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E-Meter P1 Specification

Electricity meter – P1 Port specification
(hardware and software)
for
Luxembourg's electricity meter "Smarty"

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List of Abbreviations

AAD	Additional Authenticated Data
AES	Advanced Encryption Standard
CRC	Cyclic Redundancy Check
DLMS/ COSEM	Device Language Message Specification/ COmpanion Specification for Energy Metering
DSMR	Dutch Smart Metering Specification
E-Meter	Electricity Meter
GCM	Galois Counter Mode
IDIS	Interoperable Device Interface Specification
IEC	International Electrotechnical Commission
M-Bus	DLMS M-Bus communication (wired, wireless)
OSM	Other Service Module

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1 Contact and Document Information

1.1 Contact Information

1.1.1 Contact Information DSOs

Contact information for P1 key request.

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Table 1.1 Contact Information DSOs

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Table 1.2 Contact Information Luxmetering

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Table 1.4 Document History

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2 Introduction

The E-Meter P1 port interface is designed for in-house communication, providing real-time data of the connected meters for further individual analyses or treatment or in-Home Display usage.

The details of the P1 interface are included in the not public hardware and software specification documents of the Luxemburgish E-Meter. The goal of this document is to extract the P1 specification for public usage. The P1 port interface specification is mainly based on the “P1 Companion Standard – Dutch Smart Meter requirements version 5.0.2” from Netbeheer Nederland – WG DSMR (2016) (https://www.netbeheernederland.nl).

The solution used in Luxembourg includes an additional security layer standard that is conform to the IDIS (Interoperable Device Interface Specification) package 2.0, which enables the maintainability of the solution.

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3 E-Meter – Port P1 interface specification

This chapter covers the hardware specification, software specification, protocol description and P1 security key.

3.1 P1 Hardware specification

The hardware specification documentation assigns mostly the topics to the “P1 Companion Standard – Dutch Smart Meter requirements version 5.0.2”.

3.1.1 P1 HW - Physical connector

The P1 physical connector is described in “P1 Companion Standard – Dutch Smart Meter requirements version 5.0.2” chapter .5.2 Physical Connector[1]

3.1.2 P1 HW - User safety

The P1 User safety is described in “P1 Companion Standard – Dutch Smart Meter requirements version 5.0.2” chapter .5.2 User safety with the sub chapter 5.2.1 Installation Category and 5.2.2. Galvanic Isolation. [2]

3.1.3 P1 HW - Power supply

The P1 Power supply is described in “P1 Companion Standard – Dutch Smart Meter requirements version 5.0.2” chapter .5.3 Power supply[3].

The port provides a power supply to the OSM devices, with a nominal voltage U_n = 5V.

The maximum supplied current is 250mA.

The supplied voltage is 4.9V ≤ U_n ≤ 5.3V for all currents between 0mA and 250mA.

Short circuit protection is triggered for a current I_{sc}, such as 260mA ≤ I_{sc} ≤ 350mA.

After short-circuit protection has been triggered, the current is limited to less than 50mA (fold back).

Normal operation is automatically resumed when overload condition is removed.

[1] Netbeheer Nederland – WG DSMR (2016), p. 6
[2] Netbeheer Nederland – WG DSMR (2016), p. 6-7
[3] Netbeheer Nederland – WG DSMR (2016), p. 8-10

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3.1.4 P1 HW - Variable load on power supply

The P1 Variable load on power supply is described in “P1 Companion Standard – Dutch Smart Meter requirements version 5.0.2” chapter .5.4 Variable load on power supply[4].

3.1.5 P1 HW - Metering system protection

The P1 Metering system protection is described in “P1 Companion Standard – Dutch Smart Meter requirements version 5.0.2” chapter .5.5 Metering system protection[5].

3.1.6 P1 HW - OSM (Other Service Module) protection

The P1 OSM protection is described in “P1 Companion Standard – Dutch Smart Meter requirements version 5.0.2” chapter .5.6 P1 OSM protection Metering system protection.

