



BSI Standards Publication

Open Smart Grid Protocol (OSGP)

National foreword

This Published Document is the UK implementation of CLC/TS 50586:2019.

The UK participation in its preparation was entrusted to Technical Committee PEL/13, Electricity Meters.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2019
Published by BSI Standards Limited 2019

ISBN 978 0 539 02150 9

ICS 29.020; 29.240.01; 33.200

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 November 2019.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

ICS

English Version

Open Smart Grid Protocol (OSGP)

Protocole ouvert pour Réseau Intelligent

Open Smart Grid Protocol (OSGP)

This Technical Specification was approved by CENELEC on 2019-09-02.

CENELEC members are required to announce the existence of this TS in the same way as for an EN and to make the TS available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Contents

Page

European Foreword	9
Introduction	10
1 Scope	11
2 Normative references	11
3 Terms and definitions and abbreviations	11
3.1 Terms and definitions	11
3.2 Abbreviations	16
4 PLC network management.....	18
4.1 Overview	18
4.2 Metering device lifecycle	19
4.3 ATM Protocol.....	19
4.3.1 Overview	19
4.3.2 ATM responsibilities.....	20
4.3.3 Automatic discovery	20
4.3.4 Discovery domain.....	20
4.3.5 ATM messages.....	20
4.4 Commissioning.....	24
4.4.1 Overview	24
4.4.2 Commissioning operations	25
5 OSGP Device data representation	25
5.1 General overview	25
5.2 Data types	25
5.3 Pending tables	27
5.4 Value Control Identifiers (VCI).....	28
5.5 Value	28
5.6 Register Naming Convention	28
5.7 Table and Procedure Naming Convention	28
5.8 Interface Change Alarm (ICA NACK)	29
6 Security	29
6.1 Overview	29
6.2 Security suites	29
6.2.1 Overview	29
6.2.2 OSGP-AES-128-PSK	29
6.2.3 OMAK	30
6.2.4 Access control	30
6.3 Hardware Lock	30
7 Device Functional Description of the case the OSGP device is an electric power metering device.....	30
7.1 Overview	30
7.2 Time-Of-Use Calendar (optional).....	30
7.2.1 Overview	30
7.2.2 Manual Override Option (optional).....	31
7.2.3 Over Power Threshold Tariff (optional)	32
8 Clock Adjustment (mandatory)	32
8.1 Absolute Time Synch	32
8.1.1 General.....	32
8.1.2 Clock Adjustment by Delta	32
8.2 Billing Functions.....	33

8.2.1	Self Reads (mandatory)	33
8.2.2	Total Energy (optional)	33
8.2.3	On-Demand Read of Current Billing Register Values (mandatory)	33
8.3	Load Profile (mandatory)	33
8.3.1	Overview	33
8.3.2	Use case: Reading Load Profile Data	34
8.3.3	Use case: Parsing M-Bus Load Profile Data	35
8.4	Self-Test (Alarms, Error Codes) (optional)	36
8.5	Pulse Inputs (optional)	36
8.6	Power Quality (optional)	37
8.6.1	Functional Description	37
8.7	Display (optional)	38
8.7.1	Overview	38
8.7.2	Display Source List (optional)	38
8.7.3	Display configuration (optional)	42
8.7.4	Error Codes Configuration (optional)	42
8.7.5	Simulated Wheel Rotation Configuration (optional)	42
8.7.6	Disconnect Configuration (optional)	42
8.7.7	CT and VT Ration (optional)	43
8.7.8	Firmware version on Power-Up (optional)	43
8.7.9	PLC signal quality Icons (optional)	43
8.7.10	Scheduled Display Messages (optional)	43
8.8	Local Disconnect Contactor (optional)	43
8.8.1	Overview	43
8.8.2	Maximum Power and Current Level Thresholds	44
8.8.3	Prepaid Metering (optional)	46
8.8.4	Local Manual Control (optional)	46
8.8.5	Load Contactor Remote Control (optional)	46
8.9	Control Relay (optional)	47
8.9.1	Overview	47
8.9.2	Control Relay Randomization	47
8.9.3	Time-Based Control Relay Calendar	47
8.9.4	Remote Control	48
8.10	History Log (optional)	48
8.10.1	Overview	48
8.10.2	Critical event (optional)	48
8.10.3	Critical event Categories	49
8.11	One-Time Reads (optional)	50
8.12	Group Broadcast (optional)	51
8.13	Demand Metering (optional)	51
8.13.1	Overview	51
8.13.2	Demand Values (optional)	52
8.14	Test Mode	54
8.15	MEP Device Overview	55
8.15.1	General	55
8.15.2	Downlink Data Transfer	55
8.15.3	Uplink Data Transfer	59
8.16	M-Bus Device support (optional)	66
8.16.1	Overview	66
8.16.2	Billing Data Collection	66
8.16.3	Auto-discovery	69
8.16.4	Device Removal	69
8.16.5	M-Bus Status and Alarms	69
8.17	Compatibility Setting (mandatory)	69
9	Basic OSGP services	70
9.1	Overview	70
9.2	Matching of requests and responses	70
9.3	Buffer restrictions	70
9.4	Full Table Read service	70

9.4.1	Request	70
9.4.2	Full Read Response	71
9.5	Full Table write service	71
9.5.1	Request	71
9.5.2	Response	72
9.6	Partial table read	72
9.6.1	Request	72
9.6.2	Response	73
9.7	Partial table write	73
9.7.1	Request	73
9.7.2	Response	73
9.8	Response error codes	73
9.9	Transactions	75
9.10	Procedure invocation	76
9.10.1	Overview	76
9.10.2	Procedure Timing	77
9.10.3	Slow and Non-Responsive Procedures	77
Annex A	(normative) Basic Tables	79
A.1	Basic Table 00 (BT00): General configuration	79
A.2	Basic Table 01 (BT01): General Manufacturer Identification	95
A.3	Basic Table 02 (BT02): Device Nameplate	96
A.4	Basic Table 03 (BT03): End Device Mode Status	98
A.5	Basic Table 04 (BT04): Pending Status	101
A.6	Basic Table 05 (BT05): Device Identification	103
A.7	Basic Table 06 (BT06): Utility Information	103
A.8	Basic Table 07 (BT07): Procedure Initiate	104
A.9	Basic Table 08 (BT08): Procedure Response	104
A.10	Basic Table 10 (BT10): Dimension Sources Limiting	105
A.11	Basic Table 12 (BT12): Unit of Measure Entry	106
A.12	Basic Table 13 (BT13): Demand Control	108
A.13	Basic Table 15 (BT15): Constants	109
A.14	Basic Table 16 (BT16): Source Definition	109
A.14.1	General	109
A.14.2	Measurement Source Definition Records	110
A.14.3	Extended Source IDs	120
A.15	Basic Table 20 (BT20): Dimension Register	121
A.16	Basic Table 21 (BT21): Actual Register	122
A.17	Basic Table 22 (BT22): Data Selection	123
A.18	Basic Table 23 (BT23): Current Register Data	124
A.19	Basic Table 24 (BT24): Previous Season Data	126
A.20	Basic Table 25 (BT25): Previous Demand Reset Data	126
A.21	Basic Table 26 (BT26): Self Read Data	126
A.22	Basic Table 27 (BT27): Present Register Selection	127
A.23	Basic Table 28 (BT28): Present Register Data	127
A.24	Basic Table 30 (BT30): Dimension Display	129
A.25	Basic Table 33 (BT33): Primay Display List	129
A.26	Basic Table 50 (BT50): Dimension Time and TOU	130
A.27	Basic Table 52 (BT52): Clock	131
A.28	Basic Table 53 (BT53): Time Offset	132
A.29	Basic Table 54 (BT54): Calendar	132
A.30	Basic Table 55 (BT55): Clock state	134
A.31	Basic Table 60 (BT60): Dimension Load Profile	135
A.32	Basic Table 61 (BT61): Actual Load Profile	137
A.33	Basic Table 62 (BT62): Load Profile Control	138
A.34	Basic Table 63 (BT63): Load Profile Status	139
A.35	Basic Table 64 (BT64): Load Profile Data	140
A.36	Basic Table 70 (BT70): Dimension Log	143
A.37	Basic Table 71 (BT71): Actual Log	143
A.38	Basic Table 72 (BT72): Events Identification	144

A.39	Basic Table 73 (BT73): History Log Control	160
A.40	Basic Table 74 (BT74): History Log Data	160
A.41	Basic Table 4150 (BT4150): Pending TOU Calendar.....	161
Annex B	(normative) Extended Tables.....	163
B.1	Extended Table 00 (ET00) (2048): Manufacturer Specific	163
B.2	Extended Table 01 (ET01) (2049): Manufacturer Specific	163
B.3	Extended Table 02 (ET02) (2050): RTC calibration	163
B.4	Extended Table 03 (ET03) (2051): Utility Information	163
B.5	Extended Table 04 (ET04) (2052): System Information	165
B.6	Extended Table 05 (ET05) (2053): Control Output Settings	171
B.7	Extended Table 06 (ET06) (2054): Pulse Inputs.....	180
B.8	Extended Table 07 (ET07) (2055): Display Configuration.....	181
B.9	Extended Table 08 (ET08) (2056): Manufacturer Specific	184
B.10	Extended Table 09 (ET09) (2057): Power Quality	184
B.11	Extended Table 10 (ET10) (2058): Internal Power Outages.....	189
B.12	Extended Table 11 (ET11) (2059): MFG Dimension.....	189
B.13	Extended Table 12 (ET12) (2060): Daily Consumption	191
B.14	Extended Table 13 (ET13) (2061): M-Bus/MEP Device config.....	191
B.15	Extended Table 14 (ET14) (2062): M-Bus/MEP Device Status	194
B.16	Extended Table 15 (ET15) (2063): MEP On-demand Requests	197
B.17	Extended Table 17 (ET17) (2065): Code Bank Info.....	199
B.18	Extended Table 18 (ET18) (2066): Manufacturer Specific	201
B.19	Extended Table 19 (ET20) (2067): Meter One-Time Read Queue.....	201
B.20	Extended Table 20 (ET20) (2068): M-Bus One Time Read Queue	202
B.21	Extended Table 21 (ET21) (2069): Load Profile Internam Configuration	202
B.22	Extended Table 22 (ET22) (2070): Error Codes Configuration	204
B.23	Extended Table 27 (ET27) (2075): Transaction Request Table	205
B.24	Extended Table 28 (ET28) (2076): Transaction Response Table.....	206
B.25	Extended Table 29 (ET29) (2077): Hardware Configurations	206
B.26	Extended Table 30 (ET30) (2078): Maximum power or current level control	209
B.27	Extended Table 31 (ET31) (2079): Meter One-Time Read Log	209
B.28	Extended Table 32 (ET32) (2080): MEP One-Time Read Log	211
B.29	Extended Table 33 (ET33) (2033): Group Configuration.....	212
B.30	Extended Table 34 (ET34) (2082): MEP Device Configuration 2	213
B.31	Extended Table 35 (ET35) (2083): Manufacturer Specific	214
B.32	Extended Table 36 (ET36) (2084): Mfg Actual Dimensions	214
B.33	Extended Table 37 (ET37) (2085): Build Information	216
B.34	Extended Table 38 (ET38) (2086): Manufacturer Specific	216
B.35	Extended Table 39 (ET39) (2087): Previous Demand.....	216
B.36	Extended Table 40 (ET40) (2088): Demand Configuration	216
B.37	Extended Table 41 (ET41) (2089): Historical Demand Reset Log	217
B.38	Extended Table 42 (ET42) (2090): Interface Definition	219
B.39	Extended Table 43 (ET43) (2091): Test Mode Configuration.....	223
B.40	Extended Table 44 (ET44) (2092): Test Mode Status	224
B.41	Extended Table 45 (ET45) (2093): MEP Recurring Read Log.....	224
B.42	Extended Table 46 (ET46) (2094): Control Output Read Only Data.....	225
B.43	Extended Table 47 (ET47) (2095): Calendar Override Settings	226
B.44	Extended Table 48 (ET48) (2096): Feature Activation Table	226
B.45	Extended Table 49 (ET49) (2097): LCD Output Table	227
B.46	Extended Table 50 (ET50) (2098): MEP Inbound Data Space	227
B.47	Extended Table 51 (ET51) (2099): MEP Device Configuration	229
B.48	Extended Table 52 (ET52) (2100): MEP Transaction Request Table	229
B.49	Extended Table 53 (ET53) (2101): MEP Transaction Response Table	229
B.50	Extended Table 54 (ET54) (2102): Meter Status	230
B.51	Extended Table 55 (ET55) (2103): Meter Configuration.....	233
B.52	Extended Table 56 (ET56) (2104): Load side state calibration	238
B.53	Extended Table 57 (ET57) (2105): M-Bus Data Type Table	239
B.54	Extended Table 58 (ET58) (2106): MEA Status Extension.....	240
B.55	Extended Table 59 (ET59) (2107): MEP Procedure Response	240

