IEC TS 61850-80-1

Edition 2.0 2016-07

TECHNICAL SPECIFICATION

colour inside

Communication networks and systems for power utility automation – Part 80-1: Guideline to exchanging information from a CDC-based data model using IEC 60870-5-101 or IEC 60870-5-104

IEC TS 61850-80-1:2016-07(en)

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 80-1: Guideline to exchanging information from a CDC-based data model using IEC 60870-5-101 or IEC 60870-5-104

FOREWORD

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 61850-80-1, which is a technical specification, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

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This second edition cancels and replaces the first edition published in 2008. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) IEC TS 61850-80-1:2008 is based on the definitions of IEC 61850 Edition 1. After the publication of IEC TS 61850-80-1:2008 the standard series IEC 61850 was updated to Edition 2 (almost all parts);
b) In particular, IEC 61850-7-3:2010 introduces new Common Data Classes (CDCs) which are currently not mapped to IEC 60870-5-101 or IEC 60870-5-104 in IEC 61850-80-1:2008. Those new CDCs are: ENS, HST, VSS, ENC, BAC, ENG, ORG, TSG, CUG, VSG, CSG. IEC 61400-25-4, which is currently being updated, makes reference to IEC TS 61850-80-1:2008 and therefore needs to be updated according to the definitions of this second edition of IEC 61850. The following CDCs are missing in the IEC 61850-80-1:2008 and have therefore been added to this new edition for IEC 61400-25-4 Edition 2: ENS, ENC, ENG, ORG.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
57/1649/DTS	57/1726/RVC

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

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

A list of all parts of the IEC 61850 series, published 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 website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- reconfirmed,
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- replaced by a revised edition, or
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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 80-1: Guideline to exchanging information from a CDC-based data model using IEC 60870-5-101 or IEC 60870-5-104

1 Scope

This part of IEC 61850, which is a technical specification, gives a guideline on how to exchange information from a CDC-based data model (for example IEC 61850) using IEC 60870-5-101 or IEC 60870-5-104 between substation(s) and control center(s). Mostly guidelines for functions needed in a substation gateway device are given.

The goal of this technical specification is to describe standardized mapping of device-oriented data models (for example IEC 61850) with already defined attributes of CDCs and services (for example IEC 61850-7) onto the already defined ASDUs and services of IEC 60870-5-104 or IEC 60870-5-101. It is not the goal of this technical specification to add any extensions to published standards (for example IEC 61850 or IEC 60870-5-104 or IEC 60870-5-101).

After an introduction giving a basic description of the mapping, the mapping of the information model with associated data classes, and the mapping of services are described. Clause 9 shows how the mapped data and services according to the IEC 60870-5-104 and IEC 60870-5-101 protocol are marked (selected) in the interoperability sheet.

The scope of this technical specification is to achieve real-time exchange of process information required for operational purposes between a substation using a CDC-based data model (for example IEC 61850) and (a) control center(s) using a communication link over a wide area network (WAN) compliant to the definitions of IEC 60870-5-101 or IEC 60870-5-104. The amount of real-time information provided by the substation-gateway device can vary dependent on the operational needs. Actors could be regional and nationwide control centers that receive real-time information in order to monitor and control geographically widespread processes. The described mapping can be used for several fields of application of power utilities, such as substations, hydro and wind power plants, and decentralized energy resources DER. The mapping is based on the definitions of the IEC 61850 series and IEC 60870-5-104:2006/IEC 60870-5-101:2003. The scope of the mapped IEC 60870-5-104 and IEC 60870-5-101 subset is given in Clause 9.

This technical specification focuses mainly on defining rules and functions of a gateway device as a part of the substation. However, the rules and functions are also valid when an IED may optionally be connected directly to a WAN compliant with IEC 60870-5-101 or IEC 60870-5-104 and therefore, the mapping has to be done inside the IED.

To enable an automated database management approach, which aims to ensure consistency between the databases of substations and control centers, the SCD file (substation configuration description) can be extended with IEC 60870-5-101/IEC 60870-5-104 specific information to configure the 61850 to 101/104 gateway. How the SCD file can be extended is described in Annex A.

The extended substation configuration description (SCD+) is recommended to be used to configure any gateway in a vendor independent format.

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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 60870-5-3, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 3: General structure of application data*

IEC 60870-5-4:1993, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 4: Definition and coding of application information elements*

IEC 60870-5-5:1995, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 5: Basic application functions*

IEC 60870-5-101, *Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks*

IEC 60870-5-104:2006, *Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles*

IEC 61850 (all parts), *Communication networks and systems for power utility automation*

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 61850-7-2:2003, *Communication networks and systems in substations – Part 7-2: Basic information and communication structure for substation and feeder equipment – Abstract communication service interface (ACSI)*

IEC 61850-7-2:2010, *Communication networks and systems for power utility automation – Part 7-2: Basic information and communication structure for substation and feeder equipment – Abstract communication service interface (ACSI)*

IEC 61850-7-3:2003, *Communication networks and systems in substations – Part 7-3: Basic communication structure – Common data classes*

IEC 61850-7-3:2010, *Communication networks and systems for power utility automation – Part 7-3: Basic communication structure – Common data 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*

IEEE 754:2008, *IEEE Standard for Binary Floating-Point Arithmetic*

RFC 2200, *Internet Official Protocol Standards, Request for Comments 2200 (June 1997)*

3 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

ACSI Abstract communication service interface (defined for example in IEC 61850-7-2)

ASDU Application service data unit

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CASDU	Common address of ASDU
CDC	Common data class (defined for example in IEC 61850-7-3)
CI	Counter interrogation
COT	Cause of transmission
GI	General interrogation
GOOSE	Generic object oriented substation event
HMI	Human machine interface
IED	Intelligent electronic device
IOA	Information object address
LD	Logical device
LN	Logical node
PI	Process image
P/N	Positive/negative
QOI	Qualifier of interrogation
QDS	Quality descriptor
RFC	Request for comments
S/E	Select/execute
SCL	Substation configuration language (defined for example in IEC 61850-6)
TI	Type Identification
TISSUE	Technical issue as part of the maintenance process of IEC 61850
WAN	Wide area network
XML	Extensible mark-up language

4 The mapping architecture

The mapping architecture consists of five parts:

1) conceptual architecture of a gateway device and associated use cases;
2) conceptual architecture of an IED directly connected to a WAN (optional);
3) mapping of the information model;
4) mapping of the data (which is in fact part of the information model);
5) mapping of the services.

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5 Conceptual architectures and associated use cases

5.1 Conceptual architecture of a gateway device

5.1.1 General

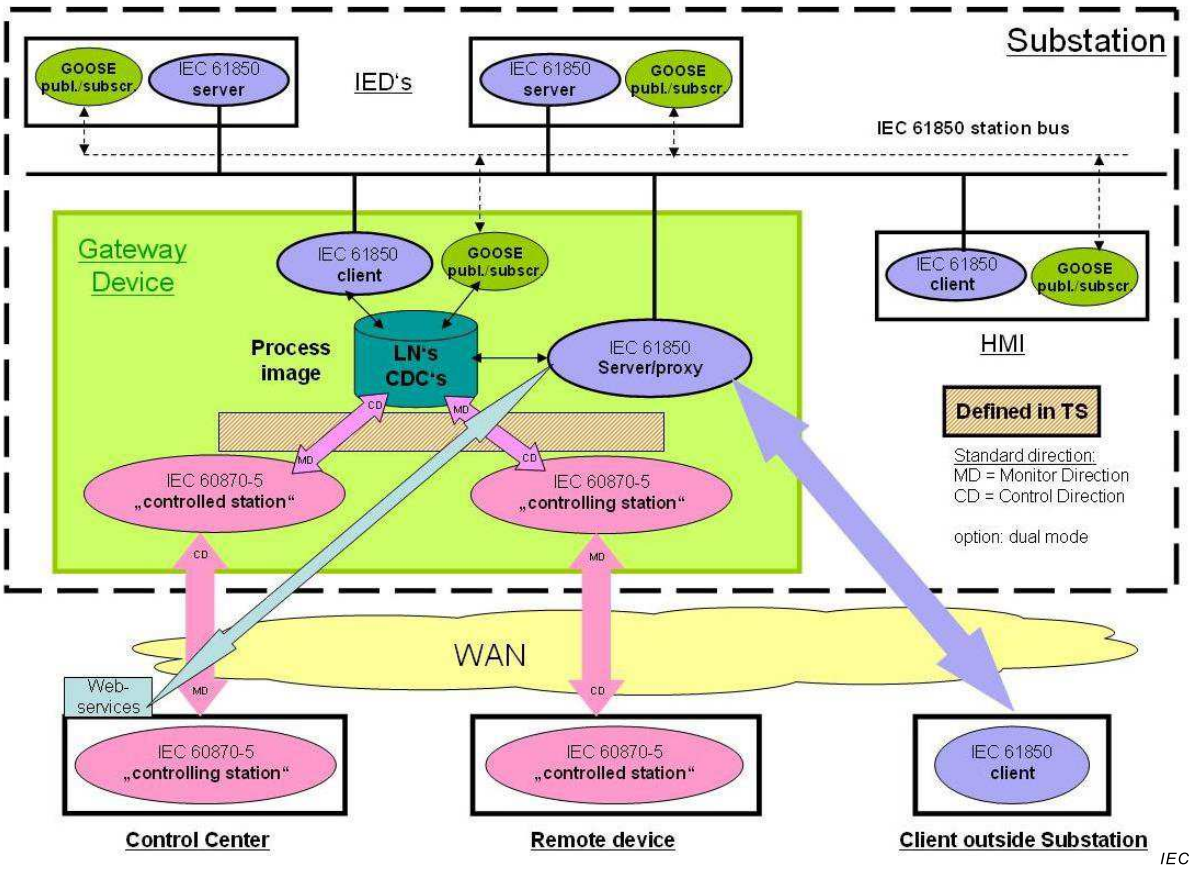

Figure 1 – Conceptual architecture of a gateway device

Figure 1 describes the conceptual architecture of a gateway device within a substation. The gateway device is decoupling the IEC 61850 station bus from the IEC 60870-5-101 or IEC 60870-5-104 WAN via a process image (PI). The advantage of this approach is that only services for control model interaction need to be mapped.

The PI is organized according the data model of IEC 61850 (LDs, LNs, CDCs).

The IEC 61850 client/GOOSE subscriber is used to update the PI with process data made available by the IEDs.

The IEC 61850 server/proxy is used to:

- make process data coming from remote devices available for IEDs inside the substation;
- retrieve the data model for:
  - IEC 61850 clients inside the substation (for example HMI);
  - IEC 61850 clients outside the substation (for example future control centers);
  - existing control centers using IEC 60870-5-101 or IEC 60870-5-104 for WAN communication by using additional services (for example SCL extensions or web services).

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The IEC 60870-5-101 or IEC 60870-5-104 controlled and controlling functionality makes use of the attributes of CDCs in a defined way to build up ASDUs to communicate with control centers or “devices on the WAN network“ using WAN communication based on IEC 60870-5-101 or IEC 60870-5-104 (including redundant connections).

The IEC 60870-5-101 or IEC 60870-5-104 controlling functionality inside the gateway device is used to connect “devices on the WAN network” with IEC 60870-5-101 or IEC 60870-5-104 controlled functionality to the substation.

The gateway device can optionally act as a “mediator” between the substation and all “devices on the WAN network”. When IEC 60870-5-101 or IEC 60870-5-104 “dual mode functionality” is used, the same ASDUs are used in the monitor and the control direction on the WAN.

5.1.2 Use case a) for a gateway device

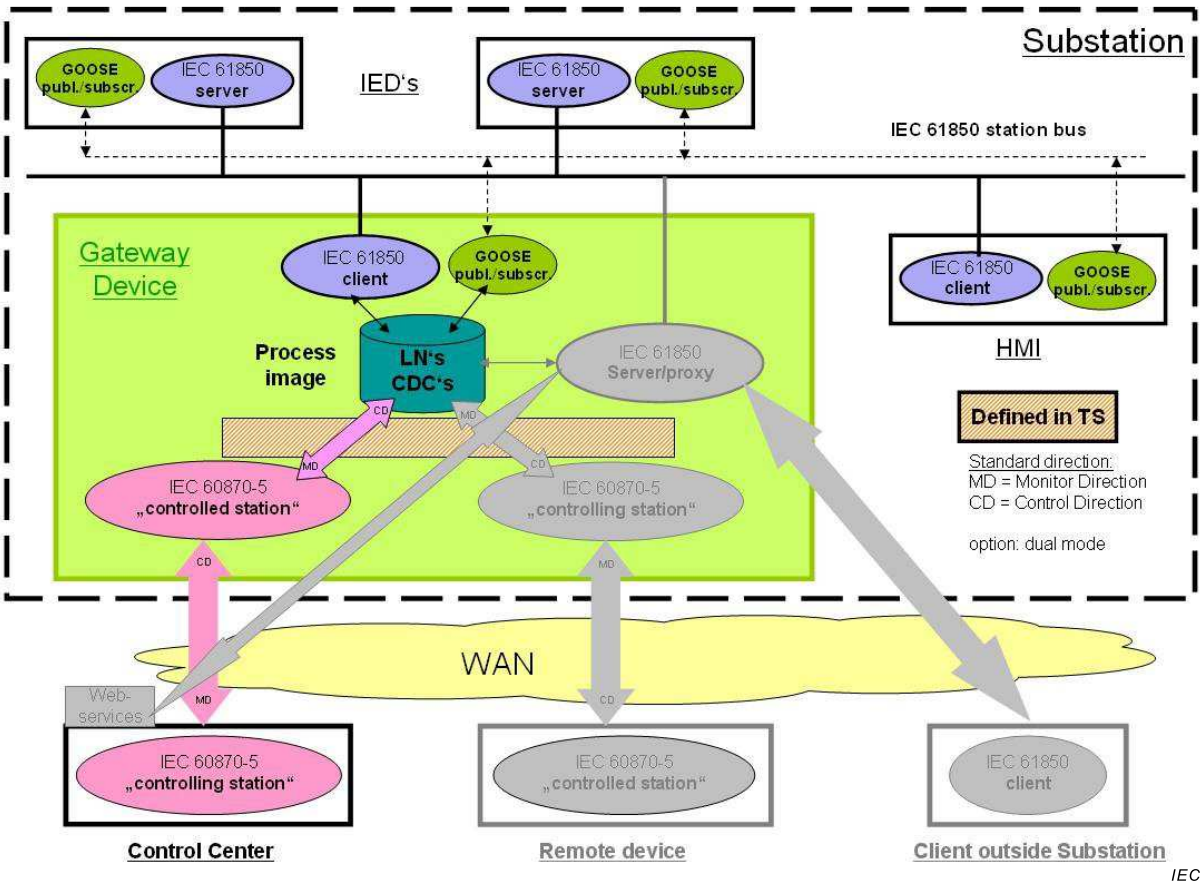

Figure 2 – Use case a) for a gateway device

Figure 2 describes use case a) using a subset of functions of the conceptual architecture. The IEC 61850 client/GOOSE subscriber is used to update the PI with process data made available by the IEDs.

The IEC 60870-5-101 or IEC 60870-5-104 controlled functionality makes use of the attributes of CDCs in a defined way to build up ASDUs to communicate with control centers using WAN communication based on IEC 60870-5-101 or IEC 60870-5-104 (including redundant connections).

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5.1.3 Use case b) for a gateway device

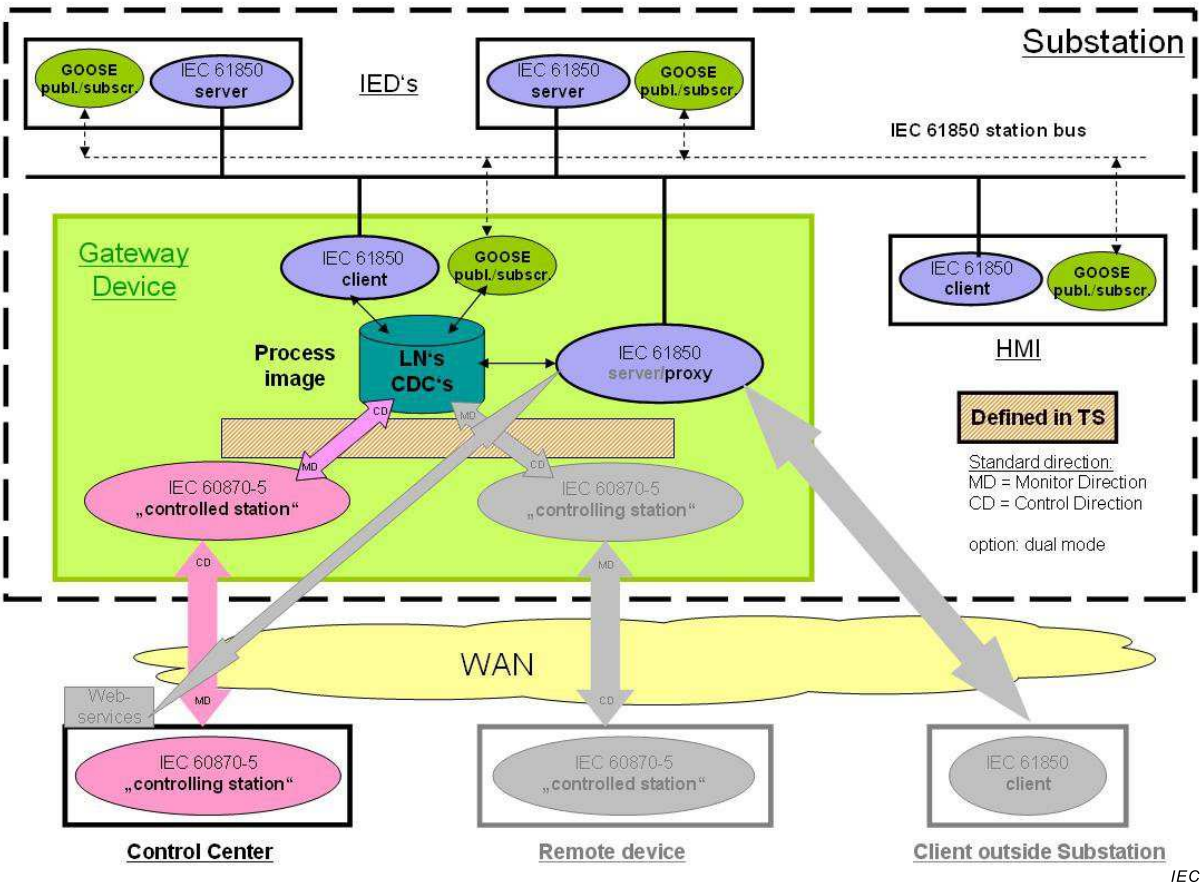

Figure 3 – Use case b) for a gateway device

Figure 3 describes use case b) using an extended subset of functions of the conceptual architecture.

The IEC 61850 client/GOOSE subscriber is used to update the PI with process data made available by the IEDs.

The IEC 61850 proxy is used to retrieve the data model for IEC 61850 clients inside the substation (for example HMI).

The IEC 60870-5-101 or IEC 60870-5-104 controlled functionality makes use of the attributes of CDCs in a defined way to build up ASDUs to communicate with control centers using WAN communication based on IEC 60870-5-101 or IEC 60870-5-104 (including redundant connections).

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5.1.4 Use case c) for a gateway device

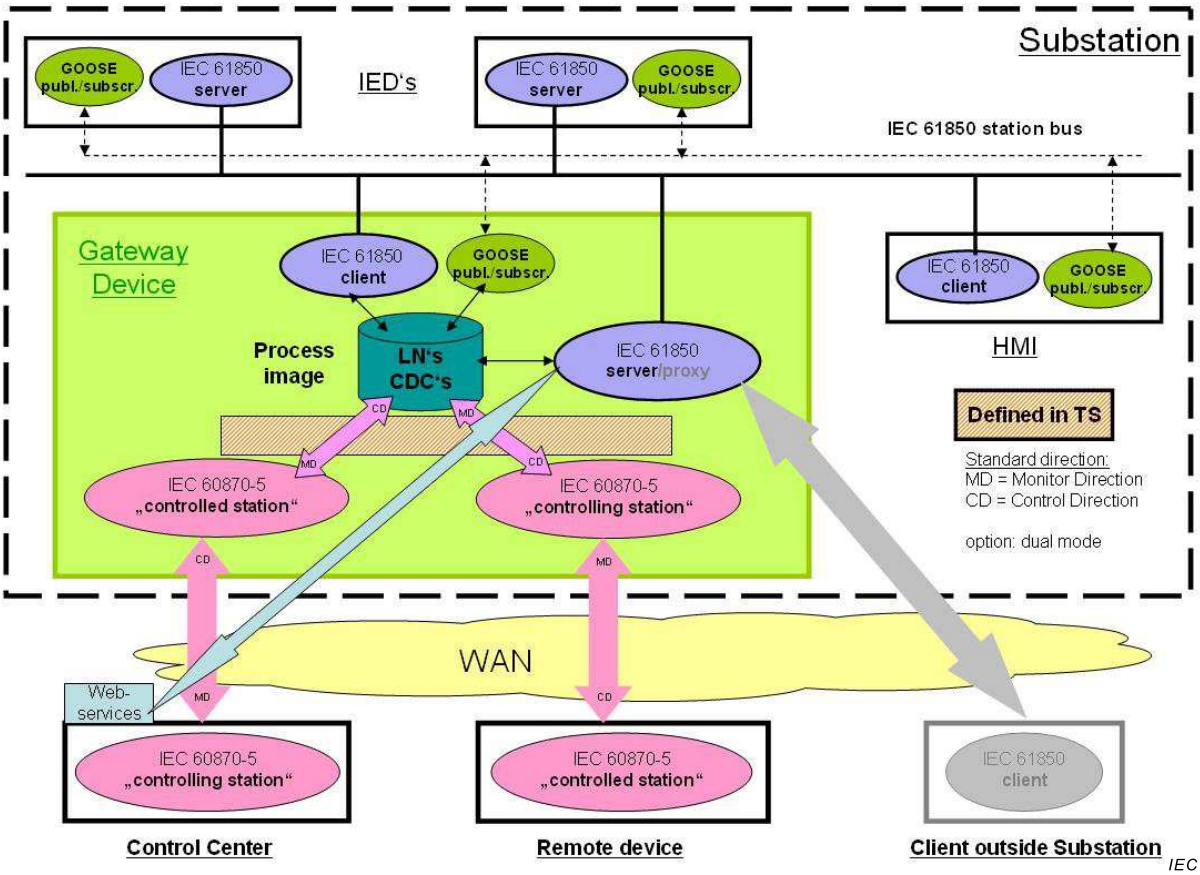

Figure 4 – Use case c) for a gateway device

Figure 4 describes use case c) using nearly all functions of the conceptual architecture. The IEC 61850 client/GOOSE subscriber is used to update the PI with process data made available by the IEDs.

The IEC 61850 server is used to:

- make process data coming from remote devices available for IEDs inside the substation;
- retrieve the data model for:
  - IEC 61850 clients inside substation (for example HMI);
  - existing control centers using IEC 60870-5-101 or IEC 60870-5-104 for WAN communication by using additional services (for example SCL extensions or web services).

The IEC 60870-5-101 or IEC 60870-5-104 controlled and controlling functionality makes use of the attributes of CDCs in a defined way to build up ASDUs to communicate with control centers or "devices on the WAN network" using WAN communication based on IEC 60870-5-101 or IEC 60870-5-104 (including redundant connections).

The IEC 60870-5-101 or IEC 60870-5-104 controlling functionality inside the gateway device is used to connect "devices on the WAN network" with IEC 60870-5-101 or IEC 60870-5-104 controlled functionality to the substation.

The gateway device can optionally act as a "mediator" between the substation and all "devices on the WAN network". When IEC 60870-5-101 or IEC 60870-5-104 "dual mode functionality" is used, the same ASDUs are used in the monitor and the control direction on the WAN.

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5.2 Conceptual architecture of an IED directly connected to a WAN (optional)

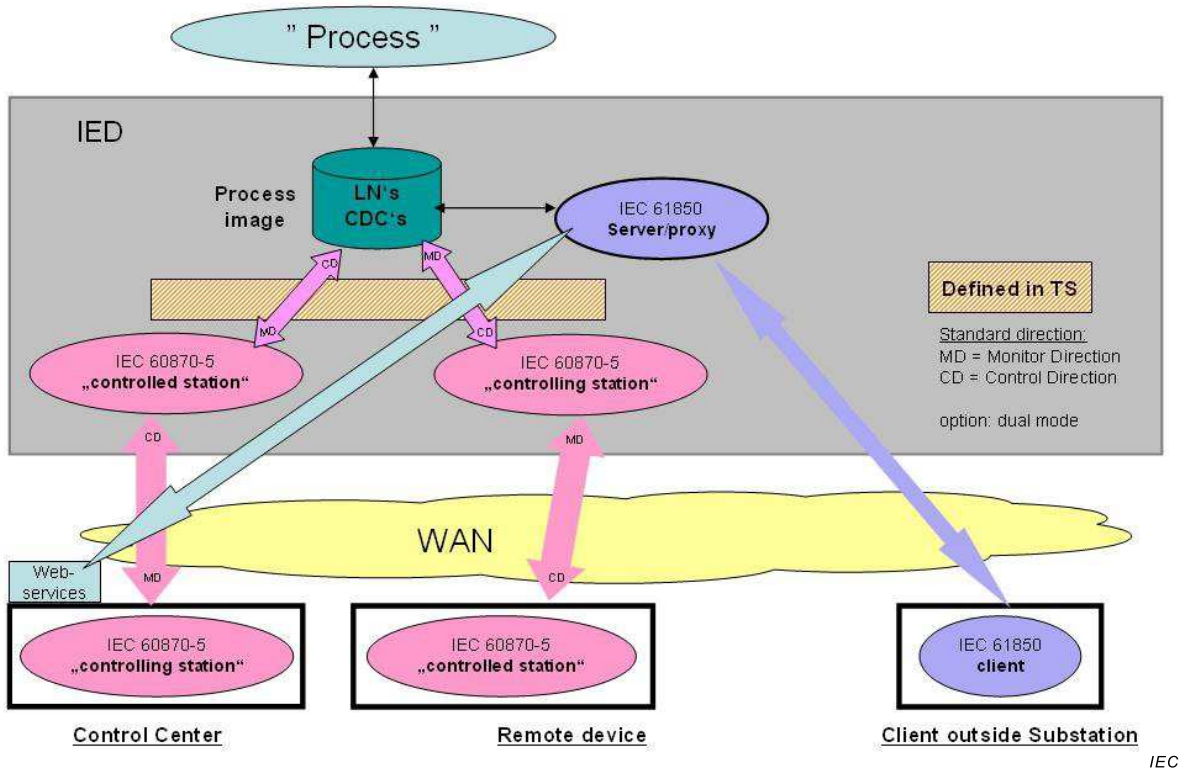

Figure 5 – Conceptual architecture of an IED

Figure 5 shows the conceptual architecture of an IED which optionally may be connected directly to a WAN complient to IEC 60870-5-104 or IEC 60870-5-101. However, the rules and functions defined for a gateway device as a part of a substation are also valid for the mapping inside an IED.

The IED decouples the process information from the IEC 60870-5-101 or IEC 60870-5-104 WAN via a process image (PI). The advantage of this approach is that only services for control model interaction need to be mapped.

The PI is organized according the data model of IEC 61850 (LDs, LNs, CDCs).

The IEC 61850 server/proxy is used to:

- make process data coming from remote devices available for the process connected to the IED;
- retrieve the data model for:
  - IEC 61850 clients outside the substation (for example future control centers);
  - existing control centers using IEC 60870-5-101 or IEC 60870-5-104 for WAN communication by using additional services (for example SCL extensions or web services).

The IEC 60870-5-101 or IEC 60870-5-104 controlled and controlling functionality makes use of the attributes of CDCs in a defined way to build up ASDUs to communicate with control centers or “devices on the WAN network” using WAN communication based on IEC 60870-5-101 or IEC 60870-5-104.

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The IEC 60870-5-101 or IEC 60870-5-104 controlling functionality inside the IED is used to connect “devices on the WAN network“ with IEC 60870-5-101 or IEC 60870-5-104 controlled functionality to the IED.

The IED can optionally act as a “mediator” between the IED and all “devices on the WAN network“. When IEC 60870-5-101 or IEC 60870-5-104 “dual mode functionality” is used, the same ASDUs are used in the monitor and the control direction on the WAN.

6 Mapping of a device-oriented information model to IEC 60870-5-104 or IEC 60870-5-101

6.1 General

The defined mapping for a device-oriented information model is based on using existing functionalities in IEC 60870-5-104 or IEC 60870-5-101 by using the

– common address of ASDU (CASDU), and the

– information object address (IOA)

to accommodate the device model using LD (logical device) and LN (logical node) and transfer of real-time information (data) using standardized ASDUs. The same is applicable for the services and the basic application functions in IEC 60870-5-104 or IEC 60870-5-101.

6.2 Mapping of a device-oriented information model reference

The device-oriented information model (for example IEC 61850) shall be mapped to a hierarchical structure. The conceptual mapping is depicted in Figure 6. The device-oriented information model (for example IEC 61850) is intended to be preserved when mapped to IEC 60870-5-104 or IEC 60870-5-101. This especially means that

– the server/proxy implements the hierarchical device-oriented information model of, for example, IEC 61850 that can be retrieved by the services according to Clause 8;

– the client implements the device-oriented information model by configuration. That can be done in different ways:

  - by using the SCL file, specifying the implemented information model, mapping and addressing details according to the rules in IEC 61850-6;
  - by other configuration methods.

– the master/client station ("controlling station") accesses the hierarchical device-oriented information model of, for example, IEC 61850 through the services provided by IEC 60870-5-104 or IEC 60870-5-101 to exchange real-time data.

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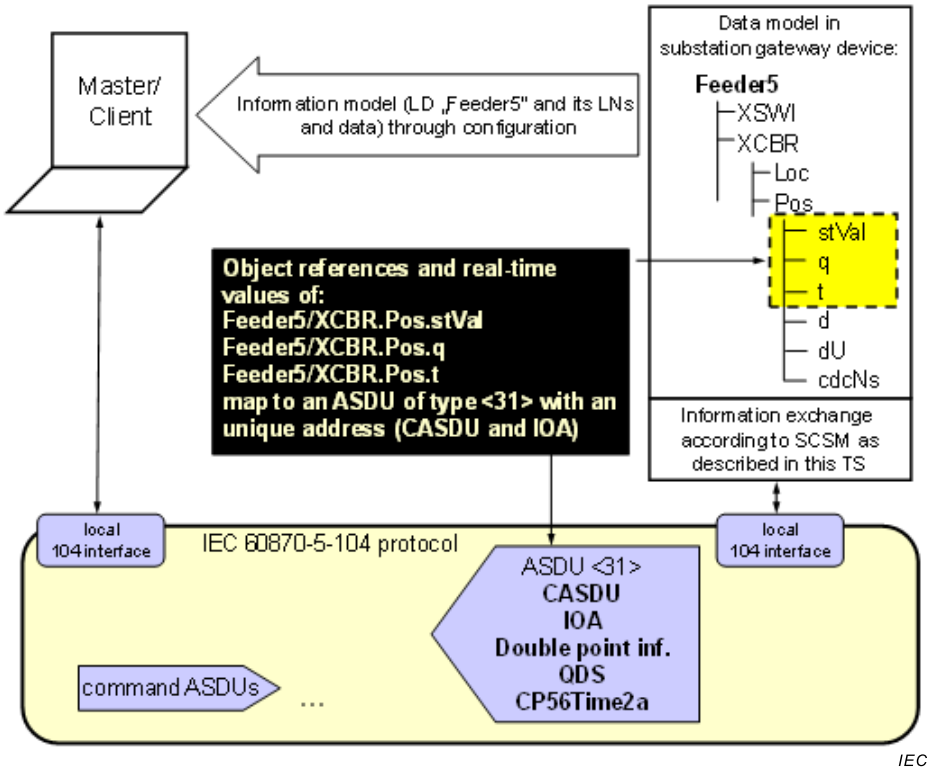

Figure 6 – Mapping architecture (conceptual)

6.3 Logical device class mapping

The logical device reference shall map to the common address of ASDU (CASDU).

The CASDU may be structured or unstructured. For example, the CASDU may identify the station ID and the logical device instance ID. It is recommended to make an addressing scheme in order to have unique address for the specific station. For example, for small stations, one CASDU can be assigned for a station, all LD will then have the same CASDU. For a large station several CASDU can be used to identify each LD. The maximum number of CASDU for one link is 65 534.

6.4 Logical node class mapping

The logical node instance ID and data attribute reference shall map to the information object address (IOA).

All attributes of the LN class are implicitly defined and visible. The IOA may be structured or unstructured. For both cases, a decimal approach for defining the IOA addresses is recommended. The maximum number of IOA addresses per CASDU is 65 536.

7 Mapping of the common data classes (CDC)

7.1 List of CDC, type Identifications and corresponding mappings for IEC 61850

Each common data class consists of one or more data attributes of a specific data type. Each data attribute shall be mapped to one specific IOA (as in 6.4). In IEC 60870-5-104 or IEC 60870-5-101, each IOA is directly related to a specific ASDU type (with or without time). Therefore, the CDC is basically mapped as in Table 1.

The mapping shown in Table 1 shall be considered as a default mapping – carefully selected out of a variety of mapping possibilities.

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The requirements for the mapping of LD,LN onto CASDU,IOA can vary in different fields of application. The most suitable way of mapping should be defined on a utility or project basis depending on the specific needs. CASDU and IOA in IEC 60870-5-101 or IEC 60870-5-104 are just numbers which have to be unique within one Utility/project.

Table 1 – Mapping structure CDC onto ASDU type

CDCs defined in IEC 61850-7-3:2003	
CDC (Attribute data types)	**ASDU type**
SPS Single point status	*monitor direction (status):* TI<30> as event TI<1> as part of GI
DPS Double point status	*monitor direction (status):* TI<31> as event TI<3> as part of GI
INS Integer status	*monitor direction (status):* TI<35> or TI <33> or TI <30> as event TI<11> or TI<7> or TI <1> as part of GI
ACT Protection activation information	*monitor direction (status):* TI<39> as event or TI<30> as event TI<1> as part of GI
ACD Directional protection activation Information	*monitor direction (status):* TI<40> as event or TI<30> as event TI<1> as part of GI
SEC Security violation counting	*monitor direction (status):* TI<37> as event or as part of CI
BCR Binary counter reading	*monitor direction (status):* TI<37> as event or as part of CI
MV Measured value	*monitor direction (status):* TI<36> or TI<35> as event TI<13> or TI<11> as part of GI
CMV Complex measured value	*monitor direction (status):* TI<36> or TI<35> as event TI<13> or TI<11> as part of GI
WYE Phase to ground related measured values in a three phase system	*monitor direction (status):* via **CMV** to TI<36> or TI<35> as event TI<13> or TI<11> as part of GI
DEL Phase to phase related measured values in a three phase system	*monitor direction (status):* via **CMV** to TI<36> or TI<35> as event TI<13> or TI<11> as part of GI
SEQ Sequence	*monitor direction (status):* via **CMV** to TI<36> or TI<35> as event TI<13> or TI<11> as part of GI
HMV Harmonic value	*monitor direction (status):* according IEC 61850-7-3:2003 TI<36> as event TI<13> as part of GI according IEC 61850-7-3:2010 via **CMV** TI<36> or TI<35> as event TI<13> or TI<11> as part of GI
HWYE Harmonic value for **WYE**	*monitor direction (status)*: according IEC 61850-7-3:2003 similar as **HMV** (Ed.1) to TI<36> as event TI<13> as part of GI according IEC 61850-7-3:2010 similar as **HMV** (Ed.2) to TI<36> or TI<35> as event TI<13> or TI<11> as part of GI

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CDCs defined in IEC 61850-7-3:2003	
CDC (Attribute data types)	**ASDU type**
HDEL Harmonic value for **DEL**	*monitor direction (status):* according IEC 61850-7-3:2003 similar as **HMV** (Ed.1) to TI<36> as event TI<13> as part of GI according IEC 61850-7-3:2010 similar as **HMV** (Ed.2) to TI<36> or TI<35> as event TI<13> or TI<11> as part of GI
SPC Controllable single point	*monitor direction (status):* TI<30> as event TI<1> as part of GI *control direction (command):* TI<45> (without time tag) or TI<58> (with time tag)
DPC Controllable double point	*monitor direction (status):* TI<31> as event TI<3> as part of GI *control direction (command):* TI<46> (without time tag) or TI<59> (with time tag)
INC Controllable integer status	*monitor direction (status):* TI<35> as event TI<11> as part of GI *control direction (command):* TI<49> (without time tag) or TI<62> (with time tag)
BSC Binary controlled step position information	*monitor direction (status):* TI<32> as event TI<5> as part of GI *control direction (command):* TI<47> (without time tag) or TI<60> (with time tag)
ISC Integer-controlled step position information	*monitor direction (status):* TI<32> as event TI<5> as part of GI *control direction (setpoint):* TI<49> (without time tag) or TI<62> (with time tag)
APC Controllable analogue set point information	*monitor direction (status):* TI<36> as event TI<13> as part of GI *control direction (command):* TI<50>(without time tag) or TI<63> (with time tag)
SPG Single point setting	*control direction (command):* TI<45> (without time tag) or TI<58> (with time tag)
ING Integer status setting	*control direction (setpoint):* TI<49> (without time tag) or TI<62> (with time tag)
ASG Analogue setting	*control direction (setpoint):* TI<50> (without time tag) or TI<63> (with time tag)

Additional CDCs defined in IEC 61400-25-2	
CDC (Attribute data types)	**ASDU type**
STV Status value	Mapped via CDC **INS** Integer status
SPV Setpoint value	Mapped via CDC **APC** Controllable analogue set point information
ALM Alarm	Mapped via CDC **INS** Integer status for Data Attribute actVal CDC **SPC** Controllable single point for Data Attribute almAck
CMD Command	Mapped via CDC **INC** Controllable integer status
CTE Event counting	Mapped via CDC **INS** Integer status for DataAttribute actCtVal CDC **SPC** Controllable single point for DataAttribute manRs

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Additional CDCs defined in IEC 61400-25-2	
CDC (Attribute data types)	**ASDU type**
TMS State timing	Mapped via CDC **SPC** Controllable single point for DataAttribute manRs CDC **INS** Integer status for DataAttribute actTmVal and for DataAttribute oldTmVal
TI:= Type Identification GI:= General Interrogation or station interrogation ASDU TI<100> CI:= Counter interrogation ASDU TI<101>	

Common data classes CURVE, DPL, LPL ,CSD and SAV from IEC 61850-7-3:2003 and AST (former ASS) from IEC 61400-25-4 cannot be mapped to ASDUs of IEC 60870-5-104 or IEC 60870-5-101.

Additional CDCs defined in IEC 61850-7-3:2010	
CDC (Attribute data types)	**ASDU type**
ENS Enumerated status	*monitor direction (status):* TI<35> or TI <30> TI<11> or TI<1> as part of GI
HST Histogramm	*monitor direction (status):* TI<35> or TI <33> TI<11> or TI<7> as part of GI
ENC Controllable enumerated status	*monitor direction (status):* TI<35> or TI <30> TI<11> or TI<1> as part of GI *control direction (command):* TI<49> (without time tag) or TI<62> (with time tag) or TI<45> (without time tag) or TI<58> (with time tag)
ENG Enumerated status setting	*control direction (setpoint):* TI<49> (without time tag) or TI<62> (with time tag) or TI<45> (without time tag) or TI<58> (with time tag)
BAC Binary controlled analog process value	*monitor direction (status):* TI<36> as event TI<13> as part of GI *control direction (command):* TI<47> (without time tag) or TI<60> (with time tag)
CSG Curve shape setting	*control direction (setpoint):* TI<50> (without time tag) or TI<63> (with time tag)
TI:= Type Identification GI:= General Interrogation or station interrogation ASDU TI <100> CI:= Counter interrogation ASDU TI <101>	

The Common data classes VSS, ORG, TSG, CUG and VSG from IEC 61850-7-3:2010 cannot be mapped to ASDUs of IEC 60870-5-104 or IEC 60870-5-101.

