

Current and voltage sensors or detectors, to be used for fault passage indication purposes

Part 1: General principles and requirements (IEC 62689-1:2016, MOD)



AS 62689.1:2022

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Current and voltage sensors or detectors, to be used for fault passage indication purposes

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Preface

This Standard was prepared by the Standards Australia Committee EL-013, Measurement and Protection Transformers.

The objective of this document is to define the minimum requirements (therefore performances) and consequent classification and tests for fault passage indicators (FPIs) and distribution substation units (DSUs).

This document is an adoption with national modifications, and has been reproduced from, IEC 62689-1:2016, *Current and voltage sensors or detectors, to be used for fault passage indication purposes – Part 1: General principles and requirements*. The modifications are additional requirements and are set out in [Appendix ZZ](#), which has been added at the end of the source text.

[Appendix ZZ](#) lists the modifications to IEC 62689-1:2016, for the application of this document in Australia.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

CURRENT AND VOLTAGE SENSORS OR DETECTORS, TO BE USED FOR FAULT PASSAGE INDICATION PURPOSES –

Part 1: General principles and requirements

FOREWORD

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International Standard IEC 62689-1 has been prepared by IEC technical committee 38: Instrument transformers.

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

FDIS	Report on voting
38/503/FDIS	38/510/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 the parts in the IEC 62689 series, under the general title *Current and voltage sensors or detectors, to be used for fault passage indication purposes*, 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- withdrawn,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.

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INTRODUCTION

0.1 General

The IEC 62689 series is a product family standard for current and voltage sensors or detectors, to be used for fault passage indication purposes by suitable devices or functions, indicated as fault passage indicator (FPI) or distribution substation unit (DSU), depending on their performances.

Different names are used to indicate FPIs depending on the region of the world and on their functionalities concerning capability to detect different kinds of faults, for instance:

- fault detector;
- smart sensor;
- faulted circuit indicator (FCI);
- short circuit indicator (SCI);
- earth fault indicator (EFI);
- test point mounted FCI.
- combination of the above.

Simpler versions, using only local information/signals and/or local communication, are called FPI, while very evolved versions are called DSU. The latter are explicitly designed for smart grids and based on IEC 60870-5 and IEC 61850 communication protocols. Compared to instrument transformers, digital communication technology is subject to on-going changes which are expected to continue in the future.

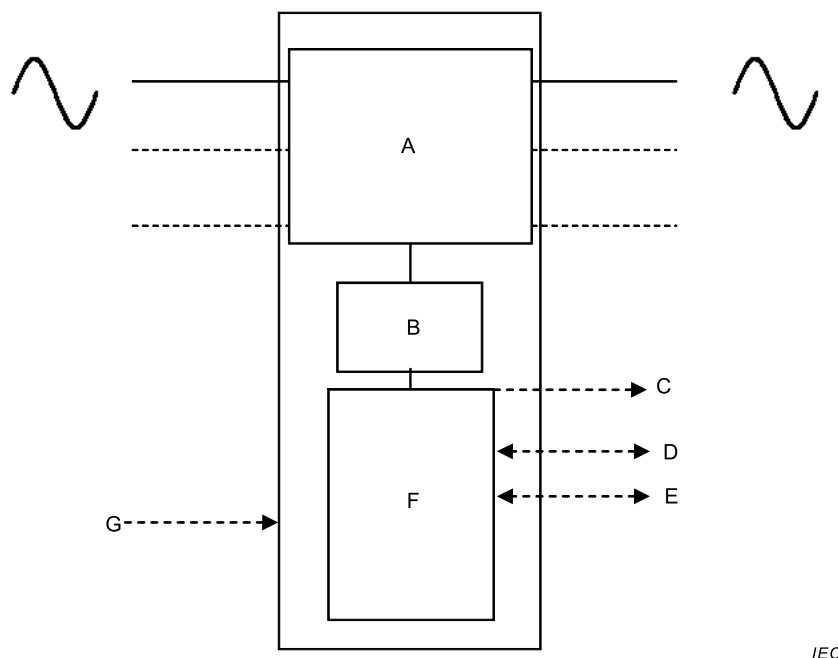
Profound experience with deep integration between electronics and instrument transformers has yet to be gathered on a broader basis, as this type of equipment is not yet widespread in the industry.