“To protect the OSM device (connect via P1 port) from an overvoltage caused by a failure at Metering System side, an OVP (Overvoltage Protection) mechanism should be implemented, which will limit the voltage to less than 15V.

Note:

The above requirement is only applicable for the “+5V” line, as the other lines (Data Request and Data) cannot be physically influenced by the Metering System due the use of opto-coupler.” [6]

3.1.7 P1 HW - Data interface specification

The P1 Data interface specification is described in “P1 Companion Standard – Dutch Smart Meter requirements version 5.0.2” chapter .5.7 Data interface specification with the sub chapter 5.7.1 “Data Request” line specification and 5.2.2. “Data” line specification. [7]

[4] Netbeheer Nederland – WG DSMR (2016), p. 10
[5] Netbeheer Nederland – WG DSMR (2016), p. 11-12
[6] Netbeheer Nederland – WG DSMR (2016), p. 12
[7] Netbeheer Nederland – WG DSMR (2016), p. 12-13

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3.1.8 P1 HW - Signal levels

		Requirement for the Meter			Requirement for OSM			
Symbol	**Description**	**Min**	**Typical**	**Max**	**Min**	**Typical**	**Max**	**Units**
U_{DR_1}	"Data request" line - HIGH level	-	-	5,5	4,0	5,0	5,5	V
I_{DR_1}	"Data request" line current	-	5	10	4	5	10	mA
U_{D_0}	"Data" line – LOW level	0	0,2	1	0	0,2	1	V
U_{D_1}	"Data" line – HIGH level	-	5,0	-	-	5,0	-	V
$I_{D\_0\_MAX}$	"Data" line max current	-	-	30	-	-	5	mA
U_L	"+5V" power supply – voltage	4,9	5	5,5	4,9	5	5,5	V
U_{RIPPLE_MAX}	"+5V" line maximum ripple voltage	-	-	100	-	-	100	mV
U_{NOISE_MAX}	"+5V" line- maximum noise	-	-	50	-	-	100	mV
V_{OVP}	OVP level ("+5V" and "Data request" lines)	5,8	5,9	15	-	-	-	V
I_{L_CONT}	"+5V" maximum continuous current	250	-	260	-	-	250	mA
I_{L_MAX}	"+5V" line overload protection trigger	260	-	300	-	-	-	mA
I_{SC}	"+5V" line Short Circuit current	-	-	50	-	-	-	mA

Logical levels are specified as follows:
SPACE "0" usually > 4V
MARK "1" as < 1 V

Figure 3.1 P1 Signal levels[8]

3.1.9 P1 HW - Data output

The data output is open collector or open drain. The typical load is a 1k pull-up to 5V.

The data output can sink a current up to 30mA with Vol ≤ 1V.

The maximum data rate is 115200 bds.

Data will be output on data output line when the data request line is "true":

True level is ≥ 4V. (Typical level = 5V)

False level is ≤ 1V

The data request line input current will be not more than 10mA for voltage up to 5V

The P1 port is protected against over voltage signals:

[8] Netbeheer Nederland – WG DSMR (2016), p. 14

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Power supply, data out and data request lines can withstand over voltage up to +/-12V with respect to port GND, with a maximum current of +/-250mA

All port lines are protected against electrostatic discharges compliant with IEC 61000 Part 4-2 Human Body Model.

The P1 port connector is RJ12 female socket. Pin assignment follows the DSMR v5.0 requirement.

3.1.10 P1 HW – Pin layout

The P1 port connector type is RJ12. The Metering System holds a female connector; the

OSM (Other Service Module) connects via standard RJ12 male plug.

