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TECHNICAL REPORT

colour inside

Communication networks and systems for power utility automation – Part 90-7: Object models for power converters in distributed energy resources (DER) systems

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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

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FOREWORD

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IEC TR 61850-90-7 has been prepared by IEC technical committee 57: Power systems management and associated information exchange. It is a Technical Report.

This second edition cancels and replaces the first edition published in 2013. This edition is primarily an editorial revision in order to be consistent with the publication of Edition 2 of IEC 61850-7-420:2021.

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

a) Clause 3 has been updated.
b) Clause 8 (IEC 61850 information models for power converter-based functions) has been deleted. This clause defined data models with the transitional namespace "(Tr) IEC 61850-90-7:2012". The data models are now defined in IEC 61850-7-420.

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

Draft	Report on voting
57/2558/DTR	57/2610/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 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 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- withdrawn,
- replaced by a revised edition, or
- amended.

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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 90-7: Object models for power converters in distributed energy resources (DER) systems

1 Scope

This part of IEC 61850, which is a Technical Report, describes functions for power converter-based distributed energy resources (DER) systems, focused on DC-to-AC and AC-to-AC conversions and including photovoltaic systems (PV), battery storage systems, electric vehicle (EV) charging systems, and any other DER systems with a controllable power converter.

The functions defined in this document were used to help define the information models described in IEC 61850-7-420 and which can be used in the exchange of information between these power converter-based DER systems and the utilities, energy service providers (ESPs), or other entities which are tasked with managing the volt, var, and watt capabilities of these power converter-based systems.

These power converter-based DER systems can range from very small grid-connected systems at residential customer sites, to medium-sized systems configured as microgrids on campuses or communities, to very large systems in utility-operated power plants, and to many other configurations and ownership models. They may or may not combine different types of DER systems behind the power converter, such as a power converter-based DER system and a battery that are connected at the DC level.

NOTE The term power converter is being used in place of "inverter" since it covers more types of conversion from input to output power:

- AC to DC (rectifier)
- DC to AC (inverter)
- DC to DC (DC-to-DC converter)
- AC to AC (AC-to-AC converter)

2 Normative references

There are no normative references in this document.

3 Terms, definitions, acronyms and abbreviated terms

For the purposes of the present document, the following terms, definitions, acronyms and abbreviated terms 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

3.1.1
autonomous
automatic operation
operating mode in which all functions of the control equipment are performed without action of a human operator

[SOURCE: IEC 60050-351:2013, 351-55-03]

3.1.2
distributed energy resource
DER
energy resource comprised of generation and/or storage and/or controllable load connected at the low or medium voltage distribution level

Note 1 to entry: DER may include associated protection, control, and monitoring capabilities, and may consist of aggregated DER units.

Note 2 to entry: DER may interact with the area and/or local electric power systems (EPS) by providing energy through the EPSs, by adapting their behaviour based on EPS conditions, and/or by providing other EPS-related services for regulatory, contractual, or market reasons.

[SOURCE: IEC 61850-7-420:2021, 3.1.13]

3.1.3
electrical connection point
ECP
point of electrical connection between the DER and any electric power system (EPS)

Note 1 to entry: Each DER (generation or storage) unit has an ECP connecting it to its local power system; groups of DER units have an ECP where they interconnect to the power system at a specific site or plant; a group of DER units plus local loads have an ECP where they are interconnected to the utility power system.

Note 2 to entry: For those ECPs between a utility EPS and a plant or site EPS, this point is identical to the point of common coupling (PCC) in the IEEE 1547, *Standard for Interconnecting Distributed Resources with Electric Power Systems*.

[SOURCE: IEC 61850-7-420:2021, 3.1.17]

3.1.4
electric power system
EPS
composite, comprised of one or more generating sources, and connecting transmission and distribution facilities, operated to supply electric energy

Note 1 to entry: A specific electric power system includes all installations and plant, within defined bounds, provided for the purpose of generating, transmitting and distributing electric energy.

[SOURCE IEC 60050-692:2017, 692-01-02]

3.1.5
electric power system, area
area EPS
electric power system that serves multiple local electric power systems

Note 1 to entry: A typical area EPS is a MV/LV distribution network.

[SOURCE: IEEE 1547:2018, modified - addition of Note 1 to entry]

3.1.6
event
event information
monitored information on the change of state of operational equipment

Note 1 to entry: In power system operations, an event is typically state information and/or state transition (status, alarm, or command) reflecting power system conditions.

