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Representation of communication in power utility automation

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Representation of communication in power utility automation

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REPRESENTATION OF COMMUNICATION IN POWER UTILITY AUTOMATION

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IEC TS 63266 has been prepared by IEC technical committee 3: Documentation, graphical symbols and representations of technical information. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
3/1611/DTS	3/1623/RVDTS

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

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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- withdrawn,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

INTRODUCTION

The data communication system is a critical point in the real time operation of a power utility automation system. Information from the system is retrieved and used for reliable operation, for supervision, and for efficient maintenance work in power utility automation systems, such as hydro power plant, thermal power plant, transmission station, distribution station, industrial site, etc.; hereby referred to as substations.

Power utility automation systems, including those for substations, have been increasingly modernized thanks to their benefits to power utilities. Digital data exchange, based on IEC 61850 (all parts), among the functions in the system, replaces the copper hardwired conventional communication.

The exchange of digital information, in the form of data objects and data attributes, between intelligent electronic devices (IEDs), has become very common in utility automation and these data are essential for control and protection of the power grid, and the amount of such data exchanges is increasing.

The engineering tools available for configuration of the communication systems are typically focusing on the data exchange between tools and less on readability for human perception. Documents prepared by these tools are often comprehensive and well-structured files, for example, in XML-format, but are difficult to read and to understand and could therefore be inappropriate in some steps of the product/system life cycle. With the increasing amount of data exchanges and the increasing level of complexity, the inconsistencies and errors in the complex documentation cannot be efficiently perceived by human users. Proper visualization of data exchanges from different entities makes the maintenance and design more reliable.

This document aims to provide a structure for documentation of exchanged information that is used for testing and maintenance of devices in the substation. This standardized documentation is called "representation of communication configuration and application", abbreviated as RCCA. This reference documentation is intended to be part of the delivery documentation for an IEC 61850 substation.

As a consequence of using IEDs and digital communication in substations, the need arises for readily available, clearly presented, human-readable representation of data for reliable and convenient use by persons in the field.

The IEC 61850 series has provided the comprehensive range of International Standards covering functional, communication and engineering aspects, but not covering the presentation and visualization of these functions.

REPRESENTATION OF COMMUNICATION IN POWER UTILITY AUTOMATION

1 Scope

This document specifies a structure for representation of exchanged information that is essential for testing and maintenance of the devices in power utility automation systems. It is mainly intended to be applied to communication equipment that communicate information in accordance with IEC 61850 (all parts) in at least one part of their communication flow.

The following communication equipment is included within the scope:

– optical instrument transformer;
– conventional instrument transformers related to IEC 61850 traffic;
– merging unit;
– stand-alone merging unit;
– protection, control and measuring devices with at least one IEC 61850 interface;
– switchgear control unit (breaker IED);
– switchgear providing IEC 61850 interface;
– IEC 61850 time synchronization device;
– IEC 61850 gateway (RTU) and station HMI;
– digital disturbance recorder / digital fault recorder;
– digital communication protocol gateways with at least one IEC 61850 interface;
– protection, control and measuring devices that utilise a proprietary protocol for communication with devices that have at least one IEC 61850 interface.

The following communication equipment, scheme and protocols are excluded from the scope:

– IEC 61850 Ethernet switches and network topology;
– PMU phasor measurement unit with at least one IEC 61850 interface;
– the full path of substation-to-substation communication;

EXAMPLE 1: The description of R-GOOSE Publisher in substation A does not include the description of R-GOOSE Subscriber in substation B.

– functions with only hardwired communication, e.g. direct analogue copper wired connection;

EXAMPLE 2: A current transformer connected to a protection relay with hardwired tripping of a circuit breaker.

– functions using only proprietary communication protocol systems;

EXAMPLE 3: A dedicated system for collecting disturbance recorder files with courier protocol or path from IEC 60870-5-103 to IEC 60870-5-101 will not be presented in this document.

– protocol mappings to XMPP (IEC 61850-8-2).

This document forms a supplement to other documentation standards in power utility automation.

It also harmonizes the representation of the logical data flow structures based on IEC 61850 communication among different devices in order to provide a reference document that can be created for any IEC 61850 substation.

This document focuses in principle on the visualization of the digital information exchanged between IEDs and control or measurement devices in a power utility automation system. The information visualization does not refer to any graphical modelling but to a tabular format of presentation. The data in tabular format can be used as a basis for other kinds of visual presentation outside the scope of this document.

For representing all kinds of substation information, a single suitable tabular form is not possible to find. This document instead presents a limited number of high visual performance representation formats.

Presentation formats described in this document provide interactive visualization that assists users in analysing data and identifying some important and essential information in a more efficient way.

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 61082-1, *Preparation of documents used in electrotechnology – Part 1: Rules*

IEC 61850-5, *Communication networks and systems for power utility automation – Part 5: Communication requirements for functions and device models*

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

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

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

IEC 61869-9, *Instrument transformers – Part 9: Digital interface for instrument transformers*

IEC 62439-3, *Industrial communication networks – High availability automation networks – Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR)*

IEC 81346-1, *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules*

IEC 81346-2, *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 2: Classification of objects and codes for classes*

ISO 81346-10, *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 10: Power supply systems*

IEC 82045-1, *Document management – Part 1: Principles and methods*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
substation
part of a power system, concentrated in a given place, including mainly the terminations of transmission or distribution lines switchgear and housing and which may also include transformers. It generally includes facilities necessary for system security and control (e.g. the protective devices)

Note 1 to entry: According to the nature of the system within which the substation is included, a prefix may qualify it.

