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High-voltage switchgear and controlgear -
Part 322: The use of digital technologies

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High-voltage switchgear and controlgear - Part 322: The use of digital technologies

FOREWORD

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IEC TR 62271-322 has been prepared by IEC technical committee 17: High-voltage switchgear and controlgear. It is a Technical Report.

This first edition cancels and replaces the first edition of IEC TR 62063 published in 1999. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) IEC numbering has been modified;
b) title has been modified;
c) updates in the field of digital technologies, like Internet of Things, cloud and edge computing, digital twins, artificial intelligence and cybersecurity have been added; in accordance with the IEC strategy themes and goals;

d) synchronization and updates in the context of the latest standards of TC 17: IEC 62271-1 and IEC 62271-3;

e) Bibliography has been added.

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

Draft	Report on voting
17/1190/DTR	17/1197/RVDTR

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 Report 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 62271 series, published under the general title *High-voltage switchgear and controlgear*, 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– withdrawn, or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.

1 Scope

Digital technologies, intelligently combined with switchgear and controlgear in electrical grids, can be enablers of reliable, sustainable, and affordable energy systems and an all-electric society. This document gives guidance for network operators, manufacturers and all parties driving the energy and electrical grid transition through the application of digital technologies. Relevant references and definitions of state-of-the-art digital technologies, like the Internet of Things (IOT), Industrial Internet of Things (IIOT), cloud and edge computing, digital twins, artificial intelligence, and cybersecurity are listed. Trends and examples in the use of network operation, service and asset management are described and examples of transition roadmaps of network operators given. Trends and the integration of adequate state-of-the-art digital technologies and application examples are described. Finally, guidance based on experiences for the identification, specification, qualification, and integration of digital technologies is given.

High-voltage switchgear and controlgear can be considered in terms of its two sub-parts:

– switching devices and equipment, i.e. the high-voltage part of the switchgear and controlgear, dedicated to high-voltage functions, e.g. current flow, insulation and switching;

– associated control and auxiliary devices and equipment, i.e. the low voltage part of the switchgear and controlgear, dedicated to the control, measuring, protective, regulating, and monitoring functions of the switching devices and equipment.

The boundary of switchgear and controlgear is then easily identified as being generally the cable connections for the switching devices and equipment and the terminal block for the auxiliary equipment.

Introducing electronic and digital technologies results in significant changes on several points:

– The location of the auxiliary equipment is not necessarily confined to the related switchgear and controlgear, but can be distributed at any location, at the local control cubicle of the switchgear and controlgear or the control room of the substation or directly at the switchgear and controlgear device with local intelligence (edge computing technology) or physically disconnected of the substation (cloud computing technology).

– Different components of the auxiliary equipment might be supplied by different manufacturers and integrated into the switchgear and controlgear independently of the manufacturer of the switchgear and controlgear equipment.

– Electronic and digital technologies using distributed architectures, microprocessor-based components, and digital communications induce new concepts in dependability. That results in modifications of maintenance policies, and asset management as well as user operation of the switchgear and controlgear.

This document describes trends and the state-of-the-art of digital technologies enabling their use in switchgear and controlgear along their life cycle. The report is a guidance for the IEC TC17 and supported by use cases or by emerging technologies, able to be implemented in power grids. The report can be used by designers, asset managers and any stakeholder dealing with interoperable and digital technologies for a switchgear and controlgear over their whole life cycle. The document consists of three main parts.

Clause 4 describes the trends in user exploitation of digital technologies within the switchgear and controlgear. Clause 5 focuses on trends regarding technology and consequences for system architectures. Clause 6 gives guidance for use of new technologies in substations.

2 Normative references

There are no normative references in this document.