The mapping of all CDC's defined for service tracking in IEC 61850-7-2:2010 − CTS, BTS, UTS, LTS, GTS, MTS, NTS, and STS − cannot be mapped to IEC 60870-5-101 or IEC 60870-5-104.

NOTE The mappings shown include the timestamp and are applicable for the monitor information if sent as an event. If the information is sent as part of GI (general interrogation/station interrogation) or CI (counter interrogation), the complete mapping is applicable, apart from the timestamp. All GI and CI data is sent excluding a timestamp.

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7.2 CDC single point status (SPS)

The data attributes of the common data class SPS depicted in Table 2 shall be mapped as shown in Table 3.

Table 2 – CDC: Single point status (SPS)

SPS class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
Data attribute					
Status					
stVal	BOOLEAN	ST	dchg	TRUE | FALSE	M
q	Quality	ST	qchg	Quality	M
t	TimeStamp	ST		Time value	M

The signal [stVal + q + t] shall map to the ASDU TI<30> "Single point information with time tag CP56Time2a" as specified in Table 3.

Table 3 – CDC: Single point status (SPS) mapping

CDC class		**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
SPS		TI<30>	
Attribute name	**Attribute type**	**information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
stVal	BOOLEAN	SIQ	SPI: <0> OFF = FALSE <1> ON = TRUE
q	Quality		validity -> IV good | invalid -> valid | invalid questionable -> NT source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp	CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence of dchg or qchg

7.3 CDC double point status (DPS)

The data attributes of the common data class DPS depicted in Table 4 shall be mapped as shown in Table 5.

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Table 4 – CDC: Double point status (DPS)

DPS class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
status					
stVal	CODED ENUM	ST	dchg	intermediate state | off | on |bad state	M
q	Quality	ST	qchg	Quality	M
t	TimeStamp	ST		Time	M

The signals [stVal + q + t] shall map to the ASDU TI<31> "Double point information with time tag CP56Time2a" as specified in Table 5.

Table 5 – CDC: Double point status (DPS) mapping

CDC class		**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
DPS		TI<31>	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
stVal	CODED ENUM	DIQ	DPI <0> intermediate state = intermediate-state <1> determined state OFF = OFF <2> determined state ON = ON <3> indeterminate = bad.state
q	Quality		validity -> IV good | invalid -> valid | invalid questionable -> NT source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp		Seven octet binary time, CP56Time2a – Time of occurrence of dchg or qchg

7.4 CDC integer status (INS)

The DataAttributes of the common data class INS depicted in Table 6 shall be mapped as shown in Table 7.

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Table 6 – CDC: Integer status (INS)

INS class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
status					
stVal	INT32	ST	dchg, dupd		M
q	Quality	ST	qchg	Quality	M
t	TimeStamp	ST		Time	M
configuration, description and extension					
units	Unit	CF	dchg	See Annex A of IEC 61850-7-3:2010	O

The signals [stVal + q + t] shall map to either ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a" or optionally ASDU TI<33> "Bitstring of 32 bits with time tag CP56Time2a" as specified in Table 7.

For the special use case that the attribute EEHealth of a logical node with the CDC INS (IEC 61850-7-4:2003) has to be mapped onto one single status to meet the requirements of existing control center systems, the signals [stVal + q + t] shall map to ASDU TI<30> "Single point information with time tag CP56Time2a".

The mapping of CDC INS to ASDU TI<33> (binary state information) is optional. It may be used if the value range for the default mapping to ASDU TI<35> (scaled value) is not sufficient.

In IEC 61850-7-3:2010 the configuration attribute “units” of type “Unit” was added to the CDC INS. The TrgOp of the attribute “units” was defined as “dchg”. Furthermore the TrgOp “dupd” was added for the attribute “stVal".

The type “Unit” consists of two attributes – “SIUnit” (as mandatory) and “multiplier” (as optional), both of type ENUMERATED.

That means that optionally the attribute “units.multiplier”, which might have an influence on the mapping of the value of stVal, can be mapped to ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a".

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Table 7 – CDC: Integer status (INS) mapping

CDC class		**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
INS		TI <35>	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
stVal	INT32	SVA = Scaled value	SVA I16<-2^{15}..+2^{15}-1> 0 map on 0 Valid range for INT32 is <-2^{15} ....+2^{15}-1>
q	Quality	QDS = Quality descriptor	validity -> IV good | invalid -> valid |invalid questionable -> NT detailQual -> OV overflow -> overflow source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp	CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrenceof dchg, qchg or dupd
CDC class		**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
INS		TI<33>	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
stVal	INT32	BSI = Binary state information	BSI:= 32BS1[1..32]<0,1>
q	Quality	QDS = Quality descriptor	validity -> IV good | invalid -> valid |invalid questionable -> NT detailQual -> OV overflow -> overflow source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp	CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence of dchg, qchg or dupd

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CDC class		IEC 60870-5-101 or IEC 60870-5-104 mapping	
INS		TI<30>	
Attribute nme	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
stVal	INT32	SIQ	stVal:= <1> ok -> SPI:=<0> OFF = FALSE stVal:= <3> Alarm -> SPI:= <1> ON = TRUE
q	Quality		validity -> IV good | invalid -> valid | invalid questionable -> NT source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp	CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence of dchg, qchg or dupd

7.5 CDC protection activated information (ACT)

The data attributes of the common data class ACT depicted in Table 8 shall be mapped as shown in Table 9.

Table 8 – CDC: Protection activated information (ACT)

ACT class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
status					
general	BOOLEAN	ST	dchg	TRUE | FALSE	M
phsA	BOOLEAN	ST	dchg	TRUE | FALSE	O
phsB	BOOLEAN	ST	dchg	TRUE | FALSE	O
phsC	BOOLEAN	ST	dchg	TRUE | FALSE	O
neut	BOOLEAN	ST	dchg	TRUE | FALSE	O
q	Quality	ST	qchg	Quality	M
t	TimeStamp	ST		Time value	M

The signals [general + phsA + phsB + phsC + neut + q + t] shall map to the ASDU TI<39> "Packed start events of protection equipment with time tag CP56Time2a" or multiple ASDUs TI<30> "Single point information with time tag CP56time 2a" as specified in Table 9.

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Table 9 – CDC: Protection activated information (ACT) mapping

a) Mapping to ASDU TI <39>			
CDC class		**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
ACT		TI<39>	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
general	BOOLEAN	SPE	GS = general start of operation:= BS1[1]<0..1> FALSE = <0>:= no general start of operation TRUE = <1>:= general start of operation
phsA	BOOLEAN	SPE	SL1 = start of operation phase L1:= BS1[2]<0..1> FALSE = <0>:= no start of operation L1 TRUE = <1>:= start of operation L1
phsB	BOOLEAN	SPE	SL2 = start of operation phase L2:= BS1[3]<0..1> FALSE = <0>:= no start of operation L2 TRUE = <1>:= start of operation L2
phsC	BOOLEAN	SPE	SL3 = start of operation phase L3:= BS1[4]<0..1> FALSE = <0>:= no start of operation L3 TRUE = <1>:= start of operation L3
neut	BOOLEAN	SPE	SIE = start of operation IE (earth current) FALSE = <0>:= no start of operation IE TRUE = <1>:= start of operation IE
q	Quality	QDP	validity -> IV good | invalid -> valid | invalid questionable -> NT EI not used:= set to zero .= elapsed time valid source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp	CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrenceof dchg or qchgt

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b) Mapping to ASDU TI<30>			
CDC class		**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
ACT		TI<30>	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
general	BOOLEAN	SIQ	SPI <0> OFF = FALSE <1> ON = TRUE
phsA	BOOLEAN	SIQ	SPI <0> OFF = FALSE <1> ON = TRUE
phsB	BOOLEAN	SIQ	SPI <0> OFF = FALSE <1> ON = TRUE
phsC	BOOLEAN	SIQ	SPI <0> OFF = FALSE <1> ON = TRUE
neut	BOOLEAN	SIQ	SPI <0> OFF = FALSE <1> ON = TRUE
q	Quality	SIQ	validity -> IV good | invalid -> valid | invalid questionable -> NT source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp	CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence of dchg or qchg

Each attribute maps to one ASDU TI<30> "Single point information with time tag CP56Time2a" as specified in Table 3 using consecutive indices:

IOA n := general

IOA n+1 := phsA (Optional)

IOA n+2 := phsB (Optional)

IOA n+3 := phsC (Optional)

IOA n+4 := neut (Optional)

7.6 CDC directional protection activation information (ACD)

The data attributes of the common data class ACD depicted in Table 10 shall be mapped as shown in Table 11.

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Table 10 – CDC: Protection activated information (ACD)

ACD class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from Data Class (see IEC 61850-7-2)				
DataAttribute					
status					
general	BOOLEAN	ST	dchg	TRUE | FALSE	M
dirGeneral	ENUMERATED	ST	dchg	unknown| forward | backward | both	M
phsA	BOOLEAN	ST	dchg	TRUE | FALSE	GC_2(1)
dirPhsA	ENUMERATED	ST	dchg	unknown | forward | backward	GC_2(1)
phsB	BOOLEAN	ST	dchg	TRUE | FALSE	GC_2(2)
dirPhsB	ENUMERATED	ST	dchg	unknown | forward | backward	GC_2(2)
phsC	BOOLEAN	ST	dchg	TRUE | FALSE	GC_2(3)
dirPhsC	ENUMERATED	ST	dchg	unknown | forward | backward	GC_2(3)
neut	BOOLEAN	ST	dchg	TRUE | FALSE	GC_2(4)
dirNeut	ENUMERATED	ST	dchg	unknown | forward | backward	GC_2(4)
q	Quality	ST	qchg	Quality	M
t	TimeStamp	ST		Time value	M

The signals [general + phsA + phsB + phsC + neut + q + t] shall map to the ASDU TI<40> "Packed output circuit information of protection equipment with time tag CP56Time2a" or multiple ASDUs TI<30> "Single point information with time tag CP56time 2a as specified in Table 11.

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Table 11 – CDC: Directional protection activated information (ACD) mapping

Without using directional attribute			
CDC class		**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
ACD		TI<40>	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
general	BOOLEAN	OCI	GC = general command to output circuit:= BS1[1]<0..1> FALSE = <0>:= no general command to output circuit TRUE = <1>:= general command to output circuit
phsA	BOOLEAN	OCI	CL1 = command to output circuit phase L1:= BS1[2]<0..1> FALSE = <0>:= no command to output circuit phase L1 TRUE = <1>:= command to output circuit phase L1
phsB	BOOLEAN	OCI	CL2 = command to output circuit phase L2:= BS1[3]<0..1> FALSE = <0>:= no command to output circuit phase L2 TRUE = <1>:= command to output circuit phase L2
phsC	BOOLEAN	OCI	CL3 = command to output circuit phase L3:= BS1[4]<0..1> FALSE = <0>:= no command to output circuit phase L3 TRUE = <1>:= command to output circuit phase L3
q	Quality	QDP	validity -> IV good | invalid -> valid | invalid questionable -> NT EI not used:= set to zero:= elapsed time valid source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp	CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence of dchg or qchg

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Use of directional attribute			
CDC class		**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
ACD		TI<30>	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
general	BOOLEAN	SIQ	SPI <0> OFF:= FALSE <1> ON:= TRUE
phsA	BOOLEAN	SIQ	SPI <0> OFF:= FALSE <1> ON:= TRUE
phsB	BOOLEAN	SIQ	SPI <0> OFF:= FALSE <1> ON:= TRUE
phsC	BOOLEAN	SIQ	SPI <0> OFF:= FALSE <1> ON:= TRUE
neut	BOOLEAN	SIQ	SPI <0> OFF:= FALSE <1> ON:= TRUE
q	Quality	SIQ	validity -> IV good | invalid -> valid | invalid questionable -> NT source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp	CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence for object

Each value of direction attribute maps to one ASDU TI<30> "Single point information with time tag CP56Time2a" as specified in Table 3 using consecutive indices:

IOA n := general + unknown
IOA n+1 := general + forward
IOA n+2 := general + backward
IOA n+3 := general + both
IOA n+4 := phsA + unknown
..

IOA n+7 := phsB + unknown
..

IOA n+10 := phsC + unknown
..

IOA n+13 := neut + unknown
..
IOA n+15 := neut + backward

7.7 CDC Security violation counting (SEC)

The data attribute of the common data class SEC depicted in Table 12 shall be mapped as shown in Table 13.

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Table 12 – CDC: Security violation counting (SEC)

SEC class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
Status					
cnt	INT32U	ST	dchg		M
t	TimeStamp	ST		Time value	M

The signal [cnt + t] shall map to the ASDU TI<37> "Integrated totals with time tag CP56Time2a" as specified in Table 13.

Table 13 – CDC: Security violation counting (SEC) mapping

CDC class		IEC 60870-5-101 or IEC 60870-5-104 mapping	
SEC		TI<37>	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
cnt	INT32U	BCR	Counter reading ... I32 <-2^{31}..+2^{31}-1>
t	TimeStamp		Seven octet binary time, CP56Time2a – Time of occurrence of dchg
		BCR-□sequence notation	SQ:= sequence number = set to zero CY:= carry = set to zero CA:= counter was adjusted = set to zero IV:= validity good -> valid

7.8 CDC binary counter reading (BCR)

The data attribute of the common data class BCR depicted in Table 14 shall be mapped as shown in Table 15.

Table 14 – CDC: Binary counter reading (BCR)

BCR class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from Data Class (see IEC 61850-7-2)				
DataAttribute					
Status					
actVal	INT128 / INT64	ST	dchg		M
frVal	INT128 / INT64	ST	dupd		GC_2(1)
frTm	TimeStamp	ST		Time value	GC_2(1)
q	Quality	ST	qchg	Quality	M
t	TimeStamp	ST		Time value	M
configuration, description and extension					
units	Unit	CF	dchg	See Annex A of IEC 61850-7-3:2010	O

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The signal [actVal + q + t] shall map to ASDU TI<37> "Integrated totals with time tag CP56Time2a" with IOA n and the *optional* signal [frVal + frTm + q] shall map to ASDU TI<37> "Integrated totals with time tag CP56Time2a" with IOA n+1 as specified in Table 15.

The type “Unit” consists of two attributes – “SIUnit” (as mandatory) and “multiplier” (as optional), both of type ENUMERATED.

Optionally the attribute “units.multiplier”, which might have an influence on the mapping of the value of actVal or frVal, can be mapped to ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a".

Table 15 – CDC: Binary counter reading (BCR) mapping

CDC class		**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
BCR		TI<37>	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
actVal	INT128 / INT64	BCR = Binary Counter Reading	counter reading I32 <$-2^{31}..+2^{31}-1$>
q	Quality	BCR-sequence notation	SQ:= sequence number = set to zero CY:= carry = set to zero CA:= counter was adjusted = set to zero IV:= validity good -> valid
t	TimeStamp	CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence of dchg or qchg
frVal	INT128 / INT64	BCR = Binary Counter Reading	counter reading I32 <$-2^{31}..+2^{31}-1$>
frTm	TimeStamp	CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence of dupd, dchg or qchg
q	Quality	BCR-sequence notation	SQ:= sequence number = set to zero CY:= carry = set to zero CA:= counter was adjusted = set to zero IV:= validity good -> valid

In IEC 61850-7-3:2010 the attribute type of “actVal” and “frVal” have been changed to INT64. The gateway or proxy shall take the least significant 31 bits plus sign extension of the value for mapping

7.9 CDC measured value (MV)

The data attributes of the common data class MV depicted in Table 16 shall be mapped as shown in Table 17.

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Table 16 – CDC: Measured value (MV)

MV class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
measured attributes					
mag	AnalogueValue	MX	dchg, dupd		M
q	Quality	MX	qchg	Quality	M
t	TimeStamp	MX		Time value	M
configuration, description and extension					
db	INT32U	CF	dchg	0 ... 100 000	O
units	Unit	CF	dchg	See Annex A of IEC 61850-7-3:2010	O
sVC	ScaledValueConfig	CF	dchg		AC_SCAV

The signal [mag + q + t] shall map to the either ASDU TI<36> "Measured value, short floating point value with time tage CP56time2a" or ASDU <35> "Measured value, scaled value with time tag CP56time2a" as specified in Table 17.

NOTE In IEC 61850-7-3:2010 the trigger option “dupd” was added for the data attribute “mag” and the trigger option “dchg” was added for the data attribute “db”.

The type “Unit” consists of two attributes – “SIUnit” (as mandatory) and “multiplier” (as optional), both of type ENUMERATED.

The type “ScaledValueConfig” consists of two attributes – “scaleFactor” and “offset”, both mandatory and of type FLOAT32.

Table 17 – CDC: Measured value (MV) mapping

CDC class			**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
MV			TI<36> or TI<35>	
Attribute name	**Attribute type**	**DAComponent**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
a) mag	AnalogueValue	mag.f FLOAT32	IEEE STD 754	R32.23{Fraction,Exponent,Sign}
b) mag	AnalogueValue	mag.i INT32	SVA	I16<-2^{15}..+2^{15}-1> 0 map on 0 Valid range for INT32 is <-2^{15} ....+2^{15}-1>
q	Quality		QDS	validity -> IV good | invalid -> valid | invalid questionable -> NT detailQual -> OV overflow -> overflow source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp		CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence of dchg or qchg

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Either a) or b) shall be mapped.

Optionally the attribute “units.multiplier”, which might have an influence on the mapping of the value of mag, can be mapped to ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a.

Optionally “sVC.scaleFactor” and “sVC.offset” which also might have an influence on the mapping of the value of mag, can be mapped to ASDU TI<36>”Measured value, short floating point value with time tag CP56Time2a”.

The optional configuration attribute "db" can be optionally set by ASDU TI<111> "Parameter of measured value, scaled value" or ASDU TI<112> "Parameter of measured value, short floating point value" as described in Clause 8.

If required, this parameter can be reported as part of an interrogation response.

7.10 CDC complex measured value (CMV)

The data attributes of the common data class CMV depicted in Table 18 shall be mapped as shown in Table 19.

Table 18 – CDC: Complex measured value (CMV)

CMV class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
measured attributes					
cVal	Vector	MX	dchg, dupd		M
q	Quality	MX	qchg		M
t	TimeStamp	MX			M
configuration, description and extension					
db	INT32U	CF	dchg	0 … 100 000	O
units	Unit	CF	dchg	See Annex A of IEC 61850-7-3:2010	O
magSVC	ScaledValueConfig	CF	dchg		AC_SCAV
angSVC	ScaledValueConfig	CF	dchg		AC_SCAV

The type “Unit” consists of two attributes – “SIUnit” (as mandatory) and “multiplier” (as optional), both of type ENUMERATED.

The type “ScaledValueConfig” consists of two attributes – “scaleFactor” and “offset”, both mandatory and of type FLOAT32.

NOTE In IEC 61850-7-3:2010 the trigger option “dupd” was added for the data attribute “cVal”and the trigger option “dchg” was added for the data attribute “db”.

Table 19 defines the mapping for data attributes of common data class CMV. The data attributes [cVal + q + t] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<36> "Measured value, short floating point value with time tag CP56Time2a" or ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a".

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Table 19 – CDC: Complex measured value (CMV) mapping

CDC class			IEC 60870-5-101 or IEC 60870-5-104 mapping	
CMV			TI<36> or TI<35>	
Attribute name	**Attribute type**	**DAComponent**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
a) cVal	Vector	cVal.mag.f FLOAT32	IEEE STD 754	R32.23{Fraction,Exponent,Sign}
b) cVal	Vector	cVal.mag.i INT32	SVA	I16<-2^{15}..+2^{15}-1> 0 map on 0 Valid range for INT32 is <-2^{15} ....+2^{15}-1>
q	Quality		QDS	validity -> IV good | invalid -> valid | invalid questionable -> NT detailQual -> OV overflow -> overflow source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp		CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence for object
a) cVal	Vector	cVal.ang.f FLOAT32	IEEE STD 754	R32.23{Fraction,Exponent,Sign}
b) cVal	Vector	cVal.ang.i INT32	SVA	I16<-2^{15}..+2^{15}-1> 0 map on 0 Valid range for INT32 is <-2^{15} ....+2^{15}-1
q	Quality		QDS	validity -> IV good | invalid -> valid | invalid questionable -> NT detailQual -> OV overflow -> overflow source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp		CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence of dchg or qchg

Either a) or b) shall be mapped in both cases.

If both attributes (mag and angle) have to be mapped, two consecutive IOA addresses is recommended to be used.

IOA n := CMV.cVal.mag.f or CMV.cVal.mag.i

IOA n+1 := CMV.cVal.ang.f or CMV.cVal.ang.i

Optionally the attribute “units.multiplier”, which might have an influence on the mapping of the value of cVal, can be mapped to ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a.

Optionally “magSVC.scaleFactor”, “magSCV.offset” and/or “angSVC.scaleFactor”, “angSVC.offset” which also might have an influence on the mapping of the value of cVal, can

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be mapped to ASDU TI<36>”Measured value, short floating point value with time tag CP56Time2a”.

The optional configuration attribute "db" can be optionally set by ASDU TI<111> "Parameter of measured value, scaled value" or ASDU TI<112> "Parameter of measured value, short floating point value" as described in Clause 8.

7.11 CDC Phase to ground related measured values of a three-phase system (WYE)

The data attributes of the common data class WYE depicted in Table 20 shall be mapped as multiple mappings of the common data Class CMV as shown in Table 19.

Table 20 – CDC: Phase to ground related measured values of a three-phase system (WYE)

WYE class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from Data Class (see IEC 61850-7-2)				
Data					
phsA	CMV				GC_1
phsB	CMV				GC_1
phsC	CMV				GC_1
neut	CMV				GC_1
net	CMV				GC_1
res	CMV				GC_1

Each present data attribute (of common data class CMV) shall map to the ASDU TI<36> "Measured value, short floating point value with time tag CP56Time2a" or ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a". Six ASDUs of TI<36> or TI<35> is recommended to be used with consecutive IOA indices:

IOA n := CMV phsA.cVal.mag.f or CMV phsA.cVal.mag.i

IOA n+1 := CMV phsB.cVal.mag.f or CMV phsB.cVal.mag.i

IOA n+2 := CMV phsC.cVal.mag.f or CMV phsC.cVal.mag.i

IOA n+3 := CMV neut.cVal.mag.f or CMV neut.cVal.mag.i

IOA n+4 := CMV net.cVal.mag.f or CMV net.cVal.mag.i

IOA n+5 := CMV res.cVal.mag.f or CMV res.cVal.mag.i

The amount of used IOA addresses is dependent on the presence of the data attributes of CDC WYE. If all data attributes are present six IOA adresses are needed as shown in the example.

If both attributes (mag and angle) of every present data attribute of type CMV have to be mapped, two consecutive IOA addresses should be used for each present data attribute.

IOA n := CMV phsA.cVal.mag.f or CMV phsA.cVal.mag.i

IOA n+1 := CMV phsA.cVal.ang.f or CMV phsA.cVal.ang.i

IOA n+2 := CMV phsB.cVal.mag.f or CMV phsB.cVal.mag.i

IOA n+3 := CMV phsB.cVal.ang.f or CMV phsB.cVal.ang.i

IOA n+4 := CMV phsC.cVal.mag.f or CMV phsC.cVal.mag.i

IOA n+5 := CMV phsC.cVal.ang.f or CMV phsC.cVal.ang.i

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IOA n+6 := CMV neut.cVal.mag.f or CMV neut.cVal.mag.i

IOA n+7 := CMV neut.cVal.ang.f or CMV neut.cVal.ang.i

IOA n+8 := CMV net.cVal.mag.f or CMV net.cVal.mag.i

IOA n+9 := CMV net.cVal.ang.f or CMV net.cVal.ang.i

IOA n+10 := CMV res.cVal.mag.f or CMV res.cVal.mag.i

IOA n+11 := CMV res.cVal.ang.f or CMV res.cVal.ang.f

The amount of used IOA addresses is dependent on the presence of the data attributes of CDC WYE. If all data attributes are present twelve IOA adresses are needed as shown in the example.

The mapping of common data class CMV is shown in detail in Table 19.

The conditional GC_1 means that at least one of the attributes shall be present for a given instance of the DataObject.

7.12 CDC phase to phase measured values of a three phase system (DEL)

The data attributes of the common data class DEL depicted in Table 21 shall be mapped as multiple mappings of the common data class CMV as shown in Table 19.

Table 21 – CDC: Phase to phase measured values of a three phase system (DEL)

DEL class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
Data					
phsAB	CMV				GC_1
phsBC	CMV				GC_1
phsCA	CMV				GC_1

Each data present attribute (of common data class CMV) shall map to the ASDU TI<36> "Measured value, short floating point value with time tag CP56Time2a" or ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a". Three ASDUs of TI<36> or TI<35> is recommended to be used with consecutive IOA indices:

IOA n := CMV phsAB.cVal.mag.f or CMV phsAB.cVal.mag.i

IOA n+1 := CMV phsBC.cVal.mag.f or CMV phsBC.cVal.mag.i

IOA n+2 := CMV phsCA.cVal.mag.f or CMV phsCA.cVal.mag.i

The amount of used IOA addresses is dependent on the presence of the data attributes of CDC DEL. If all data attributes are present three IOA adresses are needed as shown in the example.

If both attributes (mag and angle) of every present data attribute of attribute type CMV have to be mapped, two consecutive IOA addresses have to be used for each present data attribute. In that case, six ASDUs of TI<36> is recommended to be used with consecutive IOA indices:

IOA n := CMV phsAB.cVal.mag.f or CMV phsAB.cVal.mag.i

IOA n+1 := CMV phsAB.cVal.ang.f or CMV phsAB.cVal.ang.i

IOA n+2 := CMV phsBC.cVal.mag.f or CMV phsBC.cVal.mag.i

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IOA n+3 := CMV phsBC.cVal.ang.f or CMV phsBC.cVal.ang.i

IOA n+4 := CMV phsCA.cVal.mag.f or CMV phsCA.cVal.mag.i

IOA n+5 := CMV phsCA.cVal.ang.f or CMV phsCA.cVal.ang.i

The amount of used IOA addresses is dependent on the presence of the data attributes of CDC DEL. If all data attributes are present six IOA adresses are needed as shown in the example.

The mapping of common data class CMV is shown in detail in Table 19.

The conditional GC_1 means that at least one of the attributes shall be present for a given instance of the DataObject.

7.13 CDC sequence (SEQ)

The data attributes of the common data class SEQ depicted in Table 22 shall be mapped as multiple mappings of the common data class CMV as shown in Table 19.

Table 22 – CDC: Sequence (SEQ)

SEQ class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
Data					
c1	CMV				M
c2	CMV				M
c3	CMV				M

Each data attribute (of common data class CMV) shall map to the ASDU TI<36> "Measured value, short floating point value with time tag CP56Time2a" or ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a". Three ASDUs of TI<36> or TI<35> is recommended to be used with consecutive IOA indices:

IOA n := c1.cVal.mag.f or CMV c1.cVal.mag.i

IOA n+1 := c2.cVal.mag.f or CMV c2.cVal.mag.i

IOA n+2 := c3.cVal.mag.f or CMV c3.cVal.mag.i

If both attributes (mag and angle) of every attribute of attribute type CMV have to be mapped, two consecutive IOA addresses have to be used for each attribute. In that case, six ASDUs of TI <36> is recommended to be used with consecutive IOA indices:

IOA n := CMV c1.cVal.mag.f or CMV c1.cVal.mag.i

IOA n+1 := CMV c1.cVal.ang.f or CMV c1.cVal.ang.i

IOA n+2 := CMV c2.cVal.mag.f or CMV c2.cVal.mag.i

IOA n+3 := CMV c2.cVal.ang.f or CMV c2.cVal.ang.i

IOA n+4 := CMV c3.cVal.mag.f or CMV c3.cVal.mag.i

IOA n+5 := CMV c3.cVal.ang.f or CMV c3.cVal.ang.i

The mapping of common data class CMV is shown in detail in Table 19.

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7.14 CDC harmonic value (HMV)

7.14.1 CDC HMV defined in IEC 61850-7-3:2003

The data attributes of the common data class HMV depicted in Table 23 shall be mapped as shown in Table 24.

Table 23 – CDC: Harmonic value (HMV) Ed.1

HMV class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
Harmonics and interharmonics					
har	ARRAY[0..numHar] OF Vector	MX	dchg, dupd		M
Basics					
q	Quality	MX	qchg	Quality	M
t	TimeStamp	MX		Time value	M

Table 24 defines the mapping for data attributes of common data class HMV. The number of "har" attributes is variable (n:= 0 – numHar). The signals [har(n).mag + q + t] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<36> "Measured value, short floating point value with time tag CP56Time2a".

Table 24 – CDC: Harmonic value (HMV) Ed.1 mapping

CDC class			**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
HMV			TI<36>	
Attribute name	**Attribute type**	**DAComponent**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
har	Vector	har.mag.f FLOAT32	IEEE STD 754	R32.23{Fraction,Exponent,Sign}
q	Quality		QDS	validity -> IV good | invalid -> valid | invalid questionable -> NT detailQual -> OV overflow -> overflow source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp		CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence of dchg, dupd or qchg

Each data attribute "har" (of attribute type Vector) shall map to the ASDU TI<36> "Measured value, short floating point value with time tag CP56Time2a". The amount of ASDUs of TI<36> for the mapping is defined by the configuration attribute "numHar". The IOA addresses for all necessary ASDUs is recommended to be used with consecutive IOA indices:

IOA n := har[0].mag.f or har[0].mag.i

IOA n+1 := har[1].mag.f or har[1].mag.i

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IOA n+numHar:= har[numHar].mag.f or har[numHar].mag.i

7.14.2 CDC HMV defined in IEC 61850-7-3:2010

The data attributes of the common data class HMV Ed.2 depicted in Table 25 shall be mapped via the CDC CMV as shown in Table 19.

Table 25 – CDC: Harmonic value (HMV) Ed.2

HMV class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
Harmonics and interharmonics					
har	ARRAY[0..numHar] OF CMV	MX	dchg, dupd		M

The number of "har" attributes of type CMV is variable (n:= 0 – numHar). Every data attribute “har” shall be mapped via the CDC CMV as defined in 7.10. Every signal [har(n).cVal.mag.f + har(n).q + har(n).t or har(n).cVal.mag.i + har(n).q + har(n).t] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<36> "Measured value, short floating point value with time tag CP56Time2a" or ASDU TI<35> “Measured value, scaled value with time time tag as shown in Table 19 .

The amount of ASDUs of TI<36> for the mapping is defined by the configuration attribute "numHar". The IOA addresses for all necessary ASDUs are recommended to be used with consecutive IOA indices:

IOA n := har[0].cVal.mag.f or har[0].cVal.mag.i

IOA n+1 := har[1]. cVal.mag.f or har[1].cVal.mag.i

IOA n+numHar:= har[numHar].cVal.mag.f or har[numHar].cVal.mag.i

7.15 CDC harmonic value for WYE (HWYE)

7.15.1 CDC WYE (HWYE) defined in IEC 61850-7-3:2003

The data attributes of the common data class HWYE depicted in Table 26 shall be mapped as multiple mappings of the common data class HMV as shown in Table 24.

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Table 26 – CDC: Harmonic value for WYE (HWYE) Ed.1

HWYE class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
Harmonics and interharmonics					
phsAHar	ARRAY[0..numHar] OF Vector	MX	dchg, dupd		M
phsBHar	ARRAY[0..numHar] OF Vector	MX	dchg, dupd		O
phsCHar	ARRAY[0..numHar] OF Vector	MX	dchg, dupd		O
neutHar	ARRAY[0..numHar] OF Vector	MX	dchg, dupd		O
netHar	ARRAY[0..numHar] OF Vector	MX	dchg, dupd		O
resHar	ARRAY[0..numHar] OF Vector	MX	dchg, dupd		O
Basics					
q	Quality	MX	qchg	Quality	M
t	TimeStamp	MX		Time value	M

Each used data attribute of the CDC WYE (HWYE) Ed.1 shall be mapped in the same way as it is defined for the CDC HMV.

The mapping of common data class HMV is shown in detail in Table 24.

7.15.2 CDC WYE (HWYE) defined in IEC 61850-7-3:2010

The data attributes of the common data class WYE (HWYE) Ed.2 depicted in Table 27 shall be mapped as multiple mappings of the common data class HMV Ed.2 as shown in Table 25.

Table 27 – CDC: Harmonic value for WYE (HWYE) Ed.2

HWYE class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
Harmonics and interharmonics					
phsAHar	ARRAY[0..numHar] OF CMV	MX	dchg, dupd		M
phsBHar	ARRAY[0..numHar] OF CMV	MX	dchg, dupd		O
phsCHar	ARRAY[0..numHar] OF CMV	MX	dchg, dupd		O
neutHar	ARRAY[0..numHar] OF CMV	MX	dchg, dupd		O
netHar	ARRAY[0..numHar] OF CMV	MX	dchg, dupd		O
resHar	ARRAY[0..numHar] OF CMV	MX	dchg, dupd		O

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Each used data attribute of the CDC WYE (HWYE) Ed.2 shall be mapped in the same way as CDC HMV Ed.2 (shown in Table 25) using multiple mappings of CDC CMV as shown in Table 19.

7.16 CDC harmonic value for DEL (HDEL)

7.16.1 CDC DEL (HDEL) defined in IEC 61850-7-3:2003

The data attributes of the common data class DEL (HDEL) Ed.1 depicted in Table 28 shall be mapped as multiple mappings of the common data class HMV Ed.1 as shown in Table 24.

Table 28 – CDC: Harmonic value for DEL (HDEL)

HDEL class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
Harmonics and interharmonics					
phsABHar	ARRAY[0..numHar] OF Vector	MX	dchg, dupd		M
phsBCHar	ARRAY[0..numHar] OF Vector	MX	dchg, dupd		O
phsCAHar	ARRAY[0..numHar] OF Vector	MX	dchg, dupd		O
Basics					
q	Quality	MX	qchg	Quality	M
t	TimeStamp	MX		Time value	M

Each data attribute of the CDC DEL (HDEL) Ed.1 shall be mapped in the same way as it is defined for the CDC HMV Ed.1.

The mapping of common data class HMV Ed.1 is shown in detail in Table 24.

7.16.2 CDC DEL (HDEL) defined in IEC 61850-7-3:2010

The data attributes of the common data class DEL (HDEL) Ed.2 depicted in Table 29 shall be mapped as multiple mappings of the common data class HMV Ed.2 as shown in Table 25.

Table 29 – CDC: Harmonic value for DEL (HDEL) Ed.2

HDEL class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
Harmonics and interharmonics					
phsABHar	ARRAY[0..numHar] OF CMV	MX	dchg, dupd		M
phsBCHar	ARRAY[0..numHar] OF CMV	MX	dchg, dupd		O
phsCAHar	ARRAY[0..numHar] OF CMV	MX	dchg, dupd		O

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Each used data attribute of the CDC DEL (HDEL) Ed.2 shall be mapped in the same way as CDC HMV Ed.2 (shown in Table 25) using multiple mappings of CDC CMV as shown in Table 19.

7.17 CDC controllable single point (SPC)

The data attributes of the common data class SPC depicted in Table 30 shall be mapped as shown in Table 3 (for the attributes with the functional constraint ST) and Table 31 (for the parameters for control services.).

Table 30 – CDC: Controllable single point (SPC)

SPC class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
status and control mirror					
origin	Originator	ST			AC_CO_O
stVal	BOOLEAN	ST	dchg	FALSE | TRUE	AC_ST
q	Quality	ST	qchg		AC_ST
t	TimeStamp	ST			AC_ST
configuration, description and extension					
ctlModel	ctlModels	CF	dchg		M
parameter for control services					
ctlVal	BOOLEAN			off (FALSE) | on (TRUE)	

Table 3 defines the mapping for the data attributes with the functional constraint ST [stVal + q + t].

Table 31 defines the mapping for data attributes of SPC for the parameters for control services.

The data attribute [ctlVal + origin] or [ctlVal + origin + T] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<45> "Single command" or to IEC 60870-5-104 ASDU TI<58> "Single command with time tag CP56Time2a”.

In IEC 61850-7-3:2003 the parameter for control services “ctlVal” was defined with the functional constraint “CO” and the condition for attribute inclusion “AC_CO_M”. The TrgOp “dchg” for the data attribute “ctlModel” was added in IEC 61850-7-3:2010.

NOTE The attributes T and ctlModel are defined in Clause 17 of IEC 61850-7-2:2003 or Clause 20 of IEC 61850-7-2:2011.

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Table 31 – CDC: Controllable single point (SPC) mapping

CDC class		**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
SPC		TI<45> (without time tag) or TI<58> (with time tag)	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
ctlVal	BOOLEAN	SCO	SCS (Single command state) <0> OFF:= off (FALSE) <1> ON:= on (TRUE) simple SPC -> QU <0> no additional definition other QU values are not used IEC 60870-5-104 and IEC 60870-5-101 support the following modes of the IEC 61850 Control Model (ctlModel): **direct control with normal security** **direct control with enhanced security** S/E <0>:= direct control **SBO control with enhanced security** S/E <1>:= select and execute for details see Subclause 8.8
origin.orIdent	OCTET STRING64	COT	Originator Address:= UI8[9..16] <0..255> <0>:= default [a] <1..255>:= number of originator address The number of originator address shall be mapped to attribute orIdent (OCTET STRING64). NOTE Only values of the length of one octet of orIdent can be mapped to Originator Address because of the limitation in value range.
origin.orCat	ENUMERATED	COT	Cause:= UI6[1..6] <0..63> <u>Valid for parameter for control services (or FC=CO):</u> remote control <-> activation <6> *) <u>Valid for FC = ST:</u> not supported <-> not used <0> remote control <-> return information caused by remote command <11> automatic-remote -> return information caused by remote command <11> bay control <-> return information caused by local command <12> station control, automatic bay, automatic station -> return information caused by local command <12> process <-> spontaneous <3> maintenance -> spontaneous <3>

[a] If the attribute origin does not exist in the CDC the Originator Address has to be set to <0>:= default and the Cause has to be set to “activation” <6>.

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7.18 CDC controllable double point (DPC)

The data attributes of the common data class DPC depicted in Table 32 shall be mapped as shown in Table 5 (for the attributes with the functional constraint ST) and Table 33 (for the parameters for control services).

Table 32 – CDC: Controllable double point (DPC)

DPC class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
status and control mirror					
Origin	Originator	ST			AC_CO_O
stVal	CODED ENUM	ST	dchg	intermediate-state | off | on | bad-state	M
q	Quality	ST	qchg		M
t	TimeStamp	ST			M
configuration, description and extension					
ctlModel	ctlModels	CF	dchg		M
parameter for control services					
ctlVal	BOOLEAN			off (FALSE) | on (TRUE)	

Table 5 defines the mapping for data attributes of DPC with the functional constraint ST [stVal + q + t].

Table 33 defines the mapping for data attributes of DPC for the parameters for control services.

The data attribute [ctlVal+ origin] or [ctlVal + origin + T] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<46> "Double point command" " or to IEC 60870-5-104 ASDU TI<59> "Double command with time tag CP56Time2a.

In IEC 61850-7-3:2003 the parameter for control services “ctlVal” was defined with the functional constraint “CO” and the condition for attribute inclusion “AC_CO_M”. The TrgOp “dchg” for the data attribute “ctlModel” was added in IEC 61850-7-3:2010.

