



BSI Standards Publication

Communication networks and systems for power utility automation

Part 7-1: Basic communication structure — Principles and models

National foreword

This British Standard is the UK implementation of EN 61850-7-1:2011+A1:2020. It is identical to IEC 61850-7-1:2011, incorporating amendment 1:2020. It supersedes BS EN 61850-7-1:2011, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by **A1** **A1**.

The UK participation in its preparation was entrusted to Technical Committee PEL/57, Power systems management and associated information exchange.

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

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 2020
Published by BSI Standards Limited 2020

ISBN 978 0 539 02143 1

ICS 33.200

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

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2011.

Amendments/corrigenda issued since publication

Date	Text affected
31 October 2020	Implementation of IEC amendment 1:2020 with CENELEC endorsement A1:2020

**Communication networks and systems for power utility automation -
Part 7-1: Basic communication structure -
Principles and models
(IEC 61850-7-1:2011)**

Réseaux et systèmes de communication
pour l'automatisation des systèmes
électriques -
Partie 7-1: Structure de communication de
base -
Principes et modèles
(CEI 61850-7-1:2011)

Kommunikationsnetze und -systeme für
die Automatisierung in der elektrischen
Energieversorgung -
Teil 7-1: Grundlegende
Kommunikationsstruktur -
Grundsätze und Modelle
(IEC 61850-7-1:2011)

This European Standard was approved by CENELEC on 2011-08-19. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland 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

European foreword

The text of document 57/1121/FDIS, future edition 2 of IEC 61850-7-1, prepared by IEC TC 57, Power systems management and associated information exchange, was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61850-7-1:2011.

This document supersedes EN 61850-7-1:2003.

Compared to EN 61850-7-1:2003, EN 61850-7-1:2011 introduces:

- the model for statistical and historical statistical data,
- the concepts of proxies, gateways, LD hierarchy and LN inputs,
- the model for time synchronisation,
- the concepts behind different testing facilities,
- the extended logging function.

EN 61850-7-1:2011 also clarifies the following points:

- the use of numbers for data extension,
- the use of name spaces,
- the mode and behaviour of a logical node,
- the use of range and deadbanded values,
- the access to control actions and others.

The following dates are fixed:

- | | | |
|--|-------|------------|
| – latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2012-05-19 |
| – latest date by which the national standards conflicting with the document have to be withdrawn | (dow) | 2014-08-19 |

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

Endorsement notice

The text of the International Standard IEC 61850-7-1:2011 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

- | | | |
|------------------|------|---|
| IEC 61346-1 | NOTE | Harmonized as EN 61346-1. |
| IEC 61346-2 | NOTE | Harmonized as EN 61346-2. |
| IEC 61400 series | NOTE | Harmonized in EN 61400 series (not modified). |

Foreword to amendment A1

The text of document 57/2201/FDIS, future IEC 61850-7-1/A1, prepared by IEC/TC 57 “Power systems management and associated information exchange” was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61850-7-1:2011/A1:2020.

The following dates are fixed:

- latest date by which the document has to be implemented at national (dop) 2021-07-05 level by publication of an identical national standard or by endorsement
- latest date by which the national standards conflicting with the (dow) 2023-10-05 document have to be withdrawn

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 has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association.

Endorsement notice

The text of the International Standard IEC 61850-7-1:2011/A1:2020 was approved by CENELEC as a European Standard without any modification.

Remove the following reference:

IEC 61400 series NOTE Harmonized in EN 61400 series.

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application 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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC/TS 61850-2	-	Communication networks and systems in substations - Part 2: Glossary	-	
IEC 61850-3	-	Communication networks and systems in substations - Part 3: General requirements	EN 61850-3	-
IEC 61850-4	-	Communication networks and systems for power utility automation - Part 4: System and project management	EN 61850-4	-
IEC 61850-5	-	Communication networks and systems in substations - Part 5: Communication requirements for functions and device models	EN 61850-5	-
IEC 61850-6	-	Communication networks and systems for power utility automation - Part 6: Configuration description language for communication in electrical substations related to IEDs	EN 61850-6	-
IEC 61850-7-2	-	Communication networks and systems for power utility automation - Part 7-2: Basic information and communication structure - Abstract communication service interface (ACSI)	EN 61850-7-2	-
IEC 61850-7-3	-	Communication networks and systems for power utility automation - Part 7-3: Basic communication structure - Common data classes	EN 61850-7-3	-
IEC 61850-7-4	-	Communication networks and systems for power utility automation - Part 7-4: Basic communication structure - Compatible logical node classes and data object classes	EN 61850-7-4	-
IEC 61850-8-1	-	Communication networks and systems for power utility automation - Part 8-1: Specific Communication Service Mapping (SCSM) - Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3	EN 61850-8-1	-

EN 61850-7-1:2011+A1:2020 (E)

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61850-9-2	-	Communication networks and systems in substations - Part 9-2: Specific Communication Service Mapping (SCSM) - Sampled values over ISO/IEC 8802-3	EN 61850-9-2	-
IEC 61850-10	-	Communication networks and systems in substations - Part 10: Conformance testing	EN 61850-10	-
ISO/IEC 8802-3	-	Information technology - Telecommunications - and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications		
ISO/IEC 8825	Series	Information technology - ASN.1 encoding rules	-	
ISO 9506-1	-	Industrial automation systems - Manufacturing - Message Specification - Part 1: Service definition		
ISO 9506-2	-	Industrial automation systems - Manufacturing - Message Specification - Part 2: Protocol specification		

This page deliberately left blank

CONTENTS

FOREWORD	11
INTRODUCTION	13
1 Scope	14
2 Normative references	14
3 Terms and definitions	15
4 Abbreviated terms	16
5 Overview of the IEC 61850 series concepts	17
5.1 Objective	17
5.2 Topology and communication functions of substation automation systems	18
5.3 The information models of substation automation systems	19
5.4 Applications modelled by logical nodes defined in IEC 61850-7-4	21
5.5 The semantic is attached to data	24
5.6 The services to exchange information	26
5.7 Services mapped to concrete communication protocols	28
5.8 The configuration of the automation system	28
5.9 Summary	29
6 Modelling approach of the IEC 61850 series	30
6.1 Decomposition of application functions and information	30
6.2 Creating information models by stepwise composition	32
6.3 Example of an IED composition	34
6.4 Information exchange models	35
6.4.1 General	35
6.4.2 Output model	36
6.4.3 Input model	40
6.4.4 Model for statistical and historical statistical data	50
6.4.5 Model for system functions	53
7 Application view	55
7.1 General	55
7.2 First modelling step – Logical nodes and data	57
7.3 Mode and behaviour of a logical node	60
7.4 Use of measurement ranges and alarms for supervision functions	60
7.5 Data used for limiting the access to control actions	61
7.6 Data used for blocking functions described by logical nodes	61
7.7 Data used for logical node inputs/outputs blocking (operational blocking)	61
7.7.1 General	61
7.7.2 Blocking incoming commands	62
7.7.3 Blocking process outputs	62
7.7.4 Blocking the communication of status outputs updates	62
7.8 Data used for testing	63
7.8.1 General	63
7.8.2 Multicast signals used for simulation	63
7.8.3 Input signals used for testing	64
7.8.4 Test mode	66
7.9 Logical node used for extended logging functions	66
8 Device view	67

8.1	General.....	67
8.2	Second modelling step – logical device model	68
8.2.1	The logical device concept.....	68
8.2.2	The device nameplate.....	69
8.2.3	Gateways and proxies.....	70
8.2.4	Logical devices for monitoring external device health.....	74
8.2.5	Logical devices management hierarchy.....	74
9	Communication view.....	76
9.1	General.....	76
9.2	The service models of the IEC 61850 series	76
9.3	The virtualisation	78
9.4	Basic information exchange mechanisms	79
9.5	The client-server building blocks.....	81
9.5.1	Server.....	81
9.5.2	Client-server roles	82
9.6	Logical nodes communicate with logical nodes	83
9.7	Interfaces inside and between devices	84
10	Where physical devices, application models and communication meet.....	85
11	Relationships between IEC 61850-7-2, IEC 61850-7-3 and IEC 61850-7-4	86
11.1	Refinements of class definitions.....	86
11.2	Example 1 – Logical node and data object class	87
11.3	Example 2 – Relationship of IEC 61850-7-2, IEC 61850-7-3, and IEC 61850-7-4 ..	91
12	Formal specification method	93
12.1	Notation of ACSI classes	93
12.2	Class modelling	93
12.2.1	Overview	93
12.2.2	Common data class	95
12.2.3	Logical node class	99
12.3	Service parameters tables	101
12.4	Referencing instances	102
13	Namespaces.....	105
13.1	General.....	105
13.2	Namespaces defined in the IEC 61850-7-x series	106
13.3	Namespaces dependencies	110
13.3.1	General.....	110
13.3.2	Basic namespaces dependencies	110
13.3.3	Other namespaces dependencies	112
13.4	Specification of namespaces.....	113
13.5	Attributes for references to namespaces	113
13.5.1	General.....	113
13.5.2	Attribute for logical device namespace (IdNs)	114
13.5.3	Attribute for logical device basic namespace (LLN0.NamPit.InNs).....	114
13.5.4	Attribute for logical node namespace (InNs).....	115
13.5.5	Attribute for data namespace (dataNs).....	115
13.5.6	Attribute for common data class namespace (cdcNs)	115
13.5.7	Attribute for naming a common data class name (cdcName)	115
13.6	Deprecation of namespaces	116
14	Common rules for new version of classes and for extension of object classes	116

14.1	General.....	116
14.2	Basic rules	116
14.2.1	General.....	116
14.2.2	Use of optional information	119
14.2.3	General rules for enumerations types and enumeration-based data objects and attributes.....	119
14.3	Rules for extensions within private namespace	119
14.3.1	Rules for LN classes	119
14.3.2	New LN classes	120
14.3.3	Rules for Common Data Classes	120
14.3.4	Rules for enumeration types and enumeration-based data objects and attributes	121
14.4	Extensions made within product standard namespaces.....	121
14.5	Extensions made within transitional namespaces	121
14.6	Extensions made within basic and domain namespaces	121
14.7	Multiple instances of LN classes for dedicated and complex functions	122
14.7.1	Example for time overcurrent	122
14.7.2	Example for PDIS	122
14.7.3	Example for power transformer	122
14.7.4	Example for auxiliary network	122
14.8	Specialisation of data by use of number extensions	123
14.9	Examples for new LNs	123
14.10	Example for new Data.....	123
15	Compatibility between different versions of the standard	124
Annex A	(informative) Overview of logical nodes and data	125
A.1	Compatible logical node classes and data classes (IEC 61850-7-4)	125
A.1.1	List of LN groups (IEC 61850-7-4)	125
A.1.2	LN classes (IEC 61850-7-4).....	125
A.1.3	Data object classes (IEC 61850-7-4).....	125
A.2	Common data class specifications (IEC 61850-7-3)	125
Annex B	(informative) Allocation of data to logical nodes	127
Annex C	(informative) Use of the substation configuration language (SCL)	130
C.1	General.....	130
C.2	SCL and options in logical nodes	130
C.3	SCL and options in data	131
Annex D	(xxx)	132
Annex E	(informative) Relation between logical nodes and PICOMs	133
Annex F	(informative) Mapping the ACSI to real communication systems.....	134
F.1	General.....	134
F.1.1	Mapping example (IEC 61850-8-1).....	136
Annex G	(normative) LGOS/LSVS engineering	142
G.1	General.....	142
G.2	LGOS/LSVS engineering by the ICT	143
G.3	LGOS/LSVS engineering by the SCT	144
Annex H	(normative) GOOSE/SMV Subscription Configuration	146
H.1	General.....	146
H.2	SCT supplied input binding workflow.....	147
H.3	ICT supplied input binding (for later binding).....	148

Annex I (informative) Specification of namespaces for Edition 3	149
I.1 Namespaces dependencies	149
I.1.1 General.....	149
I.1.2 Namespaces dependencies	149
I.2 Example 2 – Standardized data objects used in standardized LNs	150
I.3 Example 3 – Edition 2 device: standardized data object introduced in IEC61850-7-4:2007B	151
I.4 Example 4 – Edition 2 device: standardized LN introduced in IEC61850-7-4:2007B	152
I.5 Example 5 – Edition 1 device: Logical nodes in technical reports	153
I.6 Example 6- Edition 2.1 device: Logical nodes in technical reports defining new CDCs.....	155
I.7 Example 7- Edition 2.1 device: devices for product family standards	156
I.8 Example 8 – Standardized logical nodes introduced by other domain applications	157
I.9 Example 9 – Standardized logical nodes introduced by other domain applications than moved to IEC 61850-7-4	159
Annex J (normative) Use case scenarios examples for clarifying the common rules of Clause 14	162
J.1 General.....	162
J.2 Example 1 – Private LN using standardized DOs	162
J.3 Example 2 – Standardized data objects used in standardized LNs	163
J.4 Example 3 – Edition 2 device: standardized data object introduced in IEC61850-7-4:2007B	163
J.5 Example 4 – Edition 2 device: standardized LN introduced in IEC61850-7-4:2007B	164
J.6 Example 5 – Edition 1 device: Logical nodes in technical reports	165
J.7 Example 6- Edition 2.1 device: Logical nodes in technical reports defining new CDCs.....	167
J.8 Example 7- Edition 2.1 device: devices for product family standards	168
J.9 Example 8 – Standardized logical nodes introduced by other domain applications	169
J.10 Example 9 – Standardized logical nodes introduced by other domain applications than moved to IEC 61850-7-4	171
Annex K (normative) General requirements and recommendations regarding compatibility issues between different versions of IEC 61850.....	174
K.1 Overview.....	174
K.1.1 General.....	174
K.1.2 Definitions (to go to part 2):	174
K.1.3 Introduction to compatibility discussion	175
K.1.4 Assumptions	175
K.1.5 Generic rules	176
K.1.6 Overview on use cases	177
K.2 Use cases related to the data model	181
K.2.1 Use case 1: Add new type	181
K.2.2 Use case 2: Add new FC.....	181
K.2.3 Use case 3: Extend CDC with elements of existing types and FCs	182
K.2.4 Use case 4: Add a new DataObject (DO) based on new CDCs	183
K.2.5 Use case 5: Add a new DO based on existing CDCs	184
K.2.6 Use case 6: Rename a DO.....	184
K.2.7 Use case 7: Rename a DA, subDO or subDA	184

