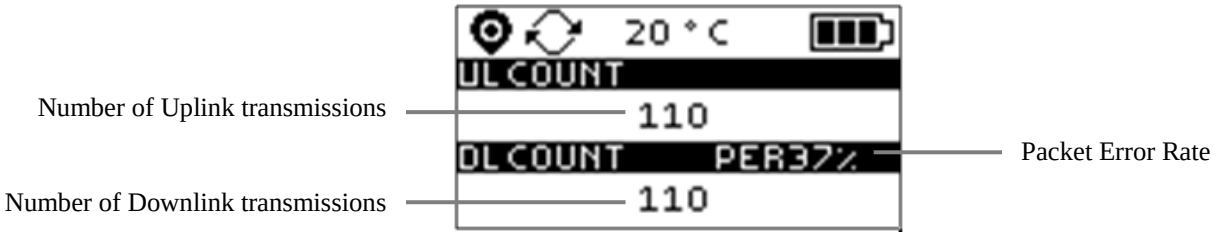


Figure 7: PER Screen

The screen displays:

- Total number of UL **(including repetitions)**
- Total number of DL
- Packet Error Rate in %

$$PER\ (\%) = \frac{DL\ COUNT}{UL\ COUNT} * 100$$

2.2 Using the FTD

2.2.1 Default configuration

The demonstrator is pre-configured at factory with the following default settings:

Parameter	Configuration
Activation mode	OTAA (Over The Air Activation)
DEVEUI	Factory set **Format = 0018B2xxxxxxxxxx**
APPEUI	Factory set
APPKEY	Factory set
Device Address	0x00
Accelerometer	Activated
T°C sensor	Activated
GPS	Activated
Communications tables/channels	US table (module tables 0 / 3 / 5)
RX2 Configuration	923.3 MHz / DR8
TX periodicity	20 s
ACK Mode	unconfirmed

2.2.2 Powering up the device

Power–ON the device by sliding the ON-OFF switch to the right. This should power ON the LCD screen
Power–OFF the device by sliding the ON-OFF switch to the left. This should power OFF the LCD screen

2.2.3 Join procedure

If the device is in OTAA mode, it will automatically execute a Join process at power-ON.

Note: In ABP mode, there is no Join procedure. All keys are entered manually by the user

2.2.4 Sending a frame

There are two ways to send a radio frame

- By default, the device is configured to send RF frames automatically and periodically
- Pressing BTN1 will trigger a manual frame transmission

2.2.5 Accelerometer

An accelerometer is available in the device. Shaking the device will trigger a “LinkCheck request”. See 3.3.9 for configuration options.

2.2.6 GPS

A high performance GPS is available in the device. When available, GPS coordinates are included in the transmission frame to allow device geolocation. See 3.3.10 for configuration options.

3 Device configuration

The device's configuration can be changed from a PC. In order to do so, the device should be turned ON and connected to a PC via its USB port and a micro-USB cable. The device will be recognized as a serial peripheral (creation of a virtual serial COM port).

3.1 Serial link parameters

Parameter	Value
Speed	115200 bps
Parity	None
Bits	8
Stop bit	1

When plugged to a PC, the device should be recognized as a serial peripheral:

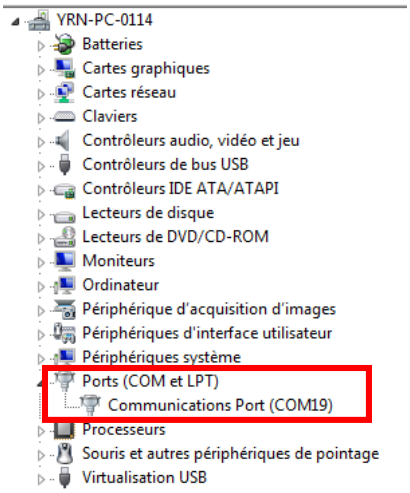


Figure 8: Device as a serial peripheral

The serial driver is available on ADEUNIS RF Website as "USB_DONGLE_DRIVER_WMBUS"

The product can then be configured via a Terminal such as Hercules:

