BOSCH

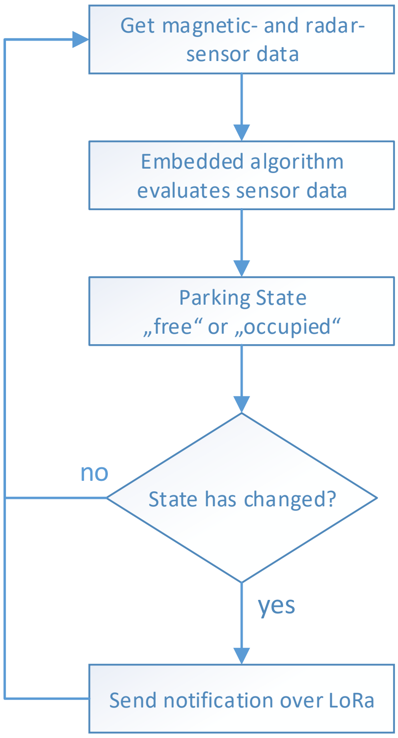
Parking Lot Sensor | PLS

Communication Interface - Technical Description rev.1
v0.39.2 PLS TPS110 EU (EU868)

Table of contents

1 Principle of operation

The parking sensor device of the PLS with TPS110 EU (EU868) sensor core contains two independent sensing elements, a magnetometer for recognizing changes in the magnetic field of the environment and a RADAR sensor for measuring the reflectivity above the sensor device.



The sensors data are processed by the devices embedded algorithm. The algorithm output is the parking state “free” or “occupied”. The device checks, if the parking status has been changed since the last processing run and in case the parking state change will be communicated via the LoRa interface. This means, that the parking sensor will only report, if the parking state has changed.

Only stable parking states, occupied or free, for at least 35 seconds are considered for detection of parking state changes. This means, 2 or more parking status changes with less than 35 seconds between them will not be detected as such and will therefore not send LoRa parking status messages. If the new stable status after several fast changes is different to the previously known parking state, then the device will detect the new stable status and send a new LoRa parking status message. Considering the additional delay caused by the LoRa transmission and possibly re-transmissions, transmission time limitation of each device, transmission from the Gateway to the LoRa network and processing by the LoRa network, the complete delay from the new parking status until the state is visible in the LoRa application server may be 40 or more seconds.

2 First commissioning

Once the sensor has been installed on the mounting plate, the Firmware of the device will initialize and self-check itself for malfunction of Hardware components. This process takes approximately 2 minutes and it also delays the first LoRa join message. Considering that the device may need to re-send the LoRa join message if it does not receive a LoRa accept message on time (caused by radio attenuation, interference, or LoRa network unavailability), the complete time since installation until the sensor is first observed in the LoRa application server may take even longer than the 2 minutes required for initialization of the sensor.

The parking sensor device is equipped with a self-learning algorithm. Thus it is not necessary to calibrate the sensor. Although the parking sensor device needs to learn how a parking event looks like. Therefore the detection performance after the installation and power-up is expected to be poor and reaches the optimal level after approximately 10 parking events. A parking event is defined as a parking status change from free to occupied or vice-versa. From this point on, the parking sensor devices learns with any new parking event. In case of a false detection or missing a parking state, the sensor will recover automatically after some parking events again.

After a reboot of the device, the sensor uses its pre-trained data until it has re-learnt the environment with 10 new parking events.

3 LoRaWAN Interface

The parking sensor device is equipped with a LoRa radio operated in Class A. The implemented functionality complies with the LoRaWAN Specification 1.0.2.

The frequencies supported and receive window parameters are according to the LoRaWAN v1.0.2 EU868 Regional Parameters rev. b. Both RX1 offset and RX2 can be reconfigured by the Join Accept message (CFList) or related MAC commands.

The battery level is reported in the DevStatusAns MAC command

3.1 Join Procedure

There is a magnetic contact between the sensor and the mounting plate, which closes only when the components are joined and thus initiates the join process. The Join procedure follows the Over-the-Air Activation (OTAA) described in the LoRaWAN Specification 1.0.2. Activation By Personalization (ABP) is not supported.

After powering up the parking sensor device, it will try to join a LoRaWAN Network by sending the join request message. In case the join request is not answered, the sensor will retry as soon as possible, according to transmission time limitations, up to 4 additional times (5 attempts in total). After the 5th unsuccessful attempt, the sensor will do an exponential reboot (see chapter 3.2) and repeat the process to try again for 5 more times.

