

# INTERNATIONAL STANDARD

**IEC**  
**61850-5**

First edition  
2003-07

---

---

## Communication networks and systems in substations –

### Part 5: Communication requirements for functions and device models

© IEC 2003 — Copyright - all rights reserved

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland  
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: [inmail@iec.ch](mailto:inmail@iec.ch) Web: [www.iec.ch](http://www.iec.ch)



Commission Electrotechnique Internationale  
International Electrotechnical Commission  
Международная Электротехническая Комиссия

PRICE CODE

**XF**

*For price, see current catalogue*

## CONTENTS

FOREWORD .....	6
INTRODUCTION .....	8
1 Scope .....	9
2 Normative references.....	9
3 Terms and definitions .....	10
4 Abbreviations.....	13
5 Substation automation system functions .....	14
5.1 Introduction .....	14
5.2 Logical allocation of functions and interfaces.....	14
5.3 The physical allocation of functions and interfaces .....	16
5.4 The role of interfaces.....	16
6 Goal and requirements .....	17
6.1 Interoperability.....	17
6.2 Static design requirements .....	17
6.3 Dynamic interaction requirements.....	17
6.4 Response behavior requirements.....	18
6.5 Approach to interoperability .....	18
6.6 Conformance test requirements .....	18
7 Rules for function definition .....	18
7.1 Function description .....	19
7.2 Logical Node description .....	19
7.3 PICOM description.....	19
8 Categories of functions .....	19
8.1 System support functions.....	19
8.2 System configuration or maintenance functions .....	19
8.3 Operational or control functions .....	20
8.4 Local process automation functions .....	20
8.5 Distributed automatic support functions .....	20
8.6 Distributed process automation functions.....	20
9 The logical node concept.....	20
9.1 Logical nodes and logical connections .....	20
9.2 The need for a formal system description .....	21
9.3 Requirements for logical node behavior.....	22
9.4 Examples for decomposition of common functions into logical nodes.....	22
10 The PICOM concept.....	23
10.1 Attributes of PICOMS .....	24
10.2 PICOMS and data models .....	25
11 List of logical nodes .....	25
11.1 Logical Nodes for protection functions .....	26
11.2 Logical Nodes for control .....	31
11.3 Physical device.....	34
11.4 System and device security .....	34
11.5 LNs related to primary equipment .....	34
11.6 LNs related to system services .....	37

12	The application of LN (informative)	37
12.1	Basic principles	37
12.2	Basic examples	38
12.3	Additional examples	39
12.4	Remarks on modeling	42
13	Message performance requirements	43
13.1	Introduction	43
13.2	Basic time requirements	43
13.3	Event time definition	44
13.4	Transfer time definition	44
13.5	The introduction and use of message types	45
13.6	The introduction and use of performance classes	45
13.7	Message types and performance classes	46
14	Requirements for data integrity	49
15	System performance requirements	49
15.1	Introduction	49
15.2	Calculation methods	50
15.3	Calculation results	51
15.4	Summary	51
16	Additional requirements for the data model	52
16.1	Requirements for the addressing of logical nodes	52
16.2	Requirements for the data model	52
	Annex A (informative) Logical nodes and related PICOMs	53
	Annex B (informative) PICOM identification and message classification	67
	Annex C (informative) Communication optimization	74
	Annex D (informative) Rules for function definition	75
	Annex E (informative) Interaction of functions and logical nodes	77
	Annex F (informative) Categories of functions	78
	Annex G (informative) Functions	80
	Annex H (informative) Results from the function description	105
	Annex I (informative) Performance calculations	111
	Annex J (informative) Examples for protection functions in compensated networks	129
	Bibliography	131
	Figure 1 – Relative position of this part of the IEC 61850 series	8
	Figure 2 – Levels and logical interfaces in substation automation systems	15
	Figure 3 – The logical node and link concept	21
	Figure 4 – Examples of the application of the logical node concept	23
	Figure 5 – Protection function consisting of 3 logical nodes	25
	Figure 6 – The basic communication links of a logical node of main protection type	29
	Figure 7 – Decomposition of functions into interacting LNs on different levels: examples for generic automatic function, breaker control function and voltage control function	38

