# IEC 61869-9

Edition 1.0 2016-04

# INTERNATIONAL STANDARD

colour inside

## Instrument transformers –
## Part 9: Digital interface for instrument transformers



IEC 61869-9:2016-04(en)



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Edition 1.0 2016-04

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colour inside

## Instrument transformers –
## Part 9: Digital interface for instrument transformers

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# INSTRUMENT TRANSFORMERS –

# Part 9: Digital interface for instrument transformers

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International Standard IEC 61869-9 has been prepared by IEC technical committee 38: Instrument transformers.

This first edition replaces the corresponding specific requirements previously contained in IEC 60044-8, published in 2002.

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

| FDIS | Report on voting |
|---|---|
| 38/502/FDIS | 38/508/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.

A list of all parts in the IEC 61869 series, published under the general title *Instrument transformers*, can be found on the IEC website.

This publication contains an attached file in the form of a .xml file. This file is intended to be used as a complement and does not form an integral part of the publication.

This International Standard contains specific requirements for electronic low power instrument transformers (LPIT) having a digital output.

This Part 9 is to be read in conjunction with, and is based on, IEC 61869-1:2007, *General Requirements* and IEC 61869-6:2016. However, the reader is encouraged to use its most recent edition.

This Part 9 follows the structure of IEC 61869-6 and IEC 61869-1 and supplements or modifies their corresponding clauses/subclauses.

When a particular clause/subclause of Part 6 is not mentioned in this Part 9, that clause/subclause applies. When this standard states “addition”, “modification” or “replacement”, the relevant text in Part 6 is to be adapted accordingly.

When a particular clause/subclause of Part 1 is not mentioned in Part 6, that clause/subclause applies. When part 6 states “addition”, “modification” or “replacement”, the relevant text in Part 1 is to be adapted accordingly.

For additional clauses, subclauses, figures, tables, annexes or note, the following numbering system is used:

– clauses, subclauses, tables, figures and notes that are numbered starting from 901 are additional to those in Part 1;
– additional annexes are lettered 9A, 9B, etc.

An overview of the planned set of standards at the date of publication of this document is given below. The updated list of standards issued by IEC TC38 is available at the website: www.iec.ch

| PRODUCT FAMILY STANDARDS | | PRODUCT STANDARD IEC | PRODUCTS | OLD STANDARD IEC |
|---|---|---|---|---|
| **61869-1** GENERAL REQUIREMENTS FOR INSTRUMENT TRANSFORMERS | | **61869-2** | ADDITIONAL REQUIREMENTS FOR CURRENT TRANSFORMERS | 60044-1<br>60044-6 |
| | | **61869-3** | ADDITIONAL REQUIREMENTS FOR INDUCTIVE VOLTAGE TRANSFORMERS | 60044-2 |
| | | **61869-4** | ADDITIONAL REQUIREMENTS FOR COMBINED TRANSFORMERS | 60044-3 |
| | | **61869-5** | ADDITIONAL REQUIREMENTS FOR CAPACITOR VOLTAGE TRANSFORMERS | 60044-5 |
| | **61869-6** ADDITIONAL GENERAL REQUIREMENTS FOR LOW POWER INSTRUMENT TRANSFORMERS | **61869-7** | ADDITIONAL REQUIREMENTS FOR ELECTRONIC VOLTAGE TRANSFORMERS | 60044-7 |
| | | **61869-8** | ADDITIONAL REQUIREMENTS FOR ELECTRONIC CURRENT TRANSFORMERS | 60044-8 |
| | | **61869-9** | DIGITAL INTERFACE FOR INSTRUMENT TRANSFORMERS | |
| | | **61869-10** | ADDITIONAL REQUIREMENTS FOR LOW POWER PASSIVE CURRENT TRANSFORMERS | |
| | | **61869-11** | ADDITIONAL REQUIREMENTS FOR LOW POWER VOLTAGE TRANSFORMERS | 60044-7 |
| | | **61869-12** | ADDITIONAL REQUIREMENTS FOR COMBINED ELECTRONIC INSTRUMENT TRANSFORMERS AND COMBINED STAND ALONE INSTRUMENT TRANSFORMERS | |
| | | **61869-13** | STAND ALONE MERGING UNIT | |
| | | **61869-14** | ADDITIONAL REQUIREMENTS FOR DC CURRENT TRANSFORMERS | |
| | | **61869-15** | ADDITIONAL REQUIREMENTS FOR DC VOLTAGE TRANSFORMERS FOR DC APPLICATIONS | |

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.

