

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Low-voltage electrical installations –
Part 8-82: Functional aspects – Prosumer's low-voltage electrical installations**

**Installations électriques à basse tension –
Partie 8-82: Aspects fonctionnels – Installations électriques à basse tension du
prosommateur**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE ELECTRICAL INSTALLATIONS –

**Part 8-82: Functional aspects –
Prosumer's low-voltage electrical installations**

FOREWORD

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IEC 60364-8-82 has been prepared by IEC technical committee 64: Electrical installations and protection against electrical shock, IEC technical committee 8: System aspects of electrical energy supply and its subcommittee 8B: Decentralized electrical energy systems. It is an International Standard.

This first edition cancels and replaces IEC 60364-8-2 published in 2018. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC 60364-8-2:2018:

- a) the vocabulary and concepts have been aligned as much as possible with those used by TC 8 and SC 8B, taking notably into account the IEC 62898 series and IEC TS 62786, still respecting the installers mindset (installers being the first users of the IEC 60364 series and being used to only refer to the IEC 60364 series);
- b) the type of system earthing and the change of type of system earthing (sequencing) when there is a change of mode of the prosuming installation, have been clarified;

- c) the conditions of connection and disconnection from the DSO network have also been described, both from the safety point of view and the proper functioning point of view;
- d) additional requirements have been introduced;
- e) the figures have been updated;
- f) a new normative Annex D on single dwelling or similar application islandable PEIs has been added;
- g) the numbering has also been reviewed to follow the updated numbering system of the IEC 60364 series, in line with the IEC Directives and compatible with Parts 7.

The text of this International Standard is based on the following documents:

Draft	Report on voting
64/2559/FDIS	64/2562/RVD

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 International Standard 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/standardsdev/publications.

A list of all parts in the IEC 60364 series, published under the general title *Low-voltage electrical installations*, can be found on the IEC website.

The reader's attention is drawn to the fact that Annex E lists all of the "in-some-country" clauses on differing practices of a less permanent nature relating to the subject of this document.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://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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INTRODUCTION

Historically, utilities were managing the public transmission and distribution network from the point of view of having a central production adapted to demand variation, a top-down energy flow, a production/consumption balance done by integrated utility companies and with rather passive users.

The following key factors are pushing the distribution network to change:

- the increasing number of electronic devices used daily and the growing needs as well as future needs (e.g. charging electric vehicles) will result in the structural growing of electricity consumption;
- the mediated pressure on climate change results in pressure on CO₂ emissions reduction;
- the electricity market is also quickly changing due mainly to its unbundling and deregulation, and to the greater number of intermittent renewable energy sources (global and local);
- users' expectations are also evolving as a result of an increasing need for better distribution networks reliability and quality, the search for better economic performance and the willingness to pro-actively manage their energy;
- technological evolution should also be considered as information and communication technology (ICT) is affordable and new energy storage solutions are emerging.

All stakeholders directly involved in the electricity generation, transmission, distribution and consumption have new expectations:

- customers are willing to reduce electrical energy costs in order to meet environment targets (renewable energy, energy efficiency) but also wish to benefit from the quality of electricity supply;
- suppliers wish to limit customer churn rate with price and service management;
- producers expect to maximize their yield of assets, to optimize their investments and to take profit from energy trading;
- the aggregator wants to create conditions suitable for new market emergence;
- the transmission system operator (TSO) aspires to a robust transmission network and to meet regulation objectives (price and level of services), while the distribution system operator (DSO) wants to meet regulation objectives (price and level of services), to reduce costs by productivity (including meter) and to have a flexible network;
- finally, governments and regulators are willing to create a competitive and sustainable energy market.

The objective of this document is to ensure that the low-voltage electrical installation is compatible with the current and future ways to deliver safely and functionally the electrical energy to current-using equipment wherever the electrical energy comes from the DSO or local generation. This document is not intended to influence all stakeholders of electricity supply on how the electrical energy should be sold and delivered.

LOW-VOLTAGE ELECTRICAL INSTALLATIONS –

Part 8-82: Functional aspects – Prosumer's low-voltage electrical installations

82.1 Scope

This part of IEC 60364 provides requirements and recommendations that apply to low-voltage electrical installations connected or not to a distribution network able to operate:

- with local power supplies, and/or
- with local storage units,

and that monitors and controls the energy from the locally connected sources delivering it to:

- current-using equipment, and/or
- local storage units, and/or
- distribution networks.

Such electrical installations are designated as prosumer's electrical installations (PEIs).

These requirements and recommendations apply to new installations and modifications of existing installations.

This document also provides requirements and recommendations for the safe, efficient and correct behaviour of these installations when integrated into a smart grid.

NOTE Requirements for electrical sources for safety services are given in IEC 60364-5-56.

Information related to grid interaction to ensure the stability of the electrical system for grid connected PEIs is given in Annex B.

This document covers the requirements related to stability of islanded and stand-alone PEIs.

82.2 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 60038, *IEC standard voltages*

IEC 60364 (all parts), *Low-voltage electrical installations*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*
IEC 60364-4-41/AMD1:2017

IEC 60364-4-42:2010, *Low-voltage electrical installations – Part 4-42: Protection for safety – Protection against thermal effects*

IEC 60364-4-43:2008, *Low-voltage electrical installations – Part 4-43: Protection for safety – Protection against overcurrent*

IEC 60364-5-51:2005, *Electrical installations of buildings – Part 5-51: Selection and erection of electrical equipment – Common rules*

IEC 60364-5-53:2019, *Low-voltage electrical installations – Part 5-53: Selection and erection of electrical equipment – Devices for protection for safety, isolation, switching, control and monitoring*

IEC 60364-5-53:2019/AMD1:2020

IEC 60364-5-54:2011, *Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors*

IEC 60364-5-55:2011, *Electrical installations of buildings – Part 5-55: Selection and erection of electrical equipment – Other equipment*

IEC 60364-5-55:2011/AMD1:2012

IEC 60364-5-55:2011/AMD2:2016

IEC 60364-5-57, *Low-voltage electrical installations – Part 5-57: Selection and erection of electrical equipment – Erection of stationary secondary batteries*

IEC 60364-6, *Low voltage electrical installations – Part 6: Verification*

IEC 60364-7-722, *Low-voltage electrical installations – Part 7-722: Requirements for special installations or locations – Supplies for electric vehicles*

IEC 60947-2:2016, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

IEC 60947-2:2016/AMD1:2019

IEC 61557-12:2018, *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 12: Power metering and monitoring devices (PMD)*

IEC 62423, *Type F and type B residual current operated circuit-breakers with and without integral overcurrent protection for household and similar uses*

IEC TS 62749, *Assessment of power quality – Characteristics of electricity supplied by public networks*

82.3 Terms and definitions

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>

82.3.1

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, 617-04-13]

82.3.2

distribution network

electric power network for the distribution of electric power from and to network users for which a distribution system operator (DSO) is responsible

[SOURCE: IEC TS 62786:2017, 3.4]

82.3.3

producer

<of electricity> entity or party generating electrical energy

[SOURCE: IEC 60050-617:2009, 617-02-01, modified – "entity or" has been added.]

82.3.4

consumer

<of electricity> entity or party which uses electricity

82.3.5

prosumer

<of electricity> entity or party which can be both a producer and a consumer of electrical energy

82.3.6

prosumer's electrical installation

PEI

low-voltage electrical installation connected or not to a distribution network able to operate:

- with local power supplies, and/or
- with local storage units,

that monitors and controls the energy from the connected sources delivering it to:

- current-using equipment, and/or
- local storage units, and/or
- distribution networks

82.3.7

electrical energy management system

EEMS

system monitoring, operating, controlling and managing energy resources and loads of the installation

Note 1 to entry: The EEMS can be a dedicated system or part of an integrated system, such as a home and building electronic system (HBES) or building management system (BMS or BACS) or other similar management system.

[SOURCE: IEC 60364-8-1:2019, 3.2.1, modified – Note 1 to entry has been added.]

82.3.8

operating mode

operation of an installation with respect to the different sources of electrical energy and to energy flow

82.3.9

direct feeding mode

operating mode in which the distribution network supplies the PEI

Note 1 to entry: Local storage units can supply current-using equipment or be charged by local power supplies and/or the distribution system.

82.3.10

reverse feeding mode

operating mode in which the PEI supplies the distribution network

Note 1 to entry: Local storage units can supply current-using equipment and/or the distribution system or be charged by local power supplies.

82.3.11

connected mode

operating mode in which the PEI is connected to the distribution network

EXAMPLE Direct feeding mode, reverse feeding mode or no feeding mode (i.e. without any energy exchange between the PEI and the distribution network).

82.3.12

island mode

operating mode in which the PEI is disconnected from the distribution network

Note 1 to entry: An island mode can be either the result of the action of automatic protections or the result of a deliberate action.

[SOURCE: IEC 60050-692:2017, 692-02-11, modified – The term "electric island" has been replaced with "island mode", the definition has been adapted to the PEI and Note 2 to entry has been deleted.]

82.3.13

grid connected PEI

PEI intended for operating only when connected to a distribution network

82.3.14

stand-alone PEI

PEI permanently not connected to a distribution network

Note 1 to entry: A stand-alone PEI is in a permanent island mode.

82.3.15

islandable PEI

PEI intended for operating either being connected to a distribution network or being disconnected from the distribution network

Note 1 to entry: An islandable PEI is in a connected mode or an intentionally island mode.

82.3.16

point of connection

POC

reference point where the prosumer's electrical installation is connected to the distribution network

Note 1 to entry: A PEI can have several points of connection for resilience.

Note 2 to entry: In IEC 60364 (all parts), the concept of origin of the installation is also used, origin of the installation meaning the point at which energy is delivered to the electrical installation. The POC is a specific origin of the installation, the one connected to the distribution network. Other origins of the installation can be the connection to the local power supply, to the storage system..

Note 3 to entry: Connection or disconnection of the prosumer electrical installation from the distribution network generally occurs at the POC.

[SOURCE: IEC 60050-617:2009, 617-04-01 modified – The definition has been adapted to the PEI and the notes to entry have been added.]

82.3.17**load shedding**

method(s) of optimizing demand by controlling the electrical loads for variable periods of time

[SOURCE: IEC 60364-8-1:2019, 3.2.2]

82.3.18**system referencing conductor**

conductor that connects one live conductor of the power system to an earthing arrangement

Note 1 to entry: The live conductor connected is the neutral or the mid-point if existing, or a line conductor when not existing.

82.3.19**electrical energy storage system****EES**

installation able to absorb electrical energy, to store it for a certain duration and to release it

[SOURCE: IEC 62933-1:2018, 3.2, modified – The definition has been adapted to the PEI and the notes to entry have been deleted.]

82.4 Integration of PEI in its environment**82.4.1 Main objectives**

Where a smart grid and an electrical installation interact a dynamic power demand/response concept should be implemented.

The smart grid has an impact on the electrical installations, thus:

- the consumer shall take into consideration the constraints of the electrical power system and can adapt its needs (e.g. through time) with the EEMS;
- the design and configuration of the installation may include load shedding and source selection by the EEMS.

As production of energy from the renewable sources such as PV or wind turbines is intermittent, a storage capacity may be installed within the PEI to ensure continuity of supply in all modes without being supplied by the grid, to support stability of the PEI and/or to maximize the self-consumption in connected mode.

82.4.2 Safety

The implementation of the requirements provided in this document shall not impair the safety of the PEI, as required by other parts of the IEC 60364 series. In case of change from any energy supply configuration (e.g. from distribution network supply to local power supplies) all protective measures shall continue to be operational or shall be automatically replaced by other standardized protective measures providing an equivalent level of safety.

82.4.3 Proper functioning

The power quality parameters are used to demonstrate reliable operation of the PEI and should not be outside the allowed operating range for all components in the PEI.

For a non stand-alone PEI, unless otherwise specified, the power quality levels at the point of connection (POC) shall be in the same range allowed in grid-connected and island mode.

When a PEI is connected to a distribution system, it shall not cause unacceptable disturbances to the other system users.

When operating in parallel with the distribution system the PEI shall not cause voltage fluctuation at the distribution system or result in flicker and rapid voltage changes outside the ranges defined in the IEC TS 62749.

NOTE See also IEC TS 60364-8-3:2020, Clause 11.