NOTE The attributes T and ctlModel are defined in Clause 17 of IEC 61850-7-2:2003 or Clause 20 of IEC 61850-7-2:2011.

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Table 33 – CDC: Controllable double point (DPC) mapping

CDC class		**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
DPC		TI<46> (without time tag) or TI<59> (with time tag)	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
ctlVal	BOOLEAN	DCO	DCS (Double command state) <0> not permitted <1> OFF:= off (FALSE) <2> ON:= on (TRUE) <3> not permitted simple DPC -> QU <0> no additional definition other QU values may be used (see clause 8.8) IEC 60870-5-104 and IEC 60870-5-101 support the following modes of the IEC 61850 Control Model (ctlModel): **direct control with normal security** **direct control with enhanced security** S/E <0>:= direct control **SBO control with enhanced security** S/E <1>:= select and execute for details see Subclause 8.8
origin.orIdent	OCTET STRING64	COT	Originator Address:= UI8[9..16] <0..255> <0>:= default <1..255>:= number of originator address The number of originator address shall be mapped to attribute orIdent (OCTET STRING64). NOTE Only values of the length of one octet of orIdent can be mapped to Originator Address because of the limitation in value range.
origin.orCat	ENUMERATED	COT	Cause:= UI6[1..6] <0..63> Valid for parameter for control services (or FC = CO): remote control <-> activation <6> Valid for FC = ST: not supported <-> not used <0> remote control <-> return information caused by remote command <11> automatic-remote -> return information caused by remote command <11> bay control <-> return information caused by local command <12> station control, automatic bay, automatic station -> return information caused by local command <12> process <-> spontaneous <3> maintenance -> spontaneous <3>

7.19 CDC controllable integer status (INC)

The data attributes of the common data class INC depicted in Table 34 shall be mapped as shown in Table 7 (for the attributes with the functional constraint ST) and Table 35 (for the parameters for control services).

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Table 34 – CDC: Controllable integer status (INC)

INC class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
status and control mirror					
Origin	Originator	ST			AC_CO_O
stVal	INT32	ST	dchg		M
q	Quality	ST	qchg		M
t	TimeStamp	ST			M
configuration, description and extension					
ctlModel	ctlModels	CF	dchg		M
units	Unit	CF	dchg	See Annex A of IEC 61850-7-3:2010	O
parameter for control services					
ctlVal	INT32				

Table 7 defines the mapping for data attributes of INC with the functional constraint ST [stVal + q + t].

Table 35 defines the mapping for data attributes of INC for the parameters for control services.

The data attribute [ctlVal + origin] or [ctlVal + origin + T] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<49> "Set point command, scaled value" or to IEC 60870-5-104 ASDU TI<62> "Set point command, scaled value with time tag CP56Time2a".

In IEC 61850-7-3:2003 the parameter for control services “ctlVal” was defined with the functional constraint “CO” and the condition for attribute inclusion “AC_CO_M”. The TrgOp “dchg” for the data attribute “ctlModel” was added in IEC 61850-7-3:2010.

NOTE The attributes T and ctlModel are defined in Clause 17 of IEC 61850-7-2:2003 or Clause 20 of IEC 61850-7-2:2011.

In IEC 61850-7-3:2010 the configuration attribute “units” of type “Unit” was added to the CDC INC. The TrgOp of the attribute “units” was defined as “dchg”. Furthermore the TrgOp “dupd” was added for the attribute “stVal".

The type “Unit” consists of two attributes – “SIUnit” (as mandatory) and “multiplier” (as optional), both of type ENUMERATED.

Optionally the attribute “units.multiplier”, which might have an influence on the mapping of the value of stVal, can be mapped to ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a"

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Table 35 – CDC: Controllable integer status (INC) mapping

CDC class		IEC 60870-5-101 or IEC 60870-5-104 mapping	
INC		TI<49> (without time tag) or TI<62> (with time tag)	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
ctlVal	INT32	SVA	SVA ... I16 <-215..+215-1> simple INC -> QU <0> no additional definition other QU values are not used IEC 60870-5-104 and IEC 60870-5-101 support the following modes of the IEC 61850 Control Model (ctlModel): **direct control with normal security** **direct control with enhanced security** S/E <0>:= direct control **SBO control with enhanced security** S/E <1>:= select and execute for details see Subclause 8.8
origin.orIdent	OCTET STRING64	COT	Originator Address:= UI8[9..16] <0..255> <0>:= default *) <1..255>:= number of originator address The number of originator address shall be mapped to attribute orIdent (OCTET STRING64). NOTE Only values of the length of one octet of orIdent can be mapped to Originator Address because of the limitation in value range.
origin.orCat	ENUMERATED	COT	Cause:= UI6[1..6] <0..63> <u>Valid for parameter for control services (or FC=CO):</u> remote control <-> activation <6> *) <u>Valid for FC = ST:</u> not supported <-> not used <0> remote control <-> return information caused by remote command <11> automatic-remote -> return information caused by remote command <11> bay control <-> return information caused by local command <12> station control, automatic bay, automatic station -> return information caused by local command <12> process <-> spontaneous <3> maintenance -> spontaneous <3>
*) NOTE If the attribute origin is not existing in the CDC the Originator Address has to be set to <0>:= default and the Cause has to be set to “activation” <6>.			

7.20 CDC binary controlled step position information (BSC)

The data attributes of the common data class BSC depicted in Table 36 shall be mapped as shown in Table 37 (for the attributes with the functional constraint ST) and Table 38 (for the parameters for control services).

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Table 36 – CDC: Binary controlled step position information (BSC)

BSC class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
status and control mirror					
origin	Originator	ST			AC_CO_O
valWTr	ValWithTrans	ST	dchg		AC_ST
q	Quality	ST	qchg		AC_ST
t	TimeStamp	ST			AC_ST
Configuration, description and extension					
ctlModel	ctlModels	CF	dchg		M
parameter for control services					
ctlVal	CODED ENUM			stop | lower | higher | reserved	

Table 37 defines the mapping for data attributes of BSC with the functional constraint ST. The data attributes [valWTr + q + t]. shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<32> "Step position information with time tag CP56Time2a".

Table 38 defines the mapping for data attributes of BSC for the parameters for control services.

The data attribute [ctlVal + origin] or [ctlVal +origin + T] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<47> "Regulating step command" or to IEC 60870-5-104 ASDU TI<60> "Regulating step command with time tag CP56Time2a".

In IEC 61850-7-3:2003 the parameter for control services “ctlVal” was defined with the functional constraint “CO” and the condition for attribute inclusion “AC_CO_M”. The TrgOp “dchg” for the data attribute “ctlModel” was added in IEC 61850-7-3:2010.

NOTE The attribute T and ctlModel are defined in Clause 17 of IEC 61850-7-2:2003 or Clause 20 of IEC 61850-7-2:2011.

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Table 37 – CDC: Binary controlled step position information (BSC) mapping of data attributes of the functional constraint ST

CDC class			IEC 60870-5-101 or IEC 60870-5-104 mapping	
BSC			TI<32>	
Attribute name	**Attribute type**	**DAComponent**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
valWTr	ValWithTrans	valWTr.posVal INT8	VTI	Value I7 <-64 ...+63>
		valWTr.transInd BOOLEAN	VTI	Transient BS1[8] <0> equipment is not in transient state:= FALSE <1> equipment is in transient state:= TRUE
q	Quality		QDS	validity -> IV good | invalid -> valid | invalid questionable -> NT detailQual -> OV overflow -> overflow source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp		CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence o f dchg or qchg

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Table 38 – CDC: Binary controlled step position information (BSC) mapping of data attributes of the functional constraint CO

CDC class		IEC 60870-5-101 or IEC 60870-5-104 mapping	
BSC		TI<47> (without time tag) or TI<60> (with time tag)	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
ctlVal	CODED ENUM	RCO	RCS Regulating step command state <0> not permitted <1> next step LOWER:= lower <2> next step HIGHER:= higher <3> not permitted simple BSC -> QU <0> no additional definition other QU values are not used IEC 60870-5-104 and IEC 60870-5-101 support the following modes of the IEC 61850 Control Model (ctlModel): **direct control with normal security** **direct control with enhanced security** S/E <0>:= direct control **SBO control with enhanced security** S/E <1>:= select and execute for details see Subclause 8.8
origin.orIdent	OCTET STRING64	COT	Originator Address:= UI8[9..16] <0..255> <0>:= default <1..255>:= number of originator address The number of originator address shall be mapped to attribute orIdent (OCTET STRING64). NOTE Only values of the length of one octet of orIdent can be mapped to Originator Address because of the limitation in value range.
origin.orCat	ENUMERATED	COT	Cause:= UI6[1..6] <0..63> Valid for parameter for control services (or FC=CO): remote control <-> activation <6> Valid for FC = ST: not supported <-> not used <0> remote control <-> return information caused by remote command <11> automatic-remote -> return information caused by remote command <11> bay control <-> return information caused by local command <12> station control, automatic bay, automatic station -> return information caused by local command <12> process <-> spontaneous <3> maintenance -> spontaneous <3>

7.21 CDC integer-controlled step position information (ISC)

The data attributes of the common data class ISC depicted in Table 39 shall be mapped as shown in Table 37 (for the attributes with the functional constraint ST) and Table 40 (for the parameters for control services).

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Table 39 – CDC: Integer-controlled step position information (ISC)

ISC class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
status and control mirror					
origin	Originator	ST			AC_CO_O
valWTr	ValWithTrans	ST	dchg		AC_ST
q	Quality	ST	qchg		AC_ST
t	TimeStamp	ST			AC_ST
configuration, description and extension					
ctlModel	ctlModels	CF	dchg		M
parameter for control services					
ctlVal	INT8			-64 … +63	

Table 37 defines the mapping for data attributes of ISC with the functional constraint ST [valWTr + q + t].

Table 40 defines the mapping for data attributes of ISC for the parameters for control services.

The data attribute [ctlVal + origin] or [ctlVal + origin + T] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<49>"Set point command, scaled value" or to IEC 60870-5-104 ASDU TI<62> "Set point command, scaled value with time tag CP56Time2a".

In IEC 61850-7-3:2003 the parameter for control services “ctlVal” was defined with the functional constraint “CO” and the condition for attribute inclusion “AC_CO_M”. The TrgOp “dchg” for the data attribute “ctlModel” was added in IEC 61850-7-3:2010.

NOTE The attribute T and ctlModel are defined in Clause 17 of IEC 61850-7-2:2003 or Clause 20 of IEC 61850-7-2:2011.

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Table 40 – CDC: Integer-controlled step position information (ISC) mapping

CDC class		IEC 60870-5-101 or IEC 60870-5-104 mapping	
ISC		TI <49> (without time tag) or TI <62> (with time tag)	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
ctlVal	INT8	SVA	I16 <-2^{15}..+2^{15}-1> simple ISC -> QU <0> no additional definition other QU values are not used IEC 60870-5-104 and IEC 60870-5-101 support the following modes of the IEC 61850 Control Model (ctlModel): **direct control with normal security** **direct control with enhanced security** S/E <0>:= direct control **SBO control with enhanced security** S/E <1>:= select and execute for details see Subclause 8.8
origin.orIdent	OCTET STRING64	COT	Originator Address:= UI8[9..16] <0..255> <0>:= default <1..255>:= number of originator address The number of originator address shall be mapped to attribute orIdent (OCTET STRING64). NOTE Only values of the length of one octet of orIdent can be mapped to Originator Address because of the limitation in value range.
origin.orCat	ENUMERATED	COT	Cause:= UI6[1..6] <0..63> Valid for parameter for control services (or FC=CO): remote control <-> activation <6> Valid for FC = ST: not supported <-> not used <0> remote control <-> return information caused by remote command <11> automatic-remote -> return information caused by remote command <11> bay control <-> return information caused by local command <12> station control, automatic bay, automatic station -> return information caused by local command <12> process <-> spontaneous <3> maintenance -> spontaneous <3>

7.22 CDC controllable analogue set point information (APC)

7.22.1 CDC APC defined in IEC 61850-7-3:2003

The data attributes of the common data class APC depicted in Table 41 shall be mapped as shown in Table 43 (for the attributes with the functional constraint MX) and Table 44 (for the attributes with the functional constraint SP).

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Table 41 – CDC: Controllable analogue set point information (APC) (Ed.1)

APC class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
setpoint and measured attributes					
setMag	AnalogueValue	CO,MX	dchg		M
origin	Originator	CO,MX			O
q	Quality	MX	qchg		M
t	TimeStamp	MX			M
Configuration, description and extension					
ctlModel	ctlModels	CF			M

NOTE 1 During the maintenance process of IEC 61850-7-3:2003, TISSUE 28 related to CDC APC has been brought up. According to TISSUE 28, the FC (functional constraint) of the attributes setMag and origin of Table 38 had been changed from SP to CO. The proposed mapping to TI<50> or TI<53> in Table 40 is in accordance with this TISSUE.

Table 43 defines the mapping for data attributes of APC with the functional constraint MX. The data attributes [setMag + q + t]. shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<36> "Measured value, short floating point value with time tag CP56Time2a".

Table 44 defines the mapping for data attributes of APC with the functional constraint CO. The data attribute [setMag + origin] or [setMag + origin + T] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<50>"Set point command, short floating point value" or to IEC 60870-5-104 ASDU TI<63> "Set point command, short floating point value with time tag CP56Time2a".

NOTE 2 The attribute T and ctlModel are defined in Clause 17 of IEC 61850-7-2:2003.

7.22.2 CDC APC defined in IEC 61850-7-3:2010

The data attributes of the common data class APC depicted in Table 42 shall be mapped as shown in Table 43 (for attributes with the functional constraint MX) and Table 44 (for parameter for control services).

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Table 42 – CDC: Controllable analogue set point information (APC) (Ed.2)

APC class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
setpoint and measured attributes					
mxVal	AnalogueValue	MX	dchg		AC_ST
origin	Originator	MX			AC_CO_O
q	Quality	MX	qchg		AC_ST
t	TimeStamp	MX			AC_ST
configuration, description and extension					
ctlModel	ctlModels	CF	dchg		M
units	Unit	CF	dchg	See ANNEX A of IEC 61850-7-3:2010	O
sVC	ScaledValueConfig	CF	dchg		AC_SCAV
db	INT32U	CF	dchg	0 ... 100 000	O
Parameters for control services					
ctlVal	AnalogueValue				

The type “Unit” consists of two attributes – “SIUnit” (as mandatory) and “multiplier” (as optional), both of type ENUMERATED.

The type “ScaledValueConfig” consists of two attributes – “scaleFactor” and “offset”, both mandatory and of type FLOAT32.

Table 43 defines the mapping for data attributes of APC with the functional constraint MX. The data attributes [mxVal + q + t]. shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<36> "Measured value, short floating point value with time tag CP56Time2a".

Table 44 defines the mapping for parameter for control services of APC. The data attribute [ctlVal + origin] or [ctlVal + origin + T] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<50>"Set point command, short floating point value" or to IEC 60870-5-104 ASDU TI<63> "Set point command, short floating point value with time tag CP56Time2a".

NOTE The attribute T and ctlModel are defined in Clause 20 of IEC 61850-7-2:2011.

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Table 43 – CDC: Controllable analogue set point information (APC) mapping of data attributes of the functional constraint MX

CDC class			IEC 60870-5-101 or IEC 60870-5-104 mapping	
APC			TI<36>	
Attribute name	**Attribute type**	**DAComponent**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
setMag /mxVal	AnalogueValue	setMag.f FLOAT32	IEEE STD 754	R32.23{Fraction,Exponent,Sign}
q	Quality		QDS	validity -> IV good | invalid -> valid | invalid questionable -> NT detailQual -> OV overflow -> overflow source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp		CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence of dchg or qchg

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Table 44 – CDC: Controllable analogue set point information (APC) mapping of data attributes of the functional constraint SP

CDC class			IEC 60870-5-101 or IEC 60870-5-104 mapping	
APC			TI<50> (without time tag) or TI<63> (with time tag)	
Attribute name	**Attribute type**	**DAComponent**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
setMag / mxVal	AnalogueValue	setMag.f FLOAT32	IEEE STD 754	R32.23{Fraction,Exponent,Sign}
origin.orIdent	OCTET STRING64		COT	Originator Address:= UI8[9..16] <0..255> <0>:= default *) <1..255>:= number of originator address The number of originator address shall be mapped to attribute orIdent (OCTET STRING64). NOTE Only values of the length of one octet of orIdent can be mapped to Originator Address because of the limitation in value range.
origin.orCat	ENUMERATED		COT	Cause:= UI6[1..6] <0..63> Valid for parameter for control services (or FC=CO): remote control <-> activation <6> *) Valid for FC = ST: not supported <-> not used <0> remote control <-> return information caused by remote command <11> automatic-remote -> return information caused by remote command <11> bay control <-> return information caused by local command <12> station control, automatic bay, automatic station -> return information caused by local command <12> process <-> spontaneous <3> maintenance -> spontaneous <3>

*) NOTE If the attribute origin is not existing in the CDC the Originator Address has to be set to <0>:= default and the Cause has to be set to “activation” <6>.

Optionally the attribute “units.multiplier”, which might have an influence on the mapping of the value of setMag/mxVal, can be mapped to ASDU TI<35> "Measured value, scaled value with **time tag CP56Time2a.**

Optionally “sVC.scaleFactor” and “sVC.offset” which also might have an influence on the mapping of the value of setMag/mxVal, can be mapped to ASDU TI<36> ”Measured value, short floating point value with time tag CP56Time2a”.

The optional configuration attribute "db" can be optionally set by ASDU TI<111> "Parameter of measured value, scaled value" or ASDU TI<112> "Parameter of measured value, short floating point value" as described in Clause 8.

7.23 CDC Single point setting (SPG)

The data attributes of the common data class SPG depicted in Table 45 shall be mapped as shown in Table 31.

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Table 45 – CDC: Single point setting (SPG)

SPG class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from Data Class (see IEC 61850-7-2)				
DataAttribute					
setting					
setVal	BOOLEAN	SP		off (FALSE) | on (TRUE)	AC_NSG_M

The data attribute [setVal] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<45> "Single command" or to IEC 60870-5-104 ASDU TI<58> "Single command with time tag CP56Time2a" as shown in Table 31.

In IEC 61850-7-3:2010 the TrgOp “dchg” was added to attribute setVal.

To create an event in monitor direction the Data Attribute setVal can be mapped like the Data Attribute stVal of CDC SPS with q = valid and t = actual time.

7.24 CDC integer status setting (ING)

The data attributes of the common data class ING depicted in Table 46 shall be mapped as shown in Table 35.

Table 46 – CDC: Integer status setting (ING)

ING class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
setting					
setVal	INT32	SP			AC_NSG_M
configuration, description and extension					
units	Unit	CF	dchg	See ANNEX A of IEC 61850-7-3:2010	O

The data attribute [setVal] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<49> "Set point command, scaled value" or to IEC 60870-5-104 ASDU TI<62> "Set point command, scaled value with time tag CP56Time2a" as shown in Table 35.

In IEC 61850-7-3:2010 the TrgOp “dchg” was added to attribute setVal.

In IEC 61850-7-3:2010 the configuration attribute “units” of type “Unit” was added to the CDC ING. The TrgOp of the attribute “units” was defined as “dchg”.

The type “Unit” consists of two attributes – “SIUnit” (as mandatory) and “multiplier” (as optional), both of type ENUMERATED.

Optionally the attribute “units.multiplier”, which might have an influence on the mapping of the value of setVal, can be mapped to ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a.

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To create an event in monitor direction the Data Attribute setVal can be mapped like the Data Attribute stVal of CDC INS with q = valid and t = actual time.

7.25 CDC analogue settings (ASG)

The data attributes of the common data class ASG depicted in Table 47 shall be mapped as shown in Table 44.

Table 47 – CDC: Analogue settings (ASG)

ASG class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from Data Class (see IEC 61850-7-2)				
DataAttribute					
setting					
setMag	AnalogueValue	SP			AC_NSG_M
configuration, description and extension					
units	Unit	CF	dchg	See ANNEX A of IEC 61850-7-3:2010	O
sVC	ScaledValueConfig	CF	dchg		AC_SCAV

The type “Unit” consists of two attributes – “SIUnit” (as mandatory) and “multiplier” (as optional), both of type ENUMERATED.

The type “ScaledValueConfig” consists of two attributes – “scaleFactor” and “offset”, both mandatory and of type FLOAT32.

The data attribute [setMag] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<50> "Set point command, short floating point value" or to IEC 60870-5-104 ASDU TI<63> "Set point command, short floating point value with time tag CP56Time2a" as shown in Table 44.

In IEC 61850-7-3:2010 the TrgOp “dchg” was added to attribute setMag.

Optionally the attribute “units.multiplier”, which might have an influence on the mapping of the value of setMag, can be mapped to ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a.

Optionally “sVC.scaleFactor” and “sVC.offset” which also might have an influence on the mapping of the value of setMag, can be mapped to ASDU TI<36>”Measured value, short floating point value with time tag CP56Time2a”

To create an event in monitor direction the Data Attribute setMag can be mapped like the Data Attribute mag of CDC MV with q = valid and t = actual time.

7.26 CDC enumerated status (ENS)

The DataAttributes of the common data class ENS depicted in Table 48 shall be mapped as shown in Table 49.

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Table 48 – CDC: Enumerated status (ENS)

ENS class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
status					
stVal	ENUMERATED	ST	dchg		M
q	Quality	ST	qchg	Quality	M
t	TimeStamp	ST		Time	M

The data attributes [stVal + q + t] shall map to either ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a".

Optionally the data attributes [stVal + q + t] can be mapped to ASDU TI<30> "Single-point information with time tag CP56Time2a" as specified in Table 49.

NOTE The semantic of stVal dependent on the corresponding Data Attribute is defined in Clause 8 of IEC 61850-7-3:2010.

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Table 49 – CDC: Enumerated status (ENS) mapping

CDC class		**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
ENS		TI<35>	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
stVal	ENUMERATED	SVA = Scaled value	SVA I16<-2^{15}..+2^{15}-1> 0 map on 0 Valid range for INT32 is <-2^{15} ....+2^{15}-1
q	Quality	QDS = Quality descriptor	validity -> IV good | invalid -> valid |invalid questionable -> NT detailQual -> OV overflow -> overflow source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp	CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrenceof dchg or qchg
CDC class		**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
ENS		TI<30>	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
stVal	ENUMERATED	SIQ = Single-point information with quality descriptor	SPI <1> ON = TRUE
q	Quality	QDS = Quality descriptor	validity -> IV good | invalid -> valid |invalid questionable -> NT source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp	CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence of dchg or qchg

If the mapping to ASDU TI <30> is used ,the semantic of the corresponding Data Attribute has an impact on the number of ASDUs needed for mapping. Every enumerated value defined for the corresponding Data Attribute shall map to one ASDU TI<30> with SPI <1> on =TRUE. For GI the ASDU TI <1> with SPI<0> = FALSE is used.

7.27 CDC Histogramm (HST)

The data attributes oft he common data class HST depicted in Table 50 shall be mapped. The number of “hstVal” attributes is variable (numPts:= 0 ... maxPts-1).The signals [hstVal (numPts)+ q + t] shall map to either ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a" or optionally ASDU TI<33> "Bitstring of 32 bits with time tag CP56Time2a" as specified in Table 7 (such as stVal).

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Table 50 – CDC: Histogramm (HST)

HST class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
status					
hstVal	ARRAY 0..numPts OF INT32	ST	dchg		M
q	Quality	ST	qchg	Quality	M
t	TimeStamp	ST		Time	M
Configuration, description and extension					
numPts	INT16U	CF		0 < numPts <= maxPts	M
maxPts	INT16U	CF			M
units	Unit	CF	dchg	See ANNEX A of IEC 61850-7-3:2010	O

Each data attribute “hstVal” (of Attribute Type INT32) shall map to either ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a" or optionally ASDU TI<33> "Bitstring of 32 bits with time tag CP56Time2a".The amount of ASDUs of TI<35> or TI<33> for the mapping is defined by the configuration attribute “numPts”. The IOA addresses for all necessary ASDUs shall be used with consecutive IOA indices:

IOA n := hstVal[0]

IOA n + 1 := hstVal[1]

IOA n+(maxPts-1) := hstVal[maxPts-1]

In IEC 61850-7-3:2010 the configuration attribute “units” of type “Unit” was added to the CDC HST. The TrgOp of the attribute “units” was defined as “dchg”.

The type “Unit” consists of two attributes – “SIUnit” (as mandatory) and “multiplier” (as optional), both of type ENUMERATED.

Optionally the attribute “units.multiplier”, which might have an influence on the mapping of the value of hstVal, can be mapped to ASDU TI<35> "Measured value, scaled value with time tag CP56Time2a.

7.28 CDC controllable enumerated status (ENC)

The data attributes of the common data class ENC depicted in Table 51 shall be mapped as shown in Table 49 (for attributes with the functional constraint ST) and Table 52 (for service parameter ctlVal).

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Table 51 – CDC: Controllable enumerated status (ENC)

ENC class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
Status and control mirror					
origin	Originator	ST			AC_CO_O
stVal	ENUMERATED	ST	dchg		M
q	Quality	ST	qchg		M
t	TimeStamp	ST			M
Configuration, description and extension					
ctlModel	ctlModels	CF	dchg		M
parameters for control services					
ctlVal	ENUMERATED				

Table 49 defines the mapping for data attributes of ENC with the functional constraint ST [stVal + q + t].

Table 52 defines the mapping for data attributes of ENC used for control services.The data attribute [ctlVal + origin] or [ctlVal + origin + T] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<49> "Set point command, scaled value" or to IEC 60870-5-104 ASDU TI<62> "Set point command, scaled value with time tag CP56Time2a".

Optionally the data attribute [ctlVal + origin] or [ctlVal + origin + T] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<45> “Single command” or to IEC 60870-5-104 ASDU TI<58> “Single command with time tag CP56Time2a”.

NOTE The attribute T and ctlModel are defined in Clause 20 of IEC 61850-7-2:2011.

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Table 52 – CDC: Controllable enumerated status (ENC) mapping

CDC class		**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
ENC		TI<49> (without time tag) or TI<62> (with time tag)	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
ctlVal	ENUMERATED	SVA	SVA ... I16 <-2^{15}..+2^{15}-1> simple ENC -> QU <0> no additional definition other QU values are not used IEC 60870-5-104 and IEC 60870-5-101 support the following modes of the IEC 61850 Control Model (ctlModel): **direct control with normal security** **direct control with enhanced security** S/E <0>:= direct control **SBO control with enhanced security** S/E <1>:= select and execute for details see Subclause 8.8
origin.orIdent	OCTET STRING64	COT	Originator Address:= UI8[9..16] <0..255> <0>:= default *) <1..255>:= number of originator address The number of originator address shall be mapped to attribute orIdent (OCTET STRING64). NOTE Only values of the length of one octet of orIdent can be mapped to Originator Address because of the limitation in value range.
origin.orCat	ENUMERATED	COT	Cause:= UI6[1..6] <0..63> Valid for parameter for control services: remote control <-> activation <6> *) Valid for FC = ST: not supported <-> not used <0> remote control <-> return information caused by remote command <11> automatic-remote -> return information caused by remote command <11> bay control <-> return information caused by local command <12> station control, automatic bay, automatic station -> return information caused by local command <12> process <-> spontaneous <3> maintenance -> spontaneous <3>

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CDC class		IEC 60870-5-101 or IEC 60870-5-104 mapping	
ENC		TI<45> (without time tag) or TI<58> (with time tag)	
Attribute name	**Attribute type**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
ctlVal	BOOLEAN	SCO	SCS (Single command state) <1> ON:= on (TRUE) simple ENC -> QU <0> no additional definition other QU values are not used IEC 60870-5-104 and IEC 60870-5-101 support the following modes of the IEC 61850 Control Model (ctlModel): direct control with normal security direct control with enhanced security S/E <0>:= direct control SBO control with enhanced security S/E <1>:= select and execute for details see Subclause 8.8
origin.orIdent	OCTET STRING64	COT	Originator Address:= UI8[9..16] <0..255> <0>:= default *) <1..255>:= number of originator address The number of originator address shall be mapped to attribute orIdent (OCTET STRING64). NOTE Only values of the length of one octet of orIdent can be mapped to Originator Address because of the limitation in value range.
origin.orCat	ENUMERATED	COT	Cause:= UI6[1..6] <0..63> Valid for parameter for control services: remote control <-> activation <<6>> [a] Valid for FC = ST: not supported <-> not used <0> remote control <-> return information caused by remote command <11> automatic-remote -> return information caused by remote command <11> bay control <-> return information caused by local command <12> station control, automatic bay, automatic station -> return information caused by local command <12> process <-> spontaneous <3> maintenance -> spontaneous <3>
[a] If the attribute origin does not exist in the CDC the Originator Address has to be set to <0>:= default and the Cause has to be set to “activation” <6>.			

If the mapping to ASDU TI <45> “Single command” or TI<58> “Single command with time tag CP56Time2a” is used, the semantic of the corresponding Data Attribute has an impact on the number of ASDUs needed for mapping. Every enumerated value defined for the corresponding Data Attribute shall map to **one** ASDU TI<45> or TI<58> with SPI <1> on =TRUE.

ASDU TI<58> can be used for IEC 60870-5-104 only.

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7.29 CDC Enumerated status setting (ENG)

The data attributes of the common data class ENG depicted in Table 53 shall be mapped as shown in Table 52.

Table 53 – CDC: Enumerated status setting (ENG)

ING class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
setting					
setVal	ENUMERATED	SP	dchg		AC_NSG_M

The data attribute [setVal] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<49> "Set point command, scaled value" or to IEC 60870-5-104 ASDU TI<62> "Set point command, scaled value with time tag CP56Time2a" or optionally to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<45> “Single command” or to IEC 60870-5-104 ASDU TI<58> “Single command with time tag CP56Time2a”as shown in Table 52.

To create an event in monitor direction the Data Attribute setVal can be mapped like the Data Attribute stVal of CDC ENS with q = valid and t = actual time.

NOTE The semantics of setVal dependent on the Data Attribute are defined in Clause 8 of IEC 61850-7-3:2010.

7.30 CDC Binary controlled analog process value (BAC)

The data attributes of common data class BAC depicted in Table 54 shall be mapped as shown in Table 55.

Table 54 – CDC Binary controlled analog process value (BAC)

ENS class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
status and control mirror					
origin	Originator	MX			AC_CO_O
mxVal	AnalogueValue	MX	dchg		AC_ST
q	Quality	MX	qchg	Quality	AC_ST
t	TimeStamp	MX		Time	AC_ST
configuration, description and extension					
ctlModel	ctlModels	CF	dchg		M
units	Unit	CF	dchg	See ANNEX A of IEC 61850-7-3:2010	O
Parameters for control services					
ctlVal	CODED ENUM			stop | lower | higher | reserved	

In IEC 61850-7-3:2010 the configuration attribute “units” of type “Unit” was added to the CDC BAC. The TrgOp of the attribute “units” was defined as “dchg”.

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The type “Unit” consists of two attributes – “SIUnit” (as mandatory) and “multiplier” (as optional), both of type ENUMERATED.

Table 55 defines the mapping for data attributes of BAC with the functional constraint MX. The data attributes [mxVal + q + t]. shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<36> "Measured value, short floating point value with time tag CP56Time2a".

Optionally the attribute “units.multiplier”, which might have an influence on the mapping of the value of mxVal, can be mapped to ASDU TI <35> "Measured value, scaled value with time tag CP56Time2a.

Table 55 – CDC: Binary controlled analog process value (BAC) mapping of data attributes of the functional constraint MX

CDC class			**IEC 60870-5-101 or IEC 60870-5-104 mapping**	
BAC			TI<36>	
Attribute name	**Attribute type**	**DAComponent**	**Information element**	**IEC 60870-5-104 or IEC 60870-5-101 object group mapping**
mxVal	AnalogueValue	mxVal.f FLOAT32	IEEE STD 754	R32.23{Fraction,Exponent,Sign}
q	Quality		QDS	validity -> IV good | invalid -> valid | invalid questionable -> NT detailQual -> OV overflow -> overflow source -> SB substituted -> substituted operatorBlocked -> BL blocked -> blocked
t	TimeStamp		CP56Time2a	Seven octet binary time, CP56Time2a – Time of occurrence of dchg or qchg

Table 38 defines the mapping for the Service parameter ctlVal of BAC. The data attribute [ctlVal + origin] or [ctlVal + origin + T] shall map to IEC 60870-5-104 or IEC 60870-5-101 ASDU TI<47> "Regulating step command" or to IEC 60870-5-104 ASDU TI<60> "Regulating step command with time tag CP56Time2a".

NOTE The attributes T and ctlModel are defined in Clause 20 of IEC 61850-7-2:2011.

7.31 CDC Curve shape setting (CSG)

The data attributes of the common data class CSG depicted in Table 56 shall be mapped as shown in Table 44.

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Table 56 – CDC: Curve shape setting CSG

CSG class					
Attribute name	**Attribute type**	**FC**	**TrgOp**	**Explanation and value / Range**	**M/O**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
setting					
crvPts	ARRAY 0..maxPts -1 OF Point	SP	dchg		AC_NSG_M
Configuration, description and extension					
maxPts	INT16U	CF			M
xUnit	Unit	CF			M
yUnit	Unit	CF			M

The type “Unit” consists of two attributes – “SIUnit” (as mandatory) and “multiplier” (as optional), both of type ENUMERATED.

As defined in Subclause 6.11 of IEC 61850-7-3:2010 the data type “Point” consists of 3 FLOAT32 Values (xVal, yVal, zVal). The data attribute zVal is optional (used for 3rd dimension) and is currently not mapped.

Each data attribute of “crvPts” (of class “Point”) of the ARRAY shall map to the ASDU TI<50> “Set point command, short floating point value” or to ASDU TI<63> “Set point command, short floating point value with time tag CP56Time2a” as shown in Table 44.

The amount of ASDUs of TI<50> or TI<63> for the mapping is defined by the configuration attribute “maxPts”.

The data attributes “xVal” and “yVal” of class “Point” shall be used with consecutive IOA indices:

IOA n := crvPts[0].xVal

IOA n+1 := crvPts[0].yVal

IOA n+2 := crvPts[1].xVal

IOA n+3 := crvPts[1].yVal

IOA n+((maxPts-1)*2) .=crvPts[maxPts-1].xVal

IOA n+((maxPts-1)*2)+1:= crvPts[maxPts-1].yVal

Optionally the attributes “xUnits.multiplier” and/or “yUnits.multiplier”, which might have an influence on the mapping of the value of “xVal” and/or “yVal”, can be mapped to ASDU TI <35> "Measured value, scaled value with time tag CP56Time2a.

8 Mapping of services

8.1 List of service models and corresponding mappings

The service models defined in ACSI (for example IEC 61850-7-2) and the corresponding mapping to IEC 60870-5-104 or IEC 60870-5-101 is summarized in Table 57.

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Table 57 – Services requiring client/server communication profile

	IEC 61850-7-2 service	Maps to
Server		**Outstation (controlled station)**
	GetServerDirectory	n.a. (to be added optionally with services outside of IEC 60870-5-104 or IEC 60870-5-101) [a]
Association		**Connection**
	Associate	Establish; IEC 60870-5-104:2006 Subclause 7.1 Station initialization
	Abort	n.a. [a]
	Release	Close; IEC 60870-5-104:2006 Subclause 7.1 Station initialization
Logical Device		**CASDU**
	GetLogicalDeviceDirectory	n.a. (to be added optionally with services outside of IEC 60870-5-104 or IEC 60870-5-101) [a]
Logical Node		**One or a set of IOA(‘es)**
	GetLogicalNodeDirectory	n.a. (to be added optionally with services outside of IEC 60870-5-104 or IEC 60870-5-101) [a]
	GetAllDataValues	Interrogation command TI<100>
Data		**One or a set of ASDU(‘es)**
	GetDataValues	Read command ASDU TI<102> (the Read procedure is defined in IEC 60870-5-101:2003 Subclause 7.4.14)
	SetDataValues	ASDU TI<111> "Parameter of measured value, scaled value" or ASDU TI<112> "Parameter of measured value, short floating point value" are optinally used to set the attribute db of CDCs MV and CMV (the procedure of parameter loading is defined in IEC 60870-5-101:2003 Subclause 7.4.9)
	GetDataDirectory	n.a. (to be added optionally with services outside of IEC 60870-5-104 or IEC 60870-5-101) [a]
	GetDataDefinition	n.a. (to be added optionally with services outside of IEC 60870-5-104 or IEC 60870-5-101) [a]
Data Set		n.a. [a]
	GetDataSetValues	n.a. [a]
	SetDataSetValues	n.a. [a]
	CreateDataSet	n.a. [a]
	DeleteDataSet	n.a. [a]
	GetDataSetDirectory	n.a. [a]
Setting Group Control Block		
	SelectActiveSG	Single command ASDU TI<45>
	SelectEditSG	n.a. [a]
	SetSGValues	n.a. [a]
	ConfirmEditSGValues	n.a. [a]

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	IEC 61850-7-2 service	Maps to
	GetSGValues	n.a. [a]
	GetSGCBValues	n.a. [a]
Report Control Block		
	Report	GI, Spontaneous and/or integrity transmission with applicable ASDUs [b]
	GetBRCBValues	n.a. [a]
	SetBRCBValues	n.a. [a c]
	GetURCBValues	n.a. [a]
	SetURCBValues	n.a. [a c]
LOG Control Block		n.a. [a]
	GetLCBValues	n.a. [a]
	SetLCBValues	n.a. [a]
LOG		n.a. [a]
	GetLogStatusValues	n.a. [a]
	QueryLogByTime	n.a. [a]
	QueryLogAfter	n.a. [a]
Control		**Controllable information object**
	Select	n.a. [a]
	SelectWithValue	ASDU TI <45,46,47,49,50>or<58,59,60,62,63>
	Cancel	ASDU TI <45,46,47,49,50>or<58,59,60,62,63>
	Operate	ASDU TI <45,46,47,49,50>or<58,59,60,62,63>
	CommandTermination	ASDU TI <45,46,47,49,50>or<58,59,60,62,63>
	TimeActivatedOperate	n.a. [a]

a) Not applicable for the mapping to IEC 60870-5-104 or IEC 60870-5-101.

b) ASDUs for spontaneous transmission: <30>,<31>,<32>,<33>,<35>,<36>,<37>,<39>,<40> (selected in Clause 9).

c) ASDU TI<100> ACT can be optionally mapped to the service SetBRCBValues/SetURCBValues with attribute GI=TRUE

8.2 Server class mapping

The server class shall be mapped to services of a controlled station as shown in Table 58.

NOTE Details of the initialization etc. of the controlled station are defined in IEC 60870-5-104 or IEC 60870-5-101.

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Table 58 – Server services mapping

	IEC 61850-7-2 service	Maps to
Server		**Outstation (controlled station)**
	GetServerDirectory	n.a. (to be added optionally with services outside of IEC 60870-5-104 or IEC 60870-5-101) [a]
[a] Not applicable for the mapping to IEC 60870-5-104 or IEC 60870-5-101.		

8.3 Association class mapping

The association service shall be mapped to services of IEC 60870-5-104 as shown in Table 59.

NOTE Details of the initialization etc. of controlled and controlling station are defined in IEC 60870-5-104.

Table 59 – Association services mapping

	IEC 61850-7-2 service	Maps to
Association		**Connection**
	Associate	Establish; IEC 60870-5-104:2006 Subclause 7.1 Station initialization
	Abort	n.a. [a]
	Release	Close; IEC 60870-5-104:2006 Subclause 7.1 Station initialization
[a] Not applicable for the mapping to IEC 60870-5-104.		

8.4 Logical node class mapping

The GetAllDataValues service shall be mapped to services of IEC 60870-5-104 or IEC 60870-5-101 as shown in Table 60.