K.2.8	Use case 8: Deprecation of a FC	185
K.2.9	Use case 9: Deprecation of a DA	186
K.2.10	Use case 10: Removal of a DA	186
K.2.11	Use case 11: Deprecation of a DO	187
K.2.12	Use case 12: Use a weaker presence condition	187
K.2.13	Use case 13: Use a stronger presence condition	188
K.2.14	Use case 14: Extend Enumeration List with an enumerated value	188
K.2.15	Use case 15: Modification of an Enumerated value	189
K.2.16	Use case 16: Deprecation of an Enumerated value	190
K.2.17	Use case 17: Extension of a PACKED LIST	190
K.2.18	Use case 18: Extend Name Length	190
K.3	Use cases related to the services I.....	191
K.3.1	Use case 30: Add new type.....	191
K.3.2	Use case 31: Using new control block class	192
K.3.3	Use case 32: Using new services	192
K.3.4	Use case 33: Extending control block class with an attribute of existing type	193
K.3.5	Use case 34: Rename a service parameter not associated with a control block attribute	193
K.3.6	Use case 35: Removing / Deprecating Control Block Classes	193
K.3.7	Use case 36: Using a stronger presence condition	194
	Bibliography	195
	Figure 1 – Relations between modelling and mapping parts of the IEC 61850 series	17
	Figure 2 – Sample substation automation topology	19
	Figure 3 – Modelling approach (conceptual).....	20
	Figure 4 – Logical node information categories	23
	Figure 5 – Build-up of devices (principle)	23
	Figure 6 – Position information depicted as a tree (conceptual)	24
	Figure 7 – Service excerpt	27
	Figure 8 – Example of communication mapping	28
	Figure 9 – Summary	30
	Figure 10 – Decomposition and composition process (conceptual).....	31
	Figure 11 – XCBR1 information depicted as a tree	33
	Figure 12 – Example of IED composition.....	35
	Figure 13 – Output and input model (principle).....	36
	Figure 14 – Output model (step 1) (conceptual)	37
	Figure 15 – Output model (step 2) (conceptual)	38
	Figure 16 – GSE output model (conceptual).....	38
	Figure 17 – Setting data (conceptual)	39
	Figure 18 – Input model for analogue values (step 1) (conceptual)	41
	Figure 19 – Range and deadbanded value (conceptual).....	42
	Figure 20 – Input model for analogue values (step 2) (conceptual)	43
	Figure 21 – Reporting and logging model (conceptual).....	44
	Figure 22 – Data set members and reporting	45
	Figure 23 – Buffered report control block (conceptual)	45

Figure 24 – Buffer time	47
Figure 25 – Data set members and inclusion-bitstring	48
Figure 26 – Log control block (conceptual).....	48
Figure 27 – Peer-to-peer data value publishing model (conceptual)	49
Figure 28 – Conceptual model of statistical and historical statistical data (1)	51
Figure 29 – Conceptual model of statistical and historical statistical data (2)	53
Figure 30 – Concept of the service tracking model – Example: control service tracking.....	55
Figure 31 – Real world devices	56
Figure 32 – Logical nodes and data (IEC 61850-7-2)	57
Figure 33 – Simple example of modelling.....	58
Figure 34 – Basic building blocks.....	58
Figure 35 – Logical nodes and PICOM	59
Figure 36 – Logical nodes connected (outside view in IEC 61850-7-x series).....	59
Figure 37 – Mode and behaviour data (IEC 61850-7-4)	60
Figure 38 – Data used for limiting the access to control actions (IEC 61850-7-4)	61
Figure 39 – Data used for logical node inputs/outputs blocking (IEC 61850-7-4)	62
Figure 40 – Data used for receiving simulation signals.....	63
Figure 80 – GOOSE subscription supervision state machine	64
Figure 81 – SV subscription supervision state machine.....	64
Figure 41 – Example of input signals used for testing	65
Figure 42 – Test mode example.....	66
Figure 43 – Logical node used for extended logging functions (GLOG)	67
Figure 44 – Logical device building block.....	68
Figure 45 – Logical devices and LLN0/LPHD	69
Figure 46 – The common data class DPL	70
Figure 47 – Logical devices in proxies or gateways.....	72
Figure 79 – Logical devices in proxies or gateways (functional naming).....	73
Figure 48 – Logical devices for monitoring external device health	74
Figure 49 – Logical devices management hierarchy	75
Figure 50 – ACSI communication methods.....	77
Figure 51 – Virtualisation	79
Figure 52 – Virtualisation and usage	79
Figure 53 – Information flow and modelling.....	80
Figure 54 – Application of the GSE model.....	80
Figure 55 – Server building blocks	81
Figure 56 – Interaction between application process and application layer (client/server)	82
Figure 57 – Example for a service.....	82
Figure 58 – Client/server and logical nodes	82
Figure 59 – Client and server roles	83
Figure 60 – Logical nodes communicate with logical nodes.....	84
Figure 61 – Interfaces inside and between devices	85
Figure 62 – Component hierarchy of different views (excerpt)	86

Figure 63 – Refinement of the DATA class.....	87
Figure 64 – Instances of a Data object class (conceptual).....	91
Figure 65 – Relation between parts of the IEC 61850 series	92
Figure 66 – Abstract data model example for IEC 61850-7-x.....	94
Figure 67 – Relation of TrgOp and Reporting.....	99
Figure 68 – Sequence diagram	102
Figure 69 – References.....	102
Figure 70 – Use of FCD and FCDA	103
Figure 71 – Object names and object reference	105
Figure 72 – Definition of names and semantics.....	106
Figure 73 – Name space as class repository	107
Figure 74 – All instances derived from classes in a single name space	108
Figure 75 – Instances derived from multiple namespaces	109
Figure 76 – Inherited namespaces	109
Figure 77 – Basic namespaces dependencies.....	111
Figure 78 – Other namespaces dependencies.....	112
Figure 78 – Basic extension rules diagram.....	117
Figure B.1 – Example for control and protection LNs combined in one physical device	127
Figure B.2 – Merging unit and sampled value exchange (topology)	128
Figure B.3 – Merging unit and sampled value exchange (data)	128
Figure C.1 – Application of SCL for LNs (conceptual)	130
Figure C.2 – Application of SCL for data (conceptual).....	131
Figure E.1 – Exchanged data between subfunctions (logical nodes)	133
Figure E.2 – Relationship between PICOMS and client/server model	133
Figure F.1 – ACSI mapping to an application layer.....	134
Figure F.2 – ACSI mappings (conceptual).....	135
Figure F.3 – ACSI mapping to communication stacks/profiles	136
Figure F.4 – Mapping to MMS (conceptual).....	136
Figure F.5 – Mapping approach	137
Figure F.6 – Mapping detail of mapping to a MMS named variable.....	138
Figure F.7 – Example of MMS named variable (process values)	138
Figure F.8 – Use of MMS named variables and named variable list.....	139
Figure F.9 – MMS information report message.....	140
Figure F.10 – Mapping example.....	141
Figure G.1 – LGOS/LSVS engineering	143
Figure G.2 – LGOS/LSVS engineering by ICT.....	144
Figure G.3 – LGOS/LSVS engineering by the SCT.....	145
Figure H.1 – GOOSE/SMV subscription engineering workflow.....	146
Figure H.2 – SCT supplied input binding	147
Figure H.3 – ICT supplied input binding (for later binding).....	148
Figure I.1 – Private LN using standardized DOs (Edition 2).....	150
Figure I.2 –Standardized data objects used in standardized LNs.....	151

Figure I.3 – Edition 2 device: standardized data object introduced in IEC61850-7-4:2007B	152
Figure I.4 – Edition 2 device: standardized LN introduced in IEC61850-7-4:2007B.....	153
Figure I.5 – Edition 1 device: Logical nodes in technical reports	154
Figure I.6 – Edition 2 device: Logical nodes in technical reports	155
Figure I.7 – Edition 2.1 device: Logical nodes in technical reports defining new CDCs	156
Figure I.8 – Edition 2.1 device: standardized LNs extended by other domains	157
Figure I.9 – Edition 2 device: standardized LN introduced in IEC 61850-7-420:2009	158
Figure I.10 – Edition 2.1 device: standardized LN introduced in IEC 61850-7-420:2015	159
Figure I.11 – Edition 2 device: standardized LN moved from introduced in IEC 61850-7-420:2009 to IEC 61850-7-4:2007	160
Figure I.12 – Edition 2.1 device: standardized LN moved from introduced in IEC 61850-7-420:2009 to IEC 61850-7-4:2007	161
Figure J.1 – Private LN using standardized DOs (Edition 2)	162
Figure J.2 –Standardized data objects used in standardized LNs	163
Figure J.3 – Edition 2 device: standardized data object introduced in IEC61850-7-4:2007B	164
Figure J.4 – Edition 2 device: standardized LN introduced in IEC61850-7-4:2007B	165
Figure J.5 – Edition 1 device: Logical nodes in technical reports.....	166
Figure J.6 – Edition 2 device: Logical nodes in technical reports.....	167
Figure J.7 – Edition 2.1 device: Logical nodes in technical reports defining new CDCs	168
Figure J.8 – Edition 2.1 device: standardized LNs extended by other domains.....	169
Figure J.9 – Edition 2 device: standardized LN introduced in IEC 61850-7-420:2009	170
Figure J.10 – Edition 2.1 device: standardized LN introduced in IEC 61850-7-420:2015	171
Figure J.11 – Edition 2 device: standardized LN moved from introduced in IEC 61850-7-420:2009 to IEC 61850-7-4:2007	172
Figure J.12 – Edition 2.1 device: standardized LN moved from introduced in IEC 61850-7-420:2009 to IEC 61850-7-4:2007	173
Table 1 – LN groups	21
Table 2 – Logical node class XCBR (conceptual)	32
Table 3 – Excerpt of integer status setting	40
Table 4 – Comparison of the data access methods	45
Table 5 – ACSI models and services.....	77
Table 6 – Logical node circuit breaker.....	88
Table 7 – Controllable double point (DPC)	90
Table 8 – ACSI class definition	93
Table 9 – Single point status common data class (SPS).....	95
Table 10 – Quality components attribute definition	96
Table 16 – Attributes of DetailQual	97
Table 11– Functional constraints (excerpt).....	98
Table 12– Trigger option.....	98
Table 13 – GenLogicalNodeClass definition.....	100
Table 14 – Excerpt of logical node name plate common data class (LPL).....	114
Table 15 – Excerpt of the abstract common data class BasePrimitiveCDC	114

Table A.2 – List of common data classes (excerpt)	125
Table K.1 – Information users and information providers	175
Table K.2 – Data model use cases	177
Table K.3 – Services use cases	179
Table K.4 – Data Forbidden cases	180
Table K.5 – Add new basic type	181
Table K.6 – Extend CDC with DA of new FC	182
Table K.7 – Add new DA using existing type and FCs	182
Table K.8 – Add a new DO based on new CDC using existing types and FCs	183
Table K.9 – Adding a new DO based on existing CDC	184
Table K.10 – Renaming a DO	184
Table K.11 – Renaming a DA, subDO or subDA	185
Table K.12 – Deprecation of a FC	186
Table K.13 – Deprecation of a DA	186
Table K.14 – Removal of a DA	187
Table K.15 – Deprecation of a DO	187
Table K.16 – Use of a weaker presence condition	188
Table K.17 – Use of a stronger presence condition	188
Table K.18 – Extend an enumeration with an enumerated value	189
Table K.19 – Modification of an enumerated value from an enumeration list	189
Table K.20 – Deprecate an enumerated value from an enumeration list	190
Table K.21 – Extension of a PACKED LIST	190
Table K.22 – Extend size of names / references	191
Table K.23 – Add new basic type	191
Table K.24 – Adding new Control Blocks	192
Table K.25 – Adding new services	192
Table K.26 – Add new attributes in control block	193
Table K.27 – Deprecating control block class	193
Table K.28 – Using a stronger presence condition	194

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 7-1: Basic communication structure – Principles and models

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61850-7-1 has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

The text of this document is based on the following documents:

FDIS	Report on voting
57/1121/FDIS	57/1145/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This second edition cancels and replaces the first edition published in 2003. This second edition constitutes a technical revision.

Compared to the first edition, this second edition introduces:

- the model for statistical and historical statistical data,
- the concepts of proxies, gateways, LD hierarchy and LN inputs,
- the model for time synchronisation,
- the concepts behind different testing facilities,
- the extended logging function.

It also clarifies the following points:

- the use of numbers for data extension,
- the use of name spaces,
- the mode and behaviour of a logical node,
- the use of range and deadbanded values,
- the access to control actions and others.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61850 series, under the general title: *Communication networks and systems for power utility automation* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This part of the IEC 61850 series provides an overview of the architecture for communication and interactions between systems for power utility automation such as protection devices, breakers, transformers, substation hosts etc.

This document is part of a set of specifications which details a layered communication architecture for power utility automation. This architecture has been chosen to provide abstract definitions of classes (representing hierarchical information models) and services such that the specifications are independent of specific protocol stacks, implementations, and operating systems.

The goal of the IEC 61850 series is to provide interoperability between the IEDs from different suppliers or, more precisely, between functions to be performed by systems for power utility automation but residing in equipment (physical devices) from different suppliers. Interoperable functions may be those functions that represent interfaces to the process (for example, circuit breakers) or substation automation functions such as protection functions. This part of the IEC 61850 series uses simple examples of functions to describe the concepts and methods applied in the IEC 61850 series.

This part of the IEC 61850 series describes the relationships between other parts of the IEC 61850 series. Finally this part defines how interoperability is reached.

NOTE Interchangeability is the ability to replace a device from the same vendor, or from different vendors, utilising the same communication interface and as a minimum, providing the same functionality, with no impact on the rest of the system. If differences in functionality are accepted, the exchange may also require some changes somewhere else in the system. Interchangeability implies a standardisation of functions and, in a strong sense, of devices which are outside the scope of this standard. Interchangeability is outside the scope, but it will be supported following this standard for interoperability.

This part of the IEC 61850 series is intended for all stakeholders of standardised communication and standardised systems in the utility industry. It provides an overview of and an introduction to IEC 61850-7-4, IEC 61850-7-3, IEC 61850-7-2, IEC 61850-6, and IEC 61850-8-1.

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 7-1: Basic communication structure – Principles and models

1 Scope

This part of the IEC 61850 series introduces the modelling methods, communication principles, and information models that are used in the various parts of the IEC 61850-7-x series. The purpose of this part of the IEC 61850 series is to provide – from a conceptual point of view – assistance to understand the basic modelling concepts and description methods for:

- substation-specific information models for power utility automation systems,
- device functions used for power utility automation purposes, and
- communication systems to provide interoperability within power utility facilities.

Furthermore, this part of the IEC 61850 series provides explanations and provides detailed requirements relating to the relation between IEC 61850-7-4, IEC 61850-7-3, IEC 61850-7-2 and IEC 61850-5. This part explains how the abstract services and models of the IEC 61850-7-x series are mapped to concrete communication protocols as defined in IEC 61850-8-1.

The concepts and models provided in this part of the IEC 61850 series may also be applied to describe, among others, information models and functions for:

- hydroelectric power plants,
- substation to substation information exchange,
- information exchange for distributed automation,
- substation to control centre information exchange,
- information exchange for metering,
- condition monitoring and diagnosis, and
- information exchange with engineering systems for device configuration.

