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Communication networks and systems in substations –

Part 5: Communication requirements for functions and device models

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMUNICATION NETWORKS AND SYSTEMS IN SUBSTATIONS –

Part 5: Communication requirements for functions and device models

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61850-5 has been prepared by IEC technical committee 57: Power system control and associated communications.

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

FDIS	Report on voting
57/641/FDIS	57/649/RVD

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

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

The content of this part of IEC 61850 is based on existing or emerging standards and applications. In particular the approach to formulate the requirements is based upon

CIGRE Technical Report, Ref. No. 180, *Communication requirements in terms of data flow within substations*. CE/SC 34 03, 2001, 112 pp. Ref. No. 180

K.P. Brand, *Communication requirements in terms of data flow within substations – Results of WG34.03 and standardization within IEC*, **Electra** 173, 77-85 (1997)

IEEE-SA TR 1550-2003: *IEEE-SA Technical Report on Utility Communications Architecture (UCA™), Version 2.0, Part 4: UCA Generic Object Models for Substation and Feeder Equipment (GOMSFE).*

IEC 61850 consists of the following parts, under the general title *Communication networks and systems in substations*.

Part 1: *Introduction and overview*

Part 2: *Glossary* [1]

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* [2]

Part 7-1: *Basic communication structure for substation and feeder equipment – Principles and models*

Part 7-2: *Basic communication structure for substation and feeder equipment – Abstract communication service interface (ACSI)*

Part 7-3: *Basic communication structure for substation and feeder equipment – Common data classes*

Part 7-4: *Basic communication structure for substation and feeder equipment – Compatible logical node classes and data classes*

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

Part 9-1: *Specific communication service mapping (SCSM) – Sampled values over serial unidirectional multidrop point to point link*

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

Part 10: *Conformance testing* [2]

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

The committee has decided that the contents of this publication will remain unchanged until 2005. At this date, the publication will be

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

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1 To be published.

2 Under consideration.

INTRODUCTION

The IEC 61850 series is intended to provide interoperability between all devices in substations. Communication between these devices has to fulfil a lot of requirements imposed by all the functions to be performed in substations. Depending on the philosophy both of the vendor and of the user and on the state-of-the-art in technology, the allocation of functions to devices and control levels is not commonly fixed. This results in different requirements for the different communication interfaces within the substation. The IEC 61850 series shall support any allocation of functions.

The IEC 61850 series should have a long lifetime but be able to follow the fast changes in communication technology by both its technical approach and its document structure. Figure 1 shows the relationship of this part of the IEC 61850 series to subsequent parts of the IEC 61850 series. The IEC 61850 series has been organized so that changes to one part do not require a significant rewriting of another part, i.e. the parts are based on the communication requirements in this part of the IEC 61850 series; the derived modelling requirements in subsequent parts will not change the requirements of this part of the IEC 61850 series. The general parts, the requirement specification and the modelling parts are independent from any implementation. The implementation needed for the use of the IEC 61850 series is defined in some dedicated parts.

This part of the IEC 61850 series defines the communication requirements for functions and device models for substations.

The modelling of communication requires the definition of objects (for example, data objects, data sets, report control, log control) and services provided by objects (for example, get, set, report, create, delete). This is defined in IEC 61850-7-x with a clear interface to implementation. To use the benefits of communication technology, in the IEC 61850 series, no new OSI stacks are defined but a standardized mapping on existing stacks is given in IEC 61850-8-x and IEC 61850-9-x. A substation configuration language (IEC 61850-6) and a standardized conformance testing complement the IEC 61850 series. Figure 1 shows the general structure of the documents of the IEC 61850 series, as well as the relative position of IEC 61850-5 within this series.

NOTE To keep the layered approach of the IEC 61850 series which does not mix application and implementation requirements, terms such as client, server, data objects, etc. are normally not used in this part of the IEC 61850 series (requirements). In IEC 61850-7-x (modeling), IEC 61850-8-x and IEC 61850-9-x (specific communication service mapping) terms belonging to application requirements such as PICOMs are normally not used.