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

**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.**

# INTRODUCTION

## General

This standard is a product family standard for instrument transformers. It provides an application of the standard series IEC 61850, which details layered substation communication architecture in the world of instrument transformers.

By providing tutorial material such as examples and explanations, it also provides access for instrument transformer, protective relay and meter experts to concepts and methods applied in the IEC 61850 series.

Compared to instrument transformers, digital communication technology is subject to on-going changes which are expected to continue in the future. Significant experience with electronics integrated directly into instrument transformers has yet to be gathered on a broader basis, as this type of equipment is not widely spread in the industry and a change of paradigm has not yet occurred.

## Position of this standard in relation to the IEC 61850 series

The IEC 61850 series is a standard intended to be used for communication networks and systems for power utility automation. The most important parts of this series define:

a) information models for the substation automation system;

b) these information models include both the models of the instrument transformers and other process equipment (like circuit-breakers and disconnectors), and the models of the substation automation system (like protection relays and meters). The models are defined in IEC 61850-7-3 and IEC 61850-7-4;

c) the communication between intelligent electronic devices (IEDs) of the substation automation system. The abstract models are defined in IEC 61850-7-2 and the mappings on communication stacks are defined in IEC 61850-8-1 and IEC 61850-9-2;

d) a configuration language used to describe the configuration aspects of the substation automation system is described in IEC 61850-6;

e) conformance testing of the communication interfaces of the IEDs of the power utility automation system including their data models. The conformance testing is defined in IEC 61850-10.

Typically, in a traditional system, IEDs like bay level controllers or protection relays interface directly through analogue signals to instrument transformers. In that case, the data models of the instrument transformers are implemented in these bay level devices. However, this is not the only realization. In the case where electronics are integrated directly into electronic LPIT, the above-mentioned data models should be implemented within the instrument transformer and the instrument transformer needs to support a communication interface. The part of an electronic LPIT that does this is known as the merging unit.

IEC 61850, being a system oriented standard series, leaves many options open in order to support present and future requirements of all sizes of substations at all voltage levels.

To reduce the engineering amount required to achieve interoperability for the digital interface between instrument transformers and equipment that uses the digital signal (like protective relays, meters or bay level controllers), this standard specifies additional constraints on implementing a digital communication interface.

The IEC 61869-9 standard:

– replaces the IEC 60044-8 digital solution;

– provides a product standard for instrument transformers with a digital interface according to the IEC 61850 series; similar to what IEC 62271-3 offers for switchgear;

– includes backward compatibility for the UCA International Users Group *Implementation Guideline for Digital Interface to Instrument Transformers Using IEC 61850-9-2*;

– uses IEC 61588 based time synchronization in accordance with IEC/IEEE 61850-9-3, with an option for 1PPS (pulse per second).

**Overview of the digital interface for instrument transformers**

An illustrative general block diagram of an instrument transformer with digital output is shown in Figure 901. It shows multiple current and/or voltage information coming from the secondary converters (SC in Figure 901) and fed into a common block labelled “merging unit”. The merging unit performs all the data processing (sampling, analogue to digital conversion, scaling, message formatting, etc.) necessary to produce a time-coherent output data stream according to this standard. For the purposes of this standard a merging unit is a physical unit (hardware subsystem) used to assemble and transmit digital output data frames.

