Easy UPS 3S, Easy UPS 3S Pro, Easy UPS 3M, Easy UPS 3M Pro and Easy UPS 3L

UPS Systems

Earthing Principles

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6/2026

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Table of Contents

Table of Contents 3
Earthing Principles 5
Decoding the Earthing Types 5
TN Systems 6
3:3 TN-C System Single Source and Single Mains 9
3:3 TN-C System Single Source and Dual Mains 10
Easy UPS 3L 3:3 TN-C System with MBP Single Source Single Mains 11
Easy UPS 3L 3:3 TN-C System with MBP Single Source Dual Mains 12
3:1 TN-C Single Source 13
3:3 TN-C-S System Single Source and Single Mains 14
3:3 TN-C-S System Single Source and Dual Mains 15
3:3 TN-C-S System Dual Source and Dual Mains 16
Easy UPS 3L 3:3 TN-C-S System with MBP Single Source Single Mains 17
Easy UPS 3L 3:3 TN-C-S System with MBP Single Source Dual Mains 18
3:1 TN-C-S System Single Source 19
3:1 TN-C-S System Single Source 20
3:1 TN-C-S System Dual Source 21
3:3 TN-S System Single Source and Single Mains 22
3:3 TN-S System Single Source and Dual Mains 23
3:3 TN-S System Dual Source and Dual Mains 24
Easy UPS 3L 3:3 TN-S System with MBP Single Source Single Mains 25
Easy UPS 3L 3:3 TN-S System with MBP Single Source Dual Mains 26
Easy UPS 3L 3:3 TN-S System with MBP Dual Source Dual Mains 27
3:1 TN-S System Single Source 28
3:1 TN-S System Dual Source 29
TT Systems 30
3:3 TT System Single Source and Single Mains 31
3:3 TT System Single Source and Dual Mains 32
3:3 TT System Dual Source and Dual Mains 33
Easy UPS 3L 3:3 TT System with MBP Single Source Single Mains 34
Easy UPS 3L 3:3 TT System with MBP Single Source Dual Mains 35
Easy UPS 3L 3:3 TT System with MBP Dual Source Dual Mains 36
3:1 TT System Single Source 37
3:1 TT System Dual Source 38
IT Systems 39
3:3 IT System Single Source and Single Mains 41
3:3 IT System Single Source and Dual Mains 42
Easy UPS 3L 3:3 IT System with MBP Single Source Single Mains 43
Easy UPS 3L 3:3 IT System with MBP Single Source Dual Mains 44
3:1 IT System Single Source and Dual Mains 45
Dimensioning 46

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 make the OCPD operate.

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

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

NOTE: The UPS installation must always comply with local and national regulations, and some countries have exceptions to the IEC 60364 standard.

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 (T = Terra (Earth)).
	I	The power system is insulated from earth or connected to earth through a sufficient high impedance (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 (N = Neutral).
Additional letters	S	The Protective Conductor (PE) and Neutral Conductor (N) are two different and separate conductors (S = Split).
	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 and separated into two conductors in another 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 60364-4-41 413.1.3.1

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 to 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 conductor 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).

UPS Systems are to be Considered as a Generating Set

IEC/EN60364-5-55 Clause 551.1.2.

Generating sets with the following electrical characteristics are considered:

- mains excited and separately excited synchronous generators;
- mains excited and self-excited asynchronous generators;
- mains-commutated and self-commutated static inverters with or without by-pass facilities.

Additional Requirements when the Generating Set (the UPS) Provides a Switched Alternative to the Public Supply (IEC/EN 60364-5-55 551.4.3.2)

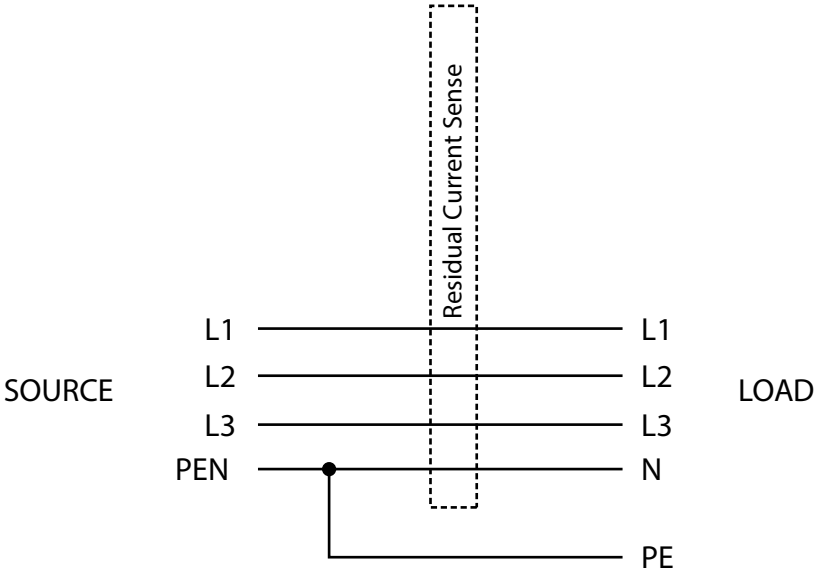
Protection by automatic disconnection of supply must not rely on the connection to the earthed points of the public supply system when the generator is operating as a switched alternative. A suitable earth electrode must be provided.

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):



Due to the required installation of the functional earth, upstream protection by Residual Current Protective Devices will not be possible, as they will malfunction due to the leakage current from the UPS.

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 specified time (five seconds - valid for distribution circuits, 413.1.3.5). The following condition fulfilling this requirement: IEC/EN 60364-4-41, 413.1.3.3.

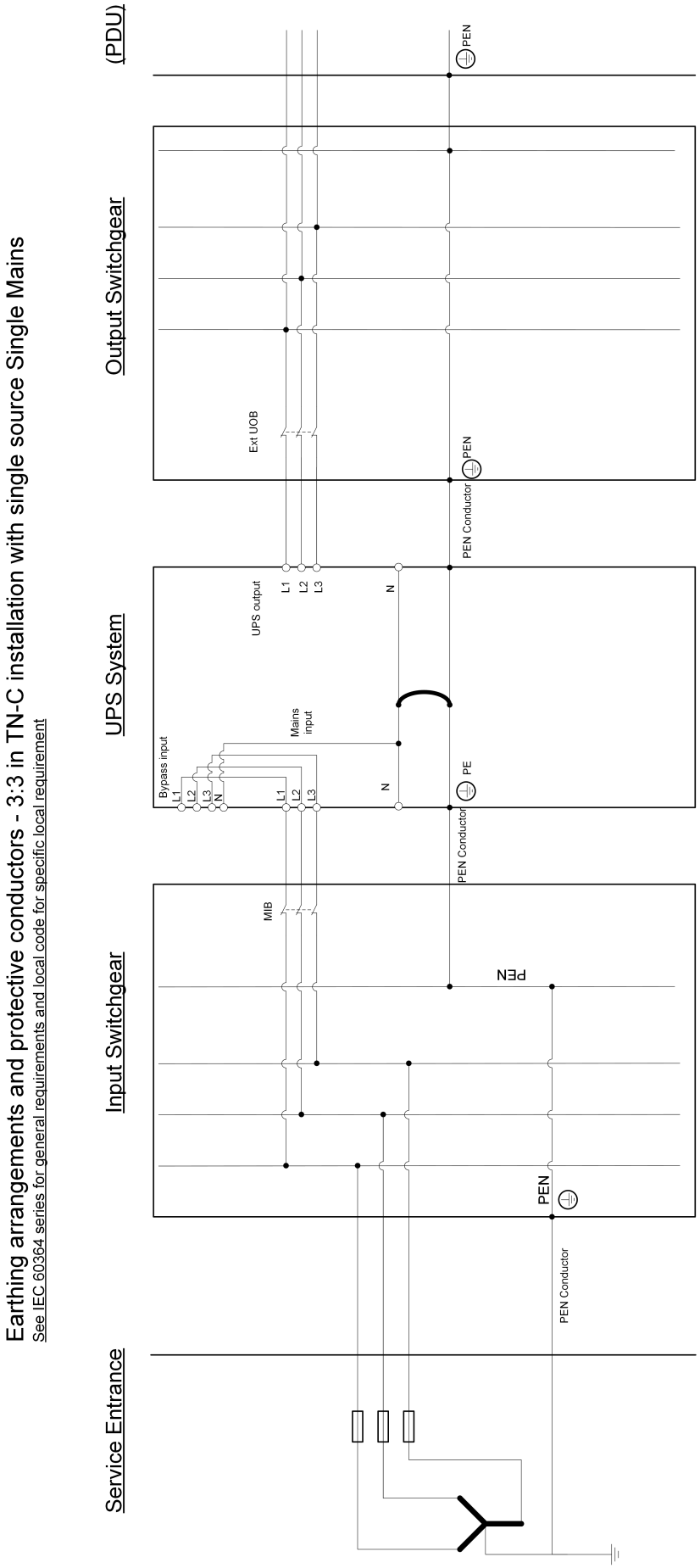
$$Z_s \times I_a \leq U_0$$

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. (Demand in IEC 60364-4-41 413.1.3.5). If a residual protective device is used, this device will of course disconnect the supply.

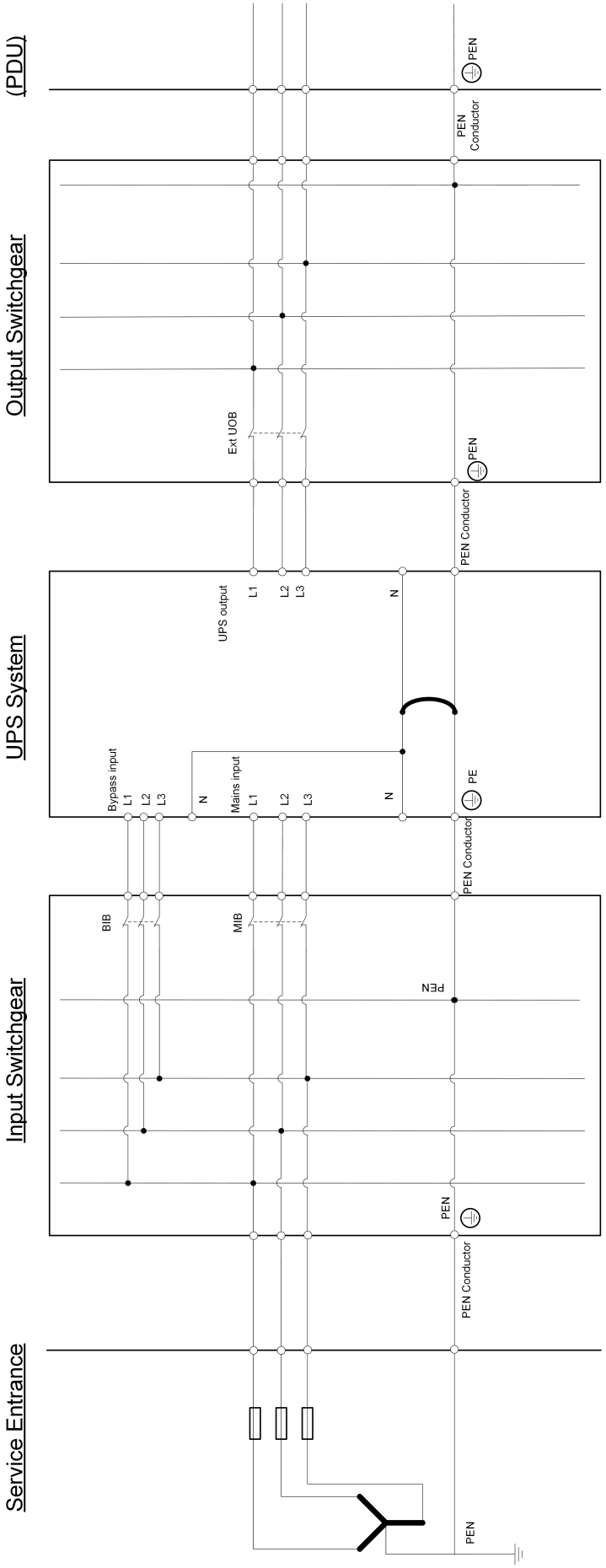
3:3 TN-C System Single Source and Single Mains