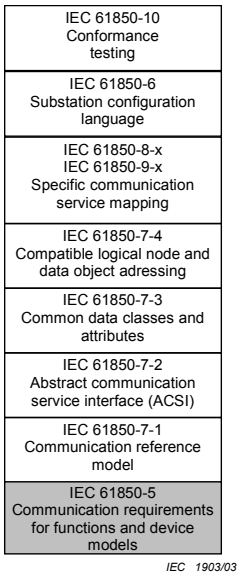

Figure 1 – Relative position of this part of the IEC 61850 series

COMMUNICATION NETWORKS AND SYSTEMS IN SUBSTATIONS –

Part 5: Communication requirements for functions and device models

1 Scope

This part of IEC 61850 applies to Substation Automation Systems (SAS). It standardizes the communication between intelligent electronic devices (IEDs) and the related system requirements.

The specifications of this part refer to the communication requirements of the functions being performed in the substation automation system and to device models. All known functions and their communication requirements are identified.

The description of the functions is not used to standardize the functions, but to identify communication requirements between technical services and the substation, and communication requirements between Intelligent Electronic Devices within the substation. The basic goal is interoperability for all interactions.

Standardizing functions and their implementation is completely outside the scope of this part of IEC 61850. Therefore, a single philosophy for allocating functions to devices cannot be assumed in the IEC 61850 series. To support the resulting request for free allocation of functions, a proper breakdown of functions into parts relevant for communication is defined. The exchanged data and their required performance are defined. These definitions are supplemented by informative data flow calculations for typical substation configurations.

Intelligent electronic devices from substations such as protective devices are also found in other installations such as power plants. Using this part of IEC 61850 for such devices in these plants also would facilitate the system integration but this is beyond the scope of this part of IEC 61850.

2 Normative references

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

IEC 60044-8, *Instrument transformers – Part 8: Electronic current transformers*

IEC 60870-4, *Telecontrol equipment and systems – Part 4: Performance requirements*

IEC 61346 (all parts), *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations*

IEC 61850-2, *Communication networks and system in substations – Part 2: Glossary* [3]

IEC 62053-22, *Electricity metering equipment (a.c.) – Particular Requirements – Part 22: Static meters for active energy (classes 0,2 S and 0,5 S)*

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[3] To be published.

IEEE Std C37.2:1996, *IEEE Standard Electrical Power System Device Function Numbers and Contact Designations*

NOTE Informative references are found in the Bibliography.

3 Terms and definitions

For the purpose of this part of IEC 61850, the following terms and definitions as well as those given in IEC 61850-2[4], apply.

3.1
function
task which is performed by the substation automation system. Generally, a function consists of subparts called logical nodes, which exchange data with each other. By definition, only logical nodes exchange data and, therefore, a function that exchanges data with other functions must have at least one logical node. As a consequence, only data contained in logical nodes can be exchanged in the context of the IEC 61850 series.

3.2
distributed function
function which is performed in two or more logical nodes that are located in different physical devices. Since all functions communicate in some way, the definition of a local or a distributed function is not unique but depends on the definition of the functional steps to be performed until the function is completed. In case of the loss of one LN or one related communication link, the function may be blocked completely or show a graceful degradation, if applicable.

3.3
system
set of interacting entities which perform a common functionality. Its backbone is some communication mechanism.

3.3.1
logical system
communicating (via its logical nodes) set of all application functions performing some overall task such as “management of a substation” in the context of IEC 61850

3.3.2
physical system
interaction set of all devices hosting these functions and the interconnecting physical communication network. The boundary of a system is given by its logical or physical interfaces. Examples are industrial systems, management systems, information systems, and within the scope of the IEC 61850 series, substation automation systems. The backbone of physical system is its communication system.

3.3.3
substation automation system
system which operates, protects, monitors, etc. the substation, i.e. the primary system. For this purpose, it uses fully numerical technology and serial communication links (communication system).

3.3.4
primary system
common term for all power system equipment and switchgear

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4 To be published.

3.3.5
secondary system
interaction set of all components and systems in the substation for operation, protection, monitoring, etc, i.e. the primary system. In case of full application of numerical technology, the secondary system is synonymous with the substation automation system.

3.3.6
communication system
interconnected set of all communication links

3.4
device
mechanism or piece of equipment designed to serve a purpose or perform a function, for example a breaker, relay, or substation computer. Communication relevant properties are described in a proper device related model.

