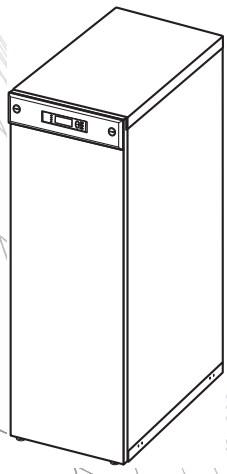
APC
by Schneider Electric

Earthing Principles

MGE™ Galaxy™ 3500 and Smart-UPS® VT

10-40 kVA
380/400/415 V



Contents

Earthing Principles

When considering a UPS installation, it is important to take into account the power system and the earthing requirements. For safety reasons proper UPS earthing is a must in case of a short circuit ensuring that a loop circuit is established for the fault current to return to its origin and thereby trip the actual protective device to clear the fault.

The following is based on the standards given in IEC 60364 and relates to the installation and earthing principles of the UPS systems from APC by Schneider Electric.

According to the standards given in IEC 60364 all power systems are divided into five earthing types: TN-S, TN-C-S, TN-C, TT, IT.

Decoding the earthing types

First letter	T	Connected directly to main earth at a certain point in the power system, normally at the supplying transformer.
	I	The power system is not connected to earth neither to main earth via a large impedance normally at the supplying transformer (I = Isolated)
Second letter	T	The exposed conductive parts are connected directly to earth e.g. the UPS chassis disregarding whether the power system is earthed or not.
	N	The exposed conductive parts e.g. the UPS chassis are connected directly to earth at the main earthing point.
Additional letters	S	The Protective Conductor (PE) and Neutral Conductor (N) are two different and separate conductors (S = Separate).
	C	The Protective Conductor (PE) and Neutral Conductor (N) are one common conductor (PEN) (C = Common).

TN Systems

Characteristics

TN systems have one point connected directly to earth. All exposed conductive parts must be connected to that point by protective conductors.

Depending on the way the neutral and protective conductors are fed, there are three types of TN systems:

- TN-S system: a separate protective conductor is used in the system
- TN-C-S system: the neutral and protective conductors are combined to one single conductor in a part of the system
- TN-C system: the neutral and protective conductors are combined to one single conductor in the whole system

Reference to IEC/EN 60364-4-41 413.1.3

All exposed conductive parts of the installation must be connected to the earthed point of the power system by protective conductors which must be earthed at or near to each relevant transformer or generator.

Exposed conductive parts that are accessible at the same time must be connected to the same earthing system, either individually, in groups or collectively.

Normally the earthed point of the power system is the neutral point. If a neutral point is not available or accessible, a phase conductor must be earthed. The phase conductor must not serve as a PEN conductor.

In fixed installations a single conductor may serve both as a protective conductor and a neutral conductor (PEN conductor).

Reference IEC/EN 60364-5-54, §543.4.3

If, from any point of the installation, the neutral and protective functions are provided by separate conductors, it is not permitted to connect the neutral conductor to any other earthed part of the installation (e.g. protective conduc-tor from the PEN conductor). However, it is permitted to form more than one neutral conductor (N) and more than one protective conductor (PE) from the PEN conductor. Separate terminals or bars may be provided for the protective and neutral conductors. In this case, the PEN conductor shall be connected to the terminal or bar intended for the protective conductor (PE).

Reference to IEC/EN 60364-5-54 546.2.3

If from any point in the installation the neutral and protective functions are provided by separate conductors, it is inadmissible to connect these conductors to each other from that point. At the point of separation, separate terminals or bars must be provided for the protective and neutral conductors. The PEN conductor must be connected to the terminal or bar intended for the protective conductor.

If there are other effective earth connections, the protective conductors must be connected to such points when it is possible. It may be necessary to earth at additional points to ensure that the potentials of protective conductors remain as close as possible to that of earth in case of a fault.

Additional requirements for generating sets (IEC/EN 60364-5-55 551.4.2)

To be used when the generating set provides a switched alternative to the public supply.

