Smart Metering System

e-MUCS H

extended Multi-Utility Companion Specification for the Consumer Interfaces

Version	Change	Publishing date
1.0	First Edition	26/04/2017
1.1	S1 interface specification added	Not published
1.2	Textual changes and addition of Flemish dataset (I1)	Not published
1.3	Minor changes to S1 section	26/04/2018

Content

1 Introduction

1.1 Scope

This document is part of a set of companion specification documents for a smart meter system for electricity and gas.

The goal of this companion specification is to reach an open, standardized protocol implementation related to the communication between several types of E-meters and other smart metering systems and devices.

The document describes the protocol and the data model of two consumer interfaces. The I1 interface and the S1 interface. The I1 interface is based upon the DSMR P1 specification and the S1 interface is a high speed communication port intended to provide measurement data at a high frequency.

Both interfaces periodically provide measurement data (and status information) to one or more customer applications. These applications can be used to store, monitor, analyse and display the provided data or use it as trigger for home automation systems to control other devices in home. The objects to configure and manage this interface are out of scope of this document, but are described in e-MUCs M_{DLMS}. The functionalities of the customer applications that can be connected to the these interfaces are also out of scope of this document.

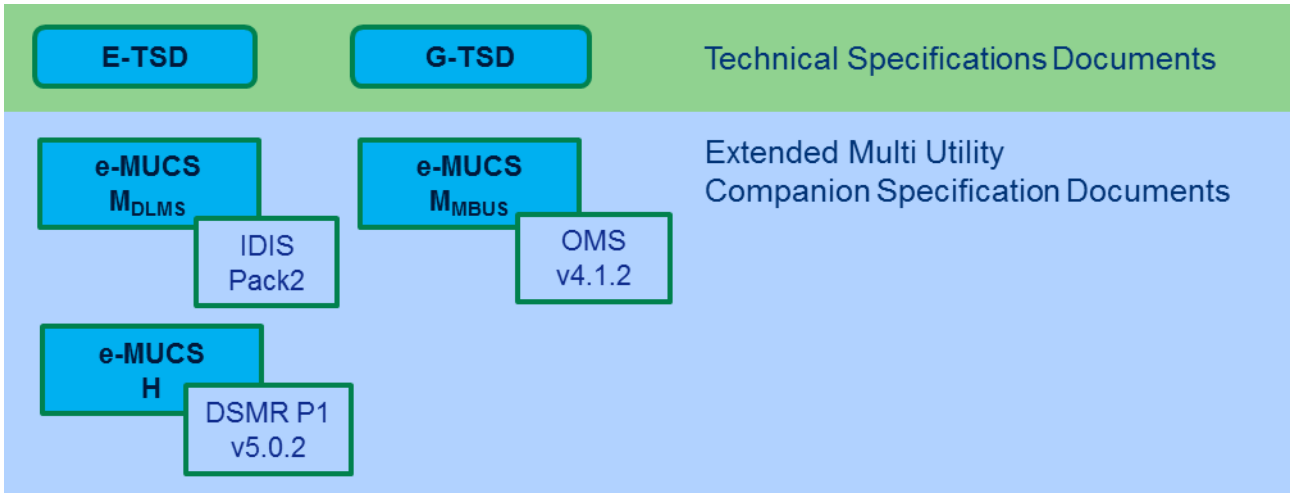

Figure 1 'Set of Requirements' structure of the Smart Metering Solution

1.2 Related Documents

The following standards are referred to in this companion specification.

- For undated references the latest edition applies.
- If a corrigendum for one of these documents is issued, then it is also applicable.

Reference	Document Title	Editor	Version
DSMR P1	Dutch Smart Meter Requirements – P1 Companion Standard	Netbeheer Nederland	5.0.2
e-MUCS M_{DLMS}	Companion Specification for I3 Interface	Fluvius / Resa / Sibelga	Ed. 1.0
IDIS Pack2	Package 2, IP Profile	IDIS association	V2.0 (+ corrigenda 1, 2, 3 & 4)

Additionally, the references listed in section 4 of DSMR P1 are also applicable.