If the Join request message is not answered with a Join accept message, the sensor will retry, following the next sequence:

Attempt	DataRate
1	Configured DR or default (DR2)
2	Configured DR or default (DR2)
3	DR2
4	DR1
5	DR0

In case the Join accept message is received at the attempt 3, 4 or 5, the sensor restores the configured DataRate to the default value (DR2). This behavior assumes that the configured DataRate does not allow communication with the Gateway.

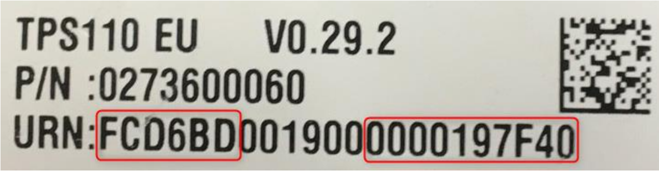
3.2 Exponential reboot

The sensor has been designed to save power and reduce the amount of messages sent while the LoRa network is not available. If the sensor detects that the LoRa network is not replying to its uplink messages, either LoRa join or regular uplink confirmed messages, the device will reboot and enter into an ultra low-power mode for an exponentially increasing amount of time.

Condition	Wait time until re-starting LoRa join request process
The device performs the first reboot, caused by either 5 unsuccessful attempts, to get a LoRa join accept message or 8 unsuccessful attempts to get an acknowledgement to a confirmed uplink message	1 minute
Subsequent reboots caused by 5 unsuccessful attempts to get a LoRa join accept message	Increasing with each reboot to 2, 4, 8, 16, 32 and 64 minutes. Once reached 64 minutes, the wait time is always 64 minutes

3.3 Device EUI

The device EUI of the sensor is pre-provisioned during production and can be derived from the URN printed on the sensor core. The URN can be found either on the bottom of the parking sensor core or on the label on top of the parking sensor core. Beside of the URN, also a barcode allowing a simplified installation process can be found. The device EUI can be derived from the URN as in this example:



DevEUI example from picture

- DevEUI [high] : DevEUI [low]
- 0xFCD6BD 0x0000197F40

Exchanging the DevEUI of the sensor is not possible.

3.4 Application EUI

The AppEUI is pre-provisioned during production and will be delivered with the sensor batch. Exchanging the AppEUI of the sensor is not possible.

3.5 Application Key

The AppKey is pre-provisioned during production and will be delivered with the sensor batch. Exchanging the AppKey of the sensor is not possible.

3.6 Adaptive Data Rate (ADR) BETA

The use-case of the Parking Lot Sensor, where a car with different size, shape and materials may park on top of the device, influences the radiated performance and therefore the Adaptive Data Rate (ADR) suitability. However, ADR may work properly under most circumstances. Given this complex scenario, ADR is supported by the PLS **as a BETA feature**, to be used at user’s own responsibility.

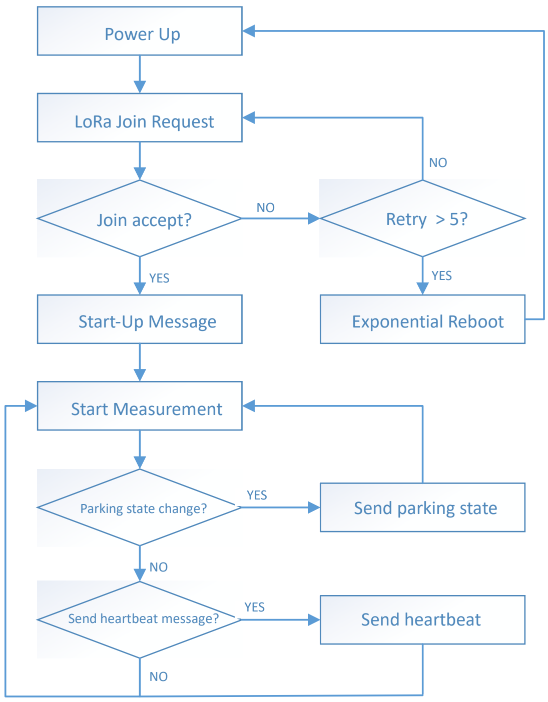
ADR can be enabled by sending a code to the device (see “Downlink messages”). ADR is mutually exclusive with the manual configuration of the device’s DataRate and the uplink’s confirmed or unconfirmed settings.