82.5 PEI concept

Any low-voltage PEI shall be considered as a set of electrical equipment having the following functions (see Figure 1):

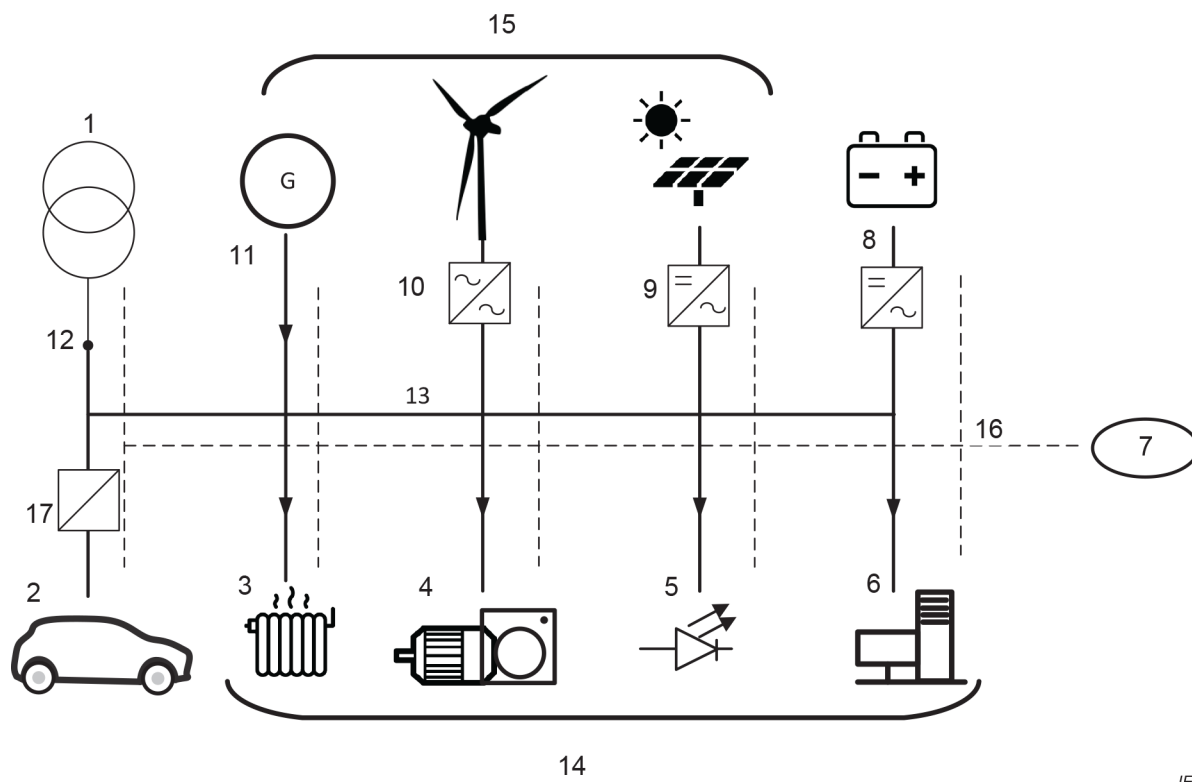
- supply (e.g. connection to public power supply, local generator, photovoltaic systems, wind turbines, electrical energy storage system);
- distribution (e.g. distribution panel, wiring systems);
- consumption (e.g. motors, heating systems, lighting, lifts);
- energy management (e.g. load shedding equipment, monitoring device).

NOTE 1 An electrical energy storage system can be considered as a generator and as a load.

The electrical distribution within the PEI can be in alternating current (a.c), direct current (d.c), or a combination of both (see examples in Figure 1 and Figure 2), as every low voltage electrical installation covered by IEC 60364 (all parts).

The electrical installations shall consider both the requests from the DSO and the needs expressed by the prosumer. An EEMS shall be implemented to combine information and/or data, from/to the DSO, the availability of energy by the local sources and the prosumer's needs. The EEMS shall ensure the data security.

An uninterruptible power supply (UPS) shall not be considered as a prosumer when this UPS does not have a reverse feeding mode to supply energy to current-using equipment in the upstream part of the electrical installation and/or the distribution network, if any.

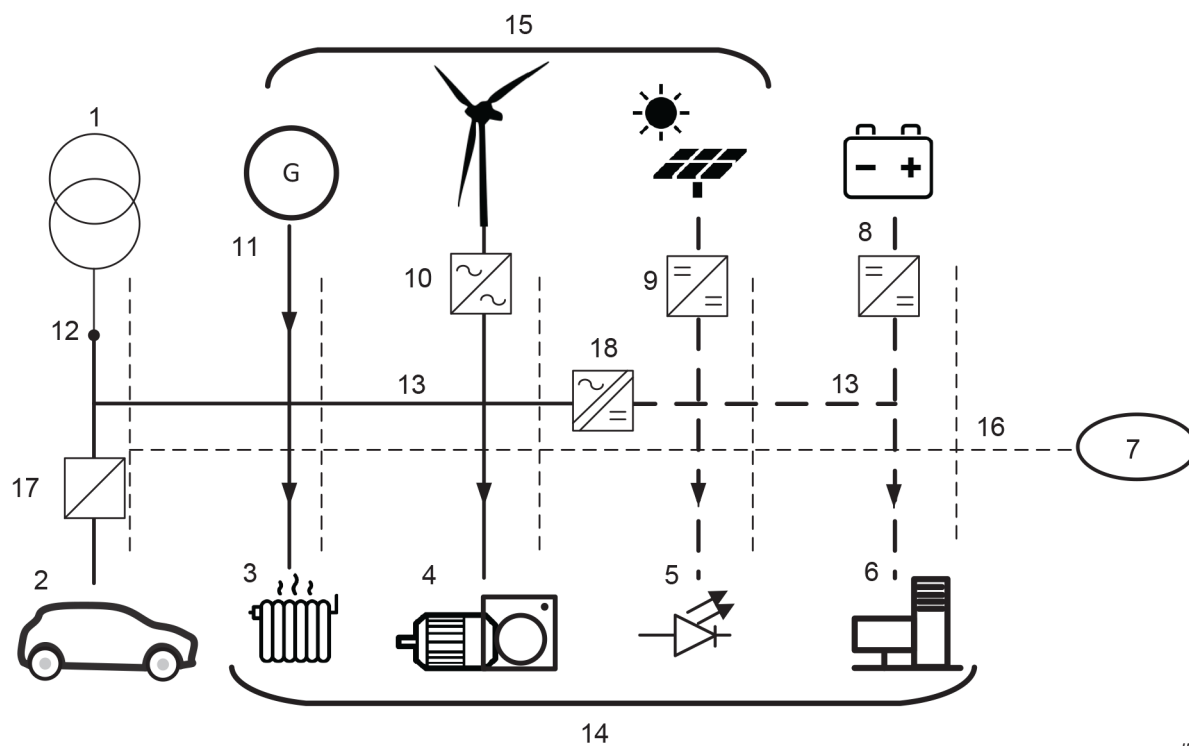


IEC

Key

1	Distribution network	10	Wind inverter
2	Electric vehicle	11	Other generator
3	Heaters	12	POC
4	Motors	13	Prosumer electrical installation
5	Lightings	14	Local consumption
6	Home appliances and electronic devices	15	Local generation
7	EEMS	16	Management signals (bidirectional exchanges)
8	Electrical energy storage system	17	EV charging station
9	Solar inverter		

Figure 1 – Example of prosumer's low-voltage electrical installation with AC electrical distribution within the PEI



IEC

Key

1	Distribution network	11	Other generator
2	Electric vehicle (sheddable load)	12	POC
3	Heaters (sheddable load)	13	Prosumer electrical installation
4	Motors, AC loads (home appliances)	14	Local consumption
5	Lightings (LED)	15	Local generation
6	DC loads (possibly sensitive loads if islandable PEI)	16	Management signals (bidirectional exchanges)
7	EEMS	17	EV charging station
8	Electrical energy storage system	18	Bidirectional AC/DC converter
9	Solar inverter		
10	Wind inverter		

Figure 2 – Example of prosumer's low-voltage electrical installation with AC and DC electrical distribution within the PEI

The PEI installation owner should, in order to supply electrical loads in the most efficient and cost-effective way, consider providing a system for supervision and control of the different power supplies connected to the installation.

Connections shall comply with the IEC 60364 series.

NOTE 2 Specific parts of the IEC 60364 series include, for example, IEC 60364-5-55:2011, Clause 551, for power supplies; IEC 60364-5-57 for energy storage systems; IEC 60364-7-712 for photovoltaic systems and IEC 60364-7-722 for supplies for electric vehicles.

Energy locally produced can be used locally or can feed the distribution network. In such a case the operator of the installation shall be considered as a consumer of electrical energy and as a producer of electrical energy (prosumer).

Interactions with the distribution network, with the service provider or aggregator, are necessary to optimize the energy production, the energy transfer and the energy sourcing depending on the conditions and the strategy of the prosumers, and also on the expected support, when needed, of the PEI to the distribution network.

Interaction with the supply system is described in Annex B.

82.6 Types of PEI

82.6.1 General

There are different types of PEI:

- grid connected PEI (see 82-3-14);
- islandable PEI (see 82-3-16);
- stand-alone PEI (see 82-3-15).

The grid connected PEI and the islandable PEI are connected to the distribution network at a point of connection (POC).

A PEI can have several POCs, for example for redundancy of power distribution connection. This document only addresses PEIs having not more than one POC.

The type of system earthing and the related protective measures of the PEI shall be selected according to the type of PEI (see 82.8). As in all electrical installations, different parts of the PEI could have different protective measures. These protective measures shall be suitable for all relevant operational modes of the PEI.

The control of the PEI is also linked to the type of PEI. It is introduced in 82.7 and described in the IEC TS 60364-8-3.

Regional, national or provincial regulations (e.g. grid code) can exist for design and operation of grid connected and islandable PEIs.

NOTE 1 Depending on the regional, national or provincial conditions, a PEI can be owned by a single owner (individual PEI) or can have some part shared between different owners (collective PEI). The technical requirements in terms of type of system earthing and protections are the same, even if the solutions implemented could be adapted to take into account the ownership of the different parts.

NOTE 2 Grid code is a local regulation for transmission and distribution, dispatching, development and security of the grid including the procedures of connection, management, planning, development and maintenance of the transmission and distribution grids, as well as dispatching and measurement of electrical energy.

NOTE 3 See Annex C for the description of architectures of PEIs (individual, collective or shared).

82.6.2 Operating modes

The operating modes presented in this document can be adopted depending on the type of PEI and are:

- connected mode (see 82.3.12) for grid connected or islandable PEIs,
- island mode (see 82.3.13) for islandable or stand-alone PEIs.

Selection of the possible operating modes can depend on the contract with the DSO or according to the national legislation.

Energy storage systems can supply current-using equipment or be charged by local power supplies or by the distribution system (except in island mode for the distribution system).

Local power supplies can supply current-using equipment or local storage units or the distribution system (except in island mode for the distribution system).

Transfer from the connected mode to island mode and vice versa can be achieved by operating the switching device for islanding (SDFI) (see 82.6.3.4.3); this can be either directly controlled (manually or remotely) or automatically controlled.

Transfer from island mode to connected mode can be done if the voltage system provided by the local power supplies is synchronized with the distribution network (see IEC 60364-5-55:2011, Clause 551) or by switching off all local power supplies before connecting (see 82.6.3.4.3).

See Annex A for examples of operating modes.

Technical requirements for the design of the PEI according to the selected operating mode are provided in 82.8.

82.6.3 Interaction with the distribution network

82.6.3.1 General

The connection with the distribution network can be done either directly in low voltage (the type of system earthing will be defined by the DSO) or through a transformer, allowing the choice for a dedicated type of system earthing for the PEI in connected mode.

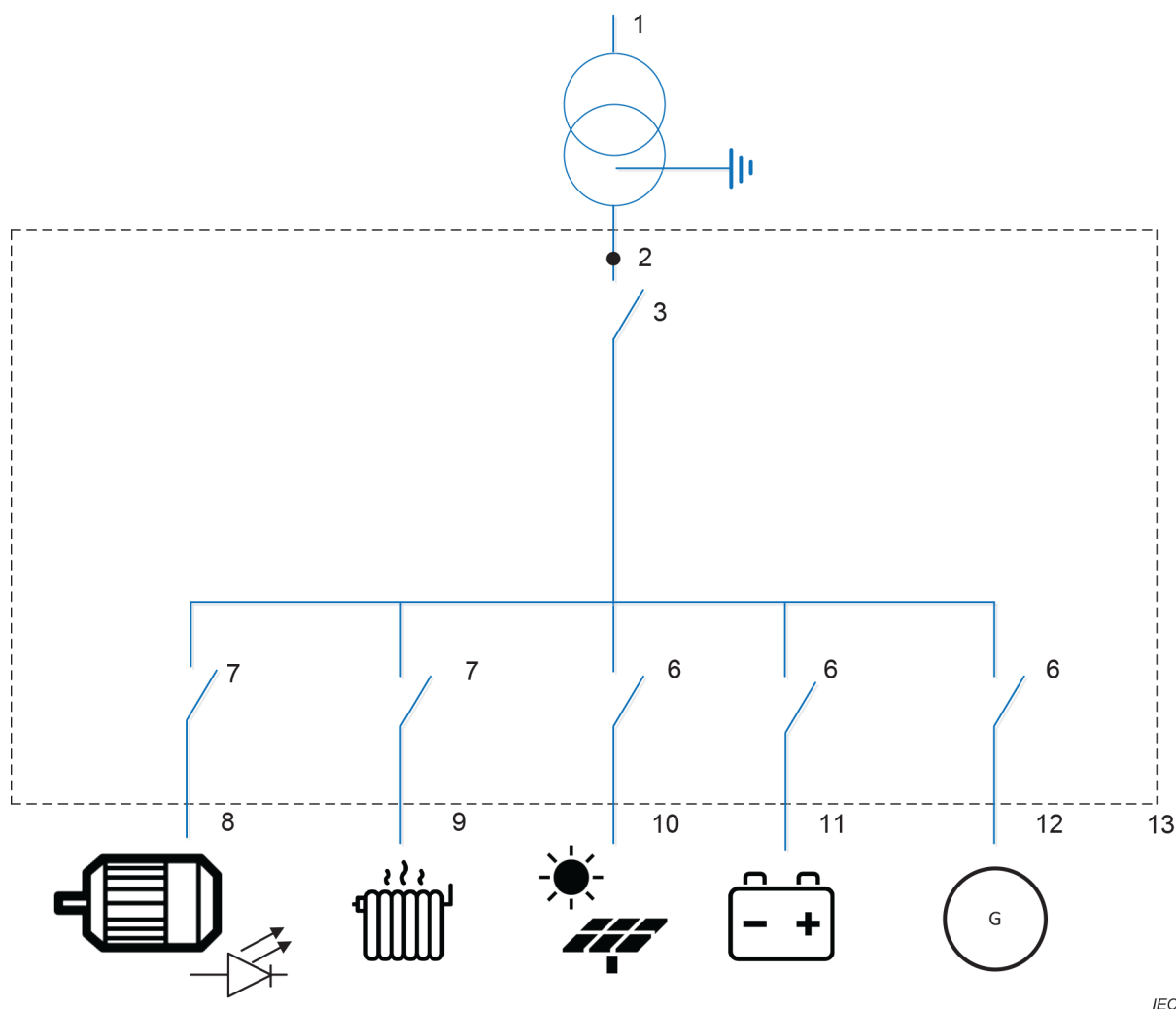
NOTE 1 The SDFI can be on the HV-, LV- or both sides of the transformer in accordance with the requirements of the DSO.