B.56	Extended Table 60 (ET60) (2108): Configurable Energy Accumulator Settings	241
B.57	Extended Table 61 (ET61) (2109): Time-Based Relay Control	241
B.58	Extended Table 62 (ET62) (2110): Load profile Display Configuration	242
B.59	Extended Table 66 (ET66) (2114): Load Profile Source ID Mapping Table	244
B.60	Extended Table 67 (ET67) (2115): Display Source ID Mapping Table	244
B.61	Extended Table 68 (ET68) (2116): Critical Events	245
B.62	Extended Table 69 (ET69) (2117): Critical Events Bitmasks	245
B.63	Extended Table 70 (ET70) (2118): RAM only status	246
B.64	Extended Table 71 (ET71) (2119): MEP Delta Data and Config	247
B.65	Extended Table 1038 (ET1038) (3086): Manufacturer Specific	248
B.66	Extended Table 4143 (ET4143) (6191): Calendar Override Settings	248
B.67	Extended Table 4156 (ET4156) (6204): Configurable Energy Accumulator Settings	248
Annex C	(normative) Basic Procedures	249
C.1	Basic Procedure 04 (BP04): Reset List Pointers	249
C.2	Basic Procedure 05 (BP05): Update Last Read Entry	249
C.3	Basic Procedure 06 (BP06): Change Mode	250
C.4	Basic Procedure 10 (BP10): Set Date and Time	251
C.5	Basic Procedure 12 (BP12): Activate All Pending Tables	252
C.6	Basic Procedure 13 (BP13): Activate Specific Pending Tables	252
C.7	Basic Procedure 14 (BP14): Clear All Pending Tables	253
C.8	Basic Procedure 15 (BP15): Clear Specific Pending Tables	254
Annex D	(normative) Extended Procedures	255
D.1	Extended Procedure 00 (EP00) (2048): Manufacturer Specific	255
D.2	Extended Procedure 01 (EP01) (2049): NV Memory Refresh	255
D.3	Extended Procedure 02 (EP02) (2050): Control Output Command	255
D.4	Extended Procedure 03 (EP03) (2051): Clear Alarms	256
D.5	Extended Procedure 04 (EP04) (2052): Manufacturer Specific	257
D.6	Extended Procedure 05 (EP05) (2053): Manufacturer Specific	257
D.7	Extended Procedure 06 (EP06) (2054): NVM Config	257
D.8	Extended Procedure 07 (EP07) (2055): Manufacturer Specific	258
D.9	Extended Procedure 08 (EP08) (2056): Erase code memory	258
D.10	Extended Procedure 09 (EP09) (2057): Download Code Packet	259
D.11	Extended Procedure 10 (EP10) (2058): Switch Code Bank	259
D.12	Extended Procedure 11 (EP11) (2059): Configure/Reset Load Profile Data Set	260
D.13	Extended Procedure 12 (EP12) (2060): Record Self-Read	262
D.14	Extended Procedure 13 (EP13) (2061): Write single Bit in Table	262
D.15	Extended Procedure 14 (EP14) (2062): Manufacturer Specific	263
D.16	Extended Procedure 15 (EP15) (2063): Set Tariff	263
D.17	Extended Procedure 16 (EP16) (2064): Change System Clock by Delta	264
D.18	Extended Procedure 17 (EP17) (2065): Remove M-Bus/MEP Device	264
D.19	Extended Procedure 18 (EP18) (2066): Clear MEP Alarm	265
D.20	Extended Procedure 19 (EP19) (2067): Post On-demand M-Bus Request	266
D.21	Extended Procedure 21 (EP21) (2069): Add prepay credit	267
D.22	Extended Procedure 22 (EP22) (2070): Switch maximum power or current level	268
D.23	Extended Procedure 23 (EP23) (2071): Remote Disconnect Request	269
D.24	Extended Procedure 24 (EP24) (2072): Post On-Time Read Request	269
D.25	Extended Procedure 25 (EP25) (2073): Reset Extended Table Logs and Queues	270
D.26	Extended Procedure 26 (EP26) (2074): Update Mfg Lists Unread Entries	271
D.27	Extended Procedure 27 (EP27) (2075): Add/Remove Group ID	271
D.28	Extended Procedure 28 (EP28) (2076): Enable/Disable Battery	272
D.29	Extended Procedure 29 (EP29) (2077): Read/Write Diagnostic Counters	273
D.30	Extended Procedure 30 (EP30) (2078): Synchronize Disconnect Status	273
D.31	Extended Procedure 31 (EP31) (2079): Activate Feature	274
D.32	Extended Procedure 32 (EP32) (2080): Billing Dimension Configuration	274
D.33	Extended Procedure 33 (EP33) (2081): Billing Reconfiguration	277
D.34	Extended Procedure 34 (EP34) (2082): Demand Reset	278
D.35	Extended Procedure 36 (EP36) (2084): Schedule Disconnect Lock Open	278
D.36	Extended Procedure 37 (EP37) (2085): NVM Config	279

D.37	Extended Procedure 39 (EP39) (2087): Post MEP Data (Urgent or Non-Urgent)	280
D.38	Extended Procedure 41 (EP41) (2089): MEP Download Initialize	282
D.39	Extended Procedure 42 (EP42) (2090): Control Output Settings	283
D.40	Extended Procedure 44 (EP44) (2092): IO Control	285
D.41	Extended Procedure 45 (EP45) (2093): Manufacturer Specific	285
D.42	Extended Procedure 46 (EP46) (2094): Manufacturer Specific	285
D.43	Extended Procedure 47 (EP47) (2095): Manufacturer Specific	285
D.44	Extended Procedure 48 (EP48) (2096): Manufacturer Specific	285
D.45	Extended Procedure 49 (EP49) (2097): Manufacturer Specific	285
Annex E (normative) OSGP OMA Digest Algorithm		286
Annex F (normative) OSGP-AES-128-PSK Security Suite		288
F.1	Introduction	288
F.2	Background	289
F.2.1	System Assumptions	289
F.2.2	Threat Model	289
F.2.3	Design Goals	289
F.2.4	Inspiration	290
F.3	Terms and Notation	290
F.3.1	Terms	290
F.3.2	Notation	292
F.3.3	Other conventions	292
F.4	Cryptographic Primitives	292
F.4.1	CMAC	293
F.4.2	CCM	293
F.5	Cryptographic Functions	293
F.5.1	OSGP_KDF: Key Derivation Function	293
F.5.2	OSGP_MAC: Message Authentication Code Function	294
F.5.3	OSGP_MAC_VERIFY: Message Authentication Code Verification Function	295
F.5.4	OSGP_AE/OSGP_AD: Authenticated Encryption/Decryption Functions	295
F.5.5	OSGP_CSPRG(num_of_bytes): Cryptographically Secure Pseudo Random Number Generator	297
F.6	Keys	297
F.7	Secure Channel Initialization	299
F.7.1	Overview	299
F.7.2	Secure Channel State(CryptoContext)	299
F.7.3	Flow	300
F.7.4	Security Suite Negotiation	306
F.7.5	Meter commissioning	306
F.7.6	Error Handling and Intrusion Detection	306
F.7.7	Messages	306
F.8	Secure Channel Communication	310
F.8.1	Overview	310
F.8.2	The General Process	311
F.8.3	Unicast Communication	312
F.8.4	Broadcast Communication	316
F.9	Firmware Downloading	318
F.10	Key Management	319
F.10.1	Renewing the Short-term, Meter-unique Keys	319
F.10.2	Renewing the Short-term, Domain-unique Keys	319
F.10.3	Updating the Long-term, Meter-unique Keys	321
F.10.4	Key Validity Periods	321
F.11	Error Messages	321
F.11.1	Overview	321
F.11.2	AuthenticationFailure	321
F.11.3	SequenceError	321
F.12	Security Considerations	322
F.12.1	Reasoning	322
F.12.2	Recommendation and Guidance for Implementers	324

F.12.3 Question and Answers	326
Annex G (normative) Repeating mechanism	328
G.1 Overview	328
G.2 Terms	328
G.3 Protocol specification	329
G.3.1 Overview	329
G.3.2 Addressing	329
G.3.3 Service Types	329
G.3.4 Timers	329
G.3.5 Request Flow	329
G.3.6 Response Flow	330
G.3.7 Authentication	330
G.3.8 Examples	331
G.3.9 Broadcast	332
G.4 Downlink Frame format	332
G.4.1 Overview	332
G.4.2 Proxy parameters of Request Frame	332
G.5 Uplink Frame format	337
G.5.1 Overview	337
G.5.2 Proxy success	337
G.5.3 Repeating Failure	337
G.5.4 Authentication Failure	338
Bibliography	339

European foreword

This document (CLC/TS 50586:2019) has been prepared by CLC/TC 13 “Electrical energy measurement and control”.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

This Document does not have the status of a harmonized Standard and cannot therefore be listed in the Official Journal of the EU and therefore provides no presumption of conformity. However, this Document may be used for the risk evaluation in the framework of the EU conformity declaration. If this document provides requirements below the level of a harmonized standard, the harmonized standard takes precedence.

Introduction

One of the outcomes of the mandate M/441 is the identification of OSGP as one of the protocols which can be used for Smart Metering deployment in Europe.

1 Scope

This document describes the data interface model, application-level communication, management functionalities, and security mechanism for the exchange of data with smart-grid devices. The following five areas are referred to as the Open Smart Grid Protocol (OSGP).

- Data exchange with smart-grid devices allows Utility Suppliers to collect customer usage information such as billing data and load profiles, monitor and control grid utilization, provision scheduling of tariffs, detect theft and tampers, and to issue disconnects, to name a few. Meter features are described in Clauses 7 and 8.
- The OSGP data interface uses a representation-oriented model (tables and procedures) which require low overhead. The model is described in Clause 5, with specific tables specified in Annex A, Annex B, and procedures in Annex C and Annex D.
- The OSGP application protocol is designed to use the EN 14908-1:2014 communication stack over narrow-band power line channels. Clause 9 describes the messages that are used to access OSGP data. An essential feature of the protocol over power line channels is a repeating mechanism which gives the application layer the control and responsibility for forwarding packets among devices, independent of the routing protocol or limitations of underlying layers. Therefore OSGP can be adapted to other communication stacks and medium, although such adaptation is outside of the scope of this specification. The repeating mechanism is described in Annex G.
- OSGP management features include the discovery of devices and the routing topology in a protocol called Automated Topology Management (described in Clause 4) commissioning of devices for secured communication (Annex F), monitoring of device connectivity, and updating of device firmware.
- OSGP security covers authentication, encryption, and key management. This is detailed in Annex F.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 14908-1:2014, *Information technology - Control network protocol - Part 1: Protocol stack*

ISO 8859-1 (or ECMA-94), *Information technology - 8-bit single-byte coded graphic character sets - Part 1: Latin alphabet No. 1*

ISO/IEC 646:1991, *Information technology - ISO 7-bit coded character set for information interchange*

IEEE Std 802.11ac-2013, *IEEE Standard for Information technology- Telecommunication and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 11 Wireless LAN Medium Access Control*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply. ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp>

— IEC Electropedia: available at <http://www.electropedia.org/>

3.1.1

active energy/power

measure of active power expended over time (resistive load)

3.1.2

apparent energy/power

multiplication of the rms voltage with the rms current

3.1.3

Byte Encryption Key

BEK

128-bit key derived from the OMAK for the purpose of OSGP encryption

3.1.4

Billing Interface Definition Number

BIDN

identifier used to identify billing-related data in OSGP device logs, see table EP 32 in annex D

3.1.5

bootrom

part of the OSGP device firmware which is fixed and cannot be changed over the network

3.1.6

broadcast

message directed at all of the network population. In OSGP systems, only the data concentrator initiates broadcast messages

Note 1 to entry: OSGP devices may repeat a broadcast message.

3.1.7

clone domain

special logical network address format that signals a node to receive rather than reject messages from a sender having the same source address as itself

Note 1 to entry: This facilitates the discovery process by allowing discovery messages to be propagated throughout nodes all having the same pre-assigned address, without requirement them to be commissioned. The clone domain address is distinguished from a normal address by having the node number byte's most significant bit set to zero instead of one.

Note 2 to entry: In addressing there can be up to 255 subnets and 127 nodes/subnet, so the high order bit of the node number byte is free for this special use.

3.1.8

Packet Cycle Count

maximum number of packet cycles over which to randomize access to the link

3.1.9

Data Concentrator

DC

gateway which supervises electrical utility OSGP devices and other devices, performing data collection and network management functions and allows access to the data and device by the HES

3.1.10

device (or OSGP device)

device which implements the OSGP protocol

3.1.11

dip

measured quantity detected at a level below a defined threshold

3.1.12**energy**

summation of power over time

3.1.13**Fast Commission Message****FCM**

specific OSGP message type used for PLC traffic optimization during initial commissioning of an OSGP device

3.1.14**group ID**

mechanism for selecting a subset of devices to process a broadcast message

Note 1 to entry: the group ID used in OSGP is an application-layer entity, and is unrelated to the 14908-1 Group ID which is used in the network layer.

3.1.15**in-phase**

condition when the phase angle between two sine waves is 0 degrees

3.1.16**Interface Change Alarm****ICA**

alarm bit in BT03 to indicate the possible change of the device's interface definition or dimensions of some OSGP device tables, due to modification of device tables or invocation of device procedures

Note 1 to entry: Attempts to read or write some device tables will not succeed until the alarm has been cleared by the HES to acknowledge the interface change. Tables affected by the Interface Change Alarm in this manner are marked with the ICA NACK attribute throughout the present document. Tables and procedures that may cause the Interface Change Alarm to be triggered are marked with the ICA SRC attribute throughout the present document.

3.1.17**load profile**

recording of one or more pieces of electrical load data at specified intervals

3.1.18**M-Bus**

protocol developed for networking and remote reading of utility meters that are attached (wired or wirelessly) to the smart grid device

Note 1 to entry: the M-Bus capabilities in the OSGP device according to the present document can discover and query up to four M-Bus devices, such as gas, water, or heat meters. The OSGP device stores the consumption data collected from the M-Bus devices along with any alarm or status messages.

3.1.19**M-Bus Auto-discovery**

process by which the device which play the role of the M-Bus master polls the M-Bus network for new and previously commissioned devices

Note 1 to entry: newly discovered devices are added to the commissioned device list for regular polling, up to a maximum of four devices.

3.1.20**M-Bus Data Type****MDT**

mapping of a M-bus Data Record Header (DRH) definition to a 5-bit ordinal

3.1.21

Multipurpose Expansion Port

MEP

physical interface through which further network devices can be added to the utility OSGP device

Note 1 to entry: a MEP device is a device that connects to the OSGP device using the MEP port to access OSGP device tables and run OSGP device procedures.

3.1.22

multicast

message directed at a subset of the devices

3.1.23

Non-Volatile Memory

NVM

generic term used to refer to memory that retains its values across power cycles and, in the present document, used to store device data

3.1.24

Non-Volatile Memory size

NVM(s)

number of bytes of non-volatile memory

Note 1 to entry: the total number of 1K blocks of NVM is available in ET04.