In order to account for the different attenuation produced by a car or its absence while ADR is enabled, a Data Rate offset can be configured to send uplink messages with a lower Data Rate while a car is parked. The ADR bit in each uplink message from the sensor is only set while there is no car parked, so that a more stable attenuation path can be used by the Network to calculate the most appropriate Data Rate.

NOTE: ADR is able to configure Data Rate, confirmed/unconfirmed with/without repetitions and TX power of the device without manual intervention. If a very aggressive ADR algorithm is used at the Network side, the connection to the device could get lost. The configuration selected has also a direct impact on the battery lifetime of the device.

4 Application protocol description

After a successful join (join accept message received) the sensor will send a start-up message, then begin with the normal operation and send park status messages whenever a change is detected. Most of the application messages (start-up message, heart-beat message, and parking state message) are sent as confirmed by default. In case the confirmation is not received, the sensor will retry 7 more times, adapting the DataRate as recommended in the LoRaWAN v1.0.2 spec, chapter 18.4. Any confirmed message which does not receive a confirmation after the 7^{th} re-transmission will initiate an exponential reboot. This behavior assumes that the connection with the network has been lost.



The parking state message can be configured as not confirmed with or without repetitions. This reduces the use of duty cycle to acknowledge all messages, but may also reduce the percentage of successfully received messages by the Gateway.

If the network (Gateway or Backend) is down, the sensor behaves in the way described in LoRaWAN spec v1.0.2 chapter 18 and chapter 3 of this document.

The DataRate used in the uplink messages by the sensor is DR2 by default, but can be configured from DR0 to DR5. Note that DR6 and DR7 shall not be used.

The application protocol may be subject of change. The functionality may be extended in the next versions.

4.1 Uplink messages

Uplink messages are those sent from the PLS to the network.

In case any confirmed message is not acknowledged (8 attempts) or the Join request is not accepted (5 attempts), the system schedules a reset, showing in the Start-up message the value 0x03 (System Request Reset) as Reset cause. This is generally a good indication that the Gateways are not able to maintain stable communication with the sensor. More details can be seen by looking into the Debug code in the Debug or Startup messages.

4.1.1 Parking status

Parking status message uses the **port 1** and is **confirmed by default**. It can be configured to unconfirmed with or without repetitions (see downlink messages).

Byte [0]	
Bit [7 ... 1] Reserved	**Bit [0] Parking status**
Reserved	0: Free parking space 1: Occupied parking space

4.1.2 Heartbeat

Heartbeat message uses the **port 2** and is **always confirmed**. The heartbeat message contains the same information as the parking status message and it is sent every 24 hours.

Byte [0] Heartbeat	
Bit [7 ... 1] Reserved	**Bit [0] Parking status**
Reserved	0: Free parking space 1: Occupied parking space

If the user has enabled **periodic temperature measurements** (see downlink messages), the Heartbeat message is extended with 1 more byte. By default, the temperature measurements are disabled.

Byte [1] Temperature measurement	**Byte [0] Heartbeat**	
Representation follows two's complement 0x00: 0°C 0x01: 1°C ... 0x7F: 127°C 0x80: -128°C 0x81: -127°C ... 0xFE: -2°C 0xFF: -1°C	**Bit [7 ... 1] Reserved**	**Bit [0] Parking status**
	Reserved	0: Free parking space 1: Occupied parking space

4.1.3 Start-up

Start-up message uses the **port 3** and is **always confirmed**. It is sent after every start-up / reboot / (re-) join event.

Byte [16] Parking status		**Byte [15] Reset cause**	**Byte [14 : 12] FW version**	**Byte [11 : 10] Reserved**	**Byte [9 : 0] Debug message**
Bit [7 ... 1] Reserved	**Bit [0] Parking status**	0x01: Watchdog reset 0x02: Power On Reset 0x03: System Request Reset 0x04 - External Pin Reset 0x05 - Lockup Reset 0x06 - Brownout Reset 0x07 - Others	Firmware Version (Currently 0.39.2)	Reserved for future use	Last debug message (see chapter 4.1.6)
Reserved	0: Free parking space 1: Occupied parking space				

4.1.4 Device Information

The Device Information message uses the **port 4** and is **always confirmed**. There are 2 possible uplink messages sent by the PLS, depending on the request made by the network (see downlink messages).