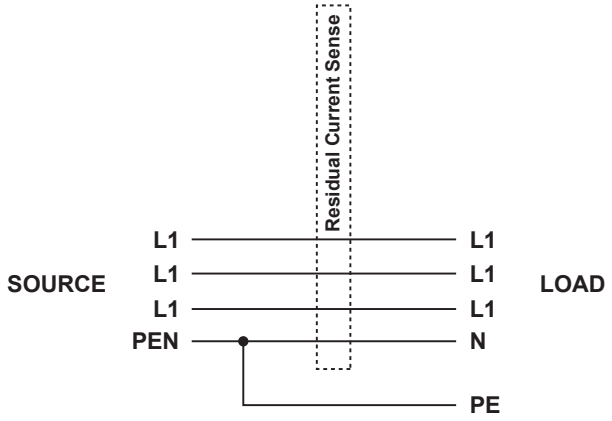
Protection by automatic disconnection of supply must not rely on the connection to the earthed points of the public supply system when the generator is operating as a switched alternative to a TN system. A suitable earth electrode must be provided.

Protective devices in TN systems

The following protective devices are recognized in TN systems:

- Overcurrent protective devices
- Residual current protective devices (not to be used in TN-C systems)

When a residual current protective device is used in a TN-C-S system, a PEN conductor must not be used on the load side. The connection of the protective conductor to the PEN conductor must be made on the source side of the residual current protective device (see below illustration):



The characteristics of protective devices and the circuit impedances shall be such that, if a fault of negligible impedance occurs anywhere in the installation between a phase conductor and a protective conductor or exposed conductive part, automatic disconnection of the supply will occur within the conventional time for TN-systems, IEC/EN 60364-4-41, §413.1.3.3

$$Z_s \times I_a \leq U_0$$

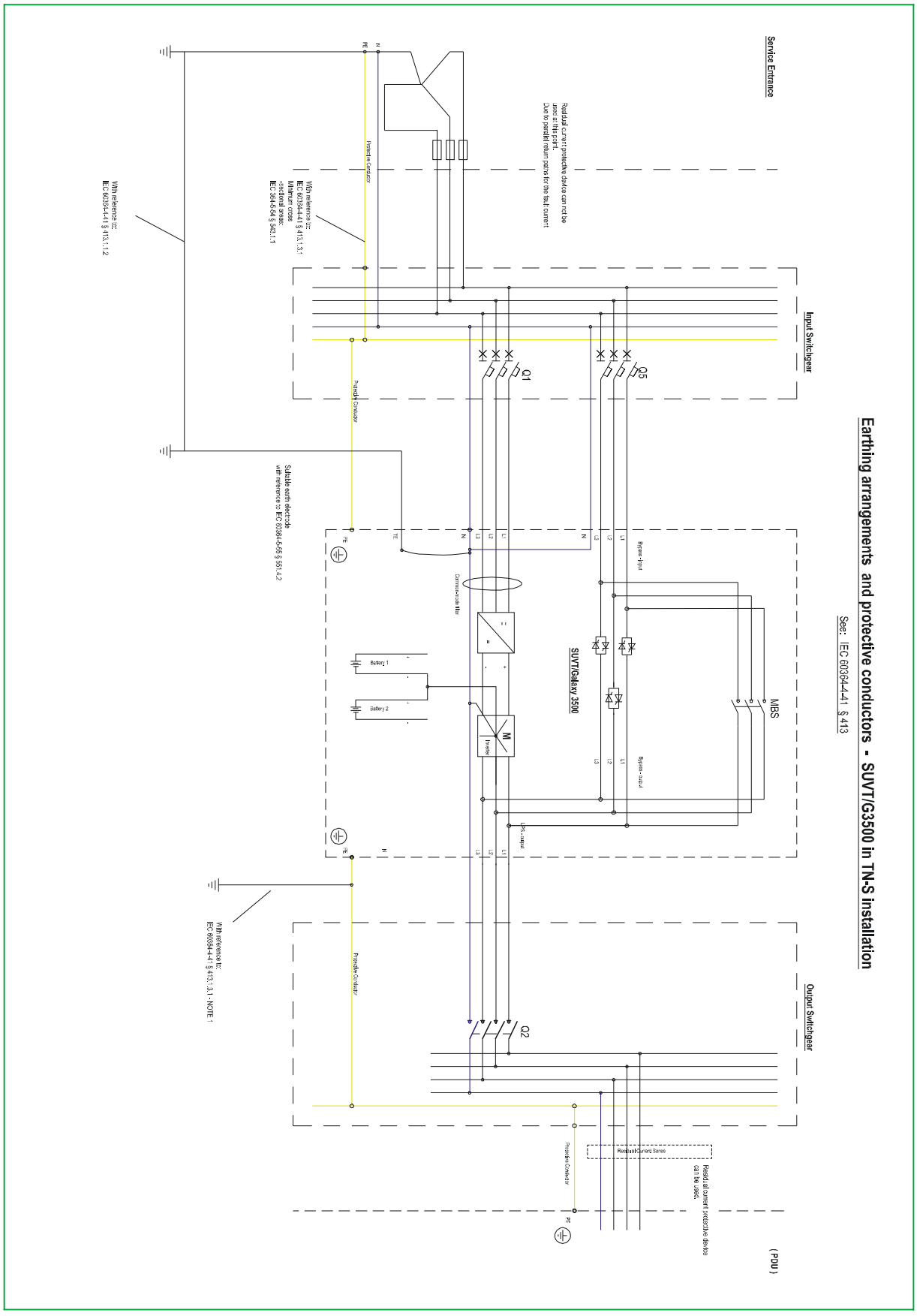
In the condition:

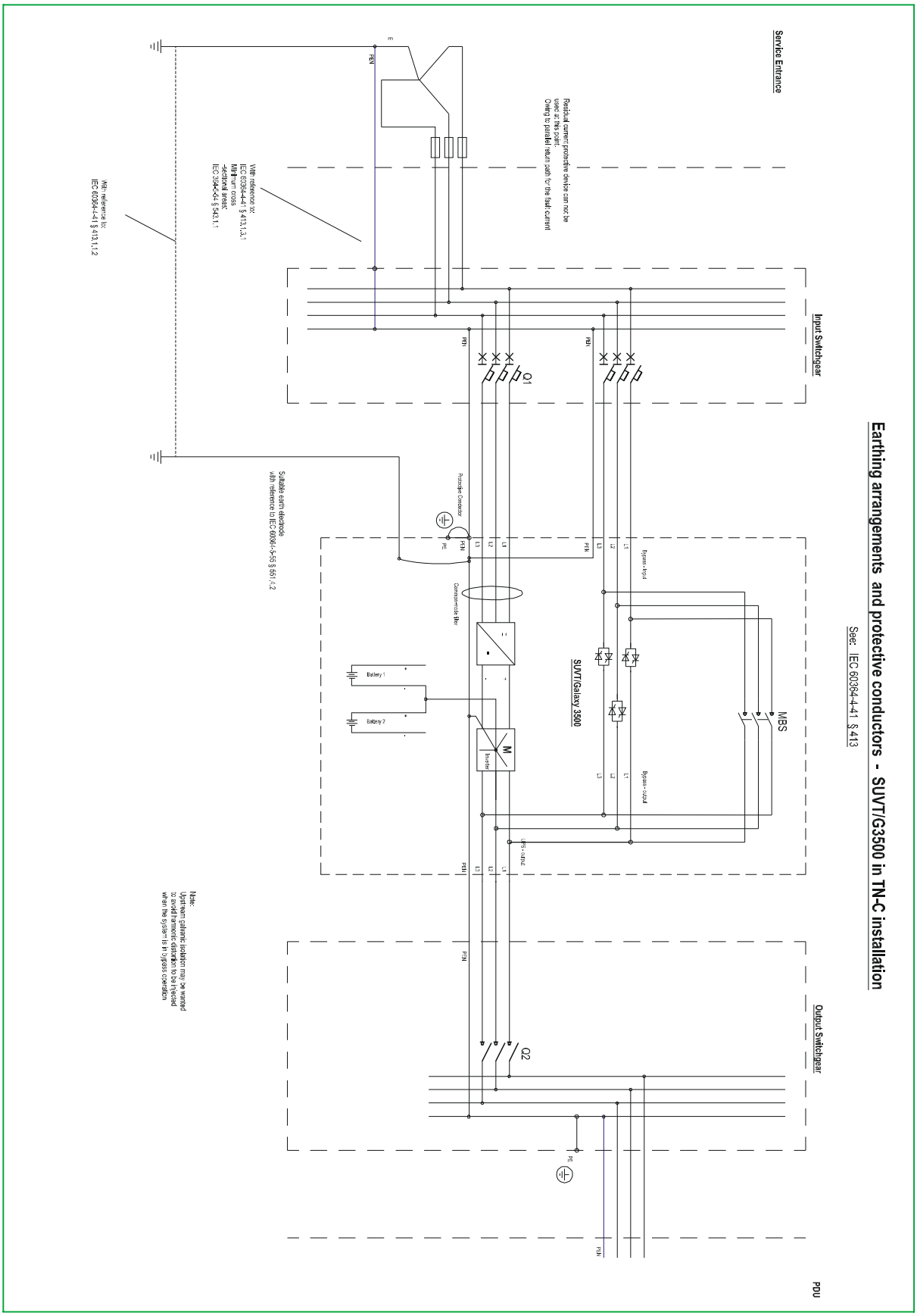
Z_s is the impedance of the fault loop comprising the source, the live conductor up to the point of the fault, and the protective conductor between the point of the fault and the source