NOTE 2 If there is an HV/LV transformer and if the SDFI is in the LV part, the requirements described in this document apply in the LV part of the installation even if the connection with the distribution network is on the HV side of the transformer (see 82.6.3.4.3 and 82.8).

NOTE 3 Additional information of interactions with the distribution network is given in Annex B.

82.6.3.2 Interaction with the distribution network for grid connected PEI

Grid connected PEIs are designed to operate only when being fed by the distribution network. The type of system earthing and automatic disconnection of supply rely on the connection to the distribution network (see Figure 3).



IEC

Key

1	Distribution network	8	Non-sheddable loads (sensitive loads)
2	Point of connection (POC)	9	Sheddable loads (adjustable loads)
3	Main switching device	10	Solar generator
4	Vacant	11	Electrical energy storage system
5	Vacant	12	Other generator (wind, etc)
6	Source switching device	13	Main distribution board
7	Load switching device		

Figure 3 – Example of grid connected PEI architecture

In case of loss of mains (see 82.6.3.5) or if voltage, frequency or other power quality values are out of their tolerances as defined by the DSO, no local power supply shall remain connected to the grid. When the distribution network is re-energized:

- the PEI is re-energized by the distribution network;
- the local power supplies may need DSO permission prior to reconnecting;

NOTE As a temporary solution, the distribution network can be re-energized with limited capacity. In such a case, the DSO can refuse to permit the PEI to connect to local sources.

- the local power supplies may need to synchronize with the network prior to reconnecting.

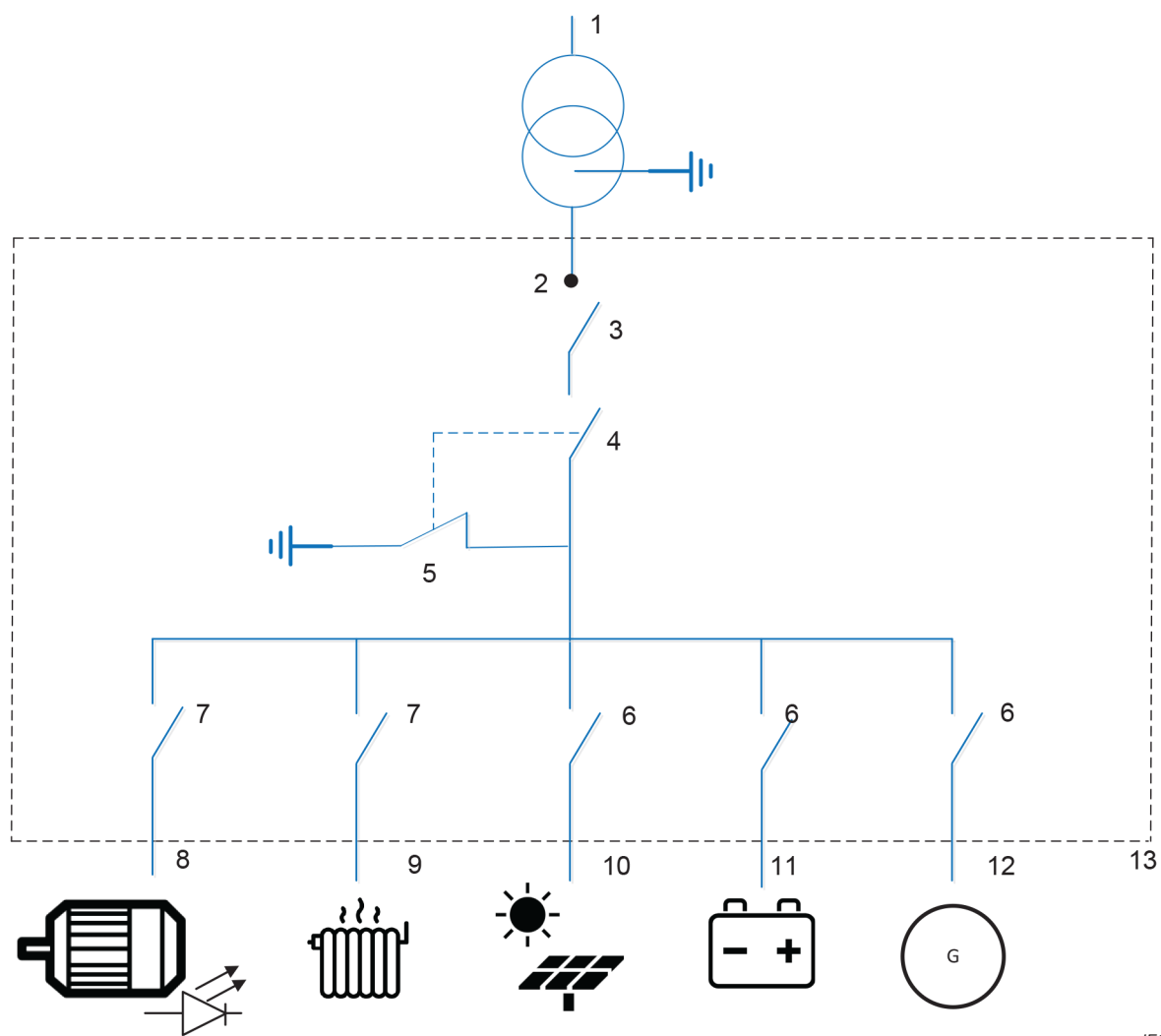
In case of opening of the main switching device:

- disconnect the local power supplies including storage;
- verify that there is no remaining power supply.

82.6.3.3 Interaction with the distribution network for islandable PEI

82.6.3.3.1 Disconnection/reconnection from/to the distribution network in case of loss of mains

The PEI designed to operate in island mode can have two different types of system earthing and related protective measures: one for island mode and one for grid connected mode (see Figure 4 and 82.8).



IEC

Key

1	Distribution network	8	Non-sheddable loads (sensitive loads)
2	Point of connection (POC)	9	Sheddable loads (adjustable loads)
3	Main switching device	10	Solar generator
4	Switching device for islanding (SDFI) (see 82.6.3.4.3)	11	Electrical energy storage system
5	System referencing conductor switching device (see 82.8.2.2.4)	12	Other generator (wind, etc.)
6	Source switching device	13	Main distribution board
7	Load switching device		

Figure 4 – Example of islandable PEI architecture

In case of loss of mains (see 82.6.3.5) or if voltage, frequency or other power quality values are out of their tolerances as defined by the DSO, no local power supply shall remain connected to the grid.

The following cases can occur:

- the PEI waits until the grid is restored (same case as in 82.6.3.2);
- the PEI switches to island mode:
 - disconnect from the distribution network (using the SDFI);
 - use the local type of system earthing (depending on the choice of type of system earthing made for island mode, see 82.8.1);
 - the protection system shall operate in the specific mode (see 82.8.2);
 - the EEMS shall manage the transition from connected mode to island mode depending on the possibility of the PEI:
 - going down then black start (IEV 617-04-24) or
 - keeping the continuity of service (on the fly).
 - the EEMS may exchange the relevant information with the DSO.

When the distribution network is re-energized, the actions are the same as for the intentional change to the connected mode (see 82.6.3.3.3).

82.6.3.3.2 Intentional disconnection from the distribution network

For the intentional change from grid connected mode to island mode (if the change is possible according to the regional, national or provincial regulations [e.g. grid code] and information received from the DSO) the following items shall be considered:

- disconnect from the distribution network (using the SDFI);
- change to the local type of system earthing (depending on the choice of type of system earthing made for island mode, see 82.8.1);
- the protection system shall operate in the specific mode (see 82.8.2);
- the EEMS shall manage the situation depending on the possibility of the PEI:
 - going down then black start, or
 - keeping the continuity of service (on the fly);
- the EEMS shall exchange the relevant information with the DSO.

NOTE This topic could be dealt with differently depending on national regulations.

82.6.3.3.3 Intentional connection to the distribution network

With regard to intentional change from island mode to grid connected mode, two possibilities occur:

- transition with interruption of supply of the loads:
 - disconnect all local power supplies from the PEI and wait until the PEI is de-energized;
 - change the local type of system earthing (if types of system earthing are different in island and grid connected modes) by switching the system referencing conductor switching device;
 - connect to the grid (using the SDFI).
- transition without interruption of supply of the loads (seamless transition):

The PEI shall use dedicated means to synchronize and the appropriate coordinated switching devices to ensure the safety and the power continuity to the critical loads during the transfer.

Connection to the grid shall be allowed within specified limits, for example:

- in alternating current, the difference between voltage amplitudes, frequencies and phase angles in the different systems, depending on requirements of the generators and the grid codes;
- in direct current, the voltage difference between the two systems depending on the design of the power system (to be calculated case by case).

When synchronization conditions are met, the EEMS shall:

- change the local type of system earthing (if types of system earthing are different in island and grid connected modes);
- connect to the grid.

NOTE The intentional connection to the grid process can differ depending on national regulations.

82.6.3.4 Main switching device and switching device for islanding

82.6.3.4.1 General

A main switching device shall be provided for the isolation and protection of the PEI from the grid and shall comply with the requirements of 82.6.3.4.2.

A switching device for islanding (SDFI) shall be provided for the connection or disconnection of the islandable PEI and shall comply with the requirements of 82.6.3.4.3

The main switching device and the switching device for islanding can be integrated into a single device, where appropriate.

These switching devices shall also fulfil the requirements from the DSO, if any.

82.6.3.4.2 Main switching device

The main switching devices in a PEI introduced in 82.6.3.2 and 82.6.3.3 shall be suitable for isolation, according to IEC 60364-5-53:2019, Clause 536.

For a grid connected PEI, when the main switching device is open, all local power supplies shall be disconnected from the PEI (and prevented from being reconnected) to avoid unintentional islanding.

Measure(s) shall be taken to avoid an opening of the main switching device in case of low voltage ride through (LVRT), in compliance with the grid code, without affecting the protections of the installation, for example, not using an undervoltage tripping coil directly supplied from the distribution network on the main switching device.

NOTE Low voltage ride through is the capability of local sources to stay connected in short periods of lower electric network voltage.

82.6.3.4.3 Switching device for islanding

The switching device for islanding (SDFI) is dedicated to the change from grid connected mode to island mode and from island mode to grid connected mode for an islandable PEI, functionally speaking, to separate/link the local sources from/to the distribution network.

NOTE 1 In IEC TS 62786 the term used for switching device for islanding is "interface switch".

Provisions shall be made to prevent the inadvertent and/or unauthorized closing of the SDFI. This can be achieved either by means of mechanical or electrical interlocks on the device, or by locating the device in a cabinet locked with a key or tool unless it is in a location where only skilled or instructed persons may obtain access.

The closing of the SDFI shall be inhibited when local supplies are connected except for an islandable PEI and when the synchronism conditions are met.

The SDFI shall have a short time withstand current greater than or equal to the maximum prospective short circuit current supplied by the distribution network. It can have a lower capacity than the maximum prospective short circuit current supplied by the distribution system if coordinated in short circuit condition with the main overcurrent protection.

The SDFI shall have a breaking and making capacity greater than or equal to the rated current of the PEI and greater than or equal to the maximum prospective short circuit current provided by local sources. It can have a lower capacity than the maximum prospective short circuit current provided by local sources if coordinated with other current protection measures at local sources.

NOTE 2 Some standards exist for transfer source and islanding e.g. IEC 60947-6-1 for transfer switching equipment (TSE). IEC 62991 for source switching equipment (SSE) is under development.

The switching device for islanding shall be interlocked with the system referencing conductor switching device, if any (see 82.8.2.2.4).

Selection of components shall be made according to the expected number of operations.