1.3 System Architecture

The I1 and S1 interfaces in Figure 2 are defined as the interfaces between a Smart Electricity Meter (E-meter) and customer applications, in example an In-Home Display or a CEMS device, as used in home automation systems.

Remark 1: The I1 interface is also referred to as 'P1' in the DSMR interface overview (DSMR P1– figure 1-1).

Remark 2: The E-meter acts as a concentrator for up to 4 M-bus devices (e.g. gas meters) via the I2 interface, therefore the data of these M-bus devices can also be provided to the customer via the I1 interface.

Remark 3: The S1 interface only provides electricity related data from the primary electricity meter (blue block in figure 2). MBUS-related data, even if this device is an secondary electricity meter, is not in scope for the S1 interface

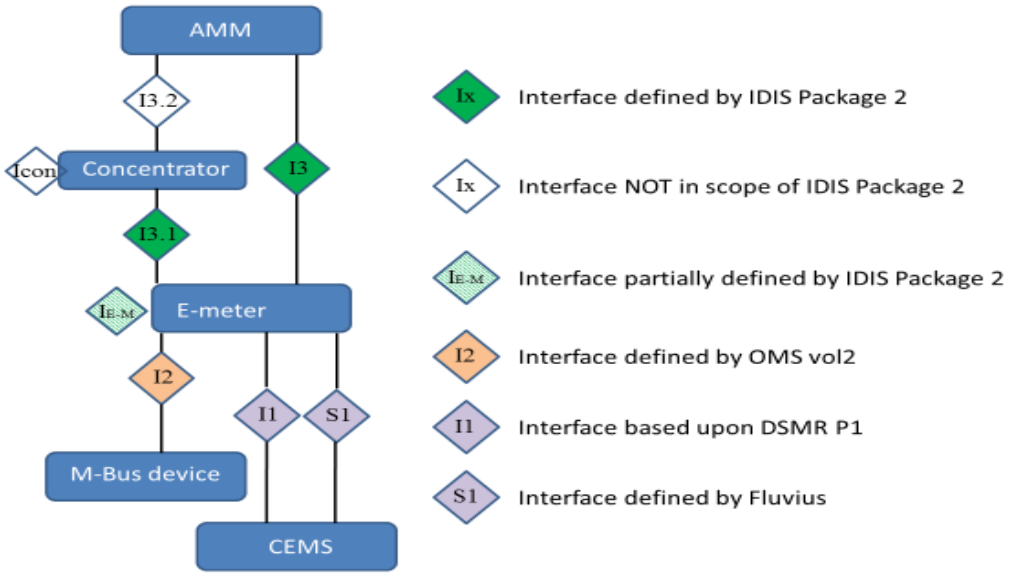

Figure 2: Communication interfaces

2 Definitions and abbreviations

The definitions and abbreviations in Section 3 of DSMR P1 is applicable. Additional abbreviations used in this document are:

AMR	Automatic Meter Reading
CEMS	Consumer Energy Management System
FCS	Frame Check Sequence
DSO	Distribution System Operator
NILM	Non Intrusive Load Monitoring

3 I1 interface description

This section specifies the main characteristics of the I1 interface

3.1 Physical interface

Section 5 of DSMR P1 is applicable.

3.2 Protocol description

Section 6 of DSMR P1 is applicable.

3.2.1 Addtional data objects

To accommodate the transfer of additional data objects, the table in section 6.12 of DSMR P1 will be extended with Table 1.

Medium	Value	OBIS reference	Attribute	Class ID	Value Format	Value Unit
	Version information	0-0:96.1.4.255 (See note 5)	2 (Value)	1 (Data)	S4, tag 9	
	Consumer message code	0-0:96.13.1.255	2 (Value)	1 (Data)	Sn (n=0..128), tag 9	
E	Breaker state	0-0:96.3.10.255	3 (control state)	70 (Disconnector control)	I1, tag 22	
	Limiter threshold	0-0:17.0.0.255	3 (Threshold active)	71 (Limiter)	F4(1,1), tag 18	kW
	Fuse supervision threshold (L1)	1-0:31.4.0.255	2 (Thresholds)	21 (Register Monitor)	F3(0,0), tag 18	A
G	M-Bus Device ID 2	0-n:96.1.1.255	2 (Value)	1 (Data)	Sn (n=0..96), tag 9	
	Valve state	0-n:24.4.0.255 (See note 3)	3 (control state)	70 (Disconnector control)	I1, tag 22	
	Last value of 'not temperature corrected' gas volume in m³, including decimal values and capture time	0-n:24.2.3.255 (See note 3)	5 (Capture time)	4 (Extended register)	TST	
			2 (Value)	4 (Extended register)	F8(2,2)/F8(3,3), tag 18 (See note 2)	m³