EXAMPLE Transmission substation (of a transmission system), distribution substation, 400 kV substation, 20 kV substation.

[SOURCE: IEC 60050-605:1983, 605-01-01]

3.2 Abbreviated terms

For the purposes of this document, the abbreviations provided in Table 1 are used.

Table 1 – Abbreviations

Abbreviated term	Full term
ASDU	Application service data unit
FAT	Factory acceptance test
FTP	File transfer protocol
GNSS	Global navigation satellite system EXAMPLES: GPS/BDS/GLONASS/GALILEO
GMC	Grand master clock
GOOSE	Generic object oriented substation event
HMI	Human machine interface
HSR	High-availability seamless redundancy
IED	Intelligent electronic device
LPIT	Low power instrument transformer
MMS	Manufacturing messaging specification
MU	Merging unit
PLC	Power line carrier
PPS	Pulse per second
PRP	Parallel redundancy protocol
PTP	Precision time protocol
RCB	Report control block
RCCA	Representation of communication configuration and application

Abbreviated term	Full term
R-GOOSE	Routable generic object oriented system event
RTU	Remote terminal unit
SAMU	Stand-alone merging unit
SAN	Single attached node
SAT	Site acceptance test
SCD	System configuration description
SCL	Substation automation system configuration description language
SFTP	Secure file transfer protocol
SLD	Single line diagram
SNTP	Simple network time protocol
SV	Sampled value
SvID	Sampled value identifier
VLAN	Virtual LAN (local area network)
XMPP	Extensible messaging presence protocol

4 General description of physical resource documentation

4.1 Secondary system documentation description

Information from other documents used to design and describe power systems like SLD, circuit diagrams, function diagrams, data sheets, etc. forms the basis for this document. The presentation format described in this document is a supplementary presentation of the information found in the documents mentioned.

4.2 Target users of the documentation

This document refers to any kind of information that can be documented either in a conventional format or by software in such a way that it is usable by humans in utility activities. Annex A shows a list of document types commonly used in system documentation. The list extends outside of the scope of IEC 61850.

This document is intended to be used by:

- operators,
- test engineers,
- maintenance technicians,
- protection and control engineers,
- electrical design engineers,
- system design technicians and engineers.

The documentation can be divided into two groups: documents for machine-to-machine communication and documents for human perception. Regarding the IEC 61850 series, the first group shall be covered by the file formats in accordance with IEC 61850-6.

The focus of this document is primarily on the presentation of communicated information for system maintenance, but may also be used in the engineering stage.

The purpose of reference documentation for human perception, is to easily get upfront information about the communication structures, data flow, applications associated to the communication flow, etc., without the need to read different documents in different formats in the search for information.

4.3 Use cases

This document will facilitate the following activities:

- FAT or SAT

  In the FAT or SAT, the consistency of other documents with a presentation format in accordance with this document will be checked and approved. This presentation can be used for preparing the test cases.

- The process of getting familiar with the described power system, including the presentation and the purpose of information exchange between functions of that system.

  The standardized presentation can assist experts to get familiar with the function and systems in a reduced amount of time.

- Maintenance

  The presentation format set out in this document is essential for identifying dependencies between equipment.

  It can even be helpful for deciding on test cases after some maintenance and revision has been carried out.

5 Documentation requirement

The presentation formats described in this document are developed on the following basis:

- the latest valid technical documentation shall be available for presentation of the information.
- the SCD file for the system shall be a part of the as-built delivery documentation of the power utility automation system and be maintained continuously (updated when changes are made to the system);
- the RCCA may be generated by the software engineering tools. Manual entry can also be applied;
- the RCCA should be maintained and kept updated continuously (as built);

  EXAMPLE Any IED replacement with a "clone" creates a new MAC address which requires the update of the RCCA.

- where mandatory information in a project is missing, the entry for that information shall be marked as "Not available".

Documents shall be formed in accordance with the requirements of IEC 61082-1. Objects shall be designated according to the IEC 81346 series. Document metadata shall be in accordance with IEC 82045-1.

6 Physical source of communication description in tabular format

6.1 Sampled value presentation

6.1.1 General

The main source of generation of the SV data stream is the merging unit (MU or SAMU). The merging unit is connected to one or more (optical) instrument transformers. For each instrument transformer there shall be one presentation in the reference RCCA (see Figure 1).

6.1.2 Creation of sampled values, LPIT

This presentation considers the cases where the MU is connected to an instrument transformer with digital output (LPIT) in accordance with IEC 61869-9, e.g. an optical instrument transformer. For a MU connected to an analogue instrument transformer, see 6.1.4.

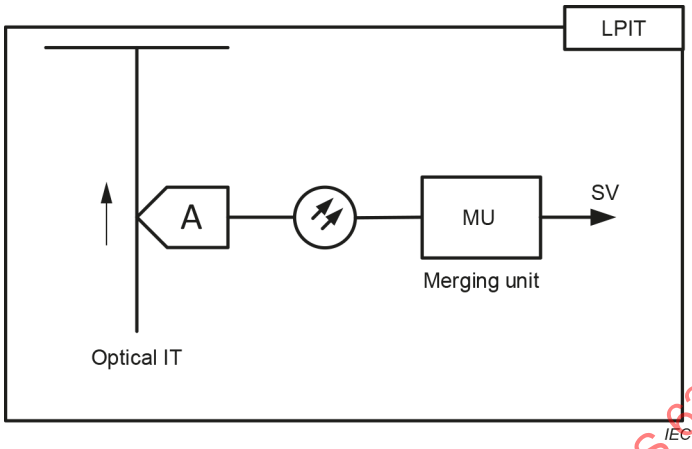

Figure 1 – Example of an optical instrument transformer with digital output (LPIT)

Table 2 contains data presentation for use in SV communication.