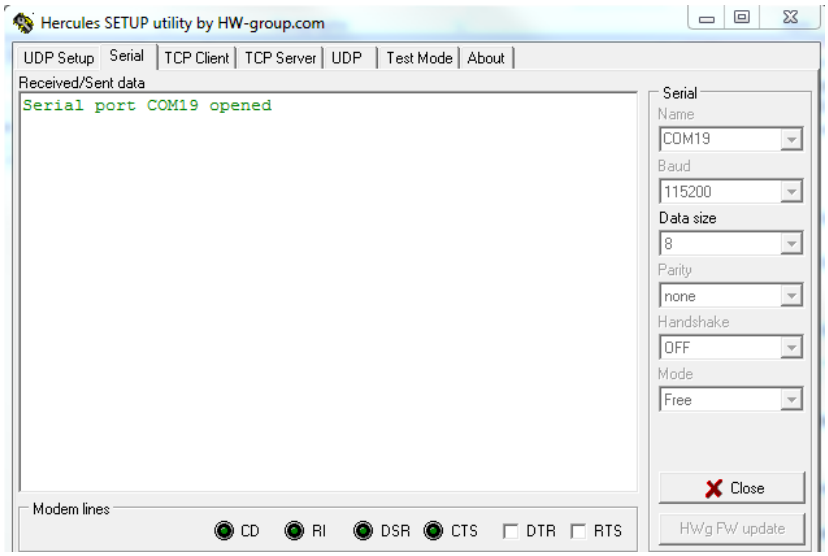


Figure 9: Hercules Terminal

3.2 Command Interface

All commands are written in ASCII

Commands can be used once the device has been placed in command mode. The commands are based on AT commands format and are structures as follows:

- Starts with 2 ASCII characters “AT”
- Followed by 1 or more ASCII characters depending on the command
- Ends by <CR> or <CR><LF>

After receiving a command, the device will emit the following response:

- ASCII character “O” if the command is accepted
- ASCII character “E” if the command is rejected
- Ends by <CR><LF>

The following commands are available:

Command	Description	Reply example
\FF\FF\FF\FF+++	Entry in command mode	«CM»<cr><lf>
AT/V	Displays the firmware version	«LORA-DEMO _v1.0»<cr><lf>
ATS<*n*>?	Returns content of register <n>	S<n>=<y><cr><lf> with <y> as the register content
AT/S	Display all user registers	/
ATS<*n*>=<*m*>	Assign value <m> to USER register <n>	«O»<cr><lf> if Ok, «E»<cr><lf> if error
ATR	Reset device configuration to factory settings	«O»<cr><lf>
AT&W	Save the new configuration	«O»<cr><lf>
ATO	Exit command mode	«O»<cr><lf>
ATT63 PROVIDER	PROVIDER password	«O»<cr><lf>
ATBOOT <*param*>	Bootloader mode <*param*> = RTU ou APP	«O»<cr><lf>

NOTE: “\FF” denotes a hexadecimal format (0xFF)

After modifying a parameter, make sure to save the new configuration by issuing the AT&W command.

3.3 Registers List

3.3.1 Network Keys

In order to access a LoRa Network, 6 different types of keys exist:

KEY	Who asks for it?	Who provides it?	What is it used for?
APP-EUI	OTAA: User ABP: unused	Operator	Needed for joint request
APP-KEY	OTAA: User ABP: unused	Operator	Needed for joint request
DEV-EUI	ADEUNIS	IEEE	Needed for Joint request Unique device ID (MAC address)
NWK-SKEY	OTAA: Device ABP: User	OTAA: Network ABP: Operator	Network Session key used for encryption of MAC commands in FRMPayload (if Fport=0)
APP-SKEY	OTAA: Device ABP: User	OTAA: Network ABP: User (arbitrarily chosen)	Application Session key used for encryption of Applicative payload in FRMPayload (if Fport≠0)
Device Address	OTAA: Device ABP: User	OTAA: Network ABP: Operator	Network address of device

There two different ways to enter a LoRa network: personalization (**ABP**) and Over-the-air activation (**OTAA**). In either case the DEV-EUI, which is essentially a MAC address, is provided by the end-point manufacturer (in this case ADEUNIS).

3.3.1.1 Activation by Personalization mode (ABP)

In personalization mode, the user has to **manually** enter the following keys in the device:

- NWK-SKEY
- APP-SKEY
- Device Address

APP-EUI and APP-Key are unnecessary.