3.1.25

Open Media Access Key

OMAK

96-bit key used for authenticating 14908-1 network management messages between nodes

3.1.26

one-time-read

method by which an electric OSGP device performs a snapshot of pertinent registers along with a timestamp, upon invocation from the HES

3.1.27

OSGP Communication Key

key for encrypting and authenticating OSGP APDUs. A separate key is used for unicast (UCK) or broadcast (BCK). Also defines access privileges to meter procedures and tables

3.1.28

packet cycle

time to transmit a packet of average length where average is for that network/messaging pattern

Note 1 to entry: packet cycle width is usually expressed in tens of milliseconds, e.g. a packet cycle width of 20 means 200 ms.

3.1.29

Pending Event Descriptor

PED

specification of the condition for activating a pending table, and associated actions to perform along with the activation

Note 1 to entry: it is defined in BT04.

3.1.30

phase alignment

addition of inductance or capacitance to current or voltage measurement channels to reduce or eliminate phase angle errors and consequent power measurement errors

3.1.31**phase loss**

absence of an electrical phase or the reduction of an electrical phase below the declared voltage by predefined percentage

3.1.32**Power Line Carrier****PLC**

communication using the existing power distribution network

3.1.33**power factor:**

active power divided by apparent power and lies within the range -1 to 1

3.1.34**Program ID****PID**

identifier for a given interface version implemented by the OSGP device firmware

Note 1 to entry: The program ID must be universally unique per firmware version and per OSGP device interface.

3.1.35**RC4**

stream encryption algorithm that uses XOR on the data stream

3.1.36**reactive energy/power**

energy alternately stored and released by inductors and/or capacitors (reactive load)

3.1.37**reverse (export) energy**

energy delivered by the customer to the utility and often considered a tamper/fraud condition if the user is not legitimately supplying energy (e.g. solar power) to the utility

3.1.38**Real Time Clock****RTC**

device functionality that maintains a complete clock-calendar with a one-second resolution

3.1.39**self-read**

method by which a device performs a snapshot of pertinent registers along with a timestamp upon scheduling

3.1.40**swell**

measured quantity detected at a level above a defined threshold

3.1.41**tariff**

published list of rate schedules and terms and conditions, or the particular schedule in effect at a given time

3.1.42**telegram**

single response message from an M-Bus slave device containing billing data and other information complete billing information from a single M-Bus slave device potentially requiring more than one telegram

3.1.43**Tier**

time at which the changes are made between tariffs

3.1.44

tilt Switch

gravity-operated switch that opens or closes based on its altitude relative to the ground or by inertial movement

3.1.45

time-of-Use metering

TOU

metering that records metered quantities based on a time schedule (time of day, day of the week, month and season) allowing the utility to track energy usage over time as well as for billing purposes potentially including one or more tariffs

3.1.46

Unique_Node_ID

48-bit identifier of the node, analogous to a MAC address. It can be used for addressing

3.1.47

Value Control Identifier

VCI

identifier to indicate which entity has primary control over the value of a particular field including, for example, whether it is a fixed value, or that its value can be configured in the OSGP device

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AC	Alternating Current
ADD	Automated Device Discovery
APDU	Application Protocol Data Unit
ASCII	American Standard Code for Information Interchange
ATM	Automated Topology Management
BCD	Binary Code Decimal
BEK	Base Encryption Key
BIDN	Billing Interface Definition Number
BOOL	Boolean
BP	Basic Procedure
BPSK	Binary Phase Shift Keyed
BRKI	Break Interrupt
BT	Basic Table
CRC	Cyclic Redundancy Check
CRC/ID	Cyclic Redundancy Check/Identification
CT	Current Transformer
CT/VT	Current Transformer/Voltage Transformer
DC	Data Concentrator
DD	Discovery Domain
DRH	Data Record Header
DST	Daylight Saving Time
EMC	Electro-Magnetic Compatibility

EN	European Norm
EOI	End of Interval
EP	Extended Procedure
ET	Extended Table
FCM	Fast Commission Message
HES	Head End System. Software running at the data center that controls the entire network.
HW	Hardware
ICA	Interface Change Alarm
ICASRC	Interface Change Alarm Source
ICS	Interface Compatibility Settings
IDT	Interface Definition
IO	Input/Output
ISSS	Invalid Service Sequence State
ITHD	Current Total Harmonic Distortion
KYZ	Kilowatt Hour (KWH) Pulse Input
LED	Light Emitting Diode
LP	Load Profile
LPO	Load Profile Options
LSB	Least Significant Byte
LSV	Load Side Voltage
MDT	M-Bus Data Type
MDTT	M-Bus Data Type Table
MEA	MEP Expansion Architecture
MEP	Multipurpose Expansion Port
MFG	Manufacturing
MP	MEP
MSB	Most Significant Byte
NAK	Negative Acknowledgement
NI	Non-Integer
NID	Node Identification
NIH	Node ID Hashes
NMI	Non-Maskable Interrupt
NV	Non-Volatile
NVM	Non-Volatile Memory
NVRAM	Non-Volatile Random Access Memory
OMA	Open Media Access
OMAK	Open Media Access Key
OSGP	Open Smart Grid Protocol
OTR	Other

PA	Phase Angle
PED	Pending Event Descriptor
PID	Program ID
PK	Provisioning Key
PLC	Power Line Carrier
PROC	Procedure Identifier
PSN	Procedure Sequence Number
RAM	Random Access Memory
RCD	Record
RDATE	Recurring Date
RMS	Root Mean Square
ROM	Read-Only Memory
RTC	Real Time Clock
SEQ	Request Sequence Number
SSI	Signal Strength Indicator
SW	Software
THD	Total Harmonic Distortion
TOU	Time-of-Use metering
UART	Universal Asynchronous Receiver/Transmitter
UOM	Unit of Measure
UTC	Universal Time Coordinated
VA	Apparent Power
VAR	Reactive Power
VATHD	Apparent Power Total Harmonic Distortion
VA-THD	Apparent Power Total Harmonic Distortion
VCI	Value Control Identifier
VT	Voltage Transformer
VTHD	Voltage Total Harmonic Distortion
XOR	Exclusive OR

4 PLC network management

4.1 Overview

The management of an EN 14908-1:2014 PLC metering network is a master-slave process in which the data concentrator has the responsibility of network management. In addition to metering data collection, the data concentrator creates the metering network, discovers new devices, determines the optimal routing path to each metering device, monitors for topology changes that require route recalculation, and monitors for metering devices that have lost communication. For network management purposes, the data concentrator uses

- ATM (Automatic Topology Management) protocol for discovery,
- FCM (Fast Commissioning Message) for enrollment and security.

4.2 Metering device lifecycle

The management lifecycle of a metering device consists of the following stages:

- a) At manufacture, the metering device is set with a Unique Node ID and the discovery domain ID (see Clause 4.3.4) and provisioned with the parameters for metrological data measurement and logging as ordered by the customer.
- b) The metering device is physically installed at the Utility customer's premise. It is said to be undiscovered initially. The metering devices do not initiate network discovery or joining. They may begin performing metrological functions so that billing data would not be missed before being added to the HES.
- c) The data concentrator discovers the metering device using the Automated Topology Management (ATM) protocol. When successful, the metering device is now said to be discovered. It is not yet configured with network address and security parameters and does not allow metering data to be collected over the PLC network.
- d) The data concentrator reports the discovered metering devices to the HES, along with signal quality information and hop count. When multiple data concentrators are connected on the same low-voltage side of a transformer, it is possible for a metering device to be discovered by multiple DCs.
- e) The HES assigns the metering device to the appropriate data concentrator according to system-specific criteria, which may take into accounts signal quality, hop count, capacity of data concentrator, and other external criteria like physical location, etc.
- f) The assigned data concentrator configures the metering device with a domain/subnet/node network address and establishes security parameters on the metering device. This process is called commissioning. The secured metering device is declared "commissioned". This state allows the DC to have secure communication with the metering device, as it can be required by the HES, allowing metering data to be collected using secured messages.
- g) After that, the data concentrator continues to use the ATM protocol to discover new metering devices and update already discovered metering devices. It continues to monitor the network for topology changes.
- h) The data concentrator also tests communication with known metering devices in order to validate connectivity, detect topology changes, and recalculates routing paths.
- i) The data concentrator collects data from the metering device and send commands to it. Each message specifies the optimal routing path currently determined by the data concentrator for the target metering device.
- j) A topology change (such as a power switch throw) may cause an extended period of loss of communication between the metering device and its data concentrator. When after that another data concentrator discovers or re-discovers that this metering device has not communicated with its DC for the specified amount of time, the metering device is said to be orphan. The latter DC reports this status to the HES, which may then reassign the metering device to the discovering data concentrator.

When the HES determines to uninstall the meter, it de-assigns the meter from the data concentrator. The data concentrator then de-configures the meter (if it is still able to communicate with it). The meter now is again undiscovered.

4.3 ATM Protocol

4.3.1 Overview

ATM protocol is based on message broadcast to all the nodes which can hear the DC via repeaters.

4.3.2 ATM responsibilities

The roles of ATM protocol are

- Automatic discovery of a device at installation,
- Automatic re-discovery of a device to a new DC when the former DC no longer can reach the device due to a topology change,
- Automated identification of test points,
- Mesh network bandwidth sharing via automatic identification of transmission slots.

4.3.3 Automatic discovery

Automatic Discovery allows the DC to discover any device conforming to the protocol (including other DCs). The discovery can be made through repeaters whether or not those repeaters are not commissioned, commissioned in the DC's domain, or commissioned in some other domain. They only need to be in a global discovery domain.

The protocol allows the DC to send broadcasts directly or via agents that ask nodes to respond based on certain criteria. Depending on whether the DC is trying to discover all devices or only those that are out of communication, it can set the criteria in an appropriate way (see Table 1).

When attempting to locate nodes that are out of communication, the focus is on finding groups of nodes that were re-located due to switch or fuse changes. Thus, it is assumed to be sufficient to attempt to discover a subset of nodes in one domain via a subset of nodes in another domain. Each subset is the set of test points in the domain. The test points are those that are closest to the boundaries of the network and thus are best suited for detecting changes at the boundary.

4.3.4 Discovery domain

ATM defines a global discovery domain (DD) using the following 6-byte domain (0x7A3340F1BCD2). All devices must be pre-configured in the DD in order to be discovered and to repeat ATM messages. The DD is configured as a EN 14908-1:2014 clone domain so that subnet/node conflicts are not an issue. The key for the DD is the upper bytes of the OMAK. All messages are sent using the 14908-1 unackd service

4.3.5 ATM messages

4.3.5.1 ATM message structure

All ATM messages are based on the same structure consisting on a header and then the message payload.

4.3.5.2 ATM message header

4.3.5.2.1 Overview

Each ATM ADD message has a header that allows the message to be sent through repeaters, even if those repeaters are not commissioned. This allows a DC to discover devices without first performing device commissioning operations. As such, all addressing is based on physical (Unique Node ID and broadcast) addressing. Each message contains a repeat chain of Unique Node IDs which is a list of repeater addresses along a path. The entire repeat chain is passed all the way out and back so that no transaction tracking is required in the repeaters.

An ATM header contains the repeat chain which has N addresses, one for each device involved.

The structure of an ATM header is as in Table 1.

Table 1 – ATM Message header structure

Data	Description	Size (byte)
0x45 or 0x4A	Message or Response code respectively	1
Address position	A one-based number M indicating the position of the destination address in the address list of N addresses. See Forwarding Rules on usage.	1
Address list	List of N addresses, including the initiator and target. Each address is of 6 bytes)	6 *N
Path mask	EN 14908-1:2014 allows a packet to be transmitted over the primary or alternate path, where a path refers to the channel frequency. The Path Mask is a bit-map specifying, to each hop's transmitter, which path to use (bit value 0=primary; 1 = alternate).	P bytes
Transaction number	Transaction number. The transaction number is used to match the query Id response to the query Id request.	1
Packet Cycle Width	Cycle width (msec/10) (outbound broadcast only). The Packet Cycle Width is a time interval on the PLC transmission channel and is used by the EN 14908-1:2014 MAC Layer. Used with Packet Cycle Count to randomize	1
Packet Cycle Count	Number of cycles to randomize over when sending a response to broadcast. Range [0, 127].	1

NOTE The Path mask has one bit per hop. The first hop is the LSB of the first byte. The number of bytes of the mask is $((N - 2) / 8 + 1)$, where N is the number of addresses in the Address List. Since the Address List contains at least the initiator and the target, N is at least 2. This formula computes the mask size to 1 byte for N = 2 to 9, 2 bytes for N = 10 to 17, etc.

The header is followed by a message-specific payload as specified in Clause 4.3.5.3.

4.3.5.2.2 Forwarding rules

4.3.5.2.2.1 Forwarding rules for outbound (request) messages

If $M > N$, the message is illegal and the message should be discarded.

If $M == N$, the message is a request for this device (target):

- The device should write its NID into the address position indicated by M (for benefit of broadcasts).
- The device should process the payload following the proxy header as a normal EN 14908 APDU.

If $M < N$, the device is a repeater and should increment M and relay the message on to address M.

The transaction number is only meaningful to the originator.

4.3.5.2.2.2 Forwarding rules for inbound (response) messages

If $M > N$, the message is illegal and the message should be discarded.

If $M == 1$, the message is a response to this device (originator). The device should process the payload following the proxy header as a normal EN 14908 APDU.

If $M < N$, the device is a repeater and should decrement M and relay the message on to address M .

The transaction number is only meaningful to the originator.

4.3.5.3 ATM message payload

4.3.5.3.1 Overview

Four types of payload are available for ATM management as shown in the Table 2.