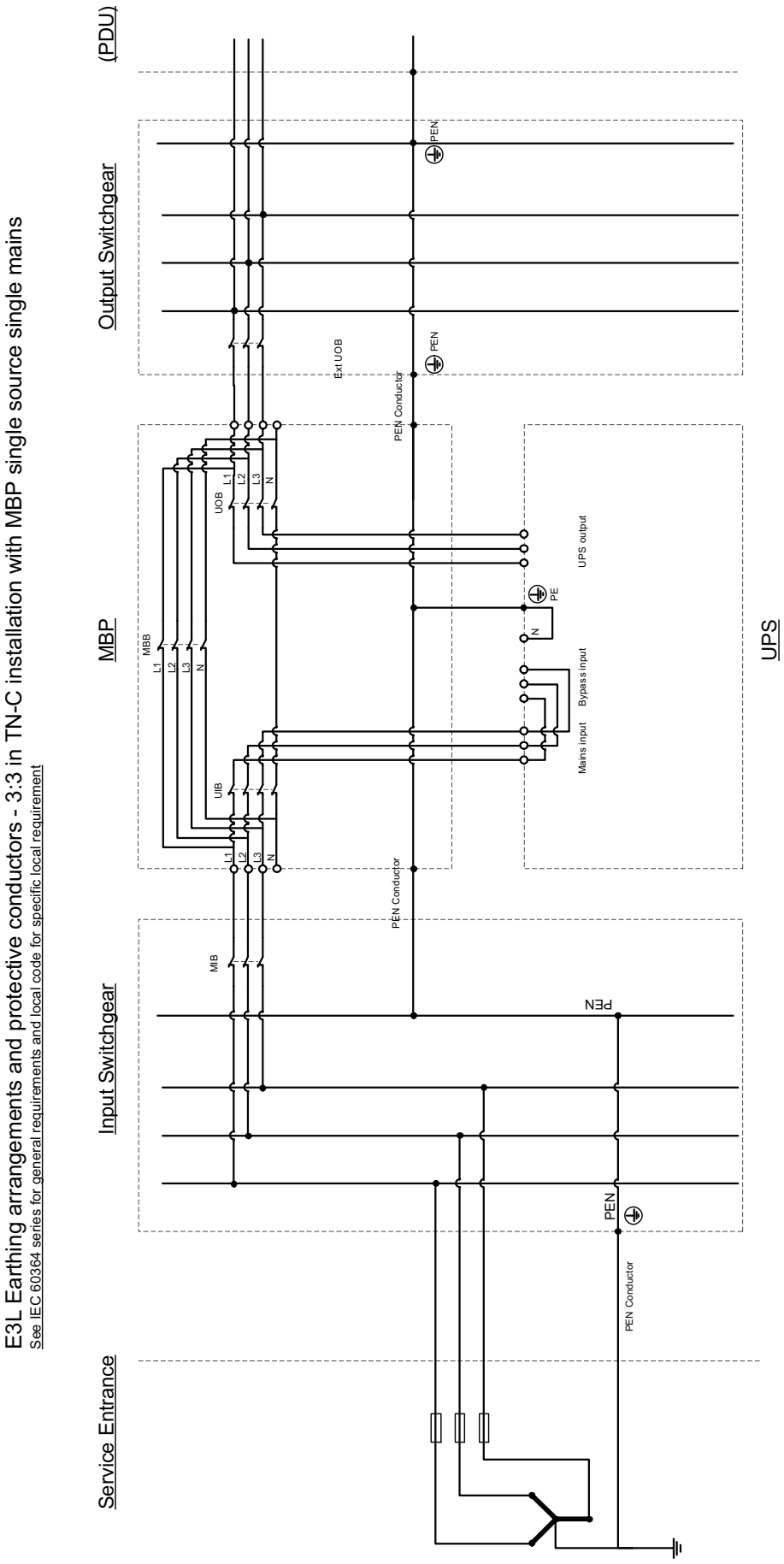
3:3 TN-C System Single Source and Dual Mains

Earthing arrangements and protective conductors - 3:3 in TN-C Installation with Single Source and Dual Mains

See IEC 60364 series for general requirements and local code for specific local requirement



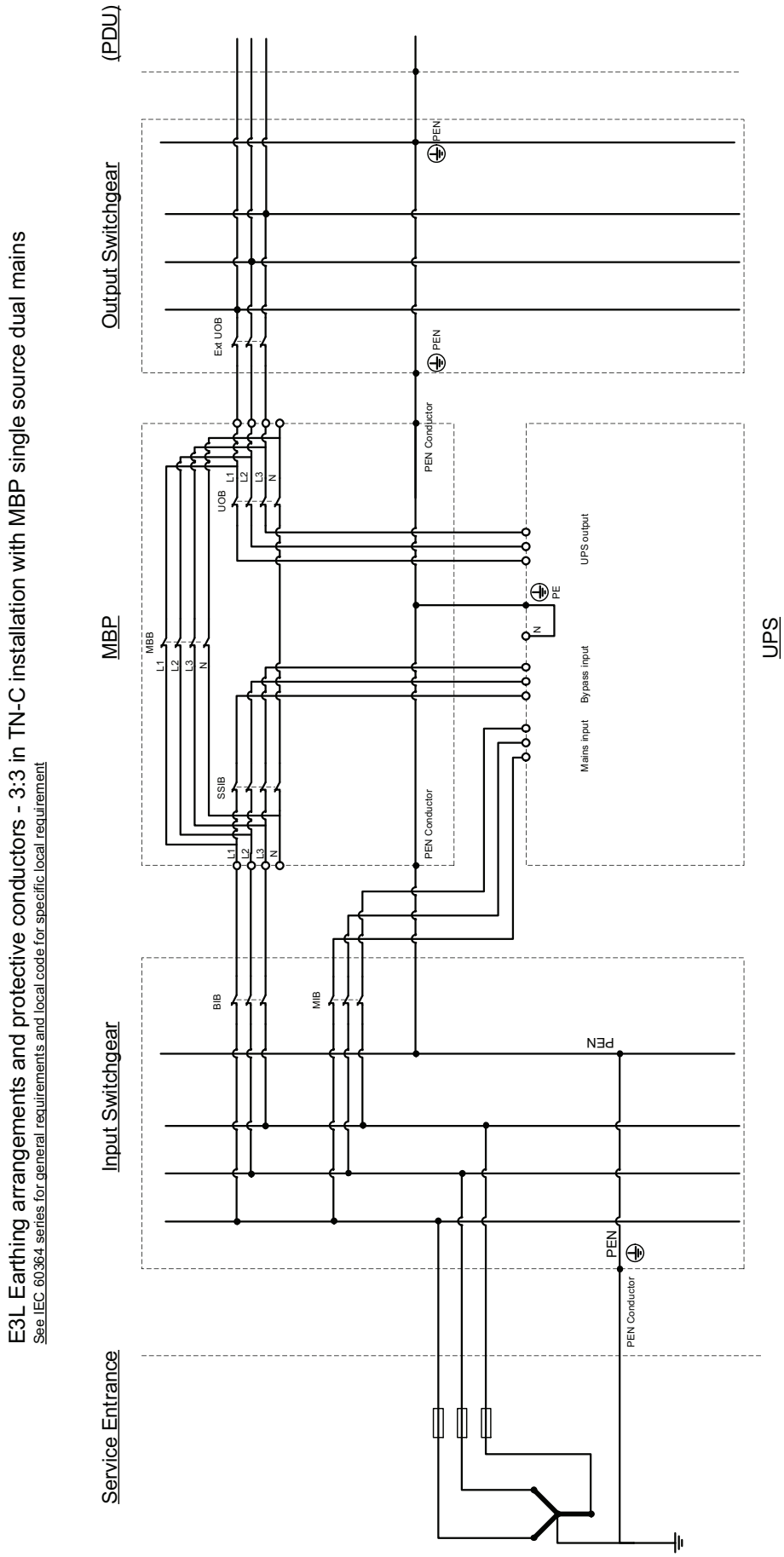
Easy UPS 3L 3:3 TN-C System with MBP Single Source Single Mains



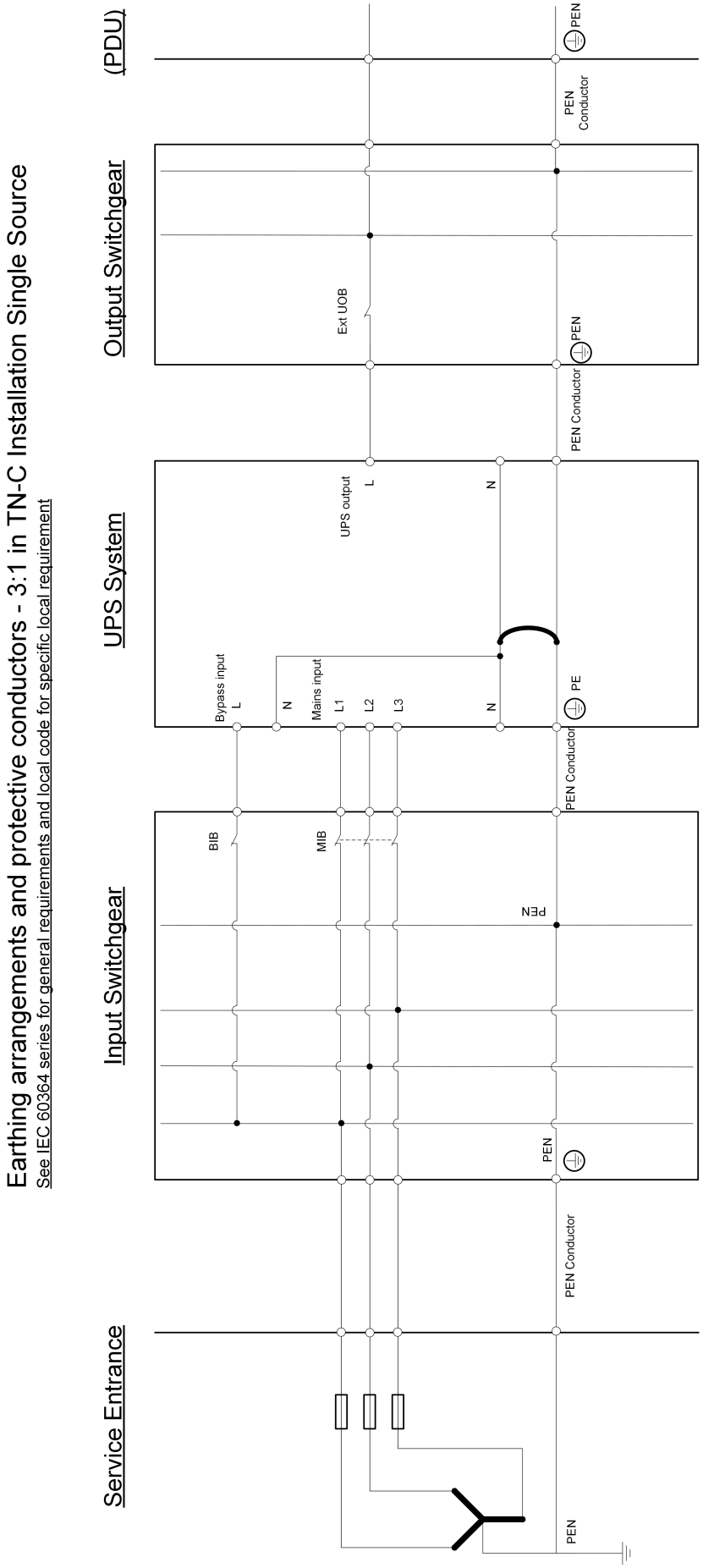
E3L Earthing arrangements and protective conductors - 3:3 in TN-C installation with MBP single source single mains

See IEC 60364 series for general requirements and local code for specific local requirement

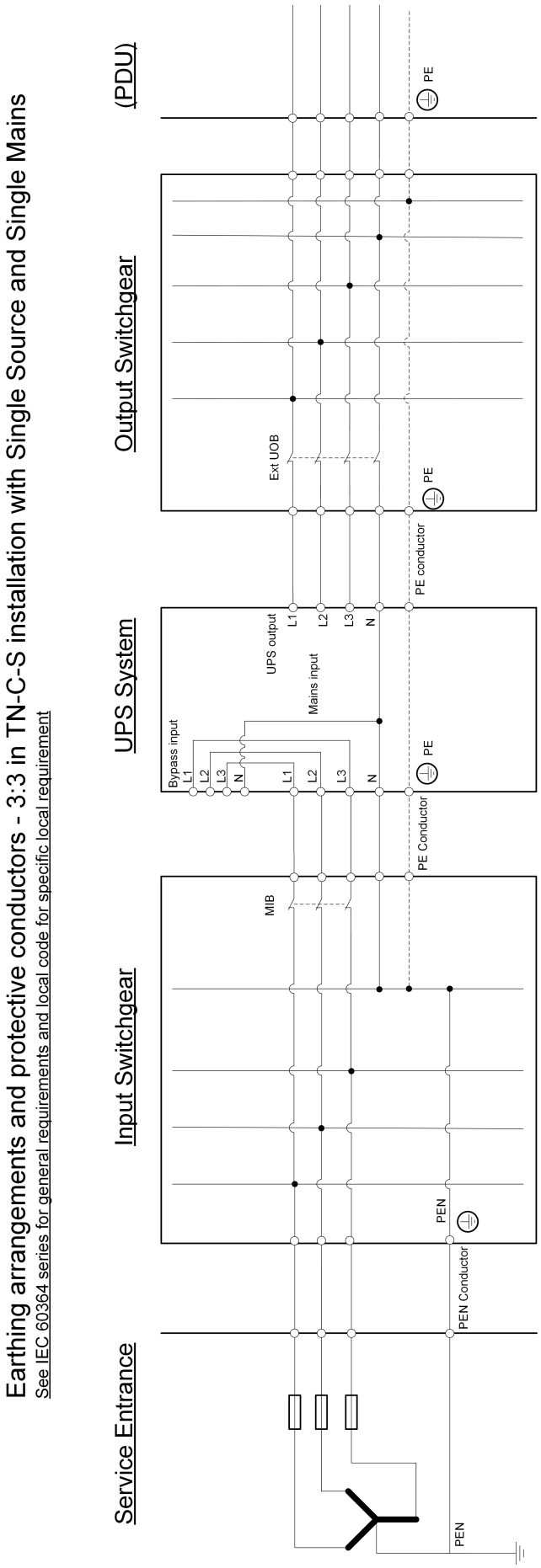
Easy UPS 3L 3:3 TN-C System with MBP Single Source Dual Mains