DSUs, besides FPI basic functions, may also optionally integrate additional auxiliary functions such as:

- voltage presence/absence detection for medium voltage (MV) network automation, with and without distributed energy resources presence (not for fault confirmation, which can be a basic FPI function depending on the adopted fault detection method, neither for safety-related aspects, which are covered by IEC 61243-5);
- measuring of voltage, current, and active and reactive power, etc., for various applications, such as MV network automation, monitoring of power flows, etc.;
- smart grid management (such as voltage control and unwanted island operation) by means of a proper interface with local distributed generators (DER);
- local output of collected information by means of suitable interfaces;
- remote transmission of collected information;
- others.

A general FPI scheme is outlined in Figure 1.

A DSU may have a much more complex scheme.



IEC

Key

A: Current (and, if necessary, voltage) sensors. 1 or 3 phases may be monitored.

B: Transmission of signals between sensors and electronics.

C: Local indications (lamps, LEDs, flags, etc.).

D: Analogue, digital and/or communication inputs/outputs for remote communication/commands (hard wired and/or wireless).

E: Connections to field apparatus.

F: Signal conditioning, processing and indicating unit (CPIU).

G: Power supply.

Current sensor(s) may detect fault current passages without any need of galvanic connection to the phase(s) (for instance in case of cable type current sensors or of magnetic field sensor).

Not all the above listed parts or functions are necessarily included in the FPI, depending on its complexity and on its technology. However, at least 1 one of C or D functions shall be present.

Figure 1 – General architecture of an FPI

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

IEC 61850 is the series of International Standards intended to be used for communication and systems to support power utility automation.

The IEC 62689 series will also introduce a dedicated namespace to support integration of FPIs/DSUs into power utility automation.

In addition, it defines proper data models and different profiles of communication interfaces to support the different use cases of these FPIs/DSUs.

Some of these use cases rely on the concept of extended substation, which is intended as the communication among intelligent electronic devices (IED) through IEC 61850 located both along MV feeders and in the main substation, for the most sophisticated FPI versions (for smart grid applications, for instance, usually DSUs). Such a profile may not be limited to FPI/DSU devices, but may embrace features needed to support extensions of these substations along the MV feeders connected to the main substation themselves.

CURRENT AND VOLTAGE SENSORS OR DETECTORS, TO BE USED FOR FAULT PASSAGE INDICATION PURPOSES –

Part 1: General principles and requirements

1 Scope

This part of IEC 62689 defines the minimum requirements (therefore performances) and consequent classification and tests (with the exception of functional and communication ones) for fault passage indicators (FPIs) and distribution substation units (DSUs) (including their current and/or voltage sensors), which are, respectively, a device or a device/combination of devices and/or functions able to detect faults and provide indications about their localization.

By localization of the fault is meant the fault position with respect to the FPI/DSU installation point on the network (upstream or downstream from the FPI/DSU's location) or the direction of the fault current flowing through the FPI/DSU itself. The fault localization may be obtained

- directly from the FPI/DSU, or
- from a central system using information from more FPIs or DSUs,

considering the features and the operating conditions of the electric system where the FPIs/DSUs are installed.

In this part of IEC 62689, the FPI/DSU classification is specified in detail, in accordance with the first “core” classification defined in IEC 62689-2, which is explicitly focused on the description of electric phenomena and electric system response during faults, considering the most widely diffused distribution system architecture and fault typologies.

Thus, IEC 62689-2 is mainly focused on helping users in the correct choice of FPIs/DSUs, whereas IEC 62689-1, IEC 62689-3 and IEC 62689-4 are mainly focused on FPI/DSU requirements, communication and testing procedures, respectively.

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 60028, *International standard of resistance for copper*

IEC 60038, *IEC standard voltages*

IEC 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-30, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60071-1, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60085, *Electrical insulation – Thermal evaluation and designation*

IEC 60121, *Recommendation for commercial annealed aluminum electrical conductor wire*

IEC 60270, *High-voltage test techniques – Partial discharge measurements*

IEC 60417, *Graphical symbols for use on equipment* (available at: <http://www.graphical-symbols.info/equipment>)

IEC 60455 (all parts), *Resin based reactive compounds used for electrical insulation*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60695-1-30, *Fire hazard testing – Part 1-30: Guidance for assessing the fire hazard of electrotechnical products – Preselection testing process – General guidelines*

IEC 60695-7-1, *Fire hazard testing – Part 7-1: Toxicity of fire effluent – General guidance*

IEC TS 60815 (all parts), *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions*

IEC TS 60815-1, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles*

IEC TS 60815-2, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 2: Ceramic and glass insulators for a.c. systems*

IEC TS 60815-3, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 3: Polymer insulators for a.c. systems*

IEC 60870-5-101, *Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks*

IEC 60870-5-104, *Telecontrol equipment and systems – Part 5-104: Transmission protocols, Network access for IEC 60870-5-101 using standard transport profiles*