I_a is the current causing the automatic operation of the disconnecting protective device within a conventional time not exceeding five seconds

U_0 is the nominal AC RMS voltage to earth

If a fault occurs directly on the output of the UPS but before the power distribution, while the UPS system is in Battery Operation and Bypass is unavailable, the available power is unable to activate the protective device. In this situation the Inverter will shut down in five seconds (IEC 60364-4-41 413.1.3.5 norm).


Earthing arrangements and protective conductors - SUVT/G3500 in TN-S installation
See: IEC 60364-4-41 § 413
Service Entrance
Input Switchgear
Output Switchgear
SUVT/Galaxy 3500
MBS
Q1
Q2
Q5
Battery 1
Battery 2
Inverter
Bypass - input
Bypass - output
Line - output
Commutation filter
Residual current protective device can not be used at this point. Due to parallel return paths for the fault current.
Residual current protective device can be used.
Residual Current Sensor
Protective Conductor
Suitable earth electrode with reference to IEC 60364-5-54 § 551.4.2
With reference to: IEC 60364-4-41 § 413.1.3.1 - NOTE 1
With reference to: IEC 60364-4-41 § 413.1.3.1
With reference to: IEC 60364-4-41 § 413.1.3.1
Minimum cross -sectional areas: IEC 364-5-54 § 542.1.1
(PDU)


Earthing arrangements and protective conductors - SUVT/G3500 in TN-C installation
See: IEC 60364-4-41 § 413
Service Entrance
Residual current protective device can not be used at this point
Owing to parallel return path for the fault current
With reference to:
IEC 60364-4-41 § 413.1.3.7
Minimum cross -sectional areas:
IEC 3364-5-54 § 543.1.1
With reference to:
IEC 60364-4-41 § 413.1.1.2
Input Switchgear
Q1
Protective Conductor
Suitable earth electrode
with reference to IEC 60364-5-54 § 542.1.2
Bypass - input
Common-mode filter
Battery 1
Battery 2
SUVT/Galaxy 3500
MBS
Inverter
Bypass - output
UPS - output
Output Switchgear
Q2
PDU
Note:
Upstream galvanic isolation may be required to avoid the neutral to be switched when the system is in bypass operation

TT Systems

Characteristics

TT systems have one point connected directly to earth and all exposed conductive parts of the installation must be connected to an earth electrode. This earth electrode is independent of the power system earthed point.

Reference to IEC/EN 60364-4-41 413.1.4

All exposed conductive parts that are protected collectively by the same protective device must be connected to a common earth electrode together with the protective conductors. In installations where several protective devices are utilized in series, the requirement applies separately to all exposed conductive parts protected by each device.

The neutral point or, if a neutral point does not exist, a phase conductor of each generator station or transformer station must be earthed.