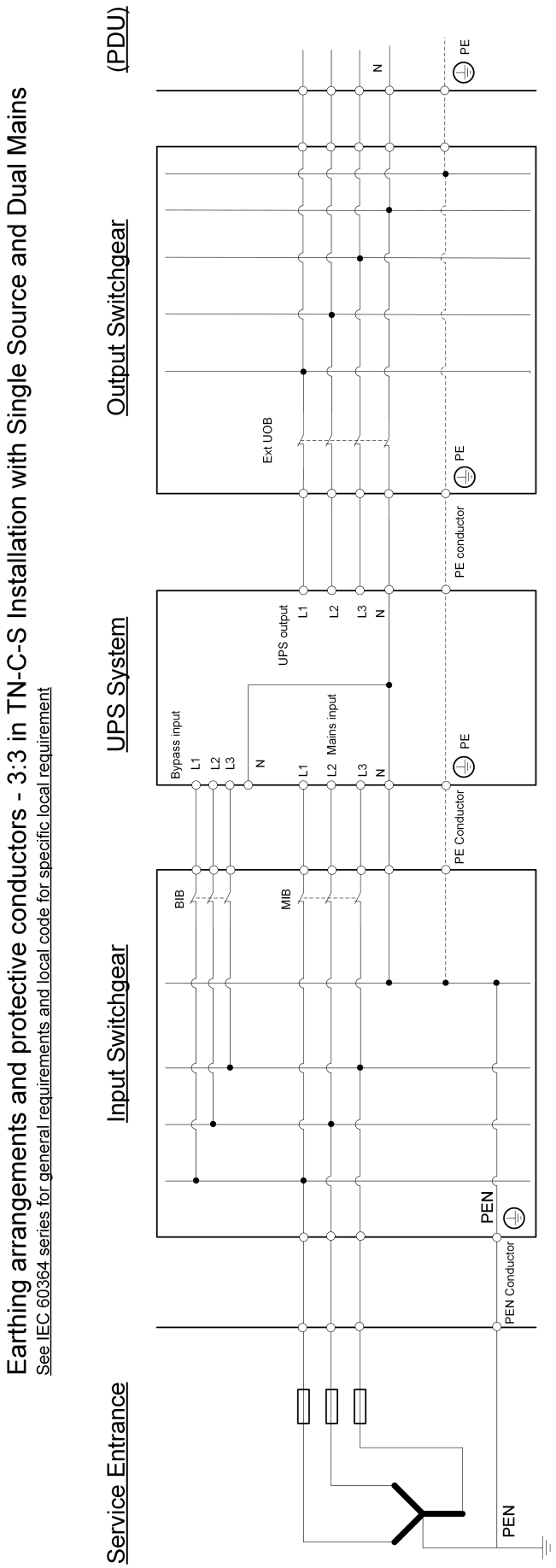
3:1 TN-C Single Source



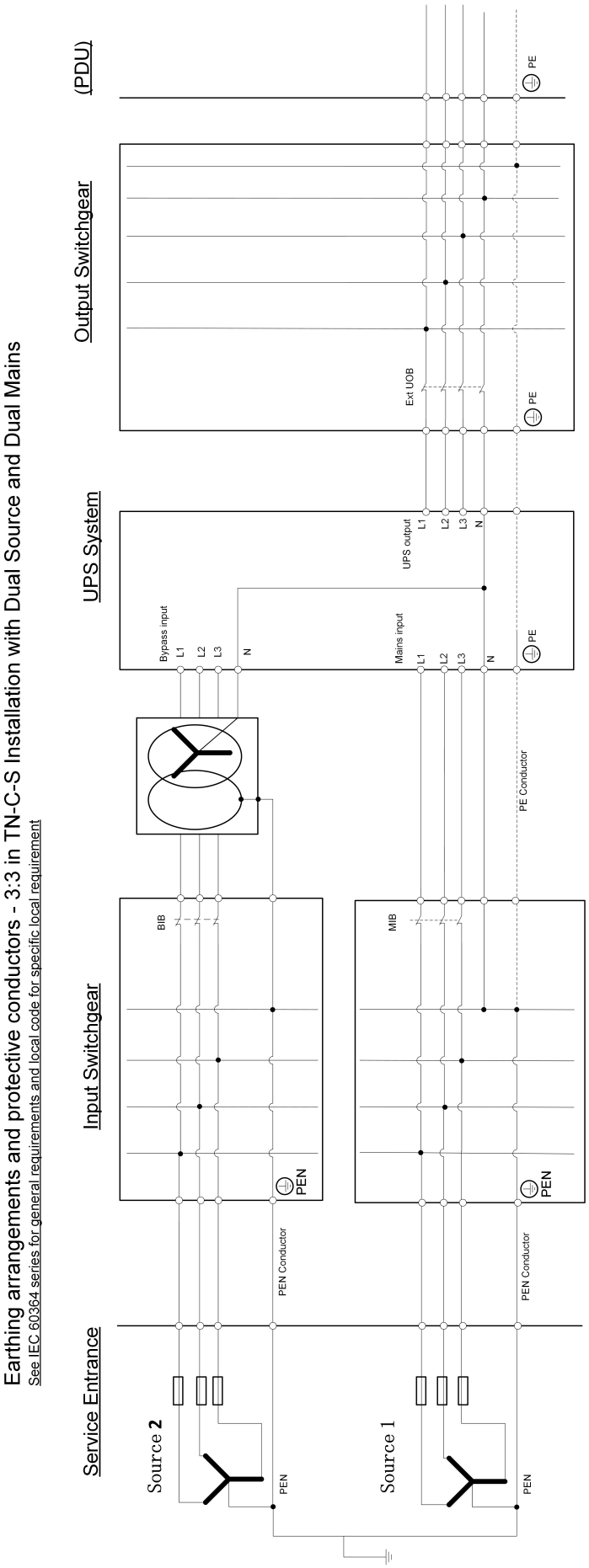
3:3 TN-C-S System Single Source and Single Mains



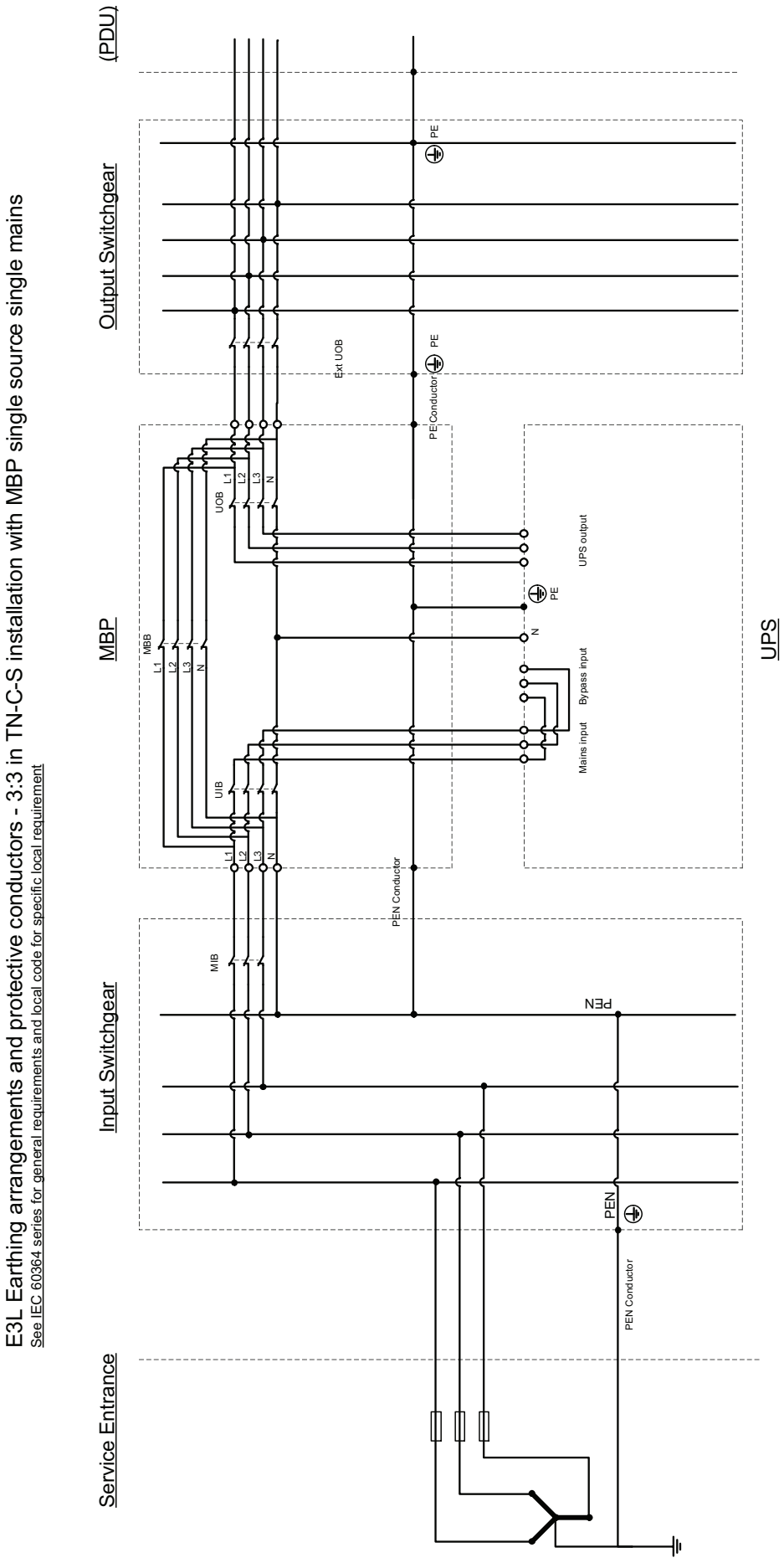
3:3 TN-C-S System Single Source and Dual Mains