Table 1: Data object representation

Note 1: Where n (in 'F**n**') is the number of digits before the decimal point on the display of the meter + the required number of decimals. So for example if on the physical display of a Heat meter is shown 1234 GJ (without decimals) the n=6 and the format of the P1 output will be 1234,56 GJ. (Note 1 is applicable on the table in DSMR P1)

Note 2: For Gas meters with a capacity up to 10 m3/h (G4 and G6) F8(3,3) is applicable. For Gas meters with higher capacities F8(2,2) is applicable.

Note 3: The M-bus channel number is indicated with 'n' in the OBIS code (e.g. 0-**n**:24.4.0.255).

Note 4: Be aware of the fact that the number of OBIS codes and the order of the OBIS codes in the messages is not fixed. The customer application must be able to interpret the OBIS codes and to understand the representation. Some example datasets are given in Annex A.

Note 5: This OBIS code replaces the one specified in DSMR P1, because that one (1-3:0.2.8.255) has a reserved meaning in the IDIS Pack2 specification.

3.3 Data objects

3.3.1 Electricity data

The table in section 7.1 of DSMR P1 is extended with:

Value	OBIS reference	
Breaker state	0-0:96.3.10.255	enum: (0) Disconnected, (1) Connected, (2) Ready_for_reconnection
Limiter threshold	0-0:17.0.0.255	
Fuse supervision threshold L1	1-0:31.4.0.255	For a polyphase meter the same threshold applies for all lines.

The statement, in DSMR P1, that mentions that "'Tariff code 1' is used for low tariff and 'Tariff code 2' is used for high tariff" is not valid in Belgium. Currently in Belgium 'Tariff code 1' is generally used for normal tariff and 'Tariff code 2' for low tariff. In general, assignment of tariffs to the tariff codes depends on the contract of the customer. Therefore it is advised to indicate the registers by their tariff number in the external application instead of a fixed assignment to High or Low.[1]

3.3.2 Messages

The table in section 7.2 of DSMR P1 is extended with:

Value	OBIS reference	
Consumer message code	0-0:96.13.1.255	Can be used to send (coded) messages to a CEMS or Home Automation system.

3.3.3 Gas Data

The table in section 7.3 of DSMR P1 is extended with:

Value	OBIS reference	
Valve state	0-n:24.4.0.255	enum: (0) Disconnected, (1) Connected, (2) Ready_for_reconnection
M-Bus Device ID 1	0-n:96.1.0.255	In DSMR P1 this value is called "Equipment identifier"

[1] The application could allow to manually select or enter more meaningful labels for the tariff registers or to assign a price in €/kWh to the different tariff registers.

		According to IDIS Pack2, this field contains the fabrication number of the M-bus device.
M-Bus Device ID 2	0-n:96.1.1.255	This field can contain additional identification information for the meter.
Last value of not temperature corrected gas volume in m³, including decimal values and capture time	0-n:24.2.3.255	

4 S1 interface description

This section specifies the main characteristics of the S1 high speed communication port intended to provide measurement data at high frequency to CEMS devices.

The S1 interface is an optional interface. The interface is only implemented in the Flemish region (Fluvius).

4.1 Physical interface

For the physical interface a solution based on the RS-422 specification is specified. The details of this interface are provided in this section.

4.1.1 Physical connector

The S1 interface connector type is RJ12. The electricity meter holds a female connector. The table below provides the pin assignment of this connector:

Pin number	Signal name	Comment
1	NC	Not connected
2	NC	Not connected
3	GND	0V reference
4	BUS_M	Output RS-422 bus line (-)
5	BUS_P	Output RS-422 bus line (+)
6	NC	Not connected

Table 2: S1 port pin assignments

4.1.2 User safety and interface protection

The interface must comply with the applicable European Directives, especially regarding electrical safety and EMC considerations.
It is to be considered that this interface is accessible to ordinary persons.