Table 2 – ATM payloads

	Payload identification	Direction
1	ATM query ID request	From DC to device
2	ATM query ID response	From device to DC
3	ATM response-to-query request	From DC to device
4	ATM response-to-query response	From device to DC

4.3.5.3.2 ATM query ID request

The ATM Query ID message is used to request nodes to respond. The structure of an ATM query ID request is as in Table 3:

Table 3 – ATM request structure

Data	Description	Size (byte)
0x49	Message code.	1
Session Id	Session Id associated with the ATM Respond to Query message. It is used to match multiple request/response transactions.	1
Hash	Unique Node ID hash. The least significant byte shall be positioned before the most significant byte. The hash is used to limit the number of responding nodes. "A device is to respond only if has a matching hash.	2
Min Comm Outage	Minimum number of minutes for use with the flag "Out of communication required". See Table 7. This parameter is used for detecting Orphans.	2
Flags	Flags to limit the responses. See Table 7 for its description.	1

4.3.5.3.3 ATM query ID response

The structure of the ATM Query ID response is as in Table 4:

Table 4 – ATM response structure

Data	Description	Size (byte)
0x48	Message code	1
PID	Program ID of the device. See Table 7.	8
Best DC UNID	Best Data Concentrator Unique Node ID. The DC UNID returned is that of the DC with the best chain quality (fewest hops or best signal strength/margin in the event of a tie).	6
Chain Quality	Best repeat chain quality value including the owning DC. A repeat chain with the smallest number of hops is the best quality. If there are two with the same number of hops to different DCs then the DC with the best signal strength is the tie-breaker. The Chain Quality has the following format: - 1st Byte: hop count - 2nd Byte bit 4...7 (MSB): margin value - 2nd Byte bit 1...3: signal strength divided by 2 - 2nd Byte bit 0 (LSB): always 1	2
Flags	See Table 7 for its description.	1

4.3.5.3.4 ATM respond-to-query

The ATM respond-to-query notifies to a device to respond or not respond further to ATM Query ID messages for a given session. This message also gives the device a repeat chain quality value to store for this DC. It is sufficient for the end device to store only the Unique Node ID and quality value for the DC with the best quality. The repeat chain quality information is based on the number of hops and the signal strength. The device must be able to maintain the context for up to 8 pairs of {DC, Session ID}. Each context consists of a flag indicating whether to respond to additional queries, and the repeat chain quality value for use in Query ID responses. The context need not be reset retained, but should be retained for 48 hours. Due to the limited space for tracking Query ID sources, it is possible that a device might lose the “respond to query off” context and respond again to subsequent queries. The DC must be capable of detecting this case and backing off by randomizing and trying later.

The structure of the ATM Respond to Query message is as specified in Table 5:

Table 5 – ATM respond to query structure

Data	Description	Size (byte)
0x47	Message code	1
Session ID	Session Id associated with the ATM Respond to Query message. It is used to match multiple request/response transactions.	1
ON/OFF	0: OFF; ON otherwise	1
Chain Quality	Chain Quality. See Table 4	2

4.3.5.3.5 ATM respond-to-query response

The structure of the ATM respond-to-query response message is as in Table 6. The ATM response-to-query response message's purpose is to acknowledge the request.

Table 6 – ATM respond-to-query response structure

Data	Description	Size (byte)
0x46	Message code	1

NOTE No other field follow the message code.

4.3.5.4 Flags

The Flags are of 1 byte. This is a bit-mask formed by OR'ing any combination of the following values:

Table 7 – Flags

Value	Name	Description
0x02	Out of communication required	A device is to respond only if it is out of communication. A device is out of communication if it has not received an application level message from its DC in N minutes. If the DC does not receive responses from the device repeatedly, it should refrain from pinging the device with application level messages, since that would restart the timer on the device
0x04	Test point required	A device is to respond only if it is a test point (a device on the boundaries of the network, for detecting topology changes)
0x08	Commissioned required	A device is to respond only if it is commissioned.
0x10	Uncommissioned required	A device is to respond only if it is uncommissioned
0x40	In communication required	A device is to respond only if it is a meter and has heard from a DC (securely or otherwise), or from a meter that has heard from a DC, in the last N minutes
other	reserved	

The objective of the flag is to allow selective discoveries, permitting to only a given classes of metering devices to take the discovery into account depending on their own state and the values set in the flag.

4.4 Commissioning

4.4.1 Overview

Commissioning is the process of configuring the device with network address and setting the security keys and communication parameters, and querying the device's capabilities. It uses the FCM message which requires less messaging than usual EN 14908-1:2014 network management messages.

4.4.2 Commissioning operations

The commissioning process include the cryptoContext establishment, and fast commissioning. The primitive allowing these operations are specified in Clauses F.7.3, F.7.4 and F.7.5. and the messages are specified in Clause F.7.7.

5 OSGP Device data representation

5.1 General overview

OSGP uses a representation-oriented model of a smart-grid device.

The device data structures are presented and used in tabular form and include binary encoded information elements. This data representation has been selected for its efficiency in terms of storage requirements, as well as compactness for network data transfers. Data tables are also particularly adapted to the storage of measurement samples.

OSGP Data concentrators interact with the OSGP device by means of primitives enabling manipulation of the data tables, or by means of procedures which invoke the meter to perform specific actions: these services are presented in Clause 9. Other systems may also interact with the data representation of the OSGP device, e.g. by means of optical ports, but these other interaction models are out of scope of OSGP.

Annex A, Annex B, Annex C and Annex D list and define the OSGP device data representation and interaction procedures.

Clause 5.2 provides definitions for the data types used in Annex A, Annex B, Annex C and Annex D.

Clause 5.3 lists the value control identifier codes, which are used to specify the entity having control of the table values.

Clauses 5.6 and 5.7 provide additional table naming conventions found in the basic and extended tables and procedures described in Annex A, Annex B, Annex C and Annex D.

5.2 Data types

This clause provides definitions for the data types used in the Application Layer protocol and referenced in the table definitions.

NOTE All multiple-byte fields, such as UINT16, INT32, and FLOAT (excluding arrays) are ordered least significant byte (LSB) first.

Table 8 – Data Types

Type	Data Type Definition
INTx (x= 8, 16, 24, 32, 40, 48)	8, 16, 24, 32, 40 or 48-bit signed integer, binary signed two's complement
UINTx (x= 8, 16, 32)	8, 16, 32-bit unsigned integer
FILLx (x= 8, 16, 32)	8, 16 or 32 bits of zeroes used as a space holder or filler
INT(x..y)	Signed integer not bounded by an 8-bit boundary. Starting bit position = x and ending bit position = y
UINT(x..y)	Unsigned integer not bounded by an 8-bit boundary. Starting bit position = x and ending bit position = y
BOOL(x)	A single bit variable (FALSE = 0, TRUE = 1)
SET(x)	A collection of 8x BOOL

Type	Data Type Definition																		
FILL(x..y)	y-x+1 bits of zeros used as a space holder or filler																		
ARRAY[x] of Data Type	A contiguous block of the defined data type. Array indices are always zero-based																		
NI_FMAT1	Non-integer format 1, defined to be INT32 for this OSGP device, as stated in Basic Table 00 (BT00)																		
NI_FMAT2	Non-integer format 2, defined to be INT32 for this OSGP device, as stated in Basic Table 00 (BT00)																		
TIME	A structure of 3 - UINT8 fields where: byte 0 = hour byte 1 = minute byte 2 = second																		
LTIME_DATE	A structure of 6 - UINT8 fields where: byte 0 = 2-digit year (02 = 2002) byte 1 = month (01 = January, 02 = February, etc.) byte 2 = day byte 3 = hour byte 4 = minute byte 5 = second																		
STIME_DATE	A structure of 5 - UINT8 fields where: byte 0 = 2-digit year byte 1 = month byte 2 = day byte 3 = hour byte 4 = minute																		
PED	Pending Event Descriptor, see BT04																		
RDATE	A structure defining a recurrent date that can be yearly, monthly, weekly, or daily. Bit field of UINT16, where: MONTH = UINT(0..3); IF MONTH IS: 1..13: OFFSET = UINT(4..7); WEEKDAY = UINT(8..10); DAY = UINT(11..15); 14: FILLER1 = FILL(4..7); WEEKDAY = UINT(8..10); FILLER2 = FILL(11..15); 15: PERIOD = UINT(4..9); DELTA = UINT(10..15); <table><tr><th>Identifier</th><th>Value</th><th>Definition</th></tr><tr><td>MONTH</td><td>0</td><td>= Unassigned</td></tr><tr><td></td><td>1..12</td><td>= Month of year</td></tr><tr><td>13</td><td></td><td>= Action is repeated monthly</td></tr><tr><td>14</td><td></td><td>= Action is repeated weekly</td></tr><tr><td>15</td><td></td><td>= Action is repeated each PERIOD plus DELTA</td></tr></table> OFFSET	Identifier	Value	Definition	MONTH	0	= Unassigned		1..12	= Month of year	13		= Action is repeated monthly	14		= Action is repeated weekly	15		= Action is repeated each PERIOD plus DELTA
Identifier	Value	Definition																	
MONTH	0	= Unassigned																	
	1..12	= Month of year																	
13		= Action is repeated monthly																	
14		= Action is repeated weekly																	
15		= Action is repeated each PERIOD plus DELTA																	

Type	Data Type Definition
	0 = No offset 1 = Advance to WEEKDAY before MONTH, DAY entered 2 = Postpone to the first WEEKDAY on or after MONTH, DAY entered 3 = Postpone to the second WEEKDAY on or after MONTH, DAY entered 4 = Postpone to the third WEEKDAY on or after MONTH, DAY entered 5 = Postpone to the fourth WEEKDAY on or after MONTH, DAY entered 6 = Postpone to the last WEEKDAY of the MONTH on or after DAY entered 7 = Observe on MONTH, DAY entered as well as day following MONTH, DAY entered 8 = Postpone to Monday if Sunday 9 = Advance to Friday if Sunday 10 = Postpone to Monday if Saturday 11 = Advance to Friday if Saturday 12 = Postpone to Monday if Sunday or Saturday 13 = Advance to Friday if Sunday or Saturday 14 = Postpone to Monday if Sunday, advance to Friday if Saturday 15 = Do not observe MONTH, DAY entered. Observe on day following MONTH, DAY entered WEEKDAY 0..6 = Sunday to Saturday 7 = Unassigned DAY 0 = Invalid 1..31 = Day of the month PERIOD 0..63 = This setting, along with DELTA, is used to schedule daily activities DELTA 0..63 = This setting, along with PERIOD, is used to schedule daily activities
ANSI_DATE	A structure defining a non recurring date that contains year, month, and day. Bit field of UINT16, where: YEAR = UINT(0..6) (02 = 2002) MONTH = UINT(7..10) (01 = January, 02 = February, etc.) DAY = UINT(11:15)
DATE	A structure defining a year, month, and day. 3 byte values where: YEAR = Byte 0 (02 = 2002) MONTH = Byte 1 (01 = January, 02 = February, etc.) DAY = Byte 2

5.3 Pending tables

Pending tables provide a way to synchronize configuration changes in multiple OSGP devices to a single moment in time. As a typical use case a utility may want to enact a new time-of-use calendar in all the meters in a particular region at precisely the same time, marking midnight of a new year or the day when a new law goes into effect. Given the unpredictability of power-line communications in terms of precise delivery time to all meters in the network, it is desirable to be able to download the new calendar to the meters well in advance to

ensure the information gets there ahead of when it is needed but with an activation time in the future at which all meters will enact the new calendar simultaneously.

This "pending" new calendar sits in a reserved area of memory with a trigger date/time that is checked continuously. At the activation time, the pending calendar is transferred into the active calendar memory space and begins to take effect.

Only a few of the OSGP device tables have corresponding pending tables. These are BT4150, ET4143 and ET6204.

5.4 Value Control Identifiers (VCI)

The VCI (Value Control Identifier) table column in the annexes show which entity has primary control over the value. The definitions for the VCI column are:

- F = Fixed value.
- M = OSGP Device controls value. OSGP agents should not attempt to write, or do not have write access to this field.

EXAMPLE: Measurement registers and statuses.

- H = OSGP agent or OSGP device reading/configuration software controls value. For example, configuration and customer identifiers.
- P = Program ID. These fields are fixed for a given program ID, but may change in the future due to a technology change, for example. It is recommended to read all fields marked with this identifier on every communication with the OSGP device.

5.5 Value

This field specifies the hard-coded value for fields marked "F" or the non-zero value in effect when the OSGP device is shipped. Fields with no value identified here are initialized to 0, but may have been changed with provisioning.

5.6 Register Naming Convention

Throughout the present document, the per-phase measurement registers are denoted as follows:

- A = Line 1 (for example 'A' Sag events).
- B = Line 2 (for example Phase 'B' Loss).
- C = Line 3 (for example RMS Current 'C').
- ABC = All phases in a polyphase OSGP device (for example Fwd Active Wh ABC).

5.7 Table and Procedure Naming Convention

The following defines the letters preceding the table or procedure numbers in the present document. This naming convention is used in titles, and in references to tables/procedures in formulas and descriptions.

- BT = Basic Table. For example, BT00, BT01, etc.
- ET = Extended Table. For example, ET01, ET03, etc.
- BP = Basic Procedure. For example, BP05, BP06, etc.
- EP = Extended Procedure. For example, EP04, EP05, etc.

The meaning of a formula value, such as BT61.11, is Basic Table 61, offset 11. The meaning of a formula value, such as BT03.4.4, is Basic Table 3, offset 4, bit 4.

When performing a read or write for an Extended Table or procedure (see Clause 9), the ID field is configured as 2 048 plus the Basic Table number.

EXAMPLE 1: To write to ET03, use the number 2 051 in the table ID field ($2\,048 + 3 = 2\,051$).

To execute EP04, issue a full write request to BT07 with the procedure ID of 2 052 ($2\,048 + 4 = 2\,052$). This number is included in each table or procedure heading in the present document. No offset is applied to the table ID field for Basic Tables (i.e. the table ID field for BT54 would be 54).