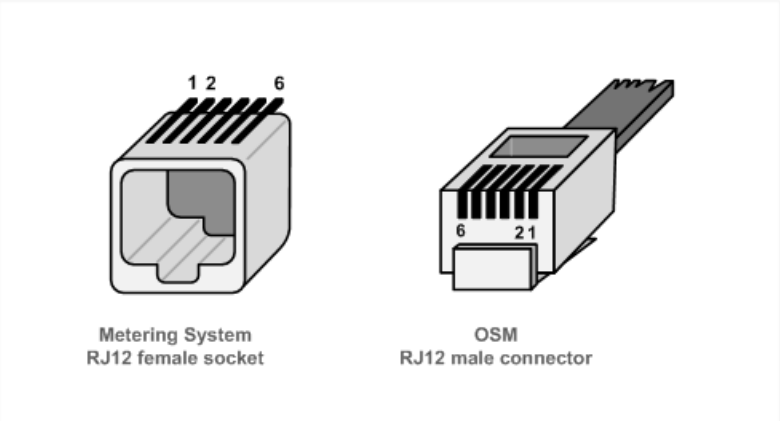

Figure 2 RJ12 Port

PIN	SIgnal	Description
1	+5V	+5V power supply
2	Data Request	Input
3	Data GND	Data ground
4	n.c	Not connected
5	Data	Output, open collector
6	Power GND	Power ground

Figure 3 Pin Layout

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3.1.11 P1 HW - Insulation

P1 port is insulated from mains network in compliance with BS EN 50470-1 - Electricity metering equipment (a.c.). General requirements, tests and test conditions. Metering equipment (class indexes A, B and C) standard[9]. See chapter Safety constraints:

- The level of the rated impulse voltage is 6kV.
- The level of the AC voltage test is 4kVrms.

3.2 P1 Software specification

Since the meter display capability is limited, a separate physical port is dedicated to customer information. An additional device can be plugged in this port to receive customer information and display it in another way.

The In-Home Display communication protocol should comply with Dutch Smart Meter Requirements v5.0.2 Final P1. [10]

Two signals are available on this interface:

- Request signal, which is a digital input for the meter
- Data signal, which is the output for the meter

The meter is constantly monitoring the Request line. It is said to be active when the level of the signal is LOW.

Data sent by the meter on the Data signal is transmitted as UART data with a baud rate fixed to 115200, 8 data bits, no parity bit and 1 stop bit.

3.2.1 P1 SW – Frame scheduling

As long as the Request signal is active, the meter sends frames periodically on the Data signal.

The periodicity is fixed to 10 seconds; the first frame being output at most 1 second following the activation of the Request signal.

The time required to send a frame cannot exceed 8 seconds.

The meter stops sending frames as soon as the Request signal becomes inactive.

[9] EN 50470-1 (2006) – chapter safety constraints
[10] Netbeheer Nederland – WG DSMR (2016)

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3.2.2 P1 SW – Frame general structure

A P1 frame is a multiline block of printable text, with CR-LF line terminations.

The first line contains a slash "/" followed by the manufacturer FLAG id (three letters code), the character "5", and then a manufacturer-specific identifier of the meter type.

The second line is an empty line.

The subsequent lines are the encoded representations of the COSEM objects selected in the P1 readout list.

The last line contains an exclamation mark "!" followed by the IBM CRC16 (polynomial 0x8005, initial value 0, no final XOR value) of the whole frame including the "!", represented in hexadecimal form MSB first.

3.2.3 P1 SW – Data encoding

Each data line starts with the OBIS code of the represented object, excluding the F group.

The encoding of the value depends on its A-XDR type. It is always represented as one or several strings contained in brackets "()".

The length of the stream is variable and is indicated with an “extra byte”. For more information, please refer to the IEC 61334-6 standard (IEC 61334, known as Distribution automation using distribution line carrier systems, is a standard for low-speed reliable power line communications by electricity meters, water meters and SCADA.) of the DLMS specification

Please refer to P1 specification for the complete list of type representation.

3.2.4 P1 SW – Readout list configuration

The P1 readout list is stored in the attribute 3 of a Profile Generic object (class 7).

The other attributes and methods of this object cannot be accessed by DLMS clients.

The capture_object must contain the DSMR P1 version as first element.