NOTE 1 This part of IEC 61850 uses examples and excerpts from other parts of the IEC 61850 series. These excerpts are used to explain concepts and methods. These examples and excerpts are informative in this part of IEC 61850.

NOTE 2 Examples in this part use names of classes (e.g. XCBR for a class of a logical node) defined in IEC 61850-7-4, IEC 61850-7-3, and service names defined in IEC 61850-7-2. The normative names are defined in IEC 61850-7-4, IEC 61850-7-3, and IEC 61850-7-2 only.

NOTE 3 This part of IEC 61850 does not provide a comprehensive tutorial. It is recommended that this part be read first – in conjunction with IEC 61850-7-4, IEC 61850-7-3, and IEC 61850-7-2. In addition, it is recommended that IEC 61850-1 and IEC 61850-5 also be read.

NOTE 4 This part of IEC 61850 does not discuss implementation issues.

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.

IEC 61850-2, *Communication networks and systems in substations – Part 2: Glossary*

IEC 61850-3, *Communication networks and systems in substations – Part 3: General requirements*

IEC 61850-4, *Communication networks and systems for power utility automation – Part 4: System and project management*

IEC 61850-5, *Communication networks and systems in substations – Part 5: Communication requirements for functions and device models*

IEC 61850-6, *Communication networks and systems for power utility automation – Part 6: Configuration description language for communication in electrical substations related to IEDs*

IEC 61850-7-2, *Communication networks and systems for power utility automation – Part 7-2: Basic information and communication structure – Abstract communication service interface (ACSI)*

IEC 61850-7-3, *Communication networks and systems for power utility automation – Part 7-3: Basic communication structure – Common data classes*

IEC 61850-7-4, *Communication networks and systems for power utility automation – Part 7-4: Basic communication structure – Compatible logical node classes and data object classes*

IEC 61850-8-1, *Communication networks and systems for power utility automation – Part 8-1: Specific Communication Service Mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3*

IEC 61850-9-2, *Communication networks and systems in substations – Part 9-2: Specific Communication Service Mapping (SCSM) – Sampled values over ISO/IEC 8802-3*

IEC 61850-10, *Communication networks and systems in substations – Part 10: Conformance testing*

ISO/IEC 8802-3, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

ISO/IEC 8825 (all parts), *Information technology – ASN.1 encoding rules*

ISO 9506-1, *Industrial automation systems – Manufacturing Message Specification – Part 1: Service definition*

ISO 9506-2, *Industrial automation systems – Manufacturing Message Specification – Part 2: Protocol specification*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61850-2 as well as the following apply.

3.1 information

knowledge concerning objects, such as facts, events, things, processes, or ideas, including concepts, that within a certain context has a particular meaning

[IEC 60050-101:1998, 101-12-01]

3.2 information model

knowledge concerning power utility functions and devices in which the functions are implemented

This knowledge is made visible and accessible through the means of the IEC 61850 series. The model describes in an abstract way a communication-oriented representation of a real function or device.

3.3 model

a representation of some aspect of reality

The purpose of creating a model is to help understand, describe, or predict how things work in the real world by exploring a simplified representation of a particular entity or phenomenon. The focus of the model defined in IEC 61850-7-x is on the communication features of the data and functions modelled.

4 Abbreviated terms

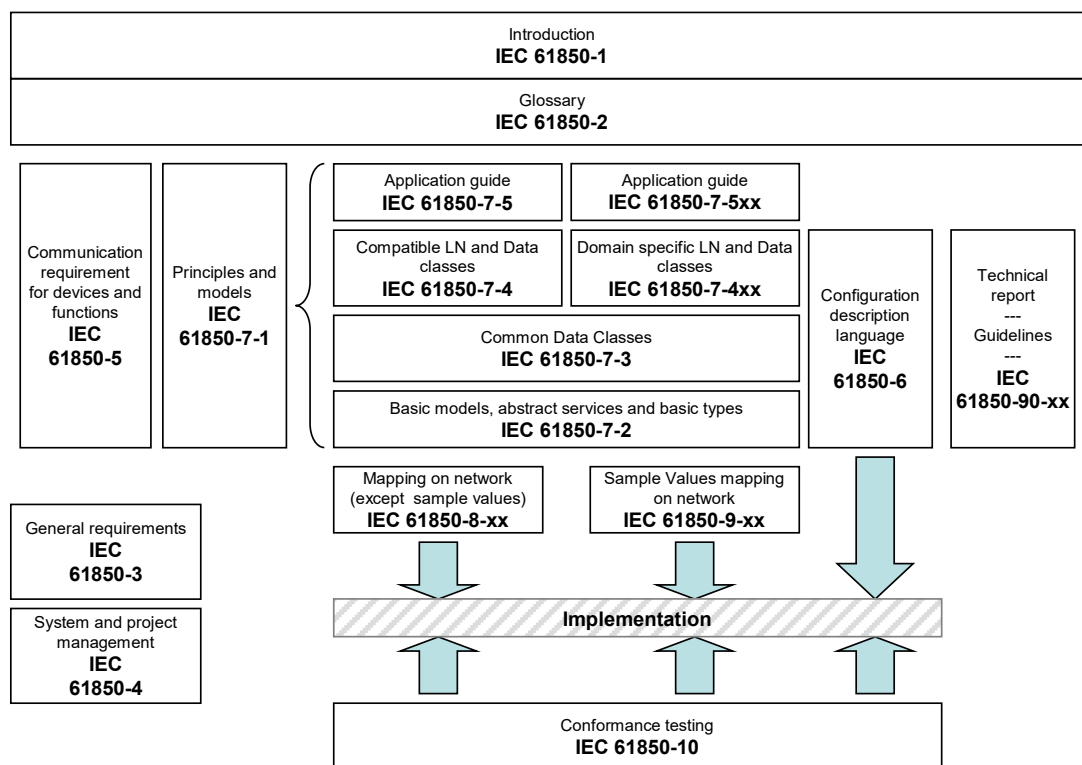
ACSI	Abstract communication service interface
ASN.1	Abstract syntax notation one
API	Application program interface
CDC	Common data class
CT	Current transformer
DST	Daylight saving time
GOOSE	Generic oriented object system event
IED	Intelligent electronic device
LD	Logical device
LN	Logical node
LLN0	Logical node zero
LPHD	Logical node physical device
 MICS	Model implementation conformance statement 
MMS	Manufacturing message specification
PHD	Physical device
PICOM	Piece of communication
 PICS	Protocol implementation conformance statement 
SAS	Substation automation system
SCSM	Specific communication service mapping
 SICS	SCL implementation conformance statement 
SoE	Sequence of events
SMV	Sample values
UCAIug	UCA international users group
UTC	Universal time coordinated
VMD	Virtual manufacturing device

VT Voltage transformer
XML extended markup language

5 Overview of the IEC 61850 series concepts

5.1 Objective

IEC 61850-7-4, IEC 61850-7-3, IEC 61850-7-2, IEC 61850-6, and IEC 61850-8-1 are closely related. This subclause provides an overview of these parts and it describes how they are interwoven. The modelling and implementation methods applied in the different parts of the standard and their relation are shown in Figure 1.



IEC 1402/11

Figure 1 – Relations between modelling and mapping parts of the IEC 61850 series

Each part defines a specific aspect of a substation IED:

- IEC 61850-1 gives an introduction and overview of the IEC 61850 series,
- IEC 61850-2 contains the glossary of specific terminology and definitions used in the context of power utility automation systems within the various parts of the standard,
- IEC 61850-3 specifies the general requirements of the communication network with regard to the quality requirements, environmental conditions and auxiliary services,
- IEC 61850-4 pertains to the system and project management with respect to the engineering process, the life cycle of the SAS and the quality assurance from the development stage to the discontinuation and decommissioning of the SAS.

- IEC 61850-5 specifies the communication requirements of the functions being performed in systems for power utility automation and to device models. All known functions and their communication requirements are identified,
- this part of IEC 61850 defines the basic principles and modelling methods,
- IEC 61850-6 specifies a file format for describing communication related IED (intelligent electronic device) configurations and IED parameters, communication system configurations, switchyard (function) structures, and the relations between them. The main purpose of the format is to exchange IED capability descriptions, and system level descriptions between engineering tools of different manufacturers in a compatible way. The defined language is called substation configuration description language (SCL). Mapping specific extensions or usage rules may be required in the appropriate parts.
- IEC 61850-7-5 defines the usage of information models for substation automation applications. It gives clear examples on how to apply LNs and data defined in IEC 61850-7-4 for different substation applications. The examples cover applications from monitoring function to protection blocking schemes. Other domain specific application guides which are within the scope of IEC technical committee 57 are defined in the IEC 61850-7-5xx series¹. Examples are hydropower and distributed energy resources domains,
- IEC 61850-7-4 defines specific information models for substation automation functions (for example, breaker with status of breaker position, settings for a protection function, etc.) – what is modelled and could be exchanged. Other domain specific information models within the scope of IEC technical committee 57 are defined in the 61850-7-4xx series,
- IEC 61850-7-3 has a list of commonly used information (for example, for double point control, 3-phase measurand value, etc.) – what the common basic information is,
- IEC 61850-7-2 provides the services to exchange information for the different kinds of functions (for example, control, report, get and set, etc.) – how to exchange information,
- IEC 61850-8-1 defines the concrete means to communicate the information between IEDs (for example, the application layer, the encoding, etc.) – how to serialise the information during the exchange,
- IEC 61850-9-2, and particularly the subset 9-2LE described in the “Implementation Guideline for Digital Interface to Instrument Transformers using IEC 61850-9-2” by the UCAIug, defines the concrete means to communicate sampled values between sensors and IEDs,
- IEC 61850-10 defines the methods and abstract cases for conformance testing of devices and engineering tools as well as the metrics to be measured within devices according to the requirements defined in IEC 61850-5,
- there may be object classes defined for various other application domains outside the scope of IEC technical committee 57. They are relevant to Figure 1 only if they are built according to the approach of the IEC 61850 series.

5.2 Topology and communication functions of substation automation systems

As shown by the topology in Figure 2, one focus of the IEC 61850 series is the support of substation automation functions by the communication of (numbers in brackets refer to the figure):

- sampled value exchange for CTs and VTs (1),
- fast exchange of I/O data for protection and control (2),
- control signals (3),
- trip signals (4),

¹ IEC 61850-7-4xx, -7-5xx, -8-xx, -9-xx and -90-xx are series of documents whose scope is similar. For example, IEC 61850-7-4 deals with data object classes used for substations while IEC 61850-7-410 deals with data object classes used for hydroelectric power plants. IEC 61850-90-xx series is reserved for technical reports or guidelines.

- engineering and configuration (5),
- monitoring and supervision (6),
- control-center communication (7),
- time-synchronisation,
- etc.

Support for other functions such as metering, condition monitoring, and asset management is provided as well.

Many functions are implemented in intelligent electronic devices (IED). Several functions may be implemented in a single IED or one function may be implemented in one IED and another function may be hosted by another IED. IEDs (i.e., the functions residing in IEDs) communicate with functions in other IEDs by the information exchange mechanisms of this standard. Therefore, functions distributed over more than one IED may be also implemented.

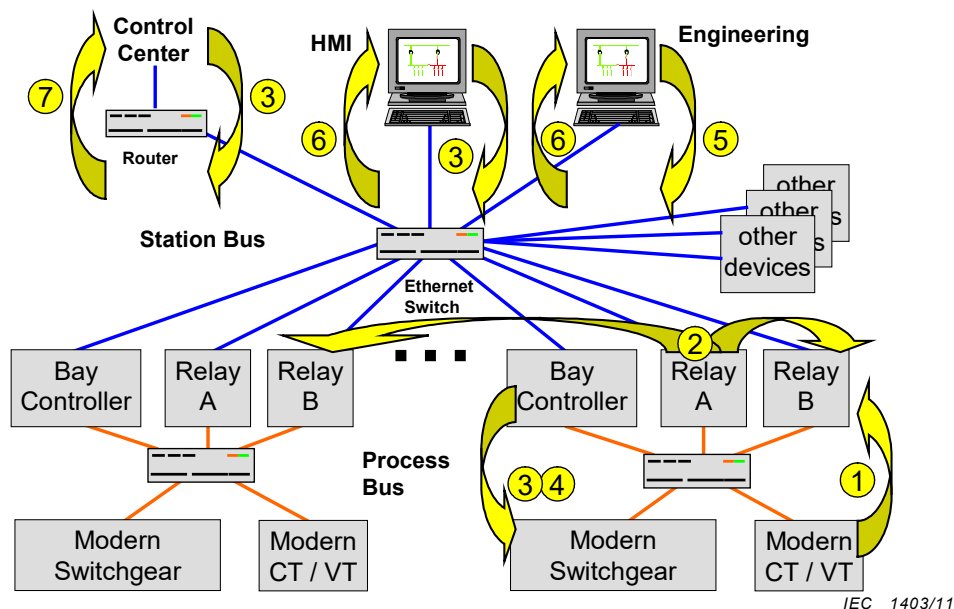
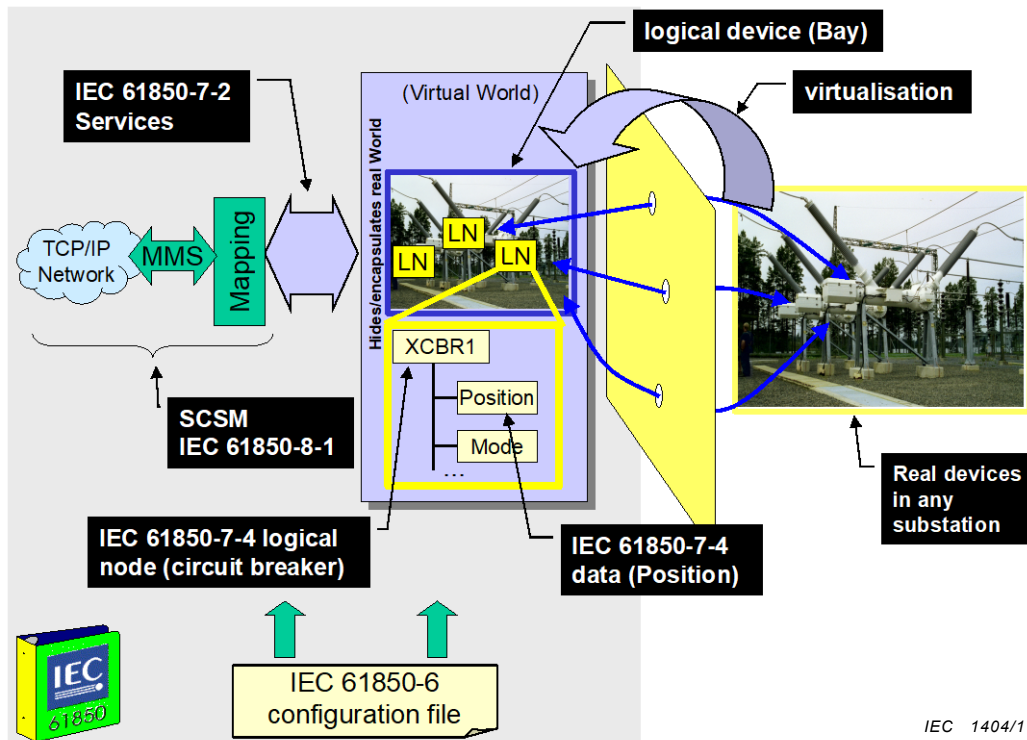


Figure 2 – Sample substation automation topology

5.3 The information models of substation automation systems

The information exchange mechanisms rely primarily on well-defined information models. These information models and the modelling methods are at the core of the IEC 61850 series. The IEC 61850 series uses the approach to model the common information found in real devices as depicted in Figure 3. All information made available to be exchanged with other devices is defined in the standard. The model provides for systems for power utility automation an image of the analogue world (power system process, switchgear).

