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# ARM-NANO ARM-N8-LW

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## UserGuide



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## I. GENERALITIES

### A. PRESENTATION

In order to answer the more accurately to various user challenges, ATIM started a new device family called Nano-Modules composed of different modules using state of the art technologies like Ultra Narrow Band (UNB), Narrow Band (NB) and Chirp Spred Spectrum (CSS). This family has been developed for users requiring high communication range.

In fact, all the ARM-N8Lx devices have a range further than 22 km in open field, the ARM-N8LORA exceeds 25 km and the ARM-N1LD (169Mhz) goes over 40 km. Some modules can also benefit an extended range with the repeater functionality.

ARM-N8LP/LD have double functionality, they can be used in local mode (P2P) (ISM network) and/or in SIGFOX networks (SIGFOX™ network). ARM-N8LORA can also be used in two mode, point to point LoRa communication or FSK local mode (P2P).

Every module is optimized to get the lowest power consumption possible, allowing users to develop battery powered devices. With the right batteries and configuration, a module can be used up to 10 years without changing batteries.

Every module are pin to pin compatible, allowing users to get different communication possibilities without having to redesign their hardware.

### B. GENERAL INFORMATIONS

#### General information :

- Frequency: 865-870MHz
- RF data rate: 100 to 1200 bps
- Modulation: CSS (LORA)
- Output power: 2 to 14 dBm
- Sensitivity: -142 dBm
- Link budget: 161dB
- Range up to: 25km
- Interface: UART
- Dimensions: 30mm x 18mm
- Certified: EN 300 220 V2.4.1
- Operating temperature: -20°C / +70°C
- LBT AFA

#### Typical application:

- Internet Of Things (IoT)
- Environment,
- Intelligent structures,
- Telemetry,
- Alarm and wireless security systems,
- M2M,
- Remote sensors,
- Remote control



## C. REGULATION ASPECTS

### 1. Radio frequency

The Table 1 shows sub-band frequencies in the 868 MHz band for "short range non specifics devices" specified in the recommendation ERC 70-03, [2].

Table 1: Power distribution in 868 band

Frequency Band		Power/Magnetic Field	Spectrum access and mitigation requirements	Modulation/ maximum occupied bandwidth	ECC/ERC Decision	Notes
g1	863-870 MHz (notes 3 and 4)	25 mW e.r.p.	$\leq 0.1\%$ duty cycle or LBT (notes 1 and 5)	$\leq 100$ kHz for 47 or more channels (note 2)		FHSS
		25 mW e.r.p. Power density: -4.5 dBm/100kHz (note 7)	$\leq 0.1\%$ duty cycle or LBT+AFA (notes 1, 5 and 6)	No spacing		DSSS and other wideband techniques other than FHSS
		25 mW e.r.p.	$\leq 0.1\%$ duty cycle or LBT+AFA (notes 1 and 5)	$\leq 100$ kHz, for 1 or more channels modulation bandwidth $\leq 300$ kHz (note 2)		Narrow /wide-band modulation
g1.1	868-868.6 MHz (note 4)	25 mW e.r.p.	$\leq 1\%$ duty cycle or LBT+AFA (note 1)	No spacing, for 1 or more channels (note 2)		Narrow / wide-band modulation No channel spacing, however the whole stated frequency band may be used
g1.2	868.7-869.2 MHz (note 4)	25 mW e.r.p.	$\leq 0.1\%$ duty cycle or LBT+AFA (note 1)	No spacing, for 1 or more channels (note 2)		Narrow / wide-band modulation No channel spacing, however the whole stated frequency band may be used
g1.3	869.4-869.65 MHz	500 mW e.r.p.	$\leq 10\%$ duty cycle or LBT+AFA (note 1)	No spacing, for 1 or more channels		Narrow / wide-band modulation The whole stated frequency band may be used as 1 channel for high speed data transmission
g1.4	869.7-870 MHz (note 11)	5 mW e.r.p. 25 mW e.r.p.	<u>No requirement</u> $\leq 1\%$ duty cycle or LBT+AFA (note 1)	No spacing for 1 or more channels		Narrow / wide-band modulation No channel spacing, however the whole stated frequency band may be used

## 2. Information about the conformity regulation

Utilization of radio frequencies is limited by national regulations. Radio modules are conceived to follow the R&TTE (Radio & Telecommunications Terminal Equipment) directive 1999/5 / CE from European Union, and can be freely used in European Union. Nevertheless, restrictions regarding RF power or duty cycle can be applied.

The ARM-N8-LD/LP is a radio module conceived to be integrated in another products, often final products. According to the R&TTE directive, the final product producer is responsible of the conformity declaration for this product. The ARM-N8xx module conformity declaration is available on demand at ATIM, however, it does not cover the product where it is integrated in.

Regulation requirements can change, ATIM does not take responsibility of the exactitude and precision aforementioned.

Legislation and national regulations, just as their interpretation can vary accordingly to the country. In case of uncertainty, it is recommended to contact ATIM or to consult local authorities in the concerned country.





## D. LORAWAN

LoRa™ is a high range, low power consumption and low datarate wireless modulation developed by Semtech, and after, supported by LoRa Alliance. LoRaWan stack is mainly developed for battery powered devices, either fixed or mobile. It is optimized for the Internet Of Things (IOT).



Figure 1: LoRa Logo



Figure 2: Semtech Logo

### 1. Generalities

Just for the record, LoRaWan protocol is still young and evolve quickly. There is constantly modifications and adaptations to realize in order to follow these evolutions. Furthermore, with the quick start and development of the LoRa Alliance, LoRaWan protocol changed its name from LoRaMac to LoRaWan. This change is not yet effective everywhere, it is possible to found documents with term LoRaMac or Mac.

LoRaWan network is typically in a Star to Star topology, see Figure 3. Gateways<sup>1</sup> pass messages between end devices and central server network (often on the internet). Gateways are connected to the network with a standard IP connection, whereas endpoints uses single hopping communication to join one or more gateways. Every communication are usually bidirectional, even if uplinks<sup>2</sup> are more frequently used than downlinks<sup>3</sup>.

Figure 3 shows Stars to Stars topology, in this example, network extremities are end devices, and those are linked to gateways to relay information to a central server network on the Internet.

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<sup>1</sup> Gateway: also know under the name of concentrator or base station.

<sup>2</sup> Uplink: communication from end device to the Internet.

<sup>3</sup> Downlink: communication from the Internet to an end device.