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Table 60 – Logical nodes services mapping

	IEC 61850-7-2 service	Maps to
Logical node		**One or a set of IOA(‘es)**
	GetAllDataValues	TI<100> General Interrogation with: – applicable CASDU address – Qualifier of interrogation (QOI)=20 <station interrogation (global)>
The corresponding process data response shall be one or more than one of the following ASDUs depending on the type of the applicable signals with cause of transmission (COT) = 20 <interrogated by station interrogation>.		
Type Id	**ASDU**	**Abbreviation**
Process information in monitoring direction		
<1>	Single-point information without time tag	M_SP_NA_1
<3>	Double-point information without time tag	M_DP_NA_1
<5>	Step position information without time tag	M_ST_NA_1
<7>	Bitstring of 32 bit	M_BO_NA_1
<11>	Measured value, scaled value without time tag	M_ME_NB_1
<13>	Measured value, short floating point value without time tag	M_ME_NC_1
	IEC 61850-7-2 service	**Maps to**
Logical node		**One or a set of IOA(‘es)**
	GetAllDataValues	TI<101>Counter Interrogation with: – applicable CASDU address – Qualifier of counter interrogation (RQT)=1-4, 5 <request counter group 1-4, general request counter> – FRZ = 0 <read>
The corresponding process data response shall be one or more than one of the following ASDUs depending on the type of the applicable signals with cause of transmission (COT) = 37, 38 – 41 <requested by general counter request, requested by group 1 – 4 counter request>.		
Type Id	**ASDU**	**Abbreviation**
Process information in monitoring direction		
<37>	Integrated totals with time tag CP56Time2a	M_IT_TB_1

8.5 Data class mapping

The GetDataValues and SetDataValues services shall be mapped to services of IEC 60870-5-104 or IEC 60870-5-101 as shown in Table 61.

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Table 61 – Data services mapping

<table>
<tr><th></th><th>IEC 61850-7-2 service</th><th colspan="2">Maps to</th></tr>
<tr><td colspan="2">Data</td><td colspan="2">One or a set of ASDU(‘es)</td></tr>
<tr><td colspan="2"></td><td>GetDataValues</td><td colspan="2">TI<102> Read command with:
– applicable CASDU address
– applicable IOA address
– COT <5>:= Request</td></tr>
<tr><td colspan="5">The corresponding process data response shall be only one of the following ASDUs depending on the type of the of requested signal with cause of transmission (COT) = 5 <requested></td></tr>
<tr><td>Type Id</td><td colspan="3">ASDU</td><td>Abbreviation</td></tr>
<tr><td colspan="5">Process information in monitoring direction</td></tr>
<tr><td><30></td><td colspan="3">Single-point information with time tag CP56Time2a</td><td>M_SP_TB_1</td></tr>
<tr><td><31></td><td colspan="3">Double-point information with time tag CP56Time2a</td><td>M_DP_TB_1</td></tr>
<tr><td><32></td><td colspan="3">Step position information with time tag CP56Time2a</td><td>M_ST_TB_1</td></tr>
<tr><td><33></td><td colspan="3">Bitstring of 32 bits with time tag CP56Time2a</td><td>M_BO_TB_1</td></tr>
<tr><td><35></td><td colspan="3">Measured value, scaled value with time tag CP56Time2a</td><td>M_ME_TE_1</td></tr>
<tr><td><36></td><td colspan="3">Measured value, short floating point value with time tag CP56Time2a</td><td>M_ME_TF_1</td></tr>
<tr><td colspan="2"></td><td>SetDataValues</td><td colspan="2">TI<111> "Parameter of measured value, scaled value" or TI <112> "Parameter of measured value, short floating point value" with:
– CASDU address of the related instance of CDCs MV or CMV
– unambiguous IOA address related to the instance of CDCs MV or CMV
– COT <6>:= activation</td></tr>
<tr><td colspan="5">These ASDUs (with Qualifier of parameter of measured value KPA <1>:= Threshold value) shall be optionally used to set the optional configuration attribute "db" of instances of CDCs MV or CMV.</td></tr>
</table>

8.6 Setting group class mapping

The SelectActiveSG service shall be mapped as shown in Table 62.

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Table 62 – Setting group services mapping

	IEC 61850-7-2 service	Maps to
Setting group control block		**Controllable IOA**
	SelectActiveSG	**Write Request:** TI<45> / TI<49> or TI<58> / TI<62> in control direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <6>:= Activation – S/E <0>:= Execute **Write Respond:** TI<45> / TI<49> or TI<58> / TI<62> in monitor direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <7>:= Activation confirmation – S/E <0>:= Execute and TI<45> / TI<49> or TI<58> / TI<62> in monitor direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <10>:= Activation termination S/E <0>:= Execute

8.7 Report control block class mapping

The Report service shall be mapped as shown in Table 63.

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Table 63 – Report control block services mapping

	IEC 61850-7-2 service	Maps to
Report control block		
	Report	ASDUs with COT <1>:= periodic/cyclic, COT <3>:= spontaneous, COT <11>:= remote controlled, COT <12>:= local controlled

The following ASDUs use the listed COTs for spontaneous or periodic/cyclic data transfer and for return information caused by a control operation.		
Type Id	**ASDU**	**Abbreviation**
Process information in monitoring direction		
<30>	Single-point information with time tag CP56Time2a	M_SP_TB_1
<31>	Double-point information with time tag CP56Time2a	M_DP_TB_1
<32>	Step position information with time tag CP56Time2a	M_ST_TB_1
<33>	Bitstring of 32 bits with time tag CP56Time2a	M_BO_TB_1
<35>	Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
<36>	Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1

8.8 Control class mapping

8.8.1 General

The CONTROL class model (defined in Clause 17 of IEC 61850-7-2) defines, depending on the application, different behaviours of a control object. The different behaviours of a control object are classified in four cases. Only two cases can be mapped almost seamless onto basic application function "command transmission" (defined in IEC 60870-5-5) used in IEC 60870-5-101 and IEC 60870-5-104:

- case 3: Direct control with enhanced security (described in 8.8.3) which is mapped onto the function "direct command" defined in Subclause 6.8 of IEC 60870-5-5:1995;
- case 4: SBO control with enhanced security (described in 8.8.4) which is mapped onto the function "select and execute command" defined in Subclause 6.8 of IEC 60870-5-5:1995.

To make use of IEDs in existing installations that use "Direct control with normal security" of the CONTROL class mapping and to avoid changing of parameter settings for control class in these IEDs, an **optional** mapping is defined as:

- case 1: Direct control with normal security (described in 8.8.2) which is mapped onto the function "direct command" defined in Subclause 6.8 of IEC 60870-5-5:1995.

NOTE 1 Not all ASDUs necessary for the function "direct command" of IEC 60870-5-5 have a corresponding IEC 61850 message, which means that in some cases, two ASDUs have to be generated in result of one IEC 61850 message (i.e. no one to one mapping of messages is possible)

For Case 2 "SBO with normal security" of the control model, as an adequate mapping to the basic application function "command transmission" of IEC 60870-5-5 is possible.

The functions for control model mapping for a gateway device and optionally for an IED by an independent function called "Ctl mapper" are shown in Figure 7 to Figure 36 as examples. These examples shall be used when the mapping is done in a gateway device that communicates with IEDs that interact with the operated device or optionally done in an IED that interacts with the operated device.

The sequence of interactions (starting from top) are identical, irrespective of the Ctl mapper is implemented in a gateway device or optionally in an IED.

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Each controllable object shall be assigned to one ctlModel in the server implementation. The client shall use the same ctlModel as assigned in the server in order to be able to control the object. It is recommended to decide on a control model that gives satisfactory safety for the contolled object. The ctlModel must be defined in the SCL file. The SCL file is described in Annex A.

For those controllable CDCs which do not have ctlModel attribute (SPG, ING, ASG, ENG, CSG) direct command transmission is recommended.

NOTE 2 The mapping of the CONTROL class model onto the basic application function "command transmission" defines the use of QU <0> (Qualifier of command:= no additional definition) for the ASDUs used in control direction. However, IEC 60870-5-101 and IEC 60870-5-104 allow the use of qualifiers of command QU with the range of <9> to <15> for the selection of other predefined functions and the range of <16> to <31> for special use (defined in Subclause 7.2.6.26 of IEC 60870-5-101:2003).

Because of the lack of an equivalent attribute in IEC 61850 control services it is not possible to map qualifiers of commands QU <> 0 of ASDU's used in control direction in a standardized way. If QU <> 0 is used in existing implementations of IEC 60870-5-104 or IEC 60870-5-101, a restricted mapping to the "Check" attribute (for 4 different QU values) of the control services of IEC 61850 is possible.

For example, if the service parameter “Check” (described in IEC 61850-7-2:2010, 20.5.2.7.) has to be mapped it could be done by the following extension of the QU in the range of <9> to <15>:

QU=0 ... with interlocking no synchrocheck (default)

QU=9 ... no interlocking no synchrocheck

QU=10 ... no interlocking with synchrocheck

QU=11 ... with interlocking with synchrocheck

As an alternative the service parameter Check can be mapped to two SPC to influence the conditions for interlocking and synchrocheck.The default values of SPC dedicated to interlocking is TRUE and the SPC dedicated to synchrocheck = FALSE.

NOTE 3 A mapping example for the service parameter Check is shown for the CDC SPC in Annex A).

Figure 7 to Figure 36 also show examples of the sequences of interactions with the operated device itself. The interface to the operated device is beyond the scope of this technical specification. Showing the interaction with the operated device itself may be useful for the understanding of the complete control operation.

NOTE 4 For Commands (C_SC, C_DC, C_RC) ACT, ACTCON, RETURN_INF (status update) and ACTTERM are mandatory. For Setpoints (C_SE) the RETURN_INF (status update) and ACTTERM are optional.

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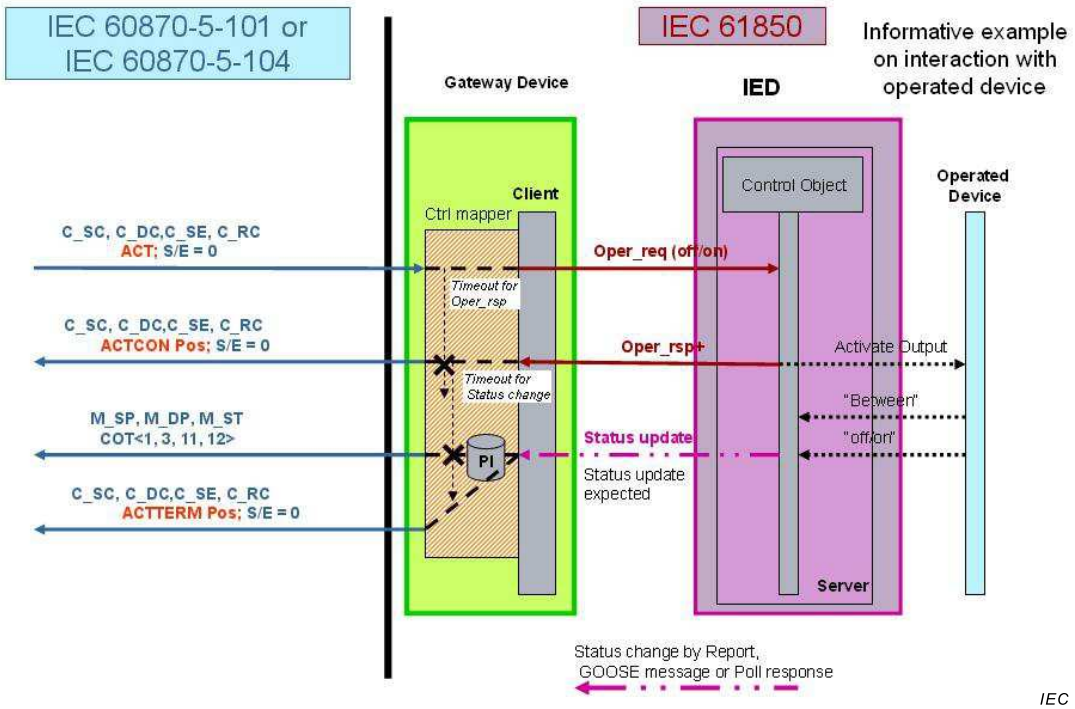
8.8.2 Direct control with normal security (optional)

8.8.2.1 Direct control with normal security with status update – positive case

8.8.2.1.1 Applied to gateway device



The return information caused by a command (M_SP, M_DP, M_ST with COT <1,3,11,12>) is supplied to the client either by a Report, GOOSE message or by a Device Object Poll-reply and should be transmitted before the command termination (C_SC, C_DC, C_SE, C_RC with ACTTERM Pos; S/E =0).

Figure 7 – Direct control with normal security with status update – positive case applied to gateway device

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8.8.2.1.2 Applied to IED

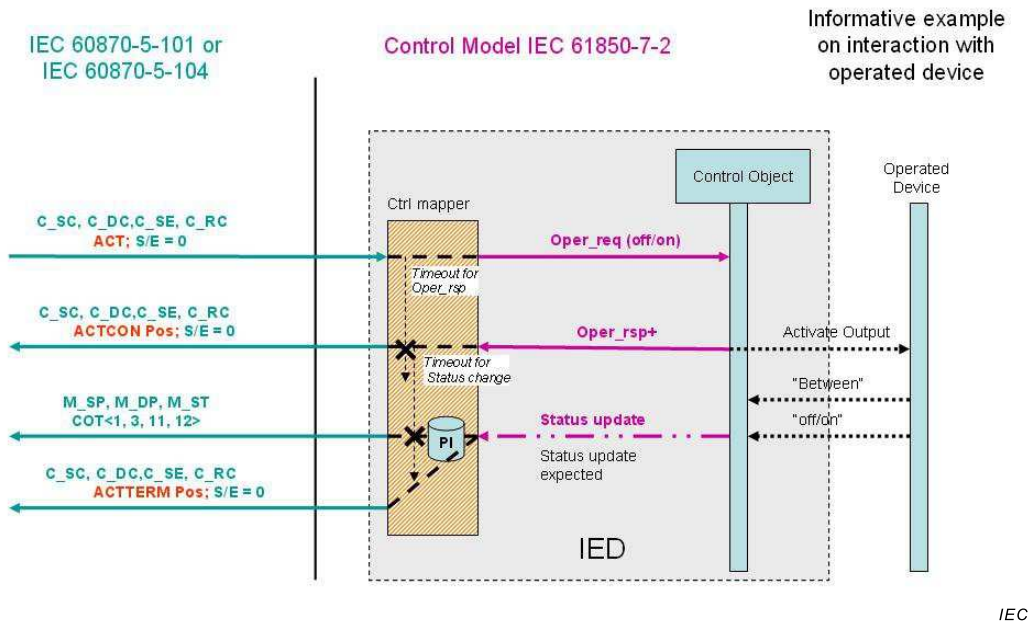

Figure 8 – Direct control with normal security with status update – positive case applied to IED

8.8.2.2 Direct control with normal security in general – negative case a) no Oper_resp from control object/server/IED

8.8.2.2.1 Applied to gateway device

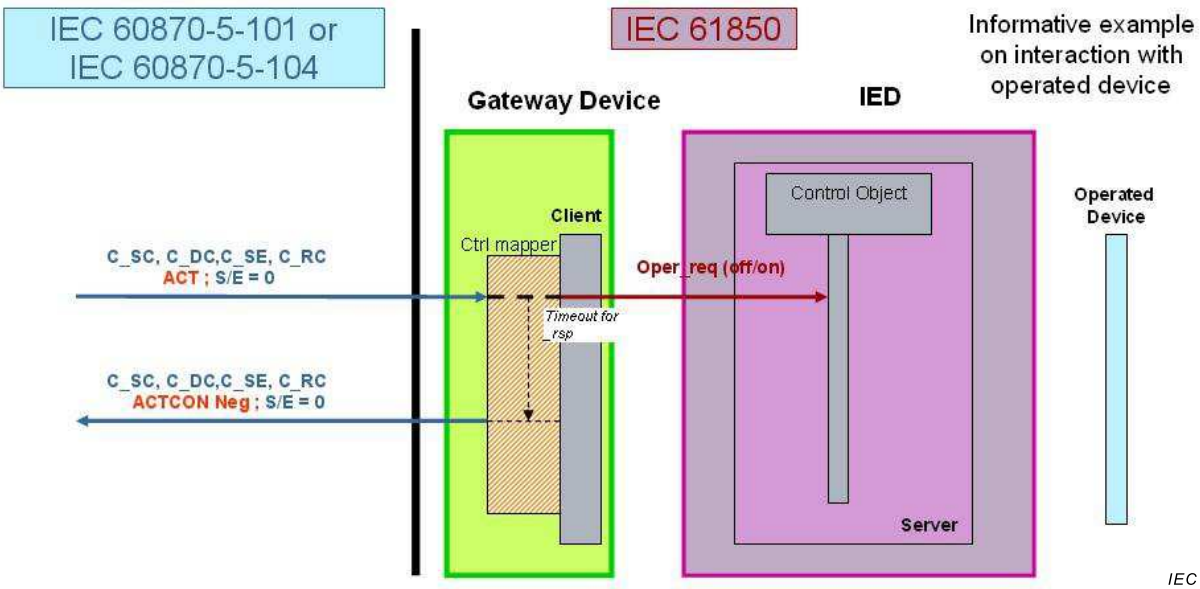

Figure 9 – Direct control with normal security in general – negative case a) applied to gateway device

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8.8.2.2.2 Applied to IED

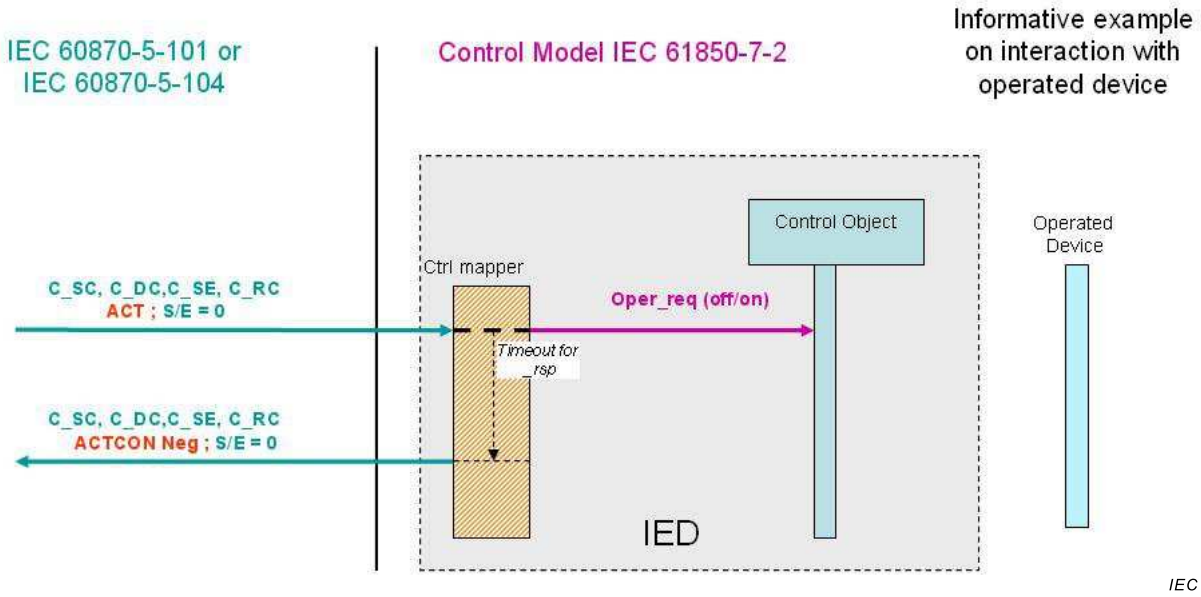

Figure 10 – Direct control with normal security in general – negative case a) applied to IED

8.8.2.3 Direct control with normal security in general – negative case b) negative Oper_resp from control object/server/IED

8.8.2.3.1 Applied to gateway device

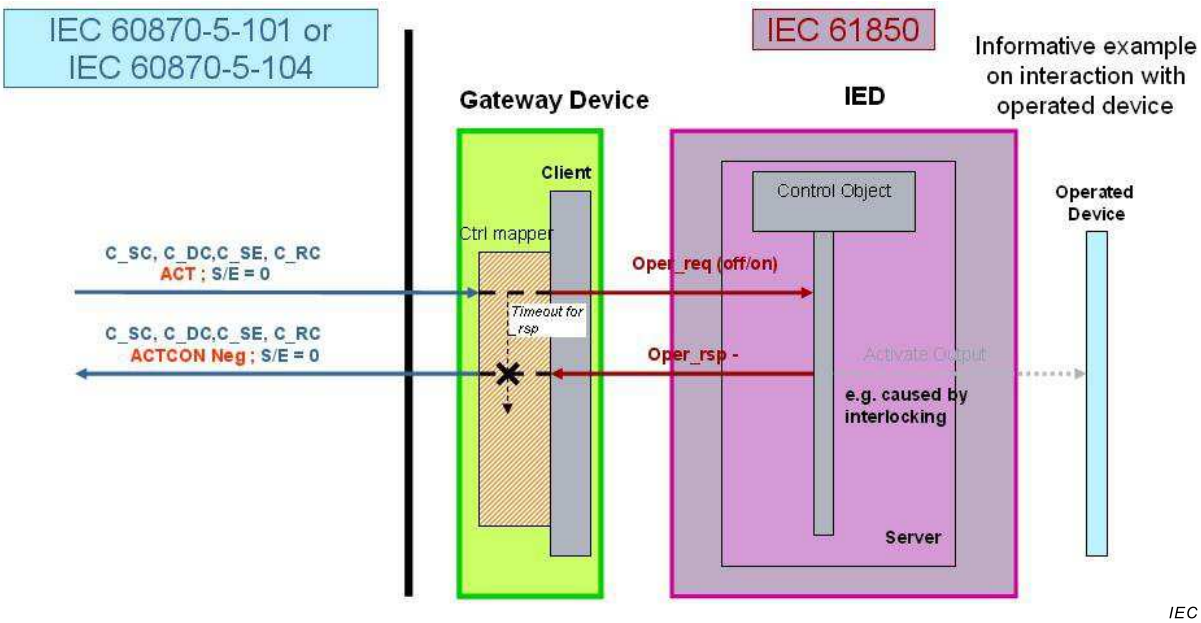

Figure 11 – Direct control with normal security in general – negative case b) applied to gateway device

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8.8.2.3.2 Applied to IED

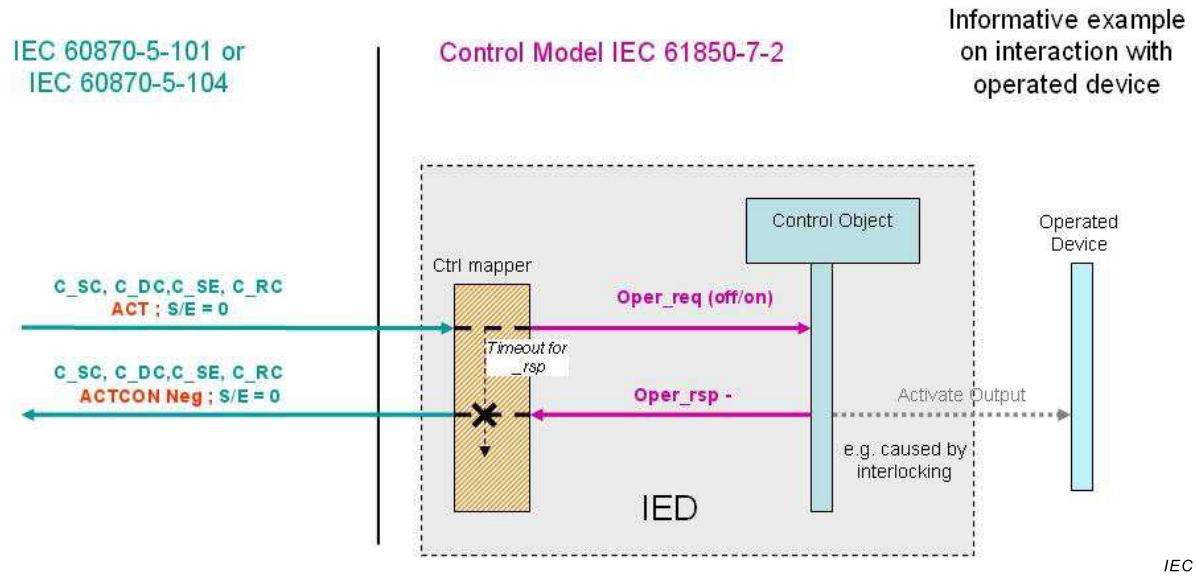

Figure 12 – Direct control with normal security in general – negative case b) applied to IED

8.8.2.4 Direct control with normal security with status update – negative case c) no status update detected

8.8.2.4.1 Applied to gateway device

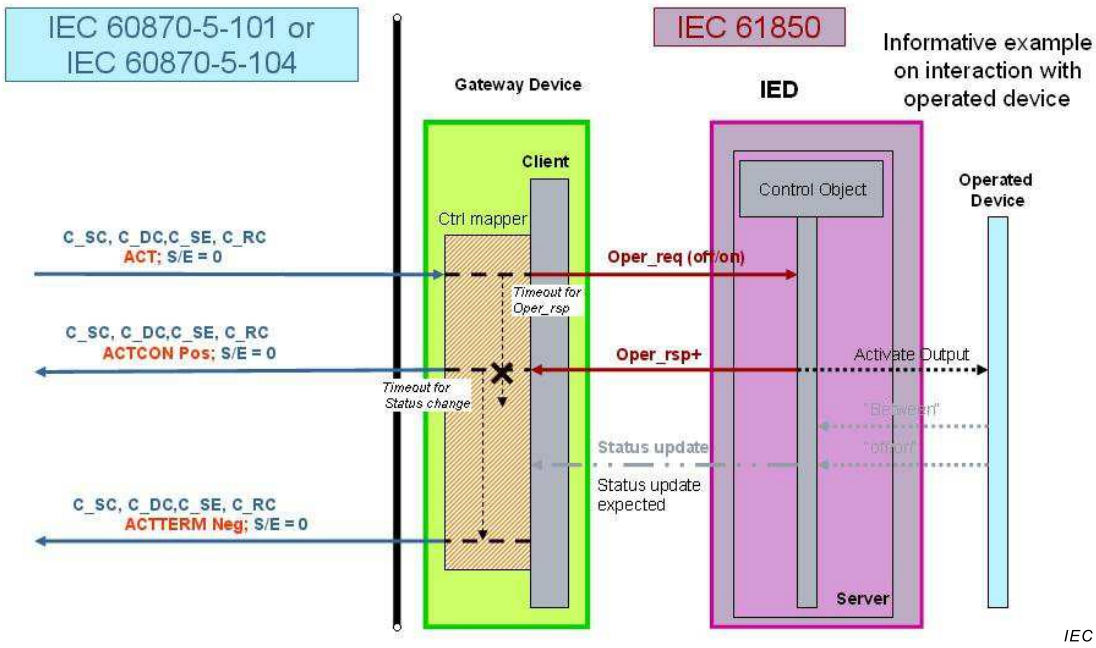

Figure 13 – Direct control with normal security with status update – negative case c) applied to gateway device

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8.8.2.4.2 Applied to IED

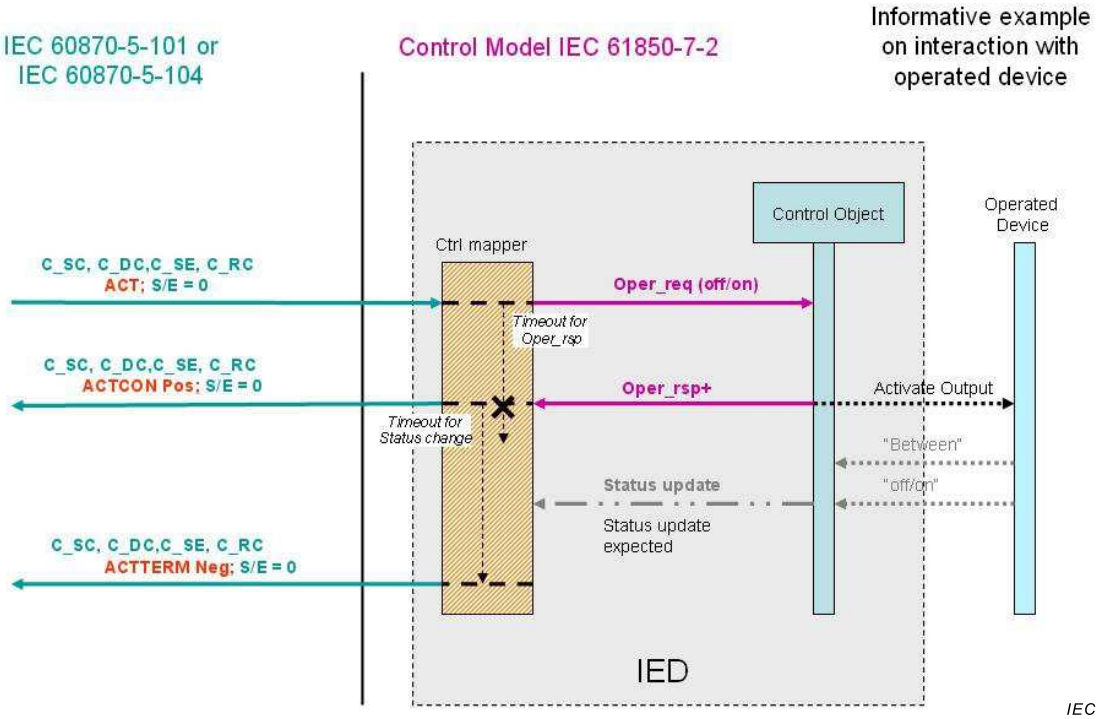

Figure 14 – Direct control with normal security with status update – negative case c) applied to IED

8.8.2.5 Direct control with normal security without status update – positive case

8.8.2.5.1 Applied to IED

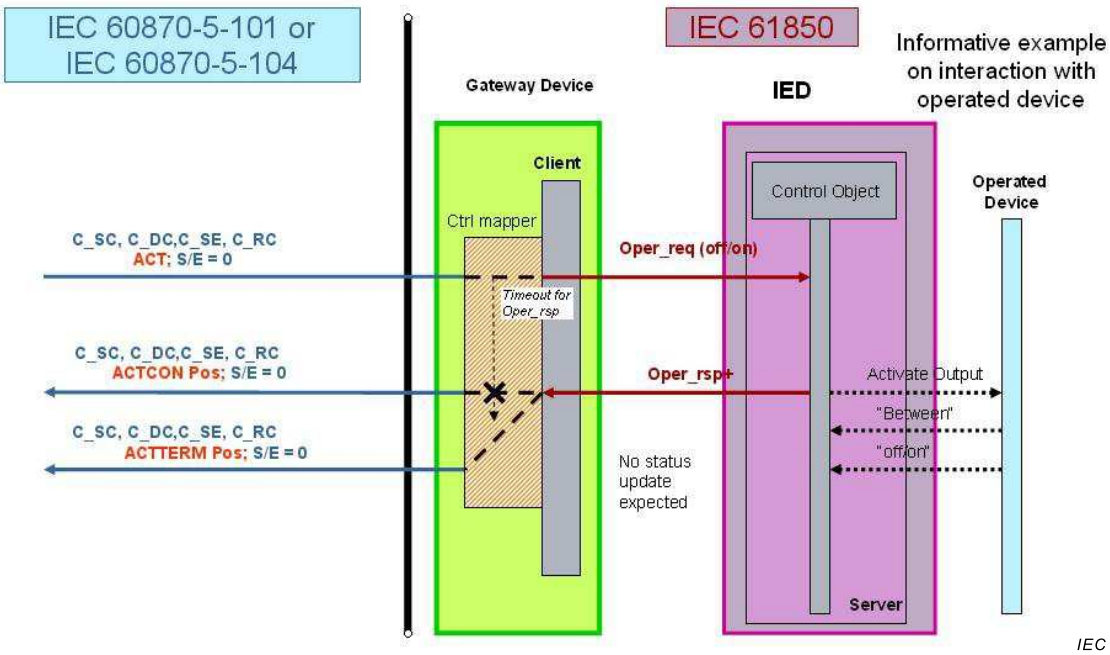

Figure 15 – Direct control with normal security without status update – positive case applied to gateway device

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8.8.2.5.2 Applied to IED

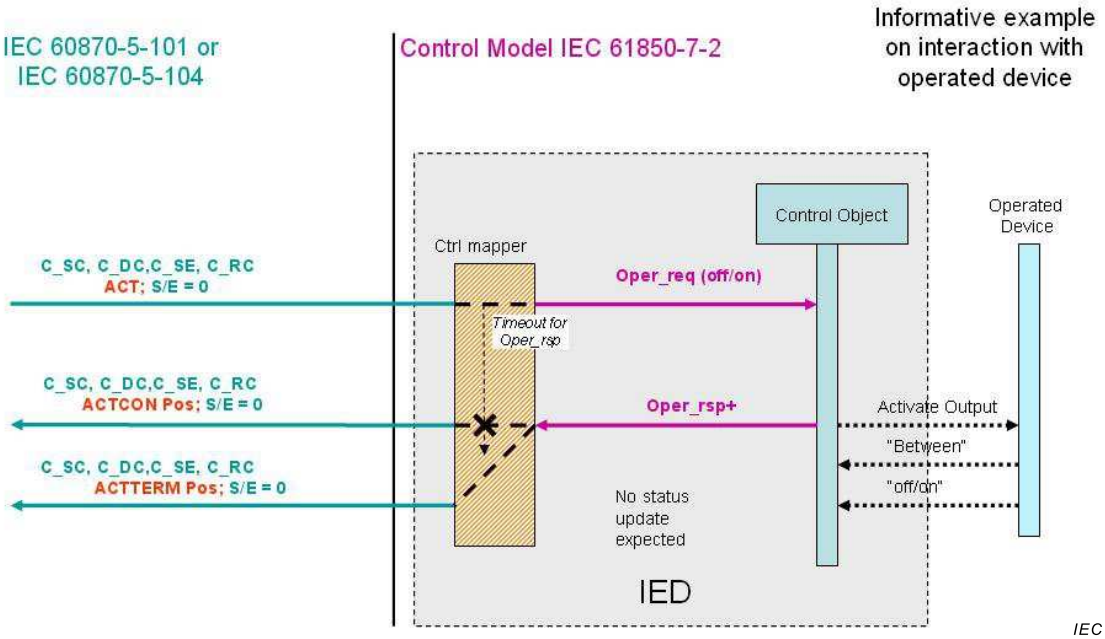

Figure 16 – Direct control with normal security without status update – positive case applied to IED

The direct control with normal security services shall be mapped as shown in Table 64.

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Table 64 – Direct control with normal security services mapping

	IEC 61850-7-2 service	Maps to
Control		**Controllable IOA**
	Operate	**Operate Request:** TI<45,46,47,49,50> or <58,59,60,62,63> in control direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <6>:= Activation – S/E <0>:= Execute **Operate Respond:** TI<45,46,47,49,50>or <58,59,60,62,63> in monitor direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <7>:= Activation confirmation – S/E <0>:= Execute and TI<45,46,47,49,50> or <58,59,60,62,63> in monitor direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <10>:= Activation termination S/E <0>:= Execute

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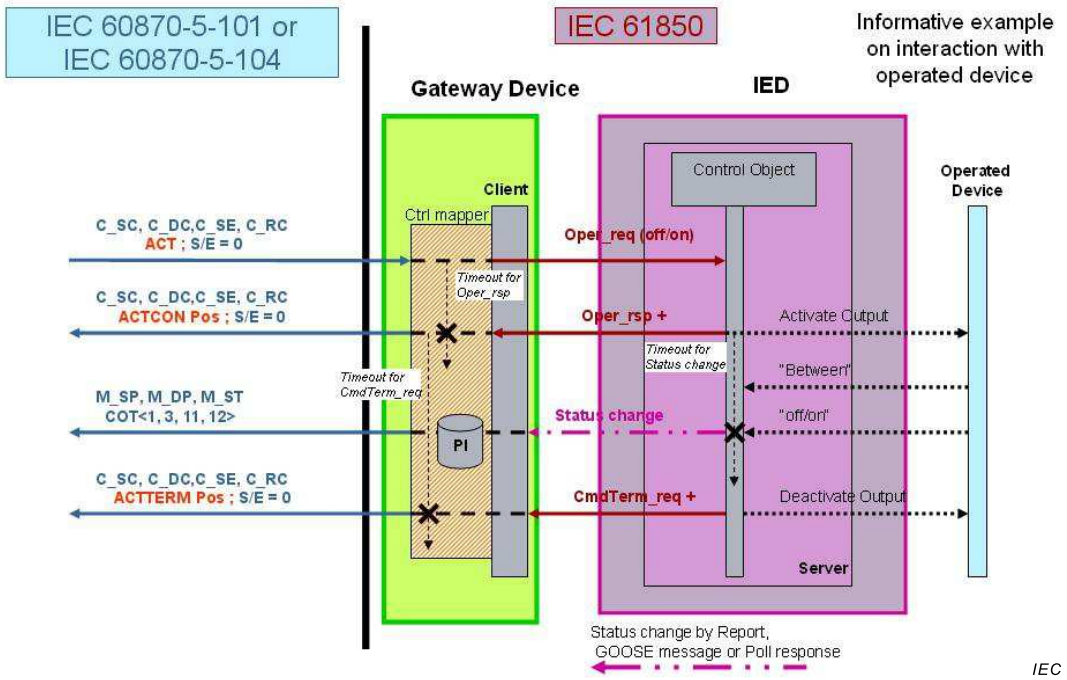
8.8.3 Direct control with enhanced security

8.8.3.1 Direct control with enhanced security – positive case

8.8.3.1.1 Applied to gateway device



The return information caused by a command (M_SP, M_DP, M_ST with COT <1,3,11,12>) is supplied to the client either by a Report, GOOSE message or by a Device Object Poll-reply and should be transmitted before the command termination (C_SC, C_DC, C_SE, C_RC with ACTTERM Pos; S/E =0).

Figure 17 – Direct control with enhanced security – positive case applied to gateway device

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8.8.3.1.2 Applied to IED

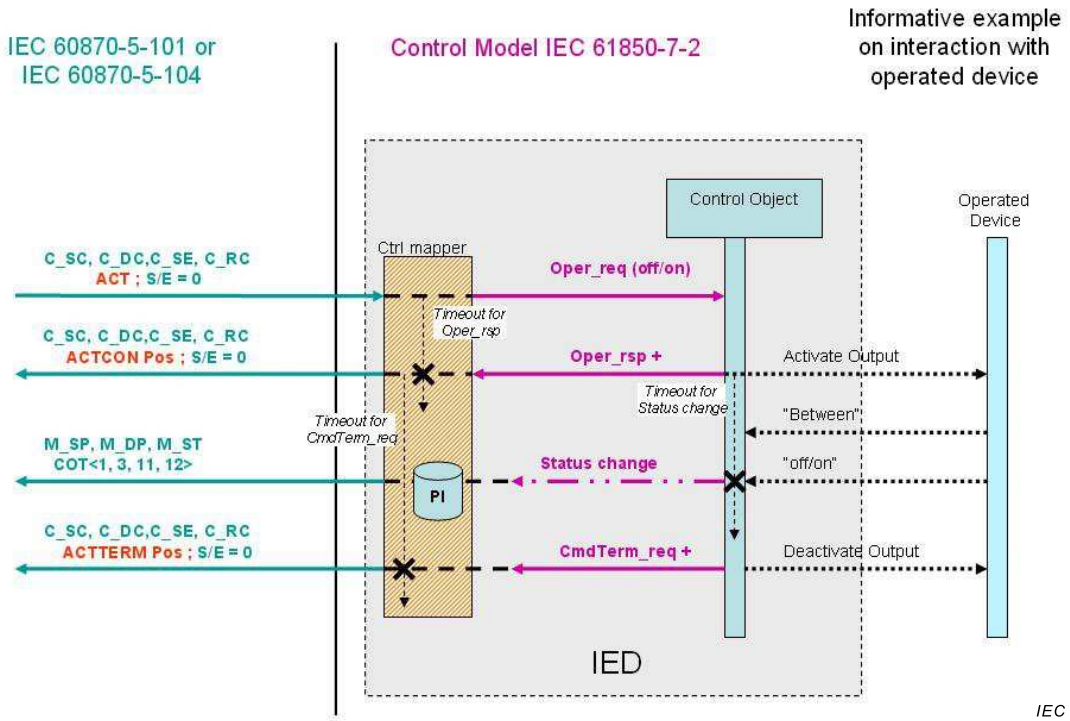

Figure 18 – Direct control with enhanced security – positive case applied to IED

8.8.3.2 Direct control with enhanced security – negative case a) no Oper_resp from control object/server/IED

8.8.3.2.1 Applied to gateway device

See Figure 9.