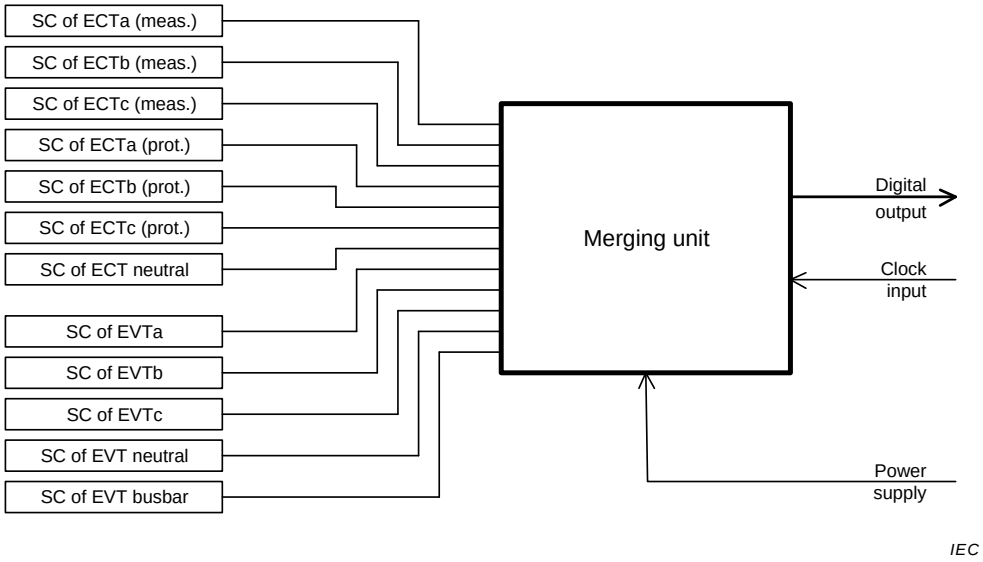



**Figure 901 – General block diagram of an electronic LPIT with digital output**

A merging unit is modelled as one or more logical devices that contain multiple logical nodes as illustrated in Figure 902.