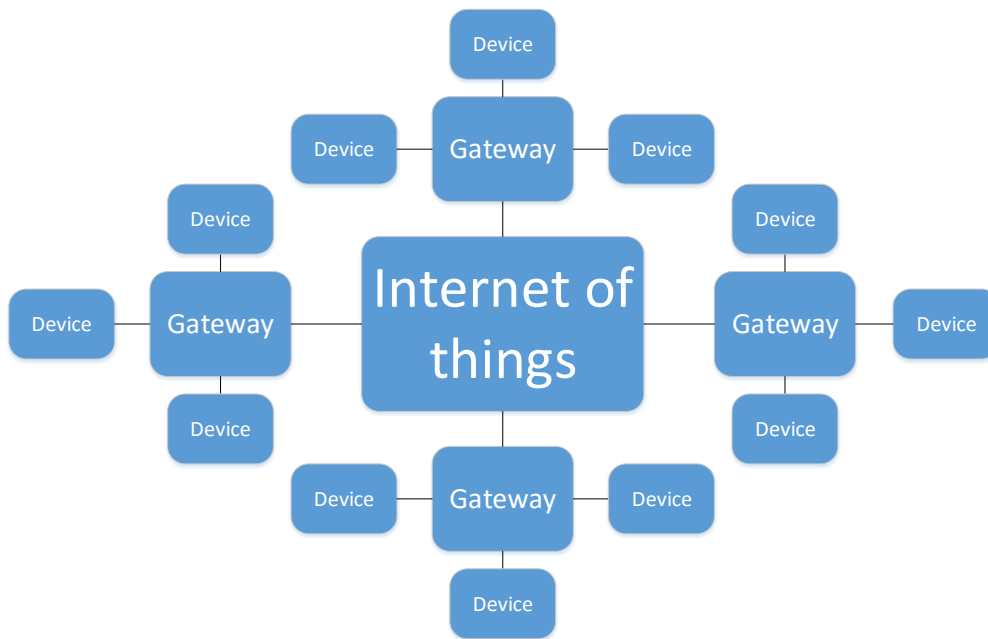


Figure 3 : Stars of Stars topology

Communication between the endpoint and concentrator is possible on different frequency channels and uses different spreading factors. The channel is chosen randomly between those available, command sent by concentrator can add new channels if needed. The choice of a spreading factor is a compromise between communication range and data rate, lower data rate will achieve higher communication range. The data rate goes from 0,3 Kb/s to 50 Kb/s. To optimize battery lifetime and network overload, network infrastructure automatically adapts spreading factor and emission power for each endpoint individually, following an Adaptive Data Rate scheme (ADR).

LoRaWan protocol defines three device classes, A, B and C. This diversity allows an answer adapted to every need. All devices implement at least functionalities of a class A device.

- **Bidirectional endpoint (Class A):**

Class A endpoint allows bidirectional communication with the applicative layer by opening two receive windows (Rx1 and Rx2) after each emission, see Figure 4.

Receive windows allows the endpoint to receive downlink communication.

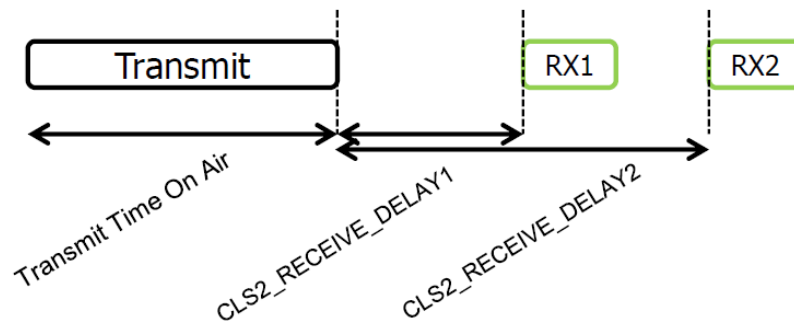


Figure 4: Class A endpoint radio scheme

- **Bidirectional endpoint with programmed receive windows (Class B):**

Class B endpoint follows Class A behaviour with the functionality to open receive windows at a precise time. This windows are based on temporal information given by the network structure.

- **Bidirectional endpoint with continuous reception (Class C):**

Class C endpoint follows Class A behaviour on top of continuous listening on a channel. It allows endpoint with continuous power supply to be in a continuous reception when it is not emitting an uplink, see Figure 5.

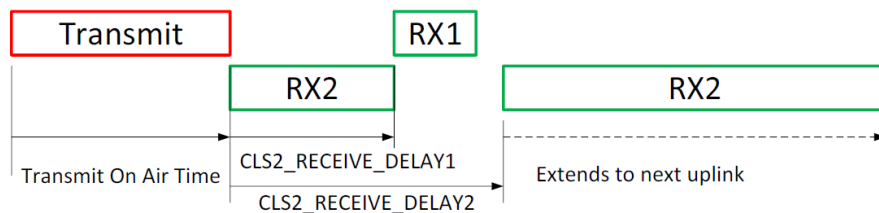


Figure 5 : Class C endpoint radio scheme

## 2. Modulation

LoRa modulation is based on CSS<sup>4</sup> type. It uses Chirp<sup>5</sup> on a wide band to communicate.

Like other wide spectrum modulation, CSS use all the band allocated. It make the communication more resistant to channel noises, and to multipath fading, even for low power emission.

An Up-Chirp example is available on Figure 6. Figure 7 shows typical emission pattern for a LoRa modulation.

<sup>4</sup> CSS: Chirp Spread Spectrum.

<sup>5</sup> Chirp: signal where frequency increased or decreased with time, also called Up-Chirp et Down-Chirp.