NOTE 1 When writing, or reading a pending table, there is an additional offset of 4 096 applied to the table or procedure number.

EXAMPLE 2: Pending table BT54 is numbered ($4\,096 + 54 = 4\,150$), and pending table ET47 is numbered ($4\,096 + 2\,048 + 47 = 6\,191$).

NOTE 2 Occasionally, references to OSGP device tables in the present document will contain an appended offset value to indicate that the reference is to a specific field in that table: the field located at that offset value.

EXAMPLE 3: "BT21.6" refers to the "Number of Occurrences" field in BT21, as that field is located at offset 6 of BT21.

5.8 Interface Change Alarm (ICA NACK)

Modifying some OSGP device data tables or calling some OSGP device procedures described in the present document may cause the OSGP device data representation to change. In this case, the dimensions of some OSGP device tables may change and the Interface Change Alarm in BT03 shall be logged. In addition, the Interface Definition Table (ET42) shall be updated to reflect the new state of affected device tables.

Attempts to read or write some OSGP device data tables shall be blocked until the alarm has been cleared. The clearing of the alarm signifies that the system acknowledges and understands the interface change and is ready to process data in the new representation. Tables affected by the Interface Change Alarm in this manner are marked with the ICA NACK attribute throughout the present document. Tables and procedures that may cause the Interface Change Alarm to be triggered are marked with the ICASRC attribute throughout the present document.

6 Security

6.1 Overview

Measures are included to protect the privacy of consumers by restricting access to data and encrypting such data to prevent access by other than authorised bodies. Measures are also included to detect attempts to circumvent metering functions such as might result in unrecorded access to utility services.

The EN 14908-1 session layer provides authentication services. However, it does not provide data confidentiality services. OSGP complements the security framework defined in EN 14908-1:2014 by its own application layer security, which provides authentication and confidentiality services at application layer.

6.2 Security suites

6.2.1 Overview

OSGP's security suite is called OSGP-AES-128-PSK. An original and weaker suite, OSGP-RC4-OMAK, is obsoleted and should be used only with meters whose firmware has not been upgraded to support OSGP-AES-128-PSK.

6.2.2 OSGP-AES-128-PSK

The OSGP-AES-128-PSK (OSGP-AES-128-CCM-CMAC) security suite provides a secure, mutually authenticated, two-way communication channel between a DC and a meter. The secure channel provides data

confidentiality, integrity, authentication, and replay protection and can be used for both broadcast messages and unicast messages. See Annex F for specification of this suite.

6.2.3 OMAK

The Open Media Access Key (OMAK) is a 96-bit key for 14908-1 network management message authentication. Each OSGP device must be manufactured with a unique OMAK, stored in the 14908-1 domain tables' authentication key entry. The key should be provided securely to the Utility for use by the HES and DC (the method of transmission is outside of the scope of this specification). The original device-specific OMAK typically gets replaced by a shared OMAK by the Data Concentrator after it has discovered the new OSGP device using ATM (see Clause 5), using EN 14908-1 'increment key' network management message or FCM message.

The OMAK is used by EN 14908-1 authentication for the Phase Measurement message. It is not used in OSGP-AES-128-PSK and is not recommended for future development.

6.2.4 Access control

A UCK or BCK determines the access privileges to meter procedures and tables. It is referred to as OSGP Communication Key in the meter table definition clauses. These privileges can also be superseded by limits defined during production (such as to prevent access to calibration data, manufacturer's identification information, and writing of register data and keys), hardware locks, or broadcast command restrictions.

6.3 Hardware Lock

In addition to the OMAK the OSGP device may employ a hardware-integrated security mechanism that supersedes the key access permissions. The hardware locks may be table and procedure specific, and may apply only to certain tables (or parts of tables) and procedures in the OSGP device. It may restrict write and read operations, as well as the execution of procedures. Attempts to access tables and procedures restricted by the hardware lock will result in the error message "Insufficient Security Clearance", despite OSGP level keys indicating the proper level of security clearance. The tables and procedures that may be restricted by the hardware lock are documented as such in the table/procedure listings in the present document. Note that the hardware lock settings, if any, may be different in different OSGP devices.

7 Device Functional Description of the case the OSGP device is an electric power metering device

7.1 Overview

The following clauses provide an overview of the primary functional areas of the device and describe which tables and procedures should be used when configuring each functional area. This includes the following clauses, a number of which are at the manufacturer's or, where implemented by the device manufacturer, at the OSGP network operator's discretion. Where an optional function is implemented, it shall comply with the relevant clauses and subclauses of the present document.

7.2 Time-Of-Use Calendar (optional)

7.2.1 Overview

Time-of-Use (TOU) is the term used to describe the partitioning of energy usage into different registers based on a schedule. The device may support up to four such registers, called tariffs (T1, T2, T3 and T4). The tariffs may be selected for different time periods within a day (midnight to midnight - local time). The time at which a tariff is changed is called a tier switch. Each 24-hour set of tier switches is called a day schedule. There may be different day schedules for weekdays, Saturday, Sunday, and holidays. Each year is identical with regard to season changes, holidays, and daylight saving time scheduling. This is called a perpetual calendar implementation. All measured energy values shall be stored as totals into the tariff registers based on the TOU schedule.

The available options of the perpetual TOU calendar are:

- Day schedules (per season):
 - 1 weekday schedule
 - 1 Saturday schedule
 - 1 Sunday schedule
 - 2 holiday schedules
- 4 seasons with programmable start dates
- 15 holidays per year
- 1 independent Self-read schedule per year
- 10 tier switches per day

1 date for DST on, 1 date for DST off, with programmable time and minutes adjustment. DST on and off can be set to occur at different times of the day.

The device, if it is a power OSGP device, shall store the following values, for each tariff:

- Active energy, forward and reverse.
- Active energy, forward + reverse.
- Active energy, forward – reverse.
- Reactive energy, import and export.

The calendar shall be programmed in BT53 and BT54. Invalid entries in BT54, such as activation of a season greater than 3, shall be ignored. If no seasons are programmed, the default active season shall be season 1. The results of all these assessments are reported in BT55, with some duplication in BT52.

7.2.2 Manual Override Option (optional)

The device may support the ability to override the currently active tariff and switch to another (user-specified) tariff manually. The tariff change can be configured to happen immediately as soon as the manual override occurs, or at a scheduled date/time at some point after the manual override is performed.

The tariff change caused by a manual override is cancelled when any of the following events occur:

- Another manual command is issued.
- The next TOU calendar-driven tariff switch occurs.
- After the interval specified for the manual override expires, or at a user-specified date/time. The duration of the manual override, or the date/time at which a manual override is to be cancelled and the standard TOU schedule is to resume, is user-configurable.

It is also possible to select the default tariff to use in case of clock error. Any time a clock error occurs, the OSGP device will begin using this tariff until the error is corrected, at which point the OSGP device will resume using whichever tariff the TOU calendar calls for.

When manual tariff override is in effect, calendar controlled demand reset and self-read, season changes are still evaluated, all BT55 fields except tariff and tariff drive are properly updated, and DST time, time zone are applied.

All combinations of activation and cancellation are supported via one or more of these configuration methods: procedure EP15, table ET47, and pending table ET47 (ET4143). EP15 can be used to enact an immediate activation with either a manual or next tier switch cancellation. Configurations written via EP15 are copied to ET47.

ET47 can be written directly to enact immediate overrides with any of the cancellation types. Pending table ET47 is used to schedule a future activation. The pending table activation can be cancelled at any time via BP14 and BP15. BT04 reflects up to two pending activations.

A clock error supersedes a manual override, so while a clock error is present, the configured clock error tier is in effect. A new activation enacted by any means while an override is in effect will immediately cancel the existing override and enact the new one. ET23 can be read to determine the presently active calendar ID.

7.2.3 Over Power Threshold Tariff (optional)

The Over Power Threshold Tariff can be enabled or disabled. When enabled, whenever instantaneous power exceeds a pre-set power threshold over a pre-set time threshold the active tariff is forced to a configured tariff. When this occurs, it supersedes any other tariff control including TOU tariff control, calendar override via EP15 or ET47 and clock error tariff. After the instantaneous power drops below the over power threshold, other tariff controls listed above would resume.

The instantaneous power value that is compared to the over power threshold can be chosen from forward power, forward+reverse power, or forward-reverse power. The three types of power sources are usually used to ignore generation and fraud, for fraud prevention, and for electricity generating users respectively.

When the over power threshold is exceeded for over the time threshold, an event is triggered to indicate this condition and when the power drops below the threshold, another event of the same kind will be set to indicate the condition is gone.

If power up power quality hold time is set to non-zero, every time after power up, the over power tariff control will restart. In this case after power up, the tariff control would always go back to other tier controls until the over power tier control restarts.

8 Clock Adjustment (mandatory)

8.1 Absolute Time Synch

8.1.1 General

BP10 is used to set the date and time of the device at the factory. When calling this procedure, UTC time shall be passed in as a parameter. The device will then directly overwrite the current clock and calendar setting with the input UTC time. Since adjusting the clock using BP10 may affect the Load Profile and TOU modules, it is NOT to be used during normal meter operation.

8.1.2 Clock Adjustment by Delta

The recommended method to modify the device's clock during normal operation is to use EP16. There are two ways to modify the device time through EP16. The first method is to send the time delta in seconds directly, which requires first reading the device clock and comparing to a reference clock. This procedure will accept the number of seconds to modify the clock (forward or reverse). The largest amount the clock may be modified by is plus or minus 600 seconds (10 minutes). The device should perform a gradual shift of the clock at the middle of every minute, by no more than 20 seconds, or the configured maximum delta increment, until the desired delta has been performed. The default 1-second per-adjustment limit ensures the clock adjustment will not affect the device's internal Load Profile and TOU schedules. The clock changes begin at the next even minute (for the first ever programmed clock change).

The second method by which to adjust the device clock via EP16 is to send the correct UTC time and the device will calculate the time delta by comparing it to the device's internal time. The same limit of plus or minus 600-second max adjustment applies. If the device calculates the delta of the input time and the device time to be greater than 600 seconds, the procedure will return an error code and not perform the adjustment.

The device issuing the EP16 command shall indicate which method is to be used.

8.2 Billing Functions

8.2.1 Self Reads (mandatory)

"Self-read" is the term used to describe the automatic, periodic storage of measurement data to a separate area of memory that can be read for billing purposes. Self-reads provide a mechanism for all meters with the same self-read schedule to record billing data at the same time of day. An OSGP device shall be capable of performing a self-read at a predefined interval. All of the energy measurement data provided in the total and all four tier registers will be captured during a self-read event.

The TOU calendar in BT54 can be configured to perform a self-read daily, weekly, monthly, or some other period of days up to 63 days. The time of day the self-read should be performed is configured in ET04. The OSGP device holds by default 24 copies of self-read data before the oldest data is overwritten. The actual number of self-read data sets the OSGP device holds is configurable via EP06. The host system can then collect this information at some time after the OSGP device has performed the self-read action. An alarm bit will be set in BT03 whenever a new self-read has been recorded in the OSGP device. The Data Concentrator can use this to determine when new data is available, but shall clear the alarm flag upon reading the data. Whether or not the self-read data is read, the OSGP device will not interrupt the programmed schedule and old data will be overwritten with new data when the self-read is scheduled to occur.

If the OSGP device is powered down at the time a self-read was scheduled to occur, the self-read will be recorded at the subsequent power-up with the timestamp of the power-up event. If the OSGP device is powered down for more than 63 days, a self-read will be recorded on power-up, regardless if any were configured.

Additionally, a self-read can be triggered manually via EP12, which creates a new self-read record immediately. The same alarm in BT03 is triggered via manual self-read and the results are placed into BT26, overwriting the previous self-read regardless of whether that was from a manual or scheduled self-read.

The self-read information is stored in BT26, which contains a snapshot of all the registers in BT23 plus some status information.

8.2.2 Total Energy (optional)

The device may also store the day's consumption for all of the total energy measurements (excluding tariff registers). This storage occurs at UTC midnight and contains only the previous day's energy consumption. This snapshot of total energy may be used by a host system to determine total usage of the secondary side of a transformer. The total energy (or daily consumption), energy consumed during the previous 24 hours, is stored in ET12 and requires no configuration from the host system.

8.2.3 On-Demand Read of Current Billing Register Values (mandatory)

BT23 can be read at any time to get the current billing register values. However, if this table is read using multiple partial reads, there is no guarantee of consistency of the data. Therefore, the transaction table (ET27) should be used to perform on-demand reads.

8.3 Load Profile (mandatory)

8.3.1 Overview

Profiling is the periodic storage of interval measurement(s). Load profile data and configuration can be found in BT61 "Actual Load Profile," BT62 "Load Profile Control," BT63 "Load Profile Status" and BT64 "Load Profile Data". All the pertinent configuration and dimension information required for interpreting load profile data also can be found in ET42 "Interface Definition Table". Instructions to follow when developing an application to read load profile data follow later in this clause.

Each OSGP device shall be capable of support a load profile data log that can be configured to record up to 16 different values at once. The load profile log is divided into groups of data called blocks, with a configurable number of intervals per block, as well as a configurable length of each interval.

The start time for the first load profile block shall also be configurable. Note that if the total block time (i.e. the interval duration multiplied by number of intervals per block) does not divide evenly into 24 hours or is not an integer multiple of 24 hours, then the actual start time for each subsequent block will not always match the start time for the first block. For example, if the user has a block start time of 00:00 and a block duration of 18 hours, then the actual block start times will rotate through these times: 00:00, 18:00, 12:00, 06:00.

Up to 16 channels can be recorded on the same interval. The 16 channels are selected from the measured values, which are listed in BT16. All channels are stored as total values (no differential values). Load profile is configured via EP11 by indicating the number of channels to be logged, the interval duration, the number of intervals per block and which channels to log.

Certain status information in the load profile log is reported only once per block, including the timestamp and status of complete intervals. Other status information is contained in tables BT61, BT62, and BT63. For ease of use, all relevant geometry and status information for the present active load profile configuration is also contained in extended table ET21.