Device URN

See Device EUI section of this document for a graphical example with the label of PLS.

Byte [10 : 6] DevEUI [low]	**Byte [5] Product Class Extension**	**Byte [4 : 3] Product Class Variant**		**Byte [2 : 0] DevEUI [high]**
DevEUI [low]	0x00: EU868 0x01: AS923	**Bit [15:4] Product code**	**Bit [3...0] Variant code**	DevEUI [high]
		0x001: Fixed for PLS	HW revision	

Firmware version

This information is also available in the Start-up message, but as compared to the Start-up message, this Device Information can be requested at any time.

Byte [2 : 0] FW version
Firmware Version (currently 0.39.2)

4.1.5 Device Usage

The Device Usage message uses the **port 5** and is **always confirmed**. There are 7 possible uplink messages sent by the PLS, depending on the request made by the network (see downlink messages). The use of this information varies from estimating the remaining battery life to basic statistics of parking utilization and quality of service of the Network used.

Note that any of these values may lose accuracy in case uncontrolled resets happen, since the information is stored in non-volatile memory only at periodic intervals of time (once per week) to save battery. An uncontrolled reset is anything different to Software requested reset, which makes sure the latest information is saved in non-volatile memory before re-starting the system. The main cause for an uncontrolled reset is a power-on reset caused by removing and placing back the sensor core from the base.

Number of parking status changes detected

Byte [4 : 1] Number of parking status changes detected	Byte [0] Request ID
Value	Request ID: 0x00

Time running in occupied state

Byte [4 : 1] Time running in occupied state	Byte [0] Request ID
Value in seconds	Request ID: 0x01

Number of uplink messages sent

Byte [18 : 1] Number of uplink messages sent						Byte [0] Request ID
Byte [18:16]	**Byte [15:13]**	**Byte [12:10]**	**Byte [9 : 7]**	**Byte [6 : 4]**	**Byte [3 : 1]**	Request ID: 0x02
DR5 (SF7)	DR4 (SF8)	DR3 (SF9)	DR2 (SF10)	DR1 (SF11)	DR0 (SF12)	

Number of times the radar has been triggered

Byte [4 : 1] Number of times the radar has been triggered	Byte [0] Request ID
Value	Request ID: 0x03

Time running since restart

Byte [4 : 1] Time running since restart	Byte [0] Request ID
Value in seconds	Request ID: 0x04

A restart is caused by any reset

Number of resets since installation

Byte [7 : 1] Number of resets since installation						Byte [0] Request ID
Byte [7 : 6]	**Byte [5]**	**Byte [4]**	**Byte [3]**	**Byte [2]**	**Byte [1]**	Request ID: 0x05
Software requested	Watchdog	Power-on	Ext. Pin	Lockup	Brown out	

The most common resets are Power-on, caused by placing the sensor core on the base and Software requested.

Time running since installation

Byte [4 : 1] Time running since installation	Byte [0] Request ID
Value in seconds	Request ID: 0x06

4.1.6 Debug messages

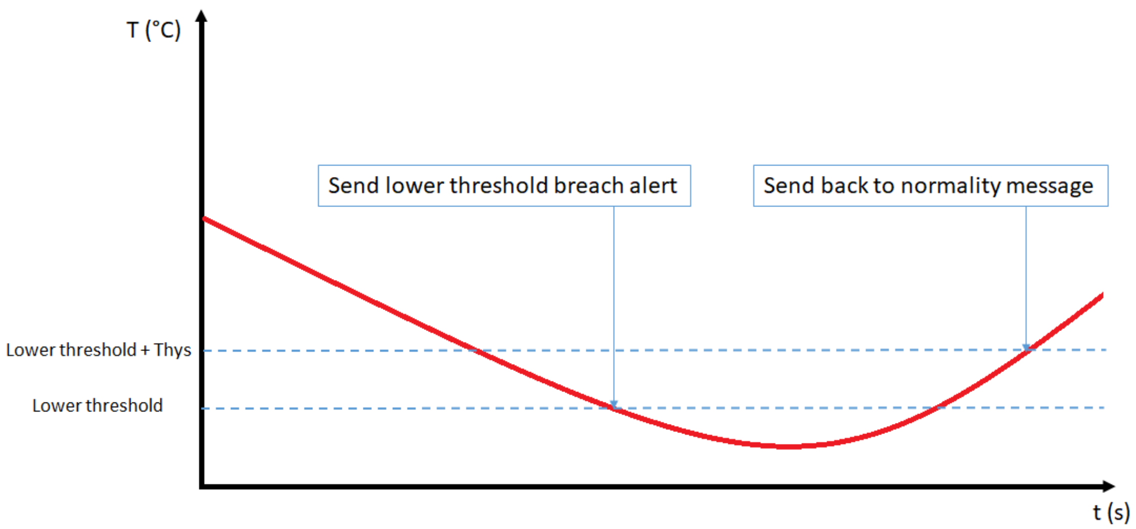
The Debug messages use the **port 6** and is **always unconfirmed**. By default these messages are enabled and without repetitions, but they can be disabled or increased the number of repetitions used (see downlink messages).