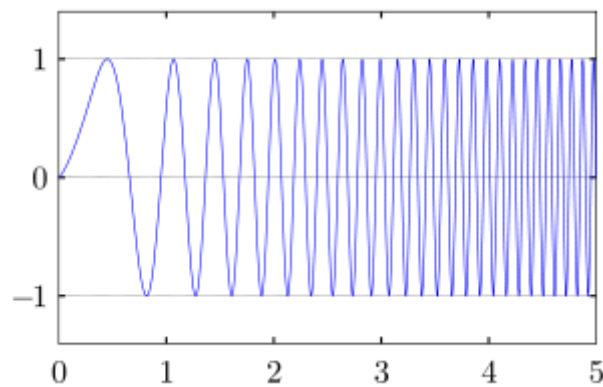


Figure 6 : Modulation Up-Chirp

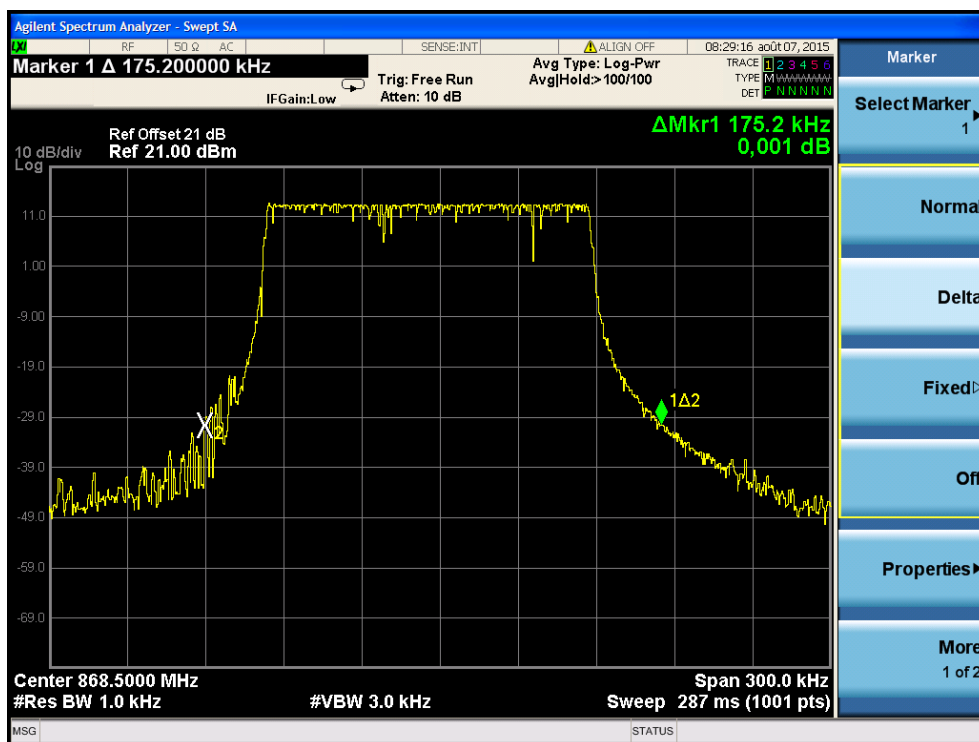


Figure 7 : Gabarit d'une émission en modulation LoRa

### 3. Communication

LoRaWAN protocol allows two types of communication, allowing users to choose between Un-Confirmed or Confirmed frame. The choice should be made accordingly to the application wished.

- **UnConfirmed frame:**

This type of frame does not need an acknowledgment. It means that the endpoint will emit the message the number of times it is configured to. If the message is lost there will be no re emission.

- **Confirmed frame:**

This type of frame need an acknowledgment. It means that the endpoint will emit the message and wait for an acknowledgment. If it does not received one, it will restart a cycle, sending the frame again and waiting for the acknowledgment. The cycle will be repeated up to the number of time it is configured to.

It allows a certain level of security in the communication, to avoid information loss.



## II. TECHNICAL CHARACTERISTICS

### A. DIMENSIONS

For every ARM-Nx-xxx module, the dimensions are the same. They also share the same footprint except for the ARM-N8-LoRaWan.

Figure 8 shows the ARM-N8-LoRaWan module dimension. Its footprint is available in Figure 9, all dimensions are in mm. Figure 13 in part III.C is the same as Figure 9 in a more readable size.

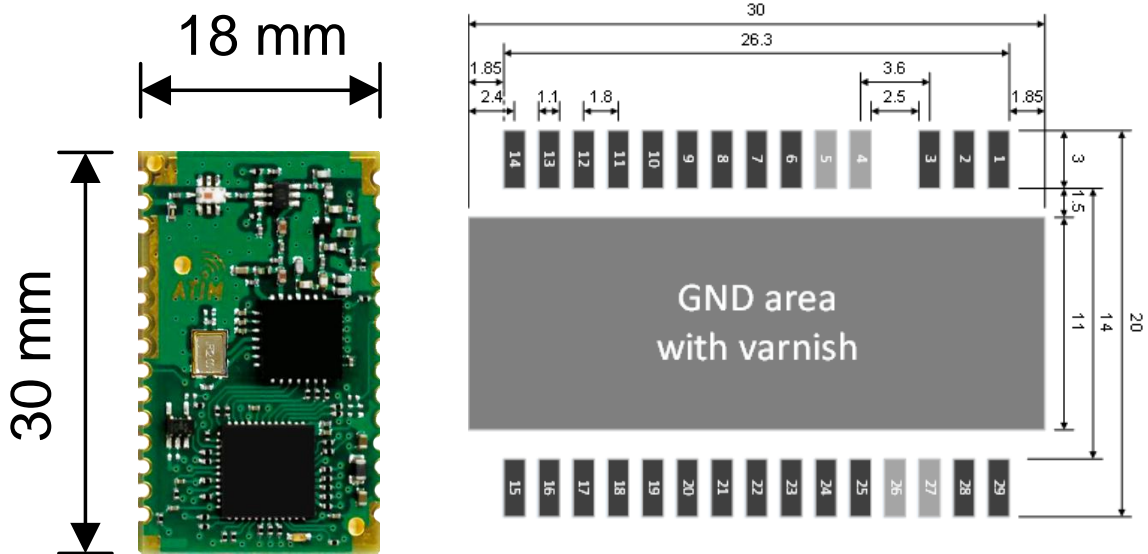


Figure 9: Module footprint

Figure 8: Module dimensions

### B. PINOUT

The Table 2 display pin affectation accordingly to the layout on Figure 9. Currently some pins are reserved for future functionality development.

Table 2: Pinout

Pin	Name	I/O	Function
1	AGND	-	Ground (1)
2	ANTENNA	I/O	RF signal
3	AGND	-	Ground (1)
4	RESERVED	-	NC
5	RESERVED	-	NC

Pin	Name	I/O	Function
6	AGND	-	Ground (1)
7	RESERVED	-	NC
8	RESERVED	-	NC
9	RESERVED	-	NC
10	RESERVED	-	NC
11	RESERVED	-	NC
12	RESERVED	-	NC
13	INT0	I	Interrupt input
14	DGND	-	Ground (1)
15	DGND	-	Ground (1)
16	VDD	-	Alimentation
17	WAKE-UP	I	Wake-up input: VCC to activate the module, ground to sleep Has to be connected to VCC to run the device
18	U1CTS	I	Clear to send UART (TBD)
19	U1RTS	O	Req. to send UART (TBD)
20	U1RX	I	RX UART
21	U1TX	O	TX UART
22	RESERVED	-	NC
23	RESERVED	-	NC
24	RESET	I	Has to be connected to the MCU Can be NC if not used
25	AGND	-	Ground (1)
26	RESERVED	-	NC
27	RESERVED	-	NC
28	AGND	-	Ground (1)
29	AGND	-	Ground (1)

(1) Every pin AGND and DGND have to be connected to the ground.

## C. ELECTRICAL FEATURES

(TBD)

Following values for electrical features are not the final ones. They are measured on the preliminary batch and will be adjusted accordingly to future batches.