3 Terms, definitions, and abbreviated terms

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

– IEC Electropedia: available at https://www.electropedia.org/
– ISO Online browsing platform: available at https://www.iso.org/obp

3.1 Terms and definitions related to switchgear and controlgear

3.1.1
switchgear and controlgear
general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures

[SOURCE: IEC 60050-441:1984 [82], 441-11-01]

3.1.2
equipment
single apparatus or set of devices or apparatuses, or the set of main devices of an installation, or all devices necessary to perform a specific task

Note 1 to entry: Examples of equipment are a power transformer, the equipment of a substation, measuring equipment

[SOURCE: IEC 60050-151:2001 [83], 151-11-25]

3.1.3
device
material element or assembly of such elements intended to perform a required function

Note 1 to entry: A device may form part of a larger device

[SOURCE: IEC 60050-151:2001, [83] 151-11-20]

3.1.4
(signal) transducer
device for transforming a physical quantity representing information into a physical quantity of different kind representing the same information, one of the two quantities being electric

[SOURCE: IEC 60050-151:2001 [83], 151-13-37]

3.1.5
sensor
measuring element
part of a measuring instrument, or measuring chain, which is directly affected by the measurand and which generates a signal related to the value of the measurand

[SOURCE: IEC 60050-311:2001 [84], 311-05-01]

3.1.6
(electric) sensor
device which, when excited by a physical phenomenon, produces an electric signal characterizing the physical phenomenon

[SOURCE: IEC 60050-151:2001 [83], 151-13-48]

3.1.7
sensor
<Internet of Things> IoT device that measures one or more properties of one or more physical entities and outputs digital data that can be transmitted over a network

Note 1 to entry: In the definition “digital data” means “data in the form of a structured sequence on bits/bytes that represents information”

[SOURCE: IEC 60050-741:2020 [85], 741-02-09]

3.1.8
actuator
<switchgear and controlgear> part of the actuating system to which an external actuating force is applied

Note 1 to entry: The actuator may take the form of a handle, knob, push-button, roller, plunger, etc.

[SOURCE: IEC 60050-441:1984 [82], 441-15-22]

3.1.9
actuator
<control technology> functional unit that generates the manipulated variable, required to drive the final controlling element, from the output variable of the controlling element

Note 1 to entry: If the final controlling element is mechanically actuated, it is controlled via an actuating drive. The actuator drives the actuating drive in this case.

[SOURCE: IEC 60050-351:2013 [86], 351-49-07, modified – The Example, Note 2, Figure 1 and Figure 2 have been removed.]

3.1.10
intelligent electronic device
IED
any device incorporating one or more processors with the capability of receiving or sending data/controls from or to an external source (for example, electronic multifunction meters, digital relays, controllers)

[SOURCE: IEC TR 61850-1;2013 [72], 3.1.6]

3.1.11
smart grid
intelligent grid
electric power system that utilizes information exchange and control technologies, distributed computing and associated sensors and actuators, for purposes such as:

– to integrate the behaviour and actions of the network users and other stakeholders;
– to efficiently deliver sustainable, economic and secure electricity supplies

[SOURCE: IEC 60050-617:2011 [87], 617-04-13]

3.1.12
intelligent switchgear and controlgear
switchgear and controlgear that utilizes information exchange and control technologies, distributed computing and associated sensors and actuators, for purposes such as:

– to integrate the behaviour and actions of the network users and other stakeholders;
– to efficiently deliver sustainable, economic and secure electricity supplies

Note 1 to entry: The definition is based on the definition of *smart grid* (3.1.11).

3.2 Terms and definitions related to functions

3.2.1
primary function
function providing the intended purpose

Note 1 to entry: Examples of primary functions of switchgear and controlgear are switching, measuring, interlocking, and communication

[SOURCE: IEC 60050-904:2014 [88], 904-03-02, modified – Note 1 has been removed and a new Note 1 to entry has been added.]

3.2.2
secondary function
function that enables, supplements or enhances a primary function

Note 1 to entry: Examples of such functions are operation counter, early warning alarms (gas loss), pole discrepancy, closing and opening times, travel curve acquisition, blocking according to stored energy (O-CO block), gas density monitoring, etc.

[SOURCE: IEC 60050-904:2014 [88], 904-03-03, modified – Note 1 has been removed and a new Note 1 to entry has been added.]