NOTE 3 Devices can be operated more frequently than in non-PEIs, up to several times a day in some applications.

When an SDFI is in the HV part of the installation, provisions shall be made to avoid energization of the HV/LV transformer from the LV side in island mode.

This requirement can be fulfilled by using an additional LV SDFI on the LV part. This SDFI shall comply with the requirements of each SDFI. In addition, this SDFI shall be interlocked with the HV SDFI to ensure the following:

- the opening of the HV SDFI shall cause the opening of the LV SDFI;
- the closing of the LV SDFI shall be inhibited when the HV SDFI is open.

82.6.3.5 Loss of mains

When the distribution network is not energized, prosumers shall operate their PEI in island mode or automatically disconnect from the distribution network and automatically disconnect all local power supplies if the PEI is not able to be operated in island mode.

When the DSO conditions to operate the distribution network are not fulfilled (e.g. overvoltage, power quality, several microgrids running together as an island from the DSO point of view), prosumers shall also operate their PEI in island mode or automatically disconnect all local power supplies if the PEI is not able to be operated in island mode.

The disconnection of the PEI from the distribution network shall be ensured by a protection usually called "loss of mains" protection which is defined by local utility specifications or local regulations. "Loss of mains" protection is generally based on one or a combination of several protection functions.

NOTE 1 Loss of mains protection is called "interface protection" in IEC TS 62786: 2017, 3.13.

One loss of mains protection shall be provided for each supply or one centralized protection for a group of supplies.

NOTE 2 One centralized protection for a group of supplies could be for example a solution when transition without interruption from grid connected mode to island mode (for the entire or part of the PEI) is expected.

A non-exhaustive list of common protection functions which can be requested is given below as examples:

- phase undervoltage and phase overvoltage protections;
- underfrequency and overfrequency protections.

Optionally, in some specific application cases, additional functions could be requested:

- rate of change of frequency protection;
- reverse power protection.

The settings are generally defined by DSO specifications or local regulations. These settings are defined to meet several requirements, which are recalled below:

- the selectivity of the voltage protection settings with low voltage ride through (LVRT) requirements shall be ensured;
- the selectivity of the frequency protection settings with frequency ride through (FRT) requirements (if any) shall be ensured;

NOTE 3 Frequency ride through is the capability of local sources to stay connected for a short period of time where the frequency is out of specified tolerance.

- the detection of non-intentional island DSO feeder, which could be supplied by sources of connected PEIs shall be ensured. In case of short-circuit (including earth fault) on the public network feeder, the corresponding feeder protection at the main distribution substation will trip and the faulty distribution network feeder could be supplied by PEI sources connected along the feeder. The loss of mains protections shall disconnect all the PEIs sources, whatever the balance between loads and source.

NOTE 4 The detection of such fault can require some special measures on the HV side such as residual/zero sequence overvoltage protection (59N according to IEEE C37.2).

NOTE 5 The DSO can require a test of the protection functions, including loss of mains, with regards to the safety of the distribution system.

- the selectivity of the loss of mains protections with short-circuit protections inside the distribution network and PEIs should be ensured. When a short circuit occurs in the distribution network on an adjacent feeder or inside a PEI, loss of mains protections should remain stable (no trip) to avoid an unwanted disconnection.

82.6.3.6 Voltage and frequency characteristics

In connected mode, voltage and frequency are set by the distribution network that is typically alternating current.

In island mode, voltage and frequency are not any more set by the distribution network. The voltage and frequency characteristics (amplitude, variations, etc.) shall be aligned with the characteristics of the connected equipment.

For stand-alone PEIs and islandable PEIs in island mode, voltage and frequency shall be set by a grid forming source (for example one rotating generator or one grid forming converter).

For stand-alone PEIs and islandable PEIs in island mode, the supply voltage range, under normal operating conditions, shall be specified. IEC 60038 shall be used as a reference. The power frequency range shall be specified according to generators and loads declared characteristics.

These characteristics are needed for defining the settings of the protection system.

NOTE These considerations apply for the supplied part of the PEI in island mode, either in alternating current or direct current (see Figure 1 and Figure 2).

For PEIs always connected to a distribution network or islandable PEIs operated in connected mode, the PEI should also comply with all the supply requirements (e.g. voltage, frequency) according to IEC TS 62749.

82.7 Control and monitoring

82.7.1 General

An electrical energy management system (EEMS) is required to ensure the correct operation of the PEI.

The objectives of the EEMS for a PEI are as follows:

- to control the connection of the PEI to the smart grid;
- to manage locally the electrical energy production;
- to manage locally the electrical consumption;
- to manage the energy exchange with the DSO.

The following are examples of functions that can be handled by the EEMS:

- power sources and loads management;
- multi-source connection management;
- load control proposal (load shedding and load shifting);
- bi-directional exchange of information with the DSO: for example,
 - the PEI should make available to the DSO the PEI operating status (disconnected, disconnected and de-energized, de-energized and in maintenance mode, disconnected but energized, in the process of being disconnected, island mode, ready to (re)connect to the grid, (re)connecting, connected, idle, consuming, producing, estimated duration of operation in island mode, situation of the type of system earthing, etc.);
 - the PEI should share with the DSO its local electrical generating characteristics:
 - i) actual active and reactive power, 4 quadrants,
 - ii) actual frequency,
 - iii) actual voltage (3 phases),
 - iv) actual power factor (PF),
 - v) actual storage capabilities (if any).
 - the PEI should collect from the DSO the authorization to cease-to-energize, authorization for reconnection;

NOTE Information on the tariff can be necessary for the PEI to decide on its operating mode.

- backup of the system management by means of energy storage system and power sources;
- control of the energy from and to the energy storage system;
- monitoring of the voltage quality;
- provision of interface with the end user.

The EEMS can manage some short time power control, stability, as far as longer time energy optimization is concerned, as specified in IEC TS 60364-8-3.

The EEMS can be installed as a separate equipment or in different pieces of equipment or can be integrated in other existing equipment.

82.7.2 Architecture of control and monitoring system

Consumption of each electrical installation part of a PEI shall be monitored, as well as all local electricity production, with energy meters, power metering and monitoring devices (PMD) according to IEC 61557-12 or other measuring equipment.

For collective and shared PEIs, the part of the local production of electrical energy consumed by each individual electrical installation should be provided.

See Annex C.

82.8 Protection of prosumer electrical installation

82.8.1 General

The prosumer's electrical installation shall be able to operate in any intended operating mode as defined in 82.6.2. According to needs, a PEI can change the operating mode at any time and can come back to the initial operating mode also at any time (for instance, from connected mode to island mode and then back to connected mode).

Protection of persons and properties shall be provided including local supplies in all operation modes and in all parts of the installations (AC or DC).

This is particularly the case for the protection of persons against electric shock when the automatic disconnection of supply is used as a protective measure for all intended operating modes. In this case, the type of system earthing used for all intended operating modes can differ and can depend on the operating mode.

– Grid connected PEI:

A means to prevent islanded operation shall be provided in order to switch off and disconnect all local supplies when the grid supply is not operating properly.

The requirements of 82.8.2.1, 82.8.3, 82.8.4 and 82.8.5 apply.

– Islandable PEI:

The requirements of 82.8.2, 82.8.3, 82.8.4 and 82.8.5 apply.

– Stand-alone PEI:

The requirements of 82.8.2.1, 82.8.2.2, 82.8.3, 82.8.4 and 82.8.5 apply.

82.8.2 Protection against electric shock

82.8.2.1 General

One of the following measures shall be used:

- double or reinforced insulation;
- SELV or PELV;
- automatic disconnection of the supply.

82.8.2.2 Protective measure by automatic disconnection of supply

82.8.2.2.1 General

When the automatic disconnection of supply is used as a protective measure it shall be provided for all intended operating modes.

For islandable and stand-alone PEIs with multiple local supplies, except for IT systems not connected to the earth, a single connection of the reference conductor to earth per galvanically isolated part of the PEI should be the preferred solution (see also IEC 60364-1:2005, Figure 31D). When, owing to the positioning of the different decentralized local sources, it is not realistic to have a single connection to earth, multiple connections of the reference conductor to earth can be used. Special attention should then be given to RCD use, interlocked management of the reference to earth connections, if necessary, and EMC concerns.

Local supplies shall be connected to the main distribution board with dedicated circuits. When, owing to the geographical positioning of the different decentralized local sources, it is not realistic to connect every local supply to the main distribution board, specific protection measures shall ensure safety.

NOTE Having the local supplies directly connected in the main distribution board and also having a system referencing conductor connected to earth in the same distribution board limits the risk of having a part of the electrical installation being supplied by a downstream grid-forming local source without reference to earth.

82.8.2.2.2 Islandable PEI connected to a low voltage distribution network

In connected mode without any transformer providing galvanic separation, the type of system earthing of the PEI is the one defined by the DSO.

NOTE If an LV-LV transformer providing galvanic separation is inserted between the PEI and the distribution network, the requirements of 82.8.2.2.3 apply.

In island mode, protection by automatic disconnection of supply shall not rely upon the connection to the earthed point of the distribution network when the local power sources are operating as a switched alternative. A suitable means of earthing shall be provided (see IEC 60364-5-55:2011, 551.4.3.2).

Where the SDFI disconnects all live conductors (see Figure 5 and Figure 7), the following applies:

- the type of system earthing of the PEI in island mode can be either TN, TT or IT;
- except for the IT system without reference, a system referencing conductor switching device shall be installed on the PEI side of the SDFI according to 82.8.2.2.4;
- where the PEI includes several earth electrodes with no interconnection (in alternating current, as this cannot be done in direct current due to corrosion), TN is not allowed;
- where the IT system is designed to not disconnect in the event of first fault, the installation shall be operated only by instructed (BA4) or skilled (BA5) persons (see IEC 60364-5-51, see also IEC 60364-5-53:2019, 537.2.1);
- for a TN system, the requirements for the earthing arrangement and protective device of 82.8.2.2.5 apply;
- for a TT system, the requirements for the earthing arrangement and protective device of 82.8.2.2.6 apply;
- for an IT system, the requirements for the earthing arrangement and protective device of 82.8.2.2.7 apply.

Table 1 details possible combinations of types of system earthing in connected mode and island mode for PEIs and the associated requirements for the system referencing conductor switching device.

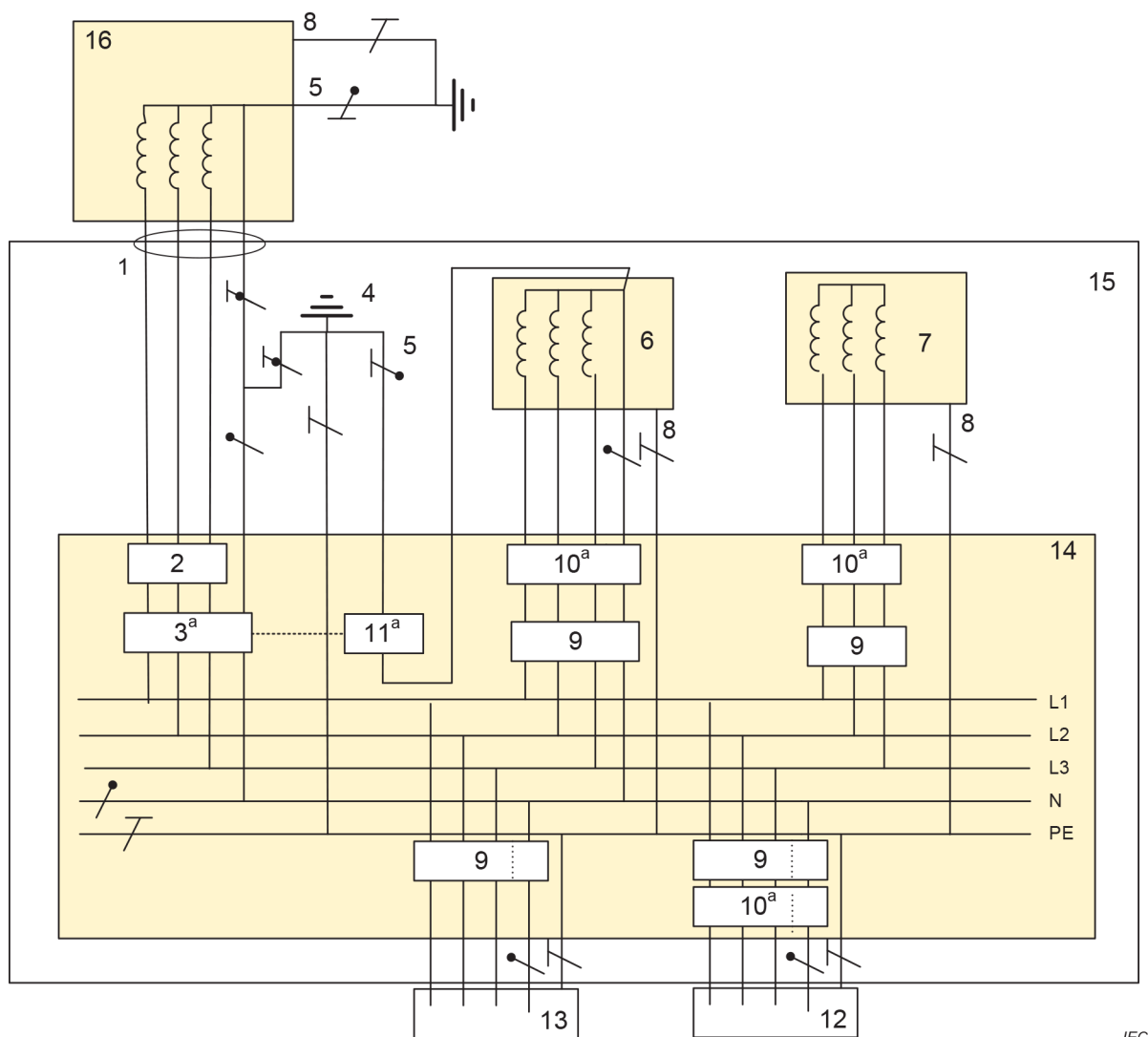
Examples of some possible configurations are given in Figure 5 to Figure 11.