Table 3: Electrical ratings

		Min.	Typ.	Max.
Alimentation(Vdd)		3V	3.3V	3.6V
Consumption (Vdd = 3.3V)	Tx / 14dBm	45 mA	50 mA	60 mA
	Rx	16 mA	18 mA	25 mA
	Veille	0.5 $\mu$ A	0.6 $\mu$ A	0.9 $\mu$ A
Input voltage		Gnd	-	0.2 x Vdd
Output voltage		0.8 x Vdd	-	Vdd

## D. COMMUNICATION INTERFACE

- UART Tx/Rx (600 – 230400 bps)
- UART Tx/Rx + RTS/CTS (TBD)
- SPI slave ( $\leq 16$ MHz) (TBD)
- Analogic input (one) (TBD)
- Analogic output (one) (TBD)
- General I/O (three) RESERVED (TBD)

## E. FUNCTIONING MODE

- Transparent bridge « UART/RF bridge »
- Transparent bridge « SPI/RF bridge » (TBD)
- Modbus (TBD)
  - Slave (TBD)
  - Master (TBD)
- AT command
  - Local
  - Distant (TBD)
- Tests mode:
  - Ping-pong (TBD)
  - Continuous Rx LoRa (TBD)
  - Continuous Tx LoRa (TBD)
  - Single Tx LoRa (TBD)
  - Continuous Rx LoRaWan (TBD)
  - Continuous Tx LoRaWan (TBD)
  - RSSI reader

## F. FIRMWARE UPDATE (TBD)

(TBD)

Preliminary version will not be subject to firmware upgrade.





Future version will be upgradable with the bootloader through UART. Last firmware version will be available on demand.

## G. RADIOFREQUENCY CHARACTERISTICS

Spreading factor can be configured from 12 to 7. It is a compromise between radio range and data rate. A spreading factor of 12 will reach higher range at a cost of a slower data rate, one of 7 will achieve higher data rate with a smaller range.

Rf output power can be chosen from 2 to 14 dBm. With higher output power, the device will reach longer range but will consume more energy.

Currently, the bandwidth is always 125 kHz, LoRaWan forecast some evolution with 250 kHz and 500 kHz.

Currently, the coding rate used is always 4/5. LoRa modulation authorize coding rate from 4/5 to 4/8, future LoRaWan evolution may be using them.

Three channels are always available, LC1: 868.1MHz, LC2: 868.3MHz and LC3: 868.5MHz. Others can be loaded via Gateway MAC command.

## H. DELAYS

(TBD)

Following delays values are not available. They will be measured with future batches.

Table 4: Timing table

		Delay
Boot	-	(TBD)
UART buffering	-	(TBD)
UART input to Tx output	LoRaWan	(TBD)
	LoRa	(TBD)
	FSK	(TBD)
Rx input to UART output	LoRaWan	(TBD)
	LoRa	(TBD)
	FSK	(TBD)
Radio transition time	Tx-Rx or Rx-Tx	(TBD)
Command mode	Entering AT (+++)	(TBD)
	Quitting AT (ATQ)	(TBD)
	Reset (ATR)	(TBD)



Sleep mode	Entering (logic '0' on WakeUp pin)	(TBD)
	Quitting (logic '1' on WakeUp pin)	(TBD)
Bootloader	Firmware up to 64 KB	(TBD)

## I. MEMORY

### 1. Memories

There are three different memories, the RAM, the EEPROM and the Flash.

The parameters that are used by the device are stored in the RAM. Access is faster but everything is lost when switched off. It is used by the device to store parameters when running.

EEPROM as a slower access but is able to keep parameters even after it is switched off. It's used to store parameters/configuration for the device.

The Flash is a read only memory. It's used to store firmware and factory configuration to restore parameters if needed.

Table 5 display the global memory organization. Flash size is 64 KB, RAM size is 10 KB and EEPROM size is 2 KB.

Table 5: Global memory organization

Function	Memory type	Capacity (Bytes)
Firmware	Flash	64k
AT parameters saved (ATM, ATO, IDs)	EEPROM	-
AT parameters used (ATM, ATO, IDs)	RAM	-
Buffer UART Rx	RAM	256
Buffer UART Tx	RAM	512
Buffer Radio Rx	RAM	128
Buffer Radio Tx	RAM	512
Buffer command mode Rx	RAM	128
Buffer command mode Tx	RAM	512

### 2. Data

There are three main structures of data in memory: the device configuration, user parameters, and the IDs.



The device configuration is accessible in Read/Write by ATM command (M). It is mainly used to store device configuration, like parameters defining if it's configured to use LoRa or LoRaWan radio, to choose the LoRaWan class, to configure UART transmission, etc.

User parameters are accessible in Read/Write by ATO command from 75 to 96 (O Param). Mainly used to configure radio parameters like spreading factor, emission power, channel, and activate Rx windows, ADR, duty cycle, etc.

IDs are accessible in read only by ATO command from 0 to 74 (O IDs).

### 3. Organization

The memory footprint is visible in the Figure 10. It explains how all the structures are stored, and how they can be accessed. It also shows data flows with the different commands explained in the part 4 "How does it work?"

### 4. How does it work?

The device uses RAM structure.

EEPROM structures are used to store user configuration. They are loaded in RAM structure each time the device boots up. Therefore, EEPROM structures are used to initialize and configure the device at every boot.

The structures can be accessed with AT commands

An ATM command will change the corresponding parameter value in the RAM structure.  
ATMS command is the only way to save this structure in EEPROM

An ATO command will change the corresponding parameter value in the RAM structure.  
ATOS command is the only way to save this structure in EEPROM

Factory settings can be restored with ATF command; it will load EEPROM structure with the one configured in Flash. IDs aren't changed by this command.

User can restore EEPROM structure in RAM, or save the RAM structure in EEPROM with command ATMS, ATMR, ATOS and ATOR. It allows to test a configuration, change RAM values and saving it after in EEPROM all parameters at once, or restoring EEPROM configuration if needed.