8.8.3.2.2 Applied to IED

See Figure 10.

8.8.3.3 Direct control with enhanced security – negative case b) negative Oper_resp from control object/server/IED

8.8.3.3.1 Applied to gateway device

See Figure 11.

8.8.3.3.2 Applied to IED

See Figure 12.

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8.8.3.4 Direct control with enhanced security – negative case c) no status change detected by control object/server/IED

8.8.3.4.1 Applied to gateway device

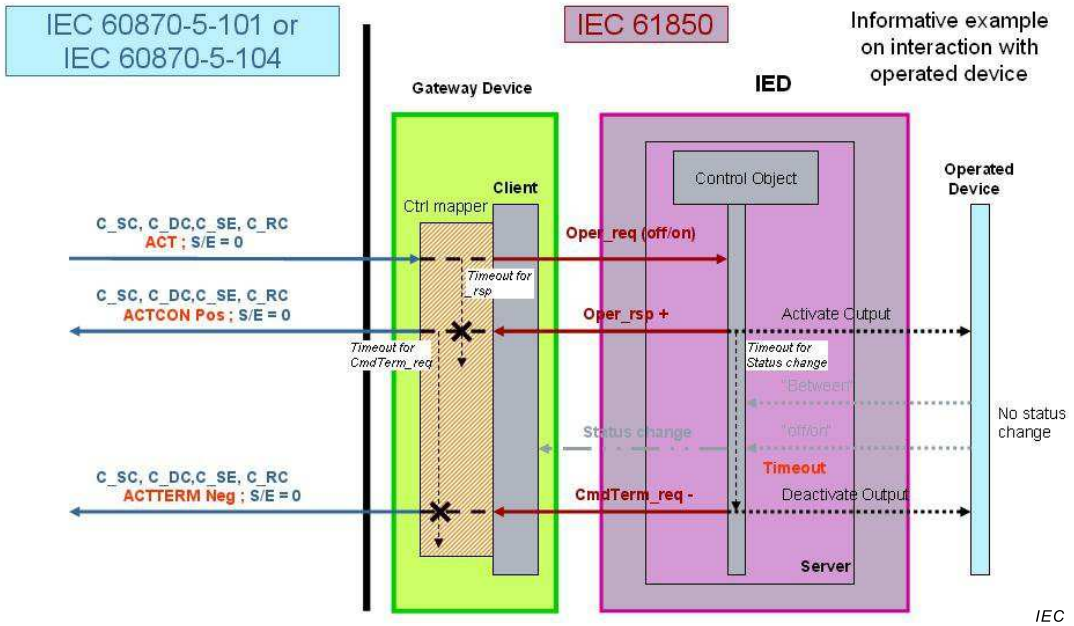

Figure 19 – Direct control with enhanced security – negative case c) applied to gateway device

8.8.3.4.2 Applied to IED

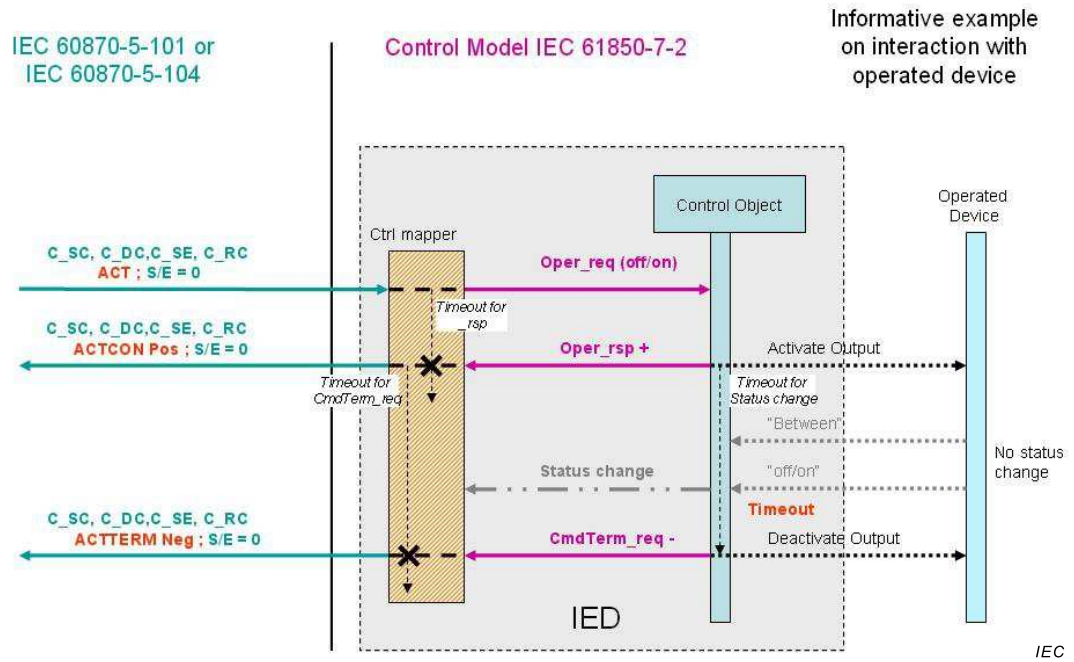

Figure 20 – Direct control with enhanced security – negative case c) applied to IED

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8.8.3.5 Direct control with enhanced security – negative case d) no CMDTerm_req from control object/server/IED

8.8.3.5.1 Applied to gateway device

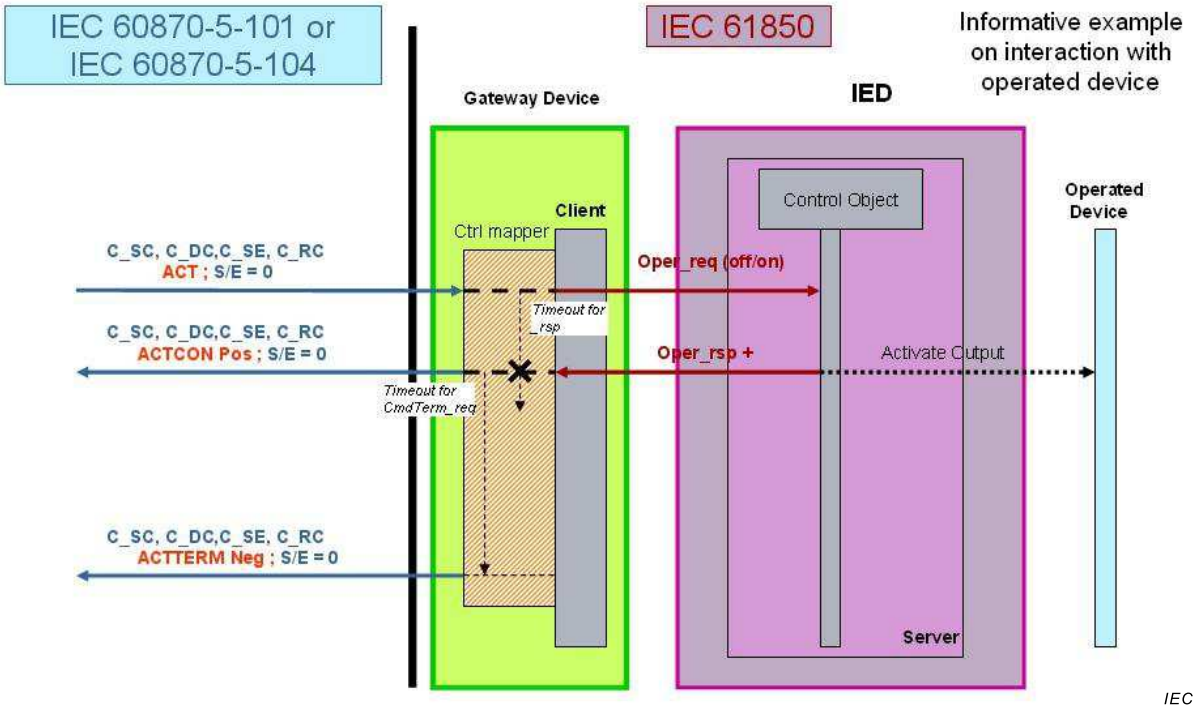

Figure 21 – Direct control with enhanced security – negative case d) applied to gateway device

8.8.3.5.2 Applied to IED

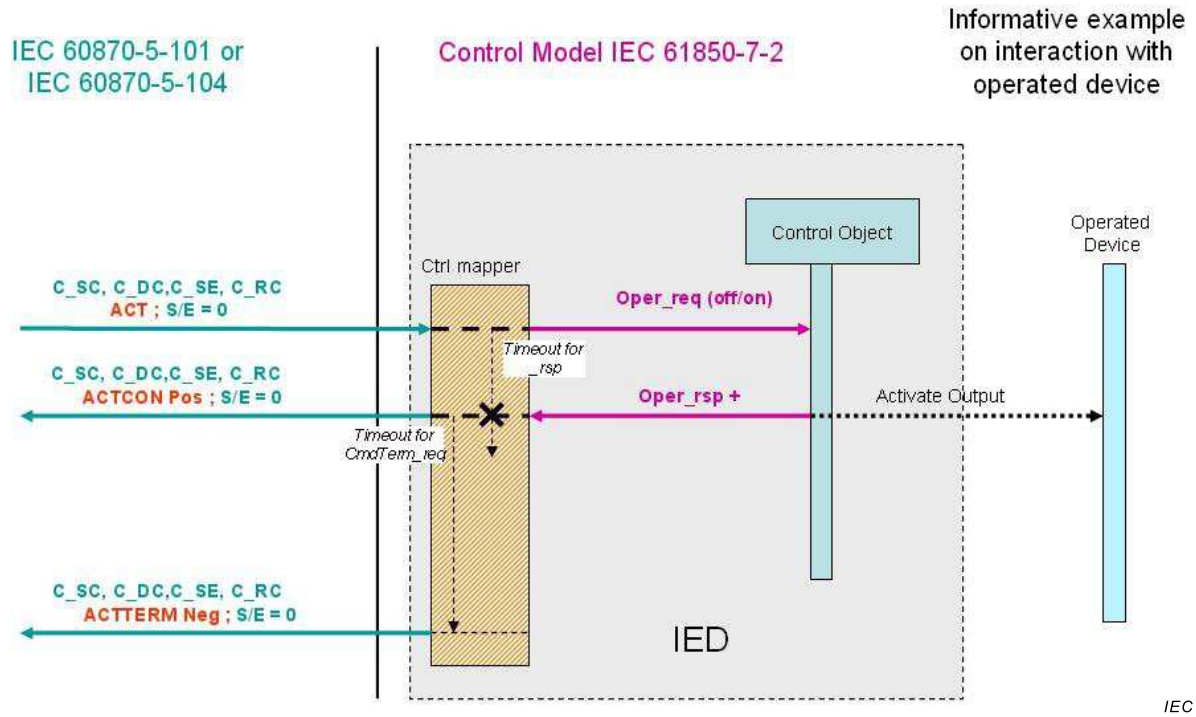

Figure 22 – Direct control with enhanced security – negative case d) applied to IED

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The direct control with enhanced security services shall be mapped as shown in Table 65.

Table 65 – Direct control with enhanced security services mapping

	IEC 61850-7-2 service	Maps to
Control		**Controllable IOA**
	Operate	**Operate Request:** TI <45,46,47,49,50> or <58,59,60,62,63> in control direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <6>:= Activation – S/E <0>:= Execute **Operate Respond:** TI <45,46,47,49,50> or <58,59,60,62,63> in monitor direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <7>:= Activation confirmation – S/E <0>:= Execute
	Command Termination	TI <45,46,47,49,50>or <58,59,60,62,63> in monitor direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <10>:= Activation Termination – S/E <0>:= Execute – P/N <0>:= no AddCause present AND Error:= NoError <0> <1>:= AddCause present OR Error <> NoError <0>

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8.8.4 SBO control with enhanced security

8.8.4.1 SBOw control – positive case

8.8.4.1.1 Applied to gateway device

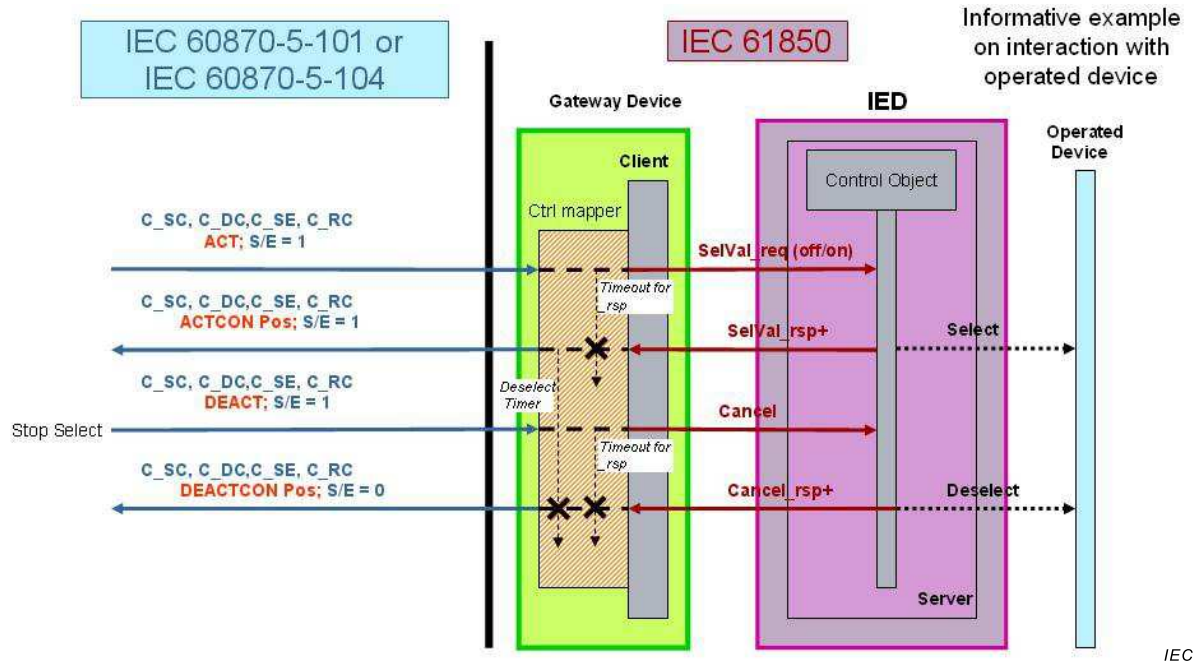

Figure 23 – SBOw control – positive case applied to gateway device

8.8.4.1.2 Applied to IED

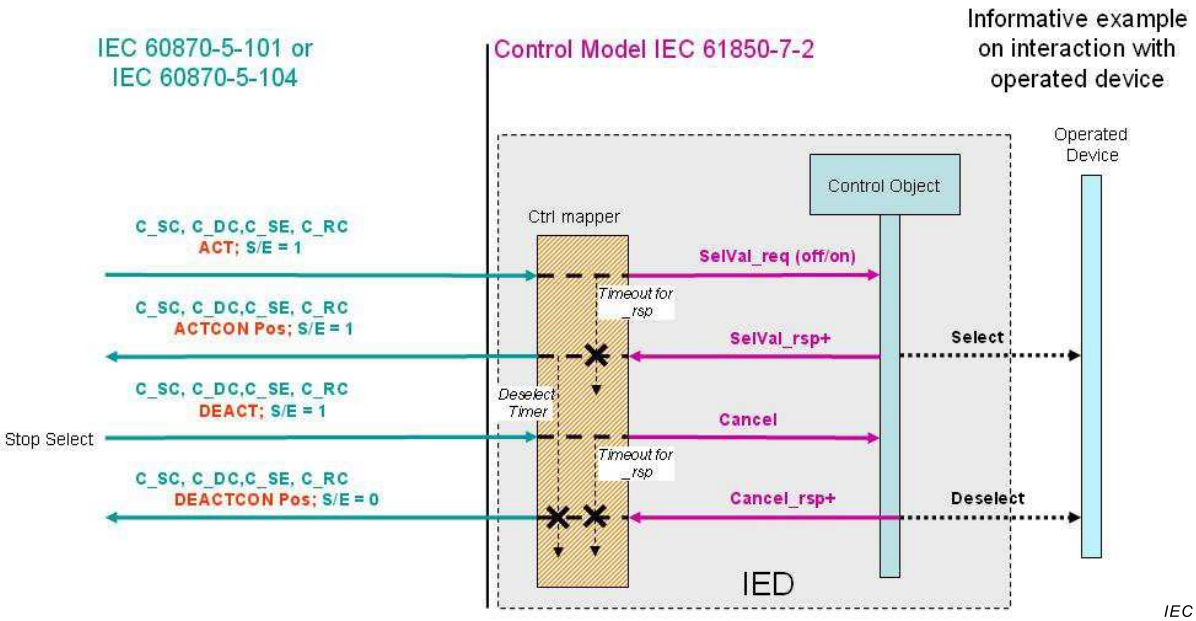

Figure 24 – SBOw control – positive case applied to IED

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8.8.4.2 SBOw control – negative case a) no _rsp from control object/server/IED

8.8.4.2.1 Applied to gateway device

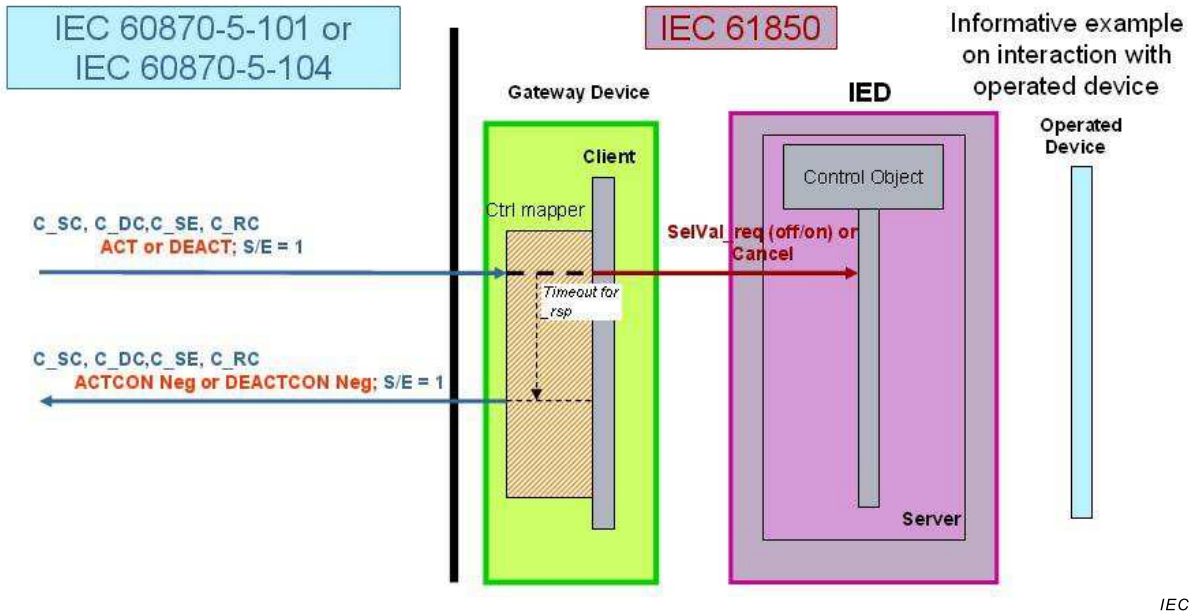

Figure 25 – SBOw control – negative case a) applied to gateway device

8.8.4.2.2 Applied to IED

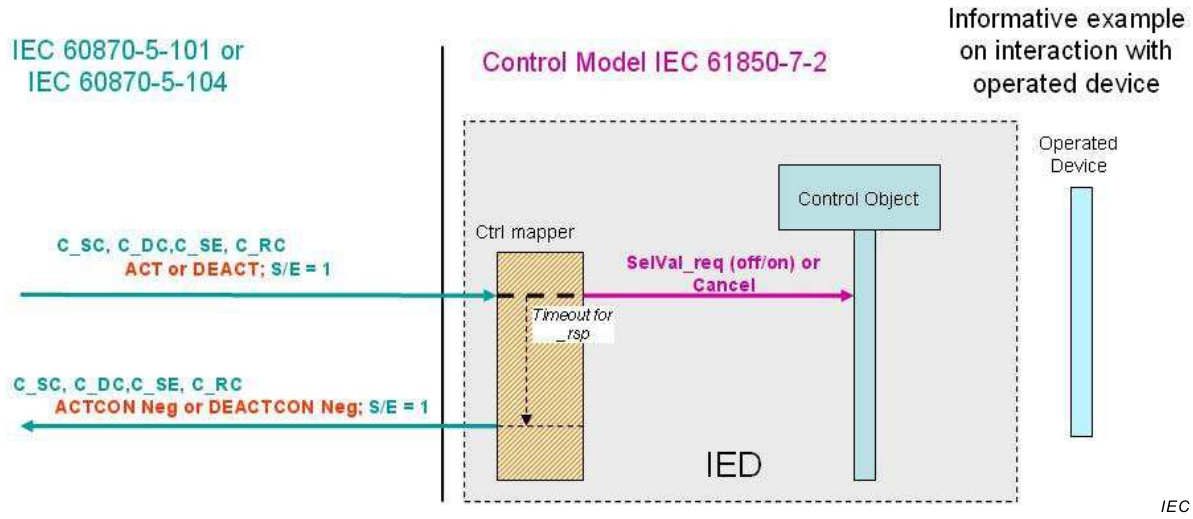

Figure 26 – SBOw control – negative case a) applied to IED

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8.8.4.3 SBOw control – negative case b) negative _rsp from control object/server/IED

8.8.4.3.1 Applied to gateway device

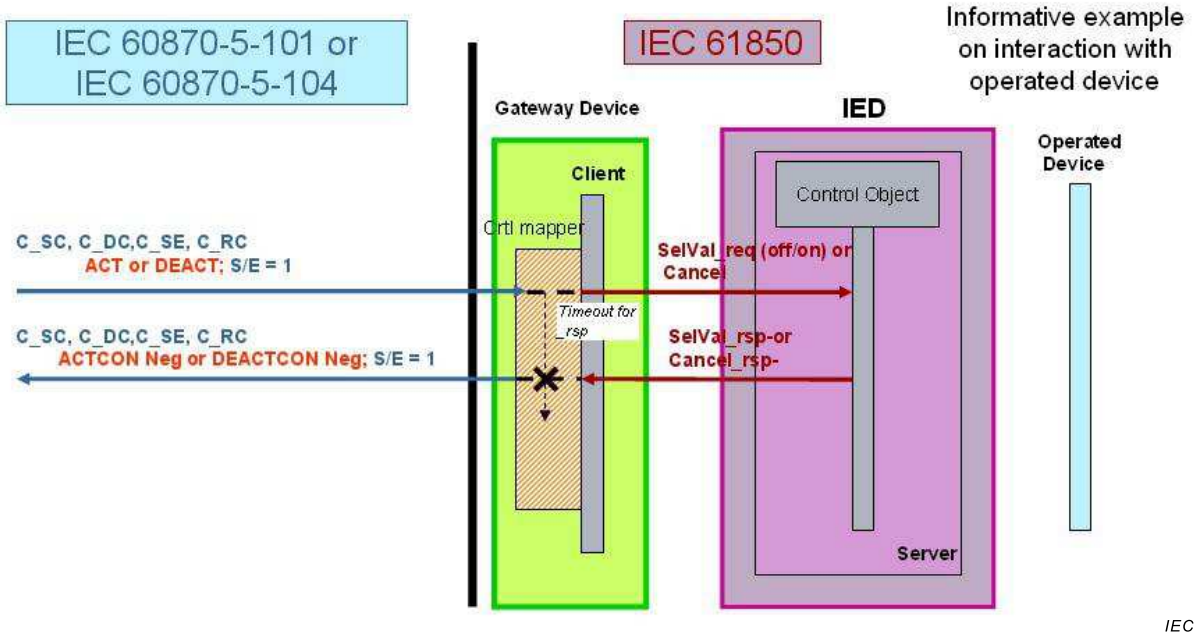

Figure 27 – SBOw control – negative case b) applied to gateway device

8.8.4.3.2 Applied to IED

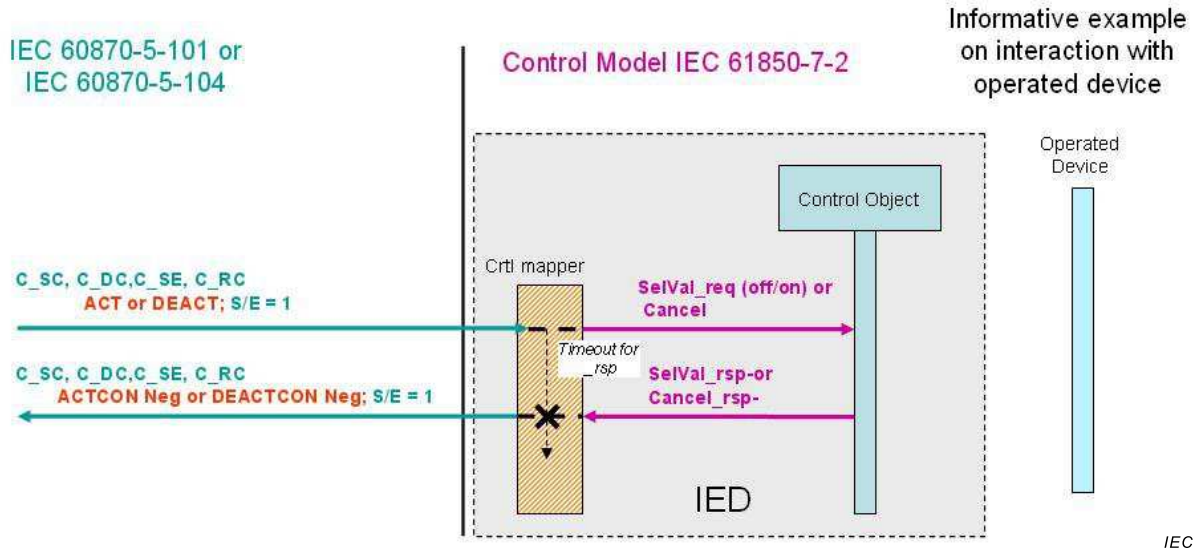

Figure 28 – SBOw control – negative case b) applied to IED

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8.8.4.4 SBOw control – negative case c) second select of same object

8.8.4.4.1 Applied to gateway device

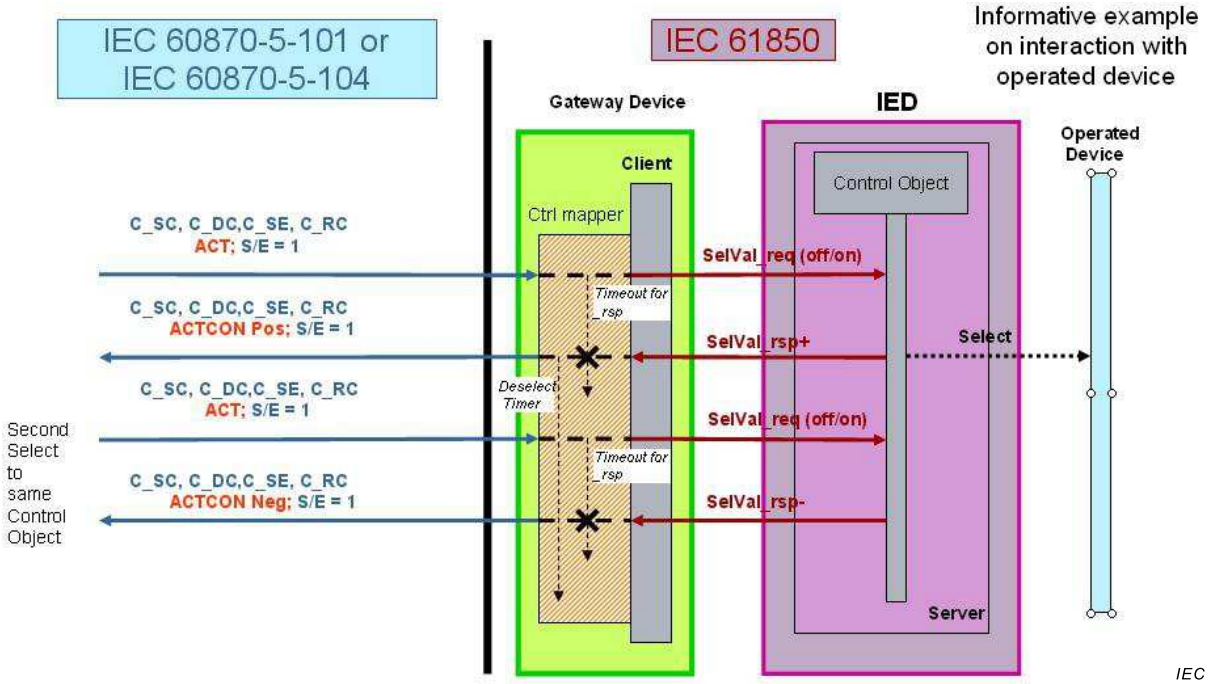

Figure 29 – SBOw control – negative case c) applied to gateway device

8.8.4.4.2 Applied to IED

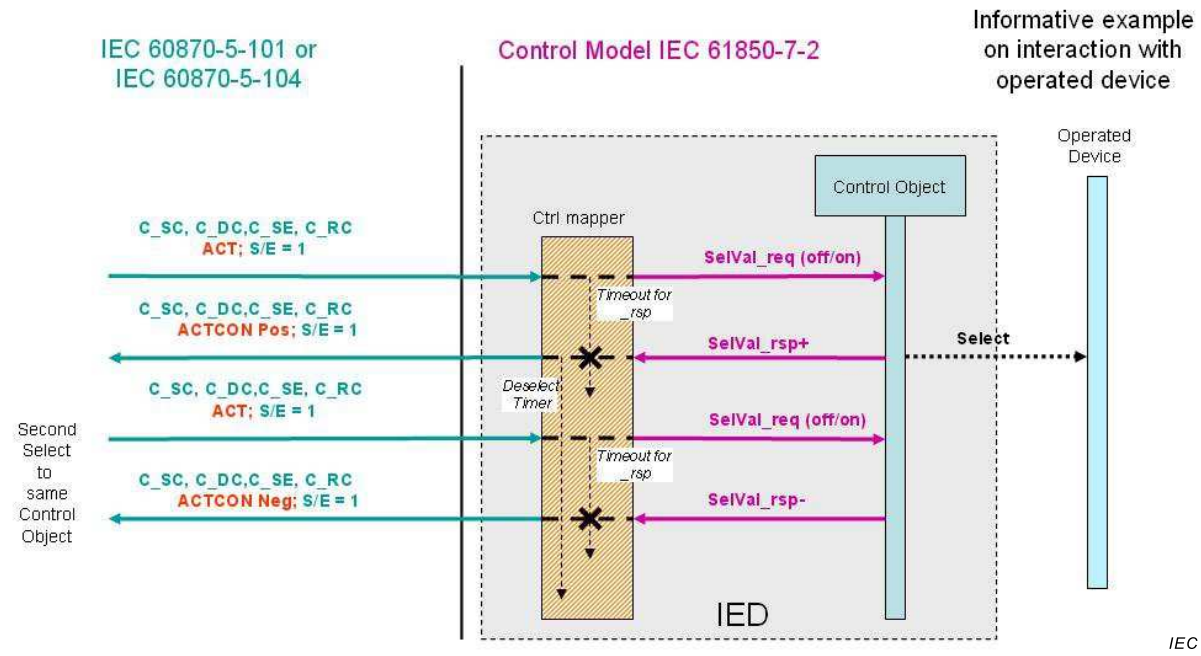

Figure 30 – SBOw control – negative case c) applied to IED

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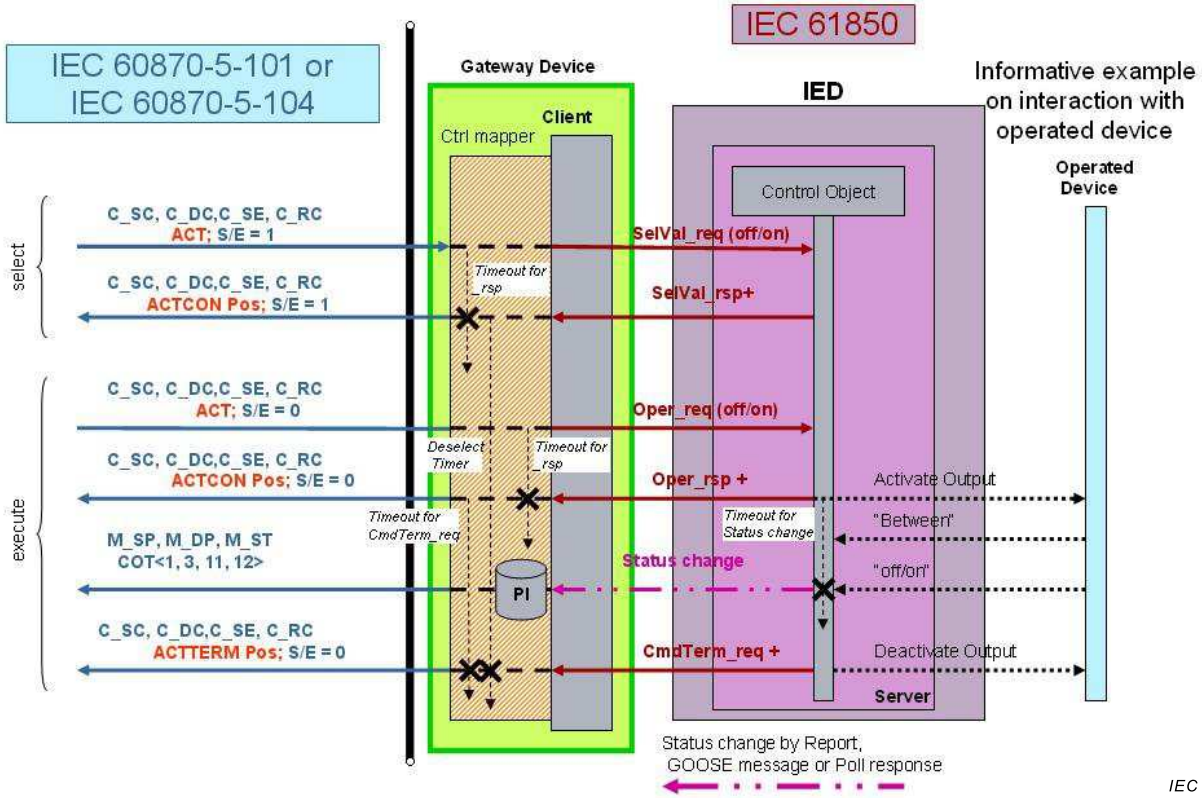
8.8.4.5 SBO with enhanced security – positive case

8.8.4.5.1 Applied to gateway device



The return information caused by a command (M_SP, M_DP, M_ST with COT <1,3,11,12>) is supplied to the client either by a Report, GOOSE message or by a Device Object Poll-reply and should be transmitted before the command termination (C_SC, C_DC, C_SE, C_RC with ACTTERM Pos; S/E =0).

