Subject: Payload documentation
CO_2 stoplicht
Date: 22 November 2020
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1. Introduction

1.1 Preface

This document describes what messages can be received from the CO_2 stoplicht (‘uplinks’) and which messages need to be sent to change the settings (‘downlinks’).

First the definitions will be explained. After that there will be a chapter on the uplinks and finally in the last chapter the downlinks will be further explained.

The various messages are divided into several subchapters. Each subchapter covers a small part of a payload. This happens just as often until the whole payload is explained.

1.2 Bit and byte notation

In this document, all bytes are read as "Little-endian". This means that all bits and bytes are being read from right to left and, starting at the number 0.

Example with the number 60:

In hexadecimal:

```
Byte 3    Byte 0
  |       |
0x00 00 00 3C
```

In binary:

```
Bit 7    Bit 0  Bit 7    Bit 0 Bit 7    Bit 0 Bit 7    Bit 0
|          |      |         |      |          |      |      |
00000000       00000000      00000000       00111100
```

1.3 Definitions

Node:	The device with the microcontroller developed by Teneo.
Uplink:	A message send from the node to the LoRaWAN network/internet.
Downlink:	A message send from the end-user/internet to the LoRaWAN node.
Payload:	The content of a message sent or received by the node.
0xA3:	The hexadecimal number A3, decimal is 163 and binary this is 1010 0011.
Unsigned int:	A positive integer.
Int:	An integer (positive or negative).
RFU:	Abbreviation, “Reserved For Future Use”.
Float:	A decimal number (positive and negative).

2. Uplinks

2.1 Port

The port, also called FPort with downlinks, is a number with a range of 1 to 223. The value of the port indicates the type of message.

2.2 BMS Header

Our firmware provides a header as the last byte of the payload with each message. The header consists of a type and parameters:

Bit	Description
7.. 6	Header Type
5.. 0	Parameters

2.2.1 Header Type

Value (bit 7..6)	Name	Description
00	Default	If there is nothing to report, this header type is used. This type has no parameters.
01	MultiMessage	LoRaWAN messages have a limited length. MultiMessage distributes a full message across multiple uplinks because it doesn't fit into one uplink message. The current version of our firmware will not exceed the maximum size of a message, so no MultiMessage messages will be sent.
10	Status	Status messages are sent when the node starts up or something has gone wrong. These messages are always sent on port 223.

2.2.1.1 Default

Bit number	Name	Description
5.. 0	Voltage	Indicates the operating voltage of the device. Calculation: Actual Voltage = 2 + (Voltage/10).

The most commonly used header is a standard header with the voltage. This header will be used unless otherwise described. For example, the default header looks like this: 0000 1100 or 0x0C.

The first two bits **(00**00 1100) indicate that it is a default message.
The second two bits (00**00** 1100) have no meaning in this case.
The last four bits (0000 **1100)** contain the voltage display. These first four bits represent the number 12.
This means that the actual voltage: 2 + (12/10) = 3,2 Volt.

2.2.1.2 Other header types

The MultiMessage is not explained because large messages are not sent.
Also, the Status messages are not explained in this documentation.

2.3 Message

The node can send the following uplink messages:

Port	Message type	Description
1	CO_2 measurement	This message displays the calibration option and CO_2 measurement, along with an optional temperature and humidity measurement.
223	Status	On port 223, status messages are sent.

2.3.1 Port 1: CO_2 measurement

Byte	Length	Description
9	1	Header
8	1	RFU
7.. 4	4	CO2 value
3.. 2	2	Temperature display
1.. 0	2	Humidity display

These values are not the actual values of the measurements, these must first be converted. For this calculation see the relevant chapters.

The CO_2 sensor controls the current measurement values.
This message will be sent with an adjustable interval.