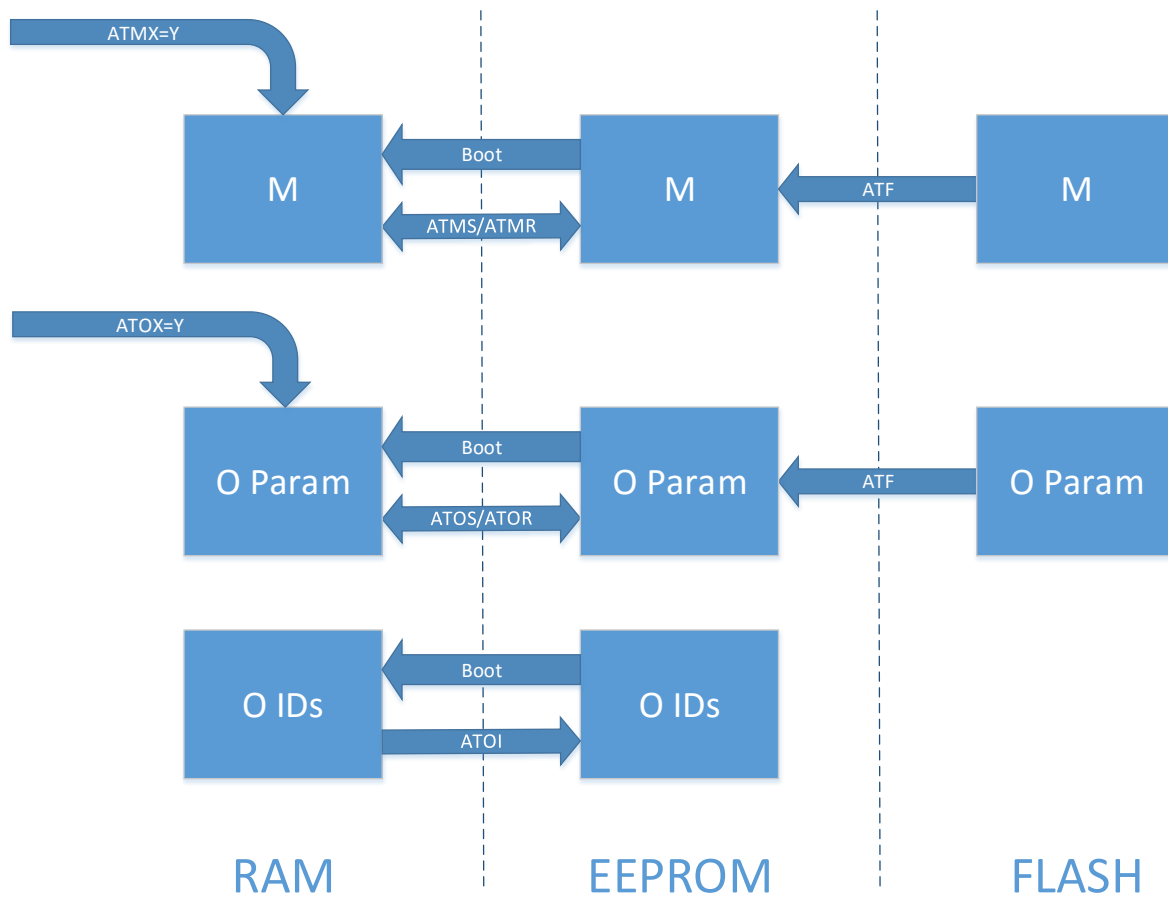


Figure 10: Memory access and organization

### III. HARDWARE INTEGRATION

#### A. ALIMENTATION

Module alimentation is between 3V and 3.6V. To assure correct alimentation, the LC filter visible in Figure 11 has to be placed the closest to Vdd pin.

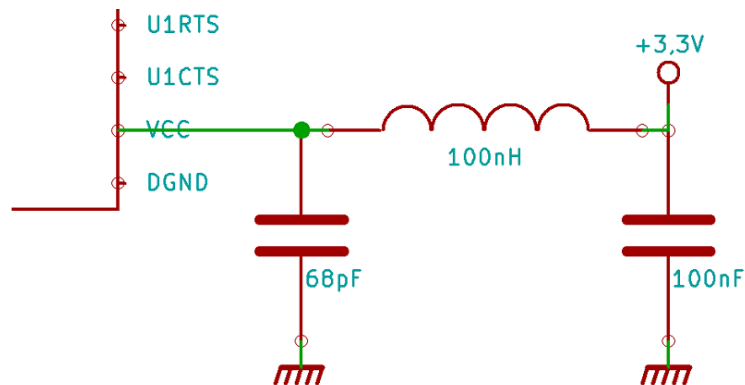


Figure 11 : Alimentation filter

#### B. IMPEDANCE ADAPTATION FOR ANTENNA PATH

Passive components to integrate between antenna and RF module pin vary in function of the path length, dielectric and antenna. ATIM will help you to choose your antenna accordingly to the wanted performances.

Main solutions are an SMA connector to mount the antenna, or directly using an electric wire of 8.5 cm soldered to the PCB.

Quick development can use a serial capacitor of 68 pF. Other components are not mounted.

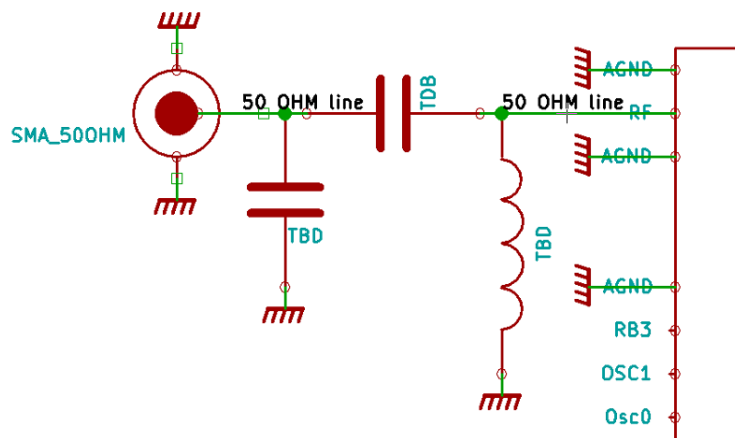


Figure 12: Impedance adaptation

### C. MODULE FOOTPRINT AND GROUND-PLAN

It is recommended to cover the entire surface under the ARM-Nx module with a ground plan. This surface has to be varnished to avoid any short circuit. It is strongly not recommended to use via in this surface.

Figure 13 show both footprint and ground plan, all dimensions are in mm.

Pins 4, 5, 26 and 27 are reserved for ATIM purpose. Users do not need to print their footprint.