4.1.3 Signals description

Data output line
The S1 interface is a unidirectional communication port from the E-meter to the CEMS terminal. This means that there is a single data bus output from the E-meter to the terminal.

The E-meter is defined as the master (driver) on this bus, and the CEMS terminal is defined as a slave (receiver). The E-meter spontaneously and continuously drives the bus to output data as soon as the S1 interface is activated.

The data bus is based on a RS-422 (TIA/EIA-422) physical specification; levels driven by the E-meter comply with values specified in this standard.

The data bus transmission is done over 2-wires in differential mode, as per the RS-422 physical definition. Those two wires shall be twisted in the "meter to CEMS terminal" cable.

The CEMS terminal shall implement the line termination to ensure signal integrity. The bus speed is set to 2 Mbps (see 4.2.4). The CEMS terminal is only permitted to receive incoming data, and never use the line to output any signal.

Ground path
The E-meter and the CEMS terminal shall share the same 0V voltage reference. A wire is provided on the physical S1 interface of the meter for that purpose.

Data input
The S1 interface does not require any data request from the CEMS terminal. The S1 interface does not and cannot receive any data from the CEMS terminal.

Power supply
The S1 interface does not provide any power supply toward the CEMS terminal.

4.2 Protocol description

4.2.1 Transfer speed and character formatting

The S1 interface supports a fixed data rate of 2 Mbps. This data rate allows the transmission of the metering data from the meter with sampling values of at least 4 kHz

The meter sends the data to the CEMS device continuously. The transmission can be enabled / disabled (software-controlled). Therefore a control object is foreseen in the meter that is controlled by the DSO. This object is described in e-MUCs M_{DLMS}
The transmission uses asynchronous characters with the following format:

- 1 start bit
- 8 data bits
- No parity bit
- 1 stop bit

4.2.2 Data format

The data are sent as telegrams. The telegram format relies on the specification IEC 13239 [Information technology -- Telecommunications and information exchange between

systems -- High-level data linkcontrol (HDLC) procedures] with the following parameters and options:

- The E-meter is a primary station
- The class of procedures is UCC (unbalanced connectionless)
- UI frames are used (option 4)
- The FCS is 16 bits only (option 14.2)
- Start/stop transmission is used instead of synchronous transmission (option 15.1)
- A frame format field is present, and the frame format type is 1 (option 22)
- Disable transparency mechanism (option 24)

The telegram format is described below:

Description	Number of bytes
Flag	1 byte
Frame format	2 bytes
Address field	1 byte
Control field	1 byte
Data	37 bytes
CRC	2 bytes
Flag	1 byte

Table 3: S1 telegram format

Field description

- **Flag:** the standard HDLC opening and closing frame delimiter. The hexadecimal value is 0x7E on one byte
- **Frame format:** coded on 2 bytes, first byte is the frame type (type 1); second byte is the frame length excluding opening and closing flag. According to the next paragraph, the frame length has a fix value of 43 bytes (i.e. 0x2B hexadecimal); so the frame format field value is 0x80,0x2B
- **Address field:** broadcast address to all-stations, the value is 0xFF
- **Control field:** the value is 0x03 (UI frame, P/F bit set to 0)
- **Data:** the info and measurement data to be provided to the CEMS device (see next paragraph)
- **CRC:** the HDLC polynomial CRC coded on two bytes

4.2.3 Representation of the measurement data

The data field of each telegram contains the following data:

- Relevant information to help in the interpretation of the provided measurement values
- Instantaneous measurement values of voltages (for each phase)
- Instantaneous measurement values of currents (for each phase and for the neutral)

It is to be noted here that the voltage and current values provided within the same telegram must be synchronous with each other (values measured at the same sampling time) and that the telegram must be output within 10ms from the actual sampling time of the contained samples.

