1. INTRODUCTION

This document describes the operation of the SensorData device, and how to interpret the data messages that are sent on the network. For examples and other support documentation, visit https://support.digitalmatter.com

The Sigfox and LoRaWAN device operation and protocols are very similar, and both handled in this document. Message

1.1. Message Size Implications

We are limited to:

- **12-byte messages on the Sigfox network.**
- **11-byte (minimum) messages on the LoRaWAN network.**

The LoRaWAN maximum message size depends on the region and spreading factor (SF). 11 bytes is the worst case (EU868 region, SF12).

Because of these constraints, this data scheme aims to pack in data as efficiently as possible into the messages.

No date/time data is sent in the messages as the receiving software should use the date/time stamp from the network.

For the LoRaWAN devices, the LoRaWAN port is used as the first byte of the message; ie, **the port is the ID of the first data field in the message, and the data for that field starts at byte 0 of the payload.**

1.2. No Acknowledgement

In addition to the size limitation, the messages are not acknowledged by the network, so the data is sent on a “best effort” basis.

The implications of this are far-reaching as data cannot be guaranteed to have been delivered. The SensorData design therefore aims to send information that will not be adversely affected by missing messages. For example, for a tipping rain gauge the SensorData will record the count of the tips and send the total tip count each time, as opposed to trying to send a message for every tip, where if one was missed then the count on the server would be wrong.

1.3. Multi-part Data Avoided

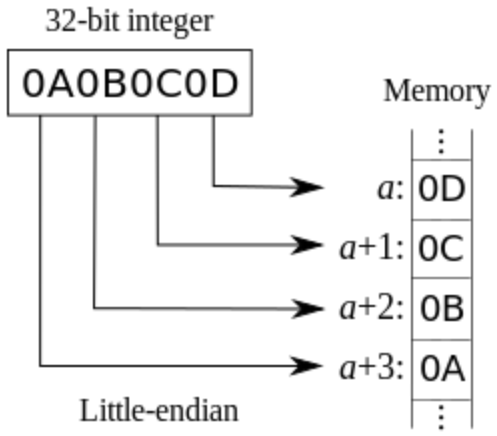
As far as possible this data scheme avoids sending related data over more than one message due to the complexity of re-assembly on the server side and transmission limitations. Data fields are always contained within a single message.

1.4. Number Formats

1.4.1. Little Endian

All data in the payloads is LITTLE ENDIAN. Be aware of this when converting data fields that consist of more than one byte from the data payload.

https://en.wikipedia.org/wiki/Endianness#Little



1.4.2. Signed (Negative) Numbers

Signed numbers are represented in “two’s complement” form. Be aware of this when converting signed fields from the data payload.

https://en.wikipedia.org/wiki/Two's_complement

All multi-byte values are treated as little-endian.

1.4.3. Bit Numbering

Bit number is from the ‘right’ – ie the LSBit is b0

2. DATA FIELDS

Each item of data that the SensorData measures and/or transmits is referred to as a “Data Field”.

Each Data Field is identified by a Data Field ID value (also known as a “key”), and the software decoding the information needs to have knowledge of the IDs being sent to it and what their corresponding lengths are.

2.1. List of Data Fields

ID	Name	Size	Units
0	Reserved		
1	System Firmware version		
2	Debug Statistics	TBD	Struct
10	GPS Position	6	Struct
20	Battery Voltage	2	UINT16 (mV)
21	Analog In 1	2	UINT16 (mV)
22	Analog In 2	2	UINT16 (mV)
23	Analog In 3	2	UINT16 (mV)

30	Digital Input [not yet defined]	1	Bitfield
31	Input 1 Pulse Count	2	UINT16
32	Input 2 Pulse Count	2	UINT16
33	Input 3 Pulse Count	2	UINT16
39	Digital Input Alert	2 + 2*N	Struct
40	Internal Temperature	2	INT16 (x100 degC)
41	Digital Matter I2C Temperature Probe 1 (Red)	2	INT16 (x100 degC)
42	Digital Matter I2C Temperature Probe 2 (Blue)	2	INT16 (x100 degC)
43	Digital Matter I2C Temperature & Relative Humidity	3	Struct
128	SDI-12 Measurement 1	N	Struct
129	SDI-12 Measurement 1 – Part 2	N	Struct
130	SDI-12 Measurement 2	N	Struct
131	SDI-12 Measurement 2 – Part 2	N	Struct
132	SDI-12 Measurement 3	N	Struct
133	SDI-12 Measurement 3 – Part 2	N	Struct
134	SDI-12 Measurement 4	N	Struct
135	SDI-12 Measurement 4 – Part 2	N	Struct
223	Reserved		
224 to 255	Reserved as the LoRaWAN specification reserves these ports		

2.2. GPS Position (10)

Length = 6 bytes

All 0xFF == no fix available

Offset	Type	Name	Units
0	INT24	Latitude	Deg x 10^7 / 256
3	INT24	Longitude	Deg x 10^7 / 256

INT24 for position gives 4m precision.