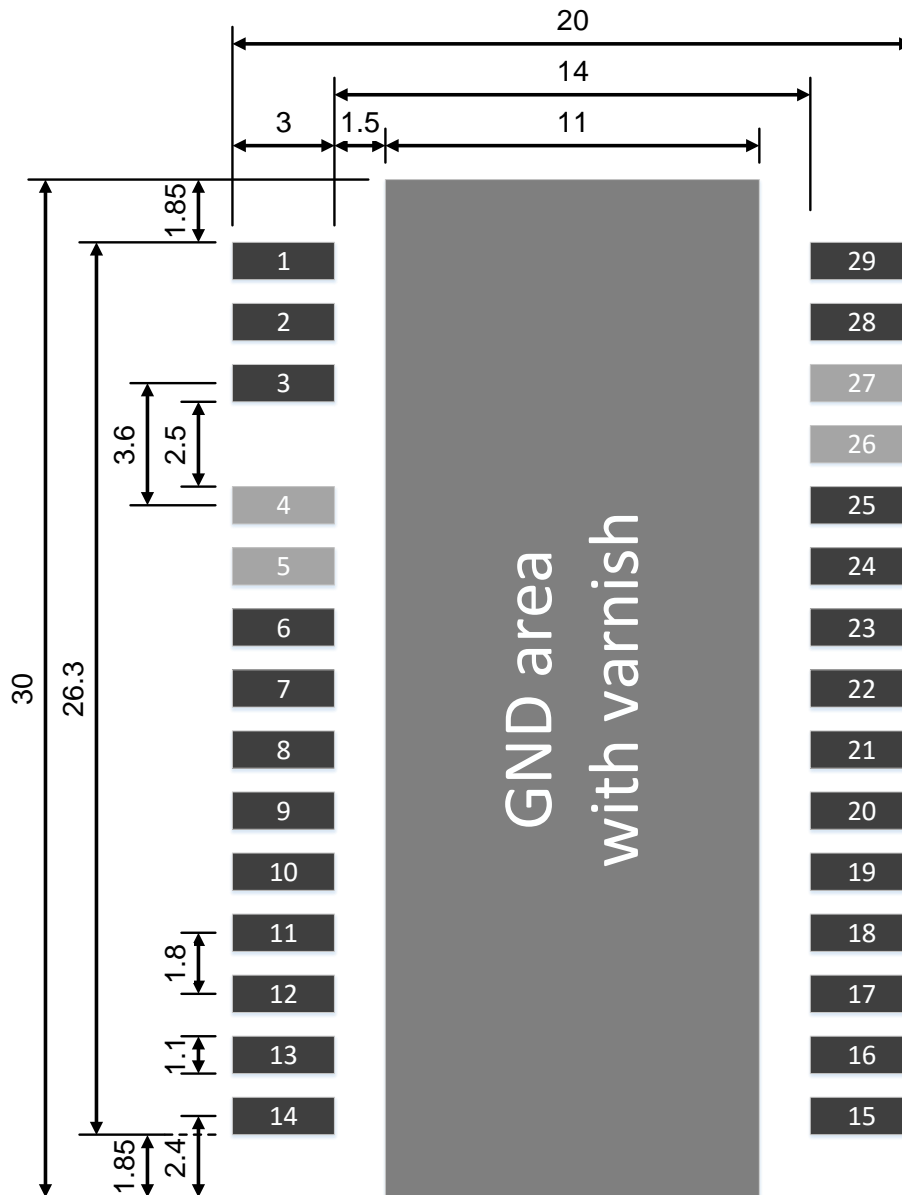


Figure 13: Module footprint and ground plan

## IV. DEVICE FUNCTIONNEMENT

### A. ORGANISATION

There is three functioning state for the device,

- Normal functioning mode
- Command mode
- Test mode

At boot, the device will be in normal functioning mode.

Command mode is used to modify device parameters and configuration with AT commands.

Test mode is used to execute some various tests.

### B. BUFFER INFORMATION

Buffer sizes are available in Table 5 page 18.

Every data entering the Rx Uart will be redirected into buffer corresponding to the current mode, Tx Radio or Rx AT.

Every data received by radio (Rx Radio) and coming from the command mode (Tx AT) will be redirected on the Tx Uart.

Uart Rx buffer can accept up to 256 Bytes. If user overflow the buffer, there will be data lost. Data flow control CTS/RTS should be implemented in a future version.

Radio Tx buffer can stack up to 32 messages for a maximum size of 512 Bytes (sum of every messages). If user overflow one of them, there will be data lost. This issue will be corrected in a future version.

AT Rx can only stack one AT command at the time, up to 128 Bytes. If an AT command arrive while the operation of the previous one is not done yet, the last one entered will be lost.



## C. NORMAL FUNCTIONING MODE

### 1. Transparent UART/Rf BRIDGE

In this mode, incoming data on the Rx UART pin are packetized with LoRaWan headers in order to be sent by radio. The payload received and available on the gateways is the same as the previous one entering UART.

In this mode, every other demand to send a frame will be ignored and discard until the previous emission cycle is finished. However, command mode can be accessed by sending the command '+++ ' as a burst frame on the UART, every command entered will be taken even if the emission cycle is not finished.

### 2. SPI / Rf BRIDGE Slave

(TBD)

### 3. MODBUS Slave

(TBD)

### 4. MODBUS Master

(TBD)

## D. COMMAND MODE

Every data entering the UART will be considered to be an AT command.

### 1. Parameters

UART default parameters are: 19200bps, 8 bits data size, no parity, 1 stop bit, no flow control, end of frame is configured to be detected after a void corresponding to the time of three characters (minimum time is 1 ms).

Entering command mode can be done in two ways:

- Sending three '+' characters consecutively when the device is in normal mode. This method will send the two first characters by radio.
- Sending three '+' characters in one frame when the device is in normal mode. This method does not send the first two characters by radio.

Parameters used are those in RAM. At boot, device loads EEPROM parameters in RAM. To use EEPROM parameters reset the device.





## 2. AT COMMAND

Table 6: AT command list

Command	Function
+++	Enter in AT command mode.
ATQ + ENTER	Exit AT command mode.
ATR + ENTER	Reset MCU.
ATM'XXX' + ENTER	Read MXXX register, XXX decimal value.
ATM'XXX'='YY' + ENTER	Write MXXX register, XXX decimal value, YY hexadecimal value, Write in RAM structure.
ATMS	Save ATM structure from RAM to EEPROM.
ATMR	Restore ATM structure from EEPROM to RAM.
ATO'XXX' + ENTER	Read OXXX register, XXX decimal value.
ATO'XXX'='YY' + ENTER	Write OXXX register, XXX decimal value, YY hexadecimal value, Write in RAM structure.
ATOS	Save ATO user parameters structure from RAM to EEPROM.
ATOR	Restore ATO user parameters structure from EEPROM to RAM.
ATF + ENTER	Restore factory parameters for ATM and ATO structure. Does not change IDs. It is best to restart module with ATR or by hardware connection for some parameters to take effect, (eg: module configuration)
ATV + ENTER	Return module version, DevEUI (LSB first), LoRaWan version.
ATL'XXX' + ENTER	List parameters for a structure. XXX can be: O to list ATO user parameters structure and IDs, M to list ATM structure,
ATT'XX'	Launch test mode XX, XX hexadecimal value.
AT\$SB='X'	Send X as a frame, X can be 0 or 1.



Command	Function
AT\$SF='XXX'	Send XXX as a frame, XXX can be the size of a normal frame.

## E. TEST MODE

Test mode allows you to use various functions in order to test the device, or the network.