The data field is described in the table below:

7	6	5	4	3	2	1	0	Nb of bytes
Meter ID (byte 1)								14 Bytes
Meter ID (byte 2)								
Meter ID (byte 3)								
Meter ID (byte 4)								
Meter ID (byte 5)								
Meter ID (byte 6)								
Meter ID (byte 7)								
Meter ID (byte 8)								
Meter ID (byte 9)								
Meter ID (byte 10)								
Meter ID (byte 11)								
Meter ID (byte 12)								
Meter ID (byte 13)								
Meter ID (byte 14)								
Additional Information								1 Byte
Sampling Frequency								1 Byte
Network Frequency (MSB)								2 Bytes
Network Frequency (LSB)								
Frame sequence number								1 Byte
Voltage L1 (byte 1 - MSB)								2 Bytes
Voltage L1 (LSB)								
Current L1 (byte 1 - MSB)								3 Bytes
Current L1 (byte 2)								
Current L1 (byte 3 - LSB)								
Voltage L2 (byte 1 - MSB)								2 Bytes
Voltage L2 (byte 2 - LSB)								
Current L2 (byte 1 - MSB)								3 Bytes
Current L2 (byte 2)								
Current L2 (byte 3 - LSB)								
Voltage L3 (byte 1 - MSB)								2 Bytes
Voltage L3 (byte 2 - LSB)								
Current L3 (byte 1 - MSB)								3 Bytes
Current L3 (byte 2)								
Current L3 (byte 3 - LSB)								
Current N (byte 1 - MSB)								3 Bytes
Current N (byte 2)								
Current N (byte 3 - LSB)								

Table 4: Data field 1

4.2.3.1 *Data field description*

Meter ID
This corresponds to the Meter identifier, as per DIN 43863-5 definition.

This identifier is shared, known and used by the system, the billing, and the end user. It is therefore considered that transporting this information over the data flow makes sense.
It is 14 characters long, coded into 14 bytes using ANSI character code set.

Byte number	Description
1	Meter Energy Type
2	Manufacturer ID [1st character]
3	Manufacturer ID [2nd character]
4	Manufacturer ID [3rd character]
5	Device Differentiation [1st character]
6	Device Differentiation [2nd character]
7	Serial number [character #1]
8	Serial number [character #2]
9	Serial number [character #3]
10	Serial number [character #4]
11	Serial number [character #5]
12	Serial number [character #6]
13	Serial number [character #7]
14	Serial number [character #8]

Where the Meter serial number (in hex) shall correspond to the Meter serial number (in dec) displayed on the front marking of the meter
Table 4: Meter ID

Additional Information

Providing some relevant additional information to help in manipulating the following metering data may be useful.
For that, one byte is provided.

Bit number	Description
0	Meter Type
1	Sampling Type
2	3/4-Wires Mode
3	Valid Samples
4	Neutral Current
5	DataFormatVersion[0]
6	DataFormatVersion[1]
7	DataFormatVersion[2]

Table 6: Additional information field 1

- Meter Type:
  - Single Phase: '0'
  - Poly-Phase: '1'
- Sampling Type:
  - Per Second fixed sampling: '0'
  - Per Period fixed sampling: '1'
- 3/4-Wires Mode (for Poly-Phase Meters):
  - 3-Wires mode: '0'
  - 4-Wires mode: '1'

  For Single Phase Meters: default '0'
- Valid Samples:
  - One or more sample value(s) somehow known for being corrupted : '0'
  - Samples values correct: '1'
- Neutral Current:
  - Neutral Current not measured and/or not provided: '0'
  - Neutral current measured and provided: '1'
- DataFormatVersion:
  - These bits can be used to allow versioning of data formatting.
  - Description provided in this document is candidate as first initial official version: '000'

Sampling frequency

The meter's sampling frequency is given in this field.
Depending on internal sampling approach, two cases are distinguished and described below.
The using of one or the other sampling method must be indicated in the dedicated bit in the "Additional Information" field.