IEC 61000-4-10, *Electromagnetic compatibility (EMC) – Part 4-10: Testing and measurement techniques – Damped oscillatory magnetic field immunity test*

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-12, *Electromagnetic compatibility (EMC) – Part 4-12: Testing and measurement techniques – Ring wave immunity test*

IEC 61000-4-16, *Electromagnetic compatibility (EMC) – Part 4-16: Testing and measurement techniques – Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz*

IEC 61000-4-18, *Electromagnetic compatibility (EMC) – Part 4-18: Testing and measurement techniques – Damped oscillatory wave immunity test*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances induced by radio-frequency fields*

IEC 61000-4-8, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61000-4-9, *Electromagnetic compatibility (EMC) – Part 4-9: Testing and measurement techniques – Pulse magnetic field immunity test*

IEC 61000-6-2:2005, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

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

IEC 60255-27:2013, *Measuring relays and protection equipment – Part 27: Product safety requirements*

IEC 61000-4-13, *Electromagnetic compatibility (EMC) – Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests*

IEC 61000-4-29, *Electromagnetic compatibility (EMC) – Part 4-29: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests*

3 Terms, definitions, abbreviations and symbols

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

3.1 General terms and definitions

3.1.1

fault passage indicator

FPI

device able to detect faults providing indications about their localization (upstream or downstream from the FPI's location) and/or about the direction of fault current (usually referred as the direction of load current, i.e. from the HV/MV transformer towards end of MV feeders in a radial operated network)

Note 1 to entry: Different names are used to indicate FPIs depending on the region of the world and on their functionalities concerning capability to detect different kinds of faults:

- fault detector;
- smart sensor;
- faulted circuit indicator (FCI);
- short circuit indicator (SCI);
- earth fault indicator (EFI);
- test point mounted FCI.
- combination of the above.

In this standard, the FPI definition includes all the above listed terms with their relevant performances.

Note 2 to entry: This note applies to the French language only.

3.1.2

accuracy class

<FPI or DSU> category of measuring instruments, all of which are intended to comply with a set of specifications regarding uncertainty

Note 1 to entry: The accuracy class of an FPI or DSU is defined as the overall system accuracy, i.e. with reference to the global chain (input to output): accuracies of sensors, of transmission of signals and of CPIU including variations due to influence quantities. See overall system accuracy as defined in IEC 60255-1:2009, Annex B, B.1 to B.4.

[SOURCE: IEC 60050-311:2001, 311-06-09, modified – Note 1 to entry has been added.]

3.1.3

substation

part of a power system, concentrated in a given place, including mainly the terminations of transmission or distribution lines switchgear and housing and which may also include transformers. It generally includes facilities necessary for system security and control (e.g. the protective devices)

Note 1 to entry: According to the nature of the system within which the substation is included, a prefix may qualify it. Examples: transmission substation (of a transmission system), distribution substation, 400 kV substation, 20 kV substation.

Note 2 to entry: In its complete configuration, a medium voltage/low voltage substation (distribution substation) may include:

- protection relays both for MV and LV feeders;
- a medium voltage/low voltage (MV/LV) transformer with its own specific protections;
- FPIs, with their relative current and/or voltage sensors;
- communication apparatus, such as modems, routers, others, for remote operation of Switches and/or Circuit Breakers and alarms;
- local automatons for MV network automation, embedded in proper intelligent electronic devices operating using FPI indications or in DSUs.

[SOURCE: IEC 60050-605:1983, 605-01-01, modified – Note 2 to entry has been added.]

3.1.4**distribution substation unit****DSU**

device (or a combination of devices and/or functions) able to perform, in addition to specific FPI functionalities, additional features, not strictly related to fault detection (for instance remote communication/commands, switch control or breaker control, network automation, distributed energy resources monitoring and control, etc)

Note 1 to entry: A DSU may consist of a single physical device including the functions of more FPIs or of an electronic unit connected to one or more physical FPIs supplying signals.

3.1.5**intelligent electronic device****IED**

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

Note 1 to entry: The definition of IED also includes devices like remote terminal units, usually denominated as RTUs.

Note 2 to entry: This note applies to the French language only.

[SOURCE: IEC TR 61850-1:2013, 3.1.6, modified – Notes 1 and 2 to entry have been added.]

3.1.6**conditioning, processing and indicating unit****CPIU**

part of the FPI/DSU in charge of transforming voltage and/or sensor signals into indications concerning faults, without or with digital treatment of sensor signals

Note 1 to entry: This note applies to the French language only.