To launch a test mode enter in command mode with '+++'. Choose the test mode with ATTxx ('xx' in hexadecimal). Send any characters to start the test. If this is a continuous test, it can be stopped by sending any character. Quitting a test mode voluntarily or after its execution, device is still in command mode.

It is recommended to restart the device after using a test mode that used the radio.

Available test modes are displayed in Table 7.

Table 7: Test mode list

ATT	Test mode
00	No Test mode
01	Ping-Pong Master (TBD)
02	Ping-Pong Slave (TBD)
03	Continuous Rx LoRa (TBD)
04	Continuous Tx LoRa (TBD)
05	Mono Tx LoRa (TBD)
06	Continuous Rx LoRaWan (TBD)
07	Continuous Tx LoRaWan (TBD)
08	Battery level (TBD)
09	Nothing
0A	Continuous RSSI reader

### 1. Ping-pong (ATT01/02)

(TBD)

### 2. Continuous Rx/Tx LoRa (ATT03/04)

(TBD)

### 3. Mono Tx LoRa (ATT05)

(TBD)



4. Continuous Rx/Tx LoRaWan (ATT06/07)

(TBD)

5. Battery level (ATT08)

(TBD)

6. Continuous RSSI reader (ATT0A)

This test mode read RSSI values, it return an average value every 35 ms.

RSSI reader uses user parameters from ATO structure, channel (077), spreading factor (075), etc.

(TBD)



## V. TUNING

### A. MODULE

The device can be configured in different modes. User can choose between local communication (P2P), network communication or test mode. Each one has other sub configuration like the device class in LoRaWan communication. Available modes are displayed in Figure 14 and listed in Table 8.

Preliminary version only gets the LoRaWan Class A functionality.

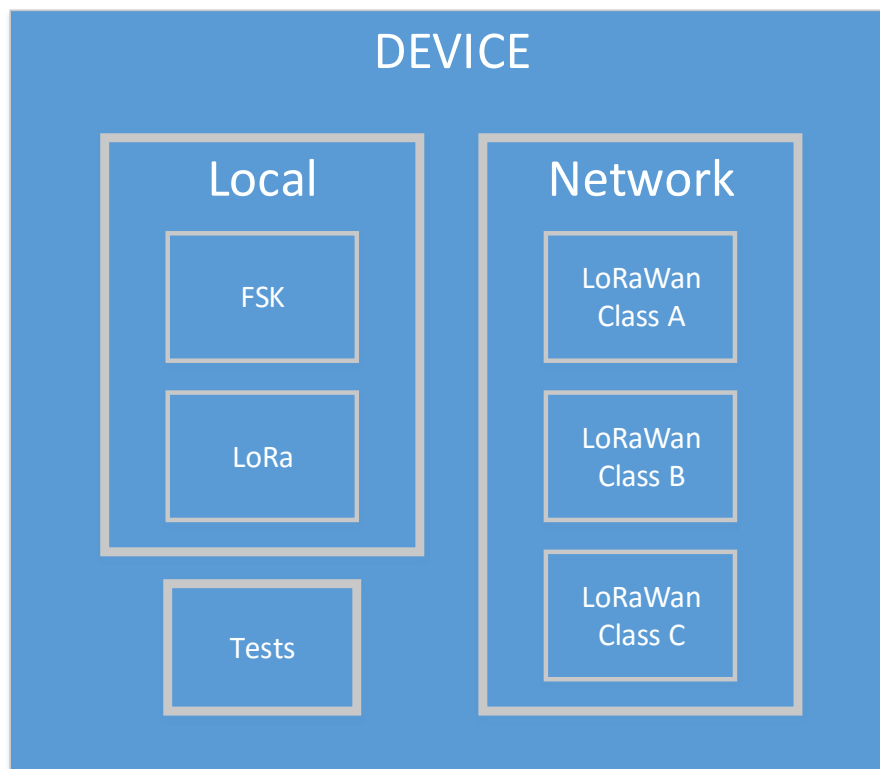


Figure 14: Device configuration

#### 1. Module configuration

Configuration is done with bit 0 of ATM000 to choose if the device will be used in local (P2P) or integrated in network. Bit 1 configures the modulation used in local (P2P), bit 2 and 3 configure the class used in network (LoRaWan class). Once again, preliminary version only gets the LoRaWan Class A functionality.

#### 2. Low power

ATM001 configure functionality. Bit 0 set on/off low power mode, it is off by default.

Low power mode is used to achieve the lowest power consumption possible. When it is sleeping the device cannot be accessed in any way, it has to be woken up before.

Currently it only exists one waking source for the ARM-N8-LW, it is the WakeUp pin. If the mode is on and the pin is set to '0' the device will go in sleep mode, if it is set to '1' it will be awake.

The device will finish his emission cycle Tx/Rx before going to sleep.

### 3. Led behaviour

ATM002 allow users to configure the Led behaviour. Bit 0 to 3 are used to choose if the Led has to get a particular value in this state. Bit 4 is used to define the value taken by the Led during these specified states, other times it will be the complement. EG: to get the Led to turn on during Tx an Rx, and be off all others times, ATM002 value has to be 0x1C. To get the led always on and turn off during Tx and Rx, ATM002 value has to be 0x0C

Table 8: Device configuration list

ATM	Bit	Parameter	Register value
000	0	Module configuration	0: Local (TBD) 1: Network (Wan)
	1	Local modulation	0: FSK only used in local (P2P) (TBD) 1: LoRa only used in local (P2P) (TBD)
	2:3	LoRaWan class	00: Class A only used in Network 01: Class B only used in Network (TBD) 10: Class C only used in Network (TBD)
	4:7	UNUSED	
001	0	Low power mode	0: Low power mode disable 1: Low power mode enable
	1:7	UNUSED	
002	0	Boot	0: Led inactive in this state 1: Led active in this state
	1	WakeUp	0: Led inactive in this state 1: Led active in this state
	2	Radio TX	0: Led inactive in this state 1: Led active in this state
	3	Radio RX	0: Led inactive in this state 1: Led active in this state
	4	Led default state	0: Led off during chosen states, on other time 1: Led on during chosen states, off other time
	5:7	UNUSED	

## B. UART

### 1. Parameters

UART communication can be configured with ATM command from 007 to 012. It is important not to forget to save the configuration entered with ATMS command.

Modification will be taken into account after a Reset, it can be hardware or software via the command ATR.