A TN-C-S system is allowed if the local source earth fault current is sufficient to trip the overcurrent protection in the maximum disconnection time given in IEC 60364-4-41. If sufficient earth fault current is not available, then other provisions shall be made.

The flow of stray currents induced by a possible DC subpart of the PEI shall be taken into account (for corrosion consideration for example, as in any TT installation).

Table 1 – Combinations of possible types of system earthing in connected mode and island mode for PEIs and associated requirements for system referencing conductor switching device

AC type of system earthing in grid connected mode	AC type of system earthing in island mode	Island mode possible Y/N	Need for system referencing conductor switching device	Illustrating figure
TT	TT	Y	Y	
	TN-S	Y	Y	Figure 7, Figure 8
	IT	Y	N but need to start insulation monitoring or switch on artificial neutral point	
TN-S	TT	Y	Y	
	TN-S	Y	Y except if neutral to earth connection on load side	Figure 9, Figure 10
	IT	Y	N but need to start insulation monitoring or switch on artificial neutral point	
TN-C-S	TT	N		
	TN-S	Y	Y	Figure 5
	TN-C-S	Y	N, but local earthing electrode needed	Figure 6
	IT	N		
TN-C	TT	N		
	TN	N		
	IT	N		
IT	TT	Y	Y	
	TN-S	Y	Y	
	IT	Y	N	Figure 12
NOTE This table deals with AC 3 lines + neutral system, for AC 1 line + neutral system, see Annex D.				

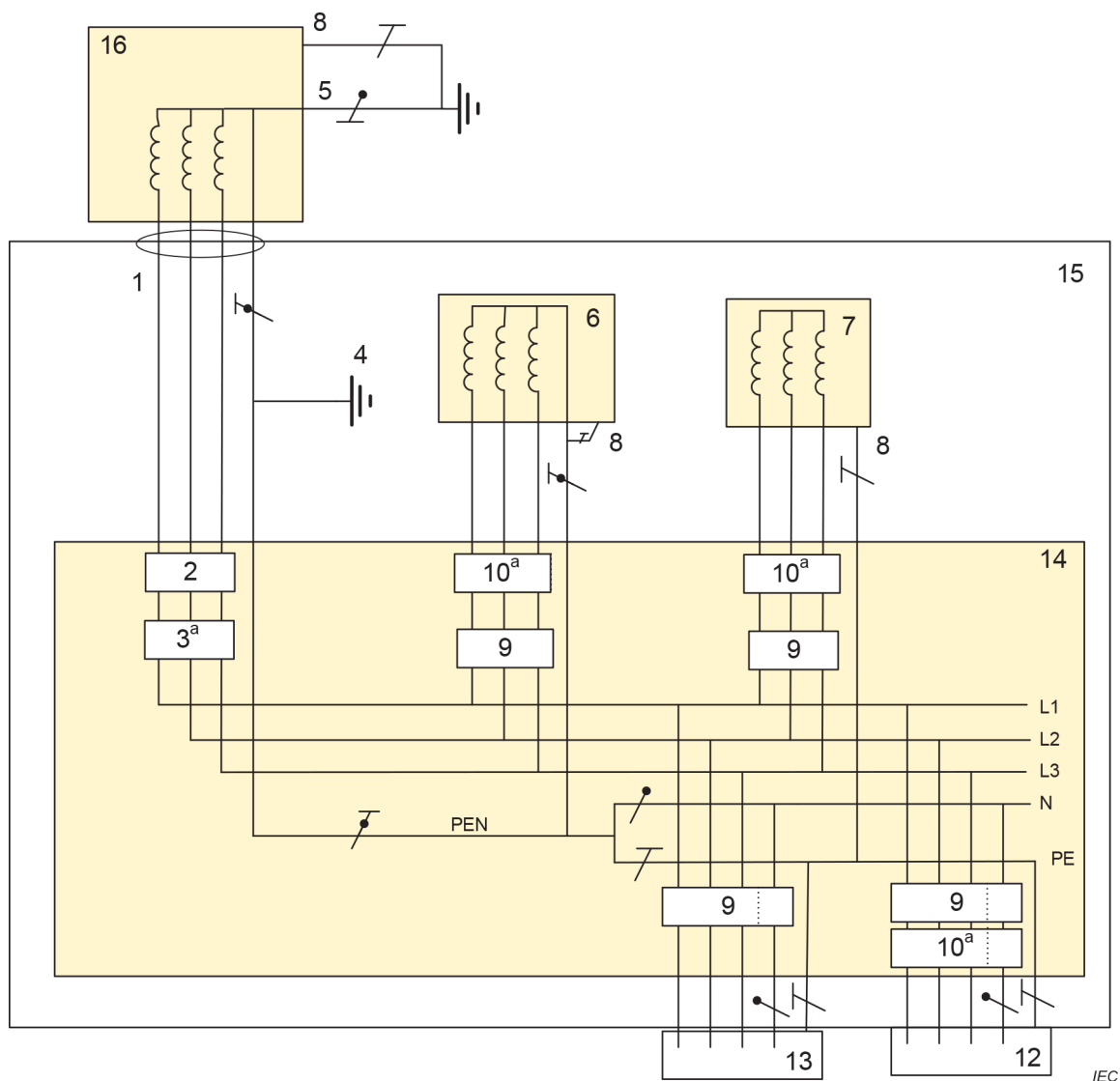


IEC

Key

- 1 Point of connection with DSO (POC)
 - 2 Main overcurrent protective device (OCPD)
 - 3 Switching device for islanding (SDFI)
 - 4 Local earthing electrode
 - 5 System referencing conductor
 - 6 Local source (rotating generator or grid forming converter)
 - 7 Local source without neutral
 - 8 Protective conductor for exposed conductive part of local source
 - 9 Overcurrent protective device suitable for isolation
 - 10 Switching device
 - 11 System referencing conductor switching device interlocked with SDFI (3)
 - 12 Sheddable loads
 - 13 Non-sheddable loads
 - 14 Main distribution board
 - 15 PEI
 - 16 DSO HV/LV transformer
- ^a These devices are controlled by the EEMS.

Figure 5 – Example of architecture of PEI connected to LV DSO operating in TN-C-S in connected mode and becoming TN-S in island mode

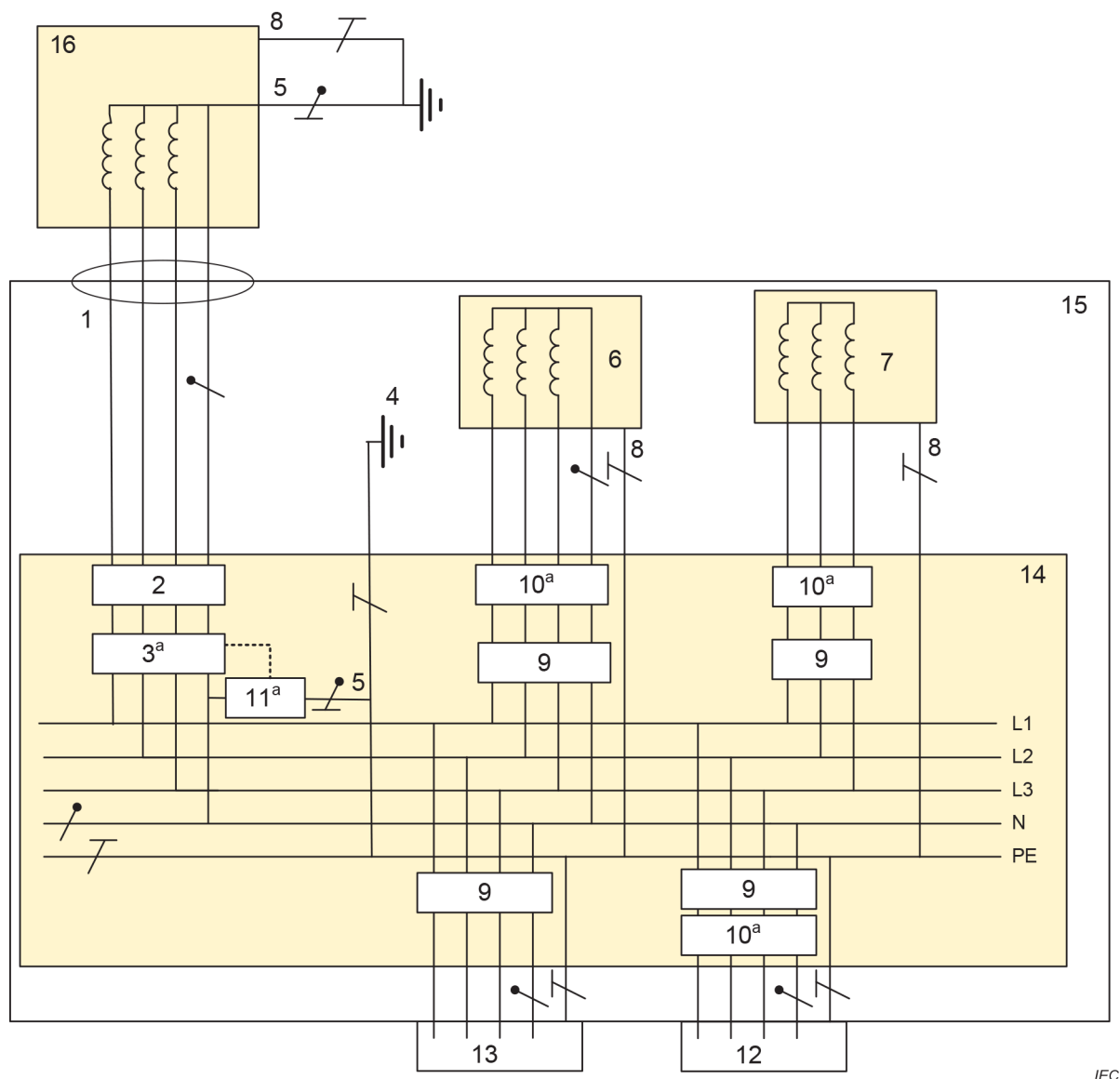


IEC

Key

- 1 Point of connection with DSO (POC)
- 2 Main overcurrent protective device (OCPD)
- 3 Switching device for islanding (SDFI)
- 4 Local earthing electrode
- 5 System referencing conductor
- 6 Local source (rotating generator or grid forming converter)
- 7 Local source without neutral
- 8 Protective conductor for exposed conductive part of local source
- 9 Overcurrent protective device suitable for isolation (possibly combined with an RCD)
- 10 Switching device
- 11 Vacant
- 12 Sheddable loads
- 13 Non sheddable loads
- 14 Main distribution board
- 15 PEI
- 16 DSO HV/LV transformer
- ^a These devices are controlled by the EEMS.

Figure 6 – Example of architecture of PEI connected to LV DSO operating in TNC-S in connected mode and in island mode



Key

- | | |
|----|---|
| 1 | Point of connection with DSO (POC) |
| 2 | Main overcurrent protective device (OCPD) |
| 3 | Switching device for islanding (SDFI) interlocked with system referencing conductor switching device (11) |
| 4 | Local earthing electrode |
| 5 | System referencing conductor |
| 6 | Local source (rotating generator or grid forming converter) |
| 7 | Local source without neutral |
| 8 | Protective conductor for exposed conductive part of local source |
| 9 | Overcurrent protective device suitable for isolation (possibly combined with an RCD) |
| 10 | Switching device |
| 11 | System referencing conductor switching device interlocked with SDFI (3) |
| 12 | Sheddable loads |
| 13 | Non sheddable loads |
| 14 | Main distribution board |
| 15 | PEI |
| 16 | DSO HV/LV transformer |
| a | These devices are controlled by the EEMS. |

Figure 7 – Example of architecture of PEI connected to LV DSO with disconnection of the neutral, operating in TT in connected mode and becoming TN in island mode

82.8.2.2.3 Islandable PEI connected to HV distribution network through HV/LV transformer

82.8.2.2.3.1 General

When the PEI is supplied in connected mode from the HV distribution network through the HV/LV transformer, selection of the low-voltage type of system earthing shall be done during the design phase.

The selection of type of system earthing shall ensure the proper functioning in both connected mode and island mode. The preferred selection is to use the same type of system earthing for connected mode and island mode.

NOTE PEIs with an SDFI in high voltage are not in the scope of this document.