After turning ON the product, LED1 will be turned steady Red and Green and will stay that way unless the device address is different from 0. If the address is different from 0, the demonstrator begins normal operation (provided that the other keys are correct).

3.3.1.2 Over The Air Activation (OTAA) mode

In OTAA mode, the user has to manually enter the following keys in the device:

- APP-EUI
- APP-KEY

After turning ON the product, LED1 will be turned steady Red and Green and will stay that way until the device recovers the NWK-SKEY and APP-SKEY wirelessly. These keys are **automatically provided/calculated by the network**. Once the keys are acquired, the device begins normal operation.

The newly acquired keys (NWK-SKEY and APP-SKEY) can be read from the corresponding registers if the product is placed in command mode.

3.3.1.3 Keys Register List

These registers are locked. In order to be unlocked, the following command must be sent:
ATT63 ROOT<CR>

The network keys are available through the following registers:

Register Number	Description	Default Value	Range / Values	Comment
214	LORA APP-EUI MSB	0		
215	LORA APP-EUI LSB	0		
216	LORA APP-KEY MSB	0		
217	LORA APP-KEY MID MSB	0		
218	LORA APP-KEY MID LSB	0		
219	LORA APP-KEY LSB	0		
222	LORA NWK_SKEY MSB	0		
223	LORA NWK_SKEY MID MSB	0		
224	LORA NWK_SKEY MID LSB	0		
225	LORA NWK_SKEY LSB	0		
226	LORA APP_SKEY MSB	0		
227	LORA APP_SKEY MID MSB	0		
228	LORA APP_SKEY MID LSB	0		
229	LORA APP_SKEY LSB	0		
281	Device Address	0		

3.3.2 Activation - OTAA/ABP

These registers are locked. In order to be unlocked, the following command must be sent:
ATT63 ROOT<CR>

Activation mode (OTAA or ABP) can be selected through register 221:

Register Number	Description	Default Value	Range / Values	Comment
221	Activation mode	0	0 = ABP 1 = OTAA	

3.3.3 Channels configuration

These registers are locked. In order to be unlocked, the following command must be sent:
ATT63 ROOT<CR>

Seven different registers associated with channels/tables are available and configurable through the following registers:

Register Number	Description	Default Value	Range / Values	Comment
250	Table 0	1		US table
251	Table 1	0		User defined
252	Table 2	0		User defined
253	Table 3	1		US table
254	Table 4	0		User defined
255	Table 5	1		US table
256	Table 6	0		User defined

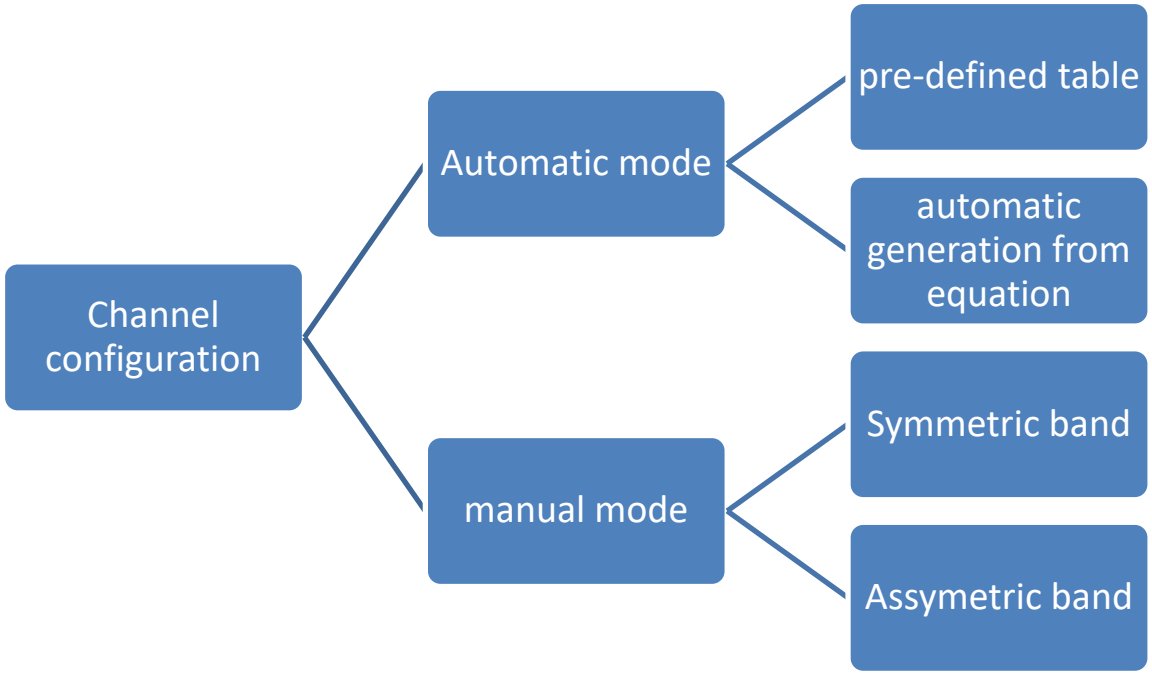
Those registers can contain 3 types of values:

Register value	Description
0	Table deactivated
1	Module default configuration
Other	User defined, will be taken into account **ONLY IF THERE IS NO CF LIST**. If the device is configured in OTAA and a CF list is transmitted by the network during OTAA, the CF list values will prevail

If a register contains other values than 0 or 1, those are custom values provided by the user. The information contained in the custom value is the channel frequency and authorized spreading factor range for ADR.

If ADR (Adaptive Datarate) is activated, the Spreading Factor actual value is automatically managed by the network; the user cannot enforce a specific value of SF. If ADR is deactivated, the SF value is the one contained in register S201.

Tables can be customized according to the following chart:



3.3.3.1 Automatic mode

Automatic mode is selected by setting bit 7 of LoRa Options register to 0 (see 3.3.5)
Symmetric or asymmetric mode can be selected through register 258 (see 3.3.12)

3.3.3.1.1 Pre-defined table

By default the product is configured on the US table. Tables 0, 3, 5 uses the LoRaWAN US parameters and channels 1,2,4,6 are deactivated. US parameters are as follows:

US TABLE					
Register Number	**Number of channels**	**Channel spacing**	**Start frequency**	**DR range**	**LoRaWAN correspondence**
250	64 (UL)	200 kHz	902.3MHz	0-3	Channels 0 -63
253	8 (UL)	1600 kHz	903 MHz	4	Channels 64-71
255	8 (DL)	600 kHz	923.3 MHz	8-13	DL channels

3.3.3.1.2 Table generation from equation

For custom configuration, a table register contains 8 **HEXA ASCII** characters, coded as such:

C7	C6	C5	C4	C3	C2	C1	C0
First channel		Total number of channels		Step width (*100kHz)		DR max	DR min

Detailed description of parameters:

parameter	description
First channel	First channel of the channel list. It can take value from range 0x00 to 0xFF (0 – 255) C0 = 902.000 MHz Cn = C0 + n * 0.1 MHz with 0 < n < 256 (n must be expressed in hexadecimal in register 250 to 256) C255 = 902.000 + 255 * 0.1 = 927.5 MHz
Number of channels	Channel number expresses the number of channel in the channel list. It can take value from range 0x00-0x40 (0 – 64) for uplink channel having 125 kHz bandwidth, 0x00 to 0x08 for uplink channel having 500 kHz bandwidth or downlink channel. Be careful: In **asymmetric** mode you can set up to 64 channels having 125 kHz bandwidth (0-63, DR0 to DR3) and up to 8 channels having 500 kHz bandwidth (64 to 71, DR4). In **symmetric** mode you can set up to 64 channels having 125 kHz bandwidth (0-63, DR0 to DR5)
Step width	Step width expresses the frequency interval between two consecutive channels. It can take the value from range 0x00 – 0x64 (0 – 100, expressed in 100's kHz)
DR max/min	DR range. For symmetric tables: - registers 250 through 256 can be used For asymmetric tables - registers 250 to 252 are used for DR0-3 (UL channels) - registers 253 & 254 are used for DR4 (UL channels) - registers 255 & 256 are used for DR8-13 (DL channels) **See ANNEX 3 for more details**

Examples:

1. **Set 64 uplink channels from 915.2 MHz to 927.8 MHz spaced by 200 kHz with data rate range from DR0 to DR3 (Bandwidth 125 kHz), the user should type in a terminal: ATS250=84400230<CR>**

