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Measuring relays and protection equipment -
Part 216-1: Digital interface - General requirements and tests for protection functions using digital communication as input and output

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IEC TS 60255-216-1 has been prepared by IEC technical committee 95: Measuring relays and protection equipment. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
95/593/DTS	95/598/RVDTS

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

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60255 series, published under the general title *Measuring relays and protection equipment*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

Process bus based on the IEC 61850 series (referred to as “IEC 61850” in this document) is being introduced widely in the protection automation and control systems (PACS). There are standards for digitally interfacing instrument transformers, in particular IEC 61869-9. In order to ensure functional interoperability, the standards of protection functions are being adapted to take this into account. The intention of this document is to define characteristics and requirements to be implemented to reach functional interoperability and simplify Protection, Automation and Control System (PACS) design and implementation for users.

This document describes the global framework for digitally interfaced protection functions, namely the relevant features in IEC 61850 and the properties of the sampled values (SV) defined in IEC 61869-1 and IEC 61869-9 used by protection functions. This is done in Annex K (Clause K.1). Subclause K.1.1 covers SV published by Stand Alone Merging Units (SAMU) (IEC 61869-13:2021) or Low Power Instrument Transformers (LPIT) (future IEC 61869-7 and IEC 61850-8). Specific requirements for protection functions are defined on this base in the clauses (Clauses 5 through 11). Sometimes this concerns an extension or a specific profile of IEC 61850 (e.g. some requirements to be mandatory instead of optional) and sometimes new requirements specific for protection functions are formulated. The associated tests are specified in Clause 12.

Compared with wire terminal interfaced Intelligent Electronic Device (IED) hosting protection functions, the digitally interfaced functional protection chain contains two or more IED types, including the merging unit interfacing the instrument transformers and the IED with hard wired binary inputs and outputs (BIOI) interfacing the circuit breaker (see Figure 1). This results in advantages of sharing IEDs and data, but also uses transmission of data between the different IEDs. This architecture is also considered for the overall operation time of the functional protection chain.

Time synchronisation is a sensible aspect for some protection functions receiving multiple sample value (SV) streams. This aspect is discussed in several clauses of this document.

Protection functions use data contained in generic object-oriented system event (GOOSE) and SV messages. These messages are technically subscribed by the IED hosting the protection function via its communication port and IEC 61850 stack. In this document, this chain is referenced to as "GOOSE signals or SV received by a protection function".

It is clear that the use of digital technology also

– facilitates automatic preventive maintenance based on the available recorded data,
– allows for substation self-supervision where automatic warnings are given in case of failures or abnormality, reducing the Mean Time To Restoration (MTTR),
– increases the availability, dependability and security of the protection system by detecting communication failures and enabling countermeasures to minimise the number of unwanted events (e.g. trips),
– facilitates simplified fault analysis and post event analysis.

The pick-up time, start time and other properties related to a specific protection function are defined in the relevant functional protection standard and are extended to the digitally interfaced protection function. See also Annex H “Expected behaviour of protection functions for non-nominal conditions”, trying to anticipate indication of properties for different protection functions.

Often the term "start" is used as synonym for "pick-up". The data object "operate" can be published by several functional elements but does not always lead to a trip. This document uses all of these terms.

This document is intended to serve as a basis for standards developed in the IEC 60255 series. For this reason, details from other standards are included for informational clarity. For standards referencing to this document, it is intended to reference the source standard in application of the IEC editorial guidelines without reproducing them.

Future evolutions on several aspects of IEC 61850 are possible, including time synchronisation, start-up, processing of quality packed list and in particular the detailed quality (detailQual). This can have an impact on product standards, including the standards of the IEC 61869 series (Instrument Transformers) and IEC 60255 (protection functions), which will have to be adapted accordingly in due time.

This document reflects the version of the product standards and of IEC 61850 series known as “edition 2.1” and of the product standards as published at the time of its completion. Formally, the amendments to the IEC 61850 documents are no standalone documents and are always read with their base edition. For this reason the formal way in IEC to refer to a consolidated “edition 2.1” document is to reference the edition 2 document and the amendment #1. E.g. for part 6, “IEC 61850-6:2009 and IEC 61850-6:2009/AMD1:2018” refers to the consolidated version of edition 2.1. This system of referencing edition 2.1 documents is applied in the whole document.