3:3 TN-C-S System Dual Source and Dual Mains



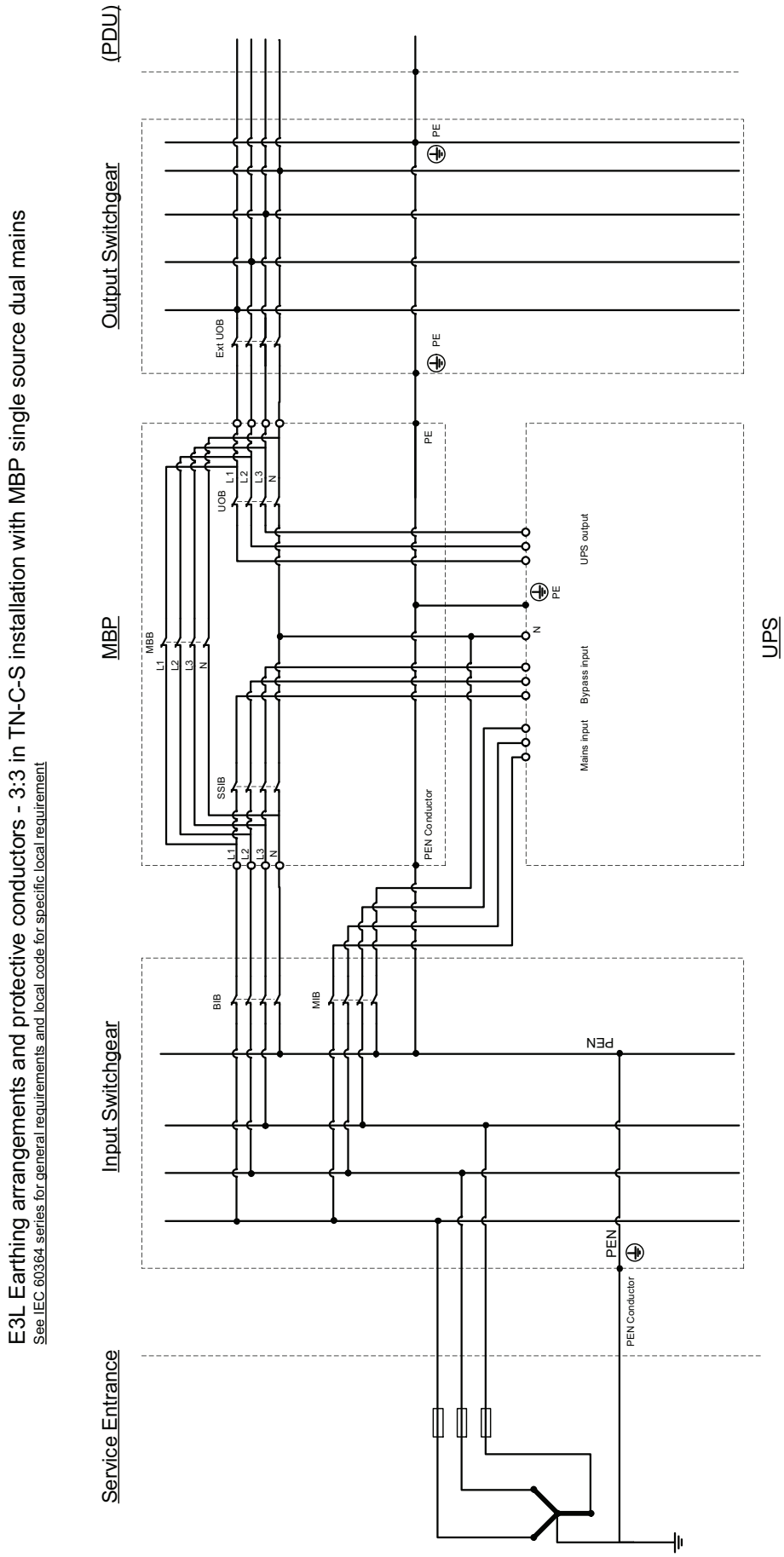
Easy UPS 3L 3:3 TN-C-S System with MBP Single Source Single Mains



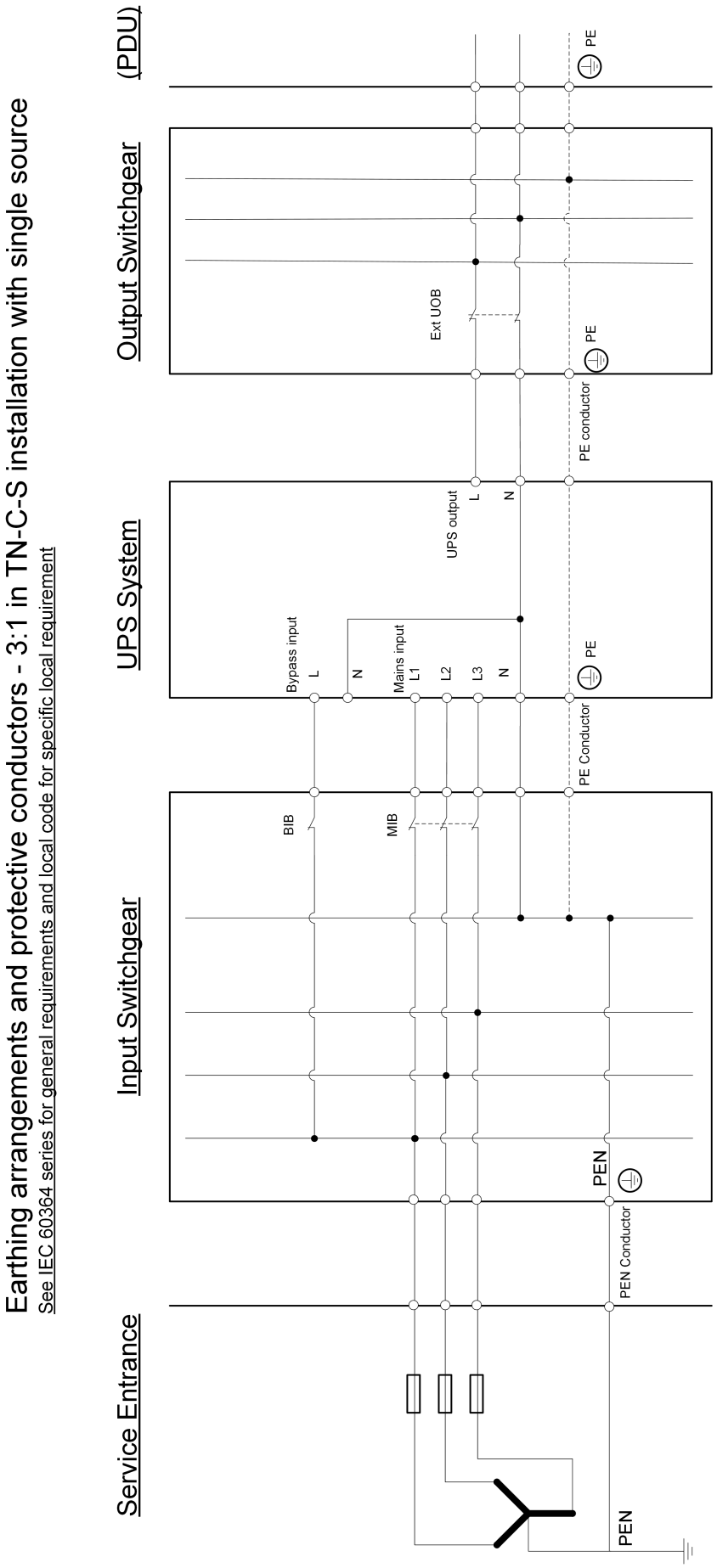
E3L Earthing arrangements and protective conductors - 3:3 in TN-C-S installation with MBP single source single mains

See IEC 60364 series for general requirements and local code for specific local requirement

Easy UPS 3L 3:3 TN-C-S System with MBP Single Source Dual Mains



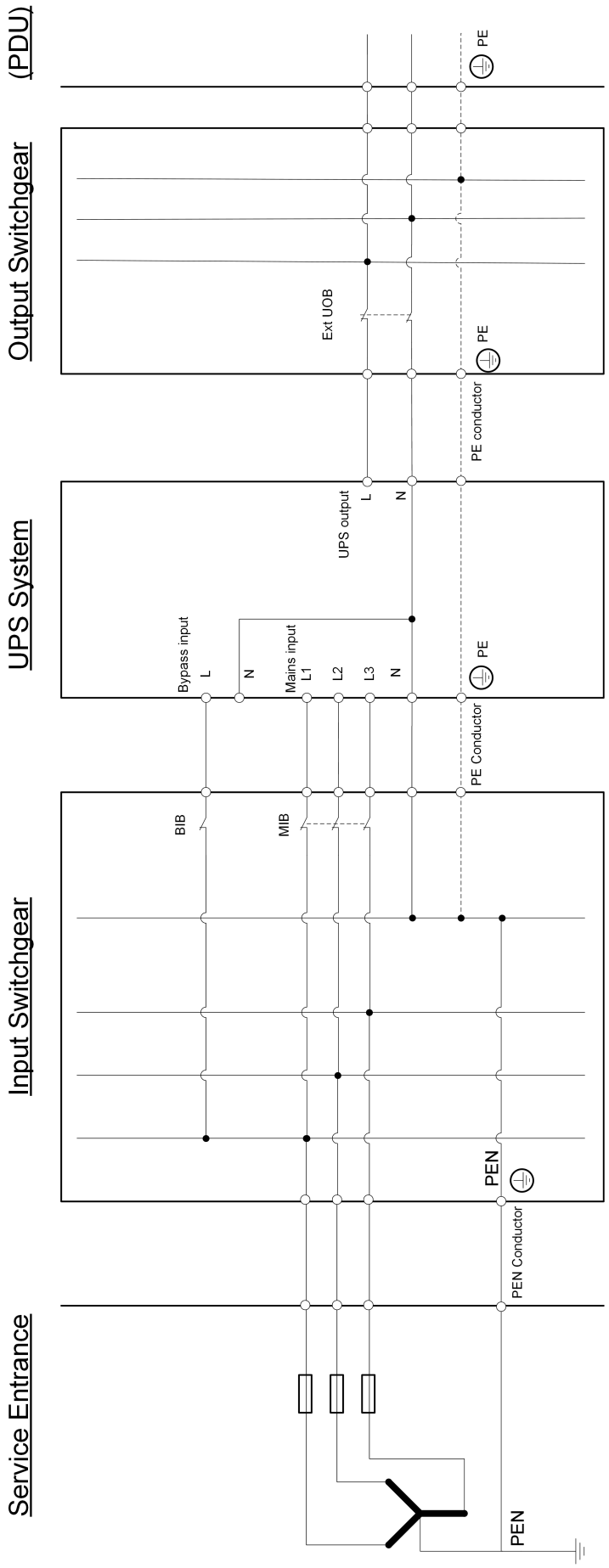
3:1 TN-C-S System Single Source



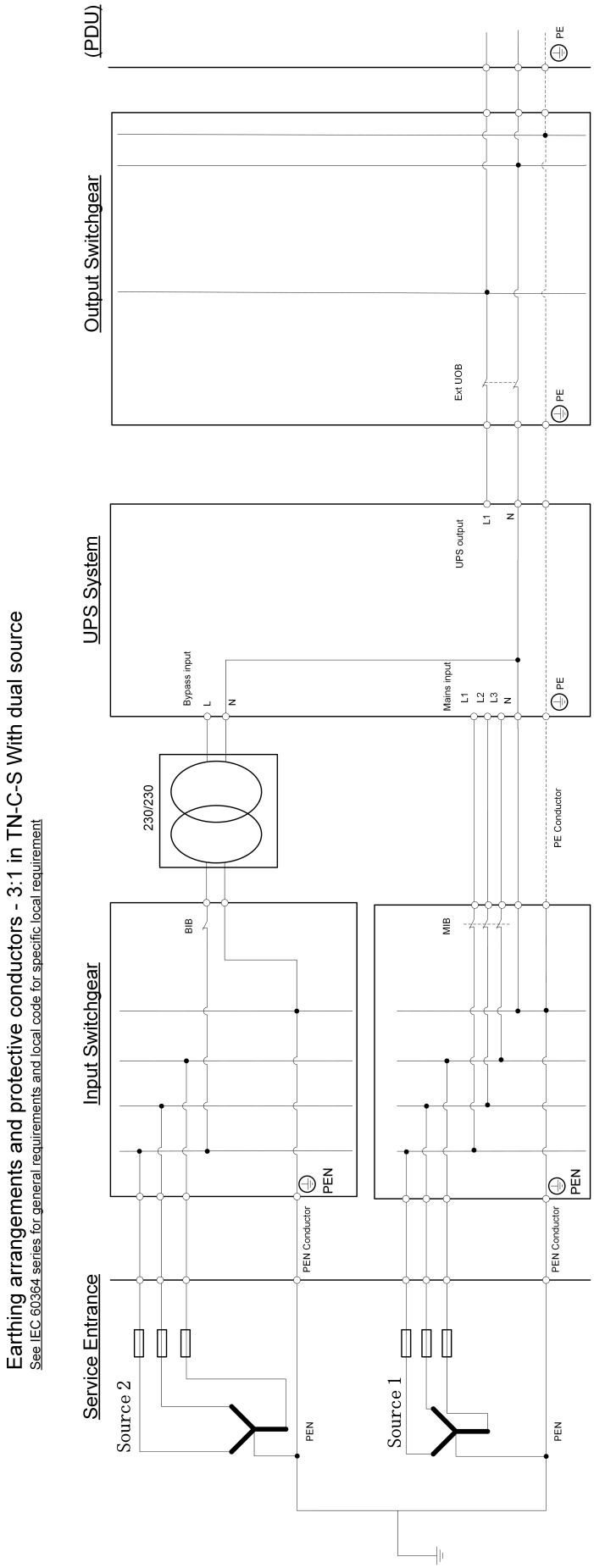
3:1 TN-C-S System Single Source

Earthing arrangements and protective conductors - 3:1 in TN-C-S installation with single source

See IEC 60364 series for general requirements and local code for specific local requirement



