

TECHNICAL REPORT



**Communication networks and systems for power utility automation –
Part 90-5: Use of IEC 61850 to transmit synchrophasor information according to
IEEE C37.118**

Document Preview

[IEC TR 61850-90-5:2012](https://standards.iteh.ai/catalog/standards/iec/8c3d697e-4db3-4cb3-8bbd-44c088139f72/iec-tr-61850-90-5-2012)

<https://standards.iteh.ai/catalog/standards/iec/8c3d697e-4db3-4cb3-8bbd-44c088139f72/iec-tr-61850-90-5-2012>



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2012 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, 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 either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

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

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

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,...).

It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

IEC TR 61850-90-5:2012

<https://standards.iteh.ai/catalog/standards/iec/8c3d697e-4db3-4cb3-8bbd-44c088139f72/iec-tr-61850-90-5-2012>

TECHNICAL REPORT



**Communication networks and systems for power utility automation –
Part 90-5: Use of IEC 61850 to transmit synchrophasor information according to
IEEE C37.118**

Document Preview

[IEC TR 61850-90-5:2012](https://standards.iteh.ai/catalog/standards/iec/8c3d697e-4db3-4cb3-8bbd-44c088139f72/iec-tr-61850-90-5-2012)

<https://standards.iteh.ai/catalog/standards/iec/8c3d697e-4db3-4cb3-8bbd-44c088139f72/iec-tr-61850-90-5-2012>

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.200

ISBN 978-2-83220-092-6

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	7
INTRODUCTION.....	9
1 Scope.....	10
2 Normative references	10
3 Terms and definitions	12
4 Abbreviated terms	13
5 Use cases	15
5.1 General.....	15
5.2 Wide area applications utilizing synchrophasors.....	15
5.3 Synchro-check	16
5.4 Adaptive relaying.....	17
5.5 Out-of-step (OOS) protection.....	19
5.6 Situational awareness	20
5.7 State estimation and on-line security assessment.....	23
5.8 Archive data (event & continuous).....	25
5.9 Wide area controls	27
5.9.1 General	27
5.9.2 Special protection schemes.....	27
5.9.3 Predictive dynamic stability maintaining system.....	30
5.9.4 Under voltage load shedding	31
5.9.5 Phenomenon assumption type WAMPAC.....	33
5.9.6 Phasor Data Concentrator (PDC).....	36
6 Modelling considerations	41
6.1 General.....	41
6.2 System hierarchy.....	42
6.3 PMU model	43
6.4 Phasor Data Concentrators (PDCs).....	44
6.4.1 General	44
6.4.2 Substation PDC model.....	44
6.4.3 Regional or system level PDC	45
6.4.4 Quality.....	45
7 Communication requirements	46
7.1 General.....	46
7.2 Direct connection with tunnelling or R-SV service.....	46
7.3 The gateway approach	48
7.4 Requirement summary	49
7.5 TCP use	51
8 Security model	51
8.1 General.....	51
8.2 Key management and cryptographic support	54
8.3 Key Distribution Center (KDC).....	56
9 Services	56
9.1 General.....	56
9.2 Command service.....	57

9.2.1	General	57
9.2.2	Control blocks	57
9.3	Configuration request service	61
9.3.1	General	61
9.3.2	CFG-1 Type of configuration data – Capabilities	61
9.3.3	CFG-2 or CFG-3 Type of configuration data – Measurements	61
9.3.4	Online access to CFG-1 configuration information	61
9.3.5	Offline access to CFG-2 and CFG-3 configuration information	61
9.4	Header information service	61
9.5	Data transmission service	62
9.5.1	General	62
9.5.2	General	62
9.5.3	Coding synchrophasors data	62
9.6	Specific data mapping	62
9.7	Common data fields	62
9.8	Time synchronization	63
9.9	Redundancy	63
10	IEC logical node modelling for synchrophasor measurements	64
11	Synchrophasor profile mappings	66
11.1	General overview	66
11.2	A-Profiles	66
11.3	A-Profile GOOSE, SV, and management A-Profile	67
11.3.1	Application layer	67
11.3.2	Session layer	71
11.3.3	Payload	76
11.3.4	Signature	83
11.3.5	ITU X.234 A-Profile options	84
11.4	KDC Profile	85
11.4.1	Signature Hash algorithm	85
11.4.2	Identification payload	86
11.4.3	Payload identification	88
11.4.4	Policy response	91
11.4.5	Key download payload	92
11.5	Internet group management protocol version 3 A-Profile	94
11.6	T-Profiles	94
11.6.1	General	94
11.6.2	T-Profile to support GOOSE and SV A-Profile over Ethernet	95
11.6.3	T-Profile to support KDC (TCP and UDP)	97
11.6.4	T-Profile to support IGMPv3	97
11.6.5	Common T-Profile standards	97
12	Effects on IEC 61850-5	99
13	Effects on the IEC 61850-6 (SCL)	100
13.1	General	100
13.2	SCL extensions to support IEC/TR 61850-90-5 defined profiles	100
13.2.1	General engineering process	101
13.2.2	Control block extensions	101
13.2.3	KDC access point	104
13.2.4	Addressing extensions	105