3.1.7**sensor**

functional unit that senses the effect of a measured variable (quantity) at its input and places a corresponding measurement signal at its output

Note 1 to entry: With reference to this standard, sensors may be both current and voltage sensors, according to relevant existing standards (e.g. ferromagnetic sensors, current and/or voltage transformers according to, for instance, IEC 61869-2, IEC 61869-3, IEC 61869-4 or electronic current and/or voltage sensors, according to IEC 60044-7 and/or IEC 60044-8, etc.), as well as other devices, not yet described in existing standards, anyway able to measure voltage and/or current and supply these measurements to the FPI's electronics for signal conditioning and indication about the passage of a fault. In both cases the overall accuracy, sensitivity and reliability of the FPI shall be declared, as for the result of tests on the whole unit (FPI or DSU with their sensors, tested input to output). The adoption of other physical principles, such as mechanical indication (rotor) or fluid with colour change principle for fault detection, also exists.

Note 2 to entry: Sensors may be either separate current sensors and voltage sensors or integrated voltage and current sensors. Additionally, they may be stand alone devices and/or sensors included in cable terminations, cable joints, switchboards post insulators, etc.).

[SOURCE: IEC 60050-351:2013, 351-56-26, modified – The term “sensing element” has been replaced here by “sensor”. In the definition, “measurand” has been replaced by “measured variable (quantity)”. The existing examples and note have been deleted and Note 1 and Note 2 to entry have been added.]

3.1.8**cable type current sensor**

current sensor without primary conductor and primary insulation of its own, which can be mounted over an insulated cable

[SOURCE: IEC 60050-321:1986, 321-02-04, modified – In the term and definition, “transformer” has been replaced with “sensor”.]

3.1.9**residual current sensor**

single, or group of three, current sensor(s) so connected as to transform only the residual current

[SOURCE: IEC 60050-321:1986, 321-02-21, modified – In the term and definition, "transformer" has been replaced with "sensor".]

3.1.10**distributed energy resources****DER**

power generation plants generally connected to medium voltage (generally in the range 10 MW maximum down to 0,1 MW) and low voltage (generally below 0,1 MW) distribution networks

Note 1 to entry: This note applies to the French language only.

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

Note 1 to entry: At the moment, the concept of smart grids is not exactly defined; therefore, in this standard we limit this to distribution grids with "presence of large amount of DER".

[SOURCE: IEC 60050-617:2009, 617-04-13, modified – Note 1 to entry has been added.]

3.1.12**upstream fault**

fault located between the high voltage/medium voltage (HV/MV) transformer and the FPI's location or on different MV feeders supplied from the same HV/MV transformer in a radial operated network

Note 1 to entry: The fault direction is designated by either downstream or upstream. In distribution networks, even though now widely used to connect DER, the present definition is to be intended as the HV/MV transformer being "upstream" of the distribution network/feeder.

3.1.13**downstream fault**

fault located in the opposite direction of the HV/MV transformer with respect to the FPI's location in a radial operated network

Note 1 to entry: The fault direction is designated by either downstream or upstream. In distribution networks, even though now widely used to connect DER, the present definition is to be intended as the HV/MV transformer being "upstream" of the distribution network/feeder.

3.1.14**earth fault****ground fault (US)**

occurrence of an accidental conductive path between a live conductor and the Earth

Note 1 to entry: The conductive path can pass through a faulty insulation, through structures (e.g. poles, scaffoldings, cranes, ladders), or through vegetation (e.g. trees, bushes) and can have a significant impedance.

Note 2 to entry: Fault currents are dependent on the MV neutral status and on the fault resistance.

[SOURCE: IEC 60050-195:1998, 195-04-14, modified – Note 2 to entry has been added.]

3.1.15**intermittent fault**

transient fault which recurs repeatedly in the same place due to the same cause

Note 1 to entry: This kind of fault may be an appreciable percentage of earth faults.

[SOURCE: IEC 60050-604:1998, 604-02-14, modified – Note 1 to entry has been added.]

3.1.16**multiple faults****cross-country fault**

insulation faults to earth, occurring simultaneously at more than two different locations in one or several circuits originating from a common source

Note 1 to entry: It is a double single phase to earth fault, involving two different phases of two different feeders. Fault currents are nearly independent from MV neutral status, and are limited mainly by the fault resistances and by the longitudinal impedances of the fault path.

Note 2 to entry: Neutral status may affect the percentage of these faults (unlikely to verify on solid earthed systems as phase to earth voltage is not increased in case of an earth fault).

[SOURCE: IEC 60050-604:1987, 604-02-23, modified – Notes 1 and 2 to entry have been added.]