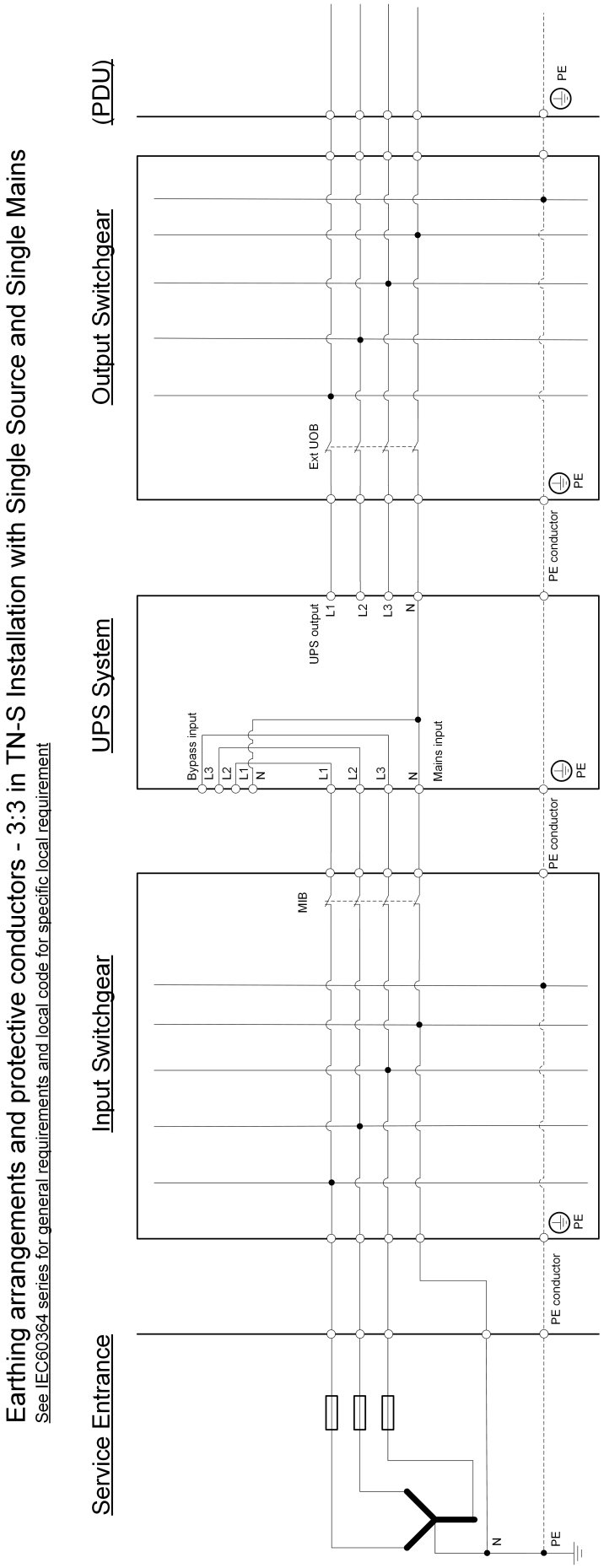
3:1 TN-C-S System Dual Source



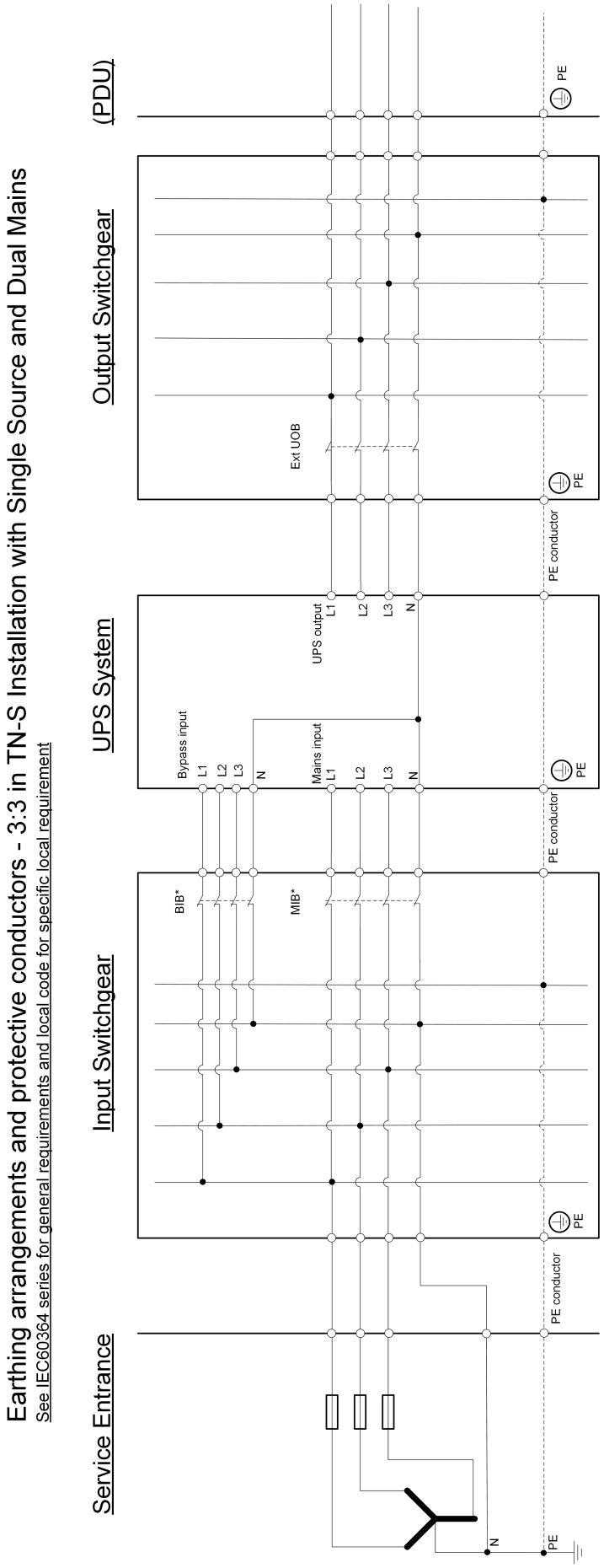
3:3 TN-S System Single Source and Single Mains

Earthing arrangements and protective conductors - 3:3 in TN-S Installation with Single Source and Single Mains

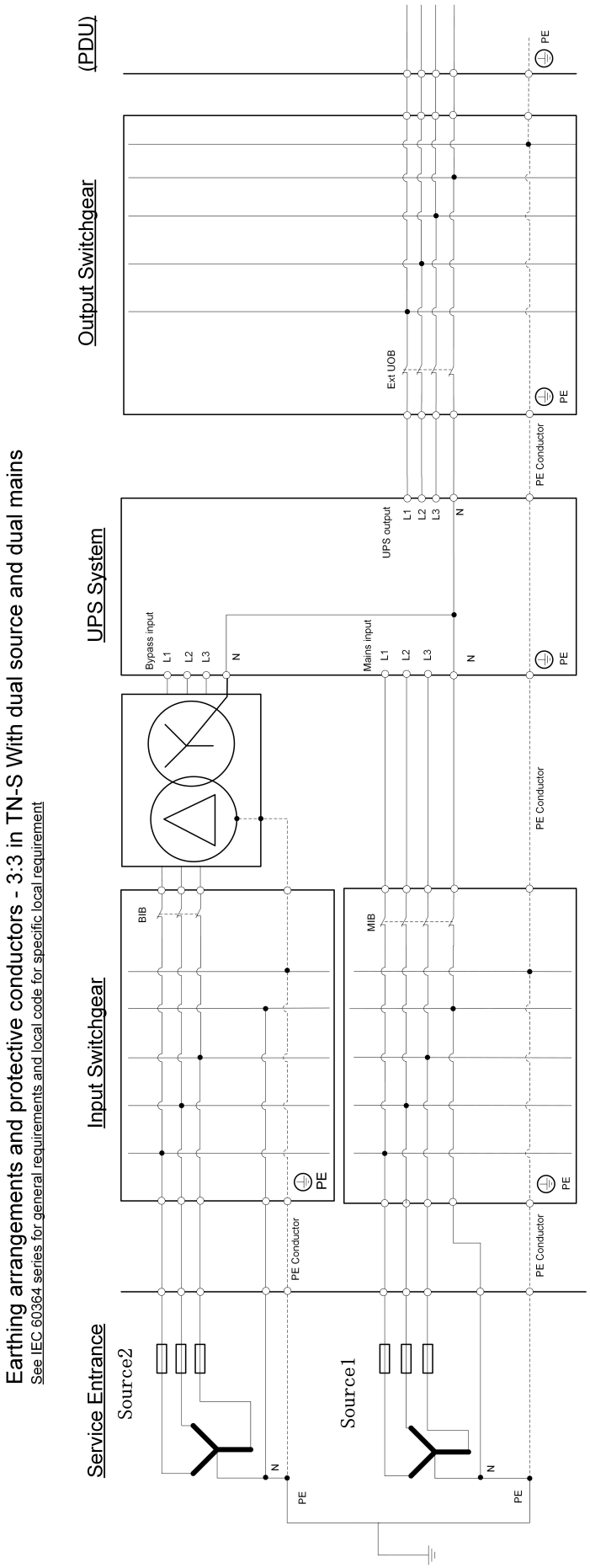
See IEC60364 series for general requirements and local code for specific local requirement



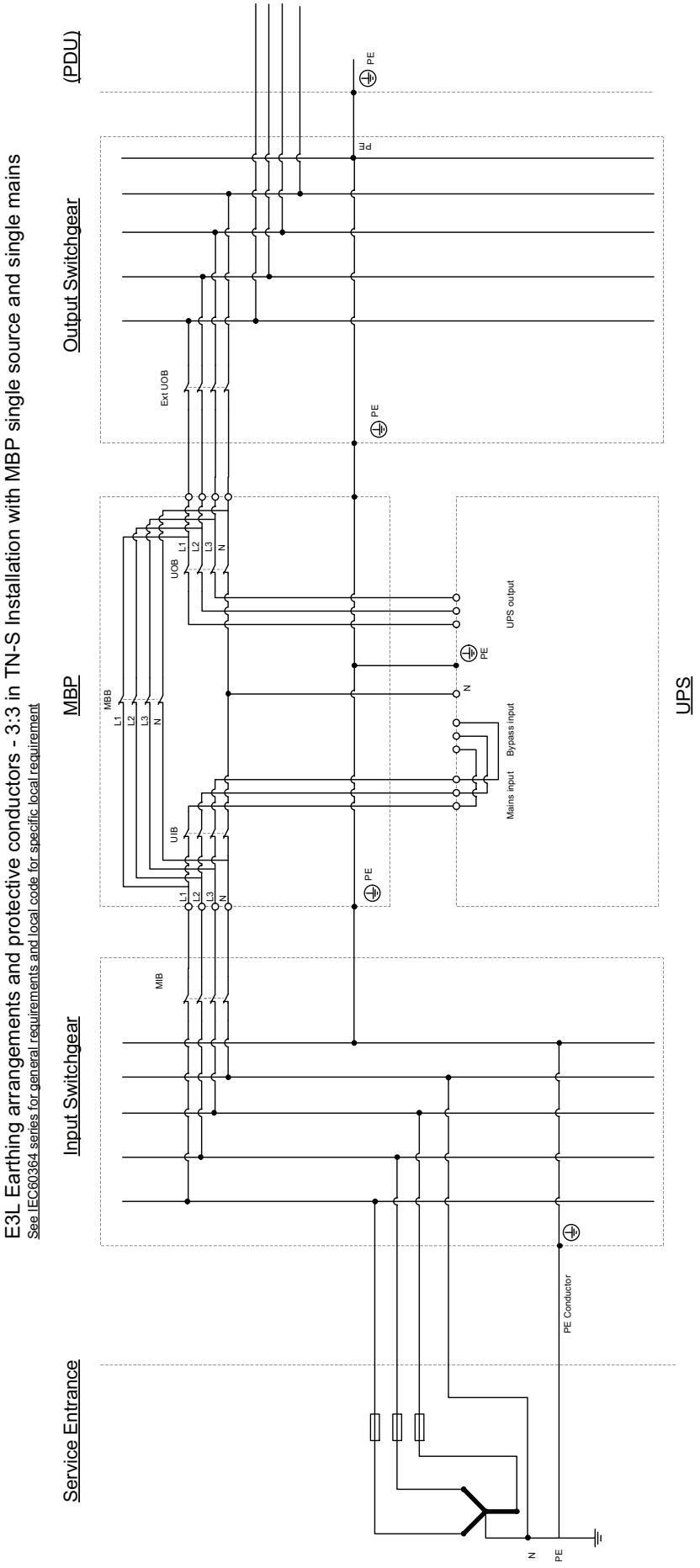
3:3 TN-S System Single Source and Dual Mains