2.3. Digital Input Alert (39)

Length = 2 + 2 x Number of digital inputs on device.

Offset	Type	Name	Units
0	BYTE	Current digital input state	Bitfield

1	BYTE	Input that triggered the alert	Number
2+(n-1)*2	UINT16	Digital input n change count	Number of changes

By comparing the old and new states, it can be determined which input has triggered the alert. The change count shows the same values as data fields 31-33.

2.4. Digital Matter I2C Temperature & Relative Humidity (43)

Length = 3

Offset	Type	Name	Units
0	INT16	Temperature	x100 degC
2	UINT8	Relative Humidity	0.5%

2.5. SDI-12 Measurements

Offset	Type	Name	Units
0.0-0.3	UINT4	Number of data points	
0.4-0.7	UINT4	Data type for this measurement 0 = soil moisture UINT8 1 = temperature UINT8 2 = INT16 (x100) 3 = INT32 (x1000) (Not Implemented)	The data type determines the data size, scale and offset to use (see below)
1	-	Data for the measurement Length depends on the data type and the number of data points	

2.5.1. SDI-12 Soil Moisture UINT8

The SensorData packs SDI-12 soil moisture values into UINT8 fields to get as many values in the message as possible.

SMP = (value in field / 2) – 5, yielding a range of -5 to 122.5 with 0.5 precision.

Using this data type the maximum number of readings that can be packed into a single message is 10. A “Part 2” data field allows for a second set of 10 readings.

2.5.2. SDI-12 Temperature UINT8

The SensorData packs SDI-12 temperature values into UINT8 fields to get as many values in the message as possible.

Temp = (value in field / 2) – 40, yielding a range of -40 to 87.5 with 0.5 precision.

Using this data type the maximum number of readings that can be packed into a single message is 10.

2.5.3. SDI-12 Generic INT16 * 100

This allows a SDI-12 reading to be +-32,767.00 with 2 decimal places.

Using this data type, the maximum number of data points that can be packed into a single message is 5.

2.5.4. SDI-12 Generic INT32 * 1000 (not implemented yet)

This allows a SDI-12 reading to be +-2,147,483 with 3 decimal places.

Using this data type, the maximum number of data points that can be packed into a single message is 2.

2.5.5. SDI-12 Error format

If the SensorData fails to take a reading from the specific sensor, the number of data points will be set to 0, and the type will be left as set. The total length will be 1 byte (no data section).

3. NON-VOLATILE COUNTER STORAGE

Where it makes sense the counter values will be written to non-volatile storage periodically (if they have changed). This is to allow them to be read if the device is reset or has its batteries changed.

4. MESSAGE PACKING

Data fields are packed into Sigfox/LoRaWAN messages as key/value pairs. The key is the ID of the data field and this is followed by the data.

The data field size is implied from the ID, or in some cases where the data is variable length then the length of the data field is encoded at the start of the data field itself.

This data layout allows us to fit as many of the data fields as we can into a limited byte size message in a flexible manner.

The SensorData firmware will determine the order and best way to pack the data fields into messages, possibly splitting the data fields across multiple messages. However, a single key/value will always be totally contained within a single message.

5. SCHEDULES

The SensorData is setup to transmit based on schedules.

Several different schedules can be setup (currently up to 5), and the schedule parameters contain information that allow the SensorData to determine the schedule timing.

Each schedule is defined to send messages that contain data from a selected list of data fields for the transmission schedule.

For example:

Schedule 1	Every 30 minutes Transmit the temperature, humidity and tipping rain gauge count
Schedule 2	Every 1 day Transmit the GPS data (location)

5.1. Message Queueing

It is important to be aware of message restrictions in terms of duty cycle depending on the region that you are located in. Sigfox networks have a maximum of 140 messages per day per device.

If a schedule results in more than one message to be sent then the messages will be sent one after another, as duty cycle limitations allow. (TBD – will Wisol rate limit our messages?)

[This is more of an issue with LoRaWAN]

6. PARAMETERS

6.1. Schedules

Each schedule is defined in a FlexiParam block.

Currently the design caters for a time interval and an offset.

There will be a hard-coded schedule for Debug Stats – easy param specified in hours. Can be zero to disable the sending of Debug Stats.

6.2. Data Fields

Certain data fields may need to have additional parameters set for them on an installation of a SensorData (eg SDI-12 sensor data) and this is done by setting data field specific parameters on the SensorData.

6.2.1. SDI-12 Measurement Parameters

Offset	Type	Name	Units
0	CHAR	Address of the SDI-12 probe	'0'..'9'
1	CHAR	Measurement number	'0'..'9'
2	UINT8	Number of data points	1-15
3	UINT8	Data type for this measurement See 2.5 for more detail	

7. CONTACT INFORMATION

View our website and online knowledge base for the latest documentation and FAQs.
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