The P1-port streams by default only the e-meter data. For M-Bus (water, gas and heat) meters, the e-meter needs to be configured. In this case the client must ask the DSO to configure the e-meter.

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If objects related to an MBUS channel are selected, the device-type of this channel must be present and be precede any other object from this channel, including the long message.

This requirement is here to be sure that the IHD knows the type of energy before processing the data.

The maximum readout list is given in the following table:

Value	OBIS reference	attribute	class	format	unit	default list
Header Information	-	-	-	Manufacturer-specific	-	x
Version for P1 output	1-3:0.2.8.255	2	1	S2	-	x
current date-time	0-0:1.0.0.255	2	8	TST		x
Logical device name	0-0:42.0.0.255	2	1	S32		x
Total imported energy register (P+)	1-0:1.8.0.255	2	3	F9(3,3)	kWh	x
Total exported energy register (P-)	1-0:2.8.0.255	2	3	F9(3,3)	kWh	x
Total imported energy register (Q+)	1-0:3.8.0.255	2	3	F9(3,3)	kvarh	x
Total exported energy register (Q-)	1-0:4.8.0.255	2	3	F9(3,3)	kvarh	x
Instantaneous imported active power (P+)	1-0:1.7.0.255	2	3	F5(3,3)	kW	x
Instantaneous exported active power (P-)	1-0:2.7.0.255	2	3	F5(3,3)	kW	x
Instantaneous imported reactive power (Q+)	1-0:3.7.0.255	2	3	F5(3,3)	kvar	x
Instantaneous exported reactive power (Q-)	1-0:4.7.0.255	2	3	F5(3,3)	kvar	x
Active threshold (SMAX)	0-0:17.0.0.255	3	71	F4(1,1)	kVA	x
Threshold for maximum imported and exported current	1-1:34.4.0.255	2	21	F3(0,0), F3(0,0), signed	A	x
Instantaneous imported apparent power (S+)	1-0:9.7.0.255	2	3	F5(3,3)	kVA	x
Instantaneous exported apparent power (S+)	1-0:10.7.0.255	2	3	F5(3,3)	kVA	x
Breaker control state	0-0:96.3.10.255	3	70	I1	-	x
Relay 1 control state	0-1:96.3.10.255	3	70	I1	-	x
Relay 2 control state	0-2:96.3.10.255	3	70	I1	-	x
Number of power failures	0-0:96.7.21.255	2	1	F5(0,0)	-	x
Number of voltage sags L1	0-0:32.32.0.255	2	1	F5(0,0)	-	x
Number of voltage sags L2	0-0:52.32.0.255	2	1	F5(0,0)	-	x
Number of voltage sags L3	0-0:72.32.0.255	2	1	F5(0,0)	-	x
Number of voltage swells L1	0-0:32.36.0.255	2	1	F5(0,0)	-	x
Number of voltage swells L2	0-0:52.36.0.255	2	1	F5(0,0)	-	x
Number of voltage swells L3	0-0:72.36.0.255	2	1	F5(0,0)	-	x
Long message E-meter	0-0:96.13.0.255	2	1	Sn(n=0..2048)	-	x
Long message channel x	0-0:96.13.x.255	2	1	Sn(n=0..2048)	-	x
Instantaneous voltage L1	1-0:32.7.0.255	2	3	F4(1,1)	V	x
Instantaneous voltage L2	1-0:52.7.0.255	2	3	F4(1,1)	V	x
Instantaneous voltage L3	1-0:72.7.0.255	2	3	F4(1,1)	V	x
Instantaneous current L1	1-0:31.7.0.255	2	3	F3(0,0)	A	x
Instantaneous current L2	1-0:51.7.0.255	2	3	F3(0,0)	A	x
Instantaneous current L3	1-0:71.7.0.255	2	3	F3(0,0)	A	x
Instantaneous active power (P+) L1	1-0:21.7.0.255	2	3	F5(3,3)	kW	x
Instantaneous active power (P+) L2	1-0:41.7.0.255	2	3	F5(3,3)	kW	x
Instantaneous active power (P+) L3	1-0:61.7.0.255	2	3	F5(3,3)	kW	x
Instantaneous active power (P-) L1	1-0:22.7.0.255	2	3	F5(3,3)	kW	x
Instantaneous active power (P-) L2	1-0:42.7.0.255	2	3	F5(3,3)	kW	x
Instantaneous active power (P-) L3	1-0:62.7.0.255	2	3	F5(3,3)	kW	x
Instantaneous reactive power (Q+) L1	1-0:23.7.0.255	2	3	F5(3,3)	Kvar	x