Table 2 – Data presentation for use in SV communication

Primary object	Comments
Primary object name	Name of the primary object as found in the latest SLD. Names should be in accordance with the International Standard 81346 series.
Type of measurement	All the quantities measured by the instrument transformer (current, voltage, phases involved), for example, currents I_{L1}, I_{L2}, I_{L3} or voltages U_{L1}, U_{L2}, U_{L3}.
Connected to MU name	Name of the device hosting a merging unit function that publishes the SV stream associated to the measured primary quantities as found in the SCD file. Names should be in accordance with the International Standard 81346 series.
Polarity (positive direction for the current)	Show with an arrow the positive reference direction for the measured current.
Rating	Nominal primary current or voltage of each measurement (core) of the instrument transformer.
Nominal range	Measurement range for each quantity measured by the instrument transformer.
Accuracy class	Accuracy class for each quantity measured by the instrument transformer.

Table 3 reports the information about all the MUs connected to the instrument transformer. There shall be one table for each MU.

Table 3 shows the data to be presented for one data stream. If the MU publisher has more than one data stream (also called logical MU), there shall be one table for each data stream.

Table 3 – Information about all MUs connected to the instrument transformer for data stream *n*

MU	Comments
Instrument transformer name	Name of the instrument transformer to which the MU is connected, according to the latest SLD. Names should be in accordance with the International Standard 81346 series.
Primary equipment connection number on MU (port)	Description of all the (proprietary) connections between the MU and the instrument transformer.
MU name	Name of the device hosting a merging unit function, as available in the SCD file. Names should be in accordance with the International Standard 81346 series.
MU IP address	IP address of the Ethernet port from which the SV data stream is published, as found in the SCD file.
MU MAC address	MAC address of the Ethernet port from which the SV data stream is published (i.e. source MAC address), as found in the SCD file.
Connection mode (HSR, PRP, SAN)	Connection mode / redundancy of the Ethernet port of the MU. SAN: No redundancy available (single attached node). PRP, HSR: Seamless redundancy connection.
Ethernet port name	Description of the Ethernet port in the MU that is used for the publication of the SV as found in the documentation of the Ethernet system within the substation.
SvID	A system-wide unique identification of the generated SV data stream, i.e., attribute MsvID (Multicast sampled value ID) or UsvID (Unicast sampled value ID) according to IEC 61850-7-2.
SV application	Description of all the applications for which the SV data stream is intended, for example, currents (I_1...I_4) for overcurrent protection and voltages (U_1...U_4) not used.
Polarity of the SV stream	Information on the data published in the data stream and if it is in phase ("in phase") with the analogue data measured by the instrument transformer or if it is inverted ("inverted") by 180°.
SV MAC address	Destination MAC address of the SV stream as found in the SCD file.
SV dataset	Name of the dataset associated to the SV data stream, as it is found in the SCD file.
VLAN ID	Value of the VLAN for the published SV stream as found in the SCD file.
VLAN Prio	Priority of the VLAN for the published SV stream as found in the SCD file.
Sampling rate	Number of acquired samples per second.
Samples per SV message	Number of samples per SV message (ASDU).
Accuracy class	Accuracy class of the published numerical data. It could be different from the accuracy class of the instrument transformer.
Data stream n	Number of the data stream

6.1.3 Sample values publisher to subscriber

This presentation is related to the description of the communication between the publishing MU and the subscribing IEDs; see Figure 2 and Table 4. If the MU publisher has more than one data stream there shall be one table for each data stream.

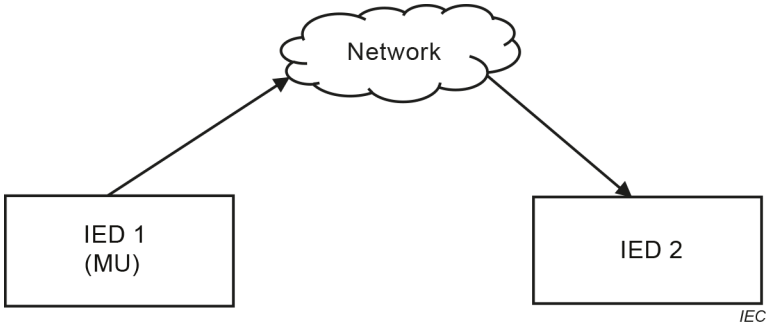

Figure 2 – Sample values publisher (IED 1) to subscriber (IED 2)

Table 4 – Communication between the publishing MU and the subscribing IEDs

Publishing MU	Comments
MU name	Name of the device hosting a merging unit function, as found in the SCD file. Names should be in accordance with the International Standard 81346 series.
MU IP address	IP address of the Ethernet port from which the SV data stream is published, as found in the SCD file.
MU MAC address	MAC address of the Ethernet port from which the SV data stream is published (i.e. source MAC address), as found in the SCD file.
Connection mode (PRP, HSR, SAN)	Connection mode / redundancy of the Ethernet port of the MU. SAN: No redundancy available (single attached node). PRP, HSR: Seamless redundancy connection.
Ethernet port name	Description of the Ethernet port in the MU that is used for the publication of the SV.
SvID	SvID of the generated SV data stream, as found in the SCD file.
SV application	Description of all the applications for which the SV data stream is intended.
Polarity of the SV stream	Information on the data published in the data stream and if it is in phase ("in phase") with the analogue data measured by the instrument transformer or if it is inverted ("inverted") by 180°.
SV MAC address	Destination MAC address of the SV stream as found in the SCD file.
SV Dataset	Name of the dataset associated to the SV data stream, as it is found in the SCD file.
VLAN ID	Value of the VLAN for the published MU as found in the SCD file.
VLAN Prio	Priority of the VLAN for the published MU as found in the SCD file.
Sampling rate	Number of acquired samples per second.
Samples per SV message	Number of samples per SV message (ASDU).
Subscriber(s)	List of all IEDs (IED Names) that are subscribing to this SV stream, as found in the SCD file.