ATM	Bit	Parameter	Register value
007	0:7	Baudrate UART	600 bps = 0x00, 1200 bps = 0x01, 2400 bps = 0x02, 4800 bps = 0x03, 9600 bps = 0x04, 14400 bps = 0x05, 19200 bps = 0x06, 38400 bps = 0x07, 56000 bps = 0x08, 57600 bps = 0x09, 115200 bps = 0x0A, 230400 bps = 0x0B,
008	0:7	Wordlength	0x00: 8 bits, 0x01: 9 bits
009	0:7	Parity	0x00: no parity, 0x01: even parity, 0x02: odd parity
010	0:7	Stop bits	0x00: 1 stop bit, 0x01: 0.5 stop bit, 0x02: 2 stop bit, 0x03: 1.5 stop bit
011	0:7	Flow control	0x00: no flow control, 0x01: rts flow control, 0x02: cts flow control, 0x03: rts/cts flow control
012	0:7	Timeout char	0xMM: 0xMM char to wait for timeout



## C. RADIO

### 1. Main parameters

Radio parameters can be configured to follow a defined behaviour and to fulfil specific tasks. This configuration is the user's responsibility, they have to choose what will be the best configuration for their application.

The main ATO command is ATO083, it defines LoRaWan behaviour, allowing the user to choose if the LoRaWan layer will:

- follow an Over The Air Activation (OTAA) (TBD)
- open Rx windows after an emission
- adapt its spreading factor automatically with Wan command (ADR)
- enforce duty cycle
- switch and adapt its channel automatically
- adapt its Rx2 window following Wan command

If ADR is on and Rx windows are off, Rx windows will be turned on. It is the same if the device is configured to send confirmed frame (see ATO080).

ATO075 and ATO076 will be used for emission only if the ADR is turned off (bit 2 of ATO083). It allows the users to choose and fix the spreading factor and output power depending on their application needs.

Rx2 Spreading factor fixed by ATO075 will be used only if the bit 5 of ATO083 is off.

ATO080 configured emission, allowing users to choose between confirmed frame and unconfirmed frame. It also set the numbers of repetition for unconfirmed and the maximum repetition for confirmed ones. Note: confirmed frame have priority on unconfirmed. Set confirmed to 0 to use unconfirmed.

ATO081 is used to add Wan command to frames. If the ATO081 value is set to 0x02, the device will add MAC\_LINK\_CHECK\_REQ in every frame it sends. The value has to be set to 0x00 to remove command addition

ATO082 is used to set the application port used to communicate.

Table 9: Main radio parameters

ATO	Bit	Parameter	Register value	Used when
075	0:2	Emission Spreading factor	0x00 : DR_SF12, 0x01 : DR_SF11, 0x02 : DR_SF10, 0x03 : DR_SF9, 0x04 : DR_SF8,	Bit 2 of ATO083 is off



ATO	Bit	Parameter	Register value	Used when
			0x05 : DR_SF7, 0x06 : DR_SF7H, 0x07 : DR_FSK	
	3:5	Rx2 Spreading factor	0x00 : DR_SF12, 0x01 : DR_SF11, 0x02 : DR_SF10, 0x03 : DR_SF9, 0x04 : DR_SF8, 0x05 : DR_SF7, 0x06 : DR_SF7H, 0x07 : DR_FSK	Bit 5 of ATO083 is off
	6:7	UNUSED		
076	0:2	Rf output power	0x00 : Unused, 0x01 : TX_POWER_14_DBM, 0x02 : TX_POWER_11_DBM, 0x03 : TX_POWER_08_DBM, 0x04 : TX_POWER_05_DBM, 0x05 : TX_POWER_02_DBM	Bit 2 of ATO083 is off
	4:7	UNUSED		
077	0:3	Emission Channel	0x00 : channel LC1, freq = 868.100 MHz, 0x01 : channel LC2, freq = 868.300 MHz, 0x02 : channel LC3, freq = 868.500 MHz, 0x03 : channel LC4, freq = 867.100 MHz, 0x04 : channel LC5, freq = 867.300 MHz, 0x05 : channel LC6, freq = 867.500 MHz, 0x06 : channel LC7, freq = 867.700 MHz, 0x07 : channel LC8, freq = 867.900 MHz, 0x08 : channel LC9, freq = 868.900 MHz	Bit 4 of ATO083 is off
	4:7	Rx2 Channel	0x00 : channel LC1, freq = 868.100 MHz, 0x01 : channel LC2, freq = 868.300 MHz, 0x02 : channel LC3, freq = 868.500 MHz, 0x03 : channel LC4, freq = 867.100 MHz, 0x04 : channel LC5, freq = 867.300 MHz, 0x05 : channel LC6, freq = 867.500 MHz, 0x06 : channel LC7, freq = 867.700 MHz, 0x07 : channel LC8, freq = 867.900 MHz, 0x08 : channel LC9, freq = 868.900 MHz	Bit 5 of ATO083 is off
078	0:7	UNUSED		
079	0:7	UNUSED		
080	0:3	Unconfirmed frame number of emission	0x0: will use LoRaWan default value, can be adapt by gateway with MacCommand 0xY: send unconfirmed frame up to Y (from 1 to F)	Always



ATO	Bit	Parameter	Register value	Used when
	4:7	Confirmed frame number of emission	0x0: Does not use confirmed frame, using un-confirmed 0xY: send confirmed frame up to Y (from 1 to F)	
081	0:7	Wan command to add in next emission	0x00: none 0x02: MAC_LINK_CHECK_REQ, else : (TBD)	Always
082	0:7	Port field	0x00 : indicates that the FRMPayload contains MAC commands only, 0x01 – 0xDF : application specific, 0xE0 – 0xFF : reserved for future standardized application extensions	Always
083	0	Over The Air Activation (OTAA)	0: off, 1: on	Always
	1	Rx windows on	0: off, 1: on	
	2	Adaptive Data Rate (ADR)	0: off, 1: on	
	3	Duty cycle on	0: off, 1: on	
	4	Adaptive channel on	0: off, 1: on	
	5	Adaptive Rx2 on	0: off, 1: on	
	6:7	UNUSED		

## 2. IDs

All IDs are accessible in READ ONLY. They can be accessed in two ways, byte by byte with commands from ATO000 to 067, or the entire ID in once with commands from 069 to 074. Table 10 shows how to read them.

Note: all IDs are stored LSB first. For example, reading DevEui with ATO070 will give back the value 0x0011223344556677, where 00 will be the LSB corresponding to ATO004 and 77 will be the MSB corresponding to ATO011.



Table 10: IDs access

ATO Byte by Byte	ATO All at once	ID or key
000-003	069	DevAddr: Use when using personalized activation. Will be given by gateway if using OTAA. (LSB first)
004-011	070	DevEui: Use when using OTAA. (LSB first)
012-019	071	AppEui: Use when using OTAA. (LSB first)
020-035	072	AppKey: Use when using OTAA. (LSB first)
036-051	073	NwkSKey: Use when using personalized activation. Will be given by gateway if using OTAA. (LSB first)
052-067	074	AppSKey: Use when using personalized activation. Will be given by gateway if using OTAA. (LSB first)