3.1.17**three-phase fault****symmetrical fault**

fault affecting the insulation of all the three phase conductors between one another and usually to earth

Note 1 to entry: These faults usually have high fault currents nearly independent from MV neutral status.

[SOURCE: IEC 60050-604:1987, 604-02-24, modified – In the definition, “an insulation fault at one point of a circuit,” has been replaced by “fault”. Note 1 to entry has been added.]

3.1.18**phase-to-phase fault****line-to-line fault (US)**

insulation fault between two-phase conductors only, and clear of earth

Note 1 to entry: These faults usually have high fault currents nearly independent from MV neutral status.

[SOURCE: IEC 60050-604:1987, 604-02-20, modified – Note 1 to entry has been added.]

3.1.19**overcurrent**

current exceeding the rated current

Note 1 to entry: In this standard, if no explicit distinction is made, overcurrent means any current exceeding the rated one consequent to a three-phase fault, a phase-to-phase fault, a cross-country fault. Earth faults, except for those in solidly earthed systems, are not included in the term overcurrent. Currents exceeding the rated one, but not consequent to faults, may be included.

[SOURCE: IEC 60050-442:1998, 442-01-20, modified. Note 1 to entry has been added.]

3.1.20**indoor, adj**

intended for operation under normal ambient conditions in a building

[SOURCE: IEC 60050-151:2001, 151-16-06]

3.1.21**outdoor**, adj

capable of operating under specific range of outdoor conditions

[SOURCE: IEC 60050-151:2001, 151-16-05]

3.1.22**barrier**

transformer the output variable of which is equal to the input variable during trouble-free operation and which limits certain variable quantities to permissible values in the event of a malfunction

Note 1 to entry: This entry was numbered 351-32-44 in IEC 60050-351:2006.

Note 2 to entry: This device is also known as insulation transformer

[SOURCE: IEC 60050-351:2013, 351-56-31, modified – Note 2 to entry has been added.]

3.1.23**electrostatic discharge****ESD**

transfer of electric charge between bodies of different electric potential in proximity or through direct contact

Note 1 to entry: Literature and teaching generally refer to transfers of charge, although strictly speaking charge carriers (IEC 60050-113:2011, 113-06-25) are transferred. Current sensor(s) may detect fault current passages without any need of galvanic connection to the phase(s) (for instance in case of cable type current sensors or of magnetic field sensor).

3.2 Terms and definitions related to neutral point treatment**3.2.1****neutral point**

common point of a star-connected polyphase system or earthed mid-point of a single-phase system

[SOURCE: IEC 60050-195:1998, 195-02-05]

3.2.2**isolated neutral system**

system where the neutral point is not intentionally connected to earth, except for high impedance connections for protection or measurement purposes

Note 1 to entry: In general, it is a system in which transformer neutrals are not connected to earth, except for high-impedance connections for signalling, measuring, or protection purposes. In this type of system, an earth fault produces a current depending on the phase to earth capacitance of the fault-free phases. Currents are small on totally overhead networks. However, currents can be high in case of networks with large cable extensions.

[SOURCE: IEC 60050-601:1985, 601-02-24, modified – Note 1 to entry has been added.]

3.2.3**resonant earthed (neutral) system****arc-suppression-coil-earth (neutral) system**

system in which one or more neutral points are connected to earth through reactances which approximately compensate the capacitive component of a single-phase to-earth fault current

Note 1 to entry: The combined inductance of all arc suppression coils is usually tuned to the earth capacitance of the system for the operating frequency or at a value slightly different. In case of faults on the MV network (with variation of capacitive current) it is possible to have a mismatch, which can be temporary (some seconds) in case of automatic unbalance coils, longer in case of manually adjustable coils. It is possible to have a high-value resistor in parallel to the coil, temporarily or permanently connected to allow fault detection and/or fault clearing (in addition it can also dump the resonant system). The magnitude of the fault current would have near zero value when an earth fault occurs.

fault occurs at any location of the same substation busbar network if no earthing resistor is adopted, a value nearly corresponding to the active current through the earthing resistor, if this solution is adopted.

When arc faults are not self-extinguishing, two different operation methods are used:

- 1) automatic fault clearing through disconnection of the entire faulty feeder (tripping of MV feeder protection devices) or only of the faulted section (by means of protection devices or FPIs) with proper timing according to relevant standards;
- 2) continuous operation during fault localization process (manual, by means of protection devices, and/or FPIs).

In order to facilitate fault localization and operation there are various supporting procedures:

- short-term earthing of neutral point for detection;
- short-term earthing of neutral point for tripping;
- permanent earthing of neutral point for tripping and/or detection;
- operation measures, such as disconnection of coupled busbars or feeder disconnection;
- phase earthing.