Table 5 provides the description of devices that subscribe to an SV stream provided by the publishing MU as described in Table 4.

Note that for each SV stream proved by the publishing MU, the subscriber information in accordance with Table 5 shall be presented.

Table 5 – Presentation of subscriber *n* to an SV stream

Subscriber n	Comments
Subscribing IED name	IED Name of the device subscribing to the SV stream, as available in the SCD file. Names should be in accordance with the International Standard 81346 series.
Subscribing IP address	IP address of the Ethernet port from which the SV data stream is subscribed to, as found in the SCD file.
Connection mode (PRP, HSR, SAN)	Connection mode / redundancy of the Ethernet port of the subscribing IED. SAN: No redundancy available (single attached node). PRP, HSR: Seamless redundancy connection.
Ethernet port name	Description of the Ethernet port of the IED that is used for the subscription of the SV.
SvID	SvID of the subscribed SV stream, as found in the SCD file.
SV Application	Description of all the applications for which the SV data stream is intended to be used in this receiving IED.
SV MAC address	Destination MAC address of the subscribed SV stream, as found in the SCD file.
SV Dataset	Name of the dataset associated to the subscribed SV data stream, as found in the SCD file.
VLAN ID	Value of the VLAN for the published SV stream as found in the SCD file.
VLAN Prio	Priority of the VLAN for the published SV Stream as found in the SCD file.
Publishing MU IED Name	IED Name of the publishing physical merging unit, as found in the SCD file. Names should be in accordance with the International Standard 81346 series.

6.1.4 Creation of sampled values by a SAMU

This presentation considers the case where the merging unit is connected to an instrument transformer that provides analogue signals (current transformer, voltage transformer, Rogowski coil or other analogue sensors).

Figure 3 is a scheme presentation of the considered system.

In this case, the merging unit is called a SAMU.

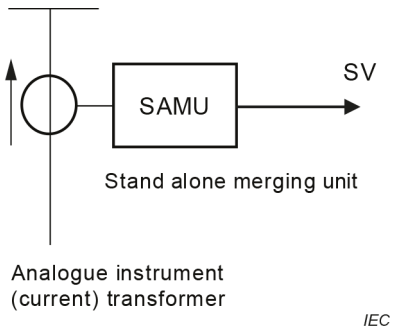

Figure 3 – Analogue transformer connected to a SAMU

As this kind of application is not widely implemented yet, this document does not provide a dedicated section for this purpose; however, where applicable, the template provided by Table 6 shall be used as the template to describe that application.

Table 6 contains data presentation for use in SV communication.

Table 6 – Data presentation for use in SV communication

Primary object	Comments
Primary object name	Name of the primary object as found in the latest SLD. Names should be in accordance with the International Standard 81346 series.
Type of measurement	All the quantities measured by the instrument transformer (current, voltage, phases involved), for example, currents I_{L1}, I_{L2}, I_{L3} or voltages U_{L1}, U_{L2}, U_{L3}.
Connected to SAMU IED name	IED name of all the stand-alone merging units that publish the SV stream associated to the measured primary quantities, as found in the SCD file. Names should be in accordance with the International Standard 81346 series.
Polarity (positive direction for the current)	Show with an arrow the positive direction for the measured current (positive reference direction if current flowing into the closest node is the preferred definition).
Rating	Nominal primary current or voltage of each measurement (core) of the instrument transformer.
Ratio	Primary to secondary quantity ratio of the instrument transformer in A / A or in kV / V, for each quantity (core).
Accuracy class	Accuracy class for each quantity measured by the instrument transformer.

Table 7 reports the information about all the SAMUs connected to the conventional instrument transformer. There shall be one table for each SAMU.

Table 7 – Presentation of a SAMU connected to a conventional transformer

SAMU	Comments
Instrument transformer name	Name of the instrument transformer to which the SAMU is connected, according to the latest SLD. Names should be in accordance with the International Standard 81346 series.
Primary equipment connection to SAMU	Description of all the analogue connections between the SAMU and the instrument transformer.
SAMU IED name	IED name of the stand-alone merging unit, as available in the SCD file. Names should be in accordance with the International Standard 81346 series.
SAMU IP address	IP address of the Ethernet port from which the SV data stream is published, as found in the SCD file.
Connection mode (HSR, PRP, SAN)	Connection mode / redundancy of the Ethernet port of the MU. SAN: No redundancy available (single attached node). PRP, HSR: Seamless redundancy connection.
Ethernet port name	Description of the Ethernet port of the SAMU that is used for the publication of the SV.
SvID	SvID of the generated SV data stream, as found in the SCD file.
SV application	Description of all the applications for which the SV data stream is intended.
Polarity of the SV stream	Inform if the data published in the data stream is in phase ("in phase") with the data measured by the instrument transformer or if it is inverted ("inverted") by 180°.
SV MAC address	Destination MAC address of the SV stream as found in the SCD file.
SV dataset	Name of the dataset associated to the SV data stream, as it is found in the SCD file.
VLAN ID	Value of the VLAN for the published SV stream as found in the SCD file.
VLAN Prio	Priority of the VLAN for the published SV stream as found in the SCD file.
Sampling rate	Number of acquired samples per second.
Samples per SV message	Number of samples per SV message (ASDU).
Accuracy class	Accuracy class of the published numerical data. It could be different from the accuracy class of the instrument transformer.