13.3 SCL extensions to support the configuration of IEEE C37.118.2	107
13.3.1 The underlying protocol	108
13.3.2 The data values	108
13.3.3 SCL example	110
14 Effect on IEC 61850-7-2	110
15 Effect on IEC 61850-7-4	110
15.1 General	110
15.2 Namespace definition	110
15.3 Extension of ClcMth	111
15.4 Addition of rate of change of frequency (ROCOF) DataObject	111
15.5 Modifications to the LTIM logical node class	111
15.6 Modifications to the LTMS logical node class	112
Annex A (informative) Full SCL example for C37.118.2 configuration	114
Annex B (informative) SCL examples for direct PMU and PDC-oriented communication	122
Annex C (informative) Migration from IEEE C37.118 to IEC 61850	135
Annex D (informative) Open system interconnect (OSI) model	138
Annex E (informative) IPv6	142
Annex F (informative) Edge authentication	144
Annex G (informative) Example of A-Profile encodings	145
Annex H (informative) Improving reliability of R-SV transmissions	146
Annex I (informative) Guidance on HMAC and truncation	147
Bibliography	148
Figure 1 – Use case diagram for Synchro-check	16
Figure 2 – Use case diagram for adaptive relaying	18
Figure 3 – Use case diagram for out-of-step (OOS) protection	19
Figure 4 – Use case diagram for situational awareness	21
Figure 5 – Use case diagram for state estimation	23
Figure 6 – Use case diagram for archiving data	25
Figure 7 – Use case diagram for wide area controls	28
Figure 8 – Use case diagram for predictive dynamic stability	30
Figure 9 – Use case diagram for under voltage load shedding	32
Figure 10 – Use case diagram for WAMPAC	34
Figure 11 – Use case diagram for phasor data concentrator	37
Figure 12 – Basic IEC 61850 model of WAMPAC functions	42
Figure 13 – System hierarchy	43
Figure 14 – PMU object model	44
Figure 15 – Substation PDC model with legacy PMUs	44
Figure 16 – Regional PDC object model	45
Figure 17 – Synchrophasor communication modelling for direct connection	47
Figure 18 – PDC as phasor concentrator and (proxy) gateway	48
Figure 19 – Application locality and time scale	51
Figure 20 – End-to-end cryptographic integrity for IEC 61850-9-2 implementations	53
Figure 21 – State transitions for key usage	55