NOTE 1 "The common information" in the context of the IEC 61850 series means that the stakeholders of power utility automation systems (users and vendors) have agreed that the information defined in the IEC 61850 series is widely accepted and required for the open exchange of information between any kind of substation IEDs.



IEC 1404/11

Figure 3 – Modelling approach (conceptual)

Implementations to reach interoperability have to be based on common understanding of definitions. Therefore, the parts describing the data model contain mandatory semantic tables which have to be considered very carefully.

The IEC 61850 series defines the information and information exchange in a way that it is independent of a concrete implementation (i.e., it uses abstract models). The standard also uses the concept of virtualisation. Virtualisation provides a view of those aspects of a real device that are of interest for the information exchange with other devices. Only those details that are required to provide interoperability of devices are defined in the IEC 61850 series.

As described in IEC 61850-5, the approach of the standard is to decompose the application functions into the smallest entities, which are used to exchange information. The granularity is given by a reasonable distributed allocation of these entities to dedicated devices (IED). These entities are called logical nodes (for example, a virtual representation of a circuit breaker class, with the standardised class name XCBR). The logical nodes are modelled and defined from the conceptual application point of view in IEC 61850-5. Several logical nodes build a logical device (for example, a representation of a Bay unit). A logical device is always implemented in one IED; therefore logical devices do not contain logical nodes from different IEDs ^{[A1] 2 [A1]}.

Real devices on the right-hand side of Figure 3 are modelled as a virtual model in the middle of the figure. The logical nodes defined in the logical device (for example, bay) correspond to well-known functions in the real devices. In this example, the logical node XCBR represents a specific circuit breaker of the bay to the right.

NOTE 2 The logical nodes of this example may be implemented in one or several IEDs as appropriate. If the logical nodes are implemented in different IEDs, they need exchange information over a network. Information exchange inside a logical node is outside the scope of the IEC 61850 series.

^{[A1] 2} There is one exception: the proxy/gateway application. For details, refer to 8.2.3 Gateways and proxies. ^[A1]

Based on their functionality, a logical node contains a list of data (for example, position) with dedicated data attributes. The data have a structure and a well-defined semantic (meaning in the context of systems for power utility automation or, e.g. more specifically, of substation automation systems). The information represented by the data and their attributes are exchanged by the services according to the well-defined rules and the requested performance as described in IEC 61850-5. The services are implemented by a specific and concrete communication means (SCSM, for example, using MMS, TCP/IP, and Ethernet among others).

The logical nodes and the data contained in the logical device are crucial for the description and information exchange for substation automation systems to reach interoperability.

The logical devices, the logical nodes and the data they contain need to be configured. The main reason for the configuration is to select the appropriate logical nodes and data from the standard and to assign the instance-specific values, for example, concrete references between instances of the logical nodes (their data) and the exchange mechanisms, and initial values for process data.

5.4 Applications modelled by logical nodes defined in IEC 61850-7-4

Table 1 lists all groups of logical nodes defined in IEC 61850-7-4. Over one hundred logical nodes covering the most common applications of substation and feeder equipment are defined. While the definition of information models for protection and protection related applications is important because of the high impact of protection for safe and reliable operation of the power system, the covered applications include many other functions like monitoring, measurement, control and power quality.

Table 1 – LN groups

Group indicator	Logical node groups
A	Automatic control
C	Supervisory control
D	DER (Distributed Energy Resources)
F	Functional blocks
G	Generic function references
H	Hydro power
I	Interfacing and archiving
K	Mechanical and non-electrical primary equipment
L	System functions
M	Metering and measurement
P	Protection functions
Q	Power quality events detection related
R	Protection related functions
S	Supervision and monitoring
T	Instrument transformer and sensors
W	Wind power
X	Switchgear
Y	Power transformer and related functions
Z	Further (power system) equipment

IEC 61850 has well-defined rules to define additional logical nodes and data, for example for additional functions within substations or for other application domains such as wind power plants. For details on the extension rules, see Clauses 13 and 14 of this document.

The following excerpt of the logical nodes has been included to provide an example of what kind of real applications the logical nodes represent:

- distance protection;
- differential protection;
- overcurrent;
- undervoltage;
- directional over power;
- volts per Hz relay;
- transient earth fault;
- directional element;
- harmonic restraint;
- protection scheme;
- zero speed or underspeed;
- measurement;
- metering;
- sequence and imbalance;
- harmonics and interharmonics;
- differential measurements;
- switch control;
- circuit breaker;
- circuit switch;
- and others.

Most logical nodes provide information that can be categorised as depicted in Figure 4. The semantic of a logical node is represented by data and data attributes. Logical nodes may provide a few or up to 30 data. Data may contain a few or even more than 20 data attributes. Logical nodes may contain more than 100 individual information (points) organised in a hierarchical structure.

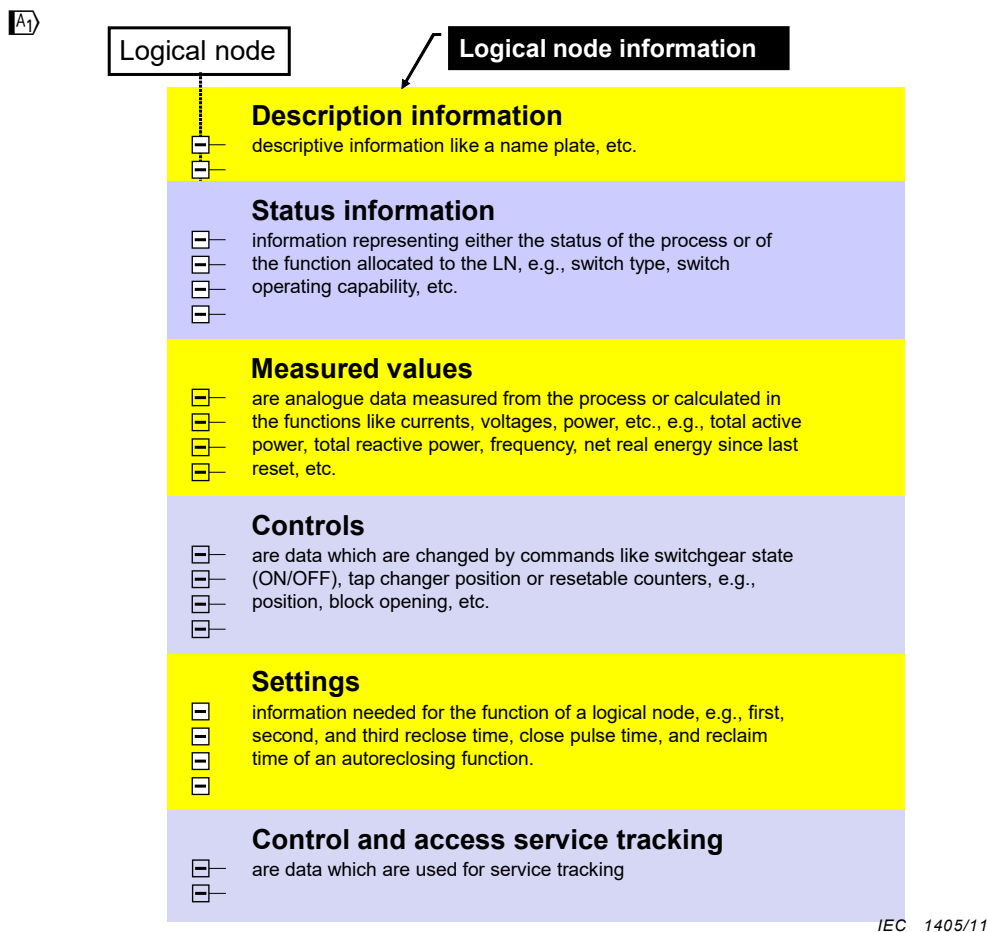


Figure 4 – Logical node information categories

IEDs are built up by composing logical nodes as depicted in Figure 5. The logical nodes are the building blocks of substation IEDs, for example, circuit breaker (XCBR) and others. In the example for each phase, one instance of XCBR is used.

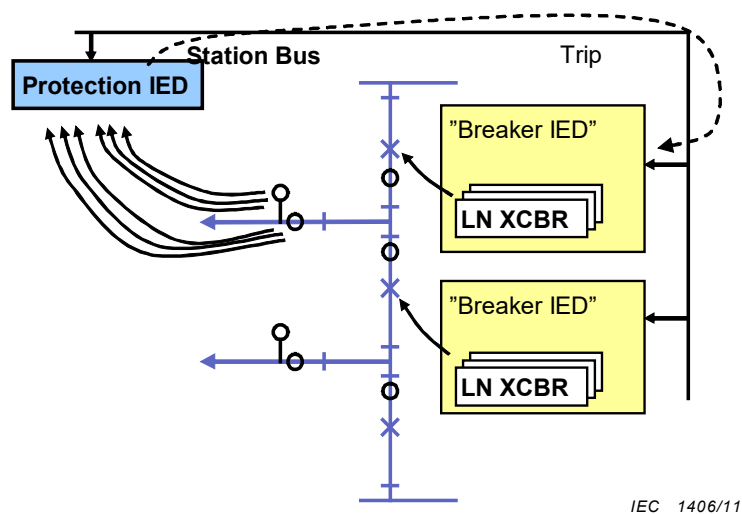


Figure 5 – Build-up of devices (principle)

In Figure 5, the protection IED receives the values for the voltage and current from conventional VT and CT. The protection functions in the protection device may detect a fault and issue or send a trip signal via the station bus. The standard supports also IEDs for digitizing VTs and CTs sending voltage and current as samples to the protection over a serial link. The output of conventional VTs and CTs may also be converted at the source to samples and transmitted over this serial link.

The logical nodes are used to build up substation IEDs.

5.5 The semantic is attached to data

The mean number of specific data provided by logical nodes defined in IEC 61850-7-4 is approximately 20. Each of the data (for example, position of a circuit breaker) comprises several details (the data attributes). The position (named "Pos") of a circuit breaker is defined in the logical node XCBR (see Figure 6). The position is defined as data. The category of the position in the logical node is "controls" – the position can be controlled via a control service.

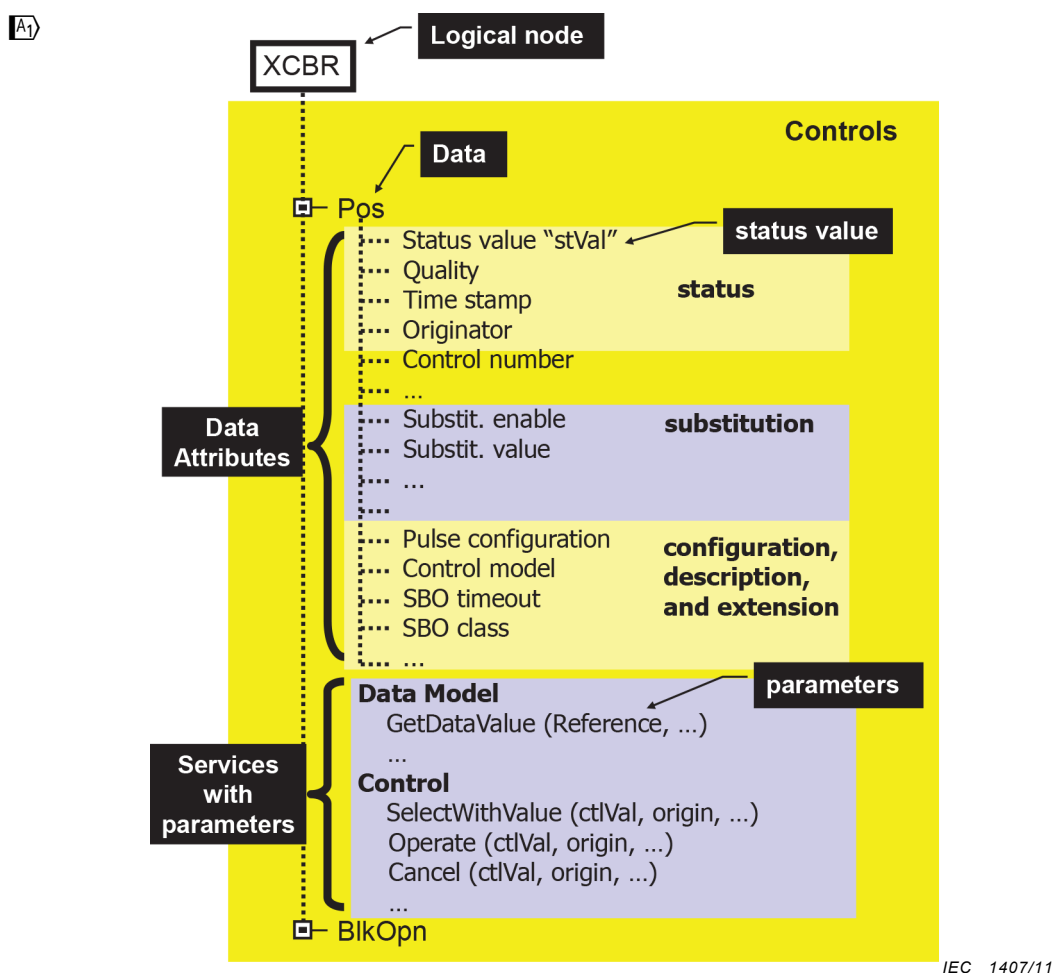


Figure 6 – Position information depicted as a tree (conceptual)

The position Pos is more than just a simple "point" in the sense of simple RTU protocols. It is made up of several data attributes. The data attributes are categorised as follows:

- status (or measured/metered values, or settings),
- control mirror,
- substitution and blocked,
- configuration, description and extension.

The data example Pos has approximately 20 data attributes accessible through different services. The data attribute Pos.stVal represents the position of the real breaker (could be in intermediate-state, off, on, or bad-state).

The position Pos can be controlled by use of control services and the associated service parameters. It is important to understand that these service parameters are not part of the data model: they do not represent data attributes. They only “live” the time of the command execution.