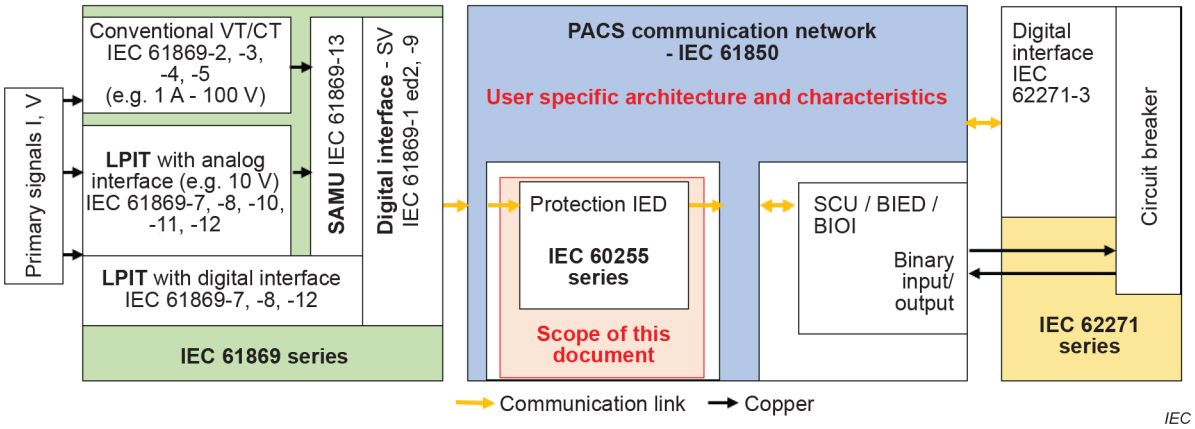
1 Scope

This document covers protection functions with digital inputs and outputs complying with IEC 61850 series and IEC 61869 series, in particular regarding

– subscription to sampled values (SV) streams representing energising inputs instead of analog inputs (see Figure 1);
– subscription to GOOSE (e.g. circuit breaker position, circuit breaker failure);
– publication of GOOSE messages (e.g. trip signals);
– subscription to time synchronisation messages.

On this basis, this document formulates requirements for protection functions with digital inputs and outputs and for the IED hosting them. The document also covers tests related to the functional interoperability and functional requirements of these protection functions, in addition to the general conformance tests required by IEC 61850-10:2012 and test related requirements in IEC TR 61850-10-3:2022 [1][1].

Requirements regarding characteristics of the communication network are not within the scope of this document. Delays and jitter due to the network are taken into account by network engineering. The expected behaviour of protection functions in case of delays, jitter or loss of SV is covered by this document. Figure 1 below shows the functional chain of a protection function, where each IED is connected to the PACS communication network. This document only considers the data received and published by the protection function as shown in Figure 1. It describes the coordination between the digitally interfaced protection functions and the characteristics of the analog acquisition chain.



NOTE 1 See the list of abbreviations in Clause 4.

NOTE 2 IEC 61869-12 is under development.

Figure 1 – Functional chain of a digitally interfaced protection function

If not mentioned otherwise, the term “switch” in this document refers to the switches used in the communication network.

The PACS communication network engineering and cyber security measures to be applied on PACS level are out of scope of this document.

[1] Numbers in square brackets refer to the Bibliography.

Requirements for protection functions switching over between two redundant SV streams acquired by different acquisition chains but reflecting the same primary values are covered in this document.

This document is applicable to protection functions for AC networks implemented in IEDs subscribing SV streams. Parts of the considerations can also apply to IEDs combining analog inputs connected to Instrument Transformers and SV subscription.

If an IED hosting protection functions is interfacing analog inputs connected to Instrument Transformers and publishes the associated SV streams, it is a multifunctional IED and complies additionally with the relevant IEC 61869 standards. This type of device is out of scope of this document.

Some aspects related to cyber security are considered in this document, e.g. reception of duplicated or corrupted messages. The implementation of specific cyber security standards, such as IEC 62351-6 [2] is covered by the general implementation requirements of the IEC 61850 series. Detailed cyber security requirements for IEDs hosting protection functions are out of scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60255-1:2022, *Measuring relays and protection equipment - Part 1: Common requirements*

IEC 60255-26:2023, *Measuring relays and protection equipment - Part 26: Electromagnetic compatibility requirements*

IEC 61588:2021, *Precision clock synchronization protocol for networked measurement and control systems*

IEC TS 61850-1-2:2020, *Communication networks and systems for power utility automation - Part 1-2: Guideline on extending IEC 61850*
IEC TS 61850-1-2:2020/AMD1:2022

IEC 61850-5:2013, *Communication networks and systems for power utility automation - Part 5: Communication requirements for functions and device models*
IEC 61850-5:2013/AMD1:2022

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 61850-6:2009/AMD1:2018
IEC 61850-6:2009/AMD2:2024

IEC 61850-7-1:2011, *Communication networks and systems for power utility automation - Part 7-1: Basic communication structure - Principles and models*
IEC 61850-7-1:2011/AMD1:2020

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 61850-7-2:2010/AMD1:2020