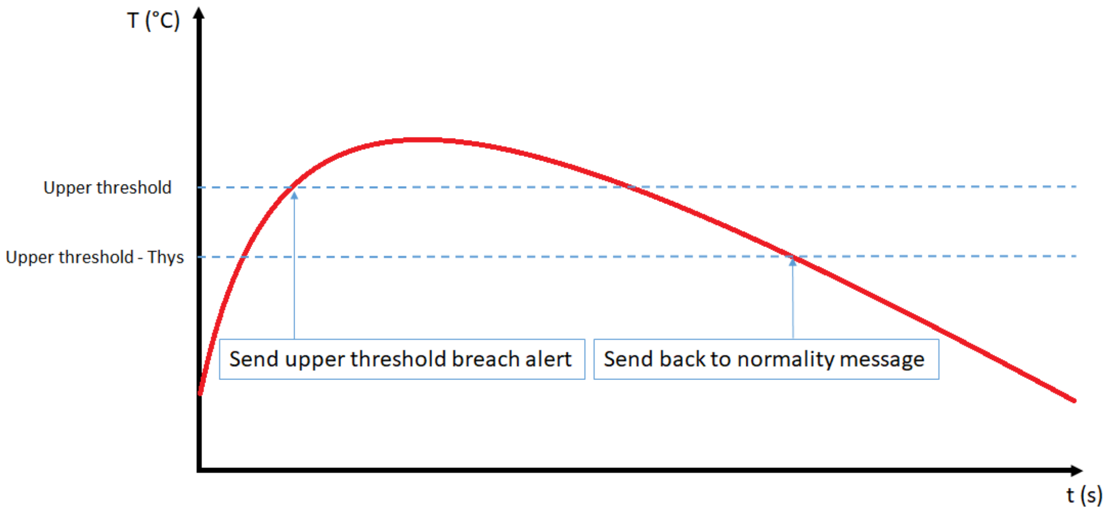
Byte [9 : 8] Sequence number	Byte [7 : 4] Debug code	Byte [3 : 0] Timestamp
Sequence number	Debug code (see Debug codes list in chapter 4.3)	Timestamp

4.1.7 Temperature alert

In case the temperature alert is enabled, a message is sent by PLS in the case of temperature passing the high and low thresholds set, including a 5ºC hysteresis from alert to normality and vice-versa. The Temperature alert uses **port 7** and is **confirmed by default**. The configuration to unconfirmed/confirmed applies by the same configuration as described for the park status message in chapter 4.2.1 (port 51).Note that temperature measurements are internally performed every 10 minutes.

A graphical representation of the temperature values at which Temperature alerts are sent can be seen below





Byte [0] Temperature alert
Representation follows two's complement 0x00: 0°C 0x01: 1°C … 0x50: 80°C (maximum value) 0x51 to 0xD7: Not used 0xD8: -40°C (minimum value) … 0xFE: -2°C 0xFF: -1°C

4.2 Downlink messages

Downlink messages are those sent from the Network to the Sensor. The sensor supports confirmed and unconfirmed downlink messages.

4.2.1 Parking status confirmable configuration

Parking status confirmable configuration uses the **port 51** and it applies only to the parking status message. The default value is Confirmed (0x00). The configuration selected is persistent.