[SOURCE: IEC 60050-371:1984, 371-02-04, modified – addition of term "event" and Note 1 to entry]

3.1.7
process control function
function to work on process variable quantities, which is composed of basic functions of process control, specific to particular functional units of the plant

[SOURCE: IEC 60050-351:2013, 351-55-16, modified - deletion of Note 1 to entry]

3.1.8
generator
energy transducer that transforms non-electric energy into electric energy

Note 1 to entry: The reverse conversion of electrical energy into mechanical energy is done by an electric motor, and motors and generators have many similarities. The source of mechanical energy may be a reciprocating or turbine steam engine, water falling through a hydropower turbine or waterwheel, an internal combustion engine, a wind turbine, a hand crank, or any other source of mechanical energy.

[SOURCE: IEC 60050-151:2001, 151-13-35, modified - addition of Note 1 to entry]

3.1.9
inverter
electric energy converter that changes direct electric current to single-phase or polyphase alternating currents

[SOURCE: IEC 60050-151:2001, 151-13-46]

3.1.10
monitor
acquire a quantity value continuously or sequentially in order to check whether it is within normal operating limits and, where appropriate, to signal if it passes its tolerance boundaries

[SOURCE: IEC 60050-351:2013, 351-43-03]

3.1.11
point of common coupling
PCC
electrical connection point (ECP) in an electric power system, electrically nearest to a particular load or generator, at which other loads or generators are, or may be, connected

Note 1 to entry: These loads can be either devices, equipment or systems, or distinct network users' installations.

Note 2 to entry: The point where a local EPS is connected to an area EPS [IEEE 1547]. The local EPS may include distributed energy resources.

[SOURCE: IEC 61850-7-420:2021, modified – addition of "connection"]

3.1.12
power converter
electronic equipment that converts:

- AC to DC (rectifier)
- DC to AC (inverter)
- DC to DC (DC-to-DC converter)
- AC to AC (AC-to-AC converter

3.2 Acronyms

DER:	Distributed Energy Resource
ECP:	Electrical Connection Point
EEI:	Edison Electric Institute
EMS:	Energy Management System
EPS:	Electric Power System
ESP:	Energy Service Provider
ISO:	Independent System Operator
L/HRVT:	Low/High Voltage Ride-Through
MMS:	Manufacturing Message Specification
PCC:	Point of Common Coupling
PF:	Power Factor
PV:	Photovoltaic
RTO:	Regional Transmission Operator
TSO:	Transmission System Operator

3.3 Abbreviated terms

Clause 4 of IEC 61850-7-4 defines abbreviated terms for building concatenated data names. Additional abbreviated terms used in this document are:

Ar	Amperes reactive
Array	Array of …
Aval	Available
Db	Deadband
Dec	Decrease
Del	Delta
Dept	Dependent
Dsct	Disconnect
Gra	Gradient
Hold	Hold
Hys	Hysteresis
Inc	Increase
Rcnt	Reconnect
Sag	Sag
Snpt	Snapshot
Swell	Swell

4 Overview of power converter-based DER functions

4.1 General

The advent of decentralized electric power production is a reality in the majority of the power systems of the world, driven by the need for new types of energy converters to mitigate the heavy reliance on non-renewable fossil fuels, by the increased demand for electrical energy, by the development of new technologies of small power production, by the deregulation of energy markets, and by increasing environmental constraints.

The numbers of interconnected DER systems are increasing rapidly. The advent of decentralized electric power production is a reality in the majority of power systems all over the world, driven by many factors:

- The need for new sources of energy to mitigate the heavy reliance on externally-produced fossil fuels.
- The requirements in many countries for renewable portfolios that have spurred the movement toward renewable energy sources such as solar and wind, including tax breaks and other incentives for utilities and their customers.
- The development of new technologies of small power production that have made, and are continuing to improve, the cost-effectiveness of small energy devices.
- The trend in deregulation down to the retail level, thus incentivizing energy service providers to combine load management with generation and energy storage management.
- The increased demand for electrical energy, particularly in developing countries, but also in developed countries for new requirements such as Electric Vehicles (EVs).
- The constraints on building new transmission facilities and increasing environmental concerns that make urban-based generation more attractive.

These pressures have greatly increased the demand for Distributed Energy Resource (DER) systems that consist of both generation and energy storage systems which are interconnected with the distribution power systems.