For example, this message looks like this: **0x0F 00 00 01 53 3B 07 53 11 4D**
The meaning of this post is:

Byte 9: 0x0F = Voltage: 3,5 V
Byte 8: 0x00 = RFU
Byte 7..4 0x00 01 53 3B = 868.43 PPM
Byte 3.. 2 0x07 53 = 18.75 degrees Celsius
Byte 1.. 0 0x11 4D = 44,29 %RH

2.3.1.1 Header

Bit number	Description
3.. 0	Batterijweergave

The systemvoltage is calculated as follows:
2 + (Batterijweergave/10)
If the battery display in the message is 0x0C (12), the system'scalculationis voltage:2 + (12/10) = 3, ,2 V.

2.3.1.2 Measured CO_2 value

Byte number	Length	Description
6.. 4	4	CO_2 measurement

This byte shows the measured CO_2 measurement. To convert this view to the measured value, this calculation must be used:
Actual measured CO_2 (in PPM) = CO_2 value / 100

0x0001533B: This has a decimal value of 86843.
86843/100 = 868,43 PPM

2.3.1.3 Measured Temperature

Byte number	Length	Description
3.. 2	2	Temperature display

The temperature can be negative, to convert it, the MSB must be looked at.

If this MSB is 1, then the actual temperature is: -(65536-temperature display)/100.
If this MSB is 0, then the actual temperature is: temperature display / 100.

For example, at value 0x0753: is binary: **0**001 0001 0100 1101, last bit is **0** thus:
0x0753 = decimal 1875: the temperature = 1875/100 = 18,75 degrees Celsius.

For example, at value 0xFCE0: is binary: **1 111**111 1100 1110 0000 0000, last bit is **1** thus:
0xFCE0 = decimal 64736: the temperature = -(65536-64736)/100 = -8.00 degrees Celsius.

2.3.1.4 Measured Humidity

Byte number	Lscary	Description
1.. 0	2	Humidity value

This byte shows the measured humidity. To convert this to the actual value, this calculation must be used:

Actual Humidity %RH = Humidity value / 100

For example, the value: 0x114D = 4429.
Humidity = 4429/100 = 44,29 % RH.

3. Downlinks

In order to be able to change the settings of the node, downlinks can be sent to the node. As with the uplinks, the FPort indicates the type of message it is, but no header needs to be sent.

The following downlinks can be sent:

FPort	Message type	Description
1	Period time	Adjusts the time between two standard downlink messages.
11	LED thresholds Green/Orange/Red	Specify the limit values for when the red, orange and green LEDs are to go on/off.
13	LED ON/OFF	Setting whether the LEDs should be used or not.

3.1 FPort 1: Period time

Byte	Length	Description
3.. 0	4	Period time in seconds

The period time message is used to set how much time (in seconds) there is between two default messages. This set time is the desired time, it can vary several percent. The minimum period time will always be the waiting time of LoRaWAN.

Payload =0x00 00 0E 10 = 3600 seconds (A message every hour)

3.2 FPort 11: LED thresholds

Byte	Length	Description
11..10	2	Minimum green value
9..8	2	Maximum green value
7..6	2	Minimum value orange
5..4	2	Maximum value orange
3..2	2	Minimum value red
1..0	2	Maximum value red

Here the limit values of the green/orange/red LEDs can be set, if the CO_2 measurement is the same or between these 2 values the relevant LED will turn on [1].
If both values of a particular LED are set to 0, the LED will never be turned on.
The example below uses the default values.

Example:
Payload 0x0000 041A 041A 060E 060E FFFF:

0x0000 = 0, 0x041A = 1050:
Green LED will come in at a CO2 value of 0 to 1050..

0x041A = 1050, 0x060E = 1550:
Orange LED will come in at a CO2 value from 1050 to 1550.

0x060E = 1550, FFFF = 65535:
Red LED will start at a CO2 value from 1550 to 65535.

[1] This setting only has an effect if the LED indication in the behavior setting is turned on.

3.3 FPort 13: LEDs OFF/ON

Byte	Length	Description
0	**1**	LEDs OFF/ON

With this setting, the 'behavior' of the sensor can be determined.
The byte has a significant meaning:

0x01 Stoplicht mode, LEDs are out
0x02 Stoplicht mode, LEDs are on. This is the default setting

Example:
Payload: 0x02 (00000010): Traffic light mode is on and the LEDs are used.