3.2.3
monitoring
observation of the operation of a system or part of a system to verify correct functioning by detecting incorrect functioning, this being done by measuring one or more variables of the system and comparing the measured values with the specified values

[SOURCE: IEC 62271-1:2017 [73], 3.1.16, modified – Note 1 to entry has been removed.]

3.2.4
parallel transmission
simultaneous transmission of the signal elements of a character signal or block signal on separate channels

[SOURCE: IEC 60050-721:1991 [89], 721-11-17]

3.2.5
serial transmission
transmission of the signal elements of a character signal or block signal at successive time intervals, either contiguous or not

[SOURCE: IEC 60050-721:1991 [89], 721-11-16]

3.2.6
stability
ability of a measuring instrument to keep its performance characteristics unchanged during a specified time interval, all other conditions being the same

[SOURCE: IEC 60050-311:2001 [84], 311-06-12]

3.3 Terms and definitions related to dependability

3.3.1
durability
<of an item> ability to perform as required, under given conditions of use and maintenance, until the end of useful life

[SOURCE: IEC 60050-192:2015 [90], 192-01-21]

3.3.2
durability
<in circular economy and material efficiency> ability to perform as required, under specified conditions of use, maintenance, and repair until the end-of-life is reached

Note 1 to entry: The criteria for transition from non-functional state to end-of-life should be specified. The criteria is based on predictable aspects (e.g. technical aspects) so that the durability can be estimated.

Note 2 to entry: Durability can be expressed in units appropriate to the part or product concerned, e.g., calendar time, operating cycles, distance run, etc.

Note 3 to entry: The term durability is also defined in the context of an item in dependability (IEV 192-01-21)

[SOURCE: IEC 60050-193:– [91],193-05-03 , modified – “technical end of life” has been replaced with “end of life is reached”, Notes 1,4 and 5 have been removed and the figure has been removed.]

3.3.3
dependability
<of an item> ability to perform as and when required

Note 1 to entry: Dependability includes availability, reliability, recoverability, maintainability, and maintenance support performance, and, in some cases, other characteristics such as durability, safety and security.

Note 2 to entry: Dependability is used as a collective term for the time-related quality characteristics of an item.

[SOURCE: IEC 60050-192:2015, 192-01-22]

3.3.4
availability
<of an item> ability to be in a state to perform as required

Note 1 to entry: Availability depends upon the combined characteristics of the reliability, recoverability, and maintainability of the item, and the maintenance support performance.

Note 2 to entry: Availability may be quantified using measures defined in availability related measures.

[SOURCE: IEC 60050-192:2015 [90], 192-01-23, modified – the domain has been added, “under given conditions” removed from the definition and Notes 1, 3 and 4 removed.]

3.3.5
instantaneous availability
probability that an item is in a state to perform as required at a given instant

[SOURCE: IEC 60050-192:2015 [90], 192-08-01]

3.3.6
reliability
<of an item> ability to perform as required, without failure, for a given time interval, under given conditions

[SOURCE: IEC 60050-192:2015 [90], 192-01-24, modified – Notes 1 to 3 to entry have been removed.]

3.3.7
maintainability
ability to be retained in, or restored to a state to perform as required, under given conditions of use and maintenance

[SOURCE: IEC 60050-192:2015 [90], 192-01-27 , modified – Notes 1 and2 to entry have been removed.]

3.3.8
maintenance
combination of all technical and management actions intended to retain an item in, or restore it to, a state in which it can perform as required

[SOURCE: IEC 60050-192:2015 [90], 192-06-01, modified – Note 1 to entry has been removed.]

3.3.9
corrective maintenance
maintenance carried out after fault detection to effect restoration

[SOURCE: IEC 60050-192:2015 [90], 192-06-06, modified – Note 1 to entry has been removed.]

3.3.10
preventive maintenance
maintenance carried out to mitigate degradation and reduce the probability of failure

[SOURCE: IEC 60050-192:2024 [90], 192-06-05, modified – The second term “preventative maintenance” has been removed and Notes 1 to 2 to entry have been removed.]