The position also has information about the originator that issued the command and the control number (given by the originator in the request). Furthermore, the position contains the cause diagnosis of a negative control response. The quality and time stamp information indicate the current validity of the status value and the time of the last change of the status value.

The current values for stVal, the quality and the time stamp (associated with the stVal) can be read, reported or logged in a buffer of the IED.

The values for stVal and quality can be remotely substituted. The substituted values take effect immediately after enabling substitution.

Several data attributes are defined for the configuration of the control behaviour, for example, pulse configuration (single pulse or persistent pulses, on/off-duration, and number of pulses) or control model (direct, select-before-operate, etc.).

Data attributes are defined primarily by an attribute name and an attribute type:

Attribute name	Attribute type	FC	TrgOp	(Value/value range) Description	PresCond
stVal	DpStatusKind	ST	dchg	Status value of the controllable data object.	M
ctlModel	CtlModelKind	CF	dchg	Control model as defined in IEC 61850-7-2 that reflects the behaviour of the controllable data object.	M

Additional information provides further details (one could say provides meta-data) on:

- the services allowed: functional constraint -> FC=SV means that specific services shall be applied only (for example SV refers to the substitution service),
- the trigger conditions that cause a report to be sent: TrgOp=dchg means that a change in the value of that attribute causes a report,
- the value or value range,
- the presence conditions, e.g. mandatory (M) or optional (O). These conditions specify presence of elements in a given context (one LN, or one CDC, or one data attribute type, or one data object for dataNs) and are specified in IEC 61850-7-2.

The data attribute names are standardised (i.e., they are reserved) names that have a specific semantic in the context of the IEC 61850 series. The semantic of all data attribute names is defined in IEC 61850-7-3. ^[A1]

The names of the data and data attributes carry the crucial semantic of a substation IED.

The position information Pos as shown in Figure 6 has many data attributes that can be found in many other switching-specific applications. The prime characteristic of the position is the data attribute stVal (status value) which represents four states: intermediate-state | off | on | bad-state. These four states (represented usually with two bits) are commonly known as “double point” information. The whole set of all the data attributes defined for the data Pos (position

is called a “common data class” (CDC). The name of the common data class of the double point information is DPC (controllable double point).

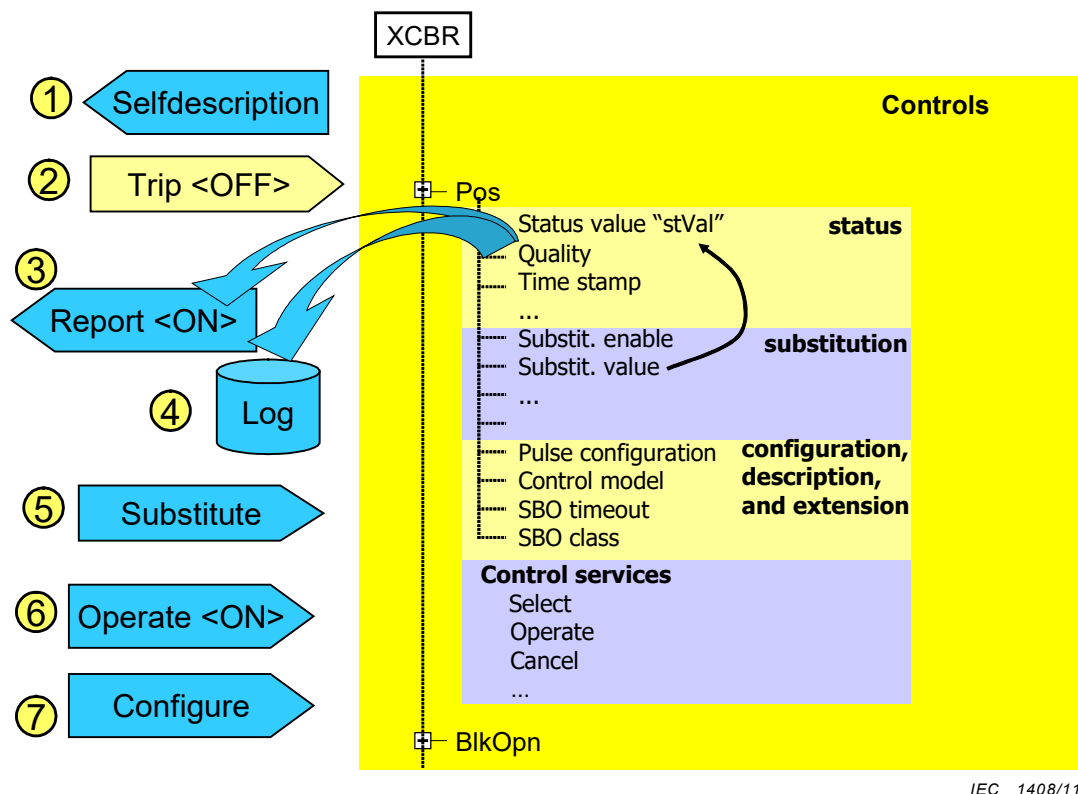
Common data classes provide a useful means to reduce the size of data definitions (in the standard). The data definition does not need to list all the attributes but needs to just reference the common data class. Common data classes are also very useful to keep the definitions of data attributes consistent. A change in the double point control CDC specific data attributes only needs to be made in a single place – in the DPC definition of IEC 61850-7-3.

IEC 61850-7-3 defines common data classes for a wide range of well-known applications. The core common data classes are classified into the following groups:

- status information,
- measurand information,
- controllable status information,
- controllable analogue information,
- status settings,
- analogue settings,
- description information, and
- Service tracking.

5.6 The services to exchange information

The logical nodes, data, data attributes and service parameters are defined mainly to specify the information required to perform an application, and for the exchange of information between IEDs. The information exchange is defined by means of services. An excerpt of the services is displayed in Figure 7.



IEC 1408/11

NOTE The circles with the numbers (1) to (7) refer to the list below.

Figure 7 – Service excerpt

The operate service manipulates the control specific service parameters of a circuit breaker position (open or close the breaker). The report services inform another device that the position of the circuit breaker has been changed. The substitute service forces a specific data attribute to be set to a value independent of the process.

The categories of services (defined in IEC 61850-7-2) are as follows:

- retrieving the self-description of a device, see (1) in Figure 7,
- fast and reliable peer-to-peer exchange of status information (tripping or blocking of functions or devices), see (2) in Figure 7,
- reporting of any set of data (data attributes), SoE – cyclic and event triggered, see (3) in Figure 7,
- logging and retrieving of any set of data (data attributes) – cyclic and event, see (4) in Figure 7,
- substitution, see (5) in Figure 7,
- handling and setting of parameter setting groups,
- transmission of sampled values from sensors,
- time synchronisation,
- file transfer,
- control devices (operate service), see (6) in Figure 7, and
- online configuration, see (7) in Figure 7.

Many services operate directly on the attributes of the information model (i.e., on the data attributes of data contained in logical nodes). The pulse configuration of the data attribute Pos of a specific circuit breaker can be set directly by a client to a new value. Directly means that the service operates on the request of the client without specific constraints of the

Other services provide a more complex behaviour which is dependent on the state of some specific state machine. A control request may be required to follow a state machine associated with the data attribute, for example, select-before-operate.

There are also several application-specific communication services that provide a comprehensive behaviour model which partially act autonomously. The reporting service model describes an operating-sequence in which the IED acts automatically on certain trigger conditions defined in the information model (for example, report on data-change of a status value) or conditions defined in the reporting service model (for example, report on a periodical event).

5.7 Services mapped to concrete communication protocols

The services defined in IEC 61850-7-2 are called abstract services. Abstract means that only those aspects that are required to describe the required actions on the receiving and sending side of a service request are defined in IEC 61850-7-2. They are based on the functional requirements in IEC 61850-5. The semantic of the service models with their attributes and the semantic of the services that operate on these attributes (including the parameters that are carried with the service requests and responses) are defined in IEC 61850-7-2.

The specific syntax (format) and especially the encoding of the messages that carry the service parameters of a service and how these are passed through a network are defined in a specific communication service mapping (SCSM). One SCSM – IEC 61850-8-1 – is the mapping of the services to MMS (ISO 9506-1 and ISO 9506-2) and other provisions like TCP/IP and Ethernet (see Figure 8), another is IEC 61850-9-2 – the direct mapping on Ethernet.

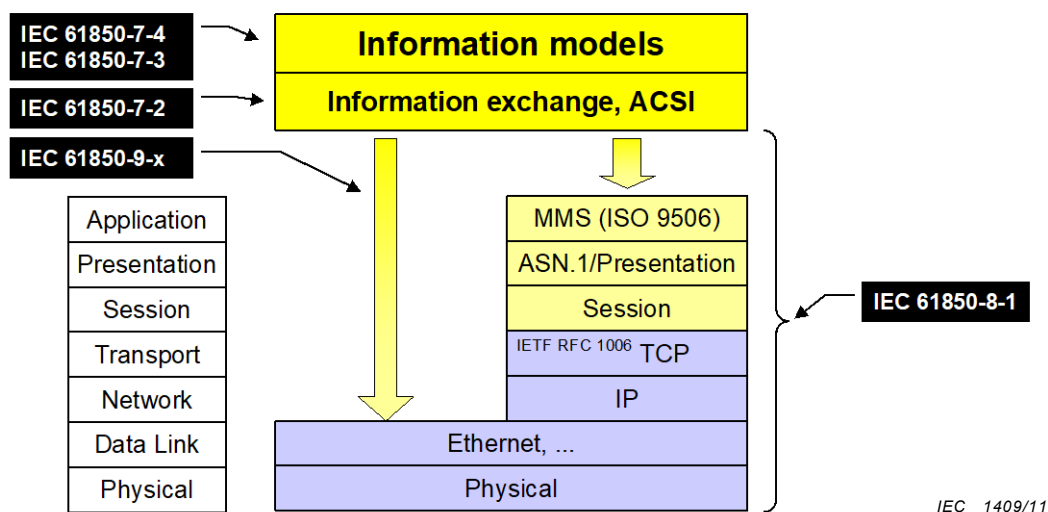


Figure 8 – Example of communication mapping

Additional mappings to other communication stacks are possible. However, to not jeopardize interoperability, the number of accepted mappings in the standard shall be a minimum. The main purpose of this flexibility is to be able to follow over time the evolution in communication technology. The ACSI is independent of the mappings.

5.8 The configuration of the automation system

IEC 61850-6 specifies a file format for describing communication related IED configurations and IED parameters, communication system configurations, switchyard (function) structures, and the relations between them. The main purpose of this format is to exchange IED capability descriptions, and SA system descriptions between IED engineering tools and the system engineering tool(s) of different manufacturers in a compatible way.

The defined language is called substation configuration description language (SCL). The configuration language is based on the extensible markup language (XML) version 1.0.

To support the intended engineering process, the SCL is capable to describe:

- a) a system specification in terms of the single line diagram, and allocation of logical nodes to parts and equipment of the single line to indicate the needed functionality,
- b) pre-configured IEDs with:
 - the logical node, datasets and report control block definitions,
 - the supported services: GOOSE, sampled values, logging, file handling,
- c) pre-configured IEDs with no semantic or a pre-configured semantic for a process part of a certain structure, for example a double busbar GIS line feeder,
- d) complete process configuration with all IEDs bound to individual process functions and primary equipment, enhanced by the access point connections and possible access paths in subnetworks for all possible clients,
- e) as item d) above, but additionally with all predefined associations and client server connections between logical nodes on data level. This is needed if an IED is not capable of dynamically building associations or reporting connections (either on the client or on the server side).

The scope of SCL is focussed on these purposes:

- 1) SAS functional specification (point a) above),
- 2) IED capability description (points b) and c) above), and
- 3) SA system description (points d) and e) above).

These purposes shall support in a standardised way system design, communication engineering and the description of the readily engineered system communication for the device engineering tools.

5.9 Summary

Figure 9 exhibits a summary of Clause 5. The four main building blocks are

- the substation automation system specific information models,
- the information exchange methods,
- the mapping to concrete communication protocols, and
- the configuration of a substation IED.

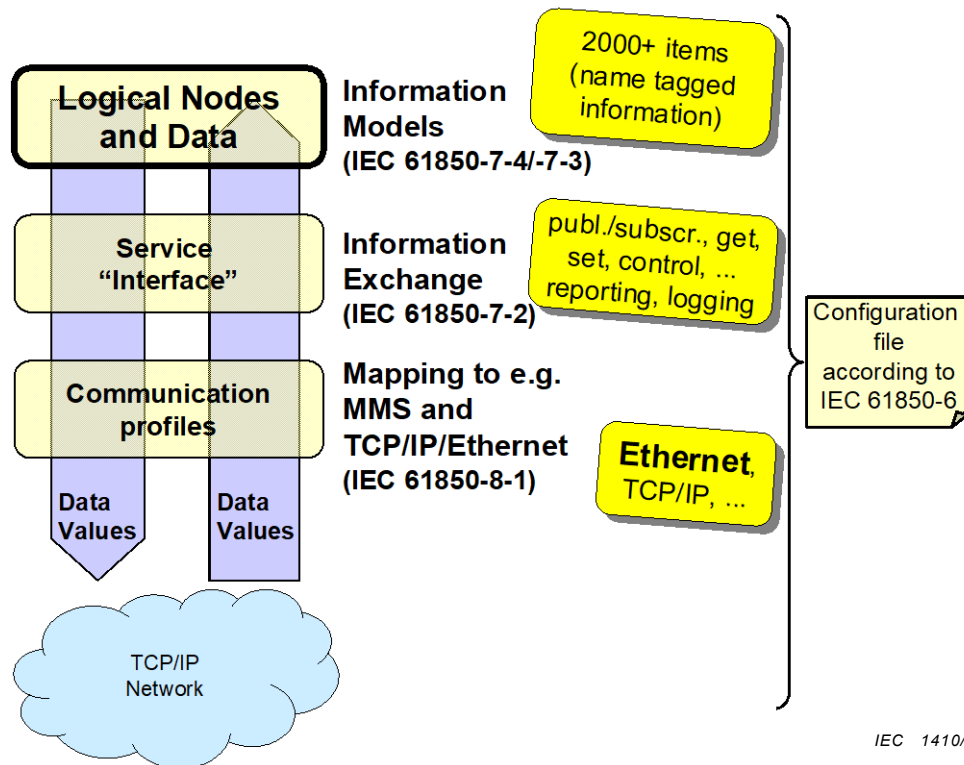


Figure 9 – Summary

These four building blocks are to a high degree independent of each other. The information is separated from the presentation and from the information exchange services. The information exchange services are separated from the concrete communication profiles. It means that the information models can easily be extended, by definition of new logical nodes and new data according to specific and flexible rules, as required by another application domain. In the same way, different communication stacks may be used following the state-of-the-art in communication technology. But to keep interoperability simple, one stack only should be selected at one time. For the selection, see IEC 61850-8-x and IEC 61850-9-x.