Figure 22 – General service mappings	66
Figure 23 – IEC/TR 61850-90-5 A-Profiles	67
Figure 24 – General byte ordering of session protocol	71
Figure 25 – Structure of IEC/TR 61850-90-5 session protocol	72
Figure 26 – Encoding of TimetoNextKey	75
Figure 27 – IEEE 802.3 frame format for SV and GOOSE	82
Figure 28 – Virtual LAN Tag.....	83
Figure 29 – General format for IEC/TR 61850-90-5 payload extensions	87
Figure 30 – Policy response frame.....	91
Figure 31 – Key download response payload definition	93
Figure 32 – A-Profile association to various T-Profiles	95
Figure 33 – From RFC 768	96
Figure 34 – Format of IP header	98
Figure 35 – ToS byte field definition RFC-2474 and RFC-3168	98
Figure 36 – Security field definition from RFC 1108	99
Figure 37 – Extension to tSampledValueControl	102
Figure 38 – Extension to agSmvOpts	102
Figure 39 – Extension of tGSEControl.....	103
Figure 40 – Definition of tPredefinedTypeOfSecurityEnum	103
Figure 41 – AccessPoint SCL production indicating a KDC function	104
Figure 42 – IED SCL XSD indicating the KDC(s) to be used.....	105
Figure 43 – SCL tKDC type.....	105
Figure 44 – Extension to tPredefinedPTypeEnum	106
Figure 45 – tP_IPbase extension for IPv6 addresses	106
Figure 46 – Definition of tP_DNSName	107
Figure 47 – Definition tp_ C37-118-IP-Port	107
Figure A.1 – Single line for SCL example.....	114
Figure D.1 – Tasks of the OSI model layers	138
Figure D.2 – Comparison between OSI model and Internet models	138
Figure D.3 – Visualizing adding layer headers	139
Figure D.4 – Peer-to-peer data exchange in the OSI model	139
Figure D.5 – Relationship of OSI services to protocol data units (PDUs).....	140
Figure D.6 – OSI model addressing	141
Figure G.1 – Example encoding of GOOSE A-Profile	145
Table 1 – Equivalent commands	57
Table 2 – R-MSVCB class definition	58
Table 3 – R-GoCB definition	59
Table 4 – Current PHYCOMADDR structure.....	60
Table 5 – UDPCOMADDR structure	60
Table 6 – Extension to ClcMth to allow P-Class and M-Class	65
Table 7 – Example encodings of SPDU length	74
Table 8 – IEC 61850 Ethertype values	82

Table 9 – Allowed values for MAC signature value calculations	84
Table 10 – RFC-3547 assigned Hash identifiers	86
Table 11 – RFC-3547 assigned payload identifiers	86
Table 12 – IEC/TR 61850-90-5 assigned payload identifiers	87
Table 13 – RFC-3547 key download type identifiers.....	92
Table 14 – IEC/TR 61850-90-5 key download type identifiers	92
Table 15 – UDP field implementation requirements	96
Table 16 – Network protocol conformance implementation statement (PICS) for IPv4 based T-Profiles	97
Table 17 – Addition of TmLeaps in LTIM	112
Table 18 – Addition of TmLok in LTMS	113
Table C.1 – Migration steps from C37.118 to IEC 61850	137

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[IEC TR 61850-90-5:2012](https://standards.iteh.ai/catalog/standards/iec/8c3d697e-4db3-4cb3-8bbd-44c088139f72/iec-tr-61850-90-5-2012)

<https://standards.iteh.ai/catalog/standards/iec/8c3d697e-4db3-4cb3-8bbd-44c088139f72/iec-tr-61850-90-5-2012>

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**COMMUNICATION NETWORKS AND SYSTEMS FOR
POWER UTILITY AUTOMATION –****Part 90-5: Use of IEC 61850 to transmit synchrophasor
information according to IEEE C37.118**

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, Publicly Available Specifications (PAS) 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 itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 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.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC 61850-90-5, which is a technical report, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

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

Enquiry draft	Report on voting
57/1144/DTR	57/1207/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 technical report has been prepared in a joint effort between IEC and IEEE. A task force consisting of members from the IEC TC 57 WG 10 as well as the IEEE Power and Energy Society/IEEE Power System Relay Committee has prepared that report with task force meetings both at the regular meetings of IEC TC 57 WG 10 as well as at the regular meetings of the IEEE Power and Energy Society/IEEE Power System Relay Committee. Once the technical report is approved and published, the results will be integrated as amendments into the relevant parts of IEC 61850.

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

A list of all parts of the IEC 61850 series, 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

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

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

A bilingual version of this publication may be issued at a later date.

<https://standards.iteh.ai/catalog/standards/iec/8c3d697e-4db3-4cb3-8bbd-44c088139f72/iec-tr-61850-90-5-2012>

INTRODUCTION

Synchrophasor data as measured and calculated by PMUs are considered to be useful information to assess the condition of the electrical power network.

The synchrophasors and related message formats to transmit synchrophasor data over long distances are defined in IEEE C37.118.

Even though the communication according to IEEE C37.118 has proven to be usable and work well, there is a desire to have a communication mechanism that is compliant to the concept of IEC 61850. This document lays out how this shall be done.