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Instantaneous reactive power (Q+) L2	1-0:43.7.0.255	2	3	F5(3,3)	Kvar	x
Instantaneous reactive power (Q+) L3	1-0:63.7.0.255	2	3	F5(3,3)	Kvar	x
Instantaneous reactive power (Q-) L1	1-0:24.7.0.255	2	3	F5(3,3)	Kvar	x
Instantaneous reactive power (Q-) L2	1-0:44.7.0.255	2	3	F5(3,3)	Kvar	x
Instantaneous reactive power (Q-) L3	1-0:64.7.0.255	2	3	F5(3,3)	kvar	x
Device type channel x	0-x:24.1.0.255	9	72	F3(0,0)		
Equipment Identifier channel x	0-x:96.1.0.255	2	1	S16		
Last Index capture-time channel x	0-x:24.2.1.255	5	4	TST		
Last Index gas channel x	0-x:24.2.1.255	2	4	F8(3,3) to F8(0,0)	m^3	
valve position gas channel x	0-x:24.4.0.255	3	70	I1		
Last Index water channel x	0-x:24.2.1.255	2	4	F8(3,3)	m^3	
Last Index heat channel x	0-x:24.2.1.255	2	4	F8(3,3)	GJ	

Table 3.1 Maximum readout list

3.2.5 P1 SW – Channel security

P1 protocol is a plain text protocol: it is required to secure the link to ensure end user data confidentiality.

In deviation to DSMR P1, an encryption layer is added over the P1 protocol.

This encryption layer is based on DLMS security suite 0 algorithm: AES128-GCM

This channel has its own separate security context: a separated Encryption key and a dedicated frame counter.

The parameters used for the encryption algorithm are the following:

- IV is 96 bits = system-title (64 bits) || frame counter (32 bits)
- AAD is 17 bytes = 30h || 00112233445566778899AABBCCDDEEFFh
- tag length is 96 bits long

AAD is used the same way as in DLMS suite 0 with a fixed "Authentication key". This is mainly to stay as close as possible to existing DLMS implementation and achieve better interoperability with IHD devices: although the Green book makes the AK optional, most implementations use it.

Encrypted data (with its tag) is sent in binary form on the serial link, using a general-glo-ciphering frame:
DBh || 08h(system-title length) || system-title || (length of the subsequent bytes: 17 + length of data) || 30h || frame counter || ciphered data || GCM tag

A security setup (class 64) instance is defined for P1 port security.

This security setup instance cannot be referenced by an Association LN instance.

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The attribute 2 is used to toggle on and off the security on P1. Only the values 0 (unencrypted) and 3 (encrypted authenticated) are permitted.

The method 2 is used to renew the encryption key. Only key_id 0 can be used with this method.

When encryption is on, the frame counter is incremented after each frame is sent.

If the frame counter reaches the maximum value 0xffffffff, the meter stops sending frames, regardless of the Request signal state.

1 frame every 10 seconds is more than 1000 years, so the frame counter overflow will never happen in real use cases.

When the encryption key is changed, the frame counter is reset to 0.

3.3 P1 Protocol

The P1 Protocol description is described in “P1 Companion Standard – Dutch Smart Meter requirements version 5.0.2” chapter .6 Protocol description.