On power-up the OSGP device software will determine if load profile records were missed through the power outage and will stuff missing intervals only on the power-off and power-on day. If the outage spans more than one block, the log will reflect a discontinuity in two successive blocks. Optionally, instantaneous values are stuffed with 0s and set the extended status to 4. This can be configured via controlled by ET04.71. Load profile statistics are always stuffed as zeroes except for the interval active at the time of the power down which gets the statistics in effect at that time.

Load profile data (BT64) reading can be disabled with the "Disable Optional Features" bit in ET55.

8.3.2 Use case: Reading Load Profile Data

To read the most recently recorded load profile data in the OSGP device, follow these steps:

- a) Read and store BT61 or ET42 for the present load profile configuration, including the number of blocks (days) with available data, the number of intervals recorded in each block, the number of channels (registers) being logged, and the interval time. This information needs to be read only once per load profile reconfiguration.
- b) Read and store BT62 or ET42 to note which registers (sources) have been logged. An OSGP device may be configured to log electric OSGP device data, M-Bus device data, and MEP data and all are stored in the same log. The source IDs listed in BT62 or ET42 define which data registers are logged in which load profile channels. This information needs to be read only once per load profile reconfiguration. If the interval source ID in BT62 is in the range of 112 to 163, this indicates it is a mapped source ID, or a key used to refer to an extended source id in ET66 "Load Profile Source ID Mapping Table". ET66 is described in more detail later in the present document.
- c) Read the "Number of Valid Blocks" and "Last Block" fields in BT63 for information on where in BT64 the occupied blocks lie. Note that the "Last Block" field in BT63 is updated as soon as any single interval in the block is marked valid.
- d) Read ET21 for the size of each block, the size of each interval, and the index of the most recently recorded interval. The values of parameters in ET21 change as load profile is being recorded so this table shall be re-read before each read of load profile data from the OSGP device.
- e) To read the most recently recorded full block of load profile data, perform a partial read of BT64 with the following parameters:
 - 1) Offset = $((BT63.3 - 1) \text{ modulo } BT61.7) \times ET21.8$.
 - 2) Count = $BT21.8$.

To read the most recently recorded one interval of load profile data, perform a partial read of BT64 with the following parameters:

$$3) \text{ Offset} = (\text{BT63.3} \times \text{ET21.8}) + \text{ET21.12} + (\text{ET21.20} \times \text{ET21.25}).$$

$$4) \text{ Count} = \text{ET21.25}.$$

More intervals within the blocks as well as earlier recorded blocks can be read with appropriate calculations for the offset and count. The reader shall remind that the load profile log is a circular buffer in the OSGP device's memory, so any calculations on offsets for earlier blocks should use modulo the number of total blocks in the load profile.

8.3.3 Use case: Parsing M-Bus Load Profile Data

8.3.3.1 General

The OSGP device load profile data can be parsed to extract and interpret M-Bus data.

- The device shall generate alerts when new M-Bus information is available for either control valve status or load profile if the "M-Bus Alerts" field in ET50 (ET50.30.2) is set to 1.
- For general information on M-Bus devices, see 8.16.

8.3.3.2 M-Bus Data Types and ET57

The previous clause on reading load profile data describes how to determine which source IDs correspond to all the configured load profile channels. Typically, only a subset of the channels will correspond to M-Bus device data. M-Bus source IDs will all be extended source ids of the following format in ET42:

b15			b12	b11			b8	b7		b5	b4			b0
4				ET13 index for polling			reserved			M-Bus Data Type, MDT value				

Figure 1 – M-Bus Data Types

An M-Bus Data Type (MDT) is a mapping of M-Bus Data Record Header (DRH) definitions to simple 5-bit ordinals. These DRH definitions and mappings can be used to interpret the M-Bus load profile data that has been collected. One or more DRHs can be mapped to a single data type. Applying multiple DRHs to the same data type may be desirable, as it is possible that separate M-Bus devices will not always use the same DRH for a given type of reading. In that case, those DRHs (i.e. those that are all applicable to the same type of reading) can be applied to the same data type, and the OSGP device will act accordingly when that data type is encountered. That way, the OSGP device is able to effectively handle each type of M-Bus device. The only known case where this could occur is a OSGP device that might return temperature corrected values sometimes, and non-temperature corrected other times. A flag in the MDT mapping table is used to indicate whether temperature correction is on or off.

The MDT-to-DRH mappings are contained in ET57 "M-Bus/MEP Data Type Table". ET57 is optimized around an assumption that the typical DRH is 3 bytes or less. DRHs longer than 3 bytes are accommodated, just not as efficiently as shorter ones. Note that ET57 does not contain lengths for each DRH, because the DRH length can be deduced from the DRH itself. If a DRH is improperly formed, then either the MDT will not match (resulting in a "skipped" channel) or the MDT could match on the wrong DRH.

Each MDT entry in ET57 can be flagged as "special". Entries flagged as special are always given precedence. If the OSGP device matches on a non-special MDT but there is another entry for that MDT marked special, the OSGP device continues to search for that until it exhausted all the DRHs. This allows the load profile to record certain types of entries such as temperature corrected volume preferentially.

If the M-Bus read contains no data that matches the medium or MDT criterion, then the channel is marked as "skipped" (see the "Extended Status" field in BT64). If a match is found, then if the value is less than 4 bytes, the unused bytes are stored as zero in the load profile interval. If the value is more than 4 bytes, only the first 4 bytes are stored. The assumption here is that only Mode 1 (little-endian) is used by M-Bus devices.

Using the source ID information in ET42 and the MDT information in ET57, the user can learn where the M-Bus data is within the OSGP device's load profile and how to interpret it. Occasionally, some extra configuration and concerns arise that the user may need to be aware of. These are addressed in the following clauses.

8.3.3.3 Load Profile Poll Rate

The load profile poll rate is configured via ET34. This determines how often M-Bus devices will be read for load profile purposes. A value of 0 means there is no limit on the polling, and the poll rate is determined by the load profile interval duration. This is an approximation, as M-Bus reads may not occur at an exact interval and retries can vary the spacing. The reason for needing a separate poll rate for M-Bus devices (instead of using the load profile interval duration) is that reading them too frequently could be a drain on their batteries. For intervals that do not require a poll, the channel is stuffed with 0 and the extended status may be marked using a value of 4 ("Skipped") if the OSGP device is configured to use this status. Otherwise, the status is 0. Polls only occur when the number of minutes in the day modulo the poll rate is 0, or if it is the last interval of the day.

8.3.3.4 Time Stamping

There are two possible behaviours of the M-Bus device. One is that the device returns instantaneous values, and the other is that it returns an hourly read. In the latter case, the hourly read should be accompanied by a time stamp. If it is, then the OSGP device will check the time stamp to make sure it is current. The OSGP device will determine the time stamp definition using an MDT entry and bit offset definitions in ET34. For example, if the M-Bus device reports a time stamp in its self-read using the full date/time format, then ET57 would contain 06 6D as the DRH, the hour locator would be 17/5, and the minute locator would be 9/6. Note that if there is no time stamp in the self-read, the OSGP device will not manufacture one, even if there is a load profile source ID specifying time. The day and invalid time fields in the time stamp are ignored.

If the locator bit count is 0, then a default locator is used as follows:

- 4-byte value (hour: 9/5; minute: 1/6).
- 6-byte value (hour: 17/5; minute: 9/6).

For example, if the M-Bus device is slow and the user initiates the hourly read at 9:00:00, then the M-Bus device could return an hourly read with a time stamp of 8:00:00, the same as an hour before. In this case, the OSGP device will repeat the read again every N (configurable) seconds until the time changes up to N (configurable) times. To reduce the chance of this occurring, the M-Bus device will not be read exactly on the hour but instead N (configurable) seconds after the hour. This should allow the M-Bus device to be ready for the read most of the time assuming time sync is configured for it.

If a "current" read cannot be made within the above parameters, then whatever value is last read is placed in the LP with an extended status of "not current". Note that if the OSGP device fails to respond on the last attempt, the value will be 0 and the status will be marked as 15.

8.4 Self-Test (Alarms, Error Codes) (optional)

The device may periodically perform self-tests and setflags to indicate when alarm conditions are detected. Self-tests will not clear any alarms if the alarm condition no longer persists. It is the responsibility of the Data Concentrator (or other mechanism e.g. optical reader) to clear the necessary alarms. BT03 contains flags for the possible alarm conditions, and ET22 defines which error codes will be shown on the display. Some self-tests are performed periodically (every second, minute, hour, daily or weekly), some self-tests are performed on power up only, while other self-tests are performed on request. BT03 documents the period at which alarms are checked.

8.5 Pulse Inputs (optional)

The device can collect pulse data from pulse output devices, such as gas and water meters, and transmit the collected data to the Data Concentrator. Tamper alarm monitoring for each pulse output device is also included. Pulse data collection is an optional item. Pulse input data collected from channel one and channel two will be stored in separate billing registers and incremented after a valid pulse has been detected. Both pulse count channels can be selected for load profiling. The pulse devices can be configured via ET06.

8.6 Power Quality (optional)

8.6.1 Functional Description

The device may monitor various parameters for power quality. All power quality recordings are stored in ET09 unless stated otherwise below. Power quality events can be read by the Data Concentrator, and can also be read directly from the OSGP device via the optical port. When a power quality event occurs, the status shall return to normal for at least 1 second for another power quality event to be recorded. The OSGP device provides power quality measurements for the following:

- **Voltage (RMS) dip (under voltage):** Records the number of voltage dip occurrences on any one phase. A voltage dip shall last continuously for the time set in the OSGP device Dip/Swell Duration Threshold to be recorded as an event. The threshold that determines if a voltage dip is recorded is configurable as a percentage below the factory-rated voltage. The threshold range is 1 % to 99 %. The lowest voltage that occurred during the most recent sag (after the duration threshold is met) is recorded, as well as the date and time that the lowest recorded voltage occurred.

The user-configurable Sag/Swell Duration Threshold sets the number of seconds that a voltage sag or swell shall be sustained to be recorded as an event. A setting of 0 (zero) forces the recording of every detected event. The range is 0 seconds to 15,555 seconds.

- **Voltage (RMS) swell (over voltage):** Records the number of voltage swell occurrences on any one phase. A voltage swell shall last continuously for the time set in the OSGP device Sag/Swell Duration Threshold to be recorded as an event. The threshold that determines if a voltage swell is recorded is configurable as a percentage above the factory-rated voltage. The threshold range is 1 % to 99 %. The highest voltage that occurred during the most recent swell (after the duration threshold is met) is recorded, as well as the date and time that the highest recorded voltage occurred.
- **Over-current (RMS):** Records the number of over-current events on any one phase. The over-current condition shall last continuously for 10 seconds to be recorded as an event. The threshold that determines if an over-current condition is recorded is configurable as a percentage over reference current which defaults to the rated current of the OSGP device. The reference current is the OSGP device's maximum current by default, unless configured otherwise. The over-current analysis is designed to detect uses above a reference level or within reason above the maximum current rating of the OSGP device. It is not designed for detecting and recording instances of high amperage current surges.
- **Power outages:** Records the duration, power on date and time, and power off date/time of the last 10 long power outages, as well as a count of all short power outages. The voltage applied to the OSGP device shall be below the Power Outage Detection Threshold, and last longer than the time (in seconds) set in the user-configurable Long Power Outage Duration Threshold for a long power outage event to be recorded. The Power Outage Detection Threshold defaults to 72 % of the rated voltage (this value can be modified in factory). When the rated voltage being applied to the OSGP device drops below that value on all phases, it is considered a power outage.

The range of the Long Power Outage Time Threshold is 0 seconds to 65,535 seconds. Power outages that are shorter than the Long Power Outage Time Threshold, but at least 250 ms (approximately), are counted as short power outages. If the Long Power Outage Duration Threshold is set to 0 (zero), then the duration and date/time of every power outage event longer than approximately 250 ms is recorded as a long power outage, with complete records for the last 10 long outages. In this case, the short outage count is never incremented.

- **Frequency:** The frequency is constantly monitored (except for the first 1 seconds to 2 seconds after power-up) and the maximum and minimum values, since last reset, are recorded along with the time of the event.
- **Phase loss:** Records the number of phase loss occurrences on any one phase as well as the date and time of the last occurrence. Voltage (RMS) drop on any phase below the internal phase loss level for a sustained duration of 10 seconds (by default) is considered a phase loss. The internal phase loss level is set to approximately 61 % of the rated voltage by default, although this figure is user-configurable via ET04.

The duration that a phase loss shall last before it will be recorded in the event log is also user-configurable. This can be configured via ET55.

Since this event may affect the accuracy of the OSGP device, energy accumulation is automatically reconfigured to exclude the lost phase. A phase loss error message can be shown on the display if configured by the user. Phase loss also causes a diagnostic code to be activated.

- **Total harmonic distortion (THD):** Records three types of total harmonic distortion: voltage total harmonic distortion (V-THD), current total harmonic distortion (I-THD) and apparent total harmonic distortion (VA-THD). THD is a ratio of the voltage or current at harmonic frequencies to the voltage or current at the fundamental frequency for the OSGP device, expressed as a percentage.

The OSGP device updates the THD values every 10 seconds. THD measurements can be recorded in the OSGP device event log. It can be specified the duration that a THD condition shall exist for before it is recorded as a THD event in the event log. It can be also specified the percentage each THD level shall reach in order for it to be recorded as a THD event. The THD thresholds should be configured carefully to ensure that the event log contains only events of interest.

If these settings have been configured (and the THD events have been enabled in the event log), the THD State Changed event will be logged whenever a THD value exceeds the specified threshold for the specified duration. Another THD State Changed event will be logged when THD falls below the threshold. Events containing the maximum THD value and the average THD value for that time period will also be logged (if they are enabled in the event log). The maximum THD value is the maximum over that period. The average THD is an average THD over that period and the period itself may vary.