Figure 31 – SBO with enhanced security – positive case applied to gateway device

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8.8.4.5.2 Applied to IED

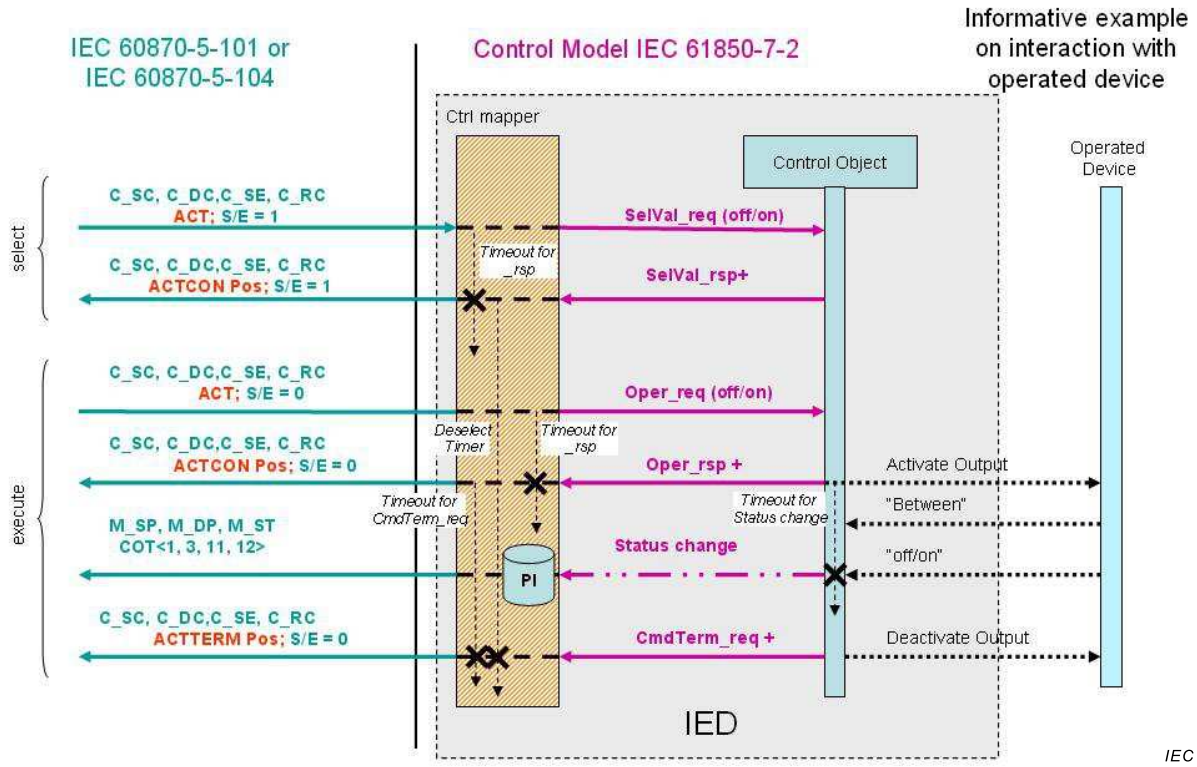

Figure 32 – SBO with enhanced security – positive case applied to IED

8.8.4.6 SBO with enhanced security – negative case a) no status change detected by control object/server/IED

8.8.4.6.1 Applied to gateway device

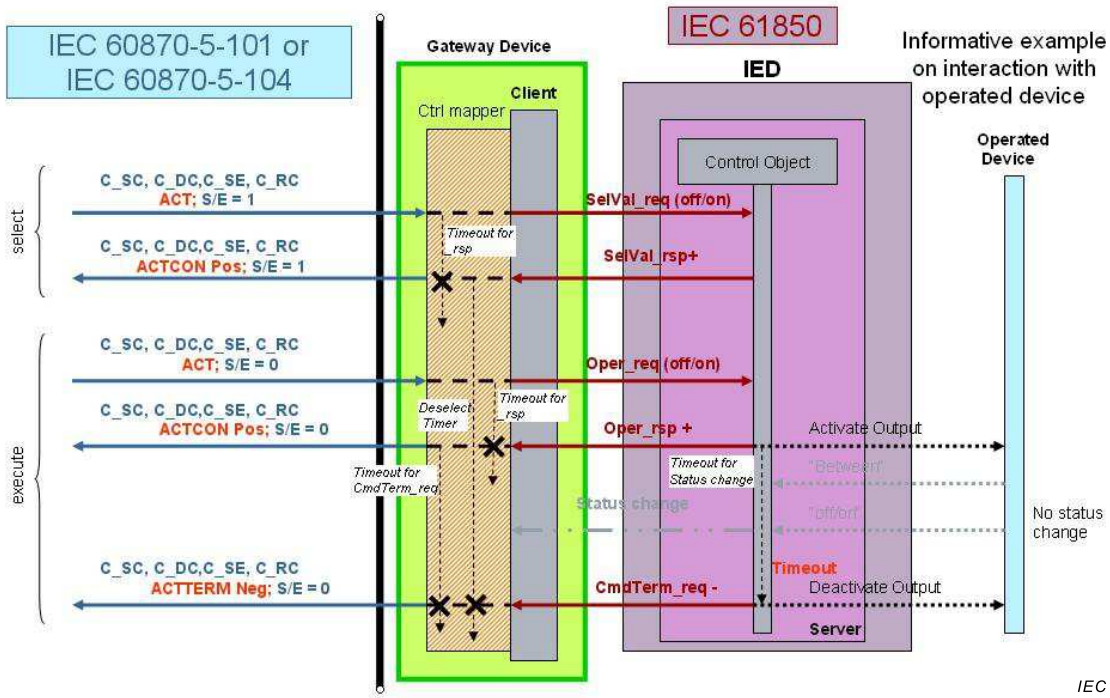

Figure 33 – SBO with enhanced security – negative case a) applied to gateway device

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8.8.4.6.2 Applied to IED

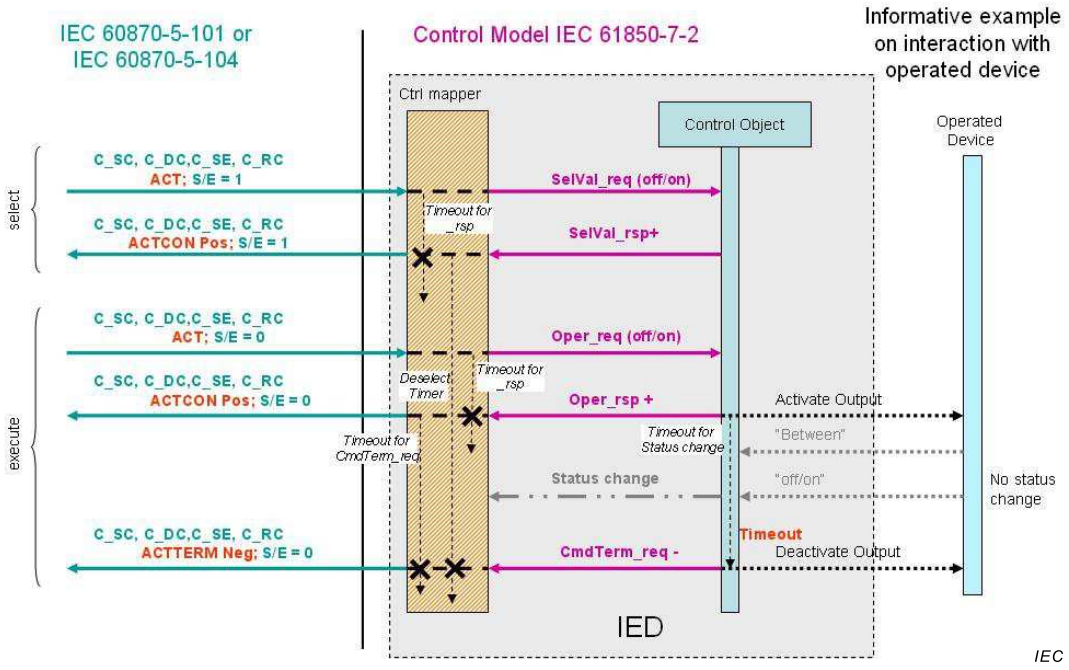

Figure 34 – SBO with enhanced security – negative case a) applied to IED

8.8.4.7 SBO with enhanced security – negative case b) no CmdTerm_req from control object/server/IED

8.8.4.7.1 Applied to gateway device

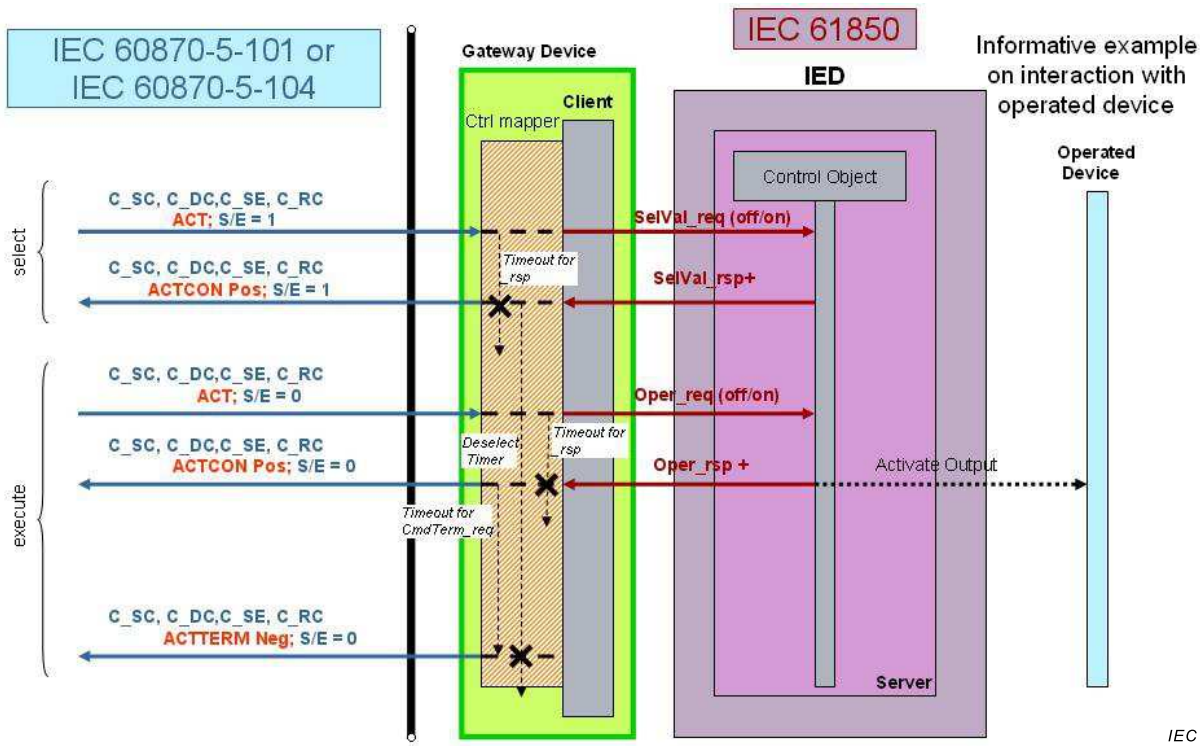

Figure 35 – SBO with enhanced security – negative case b) applied to gateway device

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8.8.4.7.2 Applied to IED

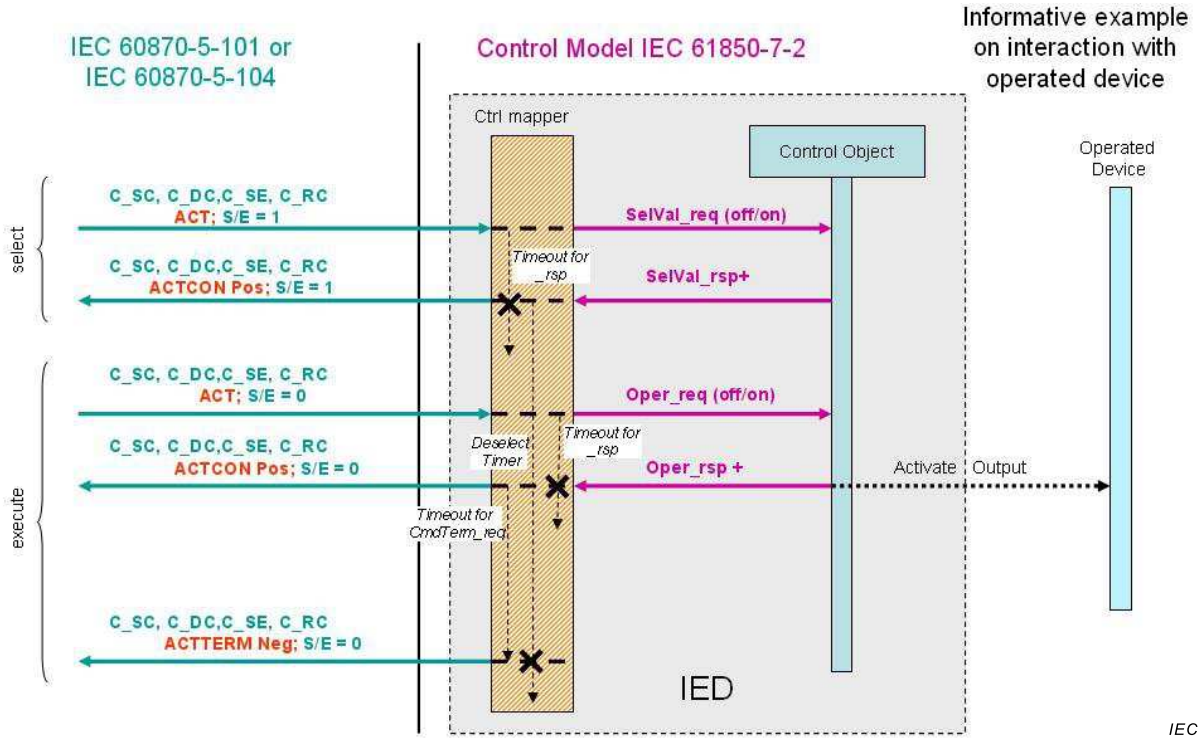

Figure 36 – SBO with enhanced security – negative case b) applied to IED

The SBO control with enhanced security services shall be mapped as shown in Table 66.

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Table 66 – SBO control with enhanced security services mapping

	IEC 61850-7-2 service	Maps to
Control		**Controllable IOA**
	SelectWithValue	**Select with Value Request:** TI<45,46,47,49,50> or <58,59,60,62,63> in control direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <6>:= Activation – S/E <1>:= Select **Select with Value Respond:** TI<45,46,47,49,50> or <58,59,60,62,63> in monitor direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <7>:= Activation confirmation – S/E <1>:= Select
	Cancel	**Cancel Request:** TI<45,46,47,49,50> or <58,59,60,62,63> in control direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <8>:= Deactivation – S/E value is irrelevant **Cancel Respond:** TI<45,46,47,49,50> or <58,59,60,62,63> in monitor direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <9>:= Deactivation confirmation S/E value is irrelevant
	Operate	**Operate Request:** TI<45,46,47,49,50> or <58,59,60,62,63> in control direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <6>:= Activation – S/E <0>:= Execute **Operate Respond:** TI<45,46,47,49,50> or <58,59,60,62,63> in monitor direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <7>:= Activation confirmation – S/E <0>:= Execute

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	IEC 61850-7-2 service	Maps to
	Command Termination	TI<45,46,47,49,50> or <58,59,60,62,63> in monitor direction: – applicable CASDU address – applicable IOA address – Qualifier of command (QOC)=0 <no additional definition> – COT <10>:= Activation Termination – S/E <0>:= Execute – P/N <0>:= no AddCause present AND Error:= NoError <0> <1>:= AddCause present OR Error <> NoError <0>

9 Protocol stack selections for IEC 60870-5-101 and IEC 60870-5-104

9.1 General

The mapping to IEC 60870-5-101 and IEC 60870-5-104 is done for the applicable data (ASDUs) and services (basic application functions) according to the marked check boxes in the interoperability sheet in 9.3.1/ 9.3.2. The interoperability sheets are subsets of the related standards.

NOTE The selections done in the interoperability sheets of IEC 60870-5-101 and IEC 60870-5-104 represent a recommended set of parameters, ASDUs and basic application functions which conform to the definitions of this guideline.

9.2 Structure of application data

9.2.1 General

IEC 60870-5-3 describes the basic application data units in transmission frames of telecontrol systems. This subclause selects specific field elements out of that standard and defines APPLICATION SERVICE DATA UNITS (ASDU) used in standard IEC 60870-5-104 and IEC 60870-5-101 protocol.

The APPLICATION SERVICE DATA UNIT (ASDU) is composed of a DATA UNIT IDENTIFIER and one or more INFORMATION OBJECTS. ASDUs containing no INFORMATION OBJECTS are permitted as well.

In addition, in some cases, the ASDU consists only of the DATA UNIT IDENTIFIER

The DATA UNIT IDENTIFIER always has the same structure for all ASDUs. The INFORMATION OBJECTS of an ASDU are always of the same structure and type, which are defined in the TYPE IDENTIFICATION field. Each ASDU always contains a single TYPE IDENTIFICATION (TI) and a single CAUSE OF TRANSMISSION.

The COMMON ADDRESS is the station address, which may be structured to permit the addressing of the whole station or just a particular station sector.

There is no data field LENGTH OF ASDU. Each frame has only a single ASDU available.

TIME TAGS (if present) always belong to an individual INFORMATION OBJECT.

If Day of week is not used, the values can be set to 0.

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The INFORMATION OBJECT consists of an INFORMATION OBJECT IDENTIFIER, a SET OF INFORMATION ELEMENTs and, if present, a TIME TAG OF INFORMATION OBJECT.

The INFORMATION OBJECT IDENTIFIER consists only of the INFORMATION OBJECT ADDRESS (IOA). In most cases, the COMMON ADDRESS OF ASDU together with the INFORMATION OBJECT ADDRESS distinguishes the complete SET OF INFORMATION ELEMENTs within a specific system. The combination of both addresses shall be unambiguous per system. The TYPE IDENTIFICATION is not a part of a COMMON ADDRESS or an INFORMATION OBJECT ADDRESS.

The set of information elements consists of a individual single information element / combination of information elements or a sequence of single information elements / combination of information elements.

NOTE The type identification (TI) defines the structure, the type and the format of the information object. All information objects of a specific ASDU (telegrams) are of the same structure, type and format.

9.2.2 Structure of application data defined in IEC 60870-5-101

The structure of the DATA UNIT IDENTIFIER is:

– one octet TYPE IDENTIFICATION (TI)
– one octet VARIABLE STRUCTURE QUALIFIER
– one or two octets CAUSE OF TRANSMISSION (INCLUDED ORIGINATOR ADDRESS)
– one or two octets COMMON ADDRESS OF ASDU
– one, two or three octets INFORMATION OBJECT ADDRESS (IOA)

Octet 3 (and optionally Octet 4:= ORIGINATOR ADDRESS) of the DATA UNIT IDENTIFIER of the ASDU defines the CAUSE OF TRANSMISSION field.

The size of the COMMON ADDRESS OF ASDU is determined by a fixed system (network specific) parameter, in this case one or two octets.

The use of two octets for COMMON ADDRESS OF ASDU is recommended.

The size of the INFORMATION OBJECT ADDRESS is determined by a fixed system (networkspecific) parameter, in this case one, two or three octets.

The use of three octets for INFORMATION OBJECT ADDRESS is recommended.

If Day of week is not used, the values shall be set to 0.

The set of information elements consists of a single information element/combination of elements or a sequence of information elements.

9.2.3 Structure of application data defined in IEC 60870-5-104

The structure of the DATA UNIT IDENTIFIER is:

– one octet type identification (TI)
– one octet variable structure qualifier
– two octets cause of transmission (Included Originator Address)
– two octets common address of ASDU
– three octets information object address (IOA)

The format CP56Time2a for TIME TAGS is used exclusively in IEC 60870-5-104.

If Day of week is not used, the values can be set to 0.

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NOTE The TYPE IDENTIFICATION (TI) defines the structure, the type and the format of the INFORMATION OBJECT. All INFORMATION OBJECTs of a specific ASDU (telegrams) are of the same structure, type and format.

9.3 IEC 60870-5 interoperability

9.3.1 IEC 60870-5-101 interoperability

9.3.1.1 General

The companion standard IEC 60870-5-101 presents sets of parameters and alternatives from which subsets shall be selected to implement particular telecontrol systems. Certain parameter values, such as the choice of “structured“ or “unstructured“ fields of the INFORMATION OBJECT ADDRESS of ASDUs represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction, allow the specification of the complete set or subsets, as appropriate for given applications. This clause summarizes the parameters of the previous clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers, it is necessary that all partners agree on the selected parameters.

NOTE 1 In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.

The selected parameters should be marked in the white boxes as follows:

☐ Function or ASDU is not used
☒ Function or ASDU is used as standardized (default)
☒ **R** Function or ASDU is used in reverse mode
☒ **B** Function or ASDU is used in standard and reverse mode

The possible selection (blank, X, R, or B) is specified for each specific clause or parameter. The selections made in Subclause 9.3.1 of this document select all parameters and ASDUs which are required for the mapping of CDCs onto IEC 60870-5-101 as described in this document.

NOTE 2 Due to the hierarchical client–server service concept (of, for example, IEC 61850), all functions or ASDUs can be used in standardized (default) mode only.

9.3.1.2 System or device

(system-specific parameter, indicate definition of a system or a device by marking one of the following with ‘**X**’)

☒ System definition
☐ Controlling station definition (Master)
☐ Controlled station definition (Slave)

9.3.1.3 Network configuration

(network-specific parameter, all configurations that are used are to be marked ‘**X**’)

☒ Point-to-point
☒ Multiple point-to-point
☐ Multipoint-partyline
☐ Multipoint star

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9.3.1.4 Physical layer

(network-specific parameter, all interfaces and data rates that are used are to be marked '**X**')

Transmission speed (control direction)

Unbalanced interchange Circuit V.24/V.28 Standard	Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200 bit/s	Balanced interchange Circuit X.24/X.27	
☐ 100 bit/s	☐ 2 400 bit/s	☐ 2 400 bit/s	☒ 56 000 bit/s
☐ 200 bit/s	☐ 4 800 bit/s	☐ 4 800 bit/s	☒ 64 000 bit/s
☐ 300 bit/s	☒ 9 600 bit/s	☒ 9 600 bit/s	
☐ 600 bit/s		☒ 19 200 bit/s	
☐ 1 200 bit/s		☒ 38 400 bit/s	

Transmission speed (monitor direction)

Unbalanced interchange Circuit V.24/V.28 Standard	Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200 bit/s	Balanced interchange Circuit X.24/X.27	
☐ 100 bit/s	☐ 2 400 bit/s	☐ 2 400 bit/s	☒ 56 000 bit/s
☐ 200 bit/s	☐ 4 800 bit/s	☐ 4 800 bit/s	☒ 64 000 bit/s
☐ 300 bit/s	☒ 9 600 bit/s	☒ 9 600 bit/s	
☐ 600 bit/s		☒ 19 200 bit/s	
☐ 1 200 bit/s		☒ 38 400 bit/s	

9.3.1.5 Link layer

(network-specific parameter, all options that are used are to be marked '**X**'. Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the type ID and COT of all messages assigned to class 2.)

Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in IEC 60870-5-101.

Link transmission procedure

☒ Balanced transmission

☐ Unbalanced transmission

Frame length

☐ Maximum length L (number of octets)

Address field of the link

☐ Not present (balanced transmission only)

☒ One octet

☒ Two octets

☐ Structured

☐ Unstructured

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When using an unbalanced link layer, the following ASDU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

☐ The standard assignment of ASDUs to class 2 messages is used as follows:

Type identification	Cause of transmission
9, 11, 13, 21	<1>

☐ A special assignment of ASDUs to class 2 messages is used as follows:

Type identification	Cause of transmission

NOTE In response to a class 2 poll, a controlled station may respond with class 1 data when there is no class 2 data available.

9.3.1.6 Application layer

Transmission mode for application data

Mode 1 (least significant octet first), as defined in Subclause 4.10 of IEC 60870-5-4:1993, is used exclusively in companion standard IEC 60870-5-101.

Common address of ASDU

(system-specific parameter, all configurations that are used are to be marked '**X**')

☐ One octet ☒ Two octets

Information object address

(system-specific parameter, all configurations that are used are to be marked '**X**')

☐ One octet
☐ Two octets
☒ Three octets

☒ structured
☒ unstructured

Cause of transmission

(system-specific parameter, all configurations that are used are to be marked '**X**')

☐ One octet

☒ Two octets (with originator address). Originator address is set to zero if not used

Length of APDU

(system-specific parameter, specify the maximum length of the APDU per system)

The maximum length of APDU for both directions is 253. It is a fixed system parameter.

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☐ Maximum length of APDU per system in control direction

☐ Maximum length of APDU per system in monitor direction

Selection of standard ASDUs

Process information in monitor direction

(station-specific parameter, mark each Type ID 'X' if it is only used in the standard direction, 'R' if only used in the reverse direction, and 'B' if used in both directions)

☒	<1> :=	Single-point information	M_SP_NA_1
☐	<2> :=	Single-point information with time tag	M_SP_TA_1
☒	<3> :=	Double-point information	M_DP_NA_1
☐	<4> :=	Double-point information with time tag	M_DP_TA_1
☒	<5> :=	Step position information	M_ST_NA_1
☐	<6> :=	Step position information with time tag	M_ST_TA_1
☒	<7> :=	Bitstring of 32 bit	M_BO_NA_1
☐	<8> :=	Bitstring of 32 bit with time tag	M_BO_TA_1
☐	<9> :=	Measured value, normalized value	M_ME_NA_1
☐	<10> :=	Measured value, normalized value with time tag	M_ME_TA_1
☒	<11> :=	Measured value, scaled value	M_ME_NB_1
☐	<12> :=	Measured value, scaled value with time tag	M_ME_TB_1
☒	<13> :=	Measured value, short floating point value	M_ME_NC_1
☐	<14> :=	Measured value, short floating point value with time tag	M_ME_TC_1
☒	<15> :=	Integrated totals	M_IT_NA_1
☐	<16> :=	Integrated totals with time tag	M_IT_TA_1
☐	<17> :=	Event of protection equipment with time tag	M_EP_TA_1
☐	<18> :=	Packed start events of protection equipment with time tag	M_EP_TB_1
☐	<19> :=	Packed output circuit information of protection equipment with time tag	M_EP_TC_1
☐	<20> :=	Packed single-point information with status change detection	M_PS_NA_1
☐	<21> :=	Measured value, normalized value without quality descriptor	M_ME_ND_1
☒	<30> :=	Single-point information with time tag CP56Time2a	M_SP_TB_1
☒	<31> :=	Double-point information with time tag CP56Time2a	M_DP_TB_1
☒	<32> :=	Step position information with time tag CP56Time2a	M_ST_TB_1
☒	<33> :=	Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
☐	<34> :=	Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
☒	<35> :=	Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
☒	<36> :=	Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
☒	<37> :=	Integrated totals with time tag CP56Time2a	M_IT_TB_1
☐	<38> :=	Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
☒	<39> :=	Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
☒	<40> :=	Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

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Either ASDUs of the set <2>, <4>, <6>, <8>, <10>, <12>, <14>, <16>, <17>, <18>, <19> or of the set <30 –40> are used.

Process information in control direction

(station-specific parameter, mark each type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[X]	<45> :=	Single command	C_SC_NA_1
[X]	<46> :=	Double command	C_DC_NA_1
[X]	<47> :=	Regulating step command	C_RC_NA_1
[ ]	<48> :=	Set point command, normalized value	C_SE_NA_1
[X]	<49> :=	Set point command, scaled value	C_SE_NB_1
[X]	<50> :=	Set point command, short floating point value	C_SE_NC_1
[ ]	<51> :=	Bitstring of 32 bit	C_BO_NA_1

System information in monitor direction

(station-specific parameter, mark an '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[X]	<70> :=	End of initialization	M_EI_NA_1

System information in control direction

(station-specific parameter, mark each type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[X]	<100>:=	Interrogation command	C_IC_NA_1
[X]	<101>:=	Counter interrogation command	C_CI_NA_1
[X]	<102>:=	Read command	C_RD_NA_1
[ ]	<103>:=	Clock synchronization command	C_CS_NA_1
[ ]	<104>:=	Test command	C_TS_NA_1
[ ]	<105>:=	Reset process command	C_RP_NA_1
[ ]	<106>:=	Delay acquisition command	C_CD_NA_1

Parameter in control direction

(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

[ ]	<110>:=	Parameter of measured value, normalized value	P_ME_NA_1
[X]	<111>:=	Parameter of measured value, scaled value	P_ME_NB_1
[X]	<112>:=	Parameter of measured value, short floating point value	P_ME_NC_1
[ ]	<113>:=	Parameter activation	P_AC_NA_1

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File transfer

(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☐	<120>:= File ready	F_FR_NA_1
☐	<121>:= Section ready	F_SR_NA_1
☐	<122>:= Call directory, select file, call file, call section	F_SC_NA_1
☐	<123>:= Last section, last segment	F_LS_NA_1
☐	<124>:= Ack file, ack section	F_AF_NA_1
☐	<125>:= Segment	F_SG_NA_1
☐	<126>:= Directory {blank or X, only available in monitor (standard) direction}	F_DR_TA_1

Type identifier and cause of transmission assignments

(station-specific parameters)

Shaded boxes: option not required.

Black boxes: option not permitted in companion standard IEC 60870-5-101.

Blank = function or ASDU is not used.

Mark Type Identification/Cause of transmission combinations:

'**X**' if only used in the standard direction,

'**R**' if only used in the reverse direction,

'**B**' if used in both directions.

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Type identification		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1														X					
<2>	M_SP_TA_1																			
<3>	M_DP_NA_1														X					
<4>	M_DP_TA_1																			
<5>	M_ST_NA_1														X					
<6>	M_ST_TA_1																			
<7>	M_BO_NA_1														X					
<8>	M_BO_TA_1																			
<9>	M_ME_NA_1																			
<10>	M_ME_TA_1																			
<11>	M_ME_NB_1														X					
<12>	M_ME_TB_1																			
<13>	M_ME_NC_1														X					
<14>	M_ME_TC_1																			
<15>	M_IT_NA_1															X				
<16>	M_IT_TA_1																			
<17>	M_EP_TA_1																			
<18>	M_EP_TB_1																			
<19>	M_EP_TC_1																			
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1			X		X						X	X							
<31>	M_DP_TB_1			X		X						X	X							
<32>	M_ST_TB_1			X		X						X	X							
<33>	M_BO_TB_1			X		X														
<34>	M_ME_TD_1																			
<35>	M_ME_TE_1			X		X														
<36>	M_ME_TF_1			X		X														
<37>	M_IT_TB_1			X																
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1			X																
<40>	M_EP_TF_1			X																
<45>	C_SC_NA_1						X	X	X	X	X						X	X	X	X
<46>	C_DC_NA_1						X	X	X	X	X						X	X	X	X
<47>	C_RC_NA_1						X	X	X	X	X						X	X	X	X
<48>	C_SE_NA_1																			
<49>	C_SE_NB_1						X	X	X	X	X						X	X	X	X

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Type identification		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<50>	C_SE_NC_1						X	X	X	X	X						X	X	X	X
<51>	C_BO_NA_1																			
<70>	M_EI_NA_1*)				X															
<100>	C_IC_NA_1						X	X			X						X	X	X	X
<101>	C_CI_NA_1						X	X			X						X	X	X	X
<102>	C_RD_NA_1					X											X	X	X	X
<103>	C_CS_NA_1																			
<104>	C_TS_NA_1																			
<105>	C_RP_NA_1																			
<106>	C_CD_NA_1																			
<110>	P_ME_NA_1																			
<111>	P_ME_NB_1						X	X							X		X	X	X	X
<112>	P_ME_NC_1						X	X							X		X	X	X	X
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1																			
<121>	F_SR_NA_1																			
<122>	F_SC_NA_1																			
<123>	F_LS_NA_1																			
<124>	F_AF_NA_1																			
<125>	F_SG_NA_1																			
<126>	F_DR_TA_1*)																			
*) blank or X only																				

9.3.1.7 Basic application functions

Station initialization

(station-specific parameter, mark '**X**' if function is used)

☐ Remote initialization

Cyclic data transmission

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☒ Cyclic data transmission *) Optional

Read procedure

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☒ Read procedure

Spontaneous transmission

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(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☒ Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous

(station-specific parameter, mark each information type '**X**' where both a Type ID without time and corresponding Type ID with time are issued in response to a single spontaneous change of a monitored object)

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

☐ Single-point information M_SP_NA_1, M_SP_TA_1, M_SP_TB_1 and M_PS_NA_1
☐ Double-point information M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1
☐ Step position information M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1
☐ Bitstring of 32 bit M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1 (if defined for a specific project)
☐ Measured value, normalized value M_ME_NA_1, M_ME_TA_1, M_ME_ND_1 and M_ME_TD_1
☐ Measured value, scaled value M_ME_NB_1, M_ME_TB_1 and M_ME_TE_1
☐ Measured value, short floating point number M_ME_NC_1, M_ME_TC_1 and M_ME_TF_1

Station interrogation

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☒ global

☐ group 1
☐ group 2
☐ group 3
☐ group 4
☐ group 5
☐ group 6
☐ group 7
☐ group 8
☐ group 9
☐ group 10
☐ group 11
☐ group 12
☐ group 13
☐ group 14
☐ group 15
☐ group 16

Information Object Addresses assigned to each group must be shown in a separate table

Clock synchronization

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☐ Clock synchronization

☐ Day of week used (Optional)

☐ RES1, GEN (time tag substituted/ not substituted) used (Optional)

☐ SU-bit (summertime) used (Optional)

Command transmission

(object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

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☒ Direct command transmission
☒ Direct set point command transmission
☒ Select and execute command
☒ Select and execute set point command
☐ C_SE ACTTERM used

☒ No additional definition
☐ Short pulse duration (duration determined by a system parameter in the outstation)
☐ Long pulse duration (duration determined by a system parameter in the outstation)
☐ Persistent output

NOTE 1 The command transmission for each control model (ctlModel) is described in 8.8.

NOTE 2 If the Option "C_SE ACTTERM used" is selected, the condition (trigger/event) for sending CE_SE ACTTERM and the related monitored information has to be specified individually per project.

Transmission of integrated totals

(station- or object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☒ Mode A: Local freeze with spontaneous transmission
☐ Mode B: Local freeze with counter interrogation
☐ Mode C: Freeze and transmit by counter interrogation commands
☐ Mode D: Freeze by counter interrogation command, frozen values reported spontaneously

☐ Counter read
☒ Counter freeze without reset
☐ Counter freeze with reset
☐ Counter reset

☒ General request counter
☐ Request counter group 1
☐ Request counter group 2
☐ Request counter group 3
☐ Request counter group 4

Parameter loading

(object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☒ Threshold value
☐ Smoothing factor
☐ Low limit for transmission of measured value
☐ High limit for transmission of measured value

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Parameter activation

(object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☐ Act/deact of persistent cyclic or periodic transmission of the addressed object

Test procedure

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☐ Test procedure

File transfer

(station-specific parameter, mark '**X**' if function is used)

File transfer in monitor direction

☐ Transparent file

☐ Transmission of disturbance data of protection equipment

☐ Transmission of sequences of events

☐ Transmission of sequences of recorded analogue values

FileA transfer in control direction

☐ Transparent file

Background scan

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☐ Background scan

Acquisition of transmission delay

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☐ Acquisition of transmission delay

9.3.2 IEC 60870-5-104 interoperability

9.3.2.1 General

The companion standard IEC 60870-5-104 presents sets of parameters and alternatives from which subsets shall be selected to implement particular telecontrol systems. Certain parameter values, such as the choice of "structured" or "unstructured" fields of the INFORMATION OBJECT ADDRESS of ASDUs represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications. This clause summarizes the parameters of the previous clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers, it is necessary that all partners agree on the selected parameters.

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The interoperability list is defined as in IEC 60870-5-101 and extended with parameters used in IEC 60870-5-104. The text descriptions of parameters which are not applicable to IEC 60870-5-104 are struck-through (corresponding check box is marked black).

NOTE In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.

The selected parameters should be marked in the white boxes as follows:

☐ Function or ASDU is not used
☒ Function or ASDU is used as standardized (default)
☒ Function or ASDU is used in reverse mode
☒ Function or ASDU is used in standard and reverse mode

The possible selection (blank, X, R, or B) is specified for each specific clause or parameter. The selections made in Subclause 9.3.2 of this document select all parameters and ASDUs which are required for the mapping of CDCs onto IEC 60870-5-104 as described in this document.

A black check box indicates that the option cannot be selected in IEC 60870-5-104.

NOTE Due to the hierarchical client–server service concept (of, for example, IEC 61850), all functions or ASDUs can be used in standardized (default) mode only.

9.3.2.2 System or device

(system-specific parameter, indicate definition of a system or a device by marking one of the following with '**X**')

☒ System definition

☐ Controlling station definition (Master)

☐ Controlled station definition (Slave)

9.3.2.3 Network configuration

(network-specific parameter, all configurations that are used are to be marked '**X**')

■ ~~Point-to-point~~ ■ ~~Multipoint-partyline~~

■ ~~Multiple point-to-point~~ ■ ~~Multipoint-star~~

9.3.2.4 Physical layer

(network-specific parameter, all interfaces and data rates that are used are to be marked '**X**')

Transmission speed (control direction)

Unbalanced interchange	Unbalanced interchange	Balanced interchange
Circuit V.24/V.28	Circuit V.24/V.28	Circuit X.24/X.27
Standard	Recommended if >1 200 bit/s	

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■ 100 bit/s	■ 2 400 bit/s	■ 2 400 bit/s	■ 56 000 bit/s
■ 200 bit/s	■ 4 800 bit/s	■ 4 800 bit/s	■ 64 000 bit/s
■ 300 bit/s	■ 9 600 bit/s	■ 9 600 bit/s	
■ 600 bit/s		■ 19 200 bit/s	
■ 1 200 bit/s		■ 38 400 bit/s	

Transmission speed (monitor direction)

Unbalanced interchange Circuit V.24/V.28 Standard	Unbalanced interchange Circuit V.24/V.28 Recommended if >1 200 bit/s	Balanced interchange Circuit X.24/X.27	
■ 100 bit/s	■ 2 400 bit/s	■ 2 400 bit/s	■ 56 000 bit/s
■ 200 bit/s	■ 4 800 bit/s	■ 4 800 bit/s	■ 64 000 bit/s
■ 300 bit/s	■ 9 600 bit/s	■ 9 600 bit/s	
■ 600 bit/s		■ 19 200 bit/s	
■ 1 200 bit/s		■ 38 400 bit/s	

9.3.2.5 Link layer

(network-specific parameter, all options that are used are to be marked '**X**'. Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the Type ID and COT of all messages assigned to class 2.)

Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in IEC 60870-5-101this companion standard.

Link transmission

■ Balanced transmission

■ Unbalanced transmission

Address field of the link

■ Not present (balanced transmission only)

■ One octet

■ Two octets

■ Structured

■ Unstructured

Frame length

■ Maximum length L (number of octets)

When using an unbalanced link layer, the following ASDU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

■ The standard assignment of ASDUs to class 2 messages is used as follows:

Type identification	Cause of transmission
9, 11, 13, 21	<1>

■ A special assignment of ASDUs to class 2 messages is used as follows:

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Type identification	Cause of transmission

~~NOTE In response to a class 2 poll, a controlled station may respond with class 1 data when there is no class 2 data available.~~

9.3.2.6 Application layer

Transmission mode for application data

Mode 1 (Least significant octet first), as defined in Subclause 4.10 of IEC 60870-5-4:1993, is used exclusively in IEC 60870-5-104.

Common address of ASDU

(system-specific parameter, all configurations that are used are to be marked '**X**')

■ ~~One octet~~ [X] Two octets

Information object address

(system-specific parameter, all configurations that are used are to be marked 'X')

■ ~~One octet~~ [X] structured

■ ~~Two octets~~ [X] unstructured

[X] Three octets

Cause of transmission

(system-specific parameter, all configurations that are used are to be marked '**X**')

■ ~~One octet~~ [X] Two octets (with originator address). Originator address is set to zero if not used (see Note)

Length of APDU

(system-specific parameter, specify the maximum length of the APDU per system)

The maximum length of APDU for both directions is 253. It is a fixed system parameter.

■ Maximum length of APDU per system in control direction

■ Maximum length of APDU per system in monitor direction

NOTE If the gateway device acts as "mediator" between the substation and all "devices on the WAN network", the originator address has to used.

Selection of standard ASDUs

Process information in monitor direction

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(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

X	<1> :=	Single-point information	M_SP_NA_1
■	~~<2> := Single-point information with time tag~~		~~M_SP_TA_1~~
X	<3> :=	Double-point information	M_DP_NA_1
■	~~<4> := Double-point information with time tag~~		~~M_DP_TA_1~~
X	<5> :=	Step position information	M_ST_NA_1
■	~~<6> := Step position information with time tag~~		~~M_ST_TA_1~~
X	<7> :=	Bitstring of 32 bit	M_BO_NA_1
■	~~<8> := Bitstring of 32 bit with time tag~~		~~M_BO_TA_1~~
☐	<9> :=	Measured value, normalized value	M_ME_NA_1
■	~~<10> := Measured value, normalized value with time tag~~		~~M_ME_TA_1~~
X	<11> :=	Measured value, scaled value	M_ME_NB_1
■	~~<12> := Measured value, scaled value with time tag~~		~~M_ME_TB_1~~
X	<13> :=	Measured value, short floating point value	M_ME_NC_1
■	~~<14> := Measured value, short floating point value with time tag~~		~~M_ME_TC_1~~
X	<15> :=	Integrated totals	M_IT_NA_1
■	~~<16> := Integrated totals with time tag~~		~~M_IT_TA_1~~
■	~~<17> := Event of protection equipment with time tag~~		~~M_EP_TA_1~~
■	~~<18> := Packed start events of protection equipment with time tag~~		~~M_EP_TB_1~~
■	~~<19> := Packed output circuit information of protection equipment with time tag~~		~~M_EP_TC_1~~
☐	<20> :=	Packed single-point information with status change detection	M_PS_NA_1
☐	<21> :=	Measured value, normalized value without quality descriptor	M_ME_ND_1
X	<30> :=	Single-point information with time tag CP56Time2a	M_SP_TB_1
X	<31> :=	Double-point information with time tag CP56Time2a	M_DP_TB_1
X	<32> :=	Step position information with time tag CP56Time2a	M_ST_TB_1
X	<33> :=	Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
☐	<34> :=	Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
X	<35> :=	Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
X	<36> :=	Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
X	<37> :=	Integrated totals with time tag CP56Time2a	M_IT_TB_1
☐	<38> :=	Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
X	<39> :=	Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
X	<40> :=	Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

In IEC 60870-5-104, only the use of the set <30> – <40> for ASDUs with time tag is permitted.