- **Fixed "Per Second" sampling**
  In that case, the sampling is performed at a fixed "real time" rate, independently from the actual network frequency.
  When the sampling is performed in that way, this field must contain the number of samples per second in multiples of 100Hz, coded on 1 byte as signed integer type with the LSB coding for a resolution of 100Hz.
  The value should remain lower than 4200Hz, so the data throughput does not overcome the bus speed.
  If for any reason the meter internal sampling frequency is greater than this value, then 1 out of 2 sample shall be provided to the S1 port, thus at a rate corresponding to half the internal sampling frequency. In that case, the value to be filled in this field must be half the internal sampling frequency (in Hz).
- **Fixed "Per Period" sampling**
  In that case, the sampling is performed at a fixed number of sample per network period, thus the actual "real time" rate varies over time depending on the actual network frequency.
  When the sampling is performed in that way, this field must contain the number of samples per period, coded on 1 byte as signed integer type with the LSB coding for a resolution of 1 (sample per network period).

The value should remain lower than 80 samples per period (considering a maximum network frequency of 52Hz, according to EN 50160; this value should be properly lowered if the forecasted maximum frequency to be seen on the network can get somehow higher), so the data throughput does not overcome the bus speed.
If for any reason the meter internal sampling frequency is greater than this value, then 1 out of 2 sample shall be provided to the S1 port, thus at a rate corresponding to half the internal sampling frequency. In that case, the value to be filled in this field must be half the internal sampling frequency (in samples per period).

Network frequency
This provides the currently measured network frequency.
The frequency value is code on 2 bytes as unsigned integer type with the LSB coding for a physical resolution of 1mH.

Frame sequence number
This gives the sequence number of the frame, so it is possible to detect loss of frame.
It is coded on 1 byte (unsigned integer) and ranges from 0x00 to 0xFF.
It is incremented by 1 at each new data field. When the value reaches 0xFF, it comes back to 0x00 at next data field.

Voltage Ln
This provides the instantaneous voltage sample value for the phase n (n = 1 or 2 or 3).
These values are adjusted values, thus already taking into account scaling factors and calibration parameters.

The voltage values are coded on 2 bytes as signed integer types with the LSB coding for a physical resolution of 25mV.

For single phase meters, values in the fields corresponding to L2 and L3 are irrelevant and should therefore be set to 0x0000.

Current Ln and current N
This field provides the instantaneous current sample value for the phase n (n = 1 or 2 or 3) and for the neutral. These values are adjusted values, thus already taking into account scaling factors and calibration parameters.

The current values are coded on 3 bytes as signed integer types with the LSB coding for a physical resolution of 1mA.

For single phase meters, values in the fields corresponding to L2 and L3 are irrelevant and should therefore be set to 0x0000.

For meters that do not implement neutral current measurement, the field corresponding to N is irrelevant and should therefore be set to 0x0000.

4.2.4 Sampling rate

The total length (including HDLC start/end flags) of the telegram is 45 bytes.

The complete telegram is output at X Hz which is the metrology sampling frequency.
X usually typically ranges from 2 kHz to 4 kHz.

As a consequence the data throughput at the CEMS port can reach up to 1.8 Mbps (1,800,000 bit/s = 45 bytes * 10 bits per byte character transfer * 4000 samplings per second).

This throughput explains the chosen fixed data rate of 2 Mbps for the S1 high speed port.
So the actual absolute maximum sampling frequency supported with this chosen data rate and proposed protocol is 4.2 kHz (keeping 5% of margin).

4.2.5 Example of the telegram

The table below gives an example of the S1 telegram recorded when testing with a single-phase meter:

Byte number	Description	Value
1	Opening flag	0x7E
2	Frame format MSB (type)	0x80
3	Frame format LSB (frame length)	0x2B
4	Address field	0xFF
5	Control field	0x03
6	Meter ID (byte 1)	0x00
7	Meter ID (byte 2)	0x00
8	Meter ID (byte 3)	0x00
9	Meter ID (byte 4)	0x00
10	Meter ID (byte 5)	0x00
11	Meter ID (byte 6)	0x00
12	Meter ID (byte 7)	0x00
13	Meter ID (byte 8)	0x00
14	Meter ID (byte 9)	0x00
15	Meter ID (byte 10)	0x00
16	Meter ID (byte 11)	0x00
17	Meter ID (byte 12)	0x00
18	Meter ID (byte 13)	0x00
19	Meter ID (byte 14)	0x00
20	Additional Information	0x0A
21	Sampling Frequency	0x34
22	Network Frequency (MSB)	0xC3
23	Network Frequency (LSB)	0xBB