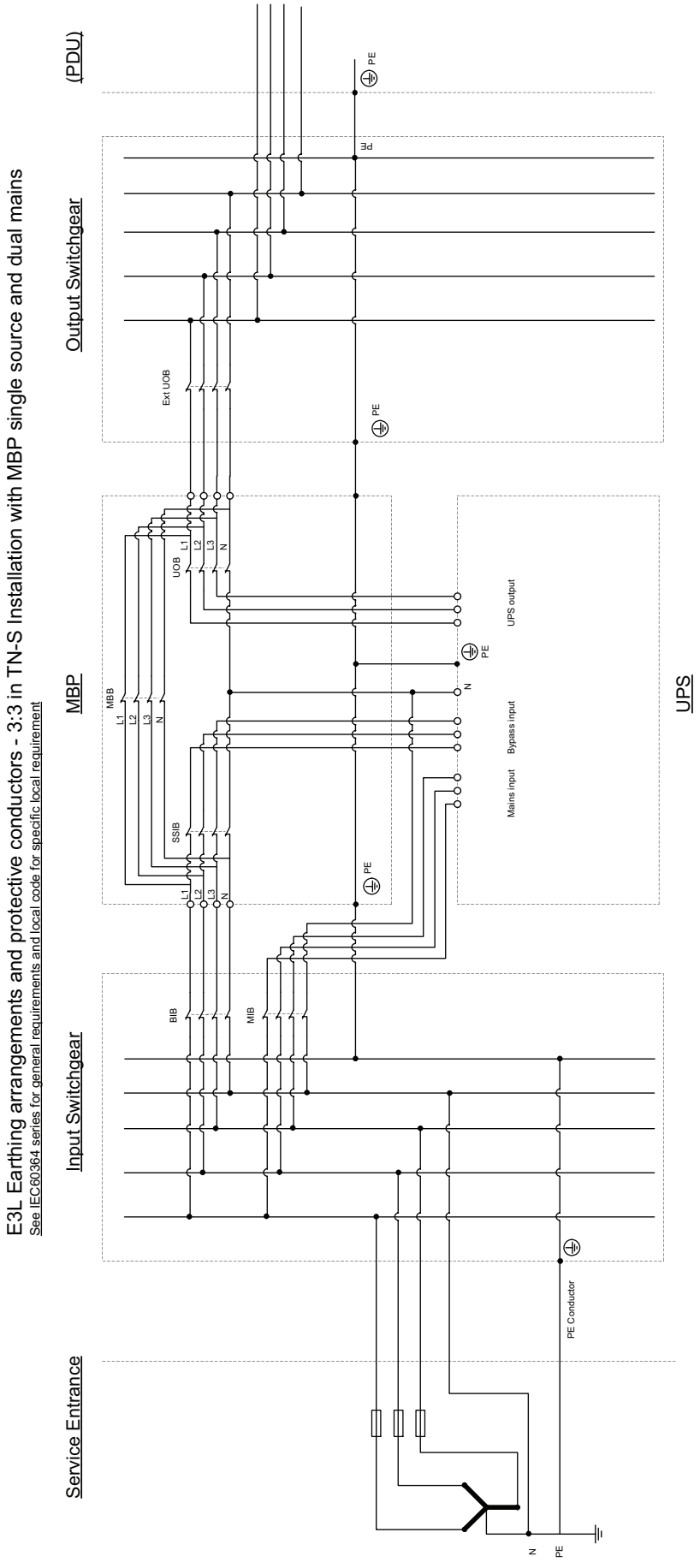
3:3 TN-S System Dual Source and Dual Mains



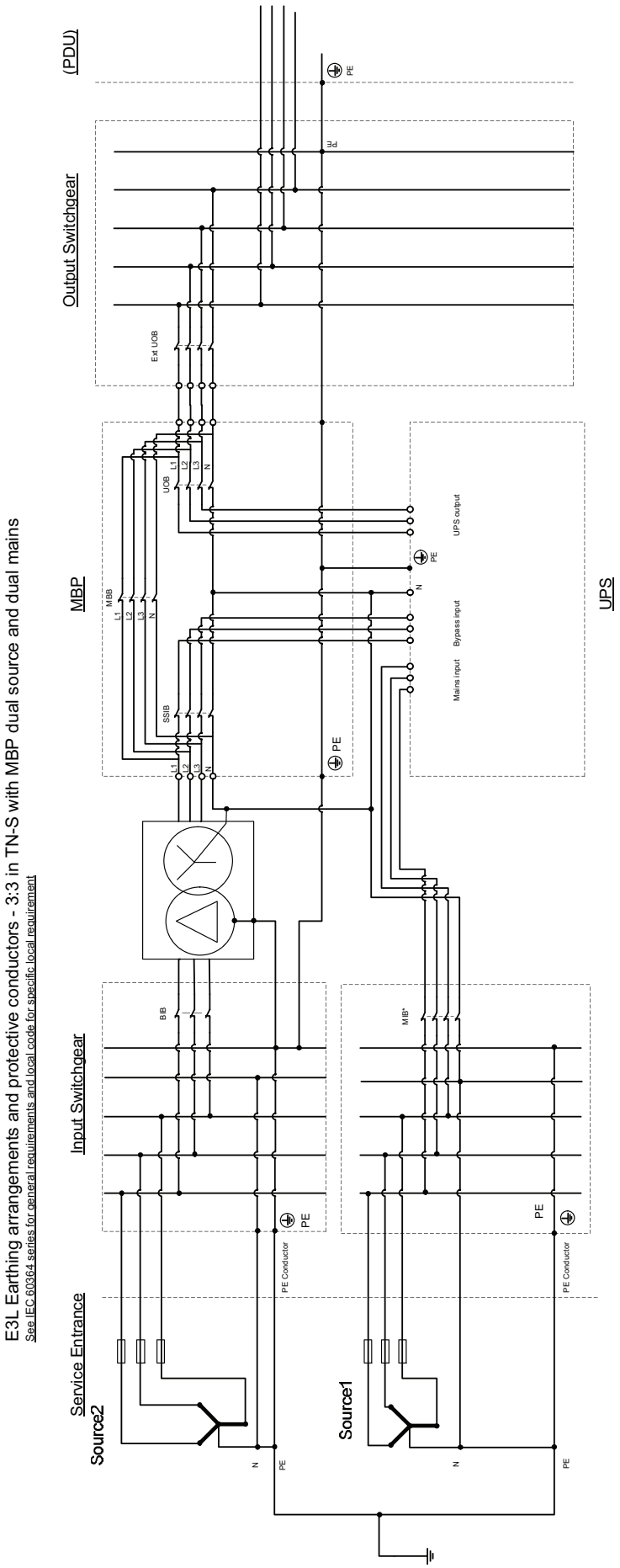
Easy UPS 3L 3:3 TN-S System with MBP Single Source Single Mains



Easy UPS 3L 3:3 TN-S System with MBP Single Source Dual Mains



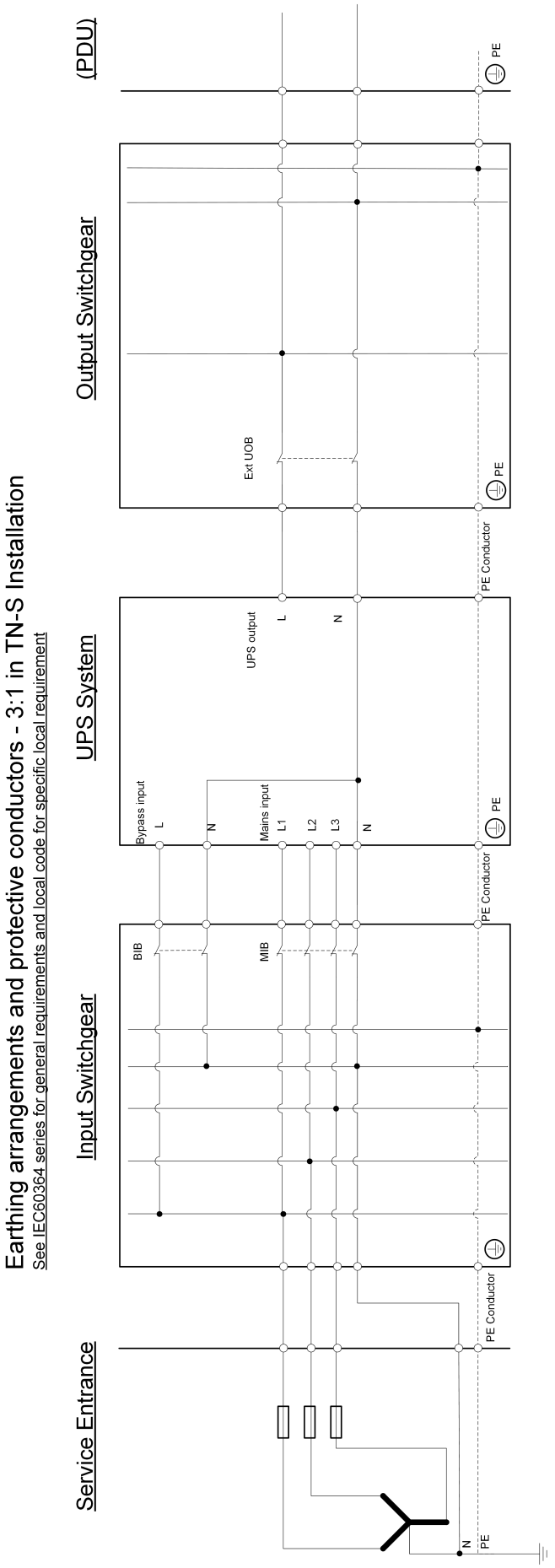
Easy UPS 3L 3:3 TN-S System with MBP Dual Source Dual Mains



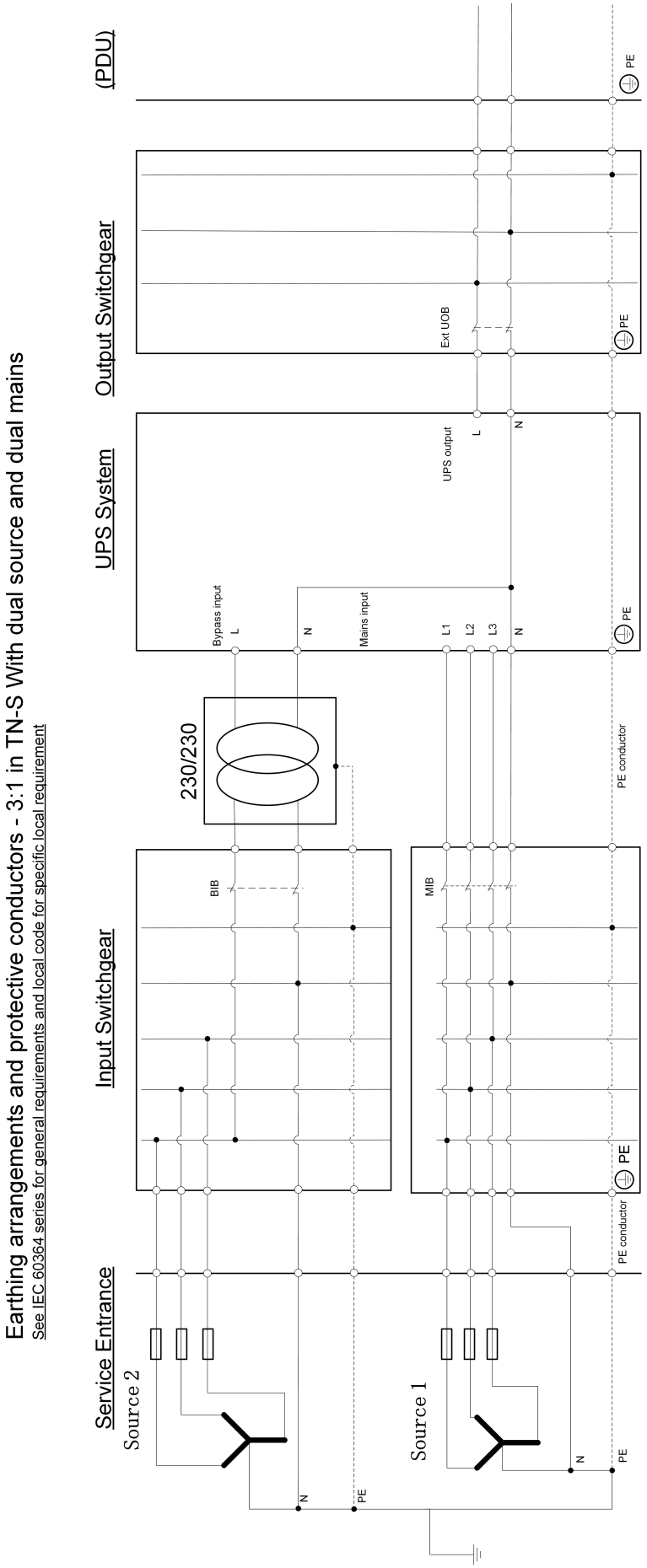
E3L Earthing arrangements and protective conductors - 3:3 in TN-S with MBP dual source and dual mains

See IEC 60364 series for general requirements and local code for specific local requirement

3:1 TN-S System Single Source



3:1 TN-S System Dual Source



TT Systems

NOTE: Due to the nature of a TT system and the use of Residual Current Protective Devices, it is recommended to install an isolation transformer upstream to the UPS.