Clause 6 provides a more detailed view of the four building blocks.

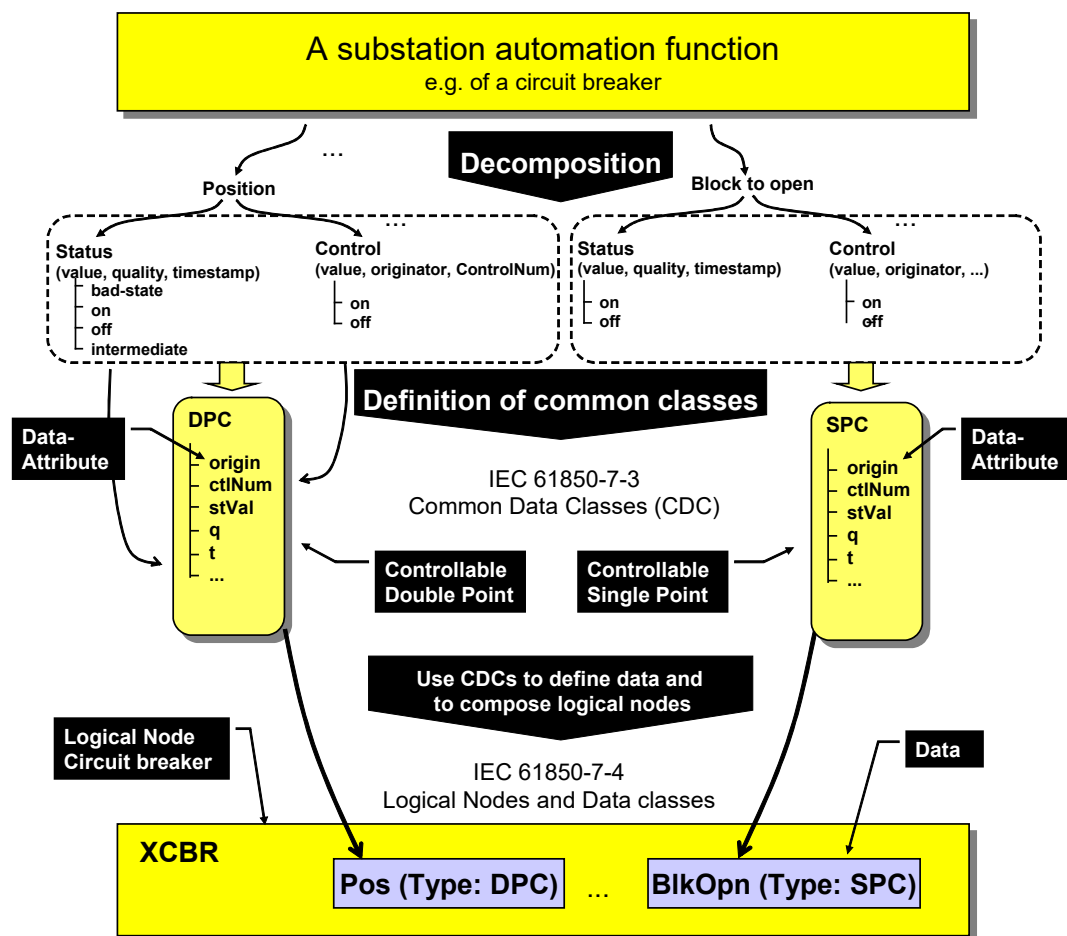
6 Modelling approach of the IEC 61850 series

6.1 Decomposition of application functions and information

As described in IEC 61850-5, the general approach of the IEC 61850 series is to decompose application functions into the smallest entities, which are then used to communicate. The granularity is given by a reasonable distributed allocation of these entities to dedicated devices (IED). The entities are called logical nodes. The requirements for logical nodes are defined – from an application point of view – in IEC 61850-5.

Based on their functionality, these logical nodes comprise data with dedicated data attributes. The information represented by the data and the data attributes are exchanged by dedicated services according to well-defined rules and the performance requested as required in IEC 61850-5.

The decomposition process (to get the most common logical nodes) and the composition process (to build up devices using logical nodes) are depicted in Figure 10. The data classes contained in logical nodes have been defined to support the most common applications in an understandable and commonly accepted way.



IEC 1411/11

Figure 10 – Decomposition and composition process (conceptual)

A small part of a function (an excerpt of a circuit breaker model) has been selected as an example to explain the decomposition process. The circuit breaker has, among many other attributes, a position which can be controlled and monitored and the capability to prevent the switch being opened (for example, by an operator in service situations, block to open). The position comprises some information that represents the status of the position providing the value of the status (on, off, intermediate, bad state), the quality of the value (good, etc.), and the timestamp of the time of the last change of the position. In addition, the function provides the capability to control the switch: Control value (on, off). To keep track of who controlled the switch, the originator stores the information about the entity that issued the last control command. A control number stores the sequence number of the last control command.

The information grouped under the position (status, etc.) represents a very common group of a four-state value that can be reused many times. Similarly, the “block to open” groups information of a two-state value. These groups are called common data classes (CDC):

- four-state reusable class is defined as controllable double point (DPC), and
- two-state reusable class is defined as controllable single point (SPC).

IEC 61850-7-3 defines many common data classes for status, measurands, controllable status, controllable analogue, status settings, and analogue settings.

6.2 Creating information models by stepwise composition

IEC 61850-7-5xx series, IEC 61850-7-4xx series, IEC 61850-7-3, and IEC 61850-7-2 define how to model the information and communication in power utility applications according to the requirements defined in IEC 61850-5. The modelling uses the logical nodes (and their data that represent a huge amount of semantical definitions) primarily as building blocks to compose the visible information of a power utility automation system. The models are used for description of the information produced and consumed by applications and for the exchange of information with other IEDs.

The logical nodes and data classes introduced in IEC 61850-5 are refined and precisely defined in the IEC 61850-7-4xx series. They have been defined in a joint effort of domain experts of the various power utility application domains and modelling experts. The logical nodes and their data are defined with regard to content (semantic) and form (syntax). The approach uses object oriented methods.

NOTE 1 The logical node classes and data classes modelled and defined in IEC 61850-7-4 meet the requirements listed in IEC 61850-5.

In the next step, the common data classes are used to define the (power utility domain-specific) data classes, see lower half of Figure 10. These data classes (defined in IEC 61850-7-4) are specialised common data classes, for example, the data class Pos (a specialisation of DPC) inherits all data attributes of the corresponding common data class DPC, i.e., the stVal, q, t, etc. The semantic of the class Pos is defined at the end of IEC 61850-7-4.

A logical node groups several data classes to build up a specific functionality. The logical node XCBR represents the common information of a real circuit breaker. The XCBR can be reused to describe the common information of circuit breakers of various makes and types.

IEC 61850-7-4 defines several tens of logical nodes making use of hundreds of data names. The logical node XCBR comprises over 15 data classes. An incomplete description of the logical node XCBR is given in Table 2.

Table 2 – Logical node class XCBR (conceptual)

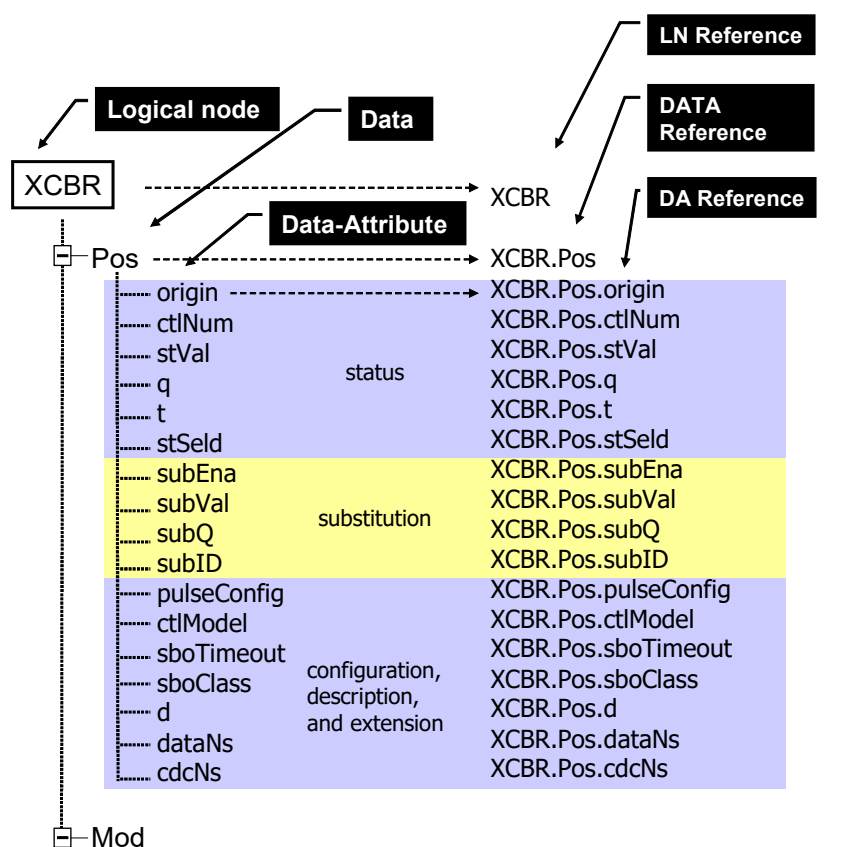
Descriptions
External equipment name plate
Name plate of the logical node
Controls
Switch position (see below for details)
Block opening
Block closing
Charger motor enabled
Control authority at station level. Switches between station and higher level.
...
Status information
Mode
Behaviour
Health
External equipment health
Operation counter
Local operation (Indicates the switchover between local and remote operation; local = TRUE, remote =FALSE)
Circuit breaker operating capability
Point on wave switching capability
Circuit breaker operating capability when fully charged
...

NOTE 2 IEC 61850-7-4 defines a standardised name for each item such as Pos for the switch position. Additionally, the tables for logical nodes contain the common data class to be used for the corresponding data class. Finally, the tables define if the data class in the table is mandatory or optional. These details are explained later in this part.

The content of the marked “switch position” (name = Pos) is introduced in Figure 11.

IEC 61850-7-x series use tables for the definition of the logical node classes and data classes (see IEC 61850-7-4), the common data classes (see IEC 61850-7-3) and service models (see IEC 61850-7-2). Data classes and data attributes form a hierarchical structure as depicted in Figure 11. The data attributes of the data class Pos are functionally grouped (status, substitution, configuration, etc.).

The data attributes have a standardized name and a standardized type. On the right-hand side the corresponding references (object reference) are shown. These references are used to provide the path information to identify the information in the tree.



IEC 1412/11

Figure 11 – XCBR1 information depicted as a tree

XCBR is the root at the level of logical nodes. The object reference XCBR references the complete tree below. XCBR contains data, for example, Pos and Mode. The data Pos (position) is precisely defined in IEC 61850-7-4 (see excerpt of the description):

Description of data

A1

Data object name	Explanation
...	...
Pos	(controllable) Circuit breaker/switch position.
...	...

A1

The content of the position Pos is a list of some 20 data attributes and 7 controllable parameters. The attributes are derived from the common data class DPC (double point control). The data attributes defined in the DPC are partly mandatory and others are optional. Only those data attributes that are required for a specific application are inherited by a data object. For example, if the position does not require the support of substitution, then the data attributes subEna, subVal, subQ, and subID are not required in the data object Pos.

The information exchange services that access the data attributes make use of the hierarchical tree. The data attribute XCBR.PosctlModel defines the type of control service which is supported. The status information could be referenced as a member (XCBR.Pos.stVal) of a data set named "AlarmXCBR". The data set could be referenced by a reporting control block named "Alarm". The report control block could be configured to send a report to a specific computer each time a circuit breaker changes its state (from open to close or from close to open).

6.3 Example of an IED composition

Figure 12 shows examples of different logical nodes being parts of IEDs. The logical nodes involved are PTOC (time overcurrent protection), PDIS (distance protection), PTRC (trip conditioning) and XCBR (circuit breaker). Case 1 shows a protection device with two functions, which are hardwired with the circuit breaker. Case 2 shows a protection device with two functions where the trip is communicated via a trip message over a network to the circuit breaker LN. Case 3 shows the two protection functions in dedicated devices, which may operate both in a fault and where the trips are transmitted as trip messages via the network independently to the circuit breaker LN (XCBR).

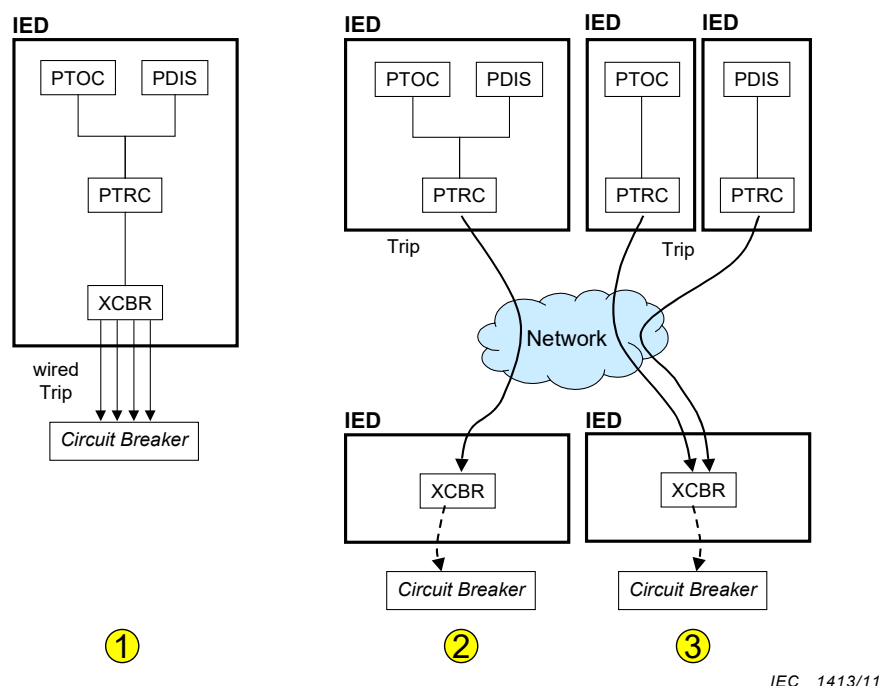


Figure 12 – Example of IED composition

In cases 2 and 3, the IED that hosts the XCBR LNs may be integrated in the real circuit breaker device or hardwired with it as in case 1, but this is outside the scope of the IEC 61850 series. The real breaker is represented for the substation automation system according to the IEC 61850 series by the XCBR LNs.

The IED composition is very flexible to meet current and future needs.