82.8.2.2.3.2 PEI with system referencing conductor on the transformer side of SDFI

NOTE 1 When the LV installation is supplied by several transformers in parallel, the requirements apply to each transformer.

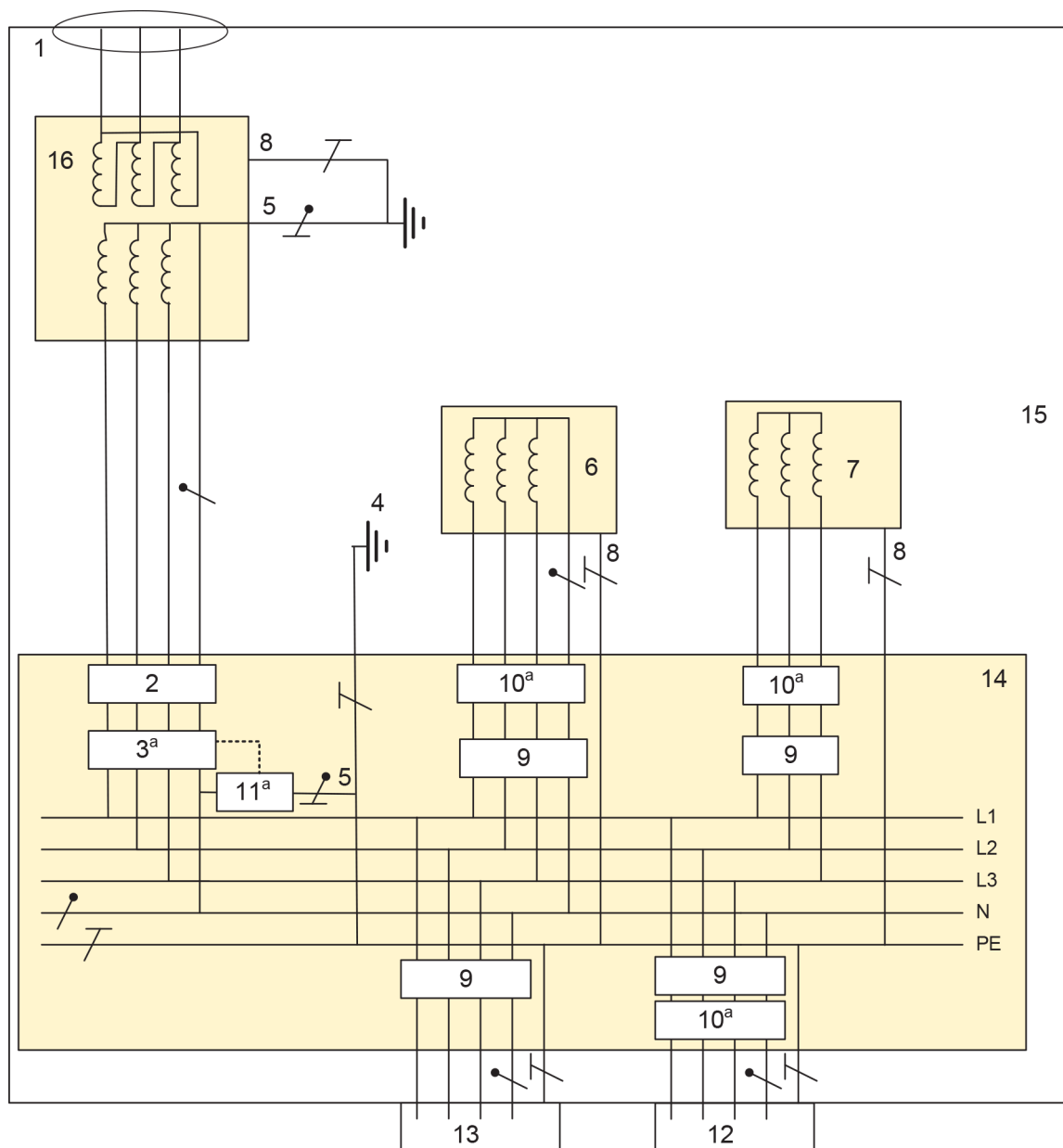
NOTE 2 When the LV installation is supplied by a generator with neutral point earthed as an alternate supply to the HV distribution network, the requirements apply the same way with the generator as with a transformer.

An SDFI according to 82.6.3.4 shall disconnect all live conductors including the neutral on the LV side of the HV/LV transformer.

The type of system earthing of the PEI in island mode can be TN, TT or IT considering the following:

- if the PEI includes several earth electrodes with no interconnection, TN shall not be selected for island mode;
- for TN, TT and IT with impedance or artificial neutral point a system referencing conductor switching device shall be installed on the PEI side of the SDFI according to 82.8.2.2.4;
- in TN, TT and IT systems, requirements for the earthing arrangement and protective device of 82.8.2.2.5, 82.8.2.2.6 and 82.8.2.2.7 respectively apply;
- the IT system designed not to disconnect in the event of first fault shall be applied only in installations operated by instructed (BA4) or skilled (BA5) persons (see also IEC 60364-5-53: 2019, 537.2.1).

In a TN system, the neutral to earth link of the transformer can be used for the neutral to earth connection, in which case the SDFI shall not disconnect the neutral. This solution is not recommended as disturbance from the HV network (overvoltage) can still affect the PEI in island mode and maintenance operation on the transformer are not possible during islanded operation. For the TN type of system earthing, it is recommended to connect the system referencing conductor to the earth on a PEI side of the SDFI (see 82.8.2.2.3.3). A TN-C system between the HV/LV transformer and the main distribution board can also be used (see Figure 8).



IEC

Key

- | | |
|----|---|
| 1 | Point of connection with DSO (POC) |
| 2 | Main overcurrent protective device (OCPD) |
| 3 | Switching device for islanding (SDFI) interlocked with system referencing conductor switching device (11) |
| 4 | Local earthing electrode |
| 5 | System referencing conductor |
| 6 | Local source (rotating generator or grid forming converter) |
| 7 | Local source without neutral |
| 8 | Protective conductor for exposed conductive part of local source |
| 9 | Overcurrent protective device suitable for isolation (possibly combined with an RCD) |
| 10 | Switching device |
| 11 | System referencing conductor switching device interlocked with SDFI (3) |
| 12 | Sheddable loads |
| 13 | Non sheddable loads |
| 14 | Main distribution board |
| 15 | PEI |
| 16 | HV/LV transformer |
| a | These devices are controlled by the EEMS. |

Figure 8 – Example of PEI installation with neutral earthing on the HV/LV transformer side: TT in connected mode, TN in island mode (as one unique earthing arrangement in the installation)

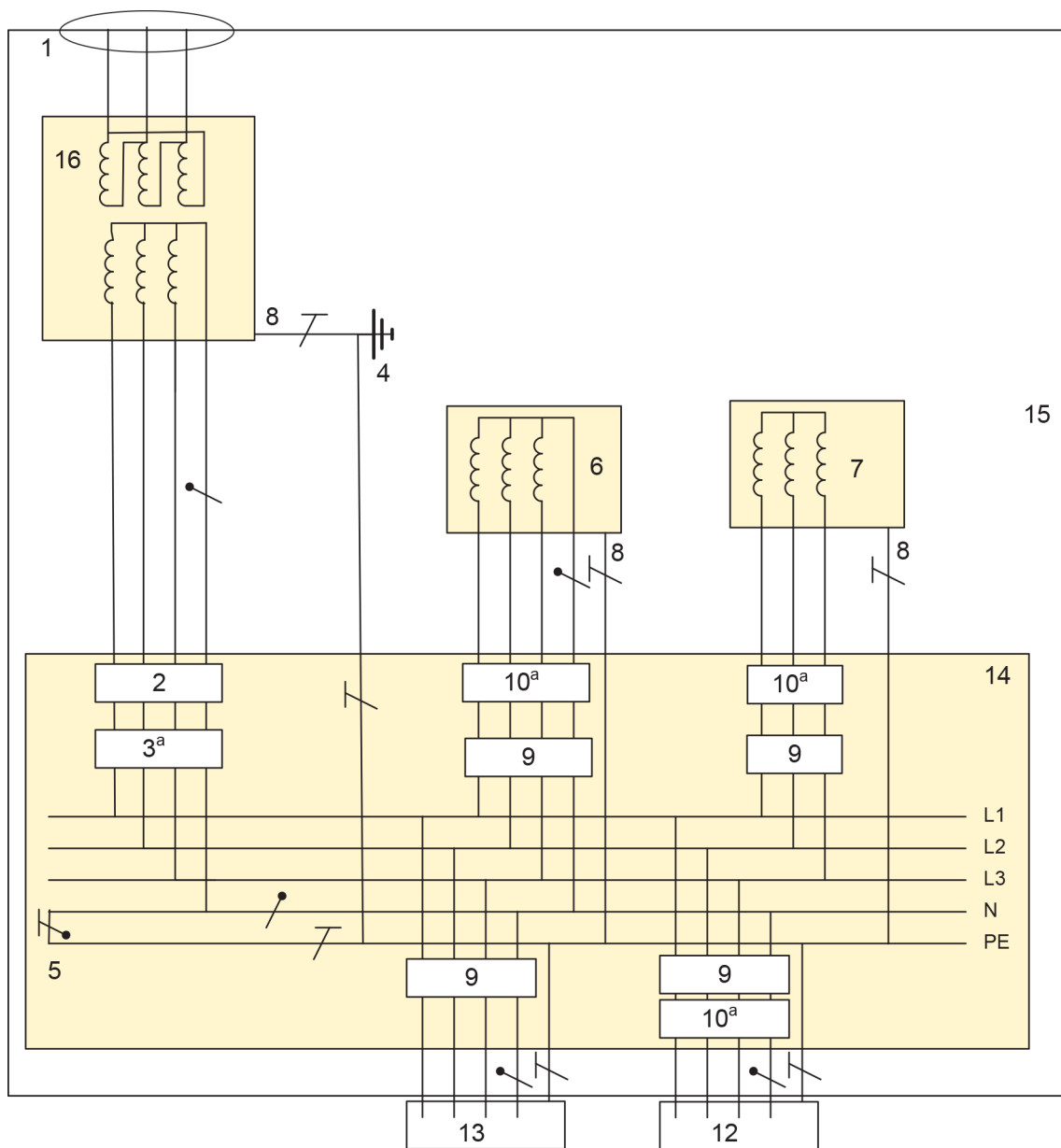
82.8.2.2.3.3 PEI with system referencing conductor on the PEI side of the SDFI

This arrangement is recommended for PEIs as it allows to have one single permanent neutral to earth link (with or without impedance).

An SDFI shall disconnect all live conductors (including the neutral on the LV side of the HV/LV transformer).

The type of system earthing of the PEI in island mode shall be the same as in connected mode (see Figure 9).

In TN, TT and IT systems, requirements for earthing arrangement and protective device of 82.8.2.2.5, 82.8.2.2.6, 82.8.2.2.7 respectively apply.



IEC

Key

- 1 Point of connection with DSO (POC)
 - 2 Main overcurrent protective device (OCPD)
 - 3 Switching device for islanding (SDFI)
 - 4 Local earthing electrode
 - 5 System referencing conductor
 - 6 Local source (rotating generator or grid forming converter)
 - 7 Local source without neutral
 - 8 Protective conductor for exposed conductive part of local source
 - 9 Overcurrent protective device suitable for isolation (possibly combined with an RCD)
 - 10 Switching device
 - 11 Vacant
 - 12 Sheddable loads
 - 13 Non sheddable loads
 - 14 Main distribution board
 - 15 PEI
 - 16 HV/LV transformer
- ^a These devices are controlled by the EEMS.

Figure 9 – Example of PEI installation in TN-S with neutral permanently earthed on PEI side

82.8.2.2.4 System referencing conductor switching device

82.8.2.2.4.1 General

When required due to the type of system earthing, the system referencing conductor switching device shall comply with the following requirements.

82.8.2.2.4.2 Characteristics of the system referencing conductor switching device

This device shall be connected between the system referencing conductor and the local earthing arrangement of the installation according to the selected type of system earthing. The system referencing conductor is connected to the neutral or mid-point, when available, or to a one-line conductor.

The earthing arrangement needed for operating the PEI in island mode shall be connected to a local earthing electrode. In addition, the one for the DSO distribution network can also be used.

Disconnection of the conductor used for connection to the earthing arrangement shall comply with the requirements of isolation according to IEC 60364-5-53:2019, 536.2.

This device and the system referencing conductor shall be capable of making and withstanding the current that could flow through it in normal operation and in case of fault. The system referencing conductor shall be selected following the rules of IEC 60364-5-54:2011, 542.3.

This device shall be interlocked with an SDFI to ensure the system referencing conductor is connected to the local earthing arrangement when the PEI is islanded from the distribution system, and that the system referencing conductor is disconnected from the local earthing arrangement when the PEI is connected to the grid.

NOTE Both functions could be done by a single device.

This device should be located close to the switching device used for islanding. Mechanical interlocking with the switching device used for islanding is preferred. When prosumer local supplies are not located close to the POC to the distribution system, an electrical interlocking can be accepted.

In island mode, if the system referencing conductor switching device is open, all local power supplies shall be disconnected from the PEI.