   84_{hex} means first channel is C132 ➔ (915.2 – 902) / 0.1 = 132
   40_{hex} means 64 channels
   02_{hex} means 2 * 100 kHz of step width
   3_{hex} means DRmax = 3
   0_{hex} means DRmin = 0

2. **Set 5 uplink channels from 915.9 MHz to 922.3 MHz spaced by 1600 kHz with data rate range from DR4 to DR4 (Bandwidth 500 kHz), the user should type in a terminal: ATS253= 8B051044<CR>**

   $8B_{hex}$ means first channel is C139 ➔ (915.9 – 902) / 0.1 = 139
   05_{hex} means 05 channels
   10_{hex} means 16 * 100 kHz of step width
   4_{hex} means DRmax = 4
   4_{hex} means DRmin = 4

3. **Set 8 downlink channels from 923.3 MHz to 927.5 MHz spaced by 600 kHz with data rate range from DR8 to DR13 (Bandwidth 500 kHz), the user should type in a terminal: ATS255= D50806D8<CR>**

   $D5_{hex}$ means first channel is C213 ➔ (923.3 – 902) / 0.1 = 213
   08_{hex} means 08 channels
   06_{hex} means 06 * 100 kHz of step width
   D_{hex} means DRmax = 13
   8_{hex} means DRmin = 8

3.3.3.2 Manual mode

Manual mode is selected by setting bit 7 of LoRa Options register to 1 (see 3.3.5)
Symmetric or asymmetric mode can be selected through register 258 (see 3.3.12)

3.3.3.2.1 Default configuration:

Default configuration in manual mode is based on US table channels

Register Number	Symmetric DR0 to DR5 / 125kHz	Asymmetric DR0 to DR3 / 125kHz
250	902.3 923.5	UL 902.3 DL 923.3
251	x	x
252	x	x
253	902.7 923.9	UL 903.9 DL 923.9
254	x	x
255	903.1 903.3	UL 905.5 DL 924.5
256	x	x

3.3.3.2.2 Custom configuration

For custom configuration, a channel register contains 8 **HEXA ASCII** characters, coded as such:

C7	C6	C5	C4	C3	C2	C1	C0
Uplink channel frequency (Asymmetric mode) First channel frequency (Symmetric mode)				Downlink channel frequency (Asymmetric mode) Second channel frequency (Symmetric mode)			

User can set up to 7 couples of uplink/downlink channel in asymmetric mode whereas in symmetric mode up to 14 channels can be set.

Detailed description of parameters:

parameter	description
Frequency	Frequency can take value from range 0x9020 to 0x9279 expressed in BCD (Values 0x000A to 0x000F are forbidden)
DR	Data rate range is managed by LoRa stack. User can define uplink min data rate by setting register 206. ○ In asymmetric mode uplink data rate range is 0 (S206 convert in DR) to 4, downlink data rate range is 8 to 13 ○ In symmetric mode data rate range is 0 (S206 convert in DR) to 7 **See ANNEX 3 for more details**

Examples:

4. **Set channel 903.3 MHz and 926.4 MHz in register 250, the user should type in a terminal:**
   ATS250=90339264<CR>

   If band type is asymmetric, 903.3 MHz will be an uplink channel and 926.4 MHz will be a downlink channel
   If band type is symmetric, both are indifferently used as uplink or downlink channel

3.3.4 RX2 window configuration

These registers are locked. In order to be unlocked, the following command must be sent:
ATT63 ROOT<CR>

The second RX window, RX2 can be configured in a similar way as the channels, with a minor difference: a specific value of DR is enforced.

It can be accessed through the following register:

Register Number	Description	Default Value	Range / Values	Comment
257	RX2 configuration	1		US table

This register can contain 3 types of values:

Register value	Description
0	Channel deactivated
1	LoRaWAN default configuration
Other	User defined, will be taken into account **ONLY IF THERE IS NO CF LIST**. If the device is configured in OTAA and a CF list is transmitted by the network during OTAA, the CF list values will prevail

By default, RX2 contains the LoRaWAN parameters. If the register value is different from 0 or 1, RX2 has a custom configuration.