Process information in control direction

(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

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☐	<45> := Single command	C_SC_NA_1
☐	<46> := Double command	C_DC_NA_1
☐	<47> := Regulating step command	C_RC_NA_1
☐	<48> := Set point command, normalized value	C_SE_NA_1
☐	<49> := Set point command, scaled value	C_SE_NB_1
☐	<50> := Set point command, short floating point value	C_SE_NC_1
☐	<51> := Bitstring of 32 bit	C_BO_NA_1
☒	<58> := Single command with time tag CP56Time 2a	C_SC_TA_1
☒	<59> := Double command with time tag CP56Time 2a	C_DC_TA_1
☒	<60> := Regulating step command with time tag CP56Time 2a	C_RC_TA_1
☐	<61> := Set point command, normalized value with time tag CP56Time 2a	C_SE_TA_1
☒	<62> := Set point command, scaled value with time tag CP56Time 2a	C_SE_TB_1
☒	<63> := Set point command, short floating point value with time tag CP56Time 2a	C_SE_TC_1
☐	<64> := Bitstring of 32 bit with time tag CP56Time 2a	C_BO_TA_1

Either the ASDUs of the set <45> – <51> or of the set <58> – <64> are used.

System information in monitor direction

(station-specific parameter, mark an '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☒	<70> := End of initialization	M_EI_NA_1

System information in control direction

(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☒	<100>:= Interrogation command	C_IC_NA_1
☒	<101>:= Counter interrogation command	C_CI_NA_1
☒	<102>:= Read command	C_RD_NA_1
☐	<103>:= Clock synchronization command	C_CS_NA_1
■	~~<104>:= Test command~~	~~C_TS_NA_1~~
☐	<105>:= Reset process command	C_RP_NA_1
■	~~<106>:= Delay acquisition command~~	~~C_CD_NA_1~~
☐	<107>:= Test command with time tag CP56time2a	C_TS_TA_1

Parameter in control direction

(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☐	<110>:= Parameter of measured value, normalized value	P_ME_NA_1
☒	<111>:= Parameter of measured value, scaled value	P_ME_NB_1
☒	<112>:= Parameter of measured value, short floating point value	P_ME_NC_1
☐	<113>:= Parameter activation	P_AC_NA_1

File transfer

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(station-specific parameter, mark each Type ID '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☐	<120>:= File ready	F_FR_NA_1
☐	<121>:= Section ready	F_SR_NA_1
☐	<122>:= Call directory, select file, call file, call section	F_SC_NA_1
☐	<123>:= Last section, last segment	F_LS_NA_1
☐	<124>:= Ack file, ack section	F_AF_NA_1
☐	<125>:= Segment	F_SG_NA_1
☐	<126>:= Directory {blank or X, only available in monitor (standard) direction}	F_DR_TA_1
☐	<127>:= Query Log – Request archive file	F_SC_NB_1

Type identifier and cause of transmission assignments

(station-specific parameters)

Shaded boxes: option not required.

Black boxes: option not permitted in IEC 60870-5-104

Blank = function or ASDU is not used.

Mark type identification/Cause of transmission combinations:

'**X**' if only used in the standard direction,

'**R**' if only used in the reverse direction,

'**B**' if used in both directions.

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Type identification		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1														X					
~~<2>~~	~~M_SP_TA_1~~			■		■						■	■							
<3>	M_DP_NA_1														X					
~~<4>~~	~~M_DP_TA_1~~			■		■						■	■							
<5>	M_ST_NA_1														X					
~~<6>~~	~~M_ST_TA_1~~			■		■						■	■							
<7>	M_BO_NA_1														X					
~~<8>~~	~~M_BO_TA_1~~			■		■														
<9>	M_ME_NA_1																			
~~<10>~~	~~M_ME_TA_1~~			■		■														
<11>	M_ME_NB_1														X					
~~<12>~~	~~M_ME_TB_1~~			■		■														
<13>	M_ME_NC_1														X					
~~<14>~~	~~M_ME_TC_1~~			■		■														
<15>	M_IT_NA_1															X				
~~<16>~~	~~M_IT_TA_1~~			■												■				
~~<17>~~	~~M_EP_TA_1~~			■																
~~<18>~~	~~M_EP_TB_1~~			■																
~~<19>~~	~~M_EP_TC_1~~			■																
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1			X		X						X	X							
<31>	M_DP_TB_1			X		X						X	X							
<32>	M_ST_TB_1			X		X						X	X							
<33>	M_BO_TB_1			X		X														
<34>	M_ME_TD_1																			
<35>	M_ME_TE_1			X		X														
<36>	M_ME_TF_1			X		X														
<37>	M_IT_TB_1			X																
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1			X																
<40>	M_EP_TF_1			X																
<45>	C_SC_NA_1																			
<46>	C_DC_NA_1																			
<47>	C_RC_NA_1																			
<48>	C_SE_NA_1																			
<49>	C_SE_NB_1																			

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Type identification		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<50>	C_SE_NC_1																			
<51>	C_BO_NA_1																			
<58>	C_SC_TA_1						X	X	X	X	X						X	X	X	X
<59>	C_DC_TA_1						X	X	X	X	X						X	X	X	X
<60>	C_RC_TA_1						X	X	X	X	X						X	X	X	X
<61>	C_SE_TA_1																			
<62>	C_SE_TB_1						X	X	X	X	X						X	X	X	X
<63>	C_SE_TC_1						X	X	X	X	X						X	X	X	X
<64>	C_BO_TA_1																			
<70>	M_EI_NA_1 *)				X															
<100>	C_IC_NA_1						X	X			X						X	X	X	X
<101>	C_CI_NA_1						X	X			X						X	X	X	X
<102>	C_RD_NA_1					X											X	X	X	X
<103>	C_CS_NA_1																			
~~<104>~~	~~C_TS_NA_1~~																			
<105>	C_RP_NA_1																			
~~<106>~~	~~C_CD_NA_1~~																			
<107>	C_TS_TA_1																			
<110>	P_ME_NA_1																			
<111>	P_ME_NB_1						X	X							X		X	X	X	X
<112>	P_ME_NC_1						X	X							X		X	X	X	X
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1																			
<121>	F_SR_NA_1																			
<122>	F_SC_NA_1																			
<123>	F_LS_NA_1																			
<124>	F_AF_NA_1																			
<125>	F_SG_NA_1																			
<126>	F_DR_TA_1*)																			
<127>	F_SC_NB_1*)																			
*) blank or X only																				

9.3.2.7 Basic application functions

Station initialization

(station-specific parameter, mark '**X**' if function is used)

☐ Remote initialization

Cyclic data transmission

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☐ Cyclic data transmission

Read procedure

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

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☒ Read procedure

Spontaneous transmission

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☒ Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous

(station-specific parameter, mark each information type '**X**' where both a Type ID without time and corresponding Type ID with time are issued in response to a single spontaneous change of a monitored object)

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

☐ Single-point information M_SP_NA_1, M_SP_TA_1, M_SP_TB_1 and M_PS_NA_1
☐ Double-point information M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1
☐ Step position information M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1
☐ Bitstring of 32 bit M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1 (if defined for a specific project)
☐ Measured value, normalized value M_ME_NA_1, M_ME_TA_1, M_ME_ND_1 and M_ME_TD_1
☐ Measured value, scaled value M_ME_NB_1, M_ME_TB_1 and M_ME_TE_1
☐ Measured value, short floating point number M_ME_NC_1, M_ME_TC_1 and M_ME_TF_1

Station interrogation

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☒ global

☐ group 1	☐ group 7	☐ group 13
☐ group 2	☐ group 8	☐ group 14
☐ group 3	☐ group 9	☐ group 15
☐ group 4	☐ group 10	☐ group 16
☐ group 5	☐ group 11	
☐ group 6	☐ group 12	

Information object addresses assigned to each group must be shown in a separate table

Clock synchronization

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☐ Clock synchronization

☐ Day of week used

☐ RES1, GEN (time tag substituted/ not substituted) used

☐ SU-bit (summertime) used

optional, see Subclause 7.6 of IEC 60870-5-104

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Command transmission

(object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

- [X] Direct command transmission
- [X] Direct set point command transmission
- [X] Select and execute command
- [X] Select and execute set point command
- [ ] C_SE ACTTERM used

- [X] No additional definition
- [ ] Short pulse duration (duration determined by a system parameter in the
- [ ] Long pulse duration (duration determined by a system parameter in the
- [ ] Persistent output

- [X] Supervision of maximum delay in command direction of commands and set point commands

[ ] Maximum allowable delay of commands and set point commands

NOTE 1 The command transmission for each control model (ctlModel) is described in 8.8.

NOTE 2 If the option "C_SE ACTTERM used" is selected, the condition (trigger) for sending CE_SE ACTTERM and the related monitored information has to be specified individually per project.

NOTE 3 The maximum allowable delay of commands and set point commands has to be specified individually per project. The maximum allowable delay is, if the supervision function is selected, valid for all commands and setpoint commands.

Transmission of integrated totals

(station- or object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

- [X] Mode A: Local freeze with spontaneous transmission
- [ ] Mode B: Local freeze with counter interrogation
- [ ] Mode C: Freeze and transmit by counter interrogation commands
- [ ] Mode D: Freeze by counter interrogation command, frozen values reported spontaneously

- [ ] Counter read
- [X] Counter freeze without reset
- [ ] Counter freeze with reset
- [ ] Counter reset

- [X] General request counter
- [ ] Request counter group 1
- [ ] Request counter group 2
- [ ] Request counter group 3
- [ ] Request counter group 4

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Parameter loading

(object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☒ Threshold value

☐ Smoothing factor

☐ Low limit for transmission of measured value

☐ High limit for transmission of measured value

Parameter activation

(object-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☐ Act/deact of persistent cyclic or periodic transmission of the addressed object

Test procedure

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☐ Test procedure

File transfer

(station-specific parameter, mark '**X**' if function is used)

File transfer in monitor direction

☐ Transparent file

☐ Transmission of disturbance data of protection equipment

☐ Transmission of sequences of events

☐ Transmission of sequences of recorded analogue values

File transfer in control direction

☐ Transparent file

Background scan

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

☐ Background scan

Acquisition of transmission delay

(station-specific parameter, mark '**X**' if function is only used in the standard direction, '**R**' if only used in the reverse direction, and '**B**' if used in both directions)

■ ~~Acquisition of transmission delay~~

Definition of time outs

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Parameter	Default value	Remarks	Selected value
t_0	30 s	Time out of connection establishment	
t_1	15 s	Time out of send or test APDUs	
t_2	10 s	Time out for acknowledges in case of no data messages $t_2 < t_1$	
t_3	20 s	Time out for sending test frames in case of a long idle state	

Maximum range of values for timeouts t_0 to t_2: (1 to 255) s, accuracy 1 s.

Recommended range for timeout t_3: 1 s to 48 h, resolution 1 s.

Long timeouts for t_3 may be needed in special cases where satellite links or dialup connections are used (for instance to establish connection and collect values only once per day or week).

Maximum number of outstanding I format APDUs k and latest acknowledge

Parameter	Default value	Remarks	Selected value
k	12 APDUs	Maximum difference receive sequence number to send state variable	
w	8 APDUs	Latest acknowledge after receiving w I-format APDUs	

Maximum range of values k: 1 to 32 767 (2^{15}-1) APDUs, accuracy 1 APDU

Maximum range of values w: 1 to 32 767 APDUs, accuracy 1 APDU (Recommendation: w should not exceed two-thirds of k).

Portnumber

Parameter	Value	Remarks
Portnumber	2 404	In all cases

Redundant connections

☐ Number N of redundancy group connections used

RFC 2200 suite

RFC 2200 is an official Internet Standard which describes the state of standardization of protocols used in the Internet as determined by the Internet Architecture Board (IAB). It offers a broad spectrum of actual standards used in the Internet. The suitable selection of documents from RFC 2200 defined in this standard for given projects has to be chosen by the user of IEC 60870-5-104.

☒ Ethernet 802.3

☐ Serial X.21 interface

☐ Other selection from RFC 2200:

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List of valid documents from RFC 2200

1. ……..

2. ……..

3. ……..

4. ……..

5. ……..

6. ……..

etc.

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Annex A
(informative)

Use of SCL (substation configuration language) to include IEC 60870-5-101 or IEC 60870-5-104 information

The SCL (substation configuration language) files include all the information needed to configure IEDs, communication networks and substation topologies. The elements described in this file format can also be used to define the information model of a complete wind power plant. In this annex, only the elements of the SCL file needed to link the process information model with the IEC 60870-5-101 or IEC 60870-5-104 addressing information are described. Apart from that, configuration and descriptive information that is not interchanged by communication means can be described inside the SCL file so both sides in the communication link can share this information.

NOTE The complete definition of the SCL language and its associated schema are defined inside IEC 61850-6.

The SCL file is a configuration file that shall be shared by both client and server. It reflects a contract that links the IEC 60870-5-101 or IEC 60870-5-104 addressing information to the LN and CDC-based information model so both sides are able to know the reference and "meaning" of any data interchanged. The SCL file shall typically be stored at the server and be accessible to clients. The content shall reflect the latest configured information.

The SCL file is described in a XML format so it can be easily interpreted and transformed. Its schema restricts the information allowed and it assures that its information can be processed by different tools.

This annex describes how the IEC 60870-5-101 or IEC 60870-5-104 addressing information can be linked with the LN and CDC-based information model using the substation configuration language (SCL). Three different approaches to hold the IEC 60870-5-101 or IEC 60870-5-104 information inside the SCL files have been analyzed:

– the use of the “sAddr” attribute of the “DAI” element;
– the extension of the “DAI” element including new attributes using a different namespace;
– the use of “private” sections.

The approach selected is based on the definition of a specific syntax to be used inside a private section. The reasons to select this alternative are the following.

– The “sAddr” attribute is an implementation specific attribute whose syntax is vendor specific. The use of this attribute to hold IEC 60870-5-101 or IEC 60870-5-104 information might alter current implementations using this attribute.
– The use of new namespaces have as a drawback that they are not maintained by IED or substation configuration tools, so this information could be lost if different tools are used.
– The syntax of private sections is not defined and the configuration tools shall ensure its persistence. The syntax used inside the private section has been defined so this information could be interpreted unambiguously by different tools.

A.1 SCL information model hierarchy

A.1.1 General

The SCL file includes five top-level elements: header, substation, communication, IED and DataTypeTemplates. The attributes related to IEC 60870-5-101 or IEC 60870-5-104 information are included inside mainly in the IED section, but also the DataTypeTemplates section is used to reduce the need to assign its type identifier to all the DAI elements of the information model.

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A.1.2 Mapping of the common address of ASDU

The common address of ASDU (CASDU) can be assigned to any of the following elements in the SCL file: IED, LDevice, LN, LN0, DOI, SDI, DAI. In the case where more than one CASDU are defined in the hierarchy, the CASDU defined in the lower level shall be used. For instance, if there is one CASDU defined in the IED level, and there is a second definition in the LDevice level, the CASDU of all the elements below that logical device shall use the CASDU address specified at the LDevice element.

A.1.3 Mapping of the IOA (information object address)

The IOA shall be defined in the DAI level. The reason to include the IOA at the DAI level and not at the DOI level is that some CDCs need to map more than one of its attributes to different TIs and therefore need more than one IOA.

A.1.4 Mapping of the type identifiers (TI)

The type identifiers can be defined either at the DAI level or inside the DataTypeTemplates inside the DA (data attribute) or BDA (basic data attribute). If it is included in the DataTypeTemplates or SDI level, all the instances (DAI) where this attribute is referenced shall use the type identifier specified in the templates, acceptin those cases where the type identifier is specified in the DAI level, this type identifier shall be used independently from the DA/BDA definition.

A.2 Use of the SCL elements

A.2.1 General

The elements IED, LDevice, LN, DOI, SDI and DAI are used to create the information model hierarchy and the object references linked to the IEC 60870-5-101 or IEC 60870-5-104 addressing information.

The object reference shall be built as defined in Clause 19 of IEC 61850-7-2:2003:

LDName/LNName.DataName[.DataName[…]].DataAttributeName[.DAComponentName[….]]

NOTE The inner square brackets [...] indicate further recursive definitions of nested data attribute components.

A.2.2 IED

IED is the top-level element in the hierarchy. Its attribute “name” shall be used to create the LDName as specified inside IEC 61850-6.

A.2.3 AccessPoint

The AccessPoint links an IED with the SCL file “communication” section. It is not used to include IEC 60870-5-101 or IEC 60870-5-104 information.

A.2.4 Server

This is the element inside the IED that grants access to its information model expressed by the logical devices information. It is not used to include IEC 60870-5-101 or IEC 60870-5-104 information.

A.2.5 LDevice

The logical device represents the information model of a physical devices.

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Its attribute “inst” is used to build the LDName part of the object reference related to the IEC 60870-5-101 or IEC 60870-5-104 information.

LDName = “name” attribute of IEDName element + “inst” attribute of LDevice element

A.2.6 LN

Its attributes, “prefix”, “lnClass” and “lnInst” define the logical node name (LNName) used to build the object reference related to the IEC 60870-5-101 or IEC 60870-5-104 information.

LNName = “prefix” + “lnClass” + “lnInst”

A.2.7 DOI

Data object instance. Its attribute “name” is used to build the object reference related to the IEC 60870-5-101 or IEC 60870-5-104 information.

A.2.8 SDI

Instantiated subdata: middle name part of a structured data name. Each element between the top-level DOI and the BasicType represented by the DAI element shall be assigned a SDI type element.

```
<DOI name=”X”>
        <SDI name=”X”>
                …
                        <SDI name=”X”>
                                <DAI name=”X” />
                        </SDI>
                …
        </SDI>
</DOI>
```

Its attribute “name” is used to build the object reference related to the IEC 60870-5-101 or IEC 60870-5-104 information.

A.2.9 DAI

DAI (data attribute instance) is the lowest element in the information model hierarchy. Its attribute “name” is used to build the object reference related to the IEC 60870-5-101 or IEC 60870-5-104 information.

The attributes “q” and “t” of a CDC are mapped to the same IOA as the DAI.

The ctlModel DAI shall be used to define the control model used.

Inside the hierarchy, the DAI element shall include a private section holding IEC 60870-5-101 or IEC 60870-5-104 related information. The reason to include the private section at the DAI level and not at the DOI level is that some CDCs need to map more than one of its attributes to different TIs and they need more than one IOA.

A.2.10 DA/BDA/SDO

DA (data attribute) or BDA (basic data attribute) are the lowest elements in the data type templates hierarchy.

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Those elements may include a private section holding IEC 60870-5-101 or IEC 60870-5-104 related information. In that private section, only the definition of a type identifier should be included.

A.2.11 Control model

Each controllable data class includes the mandatory attribute “ctlModel”. This attribute specifies the control services that must be used to operate that element. The values available are one of the following:

0 – status-only
1 – direct-with-normal-security
2 – sbo--with-normal-security
3 – direct-with-enhanced-security
4 – sbo-with-enhanced-security

In the SCL, the control model of each controllable object may be specified or not. This specification recommends the inclusion of the value of the control model used either in the IED section or the DataTypeTemplates section of the SCL.

Example of “ctlModel” definition in the DataTypeTemplate section:

```
<DA name="ctlModel" bType="Enum" type="ctlModel" fc="CF">
        <Val>direct- with-normal-security</Val>
</DA>
```

Example of “ctlModel” definition in the IED section:

```
<DAI name "ctlModel">
        <Val>sbo-with-normal-security</Val>
</DAI>
```

For ctlVal in the following examples the mapping as defined in IEC 61850-8-1 is used.

A.3 IEC 60870-5-101 or IEC 60870-5-104 private section syntax

A.3.1 General

The private sections include two attributes named “source” and “type” to describe its content. The use of the attribute “type” is mandatory and shall be used with the value “IEC_60870_5_101” or “IEC_60870_5_104”.

The content of the private section is described in the associated schema. Two different schemas have been defined.

A.3.2 IEC 60870-5-101 private section schema

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema targetNamespace="http://www.iec.ch/61850-80-
1/2007/IEC_60870_5_101" xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns="http://www.iec.ch/61850-80-1/2007/IEC_60870-5-101"
xmlns:IEC_60870_5_101="http://www.iec.ch/61850-80-1/2007/IEC_60870-5-101"
```

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```
elementFormDefault="qualified" attributeFormDefault="unqualified"
finalDefault="extension" version="1.0">
  <xs:annotation>
    <xs:documentation xml:lang="en">COPYRIGHT IEC, 2007. Version 1.0.
Release.(Uncommented)
    </xs:documentation>
  </xs:annotation>

  <xs:simpleType name="enumUsedBy">
    <xs:restriction base="xs:string">
      <xs:enumeration value="controlled-station"/>
      <xs:enumeration value="controlling-station"/>
    </xs:restriction>
  </xs:simpleType>

  <xs:simpleType name="enumCheck">
    <xs:restriction base="xs:string">
      <xs:enumeration value="interlocking"/>
      <xs:enumeration value="synchrocheck"/>
    </xs:restriction>
  </xs:simpleType>

  <xs:complexType name="tIEC_60870_5_101Address">
   <xs:attribute name="linkAddr" type="xs:unsignedInt" />
   <xs:attribute name="casdu" type="xs:unsignedInt" />
   <xs:attribute name="ioa" type="xs:unsignedInt" />
   <xs:attribute name="ti" type="xs:unsignedInt" />
   <xs:attribute name="usedBy" type="enumUsedBy" use="optional"
default="controlled-station"/>
   <xs:attribute name="expectedValue" type="xs:integer" use="optional"/>
   <xs:attribute name="inverted" type="xs:boolean" use="optional"/>
   <!--scaleMultiplier and scaleOffset are optional for mapping of  values  -->
   <xs:attribute name="scaleMultiplier" type="xs:float" use="optional"
default=”1.0”/>
   <xs:attribute name="scaleOffset" type="xs:float" use="optional"
default=”0.0”/>
   <!—Unit-Multiplier is optional for mapping of values  -->
   <xs:attribute name="unitMultiplier" type="multiplier" use="optional"
default=”0”/>
   <!—check is optional for control services defining interlock check and synchro check -->
   <xs:attribute name="check" type="enumCheck" use="optional"/>
  </xs:complexType>
  <xs:element name="Address" type="tIEC_60870_5_101Address"/>

</xs:schema>
```

A.3.3 IEC 60870-5-104 Private section schema

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema targetNamespace="http://www.iec.ch/61850-80-1/2007/IEC_60870-5-
104" xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns="http://www.iec.ch/61850-80-1/2007/IEC_60870-5-104"
xmlns:IEC_60870_5_104="http://www.iec.ch/61850-80-1/2007/IEC_60870-5-104"
elementFormDefault="qualified" attributeFormDefault="unqualified"
finalDefault="extension" version="1.0">
  <xs:annotation>
    <xs:documentation xml:lang="en">COPYRIGHT IEC, 2007. Version 1.0.
Release.(Uncommented)
```

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```
    </xs:documentation>
  </xs:annotation>

  <xs:simpleType name="enumUsedBy">
    <xs:restriction base="xs:string">
      <xs:enumeration value="controlled-station"/>
      <xs:enumeration value="controlling-station"/>
    </xs:restriction>
  </xs:simpleType>

  <xs:simpleType name="enumCheck">
    <xs:restriction base="xs:string">
      <xs:enumeration value="interlocking"/>
      <xs:enumeration value="synchrocheck"/>
    </xs:restriction>
  </xs:simpleType>

  <xs:complexType name="tIEC_60870_5_104Address">
    <xs:attribute name="casdu" type="xs:unsignedInt" />
    <xs:attribute name="ioa" type="xs:unsignedInt" />
    <xs:attribute name="ti" type="xs:unsignedInt" />
    <xs:attribute name="usedBy" type="enumUsedBy" use="optional"
default="controlled-station"/>
   <xs:attribute name="expectedValue" type="xs:integer" use="optional"/>
    <xs:attribute name="inverted" type="xs:boolean" use="optional"/>
    <!--scaleMultiplier and scaleOffset are optional for mapping of values  -->
    <xs:attribute name="scaleMultiplier" type="xs:float" use="optional"
default=”1.0”/>
    <xs:attribute name="scaleOffset" type="xs:float" use="optional"
default=”0.0”/>
      <!—Unit-Multiplier is optional for mapping of values  -->
    <xs:attribute name="unitMultiplier" type="multiplier" use="optional"
default=”0”/>
    <!—check is optional for control services defining interlock check and synchro check -->
    <xs:attribute name="check" type="enumCheck" use="optional"/>
  </xs:complexType>
  <xs:element name="Address" type="tIEC_60870_5_104Address"/>

</xs:schema>
```

A.3.4 Use of Private section examples

A.3.4.1 General

The Private section is included inside the “DAI” element. This clause gives examples of how it shall be used.

The examples describe the use for IEC 60870-5-101 and IEC 60870-5-104 according to the defined Schemas.

NOTE In the examples all the information has been included at the DAI level.

```
<DAI name="f">
      <Private type="IEC_60870_5_101">
            <IEC_60870_5_104:Address linkAddr=”3” casdu="1" ioa="1010"
ti="36"/>
      </Private>

</DAI>
```

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```
<DAI name="f">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"/>
      </Private>
</DAI>
```

A.3.4.2 SPS common data class example

```
<DOI name="MySPS">
   <DAI name="stVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="30"/>
      </Private>
  </DAI>
</DOI>
```

A.3.4.3 DPS common data class example

```
<DOI name="MyDPS">
   <DAI name="stVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="31"/>
      </Private>
  </DAI>
</DOI>
```

A.3.4.4 INS common data class example

a) Using TI<35>

```
<DOI name="MyINS">
   <DAI name="stVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="35"
unitMultiplier="6"/>
<!--unitMultiplier can be added if needed (e.g. “6” means 10^6 “Mega”)-->
      </Private>
  </DAI>
</DOI>
```

b) Using TI<33>

```
<DOI name="MyINS"> <!--for downward compatibility of EEHealth in Ed.1 -->
   <DAI name="stVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="33"/>
      </Private>
  </DAI>
</DOI>
```

c) Using TI<30>

```
<DOI name="MyINS">
   <DAI name="stVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="30"
expectedValue="3"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="30"
expectedValue="1" inverted="true"/>
      </Private>
```

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```
  </DAI>
</DOI>
```

NOTE Details of the mapping of the attribute stVal of CDC INS onto TI<30> SPI are defined in Table 7.

A.3.4.5 ACT common data class example

a) Using TI<39>

```
<DOI name="MyACT">
   <DAI name="general">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="39"/>
      </Private>
  </DAI>
</DOI>
```

NOTE The ACT common data class attributes phsA, phsB, phsC, neut, t and q are also mapped to TI<39>.

b) Using multiple TI<30>

```
<DOI name="MyACT">
   <DAI name="general">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="30"/>
      </Private>
  </DAI>
  <DAI name="phsA">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1014" ti="30"/>
      </Private>
  </DAI>
   <DAI name="phsB">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1015" ti="30"/>
      </Private>
  </DAI>
   <DAI name="phsC">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1016" ti="30"/>
      </Private>
  </DAI>
   <DAI name="neut">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1017" ti="30"/>
      </Private>
  </DAI>
</DOI>
```

A.3.4.6 ACD common data class example

a) Using TI<40>

```
<DOI name="MyACD">
   <DAI name="general">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="40"/>
      </Private>
  </DAI>
```

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```
</DOI>
```

NOTE The ACD common data class attributes phsA, phsB, phsC, neut, t and q are also mapped to TI<40>.

b) Using multiple TI<30>

```
<DOI name="MyACD">
   <DAI name="general">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="30"/>
      </Private>
   </DAI>
   <DAI name="dirGeneral">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1014" ti="30"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1015" ti="30"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1016" ti="30"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1017" ti="30"/>
      </Private>
   </DAI>
   <DAI name="phsA">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1018" ti="30"/>
      </Private>
   </DAI>
   <DAI name="dirPhsA">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1019" ti="30"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1020" ti="30"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1021" ti="30"/>

      </Private>
  </DAI>
    <DAI name="phsB">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1023" ti="30"/>
      </Private>
   </DAI>
   <DAI name="dirPhsB">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1024" ti="30"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1025" ti="30"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1026" ti="30"/>
                  </Private>
  </DAI>
    <DAI name="phsC">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1028" ti="30"/>
      </Private>
   </DAI>
   <DAI name="dirPhsC">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1029" ti="30"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1030" ti="30"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1031" ti="30"/>

      </Private>
```

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```
  </DAI>
    <DAI name="neut">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1033" ti="30"/>
      </Private>
   </DAI>
   <DAI name="dirNeut">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1034" ti="30"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1035" ti="30"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1036" ti="30"/>

      </Private>
  </DAI>
</DOI>
```

NOTE The ACD common data class attributes t, q maps to each TI<30>.

A.3.4.7 SEC common data class example

```
<DOI name="MySEC">
   <DAI name="cnt">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="37"/>
      </Private>
  </DAI>
</DOI>
```

NOTE The attribute “t” of the CDC SEC is mapped to the same IOA.

A.3.4.8 BCR common data class example

```
<DOI name="MyBCR">
   <DAI name="actVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="37"/>
      </Private>
  </DAI>
   <DAI name="frVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="37"/>
      </Private>
  </DAI>
</DOI>
```

NOTE The attribute “t” of the CDC BCR is mapped to the same IOA as actVal. The attribute “frTm” of the CDC BCR is mapped to the same IOA as frVal.

A.3.4.9 MV common data class example

a) Using TI<36>

```
<DOI name="MyMV">
   <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"
unitMultiplier=”0” scaleMultiplier=”1.5” scaleOffset=”100”/>
            <!--unitMultiplier , scaleMultiplier and scaleOffset can be added if needed)-->
            </Private>
```

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```
        </DAI>
  </SDI>
</DOI>
```

b) Using<TI 35>

```
<DOI name="MyMV">
   <SDI name="mag">
        <DAI name="i">
           <Private type="IEC_60870_5_104">
                <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="35"
unitMultiplier=”0” scaleMultiplier=”1.5” scaleOffset=”100”/>
           <!--unitMultiplier , scaleMultiplier and scaleOffset can be added if needed)-->
           </Private>
        </DAI>
  </SDI>
</DOI>
```

A.3.4.10 CMV common data class example

a) Using TI<36>

```
<DOI name="MyCMV">
  <SDI name="cVal">
   <SDI name="mag">
        <DAI name="f">
           <Private type="IEC_60870_5_104">
                <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"/>
           </Private>
        </DAI>
   </SDI>
   <SDI name="ang">
        <DAI name="f">
           <Private type="IEC_60870_5_104">
                <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="36"/>
           </Private>
        </DAI>
   </SDI>
  </SDI>
</DOI>
```

b) Using TI<35>

```
<DOI name="MyCMV">
  <SDI name="cVal">
   <SDI name="mag">
        <DAI name="i">
           <Private type="IEC_60870_5_104">
                <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="35"/>
           </Private>
        </DAI>
   </SDI>
   <SDI name="ang">
        <DAI name="i">
```

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```
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="35"/>
            </Private>
         </DAI>
   </SDI>
  </SDI>
</DOI>
```

A.3.4.11 WYE common data class example

a) Using TI<36> for attribute “mag”

```
<DOI name="MyWYE">
   <SDI name="phsA">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
   <SDI name="phsB">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="36"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
   <SDI name="phsC">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="36"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
   <SDI name="neut">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="36"/>
            </Private>
         </DAI>
```

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```
      </SDI>
     </SDI>
    </SDI>
    <SDI name="net">
     <SDI name="cVal">
       <SDI name="mag">
          <DAI name="f">
             <Private type="IEC_60870_5_104">
                   <IEC_60870_5_104:Address casdu="1" ioa="1014" ti="36"/>
             </Private>
          </DAI>
       </SDI>
     </SDI>
    </SDI>
    <SDI name="res">
     <SDI name="cVal">
       <SDI name="mag">
          <DAI name="f">
             <Private type="IEC_60870_5_104">
                   <IEC_60870_5_104:Address casdu="1" ioa="1015" ti="36"/>
             </Private>
          </DAI>
       </SDI>
     </SDI>
    </SDI>
</DOI>
```

b) Using TI<35> for attribute “mag”

```
<DOI name="MyWYE">
    <SDI name="phsA">
     <SDI name="cVal">
       <SDI name="mag">
          <DAI name="i">
             <Private type="IEC_60870_5_104">
                   <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="35"/>
             </Private>
          </DAI>
       </SDI>
     </SDI>
    </SDI>
    <SDI name="phsB">
     <SDI name="cVal">
       <SDI name="mag">
          <DAI name="i">
             <Private type="IEC_60870_5_104">
                   <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="35"/>
             </Private>
          </DAI>
       </SDI>
     </SDI>
    </SDI>
    <SDI name="phsC">
     <SDI name="cVal">
```

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```
      <SDI name="mag">
         <DAI name="i">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="35"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
   <SDI name="neut">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="i">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="35"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
   <SDI name="net">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="i">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1014" ti="35"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
   <SDI name="res">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="i">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1015" ti="35"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
</DOI>
```

c) Using TI<36> for attributes “mag” and “ang”

```
<DOI name="MyWYE">
   <SDI name="phsA">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"/>
            </Private>
         </DAI>
```

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```
    </SDI>
    <SDI name="ang">
      <DAI name="f">
        <Private type="IEC_60870_5_104">
              <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="36"/>
        </Private>
      </DAI>
    </SDI>
  </SDI>
</SDI>
<SDI name="phsB">
  <SDI name="cVal">
    <SDI name="mag">
      <DAI name="f">
        <Private type="IEC_60870_5_104">
              <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="36"/>
        </Private>
      </DAI>
    </SDI>
    <SDI name="ang">
      <DAI name="f">
        <Private type="IEC_60870_5_104">
              <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="36"/>
        </Private>
      </DAI>
    </SDI>
  </SDI>
</SDI>
<SDI name="phsC">
  <SDI name="cVal">
    <SDI name="mag">
      <DAI name="f">
        <Private type="IEC_60870_5_104">
              <IEC_60870_5_104:Address casdu="1" ioa="1014" ti="36"/>
        </Private>
      </DAI>
    </SDI>
    <SDI name="ang">
      <DAI name="f">
        <Private type="IEC_60870_5_104">
              <IEC_60870_5_104:Address casdu="1" ioa="1015" ti="36"/>
        </Private>
      </DAI>
    </SDI>
  </SDI>
</SDI>
<SDI name="neut">
  <SDI name="cVal">
    <SDI name="mag">
      <DAI name="f">
        <Private type="IEC_60870_5_104">
              <IEC_60870_5_104:Address casdu="1" ioa="1016" ti="36"/>
        </Private>
      </DAI>
```

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```
      </SDI>
      <SDI name="ang">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1017" ti="36"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
   <SDI name="net">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1018" ti="36"/>
            </Private>
         </DAI>
      </SDI>
      <SDI name="ang">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1019" ti="36"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
   <SDI name="res">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1020" ti="36"/>
            </Private>
         </DAI>
      </SDI>
      <SDI name="ang">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1021" ti="36"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
</DOI>
```

d) Using TI<35> for attributes “mag” and “ang”

```
<DOI name="MyWYE">
   <SDI name="phsA">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="i">
```

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```
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="35"/>
            </Private>
         </DAI>
      </SDI>
       <SDI name="ang">
         <DAI name="i">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="35"/>
            </Private>
         </DAI>
      </SDI>
   </SDI>
</SDI>
<SDI name="phsB">
   <SDI name="cVal">
      <SDI name="mag">
         <DAI name="i">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="35"/>
            </Private>
         </DAI>
      </SDI>
       <SDI name="ang">
         <DAI name="i">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="35"/>
            </Private>
         </DAI>
      </SDI>
   </SDI>
</SDI>
<SDI name="phsC">
   <SDI name="cVal">
      <SDI name="mag">
         <DAI name="i">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1014" ti="35"/>
            </Private>
         </DAI>
      </SDI>
       <SDI name="ang">
         <DAI name="i">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1015" ti="35"/>
            </Private>
         </DAI>
      </SDI>
   </SDI>
</SDI>
<SDI name="neut">
   <SDI name="cVal">
      <SDI name="mag">
         <DAI name="i">
```

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```
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1016" ti="35"/>
            </Private>
         </DAI>
      </SDI>
      <SDI name="ang">
         <DAI name="i">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1017" ti="35"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
   <SDI name="net">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="i">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1018" ti="35"/>
            </Private>
         </DAI>
      </SDI>
      <SDI name="ang">
         <DAI name="i">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1019" ti="35"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
   <SDI name="res">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="i">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1020" ti="35"/>
            </Private>
         </DAI>
      </SDI>
      <SDI name="ang">
         <DAI name="i">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1021" ti="35"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
</DOI>
```

A.3.4.12 DEL common data class example

a) Using TI<36> for attribute "mag"

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```
<DOI name="MyDEL">
   <SDI name="phsAB">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
   <SDI name="phsBC">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="36"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
   <SDI name="phsCA">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="36"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
</DOI>
```

All other variants of mapping have to be done similar to the CDC WYE

A.3.4.13 SEQ common data class example

a) Using TI<36> for attribute “mag”

```
<DOI name="MySEQ">
   <SDI name="c1">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
   <SDI name="c2">
    <SDI name="cVal">
```

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```
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="36"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
   <SDI name="c3">
    <SDI name="cVal">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="36"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
   </SDI>
</DOI>
```

All other variants of data attribute mapping have to be done similar to the CDC WYE

A.3.4.14 HMV common data class example

A.3.4.14.1 General

This example shows the use of SCL for three harmonic values. If more than three harmonic values are present, an SDI section has to be created for each harmonic.