Figure 8 – Decomposition of functions into interacting LN on different levels: examples for generic function with telecontrol interface, protection function and measuring/metering function .....	38
Figure 9 – Example for control and protection LNs of a transformer bay combined in one physical device (some kind of maximum allocation) .....	39
Figure 10 – Example for interaction of LNs for switchgear control, interlocking, synchrocheck, autoreclosure and protection .....	39
Figure 11 – Example for sequential interacting of LNs (local and remote) for a complex function such as point-on-wave switching – Sequence view .....	40
Figure 12 – Example for functional interacting of LNs (local and remote) for a complex function such as point-on-wave switching – Architecture view .....	40
Figure 13 – Example for automatic tap changer control for voltage regulation .....	4
Figure 14 – Circuit breaker controllable per phase (one instance of XCBR per phase) and instrument transformers with measuring units per phase (one instance of TC or TVTR per phase) .....	41
Figure 15 – Distributed busbar protection (LN instances of PBDF for central unit and for units per bay - left) and interlocking (LN instance of CILO) on bay level per switch/circuit breaker (right) .....	42
Figure 16 – Definition of overall transfer time .....	45
Figure I.1 – T1-1 small size transmission substation/ D2-1 medium size distribution substation .....	111
Figure I.2 – T1-2 small size transmission substation with one and a half breaker scheme/T2-2 large size transmission substation with ring bus .....	112
Figure I.3 – Substation of type T1-1 with allocation functions .....	114
Figure I.4 – Substation of type D2-1 with allocated functions .....	115
Figure I.5 – Substation of type T1-2 (functions allocated in the same way as for T2-2 in Figure I.6) .....	116
Figure I.6 – Substation of type T2-2 with allocated functions .....	117
Figure I.7 – Large transmission substation with a ring similar to type T2-2 (function allocation described in Clause I.2) .....	118
Figure I.8 – Large transmission substation with a ring similar to T2-2 (function allocation see text below) .....	119
Figure I.9 – Ethernet configuration with shared hub .....	128
Figure I.10 – Ethernet configuration with switched hubs .....	128
Figure J.1 – The transient earth fault in a compensated network .....	129
Figure J.2 – Short term bypass for single earth fault in compensated networks .....	130
Figure J.3 – The double earth fault in compensated networks .....	130
Table A.1 – Raw data for protection and control .....	47
Table A.2 – Raw data for metering .....	48
Table A.1 – PICOM groups .....	53
Table A.2 – Logical node list .....	53
Table B.1 – Identification and type allocation of PICOMS – Part 1 .....	68
Table B.2 – Identification and type allocation of PICOMS – Part 2 .....	69
Table B.3 – Identification and type allocation of PICOMS – Part 3 .....	70
Table B.4 – Identification and type allocation of PICOMS – Part 4 .....	71
Table B.5 – PICOM types – Part 1 .....	72
Table B.6 – PICOM types – Part 2 .....	73

Table H.1 – Function-function interaction – Part 1 .....	105
Table H.2 – Function-function interaction – Part 2 .....	106
Table H.3 – Function decomposition into Logical Nodes – Part 1 .....	107
Table H.4 – Function decomposition into Logical Nodes – Part 2 .....	108
Table H.5 – Function decomposition into Logical Nodes – Part 3 .....	109
Table H.6 – Function decomposition into Logical Nodes – Part 4 .....	110
Table I.1 – Definition of the configuration of all substations evaluated .....	112
Table I.2 – Overview of the main results of the performed calculations based on one common bus system covering all interfaces excluding interface 2 and 9 .....	113
Table I.3 – Results for the substation T1-1 .....	114
Table I.4 – Results for the substation D2-1 .....	115
Table I.5 – Results for the substation T1-2 .....	116
Table I.6 – Results for the substation T1-2 .....	117
Table I.7 – Results for the substation according to Figure I.7 (function allocation described in Clause I.2) .....	118
Table I.8 – 138 kV affected (faulted) lines and related messages .....	121
Table I.9 – Message delays of 38 – 256 byte multicast messages on a shared hub network .....	122
Table I.10 – Message delays of 38 messages on a switched hub network .....	122
Table I.11 – Message delays of a variable number of messages on a shared hub network .....	123
Table I.12 – Message delays of a variable number of messages on a switched hub network .....	123
Table I.13 – Summary table .....	124
Table I.14 – 138 kV affected lines .....	125
Table I.15 – 138 kV unaffected lines (per line) .....	125
Table I.16 – Total 138 kV lines .....	125
Table I.17 – 345 kV affected lines/per line/per relay system – Relay 1 .....	126
Table I.18 – 345 kV affected lines/per line/per relay system – Relay 2 .....	126
Table I.19 – 345 kV affected lines/per line/system communications .....	126
Table I.20 – 345 kV affected lines .....	127
Table I.21 – 345 kV unaffected lines/per line .....	127
Table I.22 – Total 345 kV lines .....	127
Table I.23 – Total LAN .....	127

## 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.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61850-5 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*<sup>1</sup>
- 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*<sup>2</sup>
- 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*<sup>2</sup>
- Part 9-1: *Specific communication service mapping (SCSM) – Sampled values over serial unidirectional multipoint to point link*
- Part 9-2: *Specific communication service mapping (SCSM) – Sampled values over ISO/IEC 8802-3*<sup>2</sup>
- Part 10: *Conformance testing*<sup>2</sup>

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.

<sup>1</sup> To be published.

<sup>2</sup> 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.

IEC 61850-10 Conformance testing
IEC 61850-6 Substation configuration language
IEC 61850-8-x IEC 61850-9-x Specific communication service mapping
IEC 61850-7-4 Compatible logical node and data object addressing
IEC 61850-7-3 Common data classes and attributes
IEC 61850-7-2 Abstract communication service interface (ACSI)
IEC 61850-7-1 Communication reference model
IEC 61850-5 Communication requirements for functions and device models

IEC 1903/03

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 61340 (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*<sup>3</sup>

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)*

---

<sup>3</sup> 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.