Protective devices in TT systems

The following protective devices are recognized in TT systems:

- Overcurrent protective devices
- Residual current protective devices

Overcurrent protective devices are only applicable for protection against indirect contact in TT systems where a low R_A value exists (see specification below).

The condition $R_A \times I_a \leq 50V$ must be fulfilled.

In the condition:

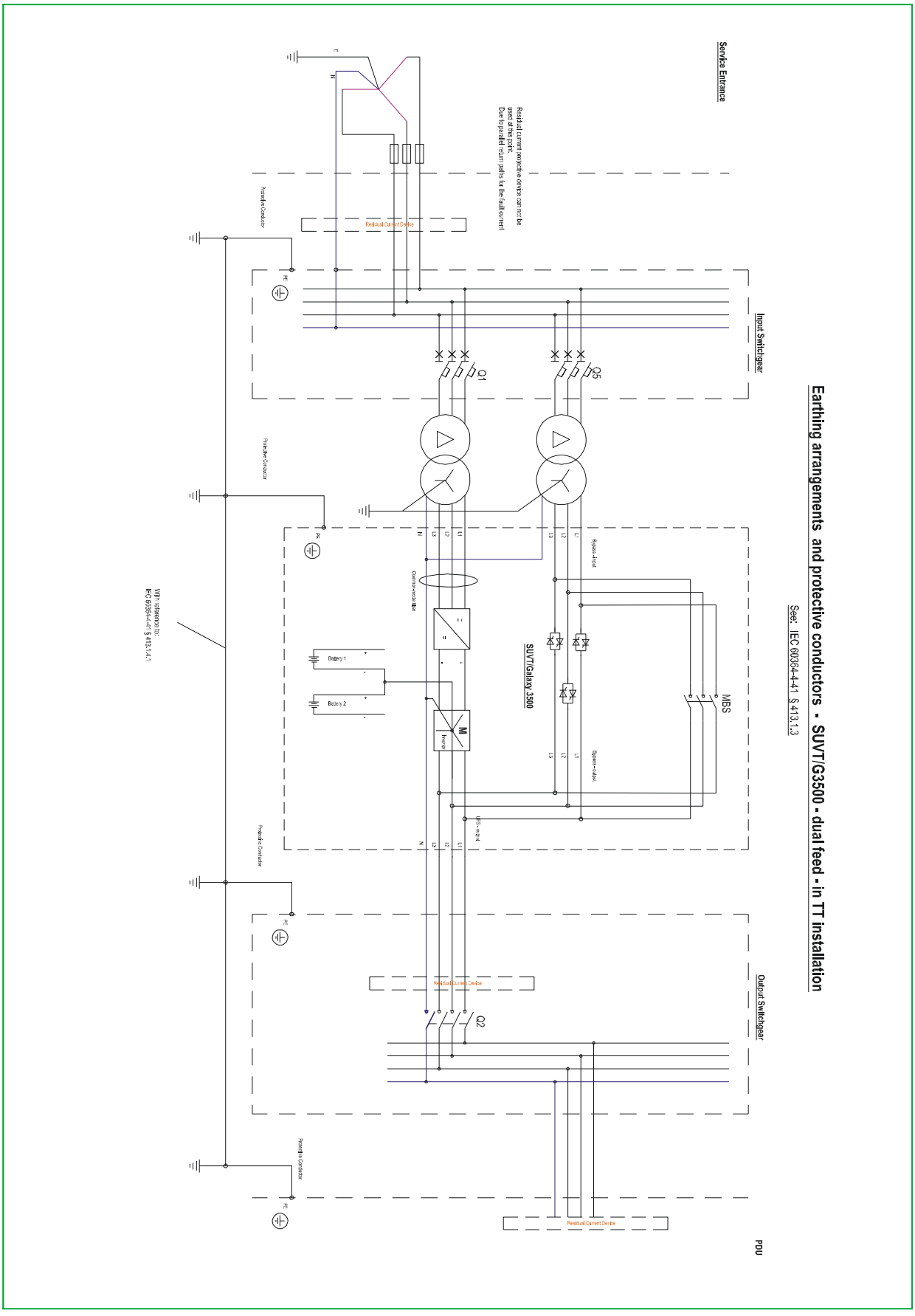
R_A is the sum of resistance of the earth electrode and the protective conductor for the exposed conductive parts

I_a is the current causing the automatic operation of the protective device.
When the protective device is a residual current protective device, I_a is the rated residual operating current $I_{\Delta n}$

For discrimination purposes, S-type residual current protective devices may be used in series with general type residual current protective devices. To provide discrimination with S-type residual current protective devices, an operating time not exceeding 1 second is permitted in distribution circuits.