For custom configuration, the register contains 8 **ASCII** characters, coded as such:

C7	C6	C5	C4	C3	C2	C1	C0
Channel frequency in MHz x100 (Example: 902000 for 902.000MHz)						DR	

Channel frequency range is: [902000, 927900]

With the SF (C1 and C0) coded in the following way:

DR value	Description
08	Downlink - SF12 - 500 kHz
09	Downlink – SF11 - 500 kHz
10	Downlink – SF10 - 500 kHz
11	Downlink – SF9 - 500 kHz
12	Downlink - SF8 - 500 kHz
13	Downlink – SF7 - 500 kHz

Examples:

5. **Set RX2 frequency at 902MHz / DR11, the user should send:**
   ATS257=90200011<CR>

3.3.5 LoRa Options

These registers are locked. In order to be unlocked, the following command must be sent:
ATT63 ROOT<CR>

The LoRa Options can be configured through register S220.

Register Number	Description	Default Value	Range / Values	Comment
220	LoRa Options	0x00000001		

This register contains 4 bytes, coded as such:

Byte 1 (reserved)	Byte 2 (reserved)	Byte 3								Byte 4							
		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Byte 4		
Bit N°	Default value	Description
0	1	0 =ADR bit disabled 1 = ADR bit enabled
1	0	0 = Standard Rx windows timing 1 = Extend Rx windows timing for TEST HOUSE certification
2	0	0 = Duty cycle management OFF 1 = Duty cycle management ON
3	0	0 = Standard device 1 = Device emulate Gateway Tx On Rx2 (Class C test)
<5:4>	0	2 : Class C Device Other : Class A Device
6	0	0 : Default channel enable 1 : Default channel disable Band 868 only. NA for 915 band
7	0	0 : Automatic Rf config enable 1 : Automatic Rf config disable (Manual) Stack 4.3 only. NA if stack 4.1
8	0	0 : Join Auto repetition disable 1 : Join Auto repetition enable Stack 4.3 only. NA if stack 4.1

Note on ADR: If ADR is activated, the device will have no control over the SF as this parameter may be changed by the network (see 3.3.3). If ADR is deactivated, the SF value is the one contained in register S201.

Note on ADRACKReq: When the device has transmitted multiple frames but hasn't received any downlink (whether it's a generic downlink or an ACQ) from the server, enabling ADRACKReq will allow the device to try and "force" a downlink from the server when a certain amount of transmitted frames is reached. That way it can ensure that it is still connected to the network.

If an ADRACKReq is sent but the device still receives no answer, it will increase its SF value in order to increase the radio link budget. The goal is to re-establish a potentially lost connection between device and server.

3.3.6 UpLink port

These registers are unlocked

The LoRa UL port can be changed through register 383:

Register Number	Description	Default Value	Range / Values	Comment
383	UL port	1	1-223	

3.3.7 ACK request + Class

These registers are unlocked

Register 382 allows configuring the device for ACK requests as well as switching between LoRaWAN classes A & C.

When sending a frame to the network, the demonstrator can ask for an acknowledge (ACK) frame in return. When asking for an acknowledge frame, the device is configured in **CONFIRMED** mode. Otherwise, it is configured in **UNCONFIRMED** mode.

By default, the device is configured in Class A (communication is asynchronous and initiated by the device) and can be configured in Class C (device in continuous RX, communication can be initiated by the gateway)

Register Number	Description	Default Value	Range / Values	Comment
382	ACK request + Class	0x00	0x00 = Class A unconfirmed 0x01 = Class A confirmed 0x10 = Class C unconfirmed 0x11 = Class C confirmed	All other values are RESERVED

3.3.8 Transmission periodicity

These registers are unlocked

Frames can be transmitted automatically by the device. The transmission periodicity in seconds can be set through the following register:

Register Number	Description	Default Value	Range / Values	Comment
380	Frame TX periodicity	20	0-86400	In seconds

⇨ If the register is set to 0, periodic transmission is disabled. Frames can only be sent by pressing BTN1

3.3.9 Accelerometer

These registers are locked. In order to be unlocked, the following command must be sent:
ATT63 ROOT<CR>

The device's accelerometer is configured by default to trigger whenever the device is shaken by hand. However, its configuration can be modified to suit the user's application. Two parameters can be changed:

- The full scale, i.e. the maximum acceleration that the accelerometer will be able to detect
- The detection threshold, i.e. the acceleration level above which the accelerometer will trigger

This can be done through registers 340 & 341:

Register Number	Description	Default Value	Range / Values	Comment
340	Full scale	8	2 to 16	Unit in g
341	Detection Threshold	2000	0 – (Full scale x 1000)	Unit in mg

The accelerometer can be deactivated or activated through register 330:

These registers are unlocked

Register Number	Description	Default Value	Range / Values	Comment
330	Accelerometer activation	0x0001F007	0x0001F007 = Activate accelerometer 0x0001F003 = deactivate accelerometer	All other values are RESERVED

3.3.10 GPS configuration

These registers are unlocked

The demonstrator contains a GPS which can be configured through register 371:

Register Number	Description	Default Value	Range (Min-Max)	Comment
371	GPS configuration	0x00000000		

The following values can be used:

Value	Description
0x00000000	GPS deactivated
0x00000001	GPS activated / CONTINUOUS mode
0x00000101	GPS activated / CONTINUOUS mode + GPS reset (Cold Start)
Other values	RESERVED

3.3.11 Payload format

These registers are unlocked

The FTD V2 is payload-compatible with the previous version of this product (called LoRaWAN/SigFox demonstrator). If desired, the payload format can be changed to add new information to it. This can be done through register 370:

Register Number	Description	Default Value	Range (Min-Max)	Comment
370	Payload format	0x00	0x00 = legacy format 0x01 = FTD format	

⇨ FTD format adds a GPS STATUS byte (byte 11) after the GPS coordinates. See 4 for more details.

3.3.12 Band type

These registers are locked. In order to be unlocked, the following command must be sent:
ATT63 ROOT<CR>

Regional frequency bands can be selected through register 258:

Register Number	Description	Default Value	Range (Min-Max)	Comment
258	Band Type	1	0-3	

Band type	Description
0	EU 868 (symmetric band)
1	915 symmetric band
2	915 asymmetric band
3	915 hybrid asymmetric band 8 uplink channels and 8 downlink channels

More details on the datarates associated with those bands can be found at ANNEX 3.

4 Payload description

The payload is divided in two frames in order to comply with TOA restrictions

4.1 Frame 1

Byte N°		Description
1		Bit 7 = 1 : 0 Bit 6 = 1 : accelerometer was triggered Bit 5 = 1 : BTN1 was triggered Bit 4 = 1 : GPS info is present Bit 3 : 0 Bit 2 : 0 Bit 1 : 0 Bit 0 : 0
2	b[7..4]	BCD coding of the integer part of Latitude's degrees (tens of degrees)
	b[3..0]	BCD coding of the integer part of Latitude's degrees (units of degrees)
3	b[7..4]	BCD coding of the integer part of Latitude's minutes (tens of minutes)
	b[3..0]	BCD coding of the integer part of Latitude's minutes (units of minutes)
4	b[7..4]	BCD coding of the decimal part of Latitude's minutes (tenths of minutes)
	b[3..0]	BCD coding of the decimal part of Latitude's minutes (hundredths of minutes)
5	b[7..4]	BCD coding of the decimal part of Latitude's minutes (thousandths of minutes)
	b[3..0]	B[3..1] = unused B0 = coding of hemisphere : 0 = North, 1 = south
6	b[7..4]	BCD coding of the integer part of Longitude's degrees (hundreds of degrees)
	b[3..0]	BCD coding of the integer part of Longitude's degrees (tens of degrees)
7	b[7..4]	BCD coding of the integer part of Longitude's degrees (units of degrees)
	b[3..0]	BCD coding of the integer part of Longitude's minutes (tens of minutes)
8	b[7..4]	BCD coding of the integer part of Longitude's minutes (units of minutes)
	b[3..0]	BCD coding of the decimal part of Longitude's minutes (tenths of minutes)
9	b[7..4]	BCD coding of the decimal part of Longitude's minutes (hundredths of minutes)
	b[3..0]	B[3..1] = unused B0 = coding of hemisphere : 0 = East, 1 = West
10	b[7..4]	DOP range (1-3) ** 1 = good accuracy / 3 = poor accuracy
	b[3..0]	Number of satellites tracked (0-15)

- **Note 1**: if the accelerometer was triggered, the *LinkCheckRequest* that results is included in the frame (MAC payload)
- **Note 2**: if no GPS coordinate is available, only the first byte is sent
- **Note 3**: if no GPS coordinate is available and transmission was generated from periodic transmission mode (no BTN1, no accelerometer), only the first byte is sent and its value will be 0x00.