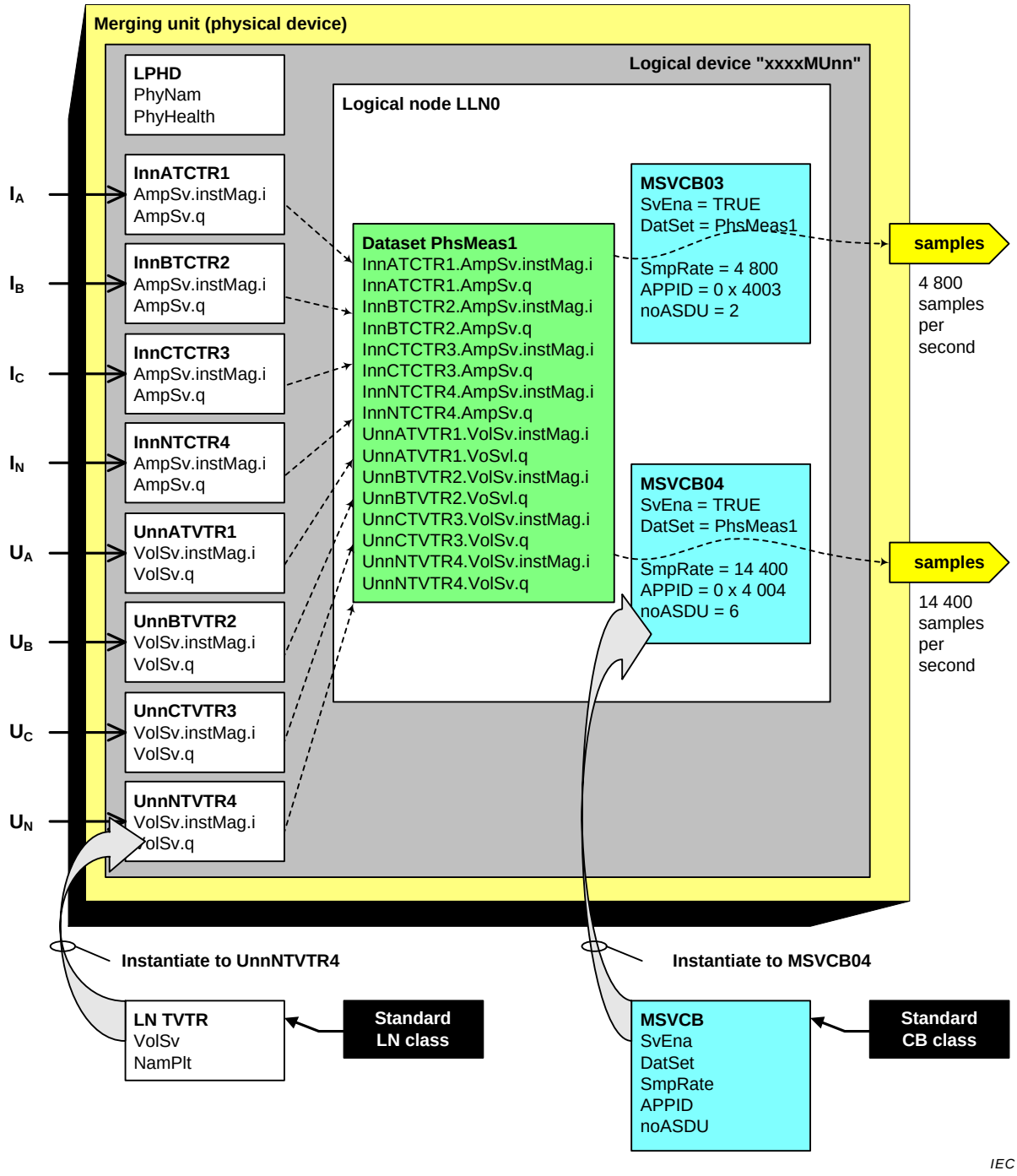



**Figure 902 – General illustration of the objects within a merging unit (example)**

Current and voltage measurements in the example merging unit in Figure 902 are modelled per IEC 61850-7-1 by using the following logical nodes:

- Class **TCTR** per IEC 61850-7-4, instantiated individually for each of the three current transformer phases, and for the neutral current measurement.
- Class **TVTR** per IEC 61850-7-4, instantiated individually for each of the three voltage transformer phases, and for the neutral voltage measurement.
- Logical node zero **LLN0** containing instances of the sampled value control blocks (MSVCB03 and MSVCB04 in this example) controlling simultaneous publishing of IEC 61850-9-2 data streams (in this example one with 4 800 samples per second and 2 samples per frame yielding a frame rate of 2 400 per second, the other with 14 400 samples per second and 6 samples per frame also yielding a frame rate of

2 400 per second), and a dataset that controls the content of the sampled value digital output messages.

Applicable sample rates, time synchronization, control blocks and dataset are defined in this standard.

Physical realization of the above concepts may vary with the applied technology determining which parts are necessary for the realization of an actual instrument transformer. One such realization showing an electronic LPIT with built-in digital data output is shown in Figure 903 and further described in the relevant product specific standards in the IEC 61869 series (Part 7, Part 8, Part 12, Part 14, Part 15).