Byte [0] **Confirmable configuration**
0x00: Confirmed (up to 8 repetitions) (default) 0x01: Unconfirmed with 1 uplink message (0 repetitions) 0x02: Unconfirmed with 2 uplink messages (up to 1 repetitions) 0x03: Unconfirmed with 3 uplink messages (up to 2 repetitions) 0x04: Unconfirmed with 4 uplink messages (up to 3 repetitions)

Note that PLS stops repeating confirmed or unconfirmed uplink messages as soon as the network sends a downlink message, which confirms that the network has received the uplink message and the sensor may save current by not sending the same message anymore.

For example, if the user configures unconfirmed messages with 3 repetitions (0x04) and after the first repetition (2nd message) the network sends a downlink message, PLS does not send the 3rd and 4th repeated messages. In this situation, it is implicitly confirmed that the network has received the uplink message, by sending a downlink message in the exact timing provided by the receiving windows 1 and/or 2.

4.2.2 DataRate configuration

DataRate configuration uses the **port 52**. The default value is DR2 (0x02). The configuration selected is persistent, unless overwritten in the join procedure. Higher DataRates increase the battery lifetime of the sensor, but may reduce the reliability of the reception of messages by the Gateway. This is specially the case for unconfirmed messages.

Byte [0] **DataRate configuration**
0x00: DR0 (SF12) 0x01: DR1 (SF11) 0x02: DR2 (SF10) (default) 0x03: DR3 (SF9) 0x04: DR4 (SF8) 0x05: DR5 (SF7)

4.2.3 Heartbeat frequency

Heartbeat frequency uses the **port 53**. The default value is Normal frequency (1 day). The Heartbeat may drift over time by approximately ±10 seconds per day, depending on several environmental conditions. The configuration selected is persistent.

Note that an increased frequency of the Heartbeat, reduces drastically the battery lifetime of PLS. The Test mode should only be used temporarily and for testing purposes, for example for network tests or verifying coverage while deploying Gateways (network optimization). Using DR0 while Test mode is selected may make the sensor irresponsive due to duty cycle limitations. The network capacity gets significantly reduced if many sensors are configured in test mode simultaneously.

Byte [0] **Heartbeat frequency**
0x00: Short (1 hour) 0x01: Normal (1 day) (default) 0x02: Long (7 days) 0x03: Test mode (2 minutes) – Note: Battery lifetime and network capacity drastically reduced! Do not use together with DR0

4.2.4 Device Information Request

Device Information Request uses the **port 54** and is used to request certain information from the sensor (see uplink messages).

Byte [0] **Device Information Request**
0x00: Device URN 0x01: Firmware version

4.2.5 Device Usage Request

Device Usage Request uses the **port 55** and is used to request certain information from the sensor (see uplink messages).

Byte [0] **Device Usage Request**
0x00: Number of parking status changes detected 0x01: Time running in occupied state 0x02: Number of uplink messages sent 0x03: Number of times radar has been triggered 0x04: Time running since restart 0x05: Number of resets since installation 0x06: Time running since installation

4.2.6 Debug configuration

Debug configuration uses the **port 56** and is used to enable or disable the Debug messages (see uplink messages) and select the number of repetitions. By default the Debug messages are enabled with 0 repetitions. The configuration selected is persistent.

Byte [0] **Debug configuration**
0x00: Debug messages disabled 0x01: 1 uplink message (0 repetitions) (default) 0x02: 2 uplink message (up to 1 repetitions) 0x03: 3 uplink message (up to 2 repetitions) 0x04: 4 uplink message (up to 3 repetitions)

4.2.7 Temperature measurements configuration

Temperature measurements configuration uses the **port 57** and is used to enable or disable the periodic Temperature measurements and Temperature alerts based on thresholds. These 3 options are mutually exclusive. Periodic Temperature measurements are attached to the Heartbeat, while Temperature alerts are sent whenever the temperature passes the threshold or comes back to normality (see Uplink messages). By default the Temperature measurements are disabled. The configuration selected is persistent. The temperature measurement is a rough indication of the system temperature inside of the sensor housing.

Byte [0] **Temperature measurements configuration**
0x00: Temperature measurements disabled (default) 0x01: Periodic Temperature measurements enabled 0x02: Threshold based temperature alert enabled

4.2.8 Adaptive Data Rate (ADR) BETA

ADR can be enabled or disabled by sending the appropriate code in the **port 58**. If enabled, ADR overrides the Data Rate and confirmed/unconfirmed manual configuration set. ADR allows automatic configuration of DR from DR0 to DR5. The configuration selected is persistent.