Permanent and short-term earthings are usually realized through a proper earthing resistor, assuring a proper value current in the fault and along the fault current path, able to be detected from protections and/or FPIs.

[SOURCE: IEC 60050-601:1985, 601-02-27, modified – Note 1 to entry has been added.]

3.2.4

solidly earthed neutral system

system whose neutral point(s) is (are) earthed directly

Note 1 to entry: The neutral conductor can be distributed or not distributed.

Note 2 to entry: The magnitude of the fault current would have high value (high overcurrents) when an earth fault occurs at any location of the same substation busbars network.

[SOURCE: IEC 60050-601:1985, 601-02-25, modified – Notes 1 and 2 to entry have been added.]

3.2.5

impedance earthed neutral system

system whose neutral point(s) is (are) earthed through impedances to limit earth fault currents

Note 1 to entry: This category also includes “systems with earthing resistor”, i.e. systems in which the transformer neutral point is intentionally connected to the Earth through a resistor. In this type of system, the resistor value determines the maximum neutral current value, which, vector summed to the capacitive current of the network, determines the maximum value of the earth fault current (generally several hundred amperes).

[SOURCE: IEC 60050-601:1998, 601-02-26, modified – Note 1 to entry has been added.]

3.3 Terms and definitions related to dielectrics ratings

3.3.1

rated primary voltage

U_{pr}
<voltage sensor> r.m.s. value of the primary voltage which appears in the designation of a voltage sensor and on which its performance is based

[SOURCE: IEC 60050-321:1986, 321-01-12, modified – In the definition, “transformer” has been replaced by “voltage sensor”; “r.m.s.” has been added.]

3.3.2

rated voltage factor

multiplying factor to be applied to the rated primary voltage to determine the maximum voltage at which a voltage sensor must comply with the relevant thermal requirements for a specified time and with the relevant accuracy requirements

[SOURCE: IEC 60050-321:1986, 321-03-12, modified – In the definition, “transformer” has been replaced by “voltage sensor”.]

3.3.3

highest voltage of a system

U_{sys}
highest value of the operating phase-to-phase voltage (r.m.s. value) which occurs under normal operating conditions at any time and at any point in the system

[SOURCE: IEC 60050-601:1985, 601-01-23, modified – The Note has been deleted and “phase-to-phase” and “(r.m.s. value)” have been added.]

3.3.4

highest voltage for equipment

U_{m}
highest r.m.s. value of phase-to-phase voltage for which the equipment is designed in respect of its insulation as well as other characteristics which relate to this voltage in the relevant equipment standards

[SOURCE: IEC 60050-604:1987, 604-03-01]

3.3.5

primary voltage terminals

terminals by means of which the primary voltage is supplied to the voltage sensor(s)

Note 1 to entry: In an FPI/DSU using voltage signals, whatever is the purpose, these terminals are always present.

Note 2 to entry: From a functional point of view, FPIs/DSUs are always considered as a unique system including sensors.

3.3.6

rated insulation level

test voltages, under specified conditions, that the insulation is designed to withstand

Note 1 to entry: These test voltages can be for instance:

- rated lightning impulse and short duration power frequency withstand voltages.
- rated lightning and switching impulse withstand voltages (phase to earth).

[SOURCE: IEC 60050-421:1987, 421-09-02]

3.3.7

secondary voltage terminals

output terminals of the primary voltage sensors

Note 1 to entry: In an FPI/DSU using voltage signals, whatever is the purpose, these terminals may be accessible, embedded, or even virtual.

3.3.8

secondary current terminals

output terminals of the primary current sensors

Note 1 to entry: In an FPI/DSU, whatever is the purpose, these terminals may be accessible, embedded, or even virtual.

3.4 Terms and definitions related to current ratings

3.4.1

rated primary current

 I_{pr}

<current sensor> value of the primary current which appears in the designation of an FPI and on which its performance is based

[SOURCE: IEC 60050-321:1986, 321-01-11, modified – In the definition, "a current transformer" has been replaced with "an FPI".]

3.4.2

rated short time thermal current

 I_{th}

maximum value of the primary current which an FPI will withstand for a specified short time without suffering harmful effects

[SOURCE: IEC 60050-321:1986, 321-02-22, modified, In the definition, "transformer" has been replaced with "FPI"; ", the secondary winding being short-circuited" has been deleted.]

3.4.3

rated dynamic current

 I_{dyn}

maximum peak value of the primary current which an FPI will withstand without being damaged electrically or mechanically by the resulting electromagnetic forces

[SOURCE: IEC 60050-321:1986, 321-02-24, modified, In the definition, "transformer" has been replaced with "FPI"; ", the secondary winding being short-circuited" has been deleted.]