THD calculations can be performed using the standard defined in IEC 61000-4-7, or using the RMS method. This is configurable via ET55.

8.7 Display (optional)

8.7.1 Overview

Each device may contain display with several programmable features. A device with a display can display up to 30 numeric value items, which are chosen from data sources including the available total and tariff energy measurements, as well as time, date, and prepay energy credit remaining. The display scrolls through each item, with a programmable scroll-time for each item of 6 seconds to 15 seconds. The scroll-time is the time that the value is shown on the display before scrolling to the next item. Each item has a unique programmable 4-character ID code that is displayed along with the value item.

The following clauses describe the tables that can be used to configure the display.

8.7.2 Display Source List (optional)

BT33 defines the items to be included in the present display list by source number and category. The 2-byte display list source number consists of a high byte and low byte. The high byte indicates the display list category. The low byte indicates the measurement source number.

The following is a list of categories (high byte of display list source #) and associated source IDs (low byte of display list source #) to define a display source item as it is entered into BT33.

Table 9 – Display Sources List

Display List Category	High Byte Value		Low byte value	Description and Location of low-byte measurement ID
	Bits 3..7	Bits 0..2		
Summation Totals and Tiers and Present Values	0	0	0..BT10.7	BT16 describes the list of items to display (Item 73 to 80 are not supported by display).

Display List Category	High Byte Value Bits 3..7 Bits 0..2		Low byte value	Description and Location of low-byte measurement ID
	0	1	2..11	Date/time of max demand 1, total and 4 tariffs: 2 = Date of total. 3 = Time of total. 4 = Date of tariff 0. 5 = Time of tariff 0.
	0	1	12..21	Date/time of max demand 2, total and 4 tariffs.
	0	1	22..31	Date/ time of max demand 3, total and 4 tariffs.
	0	1	32..41	Date/ time of max demand 4, total and 4 tariffs.
	0	1	42..51	Date/ time of max demand 5, total and 4 tariffs.
	0	1	52..61	Date/ time of max demand 6, total and 4 tariffs.
	0	1	62..71	Date/time of max demand 7, total and 4 tariffs.
	0	1	72..81	Date/ time of max demand 8, total and 4 tariffs.
Self-Read Data	1	0	0.. BT10.7 (BT23 values only)	Latest self-read data set. This includes monthly billing data, totals and tiers, no present values, no previous demand values.
	1	1	0..1	0 = Latest self-read date. 1 = Latest self-read time.
	1	1	2..11	Date/time of max demand 1, total and 4 tariffs 2 = Date of total. 3 = Time of total. 4 = Date of tariff 0. 5 = Time of tariff 0.
	1	1	12..21	Date/time of max demand 2, total and 4 tariffs.
	1	1	22..31	Date/time of max demand 3, total and 4 tariffs.
	1	1	32..41	Date/time of max demand 4, total and 4 tariffs.
	1	1	42..51	Date/time of max demand 5, total and 4 tariffs.
	1	1	52..61	Date/time of max demand 6, total and 4 tariffs.
	1	1	62..71	Date/time of max demand 7, total and 4 tariffs.
	1	1	72..81	Date/time of max demand 8, total and 4 tariffs.
One Time Read Data	1	2	0.. BT10.7 (BT23 values only)	Latest OSGP device one time read data set. This includes billing data, totals and tiers, no present values, and no previous demand values.
	1	3	0..1	0 = Latest one time read date. 1 = Latest one time read time.

Display List Category	High Byte Value Bits 3..7 Bits 0..2		Low byte value	Description and Location of low-byte measurement ID
	1	3	2..11	Date/time of max demand 1, total and 4 tariffs: 2 = Date of total. 3 = Time of total. 4 = Date of tariff 0. 5 = Time of tariff 0.
	1	3	12..21	Date/time of max demand 2, total and 4 tariffs.
	1	3	22..31	Date/time of max demand 3, total and 4 tariffs.
	1	3	32..41	Date/time of max demand 4, total and 4 tariffs.
	1	3	42..51	Date/time of max demand 5, total and 4 tariffs.
	1	3	52..61	Date/time of max demand 6, total and 4 tariffs.
	1	3	62..71	Date/time of max demand 7, total and 4 tariffs.
	1	3	72..81	Date/time of max demand 8, total and 4 tariffs.
Historical Demand Reset Data	1	4	0.. BT10.7 (BT23 values only)	Latest demand reset entry. This includes billing data, totals and tiers, no present values, no previous demand values.
	1	5	0..1	0 = Latest demand reset date. 1 = Latest demand reset time.
	1	5	2..11	Date/time of max demand 1, total and 4 tariffs: 2 = Date of total. 3 = Time of total. 4 = Date of tariff 0. 5 = Time of tariff 0.
	1	5	12..21	Date/time of max demand 2, total and 4 tariffs.
	1	5	22..31	Date/time of max demand 3, total and 4 tariffs.
	1	5	32..41	Date/time of max demand 4, total and 4 tariffs.
	1	5	42..51	Date/time of max demand 5, total and 4 tariffs.
	1	5	52..61	Date/time of max demand 6, total and 4 tariffs.
	1	5	62..71	Date/time of max demand 7, total and 4 tariffs.
	1	5	72..81	Date/time of max demand 8, total and 4 tariffs.
Date / Time	4	0	0..1	0= Present local date, 1= present local time.
Miscellaneous	5	0	0	Prepay total credit remaining.
	5	0	1	Prepay emergency credit remaining.
	5	0	2	Disconnect active maximum power limit. This will use the primary or secondary maximum power threshold defined in ET05 (whichever is active at the moment).

Display List Category	High Byte Value Bits 3..7 Bits 0..2		Low byte value	Description and Location of low-byte measurement ID
	5	0	3	Disconnect active maximum power limit. This will use the primary or secondary maximum current threshold defined in ET05 (whichever is active at the moment).
	5	1	0	Current TOU calendar ID.
	5	1	1	CT ratio multiplier, which is the "Ratio F" field in BT15.
	5	1	2	CT ratio multiplier, which is the "Ratio P" field in BT15.
	5	1	3	Relay Control ID.
	5	1	4	CT ratio actual. This is the calculated ratio based on the configured transformer secondary rated current.
	5	2	0	Firmware version number.
	5	3	0	Number of demand resets.
	5	3	1	Demand sub-interval in minutes.
	5	3	2	Demand interval in minutes.
	5	3	3	Load profile interval time between log records in minutes.
Self-Read Data	6..28	0	0.. BT10.7 (BT23 values only)	Earliest 23 self-read data sets: 6 = Most recent data set before the current one. 28 = Earliest.
	6..28	1	0..1	0 = Date of corresponding self-read data set. 1 = Time of corresponding self-read data set.
OSGP device One Time Read Data	6..28	2	0.. BT10.7 (BT23 values only)	Earliest 23 one time read data sets: 6 = Most recent data set before the current one. 28 = Earliest.
	6..28	3	0..1	0 = Date of corresponding OSGP device one time read data set. 1 = Time of corresponding OSGP device one time read data set.
Historical Demand Reset Data	6..16	4	0.. BT10.7 (BT23 values only)	Earliest 11 demand reset data sets: 6 = Most recent data set before the current one. 11 = Earliest.
	6..16	5	0..1	0 = Date of corresponding demand reset entry 1 = Time of corresponding demand reset entry

Display List Category	High Byte Value Bits 3..7 Bits 0..2		Low byte value	Description and Location of low-byte measurement ID
	6..16	5	2..11	Date/time of max demand 1, total and 4 tariffs: 2 = Date of total. 3 = Time of total. 4 = Date of tariff 0. 5 = Time of tariff 0.
	6..16	5	12..21	Date/time of max demand 2, total and 4 tariffs.
	6..16	5	22..31	Date/time of max demand 3, total and 4 tariffs.
	6..16	5	32..41	Date/time of max demand 4, total and 4 tariffs.
	6..16	5	42..51	Date/time of max demand 5, total and 4 tariffs.
	6..16	5	52..61	Date/time of max demand 6, total and 4 tariffs.
	6..16	5	62..71	Date/time of max demand 7, total and 4 tariffs.
	6..16	5	72..81	Date/time of max demand 8, total and 4 tariffs.

BT33 also controls the duration, in seconds, that each item in the display list will be shown on the display. It is also used to define the order in which items are to be displayed. The display list is a circular list with the end of the list being shown with all segments on the display list. Each item in the display list will be displayed for 6 seconds to 15 seconds, as configured in BT33. Note that this display duration can also be set to 0, which will fixate the display on the item currently displaying until the OSGP device push button is pushed to advance to the next display list item.

8.7.3 Display configuration (optional)

ET07 allows the user to define how the items in the display list will be displayed, including the ID code, the number of digits to display, whether leading zeros will be displayed or not, the active and inactive features indicated by the name plate, and the decimal point configuration associated with each item on the display list. The user may also set whether or not the all segments on is displayed after the display list has completed its cycle. The user may configure the display format for the OSGP device date format (DDMMYYYY, MMDDYYYY, YYYYMMDD, YYYYDDMM). He can enable or disable display of the OSGP device's firmware version and present tariff from this table.

8.7.4 Error Codes Configuration (optional)

ET22 allows the user to define which alarms may be configured as scrolling errors that will be displayed as the last item in the display list or locking errors that will lock the normal display regardless of position in display list and will display the errors in two screens with an error code for each screen (one for the locking error, one for scrolling errors).

8.7.5 Simulated Wheel Rotation Configuration (optional)

ET01 allows the user to configure the rate of rotation for optional simulated mechanical wheel on the display. The simulated wheel is an optional visual indicator for the relative rate of energy consumption measured by the OSGP device.

8.7.6 Disconnect Configuration (optional)

ET05 allows the user to configure text that will be displayed explaining why the load disconnect contactor was opened. The 4-digit ID code that will be displayed while the disconnect open text is shown is also configurable via ET05. The behavior of the Disconnect Open icon is also configurable via ET05. The disconnect icon will turn on when there is no load side voltage (because the disconnect is open and there is no load side generator). A

user can also configure the icon to flash, depending on whether the load disconnect contactor is locked open. The icon is not shown when the load disconnect contact is closed, or there is a load side generator.

8.7.7 CT and VT Ration (optional)

BT15 allows the user to configure how the devices CT and VT ratios will be displayed. These ratios can be displayed as an industry standard method where a ratio $X : Y$ is displayed representing the primary transformer rated current : the secondary transformer rated current, or as the multiplier value that the ratio corresponds to (e.g. a ratio of 40:5 would be displayed as 8).

8.7.8 Firmware version on Power-Up (optional)

ET07 allows the user to configure the OSGP device to display the firmware version currently running in the OSGP device on power-up. The user can configure the OSGP device to display its firmware version for 1 second to 15 seconds on power-up, if desired.

8.7.9 PLC signal quality Icons (optional)

The device may have indicators on its display to show PLC traffic detection and received-message quality. The signal strength thresholds that trigger these icons are specified via ET55.14 for non-ATM traffic. For ATM discovery queries, the initiator can specify the signal strength threshold via the query message. If this is not provided by the initiator, then the non-ATM value specified in ET55.14 is used.

8.7.10 Scheduled Display Messages (optional)

ET55 may be used to configure preset messages to be shown on the device's display. The "Scheduled Display Message Text" field defines this message, which can include up to 4 characters that will be shown on the display. The user can configure the date/time at which the preset message will be displayed, and the date/time at which the preset message will be removed from the display. If the configured start date/time is earlier than current time, the preset message will be displayed immediately. If the device is powered down at the date/time the preset message is scheduled to appear, and the end date/time has not passed when the devices powers back on, the preset message will be displayed until the end date/time has passed.

The scrolling display will be suspended while the message is on display, and will resume as soon as the message has been removed. However, the preset message can be configured so that a user can manually override the preset message (i.e. remove it from the display and resume the scrolling display schedule) by pressing the push button to the left of the OSGP device display. If the user wants to ensure that the message is displayed for the configured amount of time, he should make sure to disable the manual override option.

8.8 Local Disconnect Contactor (optional)

8.8.1 Overview

The device may contain up to two internal control outputs that can be used to control two independent devices. The primary control output shall be the load disconnect contactor used to control a circuit disconnect that controls the load to the customer. It can be programmed for use via several different automatic and manual applications:

- **Maximum Power and Current Level Thresholds:** The OSGP device contains a series of settings that establish a maximum power (or current) level threshold. When the OSGP device detects this level of power (or current), it indicates that the OSGP device has reached its trip point, and the OSGP device will automatically turn off (trip) the load disconnect contactor.
- **Prepaid Metering:** The OSGP device will automatically turn off the load disconnect contactor once the credit level in energy has gone to zero in a prepaid metering installation. The OSGP device reduces the amount of remaining credit based on energy usage and tariff level as time goes by.

Once the prepay credit is exhausted (has reached zero), the OSGP device can either be configured to turn off the load disconnect or to switch into Maximum Power mode (to avoid complete power shutoff at the

premises). When switching to Maximum Power mode is selected, the Power Threshold on Exhausted Credit value (in watts) setting is used to determine the active power level setting, in watts, at which the load disconnect turns off when prepay credit is exhausted (goes to 0). The Maximum Prepay Power Duration Threshold value programmed into the OSGP device is used to determine the number of minutes that the Power Threshold on Exhausted Credit setting shall be continuously met or exceeded for the load disconnect to turn off when prepay credit is exhausted. Normal operation resumes when the prepay credit value is increased to above zero.

- **Local Control:** Local manual control of the load disconnect contactor via the disconnect push button.
- **Remote Control:** Remote manual control of the load disconnect contactor.

The following clauses describe how each of these applications can be programmed. Most of these settings are configurable via ET05.

8.8.2 Maximum Power and Current Level Thresholds

8.8.2.1 Overview

The device contains a series of settings that establish a maximum power level threshold. When the OSGP device detects this level of power on the line, it indicates that excessive power is in use and the OSGP device will automatically shut off (trip) the load disconnect contactor. After an excessive power condition trips the load disconnect contactor in this fashion, the user can manually reset the load disconnect contactor. If the power level threshold is still exceeded after manual re-latching, the load disconnect will shut off again within a minute. This feature is intended primarily to limit consumer power usage, and is not to be used as the system safety over-current protection.

