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TECHNICAL REPORT

RAPPORT TECHNIQUE

colour inside

Communication networks and systems for power utility automation – Part 1: Introduction and overview

Réseaux et systèmes de communication pour l'automatisation des systèmes électriques – Partie 1: Introduction et présentation

IEC/TR 61850-1:2013

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 1: Introduction and overview

FOREWORD

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

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

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

- Extended application scope of the IEC 61850 standard
  - for the power quality domain;
  - for statistical and historical data;

  - for distributed generation monitoring and automation purpose;
  - for feeder automation purpose;
  - for substation to substation communication;
  - for monitoring functions according to IEC 62271.
- Smart grid considerations.
- Extensions (and provisions for extensions) of the documentation system relating to IEC 61850, especially with part 7-5xx (Application guides) and part 90-xx (Technical report and guidelines).

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

Enquiry draft	Report on voting
57/1233/DTR	57/1304/RVC

Full information on the voting for the approval of this technical report 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 in 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 web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

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INTRODUCTION

IEC 61850 consists of the following parts, under the general title *Communication networks and systems for power utility automation* (all parts may have not been published yet).

Part 1: Introduction and overview

Part 2: Glossary

Part 3: General requirements

Part 4: System and project management

Part 5: Communication requirements for functions and device models

Part 6: Configuration description language for communication in electrical substations related to IEDs

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

Part 7-2: Basic communication structure – Abstract communication service interface (ACSI)

Part 7-3: Basic communication structure – Common data classes

Part 7-4: Basic communication structure – Compatible logical node classes and data classes

Part 7-410: Hydroelectric power plants – Communication for monitoring and control

Part 7-420: Basic communication structure – Distributed energy resources logical nodes

Part 7-5: IEC 61850 – Modelling concepts[1]

Part 7-500: Use of logical nodes to model functions of a substation automation system[1]

Part 7-510: Use of logical nodes to model functions of a hydro power plant

Part 7-520: Use of logical nodes to model functions of distributed energy resources[1]

Part 8-1: Specific communication service mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3

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

Part 9-2: Specific communication service mapping (SCSM) – Sampled values over ISO/IEC 8802-3

Part 90-1: Use of IEC 61850 for the communication between substations

Part 90-2: Using IEC 61850 for the communication between substations and control centres[1]

Part 90-3: Using IEC 61850 for condition monitoring[1]

Part 90-4: Network Engineering Guidelines - Technical report[1]

Part 90-5: Using IEC 61850 to transmit synchrophasor information according to IEEE C37.118

Part 10: Conformance testing

In addition to the above parts IEC technical committee 88 has published the IEC 61850 basic communication structure for Wind Turbines as IEC 61400-25, *Wind turbines – Communications for monitoring and control of wind power plants*.

IEC 61850-1 is an introduction and overview of the IEC 61850 standard series. It describes the philosophy, work approach and contents of the other parts.

1 Under consideration.

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 1: Introduction and overview

1 Scope

This technical report is applicable to *power utility automation systems* (PUAS). It defines the communication between intelligent electronic devices (IEDs) in such a system, and the related system requirements.

This part gives an introduction and overview of the IEC 61850 standard series. It refers to and might include text and figures coming from other parts of the IEC 61850 standard series.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60870-5-103, *Telecontrol equipment and systems – Part 5-103: Transmission Protocols - Companion standard for the informative interface of protection equipment*

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

IEC 61400-25 (all parts), *Communications for monitoring and control of wind power plants*

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

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

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

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

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

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

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

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

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

IEC 61850-7-410, *Communication networks and systems for power utility automation – Part 7-410: Hydroelectric power plants – Communication for monitoring and control*

IEC 61850-7-420, *Communication networks and systems for power utility automation – Part 7-420: Basic communication structure – Distributed energy resources logical nodes*

IEC 61850-7-510, *Communication networks and systems for power utility automation – Part 7-510: Basic communication structure – Hydroelectric power plants – Modelling concepts and guidelines*

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

IEC 61850-80-1, *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 61850-9-2, *Communication networks and systems for power utility automation – Part 9-2: Specific communication service mapping (SCSM) – Sampled values over ISO/IEC 8802-3*

IEC/TR 61850-90-1, *Communication networks and systems for power utility automation – Part 90-1: Use of IEC 61850 for the communication between substations*

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

IEC 62351 (all parts), *Power systems management and associated information exchange – Data and communications security*

IEC/TR 62357-1, *Power systems management and associated information exchange – Part 1: Reference architecture*

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

ISO 9001:2008, *Quality management systems – Requirements*

IEEE C37.2, *IEEE standard electrical power system device function numbers, acronyms and contact designations*

IEEE 100:2000, *The authoritative dictionary of IEEE standards terms seventh edition*

IEEE-SA TR 1550, *Utility Communications Architecture (UCA) Version 2.0 – Part 4: UCA Generic Object Models for Substation and Feeder Equipment (GOMSFE)*

RFC 2246, *The TLS Protocol, Version 1.0*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this Technical Report, the following terms and definitions apply. However please refer to part 2 of the standard for the standard glossary of IEC 61850.