Byte number	Description	Value
24	Sample number	0x0F
25	Voltage L1 (byte 1 - MSB)	0x0B
26	Voltage L1 (LSB)	0x15
27	Current L1 (byte 1 - MSB)	0x00
28	Current L1 (byte 2)	0x05
29	Current L1 (byte 3 - LSB)	0xFA
30	Voltage L2 (byte 1 - MSB)	0x00
31	Voltage L2 (byte 2 - LSB)	0x00
32	Current L2 (byte 1 - MSB)	0x00
33	Current L2 (byte 2)	0x00
34	Current L2 (byte 3 - LSB)	0x00
35	Voltage L3 (byte 1 - MSB)	0x00
36	Voltage L3 (byte 2 - LSB)	0x00
37	Current L3 (byte 1 - MSB)	0x00
38	Current L3 (byte 2)	0x00
39	Current L3 (byte 3 - LSB)	0x00
40	Current N (byte 1 - MSB)	0x00
41	Current N (byte 2)	0x00
42	Current N (byte 3 - LSB)	0x00
43	FCS (LSB)	0xC5
44	FCS (MSB)	0xB2
45	Closing flag	0x7E

Table 5: S1 sample telegram

Annex A: I1 interface dataset

A.1 Belgian minimal dataset

Table 8 describes the dataset for the I1 interface that is currently agreed upon by all Belgian DSO's. At any moment additional values (from the tables in section 3.1.1 of this document or section 6.12 of DSMR P1) can be added by each DSO separately to support additional use cases.

Value	OBIS reference
Equipment identifier	0-0:96.1.1.255
Version information	0-0:96.1.4.255
Date-time stamp	0-0:1.0.0.255
Meter Reading electricity consumption (Tariff 1) in 0,001 kWh	1-0:1.8.1.255
Meter Reading electricity consumption (Tariff 2) in 0,001 kWh	1-0:1.8.2.255
Meter Reading electricity injection (Tariff 1) in 0,001 kWh	1-0:2.8.1.255
Meter Reading electricity injection (Tariff 2) in 0,001 kWh	1-0:2.8.2.255
Actual electricity power consumption (+P) in 1 Watt resolution	1-0:1.7.0.255
Actual electricity power injection (-P) in 1 Watt resolution	1-0:2.7.0.255
Tariff indicator (electricity)	0-0:96.14.0.255
Breaker state (elektricity)	0-0:96.3.10.255
Limiter threshold in kW	0-0:17.0.0.255
Fuse supervision threshold L1 in A	1-0:31.4.0.255
Device-Type (Gas)	0-n:24.1.0.255
M-Bus Device ID 1 (Gas)	0-n:96.1.0.255
Last value of not temperature corrected gas volume in m³, including decimal values and capture time (Gas)	0-n:24.2.3.255
Breaker state (gas)	0-n:24.4.0.255
Text message (max 1024 characters)	0-0:96.13.0.255

Table 6: Implementation of the Belgian minimum dataset for the I1 interface

Note 1: 'Version information' contains information related to DSMR hardware and protocol stack and e-MUCS version. E.g. DSMR P1 v5.0.2 and e-MUCS H v1.0 gives the value '50210' as version information.

Note 2: Values marked with *(Gas)* are only present in the dataset when a gas meter is connected to the electricity meter.

Note 3: In case the fabrication number in 'M-bus device ID 1' does not provide sufficient information to uniquely identify the meter, 'M-bus device ID 2' can be added to this dataset.

A.2 Flemish dataset (Fluvius)

The Flemish government and regulator have defined extra objects on top of the Belgian minimal dataset. These extra objects can be found in this section. This addition on top of the Belgian minimal dataset will be implemented on the meters for the Flemish DSO's

Value	OBIS reference
Instantaneous voltage L1	1-0:32.7.0.255
Instantaneous voltage L2	1-0:52.7.0.255
Instantaneous voltage L3	1-0:72.7.0.255
Instantaneous current L1	1-0:31.7.0.255
Instantaneous current L2	1-0:51.7.0.255
Instantaneous current L3	1-0:71.7.0.255