When the protective device is an overcurrent protective device, it must be either:

- a device with inverse time characteristics and I_a must be the current causing automatic operation within 5 seconds, or
- a device with an instantaneous tripping characteristic and I_a must be the minimum current causing instantaneous tripping


Earthing arrangements and protective conductors - SUVT/G3500 - dual feed - in TT installation
See: IEC 60364-4-41 § 413.1.3
Service Entrance
Input Switchgear
Output Switchgear
PDU
SUVT/Galaxy 3500
MBS
Battery 1
Battery 2
Inverter
Q1
Q5
Q2
Residual Current Device
Protective Conductor
Common-mode Bar
Bypass-input
UPS1 - output
With reference to:
IEC 60364-4-41 § 413.1.4.1

IT Systems

Characteristics

In IT systems the installation is insulated from earth or connected to earth through a sufficiently high impedance. Exposed conductive parts are earthed individually, in groups, or collectively.

Reference to IEC/EN 60364-4-41 413.1.5

In IT systems the installation must be insulated from earth or connected to earth through a sufficiently high impedance. This connection must be made either at the neutral point of the system or at an artificial neutral point. The latter may be connected directly to earth if the resulting zero-sequence impedance is sufficiently high. In installations where no neutral point exists, a phase conductor can be connected to earth through an impedance. In case of a single fault to an exposed conductive part or to earth, the fault current will be low and disconnection will not be imperative.

Exposed conductive parts must be earthed individually, in groups or collectively and the condition $R_A \times I_d \leq 50V$ must be fulfilled.

In the condition:

R_A is the resistance of the earth electrode for exposed conductive parts

I_d is the fault current of the first fault of negligible impedance between a phase conductor and an exposed conductive part. The I_d value takes the leakage currents and the total earthing impedance of the electrical installation into account

In systems where an IT system is used for continuity of supply, an insulation monitoring device must be provided to indicate the occurrence of a first fault from a live part to the exposed conductive parts or to the earth. It is recommended to eliminate a first fault as soon as possible.

Depending on whether all exposed conductive parts are interconnected by a protective conductor (collectively earthed) or are earthed in groups or individually, after a first fault, the disconnection conditions of the supply for a second fault must be as follows:

1. In installations where the exposed conductive parts are earthed in groups or individually, the protection conditions for TT systems apply (see 413.1.4.1)
2. In installations where the exposed conductive parts interconnected by a protective conductor collectively earthed, the conditions for TN systems apply

In installations where the neutral is not distributed, the following conditions must be fulfilled:

$$Z_s \equiv \frac{\sqrt{3} \times U_0}{2 \times I_a}$$

In installations where the neutral is distributed, the following conditions must be fulfilled:

$$Z'_s \leq \frac{U_0}{2 \times I_a}$$

In the condition:

U_0 is the nominal AC RMS voltage between phase and neutral

Z_s is the impedance of the fault loop comprising the phase conductor and the protective conductor of the circuit