3.3.11
condition-based maintenance
preventive maintenance based on the assessment of physical condition

[SOURCE: IEC 60050-192:2024 [90], 192-06-07, modified – Note 1 to entry has been removed.]

3.3.12
prediction
computation process used to obtain the predicted value of a quantity

[SOURCE: IEC 60050-192:2015 [90], 192-11-01]

3.3.13
predictive maintenance
maintenance that is carried out on the basis of prediction of failure occurrence and required intervention probability

3.3.14
reliability centred maintenance
RCM
systematic method for determining the respective maintenance actions and associated frequencies, based on the probability and consequences of failure

Note 1 to entry: RCM studies may be conducted at any indenture level of a system.

[SOURCE: IEC 60050-192:2015 [90], 192-06-08, modified – Notes 2 and 3 to entry have been removed.]

3.4 Terms and definitions related to digital technology

3.4.1
information
knowledge concerning objects, such as facts, events, things, processes, or ideas (including concepts) that, within a certain context, has a particular meaning

Note 1 to entry: Information can be represented for example by signs, symbols, pictures or sounds.

[SOURCE: IEC 60050-171:2015 [92], 171-01-01]

3.4.2
data
representation of information in a formalized manner suitable for human or automatic processing

[SOURCE: IEC 60050-171:2019 [92], 171-01-02, modified – Notes 1 and 2 to entry have been removed.]

3.4.3
signal
physical phenomenon whose presence, absence, or variation is considered as representing information

[SOURCE: IEC 60050-171:2019 [92], 171-01-03, modified – Notes 1 to 3 to entry have been removed.]

3.4.4
analogue
pertaining to the representation of information by means of a quantity that can, at any instant within a continuous time interval, assume any value within a continuous interval of values

[SOURCE: IEC 60050-171:2019 [92], 171-01-04, modified – Note 1 to entry has been removed.]

3.4.5
digital, adj.
pertaining to the representation of information by distinct states or discrete values at distinct instants

[SOURCE: IEC 60050-171:2019 [92], 171-01-07]

3.4.6
digital technology
technology using a digital representation of information

[SOURCE: IEC 60050-171:2019 [92], 171-01-16]

3.4.7
interface
shared boundary between two functional units, defined by functional characteristics, signal characteristics, or other characteristics as appropriate

Note 1 to entry: The concept of interface includes the specification of the connection of two devices having different functions.

[SOURCE: IEC 60050-171:2019 [92], 171-01-24]

3.4.8
application software
app
software that is specific to the solution of a problem submitted by an end user

[SOURCE: IEC 60050-171:2019 [92], 171-05-04, modified – The second term “app” has been added.]

3.4.9
artificial intelligence
AI
<capability> capability of a functional unit to perform functions that are generally associated with human intelligence, such as reasoning and learning

[SOURCE: IEC 60050-171:2019 [92], 171-09-17]

3.4.10
security
freedom from unacceptable risk to the physical units considered from the outside

Note 1 to entry: In many other languages than English there is only one word for safety and security.

[SOURCE: IEC 60050-351:2013 [86], 351-57-07]

3.4.11
cyberspace
whole of interconnected information processing systems, including the internet, and of data they are processing

[SOURCE: IEC 60050-171:2019 [92], 171-08-03]

3.4.12
cyberspace security
freedom from unacceptable risk in cyberspace

[SOURCE: IEC 60050-171:2019 [92], 171-08-04]

3.4.13
digital twin
digital representation (3.4.14) of a *target entity* (3.4.15) with data connections that enable convergence between the physical and digital states at an appropriate rate of synchronization

Note 1 to entry: Digital twin has some or all of the capabilities of connection, integration, analysis, simulation, visualization, optimization, collaboration, etc.

Note 2 to entry: Digital twin can provide an integrated view throughout the life cycle of the target entity.

[SOURCE: ISO/IEC 30173:2023 [30], 3.1.1]

3.4.14
digital representation
digital entity representing either a set of properties or behaviours or both of one or more observable elements

[SOURCE: ISO/IEC 30173:2023 [30], 3.1.8]