3.4.1
intelligent electronic device
is any device incorporating one or more processors with the capability to receive or send data/control from or to an external source, for example electronic multifunction meters, digital relays, controllers. An entity capable of executing the behavior of one or more specified logical nodes in a particular context and delimited by its interfaces. If not stated otherwise intelligent electronic devices have an internal clock by definition providing for example time tags. This adds the requirement of a system wide time synchronization of all these clocks if applicable.

3.4.2
physical device
equivalent to an intelligent electronic device as used in the context of the IEC 61850 series

3.5
Logical Node
LN
smallest part of a function that exchanges data. A Logical Node (LN) represents the function within a physical device; it performs some operations for that function. A LN is an object defined by its data and methods. Logical nodes related to primary equipment are not the primary equipment itself but its intelligent part or image in the secondary system, i.e. local or remote I/Os, intelligent sensors and actuators, etc.

3.6
connection
the links between entities

3.6.1
logical connection
communication link between logical nodes

3.6.2
physical connection
communication link between physical devices

3.7
interchangeability
the possibility to replace a device from the same vendor, or from different vendors, utilizing the same communication interface and as a minimum, providing the same functionality, and with no impact on the rest of the system. If differences in functionality are accepted, the exchange may also require some changes somewhere in the system. Interchangeability requires standardization of functions and, in a strong sense, of devices also. Both such requirements are outside the scope of the IEC 61850 series.

3.8
interoperability
ability of two or more intelligent electronic devices from the same vendor, or different vendors, to exchange information and use that information for correct co-operation. Interoperability is a prerequisite of interchangeability.

3.9
PICOM
Piece of Information for COMmunication describing an information transfer on a given logical connection with given communication attributes between two logical nodes. It also contains the information to be transmitted and, in addition, requirement attributes such as performance. It does not represent the actual structure and format for data that is exchanged over the communication network. This information is found in the parts IEC 61850-8 and IEC 61850-9. The assumed logical point-to-point connection describes the source and sink of this information transfer but does not prescribe the communication procedures. Therefore, multicast and broadcast procedures are not excluded.

NOTE The PICOM approach was adopted from CIGRE working group 34.03 (according to CIGRE – Technical Report, Ref.No.180) and allows for performance requirements also.

3.10
bay
closely connected subparts of the substation with some common functionality. Examples are the switchgear between an incoming or outgoing line and the busbar, the buscoupler with its circuit breaker and related isolators and earthing switches, the transformer with its related switchgear between the two busbars representing the two voltage levels, the diameter (see definition) in a 1½ breaker arrangement, virtual bays in ring arrangements (breaker and adjacent isolators), etc. These subparts very often comprise a device to be protected such as a transformer or a line end. The control of the switchgear in such a subpart has some common restrictions like mutual interlocking or well-defined operation sequences. The identification of such subparts is important for maintenance purposes (what parts may be switched off at the same time with a minimum impact on the rest of the substation) or for extension plans (what has to be added if a new line is linked in). These subparts are called “bays” and are managed by devices with the generic names “bay controller” and “bay protection”. The functionality of these devices represents an additional logical control level below the overall station level that is called “bay level”. Physically, this level must not exist in any substation; i.e. there may be no physical device “bay controller” at all.

3.11
diameter
applies to a 1½-breaker arrangement and comprises the complete switchgear between the two busbars, i.e. the 2 lines and the 3 circuit breakers with all related isolators, earthing switches, CTs and VTs. The diameter has some common functional relationship both for operation, maintenance and extensions.

3.12
level functions
functions related to some control levels of the substation automation system

3.12.1
bay level functions
functions using mainly the data of one bay and acting mainly on the primary equipment of one bay. The definition of bay level functions considers some kind of a meaningful substructure in the primary substation (see 3.10) configuration and, related to this substructure, some local functionality or autonomy in the secondary system (substation automation). Examples for such functions are line protection or bay control. These functions communicate via the logical interface 3 within the bay level and via the logical interfaces 4 and 5 to the process level, i.e. with any kind of remote I/Os or intelligent sensors and actuators. Interfaces 4 and 5 may be hardwired also but hardwired interfaces are beyond the scope of the IEC 61850 series.