Characteristics

TT systems have one point connected directly to earth and all exposed conductive parts of the installation must be connected to earth electrodes. These earth electrode are 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.

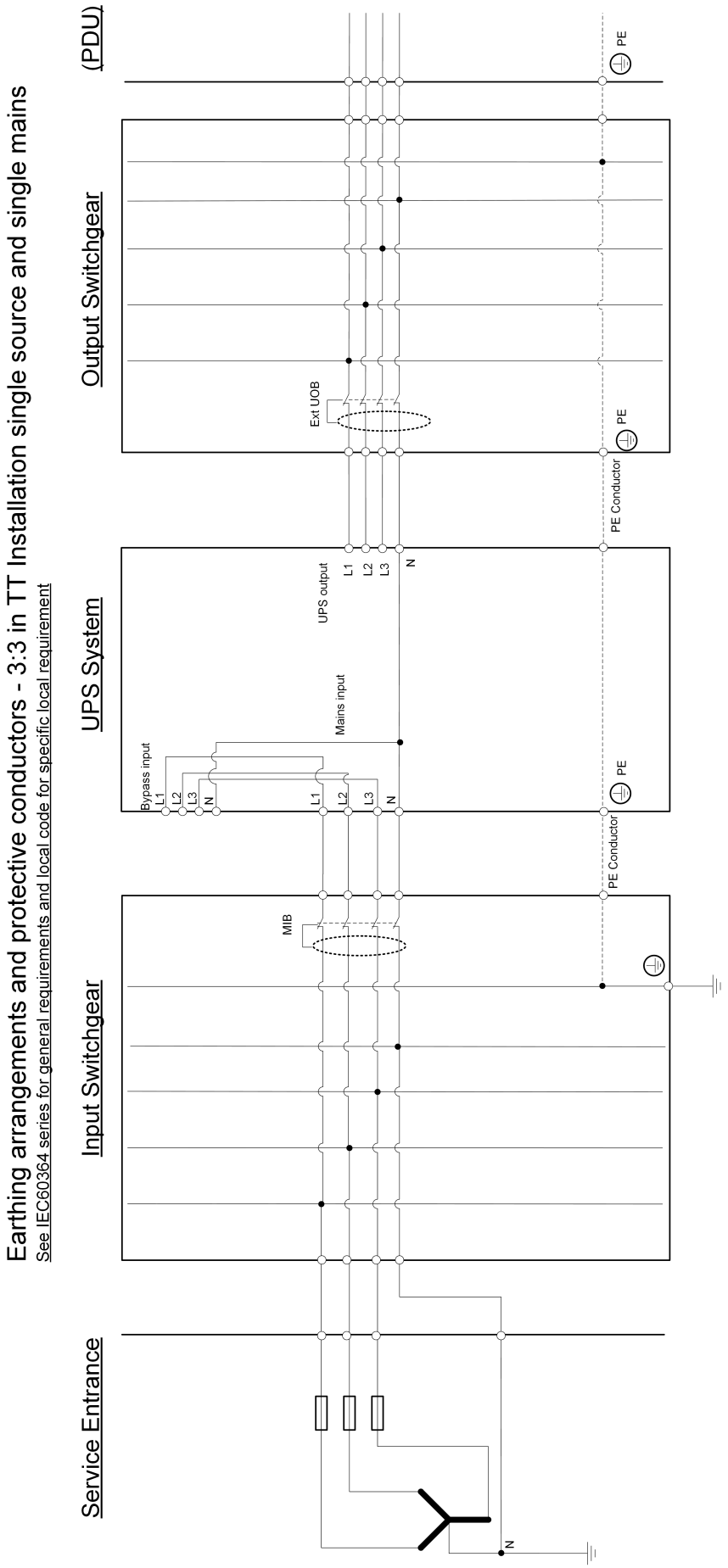
  When the protective device is a residual current protective device, I_a is the rated residual operating current $I_{\Delta n}$

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.

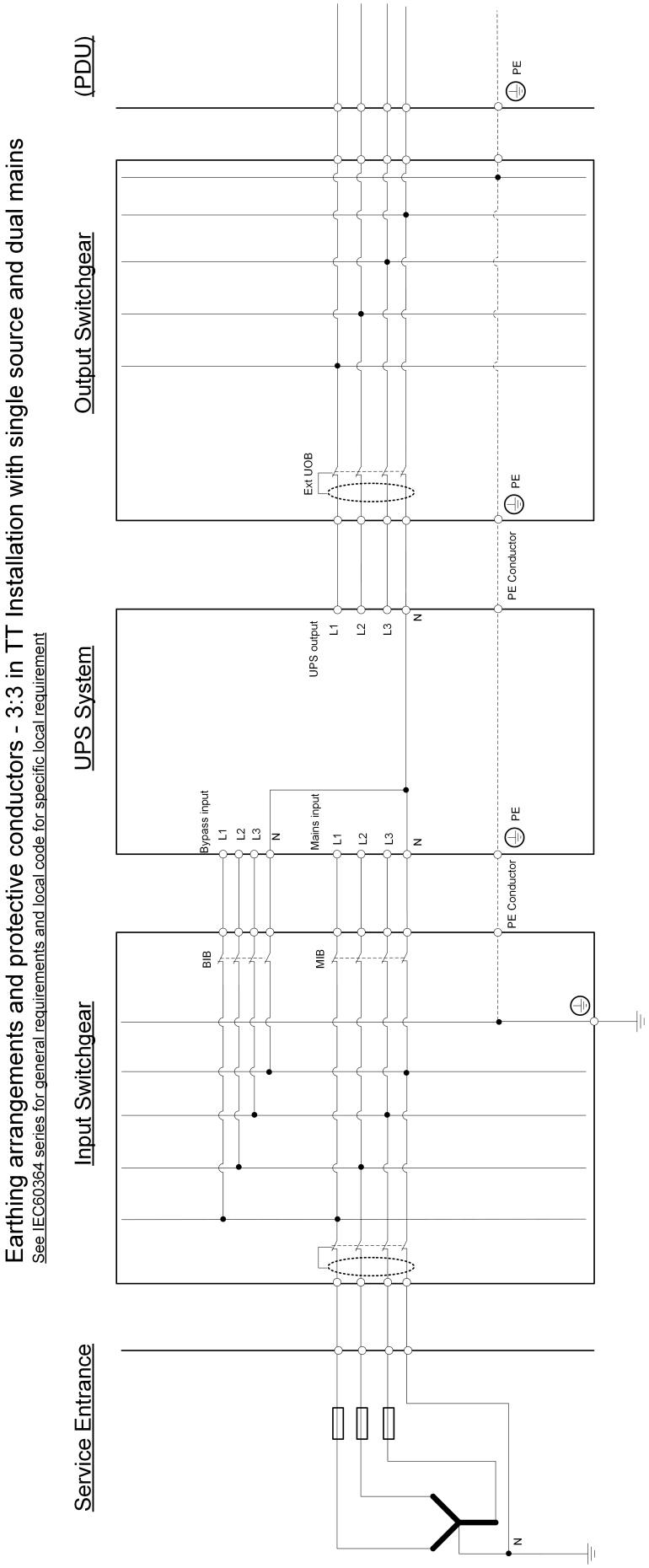
When the protective device is an overcurrent protective device, it must be either:

- 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

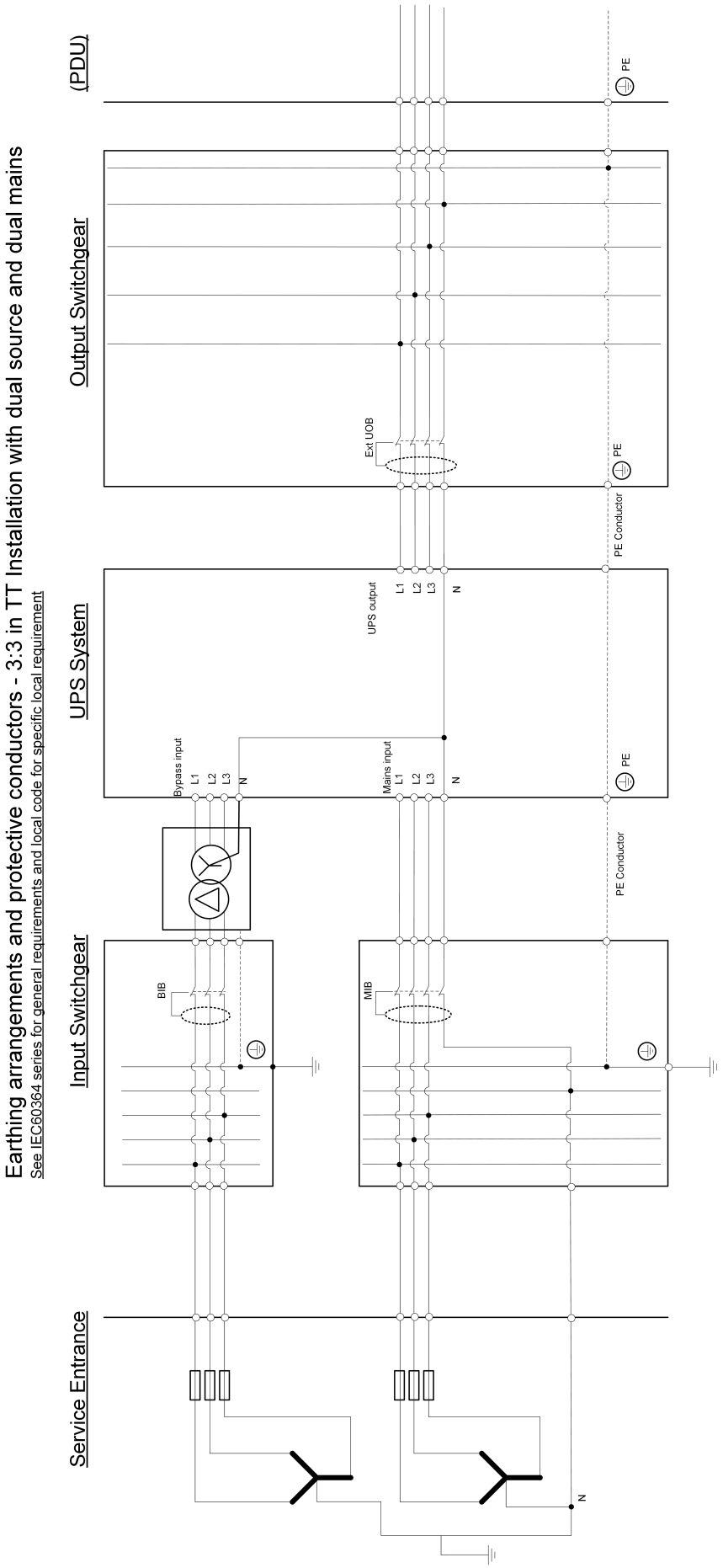
3:3 TT System Single Source and Single Mains