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[IEC TR 61850-90-5:2012](https://standards.iteh.ai/catalog/standards/iec/8c3d697e-4db3-4cb3-8bbd-44c088139f72/iec-tr-61850-90-5-2012)

<https://standards.iteh.ai/catalog/standards/iec/8c3d697e-4db3-4cb3-8bbd-44c088139f72/iec-tr-61850-90-5-2012>

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

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

1 Scope

This part of IEC 61850 provides a way of exchanging synchrophasor data between PMUs, PDCs WAMPAC (Wide Area Monitoring, Protection, and Control), and between control center applications. The data, to the extent covered in IEEE C37.118-2005, are transported in a way that is compliant to the concepts of IEC 61850.

However, given the primary scope and use cases, this document also provides routable profiles for IEC 61850-8-1 GOOSE and IEC 61850-9-2 SV packets. These routable packets can be utilized to transport general IEC 61850 data as well as synchrophasor data.

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 61850-2:2003, *Communication networks and systems in substations – Part 2: Glossary*

IEC 61850-6:2009, *Communication networks and systems in substations – 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 in substations – 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 61850-7-4:2010, *Communication networks and systems for power utility automation – Part 7-4: Basic communication structure – Compatible logical node classes and data object classes*

IEC 61850-8-1:2011, *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 61850-9-2:2010, *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/TS 62351-1, *Power systems management and associated information exchange – Data and communications security – Part 1: Communication network and system security – Introduction to security issues*

IEC/TS 62351-6:2007, *Power systems management and associated information exchange – Data and communications security – Part 6: Security for IEC 61850*

ISO/IEC 8802-3:2000, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

ISO/IEC 19772, *Information technology – Security techniques – Authenticated encryption*
Also available as: NIST SP 800-38D

ITU-T X.234, *Information technology – Protocol for Providing the OSI connectionless-mode transport service*
Amendment 1: *Addition of connectionless-mode multicast capability*

IEEE 802.1Q, *Virtual Bridged Local Area Networks*

IEEE C37.118.1, *Standard for Synchrophasor Measurements for Power Systems*

IEEE C37.118.2:2011, *Standard for Synchrophasor Data Transfer for Power Systems*

NIST Special Publication 800-38D, *Recommendation for Block Cipher Modes of Operation: Galois/Counter Mode (GCM) and GMAC*

RFC 768, *User Datagram Protocol*

RFC 791, *Internet Protocol DARPA Internet Program Protocol Specification*

RFC 793, *Transmission Control Protocol*

RFC 826, *An Ethernet Address Resolution Protocol*

RFC 894, *A Standard for the Transmission of IP Datagrams over Ethernet Networks*

RFC 1108, *U.S. Department of Defense Security Options for the Internet Protocol*

RFC 1240, *OSI Connectionless Transport Services on top of UDP Version:1*

RFC 2104, *HMAC: Keyed-Hashing for Message Authentication*

RFC 2406, *IP Encapsulating Security Payload (ESP)*

RFC 2407, *Internet Key Exchange (IKEv1) Protocol*

RFC 2474, *Definition of Differentiated Services Field (DS Field) in IPv4 and IPv6 Headers*

RFC 2991, *Multipath Issues in Unicast and Multicast Next-Hop Selection*

RFC 3168, *The Addition of Explicit Congestion Notification (ECN) to IP*

RFC 3246, *An Expedited Forwarding PHB (Per-Hop Behavior)*

RFC 3376, Internet Group Management Protocol, Version 3

RFC 3547, The Group Domain of Interpretation

RFC 5771, IANA Guidelines for IPv4 Multicast Address Assignments

UCA User's Group 61850-9-2LE- Implementation Guideline for Digital Interface to Instrument Transformers using IEC 61850-9-2

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61850-2, IEC 61850-7-2 and IEEE C37.118.1 as well as the following apply.

3.1

IED tool

short for IED configuration tool or IED configurator in the sense of IEC 61850-6

3.2

nonce

number used once

Note 1 to entry: A nonce is some value that varies with time, although a very large random number is sometimes used.

3.3

part(ial) system

part of a complete system, with a defined, self-consistent part functionality

3.4

project

system part with ownership of a set of IEDs, typically those located in one substation, and handled by one system configuration tool

3.5

gateway

internetworking system capable of allowing communications/information exchange between two networks that use different communication protocols

3.6

system

union of all communicating application-functions performing some overall task like "management of a substation", via logical nodes

Note 1 to entry: The physical system is composed of all devices hosting these functions and the interconnecting physical communication network.