Operation without reference to the system to earth is accepted during a short time (typically less than 5 s) in the case of transition from island mode to connected mode and/or connected mode to island mode without power interruption.

Provision shall be made to prevent the inadvertent and/or unauthorized opening of this device. This can be achieved by locating the device in a cabinet locked with a key or tool unless it is in a location where only skilled or instructed persons may obtain access.

82.8.2.2.4.3 Location of system referencing conductor switching device

When the PEI includes only one local supply, the earthing of the system referencing conductor can be done at the supply location.

When the PEI includes several local supplies operating in parallel, the earthing of the system referencing conductor shall be common to all supplies. It is recommended to connect all supplies to the same distribution board including also the SDFI and the system referencing conductor switching device. For extended large installations, the global installation should be split into different PEIs.

NOTE In some countries, accessibility to the DSO is required for the SDFI (control and/or status of the SDFI).

82.8.2.2.5 Island mode in TN

A local earth electrode shall be erected.

When a system referencing conductor switching device is necessary, it shall connect the reference conductor to the earth, through the main earthing terminal and local earth electrode. All exposed-conductive-parts of the installation shall be connected to the same earthing terminal (according to IEC 60364-4-41:2005, 411.4.2 and IEC 60364-4-41:2005/AMD1:2017, 411.4.2).

As the system is designed to operate in connected mode with multiple sources, IEC 60364-1:2005, 312.2.1.2 applies. A single system referencing conductor between neutral and earth exists in connected mode and in island mode.

The characteristics of the protective devices and the circuit impedances shall fulfil the requirements of IEC 60364-4-41:2005, 411.4.4 and IEC 60364-4-41:2005/AMD1:2017, 411.4.4.

The source impedance to be considered for the fault loop impedance calculation shall be the least powerful local power supplies able to run in islanding mode.

In a PEI that can operate with local power supplies based on an electronic power converter with limited capability to provide fault current:

- automatic disconnection of the supply in case of fault cannot be ensured in all cases relying only on overcurrent protection;
- RCDs shall be used to fulfil disconnection time (see IEC 60364-4-41:2005, Table 41.1). In particular when the neutral to earth link is done at the main distribution board level, an RCD located on the neutral to earth link shall disconnect all local power sources (see Figure 10);
- a TN-C system shall not be applied.

NOTE If there is only one source including a system referencing conductor switching device, an RCD can be placed on the circuit between this source and the rest of the installation.

For proper operation of the installation in island mode, division of circuits and selectivity of RCDs should be considered.

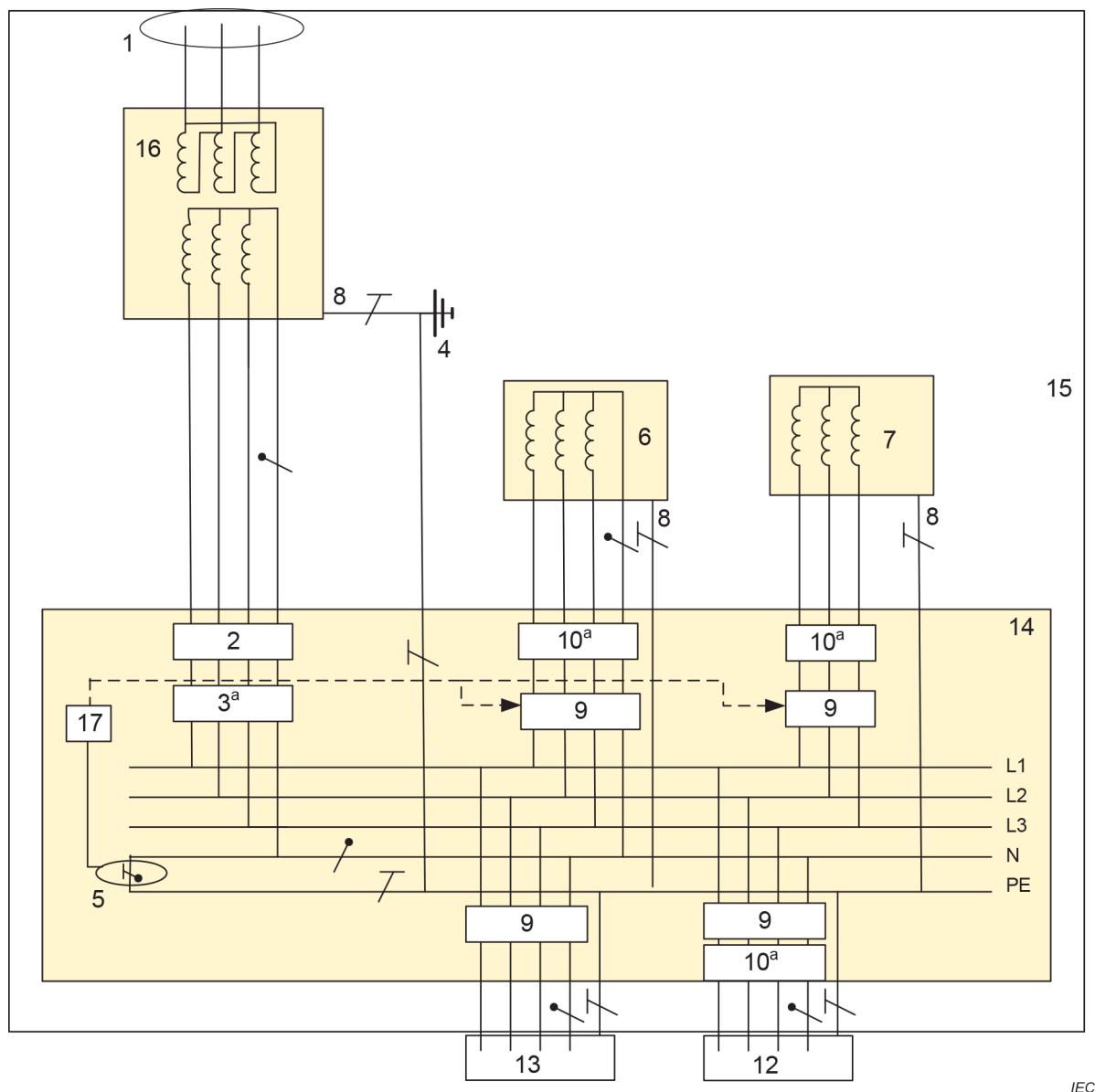
For power supplies based on an electronic power converter without manufacturer's instructions, the impedance of the grid forming the power electronic converter (PEC) can be calculated as follows:

$$Z_{\text{PEC}} = 1,2 \times U_o^2 / S_n$$

where

- Z_{PEC} is the impedance in ohms (Ω) of the PEC source to include in the fault loop;
- U_o is the nominal line to line voltage in volts (V) in AC 3 phase, or line to line voltage in DC or line to neutral in single phase voltage;
- S_n is the rated power in kVA of the PEC.

EXAMPLE A 400 V 50 kVA three phase grid forming storage unit can be characterized as a voltage supply with an internal impedance of $1,2 \times 400 \times 400 / 50\,000 = 3,84 \, \Omega$ capable of delivering an earth fault current of 60 A.



Key

- 1 Point of connection with DSO (POC)
 - 2 Main overcurrent protective device (OCPD)
 - 3 Switching device for islanding (SDFI)
 - 4 Local earthing electrode
 - 5 System referencing conductor
 - 6 Local source (rotating generator or grid forming converter)
 - 7 Local source without neutral
 - 8 Protective conductor for exposed conductive part of local source
 - 9 Overcurrent protective device suitable for isolation (possibly combined with an RCD)
 - 10 Switching device
 - 11 Vacant
 - 12 Sheddable loads
 - 13 Non-sheddable loads
 - 14 Main distribution board
 - 15 PEI
 - 16 HV/LV transformer
 - 17 Modular RCD disconnecting all local supplies of the PEI in case of fault
- ^a These devices are controlled by the EEMS.

Figure 10 – Example of PEI installation in TN-S with neutral permanently earthed on PEI side with RCD on the system referencing conductor

82.8.2.2.6 Island mode in TT

When a system referencing conductor switching device is necessary it shall connect the system referencing conductor to a local earthing electrode as specified in IEC 60364-4-41:2005, 411.5.1.

Where a residual current protective device (RCD) is used for fault protection, the requirements of IEC 60364-4-41:2005, 411.5.3 shall be fulfilled considering the value of the resistance of the local earth electrode.

Where an overcurrent protective device is used for fault protection, the requirements of IEC 60364-4-41:2005, 411.5.4 and IEC 60364-4-41:2005/AMD1:2017, 411.5.4 shall be fulfilled.

The source impedance to be considered for the fault loop impedance calculation shall be the least powerful local power supplies able to run in islanding mode.

When a neutral to earth link is done at the main distribution board level, an RCD located on the neutral to earth link shall disconnect all local power sources.

For correct operation of the installation in island mode, the division of circuits and selectivity of the RCD shall be considered.

For power supplies based on an electronic power converter, without manufacturer's instructions, the impedance of the grid forming electronic power converter (EPC) shall be calculated as described in 82.8.2.2.5.

82.8.2.2.7 Island mode in IT

When an IT system is selected for the island mode, the requirements of IEC 60364-4-41:2005, 411.6 and IEC 60364-4-41:2005/AMD1:2017, 411.6 apply.

NOTE 1 In an IT system, the following parts of the IEC 60364 series are also taken into consideration: IEC 60364-4-43:2008, 431.2.2, IEC 60364-4-44:2007, 442.4, IEC 60364-5-53:2019, Clause 531 and IEC 60364-5-53:2019/AMD1:2020, Clause 531, IEC 60364-5-53:2019, Clause 537.

An insulation monitoring device shall be provided to indicate the occurrence of a first fault from a live part to exposed-conductive-parts or to earth (see Figure 11). This device shall initiate an audible and/or visual signal which shall continue as long as the fault persists. If there are both audible and visible signals, it is permissible for the audible signal to be cancelled.

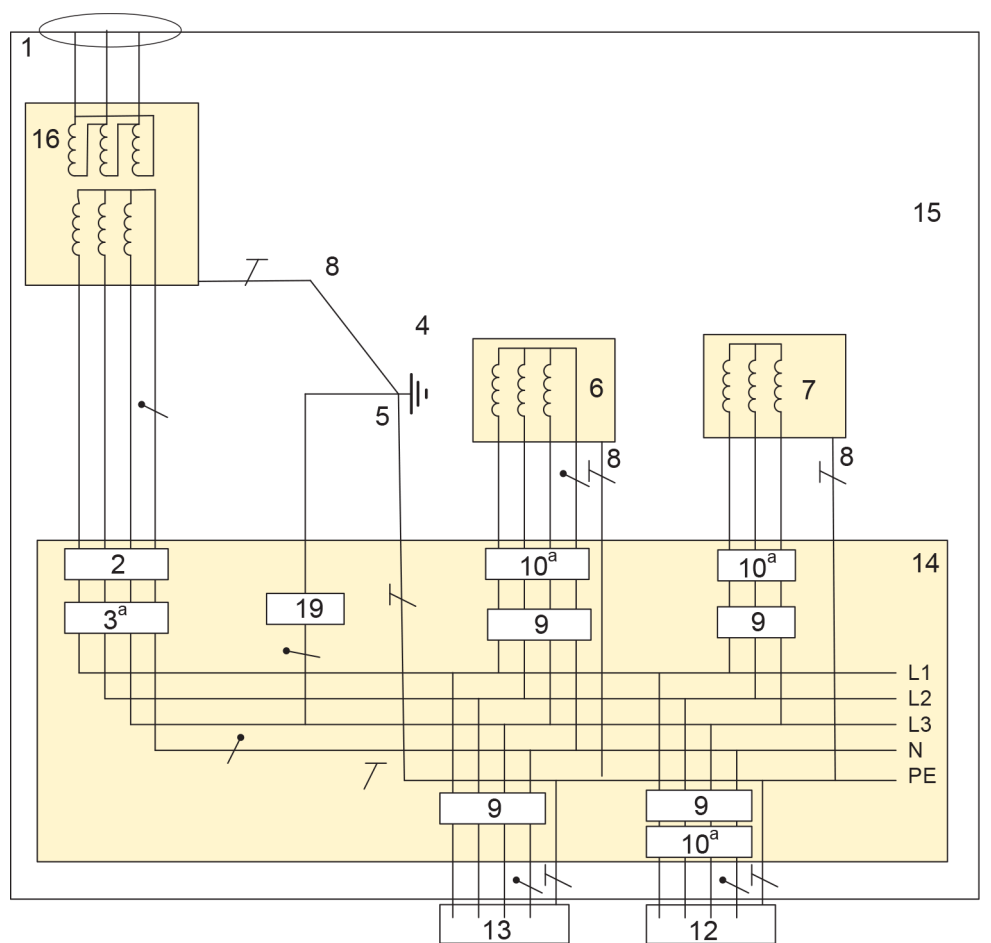
It is recommended to eliminate the first fault with the shortest practicable delay (typically less than 2 h). Therefore, an insulation fault location system can be used in order to locate rapidly the fault, before occurrence of a second fault.

NOTE 2 Requirements for monitoring are given in IEC 60364-5-53:2019, Clause 537.