3.1.1
Abstract Communication Service Interface
ACSI
virtual interface to an IED providing abstract communication services, for example connection, variable access, unsolicited data transfer, device control and file transfer services, independent of the actual communication stack and profiles used

3.1.2
bay
subpart of a substation, having some common functionality, closely connected to the other subparts, and forming a substation

3.1.3
data object
part of a logical node object representing specific information, for example, status or measurement. From an object-oriented point of view, a data object is an instance of a data object class. Data objects are normally used as transaction objects; i.e., they are data structures

3.1.4
device
mechanism or piece of equipment designed to serve a purpose or perform a function, for example, breaker, relay, or substation computer

[SOURCE: IEEE 100:2000]

3.1.5
functions
tasks which are performed by the substation automation system, i.e. by application functions

Note 1 to entry: Generally, functions exchange data with other functions. The details are dependent on the functions in consideration. Functions are performed by IEDs (physical devices). Functions may be split in parts residing in different IEDs but communicating which each other (distributed function) and with parts of other functions. These communicating function parts are called logical nodes.

Note 2 to entry: In the context of this standard, the decomposition of functions or their granularity is ruled by the communication behaviour only. Therefore, all functions considered consist of logical nodes that exchange data.

3.1.6
Intelligent Electronic Device
IED
any device incorporating one or more processors with the capability of receiving or sending data/controls from or to an external source (for example, electronic multifunction meters, digital relays, controllers)

3.1.7
interchangeability
ability to replace a device supplied by one manufacturer with a device supplied by another manufacturer, without making changes to the other elements in the system

3.1.8
interoperability
ability of two or more IEDs from the same vendor, or from different vendors, to exchange information and use that information for correct execution of specified functions

3.1.9
Logical Node
LN
smallest part of a function that exchanges data

Note 1 to entry: A LN is an object defined by its data and methods.

3.1.10
Logical Device
LD
virtual device that exists to enable aggregation of related logical nodes

3.1.11
open protocol
protocol whose stack is either standardised or publicly available

3.1.12
part
part of the IEC 61850 standard series

EXAMPLE Part 1 refers to IEC 61850-1, Part 7-2 refers to IEC 61850-7-2.

3.1.13
Physical Device
PD
equivalent to an IED as used in the context of this standard

3.1.14
process bus
process bus is the communication network which connects the IEDs at primary equipment level to other IEDs

3.1.15
protocol
set of rules that determines the behaviour of functional units in achieving and performing communication

3.1.16
Power Utility Automation System
PUAS
set of communicating components or devices (IEDs) arranged in a communication architecture to perform any type of power utility automation functions

Note 1 to entry: Power Utility Automation System includes de facto Substation Automation system, as one possible sub-system.

3.1.17
self-description
a device contains information on its configuration

Note 1 to entry: The representation of this information has to be standardised and has to be accessible via communication (in the context of this standard series).

3.1.18
station bus
communication network which inter-connects IEDs at bay level and IEDs at station level, and connects bay-level IEDs to station-level IEDs

3.1.19
system
within the scope of this standard, system always refers to substation automation systems unless otherwise stated

3.1.20
Specific Communication Service Mapping
SCSM
standardised procedure which provides the concrete mapping of ACSI services and objects onto a particular protocol stack/communication profile

Note 1 to entry: To facilitate interoperability it is intended to have a minimum number of standardized mappings (SCSM). Special application subdomains such as “station bus” and “process bus” may result in more than one mapping. However, for a specific protocol stack selected only one single SCSM and one single profile should be specified.

Note 2 to entry: A SCSM should detail the instantiation of abstract services into protocol specific single service or sequence of services which achieve the service as specified in ACSI. Additionally, a SCSM should detail the mapping of ACSI objects into object supported by the application protocol.

Note 3 to entry: SCSMs are specified in the parts 8-x and 9-x of this standard series.