3.5 Terms and definitions related to other ratings

3.5.1

rated frequency

 f_R

frequency at which the voltage/current sensors are designed to operate

[SOURCE: IEC 60050-421:1990, 421-04-03, modified – In the definition, "transformer or reactor" has been replaced with "voltage/current sensors".]

3.5.2

rated frequency range

range of frequency for which the rated accuracy class is applicable

3.5.3

rated supply voltage of auxiliary and control circuits

 U_{ar}

auxiliary power supply voltage value on which the requirements of a specification are based

3.6 Abbreviations and symbols

For the purposes of this document, the following abbreviations and symbols apply.

Abbreviation or symbol	Phrase
CPIU	conditioning, processing and indicating unit
DER	distributed energy resources
DSU	distribution substation unit
FPI	fault passage indicator



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Abbreviation or symbol	Phrase
f_R	rated frequency
HV/MV	high voltage/medium voltage
MV/LV	medium voltage/low voltage
I_{dyn}	rated dynamic current
IED	intelligent electronic device
I_{Pr}	rated primary current
I_{th}	rated short time thermal current
U_{pr}	rated primary voltage
U_{ar}	rated supply voltage of auxiliary and control circuits
U_m	highest voltage for equipment
U_{sys}	highest voltage of a system
ESD	electrostatic discharge
SPS	site pollution severity
USCD	unified specific creepage distance
VVC	voltage var control
SCADA	supervisory control and data acquisition
CPIU	conditioning, processing and indicating unit
FDIR	fault detection isolation and restoration
FLISR	fault location isolation and service restoration

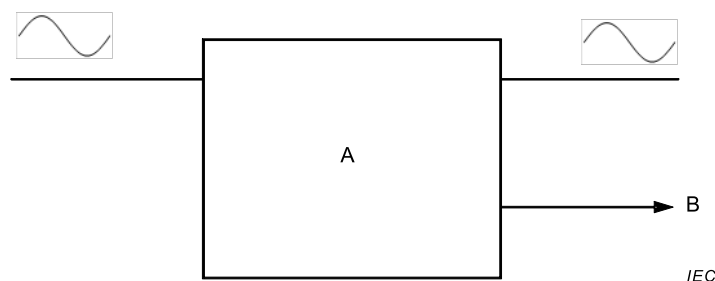
4 Choice of FPI requirements according to network and fault type

The description of indications for a proper choice of FPI/DSU and its requirements concerning fault detection is present in IEC 62689-2.

5 Overview of applications

5.1 General description

The typical FPI configuration is shown in Figure 2 (the device is strictly focused on fault detection, with possibility of a few additional functions), while a DSU in a wide extended configuration is described in Figure 3 (the device includes also the possibility of monitoring more than a single feeder and/or many additional features, even not strictly related to specific FPI functionalities).



Key

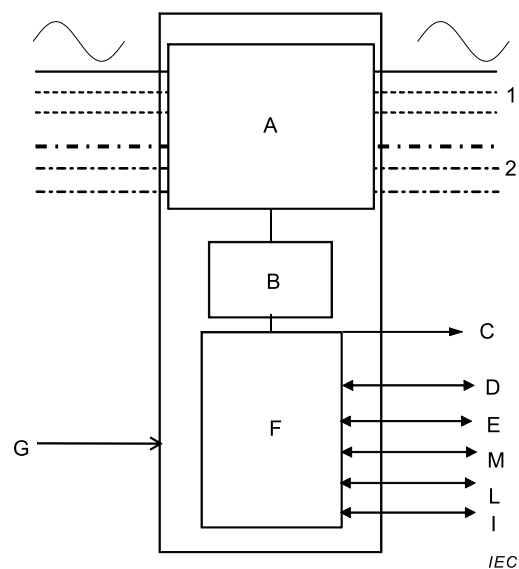
A: Current sensors: they shall be always considered as part of the FPI from a functional point of view. They may be compliant to specific standards (for instance IEC 61869-2, IEC 60044-8, etc) or not compliant to any specific standards (e.g. innovative sensors or technology). One or three phases may be monitored.

Current sensor(s) may detect fault current passages without any need of galvanic connection to the phase(s) (for instance in case of cable type current sensors or of magnetic field sensor).

B: Local indication (lamps, LED, flags, output relays, etc).