6.2 GOOSE communication presentation

6.2.1 General

IEC 61850 is used for communication within a substation between IEDs. See Figure 4. In an electrical substation, some events may be time-critical such as the protection of equipment in a substation and therefore a message like GOOSE is used for fast and reliable function. GOOSE is associated with a generic system event, GSE and uses GSE management for communication which is in accordance with IEC 61850-8-1.

The GSE management is based on the publisher-to-subscriber model and supports the publishing of the same information to more than one physical device through the multicast service.

6.2.2 Publisher to subscriber

GOOSE messages provide fast and reliable communication in substations, but the structure of the message and the content is not directly readable for humans and requires time for maintenance and design without any visualisation of the data exchange.

Table 8 contains a data presentation for use in GOOSE communication.

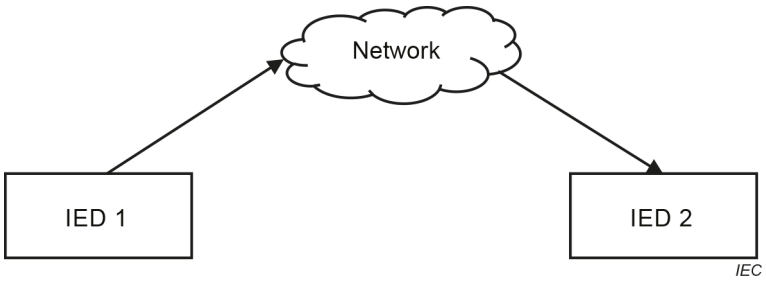

Figure 4 – Communication scheme of publisher (IED 1) to subscriber (IED 2)

Table 8 – Presentation of a publisher of a GOOSE

Publisher	Comments
IED name	The name of the IED as described in the latest available SCD file. Names should be in accordance with the International Standard 81346 series.
IP address	IP address of the Ethernet port from which the GOOSE message is sent.
Connection mode (PRP, HSR, SAN)	Describes how different GOOSE messages are published to networks, which can be useful for troubleshooting in a substation. The definition of PRP and HSR are in accordance with IEC 62439-3.
Port name	The name of the port.
Port allocation	Indication of the port allocated to the relevant GOOSE message. This information is only needed where the IED has several ports.
GOOSE MAC address	The destination MAC address for each product processing communication interface is preferably unique.
GCB name	Name of the GOOSE Control Block used to identify the message in the subscriber.
APP ID	Hexadecimal value to discriminate different GOOSE messages.
GOOSE VLAN ID	Value of the VLAN for the published GOOSE as found in the SCD file.
GOOSE VLAN Prio	Priority of the VLAN for the published GOOSE as found in the SCD file.
GOOSE Dataset	The dataset contains information and the properties of data exchanged as found in the SCD file.
GOOSE Data Object	The function of the GOOSE message as found in the SCD file.
GOOSE Description (purpose)	The description may contain information on whether it is control, indication or trip.
Internal application	Internal application refers to the function that generated or received the data, for example, transformer protection trip.
Subscriber(s) (IED names)	A list of subscriber(s) is useful to identify the IED(s) to which the GOOSE message is sent. See Table 9 for example presentations of subscribers to a GOOSE message.

Table 9 – Presentation of Subscriber to a GOOSE

Subscriber	Comments
IED name	The name of the IED as described in the latest available SCD file. Names should be in accordance with the International Standard 81346 series.
IP address	IP address of the Ethernet port from which the GOOSE message is sent.
Connection mode (PRP, HSR, SAN)	Describes how different GOOSE messages are published to networks, which can be useful for troubleshooting in a substation. The definition of PRP, and HSR are in accordance with IEC 62439-3.
Port name	The name of the port.
Port allocation	Indication of the port allocated to the relevant GOOSE message. This information is only needed where the IED has several ports.
GOOSE MAC address	The destination MAC address for each product processing communication interface is preferably unique.
GCB name	The name of the GOOSE Control Block used to identify the message in the publisher.
GOOSE VLAN ID	Value of the VLAN for the published GOOSE as found in the SCD file.
GOOSE VLAN Prio	Priority of the VLAN for the published GOOSE as found in the SCD file.
GOOSE Dataset	The dataset contains information and the properties of data exchanged as found in the SCD file.
GOOSE Data Object	The function of the GOOSE message as found in the SCD file.
GOOSE Description (purpose)	The description may contain information on whether it is control, indication or trip.
Internal application	Internal application refers to the function that generated / receives the data, for example, transformer protection trip.
Publisher	The IED name of the publisher of the GOOSE message. Names should be in accordance with the International Standard 81346 series.

6.3 Client-to-server control presentation

The control of data objects, for example for initiating a switching operation, is often done according to the client-server control concept. In this concept the client initiates a control sequence with the server. See Figure 5.

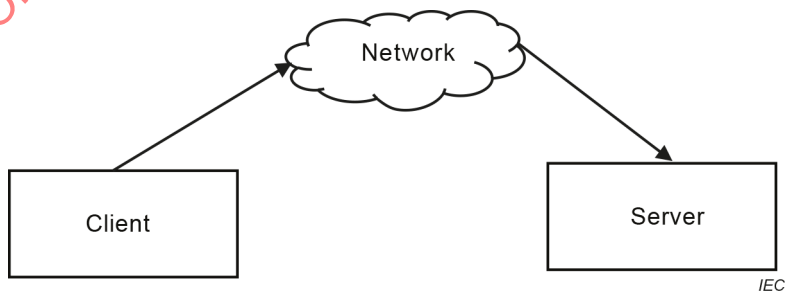

Figure 5 – Communication scheme of client to server

Typical clients: Gateway, RTU, SCADA, HMI station.