The user can configure the OSGP device to use current measurements, instead of power measurements, to determine when excessive power is in use and the OSGP device should shut off the load disconnect contactor. The OSGP device will use power measurements by default.

The following clauses describe how to configure the OSGP device's maximum power and current level thresholds.

8.8.2.2 Changing the Device's Maximum Power Level Threshold

In order to set the maximum power level threshold for the OSGP device, the user needs to configure the following settings:

- **Maximum Power Level Thresholds:** The OSGP device may contain both a Primary Power Level Threshold and a Secondary Power Level Threshold value. The OSGP device can be programmed to use either value to determine when excessive power is in use and the load disconnect contactor should be shut off. The values of these fields can be configured via ET05 "Control Output Settings".

Only one of the threshold values will be in use at any given time, and the OSGP device will use the Primary Maximum Power Level Threshold by default. However, the user can switch to the Secondary Maximum Power Level Threshold (and back) by calling EP22 "Switch Maximum Power or Current Level".

The "Active Power or Current Level" field in ET30 "Maximum Power or Current Level Control" indicates whether the primary or secondary threshold is presently in use.

- **Maximum Power Duration Thresholds:** The OSGP device also contains both a Primary Maximum Power Duration Threshold and a Secondary Maximum Power Duration Threshold value. The Primary Maximum Power Duration Threshold is used when the Primary Power Level Threshold value is in use, and the Secondary Maximum Power Duration Threshold is used when the Secondary Power Level Threshold is in use.

These fields set the duration that the associated Maximum Power Level Threshold shall be continuously met or exceeded before the load disconnect contactor will be shut off. When the power drops below the power level threshold before this interval expires, the duration is reset and starts counting again from zero.

when the power exceeds the level threshold again. When the duration threshold is set to 0, the load disconnect contactor will turn off immediately when the maximum power level threshold is reached. The range is 0 to approximately 260 minutes. These fields can be configured via ET05.

- **Power Level to Measure:** The user can also choose how the OSGP device will calculate the current power level when checking it against the maximum power level threshold:
 - Forward energy (Fwd Active [W] L1+L2+L3).
 - Forward + reverse energy (Fwd+Rev Active [W] L1+L2+L3).
 - Forward - reverse active energy (Fwd-Rev Active [W] L1+L2+L3).

The calculation method to be used is set via EP42 "Control Output Settings"

8.8.2.3 Changing the Device Maximum Current Level Threshold

If the user wants the OSGP device to use current measurements, instead of power measurements, to determine when excessive power is in use and the OSGP device should shut off the load disconnect contactor, he shall configure the settings below:

- **Maximum Current Level Thresholds:** The OSGP device contains both a Primary Current Level Threshold and a Secondary Current Level Threshold value, both of which shall be entered in Amperes. The OSGP device can be programmed to use either value to determine when excessive power is in use and the load disconnect contactor should be shut off. The values of these fields can be configured via ET05 "Control Output Settings".

Only one of the threshold values will be in use at any given time, and the OSGP device will use the Primary Maximum Current Level Threshold by default. The device can switch to the Secondary Maximum Current Level Threshold (and back) by calling EP22 "Switch Maximum Power or Current Level".

The "Active Power or Current Level" field in ET30 "Maximum Power or Current Level Control" indicates whether the primary or secondary threshold is presently in use.

- **Maximum Current Duration Thresholds:** The OSGP device also contains both a Primary Maximum Current Duration Threshold and a Secondary Maximum Current Duration Threshold value. The Primary Maximum Current Duration Threshold is used when the Primary Current Level Threshold value is in use, and the Secondary Maximum Current Duration Threshold is used when the Secondary Current Level Threshold is in use.

These fields set the duration that the associated Maximum Current Level Threshold shall be continuously met or exceeded before the load disconnect contactor reaches its trip point and shuts off. When the current drops below the threshold before this interval expires, the duration is reset and starts counting again from zero when the current exceeds the level threshold again. When the duration threshold is set to 0, the load disconnect contactor will turn off immediately when the maximum current level threshold is reached. The range is any interval up to approximately 260 minutes. These fields can be configured via ET05.

- **Disconnect Trip Point Current Source:** The user can specify how the OSGP device will measure the active current by specifying the source to use when measuring current (i.e. Forward Current, Forward + Reverse Current, Forward - Reverse Current), and whether the current should be measured per phase, or as a sum of all phases. The user can also establish which calculation method will be used by calling EP42 "Control Output Settings".

8.8.2.4 Choosing Power or Current (optional)

By default, the OSGP device will use power measurements to determine when the load disconnect contactor has reached its trip point and should be shut off. EP42 "Control Output Settings" is used to switch from power measurements to current measurements, and vice versa.

NOTE The "Disconnect Control Type" field in ET46 "Control Output Read-Only Data" can indicate whether the OSGP device is presently using power or current measurements to determine when the load disconnect contactor has reached its trip point.

8.8.3 Prepaid Metering (optional)

The device will automatically turn off the load disconnect contactor once the credit level in energy has gone to zero in a prepaid metering installation. The OSGP device reduces the amount of remaining credit based on energy usage and tariff level as time goes by.

Once the prepay credit is exhausted (has reached zero), the OSGP device can either be configured to turn off the load disconnect or to switch into Maximum Power mode (to avoid complete power shutoff at the premises). When switching to Maximum Power mode is selected, the Power Threshold on Exhausted Credit value (in watts) setting is used to determine the active power level setting, in watts, at which the load disconnect turns off when prepay credit is exhausted (goes to 0). The Maximum Prepay Power Duration Threshold value programmed into the OSGP device is used to determine the number of minutes that the Power Threshold on Exhausted Credit setting shall be continuously met or exceeded for the load disconnect to turn off when prepay credit is exhausted. Normal operation resumes when the prepay credit value is increased to above zero.

The prepay control settings can be configured via ET05:

- The prepay control settings can be enabled or disabled by writing the "Enable Prepay" field.
- The "Prepay Total Credit" field indicates the active energy credit (in Wh) remaining. The rate at which prepaid credit is deducted is determined by the "Prepay Tariff X Rate" fields in ET05, where X represents the tariff the field applies to (e.g. "Prepay Tariff 1 Rate" establishes the rate for tariff 1).
- When no credit is left, either or the emergency credit or maximum power (or both) will be checked based on configuration. The emergency credit and maximum power checks can be enabled or disabled by writing the "Enable Prepay Emergency Credit" and/or "Enable Prepay + Max Power Option" fields in ET05.

If neither of these options is enabled, the load disconnect contactor shall shut off immediately when prepaid credit runs out.

- If the maximum power check is enabled, the maximum power at which the load disconnect contactor will turn off after prepaid credit runs out can be established by writing the "Prepay Power Threshold" field. Note that the "Prepay Power Time Threshold" field in ET05 establishes a duration for which the threshold shall be met before the load disconnect contactor will be tripped.

If enabled, emergency prepay credit can be added via EP21. The maximum emergency credit that can be added is dictated by the "Maximum Prepay Total Emergency Credit" field.

8.8.4 Local Manual Control (optional)

Manual opening of the load disconnect contactor can be enabled or disabled. When configured to be disabled, the OSGP device will not respond if the consumer attempts to open or close the load disconnect contactor manually. Manual operation of the load disconnect contactor can be enabled or disabled by writing the "Disable Manual Disconnect Open" field in ET05. Note that when the load disconnect contactor is manually opened or closed, the push button shall be pressed (or the lever held) for the duration indicated by the "Minimum Disconnect Switch Hold Time" in ET05 for the change to take effect.

8.8.5 Load Contactor Remote Control (optional)

EP23 can be used to close the load disconnect contactor remotely. Upon execution of this procedure, the load disconnect contactor will close immediately. There are several OSGP device fields that can be configured to prevent execution of EP23:

- The "Enable Remote Disconnect Closed" field in ET05 can be set to prevent remote closing of the load disconnect contactor.

- The "Reject EP23 If Manually Opened" field in ET05 can be set to prevent remote closing of the load disconnect contactor after it has been opened manually.
- The "Reject Disconnect Close LSV" field in ET05 can be set to prevent remote closing of the load disconnect contactor when load side voltage is present.
- The "HW Options" field in ET29 has a field that can be used to disable the load disconnect contactor. In this case, the OSGP device will operate as if no disconnect is present. All ET05 configurations will remain unchanged but the disconnect-related settings would no longer be processed. Manual disconnect operation will be ignored. Remote disconnect operation via EP02 as well as EP21 will return result code 3 (procedure conflicts with current device setup).

8.9 Control Relay (optional)

8.9.1 Overview

One optional control relay can operate an external low current device, such as a contactor coil, which in turn can control a larger amperage device. The open or closed state of the control relay is determined by the present tariff level that is in effect. The tariff period that activates the relay is configurable.

8.9.2 Control Relay Randomization

The OSGP device includes a randomization option for control relay open and close operations. As part of this feature, the user can specify the maximum number of seconds of randomization time to open or close the control relay for each control relay operation that is sent to a group of OSGP devices. The time, the command is executed for each OSGP device in the group will vary randomly between 1 second and the maximum number of seconds set, allowing the actual implementation time for each OSGP device to vary. This is provided to reduce the possibility of spikes or sags on the power grid when multiple loads come online at roughly the same time. When the maximum number of seconds is set to 0, the relay will open or close immediately.

Randomization for control relay operations can be enabled or disabled by writing the "Randomization Enable" field in ET05. The maximum randomization interval to use can be set by writing the "Broadcast Max Random Time" and "Broadcast Max Random Minutes" fields in ET05.

8.9.3 Time-Based Control Relay Calendar

Each device can contain a calendar that specifies when the control relay should be opened or closed. The calendar supports the following types of schedules:

- Daily: The control relay calendar includes a separate schedule for each day of the week.
- Weekday/Weekend: The control relay has two schedules: one for weekdays, and one for weekends.
- Season: The control relay has four separate schedules: one for each season.
- Season Weekday/Weekend: The calendar has eight separate schedules: a weekday schedule and a weekend schedule for each season.

The type of calendar the device will use is specified by writing the "Time-Based Relay Control Mode" field in ET05. Each calendar can include up to 10 open or close operations per schedule. For example, a daily calendar includes a schedule for each day of the week, so the user can specify up to 10 open or close operations per day when using a daily calendar. The Control Relay can be configured to change state based on the time of day. The schedules for opening and closing the relay are stored in ET61 "Time-Based Relay Control".

Each calendar can be assigned an ID, which can be displayed on the device's display.

This calendar is independent of the tariff-based control provided by the OSGP device's TOU calendar, and cannot be used at the same time as the tariff-based control provided by the TOU calendar. If both the control relay calendar described in this clause and the OSGP device's tariff-based control are enabled at the same time, the tariff-based control settings will take precedence. The user can also specify which state the control relay should switch to in case a clock error occurs, and the OSGP device cannot determine which scheduled state to use.

Note that if a remote command is issued to open the control relay, then the OSGP device will suspend all programmatic (i.e. time-based or tariff based) relay operations until another remote command is issued to close the relay. At that point, the OSGP device will resume using the time-based or tariff-based relay schedule programmed into the OSGP device.

8.9.4 Remote Control

EP02 is used to control both the control relay and the load disconnect contactor. If EP02 is used to force either output open, the automatic controls (such as the time-based relay control calendar) for that output are disabled. Automatic control is re-enabled when EP02 is invoked to close the output.

If EP02 is used to force the disconnect open, a parameter indicating the priority of the command needs to be set. If the parameter indicates a low priority, the procedure will not be executed if OSGP device is configured with a high priority disconnect level. If the parameter indicates a high priority, the procedure will be executed regardless of which priority disconnect level the OSGP device is configured with.

8.10 History Log (optional)

8.10.1 Overview

The event log holds a chronological time-stamped record of alarms and events that occur in the OSGP device. Event log data can be found in BT74 "History Log Data". Dimension information is in BT70 "Dimension Log" and BT71 "Actual Log". Proper interpretation of the offsets in BT74 relies on reading BT71 first to determine the presently configured dimensions of the event log.

BT74 is implemented as a circular queue of entries. The header fields (bytes 0...9) hold the information needed to read the queue. The "Number Of Valid Entries" field indicates how many entries in the queue contain data. "Last Entry Element" is the array element of the most recently recorded entry. The "Number Of Unread Entries" field stores the number of entries that have not been read through the system. This value may or may not pertain to the optical reader. It is recommended that the user reads the entire list and uses the "Last Entry Element" field to track the starting point of the entries listed in reverse chronological order.

The events and alarms that will be logged in the history log are configured via BT72 "Events Identification".

8.10.2 Critical event (optional)

The user can define any of the status and alarm events as critical events. Once an event has been designated as a critical event, the last 10 instances of that event will be retained in the event log at all times.

Critical events will be maintained in the event log along with all of the other events that have not been designated as critical. The event log stores up to 100 of the most recent events. When the event log is full, the oldest events are over-written. However, the oldest events will now be examined before they are overwritten. If one of the older events to be removed is identified as a critical event, and replacing it would cause its retention count to be less than the minimum of 10, then that event will be relocated within the log. The relocated event will replace either the earliest instance of a non-critical event, or the earliest instance of a critical event which no longer has to be retained due to its minimum retention count being exceeded (whichever it finds first starting from the oldest entry in the log). This means that the event log may not be in timestamp order, and some event log sequence numbers may no longer be in order, after the user has defined critical events.

WARNING – When the user reconfigures the critical event log settings on his OSGP device, all critical events which occurred while the previous settings were in effect will no longer be marked as critical events (although they will remain in the event log as non-critical events). This applies even if a given alarm was classified as being a critical event both before and after the critical event log settings were modified. In this case, only the instances of the alarm which occurred after the settings were most recently configured will be classified as critical.