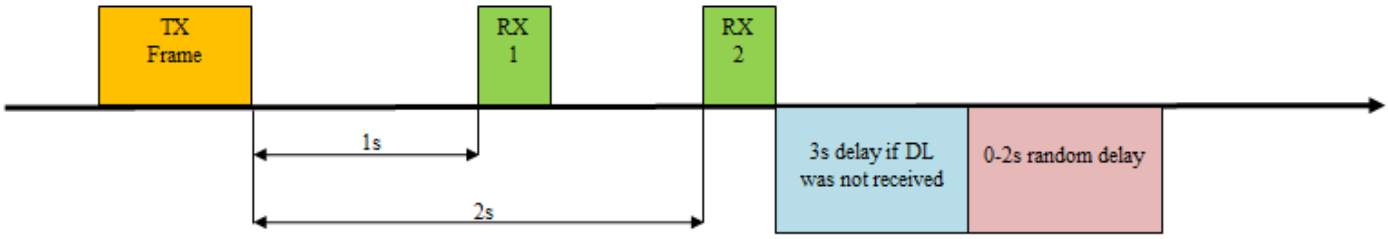
4.2 Frame 2

Byte N°	Description
1	Bit 7 = 1 : T°C info is present Bit 6 = 1 : accelerometer was triggered Bit 5 = 1 : BTN1 was triggered Bit 4 = 0 Bit 3 : MAC Down Counter is present Bit 2 : MAC up Counter is present Bit 1 = 1 : Battery voltage information is present Bit 0 : RSSI + SNR information is present
2	Temperature in °C, signed in two's complement
3	Uplink frame counter
4	Downlink frame counter
5	MSB Battery voltage (in mV)
6	LSB Battery voltage (in mV)
7	RSSI (dB, absolute value)
8	SNR (dB, signed in two's complement)

- **Note 1**: if the accelerometer was triggered, the *LinkCheckRequest* that results is included in the frame (MAC payload)

ANNEX 1: LoRa Cycle

The following diagram shows a simplified description of a LoRa cycle:



ANNEX 2: RSSI and SNR

The uplink frame contains information about the RSSI and the SNR of the previous DL.

- RSSI

The RSSI value is the actual absolute value in dB. It is in fact a negative number.

Example: if the value is 100, this means that the RSSI is -100 dBm

- SNR

The SNR value is a signed value in two's complement, ranging from -128 to +127

Values from 0 to 127 are positive values: 0=0; 1=1; 2=2…
Example: if the value is 10, the SNR is +10dB

Values from 255 to 128 are negative values: 255=-1; 254=-2; 253=-3…
Example: if the value is 251, the SNR is -5dB

ANNEX 3: Band types

- **Symmetric bands**

In symmetric band mode the set of data rate is the following:

DR value	Description
0	SF12
1	SF11
2	SF10
3	SF9
4	SF8
5	SF7
6	SF7 – BW 250kHz
7	FSK 50 kbps

- **Asymmetric bands**

In asymmetric band mode the set of data rate is the following:

DR value	Description
0	Uplink - SF10 - 125 kHz
1	Uplink - SF9 - 125 kHz
2	Uplink - SF8 - 125 kHz
3	Uplink - SF7 - 125 kHz
4	Uplink - SF8 - 500 kHz
5	RFU
6	RFU
7	RFU
8	Downlink - SF12 - 500 kHz
9	Downlink – SF11 - 500 kHz
10	Downlink – SF10 - 500 kHz
11	Downlink – SF9 - 500 kHz
12	Downlink - SF8 - 500 kHz
13	Downlink – SF7 - 500 kHz
14	RFU
15	RFU

- **Asymmetric bands – Hybrid mode**

Hybrid mode is actually only used by USA or AUSTRALIA.
In this mode 6 to 8 channels are used to transmit uplink messages and 6 to 8 channels are used to receive downlink messages.

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