Typical servers: Bay Control Unit, protection IED.

The client-server control model according to IEC 61850 is described in IEC 61850-7-2.

The (abstract) control model in IEC 61850-7-2 is mapped to the MMS communication protocol, which is described in IEC 61850-8-1.

The control model in IEC 61850 supports several services that can be used by a client to interact with a server:

- Select / Select with value
- Cancel
- Operate / Time activated operate / Time activated operate termination
- Command termination

Several control sequences are supported in IEC 61850, each with different requirements on data from the client and feedback from the server.

- Direct execute
- Select before execute
- With or without enhanced security

The client-server control association is documented in a "one client, one server" on a "per control sequence" basis. A server supporting several clients will therefore have several such associations described in its RCCA, one per client. A server with several controls (e.g. several controllable data objects) will have several such associations described in its RCCA, one per client and per service.

In the documentation of each client-server control sequence association, it is recommended that aspects/properties given in Table 10 and Table 11 are described.

Table 10 and Table 11 describe how these properties of the client-server control sequence association shall be documented as part of the MMS client's and MMS server's documentation, respectively.

Table 10 – Presentation of MMS client

MMS Client	Comments
IED name	The name of the IED as described in the latest available SCD file. Names should be in accordance with the International Standard 81346 series.
IP address	The IED's IP address associated with the port used in the control sequence association.
Connection mode (PRP, HSR, SAN)	Connection mode (HSR, PRP, SAN) Connection mode / redundancy of the Ethernet port of the IED. SAN: No redundancy available (single attached node). PRP, HSR: Seamless redundancy connection.
Ethernet port name	The used Ethernet port (A or B).
Ethernet port MAC Address	The MAC address of the Ethernet port used in the control sequence association.
Command description	A human-readable description of the purpose of this client-server control sequence.
Control Model type	The type of Control Sequence used.

Table 11 – Presentation of MMS server

MMS Server	Comments
IED name	The name of the IED as described in the latest available SCD file. Names should be in accordance with the International Standard 81346 series.
IP address	The IED's IP address associated with the port used in the control sequence association.
Connection mode (PRP, HSR, SAN)	Connection mode (HSR, PRP, SAN) Connection mode / redundancy of the Ethernet port of the IED. SAN: No redundancy available (single attached node). PRP, HSR: Seamless redundancy connection.
Ethernet port name	The used Ethernet port (A or B).
Ethernet port MAC Address	The MAC address of the Ethernet port used in the control sequence association.
Command description	A human-readable description of the purpose of this client-server control sequence.
Control Model type	The type of Control Sequence used.
Controlled Data Attribute	For services acting on Data Attributes, the name of the Data Attribute instance is documented. For Data Attributes containing enumerations, the enumeration is also documented here.

6.4 Reporting

This Subclause 6.4 considers the information that is delivered from the server (normally a protection control IED or a measurement IED) to the client (Station HMI, Station SCADA, RTU) through the MMS reporting service of IEC 61850, see Figure 6. Table 12 shows the information required for the description of the MMS Report server. Table 13 shows the information required for the description of the MMS Report client(s). This Subclause 6.4 refers to pre-configured RCBs, i.e. described in the SCD file. Dynamically configured RCBs are not recommended to be implemented in a fully commissioned IEC 61850 substation. The recommended use of dynamically configured RCBs is for testing purposes during commissioning. If dynamic report control blocks are implemented in the final commissioned substation, the RCCA shall be updated accordingly as the RCBs are not described in the SCD file.

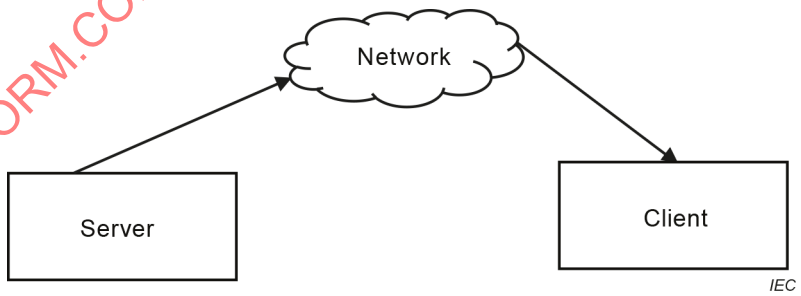

Figure 6 – Communication scheme of server to client

Table 12 – Presentation of an MMS report server

MMS report server	Comments
Server IED name	The IED name of the server IED for the report control block, as described in the latest available SCD file. Names should be in accordance with the International Standard 81346 series.
Server IP address	IP address of the Ethernet port from which the report control block is sent.
Server Ethernet port MAC address	MAC address of the Ethernet port of the server from which the report control block is sent.
Connection mode (PRP, HSR, SAN)	Connection mode / redundancy of the Ethernet port of the server IED. SAN: No redundancy available (single attached node). PRP, HSR: Seamless redundancy connection.
Ethernet port name	Description of the Ethernet port in the server IED that is used for the report messages.
RCB Name	Name of the report control block as found in the SCD file. For dynamic reports, this name is not available in the SCD file and the name needs to be manually entered into this table.
Static/Dynamic	States if the report control block is static, i.e. available in the SCD file, or if it is dynamic. When the report control block is dynamic, the information is not available in the dataset and needs to be manually listed.
Report Dataset Name	Name of the dataset associated to the report control block, as found in the latest available SCD file. If the RCB is dynamic, this information is not available in the SCD file and all the dataset shall be manually listed.
Report Description	Description of the type of information available in the dataset (i.e. alarms, trip signals, analogue measured values, etc.).
Trigger Mode	Trigger strategy of the report control block ("data-change", "quality-change", "data-update", "GI", "integrity"), as found in the SCD file. If the report control block is dynamic, this information is not available in the SCD file and it shall be manually entered.
Clients(s) (IED names)	List of the IED Names of the Clients that are interested in this report control block.
Report ID	The client-specified report identifier of the RCB.