6.4 Information exchange models

6.4.1 General

The information contained in the hierarchical models of IEC 61850-7-4 can be communicated using services defined in IEC 61850-7-2. The information exchange methods (depicted in Figure 12) fall mainly into three categories:

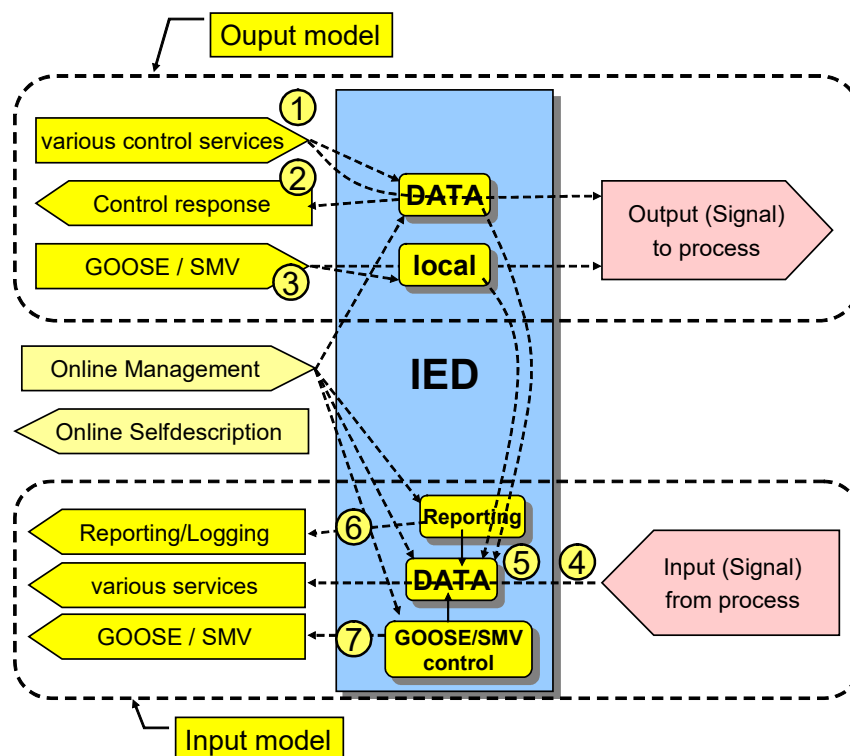
- the output model,
- the input model, and
- the model for online management and self-description.

Several services are defined for each model. The services operate on data, data attributes, and other attributes usually contained in logical nodes.

NOTE 1 Services operate actually on instances of data. To increase the readability, the term “instance of” has been omitted in most places throughout this part of IEC 61850.

Services for the output model may have an impact on an internal process only, may produce an output signal to the process via a process interface, or may change a state value of a data attribute triggering a report. If the process interface is an IED in conformance with the IEC 61850 series, this service will produce an output signal to the process directly.

NOTE 2 The terms “input” and “output” are relative to the direction from the IED to the process (output) and from the process to the IED (input).



IEC 1414/11

The numbers in the circles in this figure are used in 6.4.2, 6.4.3 and related figures as references for the description.

Figure 13 – Output and input model (principle)

Several services are defined for the input model. The services communicating input information may carry information directly from the process interface or may have been computed inside an IED.

There are also several services that may be used to remotely manage the IED to some (restricted) degree, for example, to define a data set, to set a reference to a specific value, or to enable sending specific reports by a report control block. The information models (logical nodes and data classes) and the service models (for example, for reporting and logging) provide means to retrieve comprehensive information about the information model and the services that operate on the information models (self-description).

The following description of the output and input models are conceptual only. Details on the information and services involved in the models are defined in IEC 61850-7-4, IEC 61850-7-3, and IEC 61850-7-2.

6.4.2 Output model

6.4.2.1 Control model concept

The concept of the control model is depicted in Figure 14. The example is a circuit breaker logical node (XCBR) with the controllable data object XCBR.Pos (shown in Figure 15). A control service request is issued to the controllable data object. The service request contains service parameters like the control value, the originator of the request, the time when the originator sent the request and others. The data attribute XCBR.Pos.ctrlModel (shown in Figure 15) indicates the type of control service to use. Before the right control service request performs the change of the position of a real device, some conditions have to be met, for example, the output can be generated only if the local/remote switch is in the “remote” position and the interlocking node (CILO) has released this operation. The chain of conditions to be met may possibly include:

- the local/remote behavior of the circuit breaker (data object XCBR.Loc) and/or local/remote behaviour of the logical device (LD) (data object LLN0.Loc),
- the control authority condition at the station level (data object LLN0.LocSta),
- the control output signal is not being blocked, either by the process or:
 - by the mode of the circuit breaker (data object XCBR.Mod) or,
 - following an external control request (data object XCBR.BlkOpn and/or XCBR.BlkCls),

NOTE For controllable data in LNs not having specific data like BlkOpn and BlkCls, the blocked control output signal indication could be CmdBlk.

- check conditions of the device, and
- other attributes of the controllable data, for example, interlocking, pulse configuration, control model, sbo class, and sbo timeout as defined in the common data class DPC (controllable double point in IEC 61850-7-3).

A1

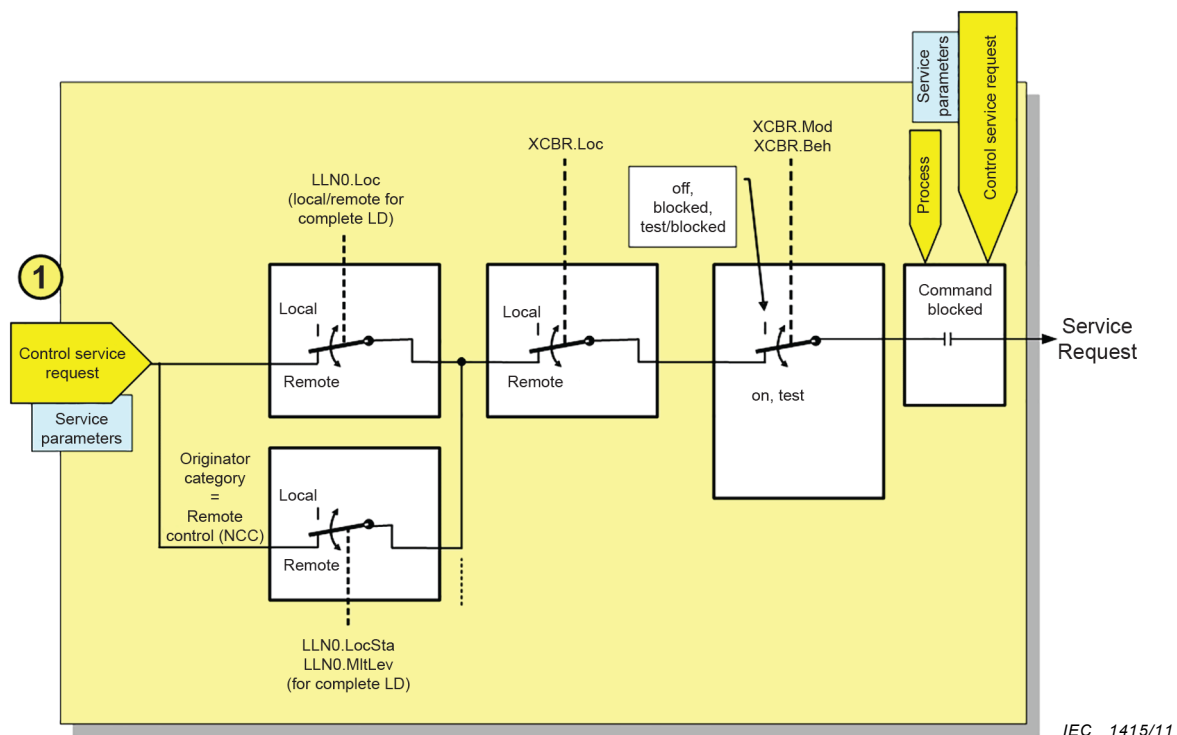
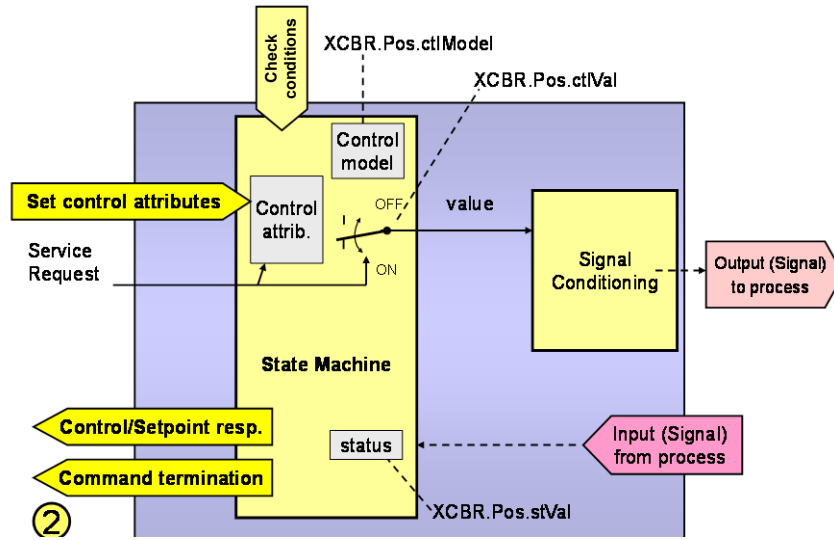


Figure 14 – Output model (step 1) (conceptual)

A1

After all conditions have been met and all checks are positive, the output signal can be conditioned and control the real equipment (the circuit breaker – not shown).



IEC 1416/11

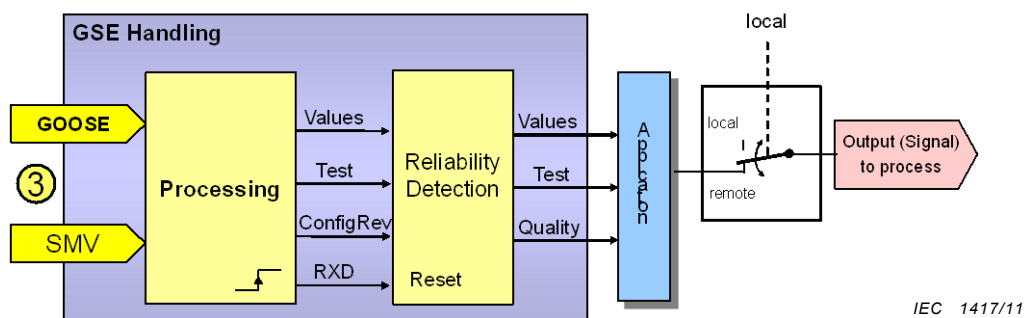
Figure 15 – Output model (step 2) (conceptual)

The state change of the real circuit breaker causes a change in the status information modelled with the data attribute XCBR.Pos.stVal. The status change issues a control service response. A command termination completes the control transaction.

6.4.2.2 GSE and SMV model concept

The generic substation event (GSE – GOOSE) and the sampled measured values (SMV), as shown in Figure 16, provides the peer-to-peer information exchange between the input data values of one IED to the output data of many other IEDs (multicast). The GOOSE and SMV messages received by an IED may be used to compute data for internal purposes also. An example for internal purposes are received switch positions to calculate the interlocking conditions locally or line current sample values to calculate the fundamental or RMS values.

NOTE 1 The GOOSE/SMV data values are defined in the input model described in 6.4.3.



IEC 1417/11

Figure 16 – GSE output model (conceptual)

The conditions to be met and the checks to run before the values are used as output signals such as interlocking are partly described within the IEC 61850 series and partly defined by the local application outside the scope of the IEC 61850 series.

A1 The act of receiving GOOSE and SMV messages by an IED is called subscription. How to define subscriptions by means of configuration tools is given in the normative Annex H. **A1**

NOTE 2 Many GOOSE messages may be transmitted in certain cases, for example, fault detected by a protection relay. A SCSM usually filters these messages at the data link layer to prevent flooding the IEDs.

6.4.2.3 Attributes of data and control blocks

Many data attributes of the hierarchical information model can be set with a Set-service, for example, SetDataValues and SetDataSetValues. Setting the values of data attributes is usually constrained only by the application.

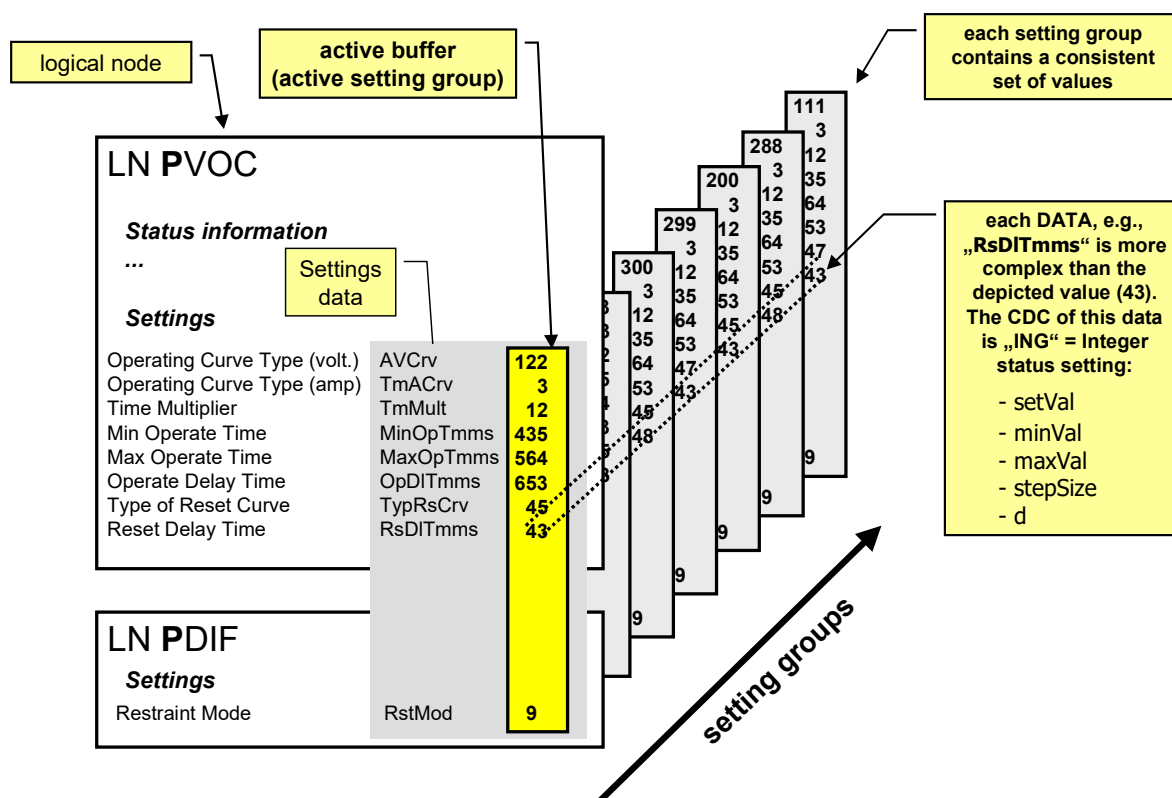
The various control blocks, for example, the setting group control block (SGCB), the buffered report control block (BRCB) and log control block (LCB), have control block attributes that can usually be set to a specific value. The services to set these attributes are defined with the control blocks in IEC 61850-7-2. Setting the values of the control block attributes is constrained by the state machine of the corresponding control block.