The condition of automatic disconnection of the supply in case of second fault shall be checked according to IEC 60364-4-41:2005, 411.6.4 considering local supply impedance. For power supplies based on electronic power converter, without manufacturer's instructions, the impedance of the grid forming power electronic converter (PEC) shall be calculated as described in 82.8.2.2.5. For an IT system with artificial neutral point, an automatic disconnection of supply can be used to eliminate the first fault and so insulation monitoring device is not compulsory.

For an IT system with artificial neutral point, the requirements applying to the system referencing conductor switching device shall apply to the switching device connecting the transformer creating the artificial neutral point (see Figure 12).

For an IT system with artificial neutral point, the system referencing conductor switching device shall be installed between line conductors and the artificial neutral point.

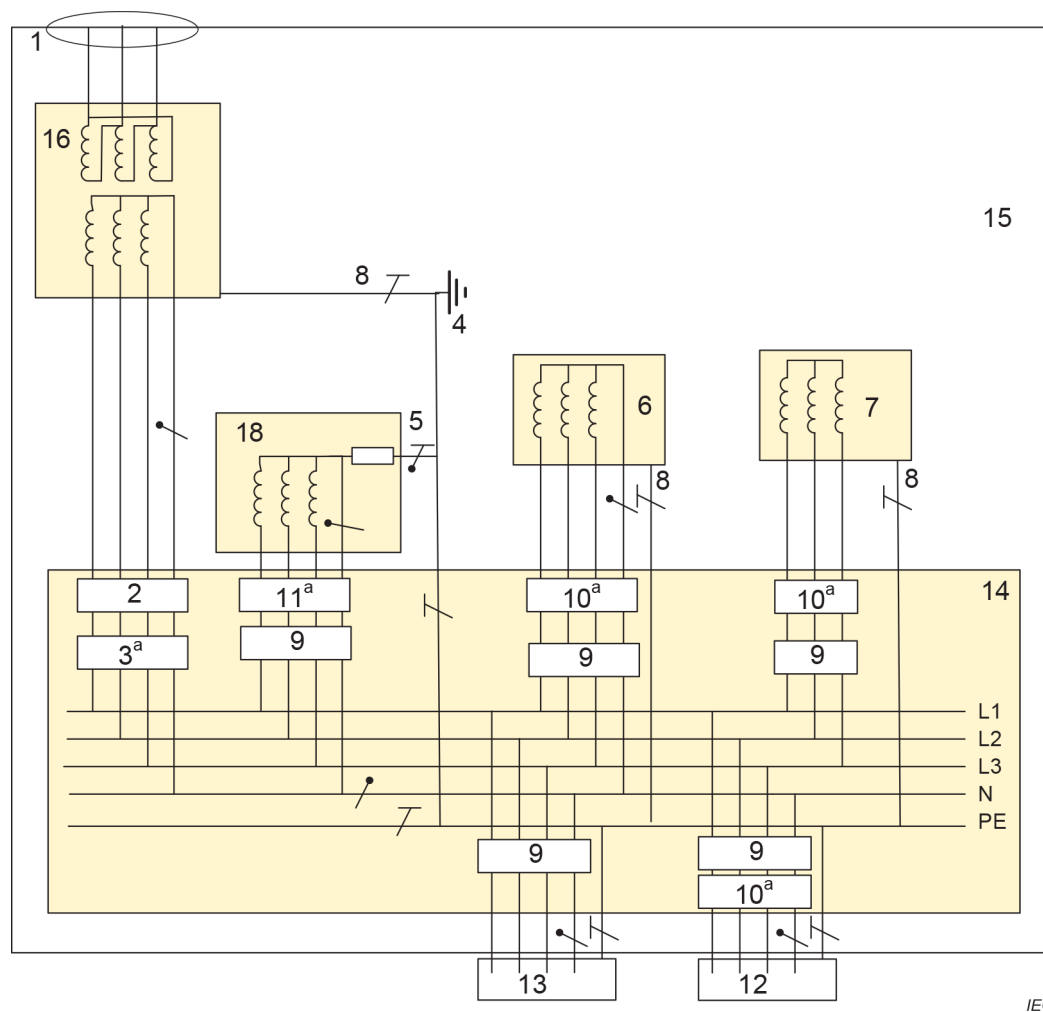


IEC

Key

- 1 Point of connection with DSO (POC)
 - 2 Main overcurrent protective device (OCPD)
 - 3 Switching device for islanding (SDFI)
 - 4 Local earthing electrode
 - 5 System referencing conductor
 - 6 Local source with neutral (rotating generator or grid forming converter)
 - 7 Local source without neutral
 - 8 Protective conductor for exposed conductive part of local source
 - 9 Overcurrent protective device suitable for isolation (possibly combined with an RCD)
 - 10 Switching device
 - 11 Vacant
 - 12 Sheddable loads
 - 13 Non sheddable loads
 - 14 Main distribution board
 - 15 PEI
 - 16 HV/LV transformer
 - 17 Vacant
 - 18 Vacant
 - 19 Insulation monitoring device
- ^a These devices are controlled by the EEMS.

Figure 11 – Example of PEI in IT system in island mode



IEC

Key

- 1 Point of connection with DSO (POC)
- 2 Main overcurrent protective device (OCPD)
- 3 Switching device for islanding (SDFI)
- 4 Local earthing electrode
- 5 System referencing conductor
- 6 Local source (rotating generator or grid forming converter)
- 7 Local source without neutral
- 8 Protective conductor for exposed conductive part of local source
- 9 Overcurrent protective device suitable for isolation (possibly combined with an RCD)
- 10 Switching device
- 11 Switching device for artificial neutral point
- 12 Sheddable loads
- 13 Non sheddable loads
- 14 Main distribution board
- 15 PEI
- 16 HV/LV transformer
- 17 Vacant
- 18 Artificial neutral point (eg Wye Delta or ZigZag transformer)
- ^a These devices are controlled by the EEMS.

Figure 12 – Example of PEI in IT system in island mode with automatic disconnection of supply

82.8.2.3 Bidirectional AC/DC converter (active front end)

Regarding protective measures to be implemented in a PEI with AC and DC subparts (see Figure 2), and specifically regarding the protection of the AC side against earth faults on the DC side, two situations occur depending on the arrangement between the AC side and the DC side of the installation.

- the installation provides at least a simple separation between the AC side and the DC side:
This insulation is provided by separate windings of a transformer or relies on the insulation provided by the converter. In this last case, the manufacturer's instructions shall state that the converter provides at least simple separation between the AC side and the DC side.

A dedicated earthing system and related protective measures shall be implemented on the DC part, but no supplementary measure is required on the AC side to protect against line to earth fault on the DC side.

- the installation does not provide a separation between the AC side and the DC side:

An RCD shall protect the AC side against line to earth fault on the DC side.

The RCD shall be of type B in accordance with IEC 62423 for residual current operated circuit-breakers or with IEC 60947-2:2016, Annex B for circuit-breakers incorporating residual current protection or Annex M for modular residual current devices and IEC 60947-2:2016/AMD1:2019, Annex B or Annex M.

In case of line to earth fault on the DC side, two possibilities occur:

- the DC part is designed to operate in an IT system, and adequate protective measures are implemented (see IEC 60364-4-41:2005, 411.6 and IEC 60364-4-41:2005/AMD1:2017, 411.6);
- the DC part is not designed to operate in an IT system, and all local supplies supplying this DC part shall be disconnected.

Without separation between the AC side and DC side, DC currents from the DC side will have an impact on the AC side (saturation of transformers, corrosion, earthing issues, EMC, selectivity from AC to DC faults and vice versa, RCD functioning on AC side, etc.) and vice versa.

82.8.3 Protection against thermal effect

The requirements of IEC 60364-4-42 apply to PEIs.

To protect against fire in case of a fault within the installation, any fault current as a result of a short circuit shall be cleared within 5 s, except for fault currents as a result of a first earth fault in an IT installation.

In most cases this is done by the overcurrent protection device. The overcurrent protection does not protect against fire in a PEI that can operate with local power supplies based on an electronic power converter with limited capability to provide fault current. Complementary measures shall be provided.

NOTE Examples of solutions are undervoltage relays, or a combination of undervoltage relays and overcurrent protections.

As a PEI can include batteries, fire prevention regarding this type of equipment shall be taken into consideration (see IEC 60364-5-57).

82.8.4 Protection against overcurrent

82.8.4.1 Magnitude of overcurrent

Overload and short circuit currents shall be determined at every point of the PEI where a protective device shall be installed:

- for all possible configurations of each type of PEI; and

- for situations corresponding to the minimum and maximum current magnitudes.

To comply with the requirements of IEC 60364-4-43 in all circumstances, the following shall be taken into consideration:

- the operating mode affects the overcurrent's magnitude and direction. For an islandable PEI, the short-circuit current will have a different magnitude and possibly direction when the PEI is connected or intentionally in island mode. The short circuit can be fed by each source. The solar photovoltaic cells are considered to be current mode power sources with the short-circuit current close to the maximum current in normal operation; therefore, detection of a short circuit powered only by such a local source can be difficult using only overcurrent protective devices and shall require complementary means.
- in the case where a system of batteries is connected in parallel with the solar photovoltaic system, the short-circuit current can be higher.

The selection of overcurrent protective devices shall consider:

- the maximum short-circuit level (typically connected mode) for the selection of breaking capacity; and
- the minimum short-circuit level (typically island mode) for the setting of the tripping characteristics of the short-circuit protective device in each mode intended to be used.

82.8.4.2 Location of overcurrent protective devices

According to IEC 60364-5-53:2019, 533.4.1, devices required by IEC 60364-4-43 for either overload or short-circuit protection or both shall be installed at the origin of each circuit, unless the exceptions of either IEC 60364-5-53:2019, 533.4.2 for overload protection or IEC 60364-5-53:2019, 533.4.3 for short-circuit protection or both are applied.

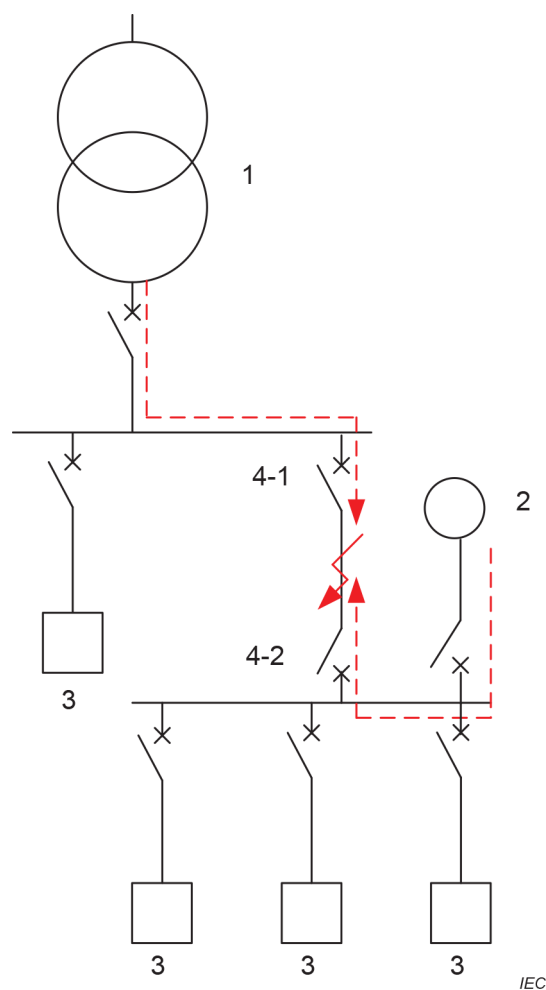
In a PEI, the origin of a circuit interconnecting two or more sources (local sources and/or DSO) able to deliver a short-circuit current will depend on the operating mode.

Such a circuit shall be protected against overload and short circuit as follows:

- the device protecting the conductor against overload can be connected within the run of the circuit according to IEC 60364-5-53:2019, 533.4.2.2;
- a device protecting the conductor against short circuit shall be placed at each extremity of the circuit.

Overcurrent protection threshold and operating time of each protective device shall be determined according to the prospective short-circuit current supplied by the source(s) located on the same extremity of the circuit (see Figure 13). Both devices shall be able to make and break the maximum short-circuit current of the two possible supplies. Both devices shall operate to clear a fault within a specified disconnection time.

NOTE Some overcurrent protective device with identified line and load terminals such as a polarized circuit breaker are not suitable for such applications.



Key

- 1 Distribution network
- 2 Local power supply
- 3 Load
- 4-1 Overcurrent protection device (OCPD 1)
- 4-2 Overcurrent protection device (OCPD 2)

Figure 13 – Example of double short-circuit protection for the same circuit

It is recommended to connect local power supplies and local storage units directly to the main distribution board to avoid circuits potentially supplied by both sides.

82.8.4.3 Combined short circuit protection

In case combined short circuit protection is used in the electrical installation in accordance with IEC 60364-5-53:2019, 535.5, coordination between two or more short-circuit protective devices shall consider all possible configurations of power supplies. This requires that the installation designer considers all possible short-circuit currents through all short-circuit protective devices and verifies if coordination between two or more short-circuit protective devices is efficient where needed.

NOTE In some configurations, the short-circuit current through coordinated protective devices cannot be the same.