Table 13 – Presentation of an MMS report client

MMS report client	Comments
Client IED name	The IED name of the client IED for the report control block, as described in the latest available SCD file. Names should be in accordance with the International Standard 81346 series.
Client IP address	IP address of the Ethernet port from which the report control block is sent.
Client Ethernet port MAC address	MAC address of the Ethernet port of the client IED from which the report control block is "received".
Connection mode (PRP, HSR, SAN)	Connection mode / redundancy of the Ethernet port of the client IED. SAN: No redundancy available (single attached node). PRP, HSR: Seamless redundancy connection.
Ethernet port name	Description of the Ethernet port in the client IED that is used for the report messages.
Internal application	Description of the application based on the information received from the report control block (i.e. station SLD information update, event reporting, resending to higher level outside substation, etc.).
Server IED name	The IED name of the server IED for the report control block, as described in the latest available SCD file. Names should be in accordance with the International Standard 81346 series.
Server IP address	IP address of the Ethernet port from which the report control block is sent.
RCB Name	Name of the report control block as found in the SCD file. For dynamic reports, this name is not available in the SCD file and the name will be manually entered into this table

6.5 Time synchronization

6.5.1 General

To obtain a correct sequence of events across different places in the power system, a time tagging with precise global (UTC) time is provided. All related devices are synchronized with the requested accuracy. A station bus can be time synchronized with a SNTP or PTP time server. A process bus can be time synchronized with a PTP time server which provides a high degree of accuracy. Time synchronization classes and accuracies are in accordance with IEC 61850-5.

6.5.2 SNTP time synchronization

Figure 7 shows a schematic representation of a SNTP synchronization scheme. Table 14 describes how properties of the server-client time synchronization application using a SNTP server shall be documented, respectively.

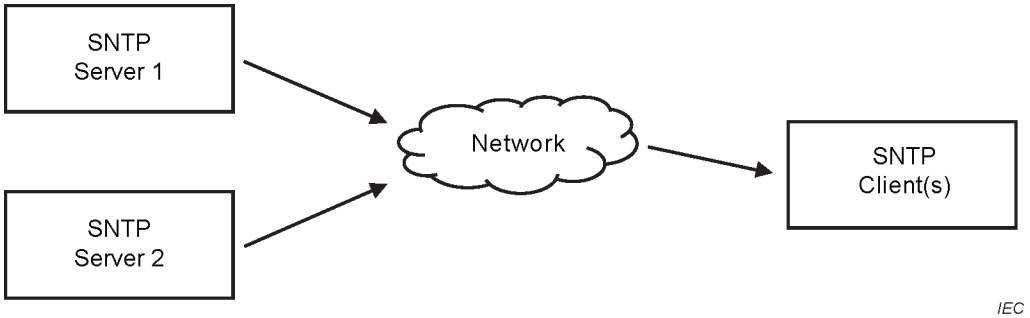

Figure 7 – Communication scheme of SNTP time synchronization

Table 14 – Presentation of a SNTP server

SNTP Server n	Comments
Server IED name	Each IED in a substation contains a name and the IED name is available in the SCD file. In this case the IED is the SNTP timeserver. Names should be in accordance with the International Standard 81346 series.
IP address	The IP address associated with the port used in the SNTP server for time server synchronization application.
Connection mode (PRP, HSR, SAN)	The type of connection to the network used by the port. SAN: No redundancy available (single attached node). PRP, HSR: Seamless redundancy connection.
Ethernet port name	The Ethernet port used (A or B).
Ethernet port MAC address	The MAC address (physical address) of the Ethernet port used.
Source type (GNSS, atomic clock, ext. server)	Definition of the source where time synchronization messages are produced. It can be a GNSS based time server located on the station or external in the system network or in some cases even in an RTU device.
SNTP server version number	The version of the SNTP server device
SNTP mode	Indication on the mode for the SNTP server: Broadcast mode Unicast mode
SNTP stratum level	The level of the SNTP server in the hierarchy of time servers.

Table 15 shows the presentation of the SNTP clients: one table for each client.

Table 15 – Presentation of a client

Client	Comments
Client IED name	Each IED in a substation contains a name and an IED name is available in the SCD file. Names should be in accordance with the International Standard 81346 series.
IP address	The IP address associated with the port used in the SNTP client for time server synchronization application.
IP Add Main Server (Prioritized)	The publishing SNTP server IP address associated with the port used in the time synchronization application.
IP Add Secondary Server	The publishing backup SNTP server IP address associated with the port used in the time synchronization application.
Connection mode (PRP, HSR, SAN)	The type of connection to the network used by the port. SAN: No redundancy available (single attached node). PRP, HSR: Seamless redundancy connection.
Ethernet port name	The Ethernet port used (A or B).
Ethernet port MAC address	The MAC address (physical address) of the Ethernet port used.