A.3.4.14.2 Defined in IEC 61850-7-3:2003

```
<DOI name="MyHMV">
   <SDI name="har" ix="0">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"/>
            </Private>
         </DAI>
       </SDI>
   </SDI>
   <SDI name="har" ix="1">
       <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="36"/>
            </Private>
         </DAI>
       </SDI>
   </SDI>
   <SDI name="har" ix="2">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
```

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```
                <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="36"/>
            </Private>
        </DAI>
    </SDI>
</SDI>
</DOI>
```

A.3.4.14.3 Defined in IEC 61850-7-3:2010

```
<DOI name="MyHMV">
   <SDI name="har" ix="0">
      <SDI name="cVal">
        <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"/>
            </Private>
         </DAI>
      </SDI>
     </SDI>
   </SDI>
   <SDI name="har" ix="1">
     <SDI name="cVal">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="36"/>
            </Private>
         </DAI>
      </SDI>
     </SDI>
   </SDI>
   <SDI name="har" ix="2">
     <SDI name="cVal">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="36"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
  </SDI>
</DOI>
```

A.3.4.15 WYE (HWYE) common data class example

A.3.4.15.1 General

This example shows the use of SCL for two harmonic values per phase. If more them two harmonic values are present, an SDI section has to be created for each harmonic.

A.3.4.15.2 Defined in IEC 61850-7-3:2003

```
<DOI name="MyWYE">
   <SDI name="phsAHar" ix="0">
     <SDI name="mag">
```

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```
        <DAI name="f">
           <Private type="IEC_60870_5_104">
                 <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"/>
           </Private>
        </DAI>
     </SDI>
  </SDI>
  <SDI name="phsAHar" ix="1">
    <SDI name="mag">
        <DAI name="f">
           <Private type="IEC_60870_5_104">
                 <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="36"/>
           </Private>
        </DAI>
    </SDI>
  </SDI>
  <SDI name="phsBHar" ix="0">
    <SDI name="mag">
        <DAI name="f">
           <Private type="IEC_60870_5_104">
                 <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="36"/>
           </Private>
        </DAI>
    </SDI>
 </SDI>
 <SDI name="phsBHar" ix="1">
   <SDI name="mag">
        <DAI name="f">
           <Private type="IEC_60870_5_104">
                 <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="36"/>
           </Private>
        </DAI>
   </SDI>
  <SDI name="phsCHar" ix="0">
    <SDI name="mag">
        <DAI name="f">
           <Private type="IEC_60870_5_104">
                 <IEC_60870_5_104:Address casdu="1" ioa="1014" ti="36"/>
           </Private>
        </DAI>
    </SDI>
 </SDI>
 <SDI name="phsCHar" ix="1">
   <SDI name="mag">
        <DAI name="f">
           <Private type="IEC_60870_5_104">
                 <IEC_60870_5_104:Address casdu="1" ioa="1015" ti="36"/>
           </Private>
        </DAI>
    </SDI>
  </SDI>
  <SDI name="neutHar" ix="0">
    <SDI name="mag">
        <DAI name="f">
```

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```
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1016" ti="36"/>
            </Private>
         </DAI>
      </SDI>
   </SDI>
   <SDI name="neutHar" ix="1">
     <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1017" ti="36"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
    <SDI name="netHar" ix="0">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1018" ti="36"/>
            </Private>
         </DAI>
      </SDI>
   </SDI>
   <SDI name="netHar" ix="1">
     <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1019" ti="36"/>
            </Private>
         </DAI>
      </SDI>
    </SDI>
    <SDI name="resHar" ix="0">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1020" ti="36"/>
            </Private>
         </DAI>
      </SDI>
   </SDI>
   <SDI name="resCHar" ix="1">
     <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1021" ti="36"/>
            </Private>
         </DAI>
      </SDI>
</SDI>
</DOI>
```

A.3.4.15.3 Defined in IEC 61850-7-3:2010

```
<DOI name="MyWYE">
```

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```
<SDI name="phsAHar" ix="0">
 <SDI name="cVal">
     <SDI name="mag">
      <DAI name="f">
         <Private type="IEC_60870_5_104">
               <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"/>
         </Private>
      </DAI>
   </SDI>
 </SDI>
</SDI>
<SDI name="phsAHar" ix="1">
  <SDI name="cVal">
   <SDI name="mag">
      <DAI name="f">
         <Private type="IEC_60870_5_104">
               <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="36"/>
         </Private>
      </DAI>
   </SDI>
 </SDI>
</SDI>
<SDI name="phsBHar" ix="0">
  <SDI name="cVal">
   <SDI name="mag">
      <DAI name="f">
         <Private type="IEC_60870_5_104">
               <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="36"/>
         </Private>
      </DAI>
   </SDI>
  </SDI>
</SDI>
<SDI name="phsBHar" ix="1">
   <SDI name="cVal">
    <SDI name="mag">
      <DAI name="f">
         <Private type="IEC_60870_5_104">
               <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="36"/>
         </Private>
      </DAI>
   </SDI>
  </SDI>
 <SDI name="phsCHar" ix="0">
  <SDI name="cVal">
   <SDI name="mag">
      <DAI name="f">
         <Private type="IEC_60870_5_104">
               <IEC_60870_5_104:Address casdu="1" ioa="1014" ti="36"/>
         </Private>
      </DAI>
   </SDI>
  </SDI>
</SDI>
```

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```
<SDI name="phsCHar" ix="1">
   <SDI name="cVal">
    <SDI name="mag">
       <DAI name="f">
          <Private type="IEC_60870_5_104">
                <IEC_60870_5_104:Address casdu="1" ioa="1015" ti="36"/>
          </Private>
       </DAI>
    </SDI>
  </SDI>
 </SDI>
 <SDI name="neutHar" ix="0">
   <SDI name="cVal">
    <SDI name="mag">
       <DAI name="f">
          <Private type="IEC_60870_5_104">
                <IEC_60870_5_104:Address casdu="1" ioa="1016" ti="36"/>
          </Private>
       </DAI>
    </SDI>
  </SDI>
</SDI>
<SDI name="neutHar" ix="1">
   <SDI name="cVal">
    <SDI name="mag">
       <DAI name="f">
          <Private type="IEC_60870_5_104">
                <IEC_60870_5_104:Address casdu="1" ioa="1017" ti="36"/>
          </Private>
       </DAI>
    </SDI>
  </SDI>
 </SDI>
  <SDI name="netHar" ix="0">
   <SDI name="cVal">
    <SDI name="mag">
       <DAI name="f">
          <Private type="IEC_60870_5_104">
                <IEC_60870_5_104:Address casdu="1" ioa="1018" ti="36"/>
          </Private>
       </DAI>
    </SDI>
  </SDI>
</SDI>
<SDI name="netHar" ix="1">
   <SDI name="cVal">
    <SDI name="mag">
       <DAI name="f">
          <Private type="IEC_60870_5_104">
                <IEC_60870_5_104:Address casdu="1" ioa="1019" ti="36"/>
          </Private>
       </DAI>
    </SDI>
  </SDI>
```

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```
    </SDI>
     <SDI name="resHar" ix="0">
      <SDI name="cVal">
       <SDI name="mag">
          <DAI name="f">
             <Private type="IEC_60870_5_104">
                   <IEC_60870_5_104:Address casdu="1" ioa="1020" ti="36"/>
             </Private>
          </DAI>
       </SDI>
      </SDI>
    </SDI>
    <SDI name="resCHar" ix="1">
       <SDI name="cVal">
        <SDI name="mag">
          <DAI name="f">
             <Private type="IEC_60870_5_104">
                   <IEC_60870_5_104:Address casdu="1" ioa="1021" ti="36"/>
             </Private>
          </DAI>
        </SDI>
      </SDI>
  </SDI>
</DOI>
```

A.3.4.16 DEL (HDEL) common data class example

A.3.4.16.1 General

This example shows the use of SCL for two harmonic values for each "delta". If more than two harmonic values are present, an SDI section has to be created for each harmonic.

A.3.4.16.2 Defined in IEC 61850-7-3:2003

```
<DOI name="MyDEL">
   <SDI name="phsABHar" ix="0">
     <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"/>
            </Private>
         </DAI>
      </SDI>
   </SDI>
   <SDI name="phsABHar" ix="1">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="36"/>
            </Private>
         </DAI>
      </SDI>
   </SDI>
   <SDI name="phsBCHar" ix="0">
      <SDI name="mag">
         <DAI name="f">
```

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```
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="36"/>
            </Private>
         </DAI>
      </SDI>
   </SDI>
   <SDI name="phsBCHar" ix="1">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="36"/>
            </Private>
         </DAI>
      </SDI>
   </SDI>
   <SDI name="phsCAHar" ix="0">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1014" ti="36"/>
            </Private>
         </DAI>
      </SDI>
   </SDI>
   <SDI name="phsCAHar" ix="1">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1015" ti="36"/>
            </Private>
         </DAI>
      </SDI>
   </SDI>
</DOI>
```

A.3.4.16.3 Defined in IEC 61850-7-3:2010

```
<DOI name="MyDEL">
   <SDI name="phsABHar" ix="0">
     <SDI name="cVal">
        <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"/>
            </Private>
         </DAI>
      </SDI>
     </SDI>
   </SDI>
   <SDI name="phsABHar" ix="1">
     <SDI name="cVal">
      <SDI name="mag">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="36"/>
            </Private>
```

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```
            </DAI>
         </SDI>
        </SDI>
     </SDI>
     <SDI name="phsBCHar" ix="0">
        <SDI name="cVal">
         <SDI name="mag">
            <DAI name="f">
               <Private type="IEC_60870_5_104">
                     <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="36"/>
               </Private>
            </DAI>
         </SDI>
        </SDI>
     </SDI>
    <SDI name="phsBCHar" ix="1">
        <SDI name="cVal">
         <SDI name="mag">
            <DAI name="f">
               <Private type="IEC_60870_5_104">
                     <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="36"/>
               </Private>
            </DAI>
         </SDI>
        </SDI>
     </SDI>
     <SDI name="phsCAHar" ix="0">
        <SDI name="cVal">
         <SDI name="mag">
            <DAI name="f">
               <Private type="IEC_60870_5_104">
                     <IEC_60870_5_104:Address casdu="1" ioa="1014" ti="36"/>
               </Private>
            </DAI>
         </SDI>
        </SDI>
     </SDI>
    <SDI name="phsCAHar" ix="1">
        <SDI name="cVal">
         <SDI name="mag">
            <DAI name="f">
               <Private type="IEC_60870_5_104">
                     <IEC_60870_5_104:Address casdu="1" ioa="1015" ti="36"/>
               </Private>
            </DAI>
         </SDI>
        </SDI>
     </SDI>
</DOI>
```

A.3.4.17 SPC common data class example

1) for IEC 60870-5-101:

```
<DOI name="MySPC">
   <DAI name="stVal">
```

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```
      <Private type="IEC_60870_5_101">
            <IEC_60870_5_101:Address casdu="1" ioa="1010" ti="30"/>
      </Private>
  </DAI>

  < SDI name="Oper">
      <DAI name="ctlVal"
            <Private type="IEC_60870_5_101">
                  <IEC_60870_5_101:Address casdu="1" ioa="1011" ti="45"/>
            </Private>
      </DAI>
      <!—example for mapping of service parameter "Check" (see Clause 8.8) -->
      <DAI name="Check"
            <Private type="IEC_60870_5_101">
                  <IEC_60870_5_101:Address casdu="1" ioa="1015" ti="45"
            check="interlocking"/>
                  <IEC_60870_5_101:Address casdu="1" ioa="1016" ti="45"
            check="synchrocheck"/>
            </Private>
      </DAI>
  </SDI>

</DOI>
```

2) for IEC 60870-5-104:

```
<DOI name="MySPC">
   <DAI name="stVal">
          <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="30"/>
      </Private>
  </DAI>

  <DAI name="Oper">
      <DAI name="ctlVal"
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="58"/>
            </Private>
      </DAI>
      <!—example for mapping of service parameter "Check" (see Clause 8.8) -->

      <DAI name="Check"
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1015" ti="58"
            check="interlocking"/>
                  <IEC_60870_5_104:Address casdu="1" ioa="1016" ti="58"
            check="synchrocheck"/>
            </Private>
      </DAI>
  </DAI>

</DOI>
```

A.3.4.18 DPC common data class example

1) for IEC 60870-5-101:

```
<DOI name="MyDPC">
```

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```
   <DAI name="stVal">
      <Private type="IEC_60870_5_101">
            <IEC_60870_5_101:Address casdu="1" ioa="1010" ti="31"/>
      </Private>
  </DAI>

  <SDI name="Oper">
      <DAI name="ctlVal"
            <Private type="IEC_60870_5_101">
                  <IEC_60870_5_101:Address casdu="1" ioa="1011" ti="46"/>
            </Private>
      </DAI>
  </SDI>

</DOI>
```

2) for IEC 60870-5-104:

```
<DOI name="MyDPC">
   <DAI name="stVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="31"/>
      </Private>
  </DAI>

  <SDI name="Oper">
      <DAI name="ctlVal"
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="59"/>
            </Private>
      </DAI>
  </SDI>

</DOI>
```

A.3.4.19 INC common data class example

1) for IEC 60870-5-101:

```
<DOI name="MyINC">
   <DAI name="stVal">
      <Private type="IEC_60870_5_101">
            <IEC_60870_5_101:Address casdu="1" ioa="1010" ti="35"/>
      </Private>
  </DAI>

  <SDI name="Oper">
      <DAI name="ctlVal"
            <Private type="IEC_60870_5_101">
                  <IEC_60870_5_101:Address casdu="1" ioa="1011" ti="49"/>
            </Private>
      </DAI>
  </SDI>

</DOI>
```

2) for IEC 60870-5-104:

```
<DOI name="MyINC">
```

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```
   <DAI name="stVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="35"/>
      </Private>
  </DAI>

  <SDI name="Oper">
      <DAI name="ctlVal"
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="62"/>
            </Private>
      </DAI>
  </SDI>

</DOI>
```

A.3.4.20 BSC common data class example

1) for IEC 60870-5-101:

```
<DOI name="MyBSC">
  <SDI name="valWTr">
   <DAI name="posVal">
      <Private type="IEC_60870_5_101">
            <IEC_60870_5_101:Address casdu="1" ioa="1010" ti="32"/>
      </Private>
   </DAI>
 </SDI>
  <SDI name="Oper">
      <DAI name="ctlVal"
            <Private type="IEC_60870_5_101">
                  <IEC_60870_5_101:Address casdu="1" ioa="1011" ti="47"/>
            </Private>
      </DAI>
  </SDI>

</DOI>
```

2) for IEC 60870-5-104:

```
<DOI name="MyBSC">
  <SDI name=" valWTr">
   <DAI name="posVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="32"/>
      </Private>
   </DAI>
 </SDI>
  <SDI name="Oper">
      <DAI name="ctlVal"
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="60"/>
            </Private>
      </DAI>
  </SDI>

</DOI>
```

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A.3.4.21 ISC common data class example

1) for IEC 60870-5-101:

```
<DOI name="MyISC">
  <SDI name="valWTr">
   <DAI name="posVal">
      <Private type="IEC_60870_5_101">
            <IEC_60870_5_101:Address casdu="1" ioa="1010" ti="32"/>
      </Private>
   </DAI>
 </SDI>

  <SDI name="Oper">
      <DAI name=“ctlVal”
            <Private type="IEC_60870_5_101">
                  <IEC_60870_5_101:Address casdu="1" ioa="1011" ti="49"/>
            </Private>
      </DAI>
  </SDI>
</DOI>
```

2) for IEC 60870-5-104:

```
<DOI name="MyISC">
  <SDI name=" valWTr">
   <DAI name="posVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="32"/>
      </Private>
   </DAI>
 </SDI>

  <SDI name="Oper">
      <DAI name=“ctlVal”
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="62"/>
            </Private>
      </DAI>
  </SDI>
</DOI>
```

A.3.4.22 APC common data class example

A.3.4.22.1 Defined in IEC 61850-7-3:2003

1) for IEC 60870-5-101:

```
<DOI name="MyAPC">
   <SDI name="setMag">
     <DAI name="f">
      <Private type="IEC_60870_5_101">
            <IEC_60870_5_101:Address casdu="1" ioa="1010" ti="36"/>
      </Private>
    </DAI>
  </SDI>
 <SDI name="Oper">
   <SDI name="setMag">
```

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```
      <DAI name="f">
       <Private type="IEC_60870_5_101">
             <IEC_60870_5_101:Address casdu="1" ioa="1011" ti="50"/>
       </Private>
     </DAI>
    </SDI>
  </SDI>
</DOI>
```

2) for IEC 60870-5-104:

```
<DOI name="MyAPC">
   <SDI name="setMag">
     <DAI name="f">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"/>
      </Private>
     </DAI>
   </SDI>
  <SDI name="Oper">
    <SDI name="setMag">
      <DAI name="f">
       <Private type="IEC_60870_5_104">
             <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="63"/>
       </Private>
     </DAI>
    </SDI>
  </SDI>
</DOI>
```

A.3.4.22.2 Defined in IEC 61850-7-3:2010

1) for IEC 60870-5-101:

```
<DOI name="MyAPC">
   <SDI name="mxVal">
     <DAI name="f">
      <Private type="IEC_60870_5_101">
            <IEC_60870_5_101:Address casdu="1" ioa="1010" ti="36"/>
      </Private>
     </DAI>
   </SDI>

<SDI name="Oper">
     <SDI name="ctlVal">
      <DAI name="f">
       <Private type="IEC_60870_5_104">
             <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="50"/>
       </Private>
     </DAI>
    </SDI>
</SDI>


</DOI>
```

2) for IEC 60870-5-104:

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```
<DOI name="MyAPC">
   <SDI name="mxVal">
     <DAI name="f">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"/>
      </Private>
    </DAI>
  </SDI>
  <SDI name="Oper">
    <SDI name="ctlVal">
     <DAI name="f">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="63"/>
      </Private>
    </DAI>
   </SDI>
  </SDI>
</DOI>
```

A.3.4.23 SPG common data class example

1) for IEC 60870-5-101:

```
<DOI name="MySPG">
   <DAI name="setVal">
      <Private type="IEC_60870_5_101">
            <IEC_60870_5_101:Address casdu="1" ioa="1010" ti="45"/>
      </Private>
    </DAI>
</DOI>
```

2) for IEC 60870-5-104:

```
<DOI name="MySPG">
   <DAI name="setVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="58"/>
      </Private>
   </DAI>
</DOI>
```

A.3.4.24 ING common data class example

1) for IEC 60870-5-101:

```
<DOI name="MyING">
   <DAI name="setVal">
      <Private type="IEC_60870_5_101">
            <IEC_60870_5_101:Address casdu="1" ioa="1010" ti="49"/>
      </Private>
    </DAI>
</DOI>
```

2) for IEC 60870-5-104:

```
<DOI name="MyING">
   <DAI name="setVal">
```

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```
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="62"/>
      </Private>
   </DAI>
</DOI>
```

A.3.4.25 ASG common data class example

1) for IEC 60870-5-101:

```
<DOI name="MyASG">
   <SDI name="setMag">
     <DAI name="f">
      <Private type="IEC_60870_5_101">
            <IEC_60870_5_101:Address casdu="1" ioa="1010" ti="50"/>
      </Private>
    </DAI>
  </SDI>
</DOI>
```

2) for IEC 60870-5-104:

```
<DOI name="MyASG">
   <SDI name="setMag">
     <DAI name="f">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="63"/>
      </Private>
    </DAI>
  </SDI>
</DOI>
```

A.3.4.26 ENS common data class example

a) Using TI<35>

```
<DOI name="MyENS">
   <DAI name="stVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="35"/>
      </Private>
  </DAI>
</DOI>
```

b) Using TI<30>

The example shows the use of SCL for three enumerated values of “stVal”. If more than three enumerated values are defined, the address section within the private type has to be extended accordingly.

```
<DOI name="MyENS">
   <DAI name="stVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="30"
expectedValue="1"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="30"
expectedValue="2"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="30"
expectedValue="3"/>
```

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```
      </Private>
  </DAI>
</DOI>
```

NOTE Details of the mapping of the attribute stVal of CDC ENS onto TI<30> SPI are defined in Table 49 .

A.3.4.27 HST common data class example

The example shows the use of SCL for three values of the histogram. If more them three values of the histogram are present, an SDI section has to be created for each histogram value

a) Using TI<35>

```
<DOI name="MyHST">
   <DAI name="hstVal" ix="0">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="35"/>
      </Private>
  </DAI>
   <DAI name="hstVal" ix="1">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="35"/>
      </Private>
  </DAI>
   <DAI name="hstVal" ix="2">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="35"/>
      </Private>
  </DAI>
</DOI>
```

b) Using TI<33>

```
<DOI name="MyHST">
   <DAI name="hstVal" ix="0">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="33"/>
      </Private>
  </DAI>
   <DAI name="hstVal" ix="1">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="33"/>
      </Private>
  </DAI>
   <DAI name="hstVal" ix="2">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="33"/>
      </Private>
  </DAI>
</DOI>
```

A.3.4.28 ENC common data class example

1) for IEC 60870-5-101:

   a) Using TI<35>

```
<DOI name="ENC01">
   <DAI name="stVal">
      <Private type="IEC_60870_5_101">
```

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```
            <IEC_60870_5_101:Address casdu="1" ioa="1011" ti="35"/>
        </Private>
    </DAI>
    <SDI name="Oper">
     <DAI name="ctlVal">
        <Private type="IEC_60870_5_101">
            <IEC_60870_5_101:Address casdu="1" ioa="1011" ti="49"/>
        </Private>
     </DAI>
    </SDI>
</DOI>
```

b) Using TI<30>

The example shows the use of SCL for three enumerated values of “stVal” and “ctlVal”. If more than three enumerated values are defined, the address section within the private type has to be extended accordingly.

```
<DOI name="MyENC">
    <DAI name="stVal">
        <Private type="IEC_60870_5_101">
            <IEC_60870_5_101:Address casdu="1" ioa="1011" ti="30"
expectedValue="1"/>
            <IEC_60870_5_101:Address casdu="1" ioa="1012" ti="30"
expectedValue="2"/>
            <IEC_60870_5_101:Address casdu="1" ioa="1013" ti="30"
expectedValue="3"/>
        </Private>
    </DAI>
    <SDI name="Oper">
     <DAI name="ctlVal">
        <Private type="IEC_60870_5_101">
            <IEC_60870_5_101:Address casdu="1" ioa="1011" ti="45"
expectedValue="1"/>
            <IEC_60870_5_101:Address casdu="1" ioa="1012" ti="45"
expectedValue="2"/>
            <IEC_60870_5_101:Address casdu="1" ioa="1013" ti="45"
expectedValue="3"/>
        </Private>
     </DAI>
    </SDI>
</DOI>
```

2) for IEC 60870-5-104:

a) Using TI<35>

```
<DOI name="MyENC">
    <DAI name="stVal">
        <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="35"/>
        </Private>
    </DAI>
    <SDI name="Oper">
     <DAI name="ctlVal">
        <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="62"/>
        </Private>
     </DAI>
```

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```
  </SDI>
</DOI>
```

b) Using TI<30>

The example shows the use of SCL for three enumerated values of “stVal” and “ctlVal”. If more than three enumerated values are defined, the address section within the private type has to be extended accordingly.

```
<DOI name="MyENC">
   <DAI name="stVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="30"
expectedValue="1"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="30"
expectedValue="2"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="30"
expectedValue="3"/>
      </Private>
  </DAI>
  <SDI name="Oper">
   <DAI name="ctlVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="58"
expectedValue="1"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="58"
expectedValue="2"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="58"
expectedValue="3"/>
      </Private>
   </DAI>
  </SDI>
</DOI>
```

NOTE Details of the mapping of the attribute stVal of CDC ENC onto TI<30> SPI are defined in Table 49 .

A.3.4.29 ENG common data class example

1) using TI<49> , TI<62>

a) for IEC 60870-5-101:

```
<DOI name="MyENG">
   <DAI name="setVal">
      <Private type="IEC_60870_5_101">
            <IEC_60870_5_101:Address casdu="1" ioa="1010" ti="49"/>
      </Private>
   </DAI>
</DOI>
```

b) for IEC 60870-5-104:

```
<DOI name="MyENG">
   <DAI name="setVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="62"/>
      </Private>
   </DAI>
</DOI>
```

2) using TI<45> , TI<58>

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a) for IEC 60870-5-101:

The example shows the use of SCL for three enumerated values of “setVal”. If more than three enumerated values are defined, the address section within the private type has to be extended accordingly.

```
<DOI name="MyENG">
   <DAI name="setVal">
      <Private type="IEC_60870_5_101">
            <IEC_60870_5_101:Address casdu="1" ioa="1011" ti="45"
expectedValue="1"/>
            <IEC_60870_5_101:Address casdu="1" ioa="1012" ti="45"
expectedValue="2"/>
            <IEC_60870_5_101:Address casdu="1" ioa="1013" ti="45"
expectedValue="3"/>
      </Private>
   </DAI>
</DOI>
```

3) for IEC 60870-5-104:

```
<DOI name="MyENG">
   <DAI name="setVal">
      <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="58"
expectedValue="1"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="58"
expectedValue="2"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="58"
expectedValue="3"/>
      </Private>
   </DAI>
</DOI>
```

NOTE Details of the mapping of the attribute stVal of CDC ENG onto TI<30> SPI are defined in Table 49 .

A.3.4.30 BAC common data class example

1) for IEC 60870-5-101:

```
<DOI name="MyBAC">
   <SDI name="mxVal">
         <DAI name="f">
            <Private type="IEC_60870_5_101">
                  <IEC_60870_5_101:Address casdu="1" ioa="1010" ti="36"/>
            </Private>
         </DAI>
  </SDI>
   <SDI name="Oper">
        <DAI name="ctlVal">
            <Private type="IEC_60870_5_101">
                  <IEC_60870_5_101:Address casdu="1" ioa="1011" ti="47"/>
            </Private>
        </DAI>
   </SDI>
</DOI>
```

2) for IEC 60870-5-104:

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```
<DOI name="MyBSC">
   <SDI name="mxVal">
         <DAI name="f">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1010" ti="36"/>
            </Private>
         </DAI>
   </SDI>
   <SDI name="Oper">
         <DAI name="ctlVal">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="60"/>
            </Private>
         </DAI>
   </SDI>
</DOI>
```

A.3.4.31 CSG common data class example

The example shows the use of SCL for three values of the curve shape setting. If more them three values of the curve shape are present, an SDI section has to be created for each curve point value

1) for IEC 60870-5-101:

```
<DOI name="MyCSG">
   <SDI name="crvPts" ix="0">
     <DAI name="xVal">
            <Private type="IEC_60870_5_101">
                  <IEC_60870_5_101:Address casdu="1" ioa="1011" ti="50"/>
            </Private>
     </DAI>
     <DAI name="yVal">
            <Private type="IEC_60870_5_101">
                  <IEC_60870_5_101:Address casdu="1" ioa="1012" ti="50"/>
            </Private>
     </DAI>
  </SDI>
   <SDI name="crvPts" ix="1">
     <DAI name="xVal">
            <Private type="IEC_60870_5_101">
                  <IEC_60870_5_101:Address casdu="1" ioa="1013" ti="50"/>
            </Private>
     </DAI>
     <DAI name="yVal">
            <Private type="IEC_60870_5_101">
                  <IEC_60870_5_101:Address casdu="1" ioa="1014" ti="50"/>
            </Private>
     </DAI>
  </SDI>
   <SDI name="crvPts" ix="2">
     <DAI name="xVal">
            <Private type="IEC_60870_5_101">
                  <IEC_60870_5_101:Address casdu="1" ioa="1015" ti="50"/>
            </Private>
     </DAI>
     <DAI name="yVal">
```

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```
            <Private type="IEC_60870_5_101">
                  <IEC_60870_5_101:Address casdu="1" ioa="1016" ti="50"/>
            </Private>
      </DAI>
  </SDI>
</DOI>
```

2) for IEC 60870-5-104:

```
<DOI name="MyCSG">
   <SDI name="crvPts" ix="0">
     <DAI name="xVal">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1011" ti="63"/>
            </Private>
     </DAI>
     <DAI name="yVal">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1012" ti="63"/>
            </Private>
     </DAI>
  </SDI>
   <SDI name="crvPts" ix="1">
     <DAI name="xVal">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1013" ti="63"/>
            </Private>
     </DAI>
     <DAI name="yVal">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1014" ti="63"/>
            </Private>
     </DAI>
  </SDI>
   <SDI name="crvPts" ix="2">
     <DAI name="xVal">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1015" ti="63"/>
            </Private>
     </DAI>
     <DAI name="yVal">
            <Private type="IEC_60870_5_104">
                  <IEC_60870_5_104:Address casdu="1" ioa="1016" ti="63"/>
            </Private>
     </DAI>
  </SDI>
</DOI>
```

A.3.4.32 Example for mapping of SelectActiveSG:

The example shows the use of SCL for four Setting Groups. If more them four Setting Groups are present, the Private section has to be extended for the required numbers of Setting Groups.

```
<SettingControl actSG="1" numOfSGs="4">
   <Private type="IEC_60870_5_104">
            <IEC_60870_5_104:Address casdu="1" ioa="1022" ti="45"
expectedValue="1"/>
```

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```
            <IEC_60870_5_104:Address casdu="1" ioa="1023" ti="45"
expectedValue="2"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1024" ti="45"
expectedValue="3"/>
            <IEC_60870_5_104:Address casdu="1" ioa="1025" ti="45"
expectedValue="3"/>
   </Private>
</SettingControl >
```

A.4 IEC 60870-5-101 communication parameters configuration using SCL

The communication section of the SCL file can be used to hold the IEC 60870-5-101 specific information about link parameters such as transmission speed, addresses and ASDU structure.

The controlling and controlled stations are linked using the same “SubNetwork” element of the SCL communication section. The “type” attribute shall be “101”.

This information shall be kept inside the "P" type of the "Address" element of the SCL. Table A.1 defines the names of the parameters that can be used.

Table A.1 – Extension of the “P” element types to hold IEC 60870-5-101 information

P type attribute value	Description
StationType	Type of station (controlling-station | controlled-station)
NetworkConf	Network configuration (point-to-point | multiple-point-to-point | multipoint-partyline | multipoint-star)
LinkTransProc	Link transmission procedure (balanced | unbalanced)
PhysLayer	Standard of physical layer (V.24/V.28 |, X.24/X.27)
SpeedMonDir	Link layer transmission speed [bits/s] in monitor direction [bits/s] (9600 | 19200 | 38400 | 56000 | 64000)
SpeedConDir	Link layer transmission speed [bits/s] in control direction (9600 | 19200 | 38400 | 56000 | 64000)
LinkAddrSize	Number of octets for link address (1 | 2)
LinkAddr	Link address (1 ... 65534)
FrameLength	Maximum length of link frame (in octets) (32 ... 255)
CASDUSize	Number of octets for CASDU (2)
IOASize	Number of octets for IOA (3)
COTSize	Number of octets for COT (2)

NOTE The configurable values have been extracted from 9.3.1. “IEC 60870-5-101 Interoperability”.

An example of use of the SCL communication section for a balanced connection.

```
<Communication>
      <SubNetwork name=”sub101-1” type=”101”>
            <ConnectedAP iedName=”IED1” apName=”AP1”>
                  <Address>
                        <P type=”StationType”>controlling-station</P>
                        <P type=”NetworkConf”>point-to-point</P>
                        <P type=”LinkTransProc”>balanced</P>
                        <P type=”PhysLayer”>V.24/V.28</P>
                        <P type=”SpeedMonDir”>9600</P>
```

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```
                        <P type="SpeedConDir">4800</P>
                        <P type="LinkAddrSize">1</P>
                        <P type="LinkAddr">3</P>
                        <P type="FrameLength">64</P>
                        <P type="CASDUSize">2</P>
                        <P type="IOASize">3</P>
                        <P type="COTSize">2</P>
                  </Address>
            </ConnectedAP>
                  <ConnectedAP iedName="IED2" apName="AP1">
                  <Address>
                        <P type="StationType">controlled-station</P>
                        <P type="NetworkConf">point-to-point</P>
                        <P type="LinkTransProc">balanced</P>
                        <P type="PhysLayer">V.24/V.28</P>
                        <P type="SpeedMonDir">4800</P>
                        <P type="SpeedConDir">9600</P>
                        <P type="LinkAddrSize">1</P>
                        <P type="LinkAddr">5</P>
                        <P type="FrameLength">64</P>
                        <P type="CASDUSize">2</P>
                        <P type="IOASize">3</P>
                        <P type="COTSize">2</P>
                  </Address>
            </ConnectedAP>
      </SubNetwork>
</Communication>
```

The term SubNetwork is used to define the link between the controlling and controlled station for IEC 60870-5-101 connections. Both devices include a ConnectedAP in the same SubNetwork. In order to communicate properly, both should include the same communication parameter values.

An example of use of the SCL communication section for an unbalanced multipoint-partyline connection.

```
<Communication>
      <SubNetwork name="sub101-1" type="101">
            <ConnectedAP iedName="IED1" apName="AP1">
                  <Address>
                        <P type="StationType">controlling-station</P>
                        <P type="NetworkConf">multipoint-partyline</P>
                        <P type="LinkTransProc">unbalanced</P>
                        <P type="PhysLayer">V.24/V.28</P>
                        <P type="SpeedMonDir">9600</P>
                        <P type="SpeedConDir">4800</P>
                        <P type="LinkAddrSize">1</P>
                        <P type="FrameLength">64</P>
                        <P type="LinkAddr">1</P>
                        <P type="CASDUSize">2</P>
                        <P type="IOASize">3</P>
                        <P type="COTSize">2</P>
                  </Address>
            </ConnectedAP>
                  <ConnectedAP iedName="IED2" apName="AP1">
                  <Address>
```

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```
                        <P type="StationType">controlled-station</P>
                        <P type="NetworkConf">multipoint-partyline</P>
                        <P type="LinkTransProc">unbalanced</P>
                        <P type="PhysLayer">V.24/V.28</P>
                        <P type="SpeedMonDir">4800</P>
                        <P type="SpeedConDir">9600</P>
                        <P type="LinkAddrSize">1</P>
                        <P type="LinkAddr">5</P>
                        <P type="FrameLength">64</P>
                        <P type="CASDUSize">2</P>
                        <P type="IOASize">3</P>
                        <P type="COTSize">2</P>
                  </Address>
            </ConnectedAP>
            </ConnectedAP>
                  <ConnectedAP iedName="IED3" apName="AP1">
                  <Address>
                        <P type="StationType">controlled-station</P>
                        <P type="NetworkConf">multipoint-partyline</P>
                        <P type="LinkTransProc">unbalanced</P>
                        <P type="PhysLayer">V.24/V.28</P>
                        <P type="SpeedMonDir">4800</P>
                        <P type="SpeedConDir">9600</P>
                        <P type="LinkAddrSize">1</P>
                        <P type="LinkAddr">3</P>
                        <P type="FrameLength">64</P>
                        <P type="CASDUSize">2</P>
                        <P type="IOASize">3</P>
                        <P type="COTSize">2</P>
                  </Address>
            </ConnectedAP>
      </SubNetwork>
</Communication>
```

A.5 IEC 60870-5-104 communication parameters configuration using SCL

The communication section of the SCL file can be used to hold the IEC 60870-5-104 specific information about delays, addresses and communication ports.

The controlling and controlled stations are linked using the same “SubNetwork” element of the SCL communication section. The “type” attribute shall be “104”.

This information shall be kept inside the “P” type of the “Address” element of the SCL. Table A.2 defines the names of the parameters that can be used if redundancy is not used.

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Table A.2 – Extension of the "P" element types to hold IEC 60870-5-104 information

P type attribute value	Description
StationType	Type of station (controlling-station | controlled-station)
W-FACTOR	Value of the w parameter [APDUs] (1 … 32767)
K-FACTOR	Value of the k parameter [APDUs] (1 … 32767)
TIMEOUT-0	Time-out in seconds of connection establishment (t_0) (1 …255)
TIMEOUT-1	Time-out in seconds of sent or test APDUs (t_1) (1 … 255)
TIMEOUT-2	Time-out in seconds for acknowledges in case of no data messages (t_2) (1 …255)
TIMEOUT-3	Time-out in seconds for sending test frames in case of a long idle state (t_3) (1-255)

NOTE The configurable values have been extracted from 9.3.2. "IEC 60870-5-104 Interoperability".

An example of use of the SCL communication section with one link and without redundancy is shown.

```
<Communication>
     <SubNetwork name="sub104-1" type="104">
           <ConnectedAP iedName="IED1" apName="AP1">
               <Address>
                 <P type="StationType">controlling-station</P>
                 <P type="IP">192.168.0.1</P>
                 <P type="IP-SUBNET">255.255.255.0</P>
                 <P type="W-FACTOR">8</P>
                 <P type="K-FACTOR">12</P>
                 <P type="TIMEOUT-0">30</P>
                 <P type="TIMEOUT-1">15</P>
                 <P type="TIMEOUT-2">10</P>
                 <P type="TIMEOUT-3">20</P>
              </Address>
           </ConnectedAP>
           <ConnectedAP iedName="IED2" apName="AP1">
               <Address>
                 <P type="StationType">controlled-station</P>
                 <P type="IP">192.168.0.51</P>
                 <P type="IP-SUBNET">255.255.255.0</P>
                 <P type="W-FACTOR">8</P>
                 <P type="K-FACTOR">12</P>
                 <P type="TIMEOUT-0">30</P>
                 <P type="TIMEOUT-1">15</P>
                 <P type="TIMEOUT-2">10</P>
                 <P type="TIMEOUT-3">20</P>
              </Address>
           </ConnectedAP>
     </SubNetwork>
</Communication>
```

If redundancy groups are used, the IEC 60870-5-104 parameters shall be used as defined in Table A.3.

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Table A.3 – Extension of the "P" element types using redundancy groups

P type attribute value	Description
RGx-LLy-IP	IP address of the logical link "y" of the redundancy group "x"
RGx-LLy-IP-SUBNET	Subnetwork mask of the IP address of the logical link "y" of the redundancy group "x"
RGx-W-FACTOR	W factor of the logical link "y" of the redundancy group "x"
RGx-K-FACTOR	K factor of the logical link "y" of the redundancy group "x"
RGx-TIMEOUT-0	Time-out 0 of the redundancy group "x"
RGx-TIMEOUT-1	Time-out 1 of the redundancy group "x"
RGx-TIMEOUT-2	Time-out 2 of the redundancy group "x"
RGx-TIMEOUT-3	Time-out 3 of the redundancy group "x"
NOTE "x" is the number of the redundancy group and "y" is the number of the logical link.	

An example of use of the SCL communication section with two redundancy groups, each redundancy group consisting of three logical links, is shown:

```
<Communication>
  <Subnetwork name="sub104-1" type="104">
      <ConnectedAP iedName="IED1" apName="AP1">
          <Address>
                <P type="StationType">controlling-station</P>
                <P type="RG1-W-FACTOR">8</P>
                <P type="RG1-K-FACTOR">12</P>
                <P type="RG1-TIMEOUT-0">30</P>
                <P type="RG1-TIMEOUT-1">15</P>
                <P type="RG1-TIMEOUT-2">10</P>
                <P type="RG1-TIMEOUT-3">20</P>
                <P type="RG1-LL1-IP">192.168.0.1</P>
                <P type="RG1-LL1-IP-SUBNET">255.255.255.0</P>
                <P type="RG1-LL2-IP">192.168.0.2</P>
                <P type="RG1-LL2-IP-SUBNET">255.255.255.0</P>
                <P type="RG1-LL3-IP">192.168.0.3</P>
                <P type="RG1-LL3-IP-SUBNET">255.255.255.0</P>
                <P type="RG2-W-FACTOR">8</P>
                <P type="RG2-K-FACTOR">12</P>
                <P type="RG2-TIMEOUT-0">30</P>
                <P type="RG2-TIMEOUT-1">15</P>
                <P type="RG2-TIMEOUT-2">10</P>
                <P type="RG2-TIMEOUT-3">20</P>
                <P type="RG2-LL1-IP">192.168.0.11</P>
                <P type="RG2-LL1-IP-SUBNET">255.255.255.0</P>
                <P type="RG2-LL2-IP">192.168.0.12</P>
                <P type="RG2-LL2-IP-SUBNET">255.255.255.0</P>
                <P type="RG2-LL3-IP">192.168.0.13</P>
                <P type="RG2-LL3-IP-SUBNET">255.255.255.0</P>
          </Address>
       </ConnectedAP>

      <ConnectedAP iedName="IED1" apName="AP1">
            <Address>
              <P type="StationType">controlled-station</P>
              <P type="RG1-W-FACTOR">8</P>
```

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```
            <P type="RG1-Kk-FACTOR">12</P>
            <P type="RG1-TIMEOUT-0">30</P>
            <P type="RG1-TIMEOUT-1">15</P>
            <P type="RG1-TIMEOUT-2">10</P>
            <P type="RG1-TIMEOUT-3">20</P>
            <P type="RG1-LL1-IP">192.168.0.51</P>
            <P type="RG1-LL1-IP-SUBNET">255.255.255.0</P>
            <P type="RG1-LL2-IP">192.168.0.52</P>
            <P type="RG1-LL2-IP-SUBNET">255.255.255.0</P>
            <P type="RG1-LL3-IP">192.168.0.53</P>
            <P type="RG1-LL3-IP-SUBNET">255.255.255.0</P>
            <P type="RG2-W-FACTOR">8</P>
            <P type="RG2-K-FACTOR">12</P>
            <P type="RG2-TIMEOUT-0">30</P>
            <P type="RG2-TIMEOUT-1">15</P>
            <P type="RG2-TIMEOUT-2">10</P>
            <P type="RG2-TIMEOUT-3">20</P>
            <P type="RG2-LL1-IP">192.168.0.61</P>
            <P type="RG2-LL1-IP-SUBNET">255.255.255.0</P>
            <P type="RG2-LL2-IP">192.168.0.62</P>
            <P type="RG2-LL2-IP-SUBNET">255.255.255.0</P>
            <P type="RG2-LL3-IP">192.168.0.63</P>
            <P type="RG2-LL3-IP-SUBNET">255.255.255.0</P>
          </Address>
        </ConnectedAP>
      </Subnetwork>
    </Communication>
```

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

3, rue de Varembé
PO Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
Fax: + 41 22 919 03 00
info@iec.ch
www.iec.ch

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