The control blocks behave according to the values of their attribute set. The values may also be configured using the SCL file or by other local means.

All control block attributes can be read by another IED.

6.4.2.4 Setting data and setting group control block

A special treatment of output data values is required for setting data contained in several logical nodes as defined in IEC 61850-7-4, for example, the settings for the voltage controlled overcurrent protection logical node PVOC (see Figure 17). The setting data (for example AVCrv, TmACrv, TmMult, etc.) have as many values as setting groups are defined. Each setting group has a consistent set of values.



IEC 1418/11

Figure 17 – Setting data (conceptual)

The values depicted are complex in the sense that each data has a type derived from a common data class. The RsDITmms is derived from the common data class ING. The ING has several data attributes as listed in Table 3.



Table 3 – Excerpt of integer status setting

ING class					
Attribute name	Attribute type	FC	TrgOp	Value/value range	PresCond
DataAttribute for configuration, description and extension					
<i>setting</i>					
setVal	INT32	SP	dchg	The value of the status setting.	M
setVal	INT32	SG, SE		The value of the status setting.	M
<i>configuration, description and extension</i>					
minVal	INT32	CF	dchg	Minimum setting for 'setVal'.	O
maxVal	INT32	CF	dchg	Maximum setting for 'setVal'.	O
stepSize	INT32U	CF	dchg	(range=[1...(maxVal-minVal)]) Step between the individual values of 'setVal'.	O
units	Unit	CF	dchg	Unit for 'setVal', 'minVal', 'maxVal', 'stepSize'.	O
d	VISIBLE STRING255	DC		Textual description of the data. In case it is used within the CDC LPL, the description refers to the logical node.	O
...	...	...			...



The values of a specific setting group contained in the setting data can be set only if that group is in the “EDIT” state (indicated by the FC=SE; edit setting data). After all values of that group are set, the values of that group can be confirmed as containing a consistent set of values. This newly confirmed set of values can then be selected for use by the application (setting group in active state: FC=SG; active setting data).

The setVal of FC=SP means “simple” setting data (set point); applied when the setting group control model is not supported. This value can be set as a regular data attribute.

6.4.3 Input model

6.4.3.1 Input analogue signal acquisition

The concept of the input analogue signal acquisition is depicted in Figure 18. Normally, the signal is conditioned by a signal conditioner. In the IEC 61850 model, an analogue input does not exist as data before it is converted from analogue to digital. The sample rate (data attribute smpRate of a configurable data) determines how often the value shall be sampled. Alternatively, the raw digital values may be directly obtained from sample values transmitted over communication links (see also Figure 27). The method used for processing the signal (True RMS, Peak amplitude, ...) may be set through the data ClcMth. In absence of the data ClcMth, the calculation method shall be considered as UNSPECIFIED, meaning UNKNOWN.

The conditions to be met before the value can be communicated (modelled as the data attribute instMag of the data, for example, a voltage of a specific phase – see Figure 18) may comprise the values of the following attributes:

- substitute/unsubstitute “switch” of the data (modelled as the data attribute subMag of the data, for example, a voltage of a specific phase),
- operator blocked or unblocked “switch”.

The result of these first steps is the “intermediate value” (still an analogue value) accompanied by the corresponding quality information.

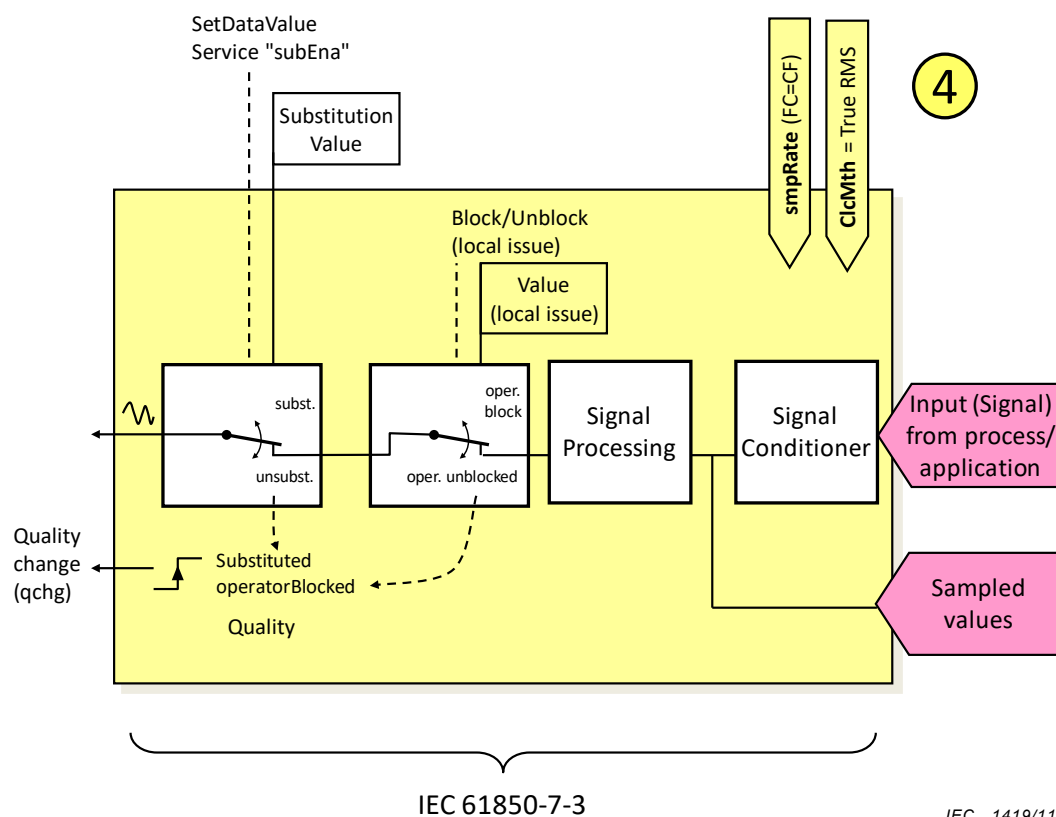


Figure 18 – Input model for analogue values (step 1) (conceptual)

6.4.3.2 Data attribute value processing, monitoring and event detection

The “intermediate value” is used for various purposes. As shown in Figure 20, the first use is to provide this value as the instantaneous data attribute value (magnitude) of the data. The data attribute has the name `instMag`; with the functional constraint `FC=MX` (indicating a measurand value). There is no trigger option associated with the instantaneous value.

The second application is the calculation of the deadbanded value, the `mag` value. The deadbanded value shall be based on a deadband calculation from `instMag` as illustrated in Figure 19. **A1** The value of `mag` shall be updated to the current value of `instMag` when the value has changed according to the value of the configuration parameters `db` and `dbRef` of this data. **A1**

A1

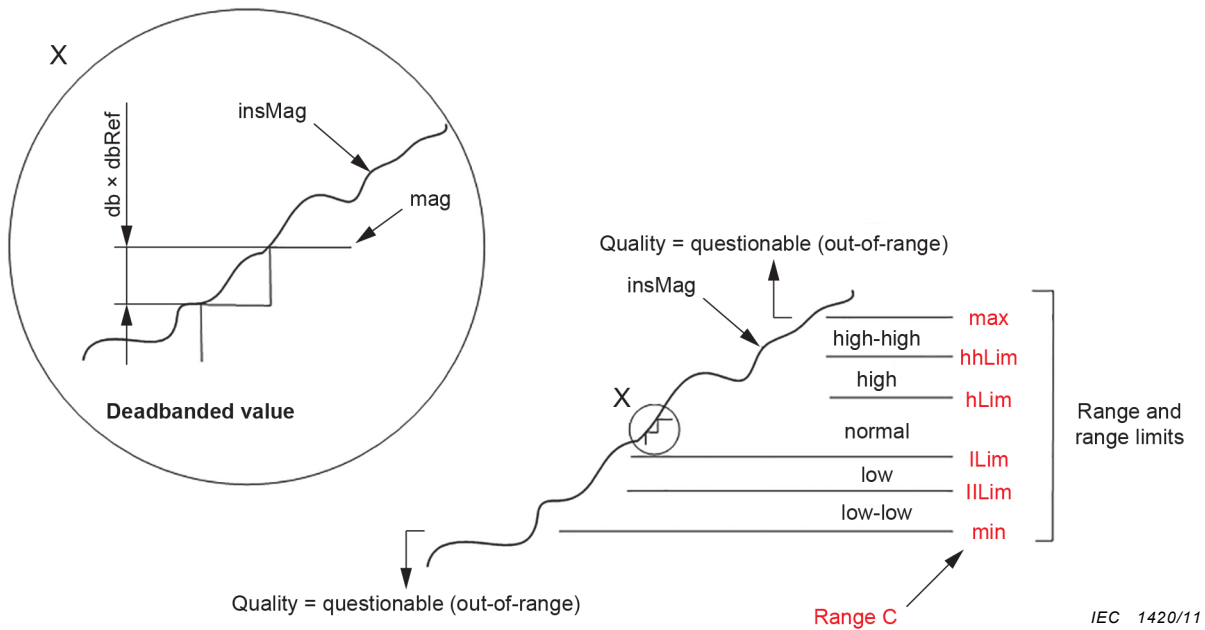


Figure 19 – Range and deadbanded value (conceptual)

The value of the deadband configuration *db* shall represent the percentage of the deadband reference *dbRef* in units of 0,001 % (fixed deadband). A value of *dbRef* of 0 means that the value *db* shall represent the percentage of the last transmitted values in units of 0,001 %. This allows for a deadband calculation that is related to the last refreshed value (variable deadband). A1

NOTE The *db* value has nothing to do with the accuracy of the data defined both by the accuracy of the analogue transducer and by the accuracy of the A/D conversion.

An internal event is created any time the *mag* value changes. The deadbanded value *mag* and the event (data change – according to the trigger option *TrgOp=dchg*) are made available for further actions, for example, reporting or logging.

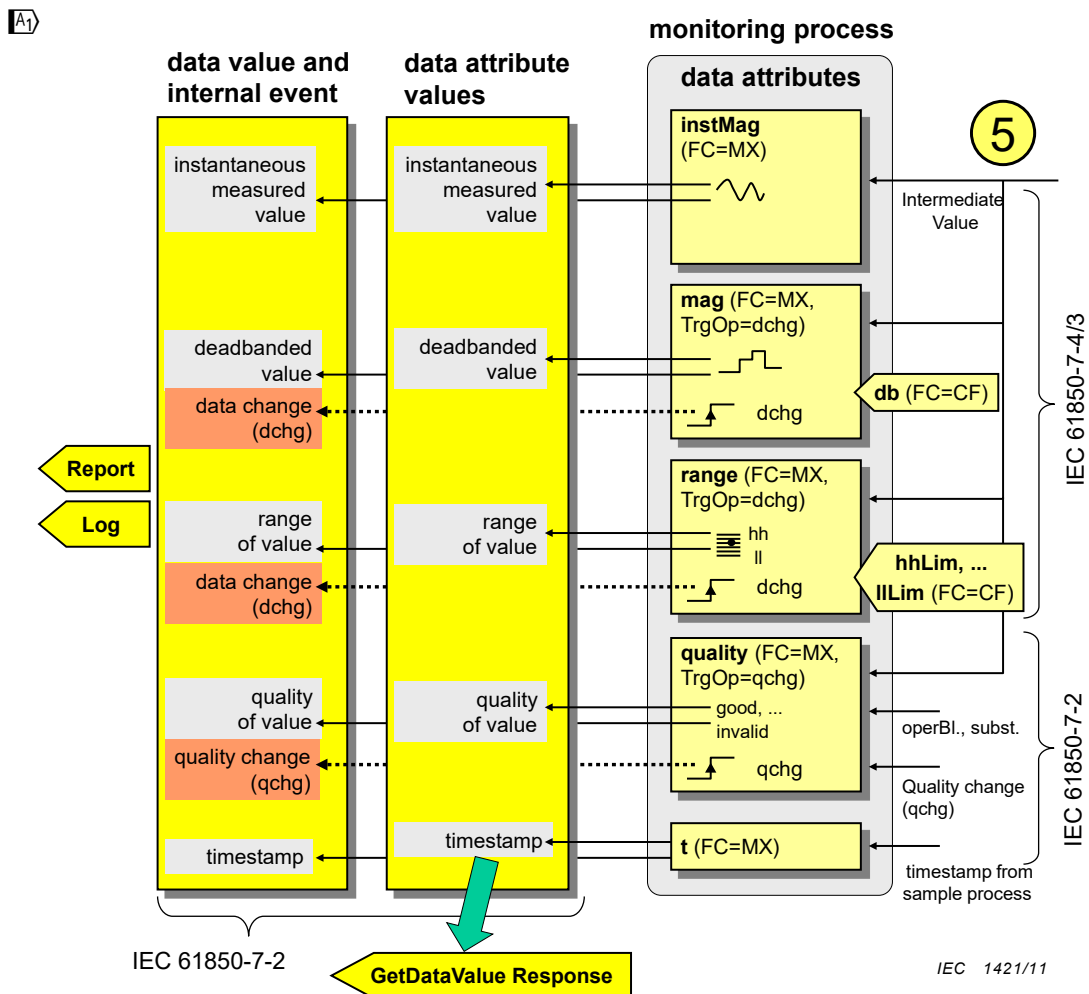


Figure 20 – Input model for analogue values (step 2) (conceptual)

A₁

A third application is to monitor the “intermediate value” to determine the current range of the value.

An internal event is created any time the instMag value crosses a range limit (see Figure 20). The range value and the event (data change – according to the trigger option TrgOp=dchg) are made available for further actions, for example, reporting or logging. The attribute rangeC is used to configure the parameters associated with the different limits.

In addition to the various values, the two attributes quality and t (time stamp) are available at any time. The time stamp is determined at the time that the value change of the data attributes mag and range has been detected and/or at the time a change of the quality has been detected. A change in the quality can be used to issue an internal event as well.

A₁ Text deleted **A₁**

6.4.3.3 Data reporting and logging

6.4.3.3.1 General

The internal events (process values, corresponding trigger values that caused the event, time stamps and quality information) are used as a trigger foundation for reporting and logging (see Figure 21). This information is grouped using a data set. The data set is the content basis for reporting and logging. It is also the content basis for GOOSE and SMV messages (see 6.4.3.4 and 6.4.3.5). The data set contain references to the data and data attribute values.