3.3.1 P1 Protocol description

“The protocol is based on NEN-EN-IEC 62056-21 Mode D. Data transfer is requested with request line and automatically initiated every second until request line is released. The information in the P1 telegram must be updated every second.“ [11]

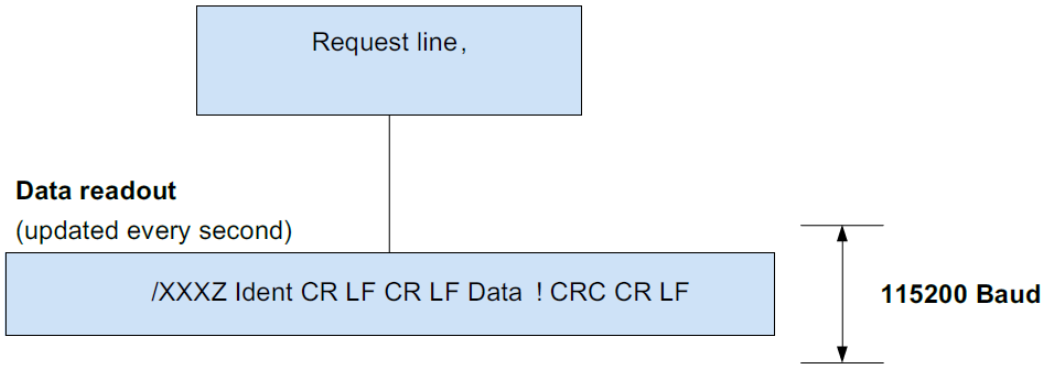

Figure 3.4 P1 Protocol[12]

[11] Netbeheer Nederland – WG DSMR (2016), p. 15
[12] Netbeheer Nederland – WG DSMR (2016), p. 15
…

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3.3.1.1 Representation of COSEM objects

The P1 protocol - Representation of COSEM objects is described in “P1 Companion Standard – Dutch Smart Meter requirements version 5.0.2” chapter .6.4 Representation of COSEM objects[13].

Value Format	Format/Example	Meaning
Fn(x,y)	F7(3,3) – YYYY.YYY	Floating decimal number with a fixed number of decimals behind the decimal point (in this case 3)
Fn(x,y)	F7(0,3) – YYYY.YYY or YYYYY.YY or YYYYYY.Y or YYYYYYY	Floating decimal number with a variable number of decimals behind the decimal point (with a maximum of 3)
In	I4 - YYYY	Integer number
Sn	S6 - CCCCCC	Alphanumeric string
TST	YYMMDDhhmmssX	ASCII presentation of Time stamp with Year, Month, Day, Hour, Minute, Second, and an indication whether DST is active (X=S) or DST is not active (X=W).

Figure 3.5 Representation of COSEM objects[14]

[13] Netbeheer Nederland – WG DSMR (2016), p. 16
[14] Netbeheer Nederland – WG DSMR (2016), p. 16

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3.4 P1 Security keys

3.4.1 P1 Security keys – functionality

The secrets are owned by the Luxmetering system and entity. There are two keys to cover-up the security context of P1 Interface. In that regards one key (“Authentication key”) enables to authenticate the devices of Luxmetering as mentioned in the chapter 3.2.5 Channel security. This key has to be hardcoded within the product as it will be the same for all the metering devices.

In parallel Luxmetering owns the P1 unitary keys (“Encryption key”) of all the devices which enables to secure the end customer sensitive consumption data. This key shall be locally entered into the In-Home Display or Home Server solution in order to enable on unitary base the service to the end customer upon his request. The definition of the key described in the chapter 3.2.5 Channel security.

3.4.2 P1 Security keys – key provisioning

In order to use the P1 port, the customer has to enter the encryption key in his In-Home Display or Home Server. The customer must request this key either directly from the DSO or mandate his energy supplier or energy service company to request it.

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List of Literature

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IEC 61334-6:2000 (2000): Distribution automation using distribution line carrier systems - Part 6: A-XDR encoding rule.