Byte [1 : 0] **Adaptive Data Rate (ADR) BETA**
0x0000: ADR disabled (default) 0xAD6E: ADR enabled – Note: This is a BETA feature and shall be used at user's own risk

4.2.9 ADR offset BETA

While ADR is enabled, a Data Rate offset can be configured to account for the different attenuation of having a car parked or not, by sending a downlink message in **port 59**. The offset is relative to the DR set by ADR. Example:
Assumptions: ADR has been enabled during several days, so that the ADR algorithm at the Network side has received enough uplink messages to calculate the proper DR. The user has not changed the ADR offset (default value, which is DR - 3).

- ...
- 22.11.2020 10:23 – PLS reports parking space free (DR3, ADR bit set)
- 22.11.2020 10:42 – PLS reports parking space occupied (DR0, ADR bit unset)
- 22.11.2020 11:25 – PLS reports parking space free (DR3, ADR bit set)
- 22.11.2020 11:25 – LoRa network replies PLS with MAC command to change DR to DR4
- 22.11.2020 11:42 – PLS reports parking space occupied (DR1, ADR bit unset)
- 22.11.2020 12:11 – PLS reports parking space free (DR4, ADR bit unset)
- ...

Byte [0] **ADR Offset BETA**
0x00: DR - 0 (no offset) 0x01: DR - 1 0x02: DR - 2 0x03: DR - 3 (default) 0x04: DR - 4 0x05: DR - 5

4.2.10 Temperature Thresholds for temperature alerts

If the user enables Temperature alerts, the higher and lower thresholds can be configured using **port 60**. By default, 4°C and 50°C for the the lower and higher thresholds respectively. The difference between these 2 values shall be set higher than or equal to 10°C (2 times the hysteresis of 5°C). The complete range of temperature values which can be set as thresholds spans from -15°C to 60°C.

Byte [1] **Temperature high threshold**	**Byte [0]** **Temperature low threshold**
Representation follows two's complement 0x00: 0°C 0x01: 1°C … 0x32: 50°C (default high threshold) … 0x3C: 60°C 0x3D to 0xF0: Values not allowed 0xF1: -15°C … 0xFC: -4°C 0xFD: -3°C 0xFE: -2°C 0xFF: -1°C	**Representation follows two's complement** 0x00: 0°C 0x01: 1°C … 0x32: 50°C … 0x3C: 60°C 0x3D to 0xF0: Values not allowed 0xF1: -15°C … 0xFC: -4°C (default low threshold) 0xFD: -3°C 0xFE: -2°C 0xFF: -1°C

4.3 Debug codes

The PLS produces and stores debug codes and tries to send them to the Network using the Debug messages or after the device has re-joined as part of the Start-up message and possibly again the Debug messages (see uplink messages). Internally the sensor has a buffer, which is able to temporarily store several debug codes. The debug codes are produced by different reasons, for example in case the user is sending an invalid parameter in a downlink message, the network is not answering confirmed messages or several failure conditions which may or may not lead to a Software requested reboot.

These codes follow the next format:

Byte [3 : 2] Debug code		**Byte [1 : 0] Reserved**
Bit [15 … 12] Reserved	**Bit [11 … 0] Debug code**	Reserved for internal use
Reserved for internal use	Debug code	

4.3.1 Debug codes list

Codes (decimal)	Description	Leads to Software requested reboot
201	LoRa join request failed	YES
208	Cause for last reset: Watchdog	NO
209	Cause for last reset: Power-on	NO
210	Cause for last reset: Unknown	NO
215	Cause for last reset: Lockup	NO
216	Cause for last reset: External PIN	NO
217	Cause for last reset: Brown-out	NO
404	Park detection algorithm recalibrating	YES
717	Confirmed uplink message not acknoledged after 8 re-tries	YES
720	LoRa join request failed	YES
729	Confirmed uplink message not acknoledged after 8 re-tries	YES
800	Invalid downlink message port	NO
802	Invalid downlink message length	NO
804	Invalid frame type request	NO
805	Configuration selected was already active	NO
808	Invalid DataRate value selected (port 52, ADR ON)	NO
809	Invalid Parking status configuration selected (port 51, ADR ON)	NO
810	Invalid Debug configuration selected (port 56, ADR ON)	NO
880	Invalid value for DataRate (port 52)	NO