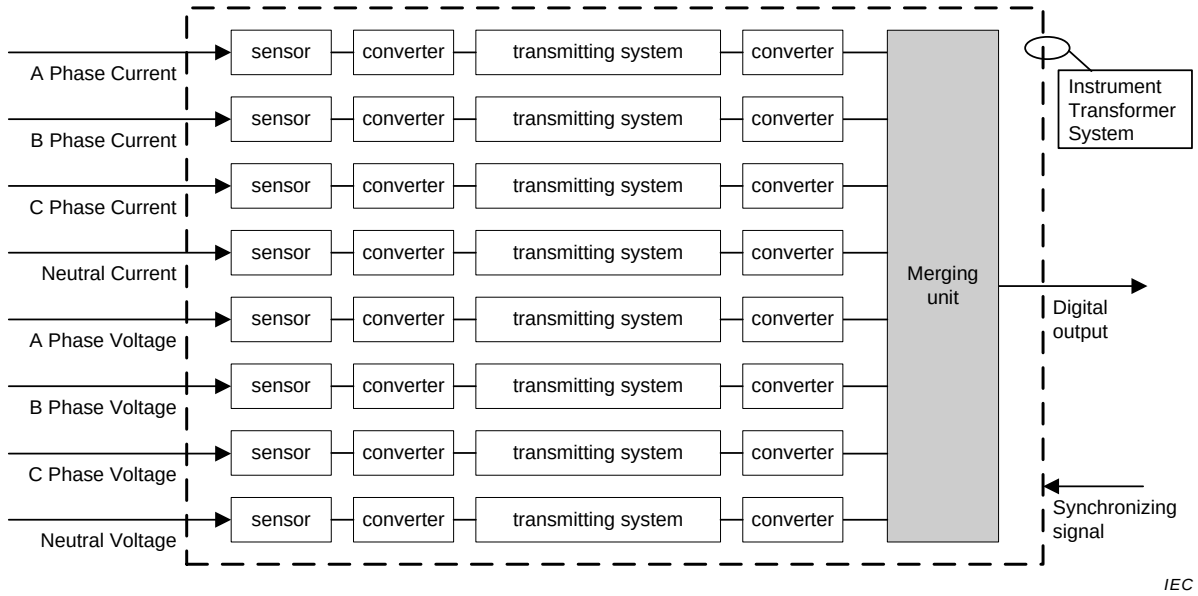
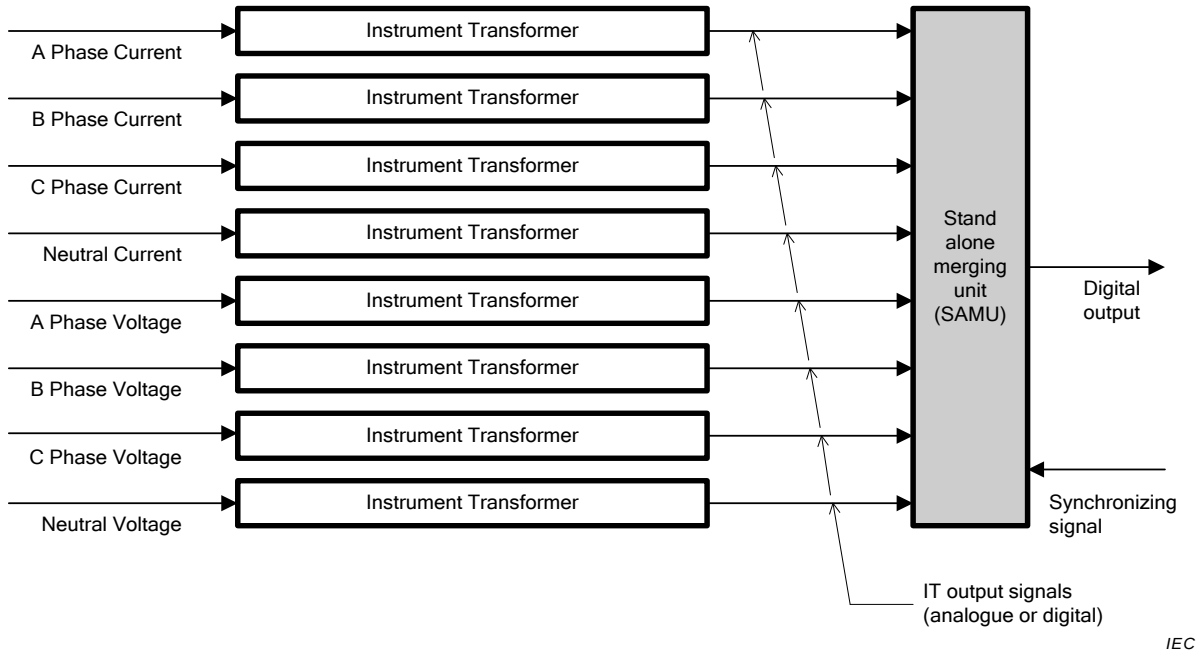



**Figure 903 – Electronic LPIT with digital output (concept example)**

It is not absolutely necessary that all parts shown in Figure 903 be included. For clarity, power supplies are not shown here. An instrument transformer may be implemented in a single physical unit or in multiple physical units. For example, there may be a separate physical unit for each phase containing the primary voltage and/or current sensors, primary converters and primary insulation, with all secondary converters and the merging unit in a separate physical unit located in the control house. The number of primary inputs and their type (voltage or current) in a single instrument transformer may be other than shown here.

For comparison, an illustrative general block diagram of an installation using a stand-alone merging unit (SAMU) is shown in Figure 904. Unlike the merging unit in an instrument transformer, a SAMU is a separate product covered in IEC 61869-13. It accepts as inputs the outputs of instrument transformers, said outputs conforming to the specifications of one of the product standards in the IEC 61869 series. The number of inputs and their type (voltage or current) may be other than shown in Figure 904. Output produced by a SAMU and output produced by an electronic LPIT with built in merging unit should in principle be indistinguishable from each other (excluding the fact that SAMU output will typically have lower accuracy due to cascading the separately given instrument transformer and SAMU accuracy specifications).