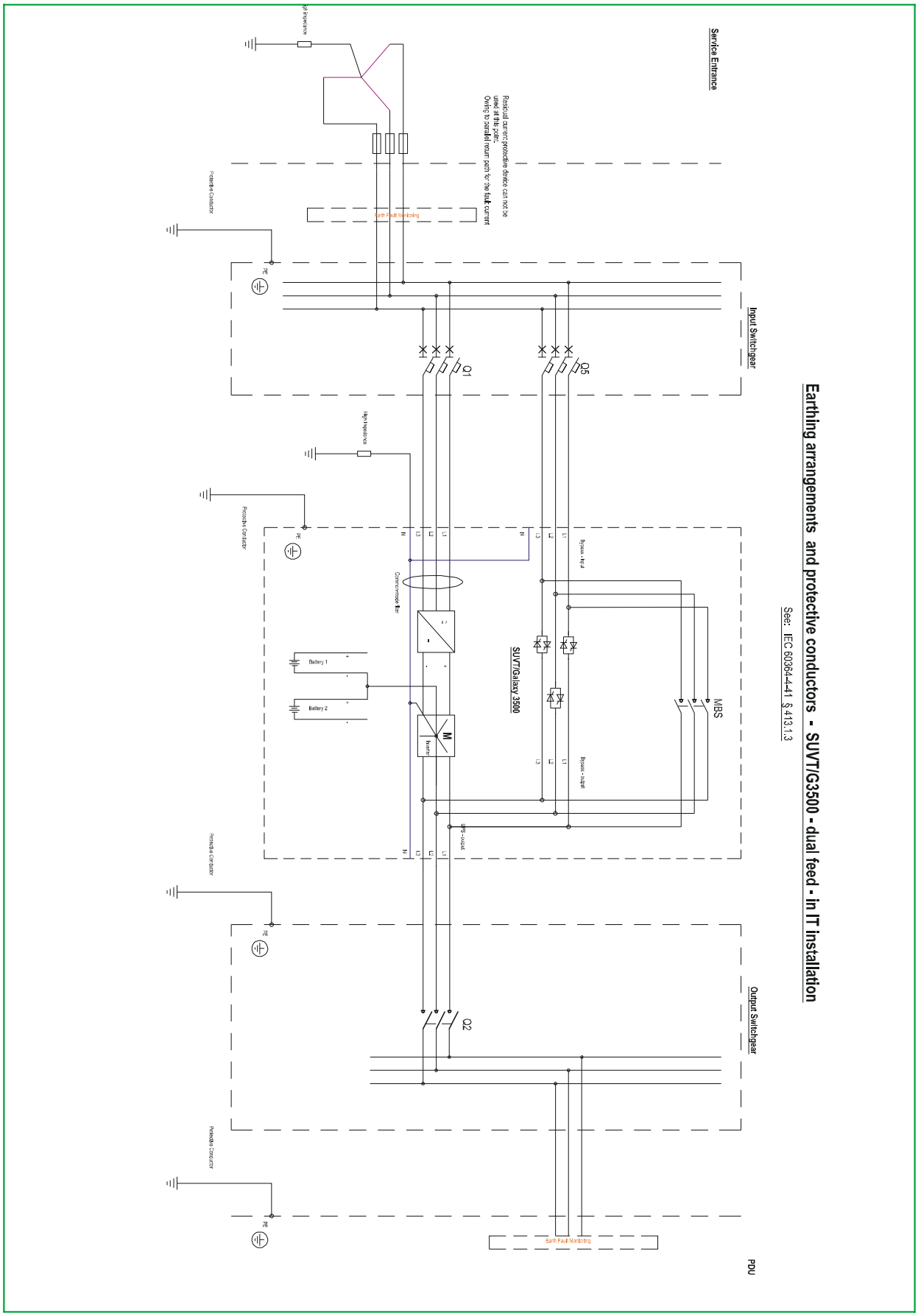
Z'_s is the impedance of the fault loop comprising the neutral conductor and the protective conductor of the circuit

I_a is the operating current of the protective device.

Protective devices in IT systems

The following protective devices are recognized in IT systems:

- Earth fault monitoring devices
- Overcurrent protective devices
- Residual current protective devices


Earthing arrangements - SUVT/G3500 - dual feed - in IT installation
See: IEC 60364-4-41 § 413.1.3
Service Entrance
Input Switchgear
Output Switchgear
PDU
SUVT/Galaxy 3500
Q1
Q2
Q5
MBS
Battery 1
Battery 2
Inverter
Bypass - input
Bypass - output
UPS - output
Commonmode filter
Earth Fault Monitoring
Residual current protective device can not be used at this point.
Owing to parallel return path for the fault current
PE

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  - **www.apc.com/support/**
    Global support searching APC Knowledge Base and using e-support.
- Contact the APC Customer Support Center by telephone or e-mail.
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