NEN-EN-IEC 62056-21 (2002): Electricity metering - Data exchange for meter reading, tariff and load control - Part 21: Direct local data exchange

Netbeheer Nederland – WG DSMR (2016): P1 Companion Standard – Dutch Smart Meter requirements version 5.0.2 (26th February 2016): https://www.netbeheernederland.nl/_upload/Files/Slimme_meter_15_a727fce1f1.pdf [State: 6.7.2020]

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Appendix

A P1 datagram example

The following table shows an example of the P1 telegram that is in accordance to IEC 62056-21 Mode D. Be aware of the fact that the number of OBIS codes and the order of OBIS codes is not fixed. The P1 device must be able to interpret the OBIS codes and understand the representation. For example: depending on installation, the OBIS codes for a heat/cold meter might be sent before the OBIS codes of a Gas meter.

The example telegram in clear below is based on:

- Luxembourg Smart meter from the test system in version 2.90
- It is send at 06/07/2020 10:40
- Gas value presented on 06/07/2020 10:40
- Water meter presented on 06/07/2020 10:40

```
/Lux5\253694471_M

1-3:0.2.8(42)
0-0:1.0.0(200706104157S)
0-0:42.0.0(534147313033303739303030323537 34)
1-0:1.8.0(000025.653*kWh)
1-0:2.8.0(000000.040*kWh)
1-0:3.8.0(000000.835*kvarh)
1-0:4.8.0(000063.781*kvarh)
1-0:1.7.0(00.005*kW)
1-0:2.7.0(00.000*kW)
1-0:3.7.0(00.000*kvar)
1-0:4.7.0(00.000*kvar)
0-0:17.0.0(069.0*kVA)
1-0:9.7.0(00.021*kVA)
1-0:10.7.0(00.000*kVA)
1-1:31.4.0(100*A)(-063*A)
0-0:96.3.10(1)
0-1:96.3.10(0)
0-2:96.3.10(0)
0-0:96.7.21(00099)
1-0:32.32.0(00040)
1-0:52.32.0(00003)
1-0:72.32.0(00002)
1-0:32.36.0(00000)
1-0:52.36.0(00000)
1-0:72.36.0(00000)
0-0:96.13.0()
0-0:96.13.2()
0-0:96.13.3()
0-0:96.13.4()
0-0:96.13.5()
1-0:32.7.0(233.0*V)
1-0:52.7.0(000.0*V)
1-0:72.7.0(001.0*V)
1-0:31.7.0(000*A)
1-0:51.7.0(000*A)
1-0:71.7.0(000*A)
```


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```
1-0:21.7.0(00.005*kW)
1-0:41.7.0(00.000*kW)
1-0:61.7.0(00.000*kW)
1-0:22.7.0(00.000*kW)
1-0:42.7.0(00.000*kW)
1-0:62.7.0(00.000*kW)
1-0:23.7.0(00.000*kvar)
1-0:43.7.0(00.000*kvar)
1-0:63.7.0(00.000*kvar)
1-0:24.7.0(00.000*kvar)
1-0:44.7.0(00.000*kvar)
1-0:64.7.0(00.000*kvar)
0-1:24.1.0(003)
0-1:96.1.0(464C4F313839393030303630333535)
0-1:24.2.1(200706103140S)(00000.006*m3)
0-1:24.4.0(0)
0-2:24.1.0(007)
0-2:96.1.0()
0-2:24.2.1(632525252525S)(00000.000)
0-2:24.4.0(1)
0-3:24.1.0(007)
0-3:96.1.0()
0-3:24.2.1(632525252525S)(00000.000)
0-3:24.4.0(1)
0-4:24.1.0(003)
0-4:96.1.0(454C533335333538393938303330 30)
0-4:24.2.1(200706102900S)(00028.103*m3)
0-4:24.4.0(1)
!8B52
```

B P1 Companion Standard – Dutch Smart Meter requirements version 5.0.2

Only available in in the Word document. The source of the documents “P1 Companion Standard – Dutch Smart Meter requirements version 5.0.2” (26th February 2016) is listed in the chapter List of Literature.

P1 Companion Standard – DSMR_5.0

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