An example will be presented in IEC 61869-13[1], as soon as this standard will be available.

**Figure 904 – Standalone merging unit**

1 Under consideration.

# INSTRUMENT TRANSFORMERS –

# Part 9: Digital interface for instrument transformers

## 1 Scope

This part of IEC 61869 is a product family standard applicable to instrument transformers with digital output. The product standard is composed of IEC 61869-1 and IEC 61869-6, in addition to this standard and the relevant product specific standards in the IEC 61869 series (Part 7, Part 8, Part 12, Part 13, Part 14, and Part 15).

This standard defines requirements for digital communications of instrument transformer measurements. It is based on the IEC 61850 series, UCA international users group document *Implementation guideline for digital interface to instrument transformers using IEC 61850-9-2*, and the relevant parts of IEC 60044-8 that are replaced by this standard. It includes additional improvements including the IEC 61588 network based time synchronization.

## 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.

Clause 2 of IEC 61869-6:2016 is applicable with the following additions:

IEC 61588:2009, *Precision clock synchronization protocol for networked measurement and control systems*

IEC 61850-6:2009*, Communication networks and systems for power utility automation – Part 6: Configuration description language for communication in electrical substations related to IEDs*

IEC 61850-7-1:2011, *Communication networks and systems for power utility automation – Part 7-1: Basic communication structure – Principles and models*

IEC 61850-7-2:2010, *Communication networks and systems for power utility automation – Part 7-2: Basic information and communication structure – Abstract communication service interface (ACSI)*

IEC 61850-7-3:2010, *Communication networks and systems for power utility automation – Part 7-3: Basic communication structure – Common data 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 61850-9-2:2011, *Communication networks and systems for power utility automation – Part 9-2: Specific communication service mapping (SCSM) – Sampled values over ISO/IEC 8802-3*

IEC/IEEE 61850-9-3:2016, *Communication networks and systems for power utility automation – Part 9-3: Precision time protocol profile for power utility automation*

IEC 61850-10:2012, *Communication networks and systems for power utility automation – Part 10: Conformance testing*

IEC 61869-6:2016, *Instrument transformers – Part 6: Additional general requirements for low-power instrument transformers*

UCA (International Users Group), *Implementation guideline for digital interface to instrument transformers using IEC 61850-9-2*

## 3 Terms and definitions

### 3.5 Terms and definitions related to other ratings

For the purposes of this document, the terms and definitions in IEC 61869-6:2016 apply, with the following additions:

**3.5.901**
**rated holdover time**
rated duration over which the merging unit continues to send samples maintaining the sample timing required for the measuring accuracy class following loss of the time signal

**3.5.902**
**processing delay time**
**$t_{pd}$**
difference between the time encoded by the field SmpCnt in a digital output message and the time this message appears at the digital output

**3.5.903**
**maximum processing delay time**
longest processing delay time ($t_{pd}$) under all rated operating conditions

**3.5.904**
**free running mode**
operating mode where sampled values issued by the merging unit are not synchronised to an external clock to the degree required to meet the measuring accuracy class phase error limit

Note 1 to entry: The values are based on an internal clock oscillator.

### 3.7 Index of abbreviations

Index of abbreviations of IEC 61869-6:2016 is extended by the addition of the following:

9-2LE The sampled value protocol defined by UCA International Users Group document *Implementation Guideline for Digital Interface to Instrument Transformers using IEC 61850-9-2*, modification Index R2-1 dated 2004-07-07

ASDU Application Service Data Unit

ACSI Abstract Communications Service Interface

SCSM Specific Communication Service Mapping

SAV Common data class defined in IEC 61850-7-3:2010, 7.4.4 for modelling sampled values.

TCTR Logical node defined in IEC 61850-7-4:2010, 5.15.4 for modelling sampled values from current transformers

TVTR Logical node defined in IEC 61850-7-4:2010, 5.15.20 for modelling sampled values from voltage transformers