3.2 Abbreviated terms

ACSI	Abstract Communication Service Interface
CDC	Common Data Class
CIM	Common Information Model
DA	Data Attribute
DER	Distributed Energy Resource
DO	Data Object
EMC	Electromagnetic Compatibility
GSE	Generic Substation Event (communication model)
GSSE	Generic Substation State Event (communication model)
GOOSE	Generic Object Oriented System Event (communication model)
IED	Intelligent Electronic Device
LN	Logical Node
LD	Logical Device
PD	Physical Device
PUAS	Power Utility Automation System
SCL	System Configuration description Language
SCSM	Specific Communication Service Mapping
TLS	Transport Layer Security
VLAN	Virtual Local Area Network
XML	eXtensible Markup Language

4 Objectives

The possibility to build Power Utility Automation Systems (PUAS) rests on the strong technological development of large-scale integrated circuits, leading to the present availability of advanced, fast, and powerful microprocessors. The result was an evolution of substation secondary equipment, from electro-mechanical devices to digital devices. This in turn provided the possibility of implementing Power Utility Automation System using several intelligent electronic devices (IEDs) to perform the required functions (protection, local and remote monitoring and control, etc.). As a consequence, the need arose for efficient communication among the IEDs, especially for a standard protocol. Initially specific proprietary communication protocols developed by each manufacturer where used, requiring complicated and costly protocol converters when using IEDs from different vendors.

The industry's experiences have demonstrated the need and the opportunity for developing standard semantics, abstract communication services that can be mapped to different protocols, configuration descriptions and engineering processes, which would support interoperability of IEDs from different manufacturers. Interoperability in this case is the ability to operate on the same network or communication path sharing information and commands. There is also a desire to have IED interchangeability, i.e. the ability to replace a device supplied by one manufacturer with a device supplied by another manufacturer, without making changes to the other elements in the system. Interchangeability would also require standardisation of functions which is beyond this communication standard. Interoperability is a common goal for electric utilities, equipment vendors and standardisation bodies.

The objective of PUAS standardisation is to develop a communication standard that will meet functional and performance requirements, while supporting future technological developments. To be truly beneficial, a consensus must be found between IED manufacturers and users on the way such devices can freely exchange information.

The communication standard must support the operation functions within the substation and distributed throughout the power grid. Therefore, the standard has to consider the operational requirements, but the purpose of the standard is neither to standardise (nor limit in any way) the functions involved in substation operation nor their allocation within the Power Utility Automation System. The application functions will be identified and described in order to define their interface and then their communication requirements (for example, amount of data to be exchanged, exchange time constraints, etc.). The communication standard, to the maximum possible extent, should make use of existing standards and commonly accepted communication and engineering principles.

This standard aims to ensure, among others, the following features:

– That the complete communication profile is based on existing IEC/IEEE/ISO/OSI communication standards, if available.

– That the protocols used will be open and will support self-descriptive devices. It should be possible to add new functionality.

– That the standard is based on data objects related to the needs of the electric power industry.

– That the communication syntax and semantics are based on the use of common data objects related to the power system.

– That the communication services can be mapped to different state-of-the art protocols.

– That the communication standard considers the implications of the substation being one node in the power grid, i.e. of the Power Utility Automation System being one element in the overall power control system.

– That the complete topology of an electrical system (single line diagram), the generated and consumed information, and the information flow between all IEDs is specified, using a machine readable language.

5 Approach of the IEC 61850 standard

5.1 Scope of application

The main parts of the IEC 61850 standard were first published from 2002 to 2005. The standard was the result of nearly ten years of work within IEEE/EPRI on Utility Communications Architecture (UCA) (IEEE-SA TR 1550) and within the working group "Substation Control and Protection Interfaces" of IEC Technical Committee 57. The initial scope of IEC 61850 was standardisation of communication in substation automation systems.

The first edition of the standard was primarily related to protection, control and monitoring. From 2009 onwards the original parts of the IEC 61850 series have been updated and extended to cover also measurement (including statistical and historical data handling) and power quality. New parts of the standard will also be added to handle condition monitoring.

The concepts defined in IEC 61850 have been applied beyond the substation domain:

– The modelling of hydropower plants (see IEC 61850-7-410) distributed energy resources (see IEC 61850-7-420) are also covered by the IEC 61850 series.
– The modelling of wind turbines has been standardized ,according to IEC 61850, within the IEC 61400-25 series, *Communications for monitoring and control of wind power plants*.
– The communication has also been extended to substation to substation communication (see IEC 61850-90-1).

IEC 61850 is planned to be applied to new areas such as:

– Communication to network control centre (IEC/TR 61850-90-2[2])
– Feeder automation domain

Harmonization of IEC 61850 modelling with the IEC Common Information Model (CIM, IEC 61968/61970) is also considered as a high-priority item to fulfil Smart Grid objectives.

Given the extended scope, today's naming of the IEC 61850 standard is *Communication networks and systems for power utility automation*. The final scope of application of IEC 61850 (and affiliates) is described in Figure 1.

2 To be published.