DER systems challenge traditional power system management. These increasing numbers of DER systems are also leading to pockets of high penetrations of these variable and often unmanaged sources of power which impact the stability, reliability, and efficiency of the power grid. DER systems can be no longer viewed only as “negative load” and therefore insignificant in power system planning and operations. Their unplanned locations, their variable sizes and capabilities, and their fluctuating responses to both environmental and power situations make them difficult to manage, particularly as greater efficiency and reliability of the power system is being demanded.

At the same time, DER systems could become very powerful tools in managing the power system for reliability and efficiency. The majority of DER systems use power converters to convert their primary electrical form (often direct current (DC) or non-standard frequency) to the utility power grid standard electrical interconnection requirements of 60 Hz or 50 Hz and alternating current (AC). In addition to these basic conversions, power converters can readily modify many of their electrical characteristics through software settings and commands, so long as they remain within the capabilities of the DER system that they are managing and within the standard requirements for interconnecting the DER to the power system.

DER systems are becoming quite “smart” and can perform “autonomously”[1] most of the time according to pre-established settings or “operating modes”, while still responding to occasional commands to override or modify their autonomous actions by utilities and/or energy service providers (ESPs). DER systems can “sense” local conditions of voltage levels, frequency

[1] Not controlled by others or by outside forces; independent. This word is used in the definition of “distributed process computer system” as a ”set of spatial distributed process computer systems for the monitoring and control of basically autonomous sub-processes” (IEC 60050-351:2006, 351-30-05).

deviations, and temperature, and can receive emergency commands and pricing signals, which allow them to modify their power and reactive power output. These autonomous settings can be updated as needed. To better coordinate these DER autonomous capabilities while minimizing the need for constant communications, utilities and ESPs can also send schedules of modes and commands for the DER systems to follow on daily, weekly, and/or seasonal timeframes.

Given these sophisticated capabilities, utilities and energy service providers (ESPs) are increasingly desirous (and even mandated by some regulations) to make use of these capabilities to improve power system reliability and efficiency. Several countries are using the concept of "operating envelopes" that define upper and lower limits on the import or export power in a given time interval for specific connection points. The DER systems are then responsible for applying appropriate limits to individual energy resources.

None of the functions described in this document are necessarily “mandatory” from an implementation perspective – actually requiring certain functions to be implemented is the purview of regulators and of the purchasers of systems.

4.2 Power converter configurations and interactions

Bulk power generation is generally managed directly, one-on-one, by utilities. This approach is not feasible for managing thousands if not millions of DER systems.

DER systems cannot and should not be managed in the same way as bulk power generation. New methods for handling these dispersed sources of generation and storage must be developed, including both new power system functions and new communication capabilities. In particular, the “smart” capabilities of power converter-based DER systems must be utilized to allow this power system management to take place at the lowest levels possible, while still being coordinated from region-wide and system-wide utility perspectives.

This “dispersed, but coordinated intelligence” approach permits far greater efficiencies, reliability, and safety through rapid, autonomous DER responses to local conditions, while still allowing the necessary coordination as broader requirements can be addressed through communications on an as-needed basis.

Communications, therefore, play an integral role in managing the power system, but are not expected or capable of continuous monitoring and control. Therefore the role of communications must be modified to reflect this reality.

Power converter-based DER functions range from the simple (turn on/off, limit maximum output) to the quite sophisticated (volt-var control, frequency/watt control, and low-voltage ride-through). They also can utilize varying degrees of autonomous capabilities to help cope with the sophistication.

At least three levels of information exchanges are envisioned:

a) Autonomous DER behaviour responding to local conditions with controllers focused on direct and rapid monitoring and control of the DER systems: This autonomous behaviour would use one or more of the pre-set modes and/or schedules to direct their actions, thus not needing remote communications except occasionally to modify which modes or schedules to use.
   – Autonomous behaviour is defined as DER systems utilizing pre-set modes and schedules that respond to locally sensed conditions, such as voltage, frequency, and/or temperature, or to broadcast information, such as pricing signals or requests for using specific modes. These pre-settings are updated as needed (not in real-time), possibly through the Internet or through other communication methods.
   – The DER systems would utilize its detailed knowledge of the status and capabilities of the DER equipment as well as the status of the local electric power grid, such as voltage and frequency, to determine the output from the DER system.