881	Invalid length for DataRate (port 52)	NO
882	Invalid value for Device Information Request (port 54)	NO
883	Invalid length for Device Information Request (port 54)	NO
884	Invalid value for Parking status confirmable configuration (port 51)	NO
885	Invalid length for Parking status confirmable configuration (port 51)	NO
886	WARNING: Heartbeat test mode enabled! (port 53)	NO
887	Invalid value for Heartbeat frequency (port 53)	NO
888	Invalid length for Heartbeat frequency (port 53)	NO
889	Invalid value for Debug configuration (port 56)	NO
890	Invalid length for Debug configuration (port 56)	NO
891	Invalid value for Temperature measurements configuration (port 57)	NO
892	Invalid length for Temperature measurements configuration (port 57)	NO
893	Invalid value for Device Usage Request (port 55)	NO
894	Invalid length for Device Usage Request (port 55)	NO
895	Invalid value for ADR configuration request (port 58)	NO
896	Invalid length for ADR configuration request (port 58)	NO
897	Invalid value for ADR offset request (port 59)	NO
898	Invalid length for ADR offset request (port 59)	NO
899	Invalid user request	NO
900	Invalid value for temperature threshold configuration request (port 60)	NO
901	Invalid value for temperature threshold offset configuration request (port 60)	NO
902	Invalid length for temperature threshold configuration request (port 60)	NO
1001	User configuration parameters are recovered	NO
1003	Communication parameters are recovered	NO

5 Changelog

v0.39.2 EU868 17 Sep 2020

Features

- Battery level estimation is now provided in DevStatusAns LoRaWAN MAC command

Known issues and limitations

- "Time running since installation" has a cumulative error of ~1.5 seconds per device reboot
- Reply to downlink MAC commands might be dropped if the device is restricted by duty cycle. Additional downlink MAC commands might be required in this situation

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v0.38.0 AS923 28 Jul 2020

Features

- Initial version of AS923 variant with adaptions for restricted maximum payload size (11 bytes)
- Configurable temperature alerts based on thresholds
- Frame pending bit is now supported
- Non-Volatile Memory integrity is guaranteed through backup and integrity verification (CRC)

Known issues and limitations

- DR6 and DR7 shall not be used
- "Time running since installation" has a cumulative error of ~1.5 seconds per device reboot
- Reply to downlink MAC commands might be dropped if the device is restricted by duty cycle. Additional downlink MAC commands might be required in this situation

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v0.29.2 07 Jun 2019

Features

- Configurable temperature measurements with heartbeat message
- Configurable heartbeat frequency
- Device information
- Debug information
- Device usage statistics
- Configurable number of repetitions for unconfirmed parking status messages
- Configurable ADR support
- Bugfixes
  - MIC errors are now discarded, not leading to a reboot
  - Repeated downlink messages with same Frame Counter are now discarded, not leading to a reboot
  - AppEUI is now expected to be sent in little endian format, as defined by the LoRaWAN spec
  - The probability of a malfunction due to a power cycle has been minimized
  - Corrected the demodulation margin value in the DevStatusAns

Known issues and limitations

- Too many frames lost (>16384) leads to a reboot

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v0.23.3 24 Oct 2018
Features

- LoRaWAN v1.0.2 compliant
- Configurable DataRate and confirmed/unconfirmed park status messages
- Parking status message with new simplified format
- Hearbeat with new format
- Startup with new format
- Uplink messages queue
- Improved LoRa join retry handling and exponential reboots

Known issues and limitations

- MIC errors may lead to a reboot of the device
- Repeated downlink messages with same Frame Counter may lead to a reboot of the device
- AppEUI needs to be sent in big endian format, which is not LoRaWAN compliant
- A power cycle of the device while running may lead to malfunction in very unlikely scenarios

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v0.17.1 01 May 2018 – Prototype PoC
Features

- Payload based on Type-Length-Value format

Known issues and limitations

- Not completely LoRaWAN v1.0.2 compliant
- Lack of uplink messages queue may silently drop messages when there is not enough duty cycle
- This is a Prototype release, which is only intended for experimental use cases

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