6.5.3 PTP IEC/IEEE 61850-9-3 time synchronization

Figure 8 shows a schematic representation of a PTP IEC/IEEE 61850-9-3 synchronization scheme. Table 16 describes the properties of the GMC to be documented.

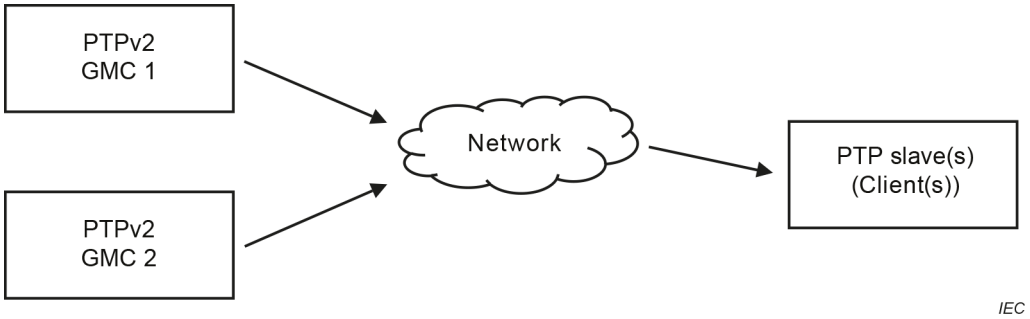

Figure 8 – Communication scheme of PTP IEC/IEEE 61850-9-3

Table 16 – Presentation of PTP GMC

PTP GMC	Comments
GMC IED name	Each IED in the substation contains a name and an IED name is available in the SCD file. In this case the IED is the PTP timeserver. Names should be in accordance with the International Standard 81346 series.
IP address	The IP address associated with the port used in the PTP GM for time synchronization application.
Connection mode (PRP, HSR, SAN)	The type of connection to the network used by the port. SAN: No redundancy available (single attached node). PRP, HSR: Seamless redundancy connection.
Ethernet port name	The Ethernet port used (A or B).
Ethernet port MAC address	The MAC address (physical address) of the Ethernet port used.
Source Type (GPS, Atomic Clock, Ext. Server)	Definition of the source where time synchronization telegrams are produced. It can be GPS / GNSS based IEEE 1588 PTPv2 GM located on station or external in the system network.
PTP Priority 1	The attribute priority1 is used in the execution of the best master clock algorithm. Lower values take precedence. The initialization value of priority1 is specified in a PTP profile. The value of priority1 shall be configurable to any value in the range 0 to 255, unless restricted by limits established by an applicable PTP profile.
PTP Priority 2	The attribute priority2 is used in the execution of the best master clock algorithm. Lower values take precedence. The initialization value of priority2 is specified in a PTP profile. The value of priority2 shall be configurable to any value in the range 0 to 255, unless restricted by limits established by an applicable PTP profile.
PTP Domain number	The domain is identified by an integer. Network engineering should ensure that all clocks participating in the PTP time distribution are set to the same time domain. To avoid conflict with another PTP time distribution, domains are settable from 0 to 255.
PTP VLAN	VLAN)is identified by an integer. It shall be published in the PTP message as found in the (as built) / SCD file.
PTP VLAN Prio	VLAN priority with which the PTP telegram will be transported. It shall be published in the PTP message as found in the (as built) / SCD file.

Table 17 shows the presentation of the PTP slave clock: one table for each slave clock.

Table 17 – Presentation of a PTP slave clock

PTP slave clock	Comments
Slave clock IED name	Each IED in a substation contains a name and the IED name is available in the SCD file. Names should be in accordance with the International Standard 81346 series.
IP address	The receiving PTP clocks IP address associated with the port used in the time synchronization application.
Connection mode (PRP, HSR, SAN)	The type of connection to the network used by the port. SAN: No redundancy available (single attached node). PRP, HSR: Seamless redundancy connection.
Ethernet port name	The Ethernet port used (A or B).
Ethernet port MAC address	The MAC address (physical address) of the Ethernet port used.
Clock type (OC, BC)	This specification distinguishes and describes clocks by their capabilities. • OC – Ordinary Clock; • BC – Boundary Clock; • TC – Transparent Clock.
PTP Priority 1	The attribute priority1 is used in the execution of the best master clock algorithm. Lower values take precedence. The initialization value of priority1 is specified in a PTP profile. The value of priority1 shall be configurable to any value in the range 0 to 255, unless restricted by limits established by an applicable PTP profile.
PTP Priority 2	The attribute priority2 is used in the execution of the best master clock algorithm. Lower values take precedence. The initialization value of priority2 is specified in a PTP profile. The value of priority2 shall be configurable to any value in the range 0 to 255, unless restricted by limits established by an applicable PTP profile.
PTP Domain number	The domain is identified by an integer. Network engineering should ensure that all clocks participating in the PTP time distribution are set to the same time domain. To avoid conflict with another PTP time distribution, domains are settable from 0 to 255.
PTP VLAN	VLAN is identified by an integer. It shall be published in the PTP message as found in the (as built) / SCD file.

6.6 Disturbance recorder

Beside IED internal disturbance recorders, centralized digital disturbance recorders are used to collect power system information. Centralized digital disturbance recorders receive data either hardwired or via IEC 61850-8-1 (GOOSE) and IEC 61850-9-2 (Sampled Values) services inside the substation.

NOTE A disturbance recorder is commonly used for fault recordings, often then named as a digital fault recorder (DFR).

To analyse the captured fault recorder data, it shall be exported to customer systems via IEC 61850 protocols and in COMTRADE format (see IEC 60255-24 (IEEE C37.111)). Figure 9 represents the communication flow between the COMTRADE file server and the client.