Figure 2 – Possible architecture of a typical FPI





Key

- 1: feeder 1
 2: feeders 2, 3, ..., n
- A: Current sensors (and voltage sensors, optional, depending on fault detection principles and on additional functions). 1 or 3 phases may be monitored, as well as more than one feeder. Sensors, which shall be always considered as part of the DSU from a functional point of view, may be compliant to specific standards (for instance IEC 61869-2, IEC 61869-3, IEC 61869-4, IEC 60044-7, IEC 60044-8, etc) or not compliant to any specific standards (e.g. innovative sensors or technology).
- B: Transmission of signals between sensors and electronics. Up to manufacturer.
- C: Local indication (lamps, LED, flags, output relays, etc). These indications are mandatory for stand alone applications (FPIs non inserted in a network control system), optional in case of FPIs inserted in a network automation system and/or for smart grid application.
- D: Remote indication communications and/or commands (bi-directional communication, directly or through other apparatus), optional for standard applications, mandatory for network automation system and/or for smart grid application. These signals/commands may be transmitted/received both through analogue, digital and/or communication inputs/outputs for remote communication/commands (hard wired and/or wireless).
- E: Possible connections to field apparatus (hard wired).
- F: CPU.
- G: Power supply:
 - self-supply from the current signal;
 - power supply from a non rechargeable battery;
 - power supply from a.c. mains (a suitable backup is recommended);
 - power supply from a d.c. supply.
 Recommend supply from suitable energy station (rechargeable battery or power d.c. supply) in case of network automation/smart grid applications.
- I: (Ethernet) Interface (copper or optical fibre) to router for communication through IEC 61850 protocol to SCADA or other FPI (IEDs) outside the distribution station; physical interface.
- L: (Ethernet) Interface (copper or optical fibre) to router for communication through IEC 61850 protocol to apparatus inside prosumer's plant (inverters, generators control systems, etc.); physical interface.
- M: (Ethernet) Interface (copper or optical fibre) to router for communication through IEC 61850 protocol to other FPI (IEDs) in the same distribution station; physical interface.
- I, L and M may also be different data flows using a single physical interface.
- Current sensor(s) may detect fault current passages without any need of galvanic connection to the phase(s) (for instance in case of cable type current sensors or of magnetic field sensor).
- If IEC 61850 communication is present, D could be removed, unless compatibility with older solutions is necessary

Figure 3 – Possible detailed architecture of a DSU in a wide extended configuration

Other possible examples of FPI/DSU architectures are given in Figure B.1, Figure B.3 and Figure B.5.

5.2 Application with regard to installation type

5.2.1 Overhead line applications

5.2.1.1 General

These FPIs/DSUs are for outdoor installation. They provide information concerning the fault passage (local and/or remote, through lights, flags, contacts, etc.) to allow easier fault location by operators (in field or in the network control room). For network automation, they shall be able to deliver suitable signals (digital and/or analogue) and commands to appropriate devices (from a simple relay or combination of relays up to IEDs, depending on the fault detection if performed from an FPI or from a DSU), operating in such a way that switch disconnectors and/or circuit breakers are able to allow automatic fault clearing and supply restoration.

5.2.1.2 Clip on line devices

These devices can be installed directly on single feeders (phase conductor). Feeder outage may be required for the installation, depending on how the FPI is realized. If so, this shall be indicated.

5.2.1.3 Pole mounted devices

These devices shall be installed on feeder poles, with no direct contact with live wires. Usually, no feeder outage is required.

5.2.1.4 Portable devices

These devices can be used by personnel to indicate the passage of a fault current during manual fault location procedures. No installation, so no feeder outage, is required.

5.2.2 Underground cable application

These devices are for indoor installation. They can be installed directly on the cable or the switchboard. They can simply provide information concerning the fault passage (local and/or remote, through lights, flags, contacts, etc.) to allow an easier fault location for operators (in field or in the network control room) or for network automation. They shall supply suitable signals and commands to appropriate devices (from a simple relay or combination of relays up to IEDs, depending on the fault detection if performed from an FPI or from a DSU), operating in such a way that switch disconnectors and/or circuit breakers are able to allow automatic fault clearing and supply restoration.

5.3 Application with regard to fault detection capability

5.3.1 Single phase application

For overcurrent detection, usually with non-directional indication.

NOTE In case of single-phase systems, one current sensor and one voltage sensor are enough to detect direction.

5.3.2 Three-phase application

For overcurrent detection, fault indication may be realized with non-directional or directional fault detection. Three-phase application does not necessarily require voltage and/or current sensors for each phase. Two current sensors are enough for non-directional overcurrent detection; in addition, two current sensors and two voltage sensors are enough to detect also directional overcurrent, but the monitoring of the three phases is still recommended.