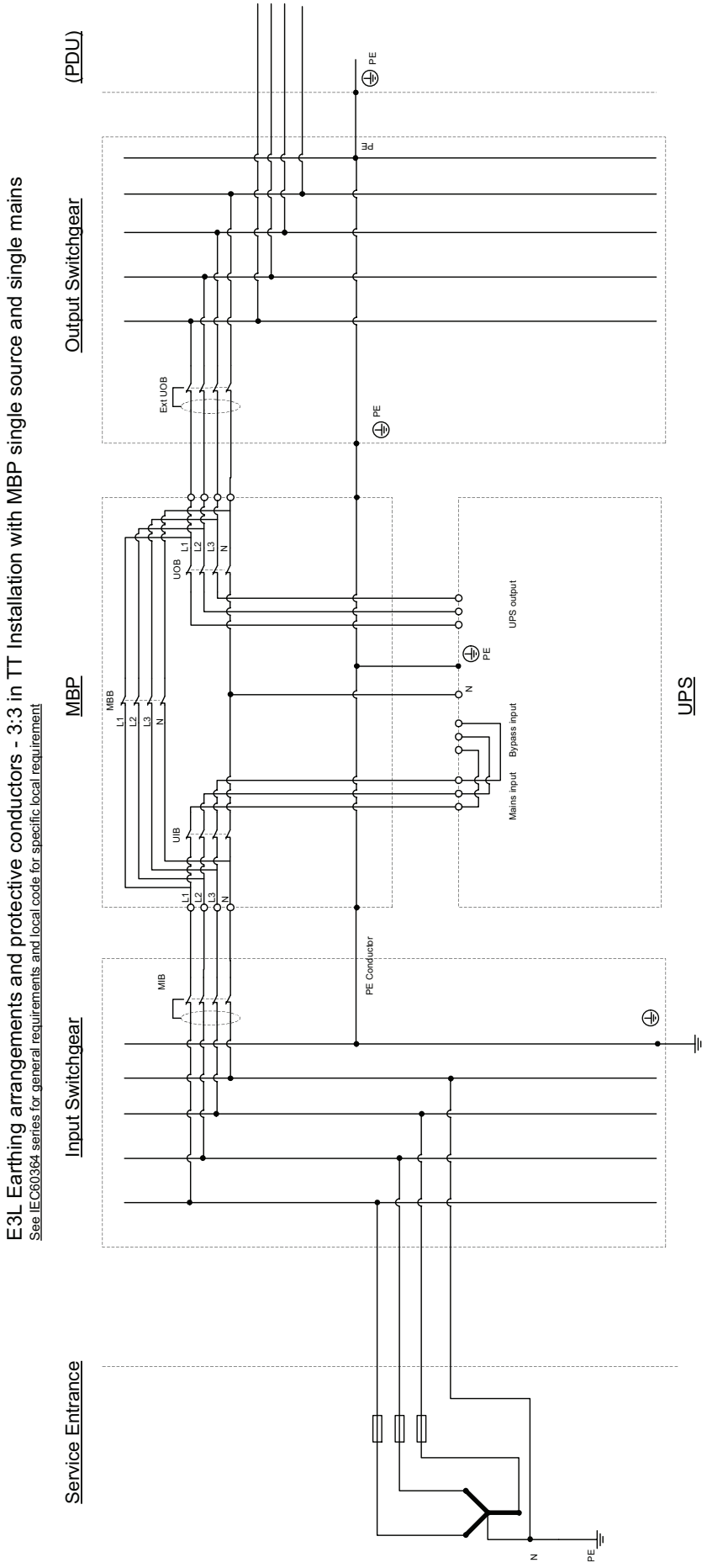
3:3 TT System Single Source and Dual Mains



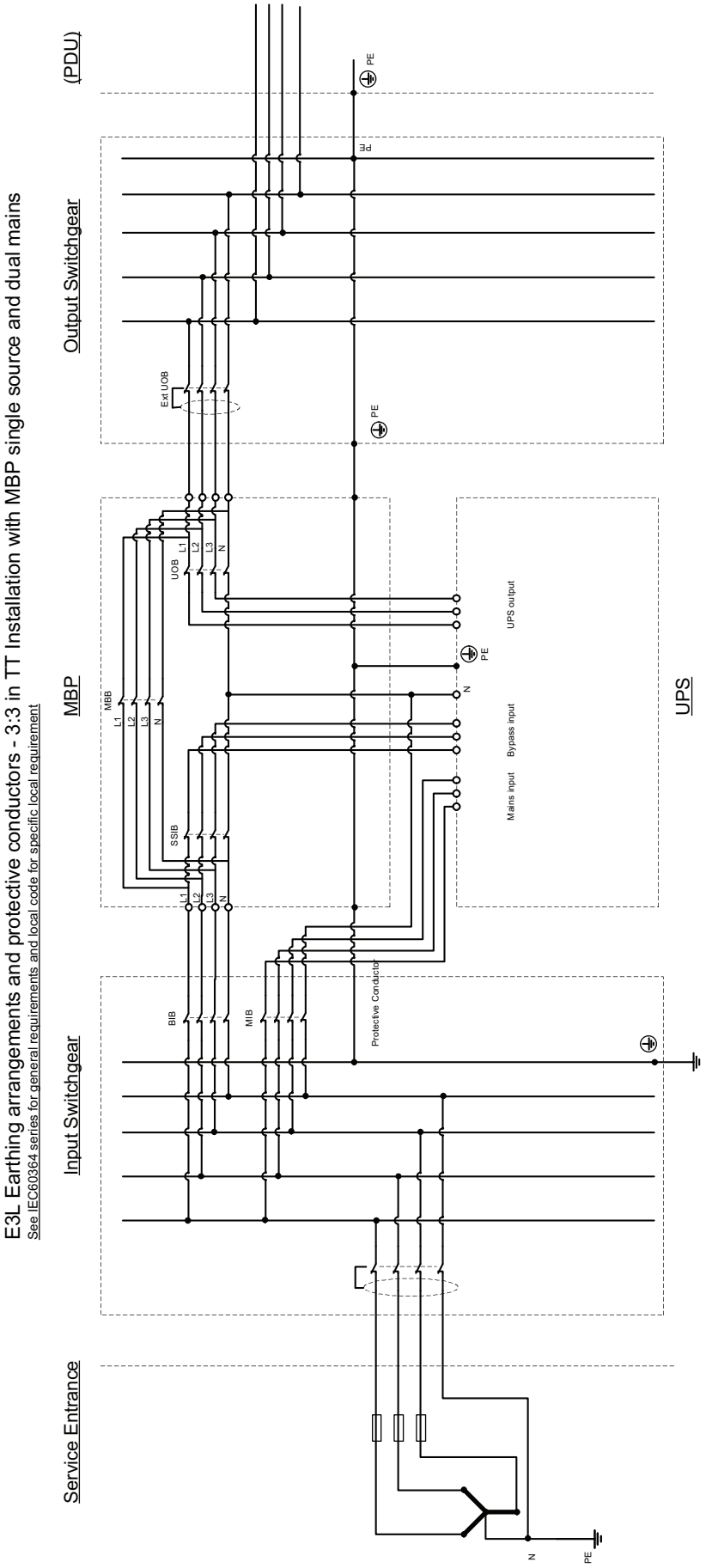
3:3 TT System Dual Source and Dual Mains



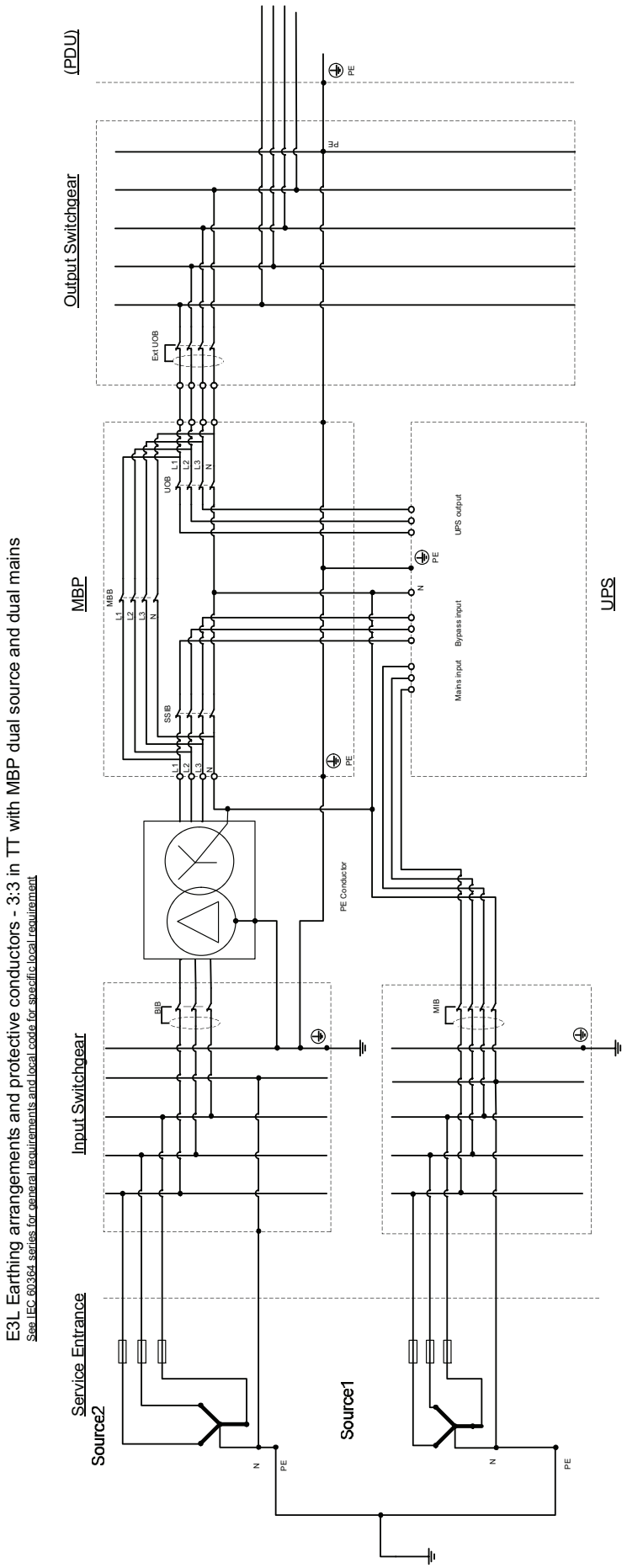
Easy UPS 3L 3:3 TT System with MBP Single Source Single Mains



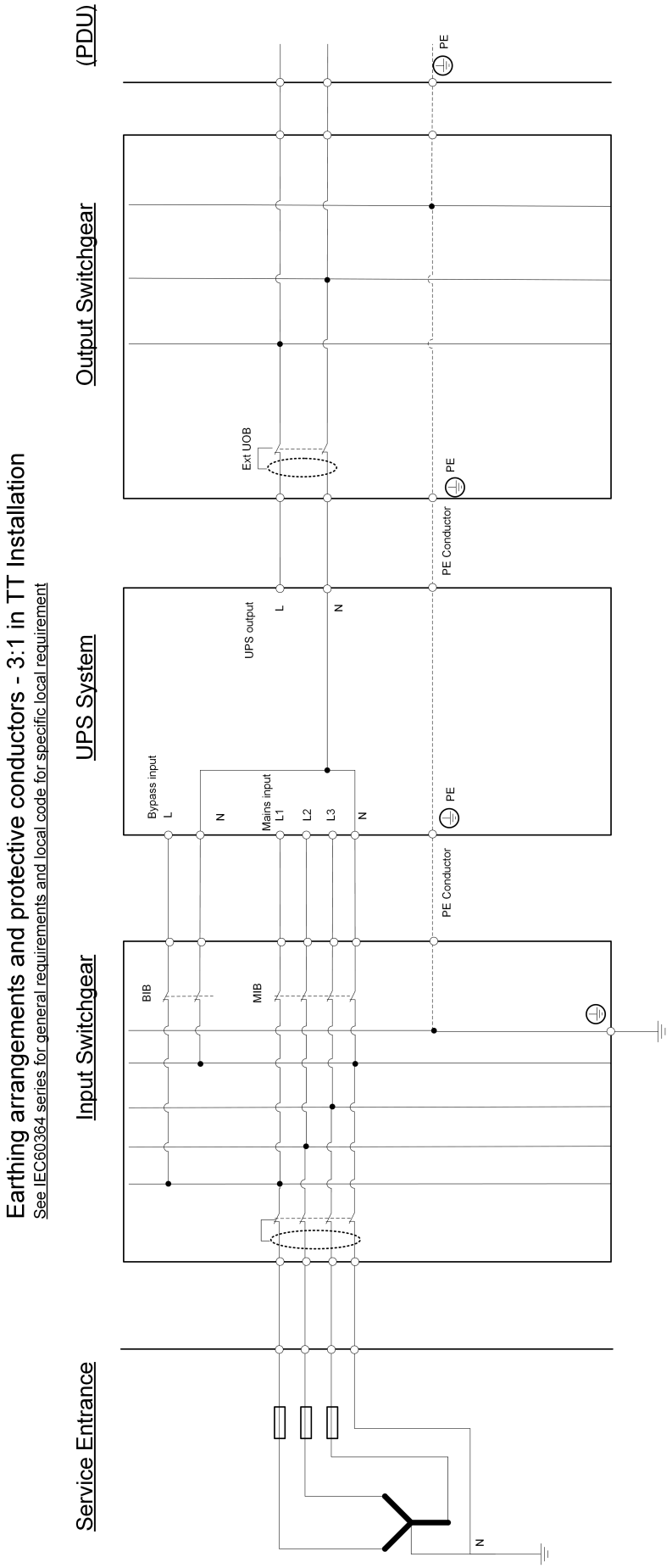
Easy UPS 3L 3:3 TT System with MBP Single Source Dual Mains



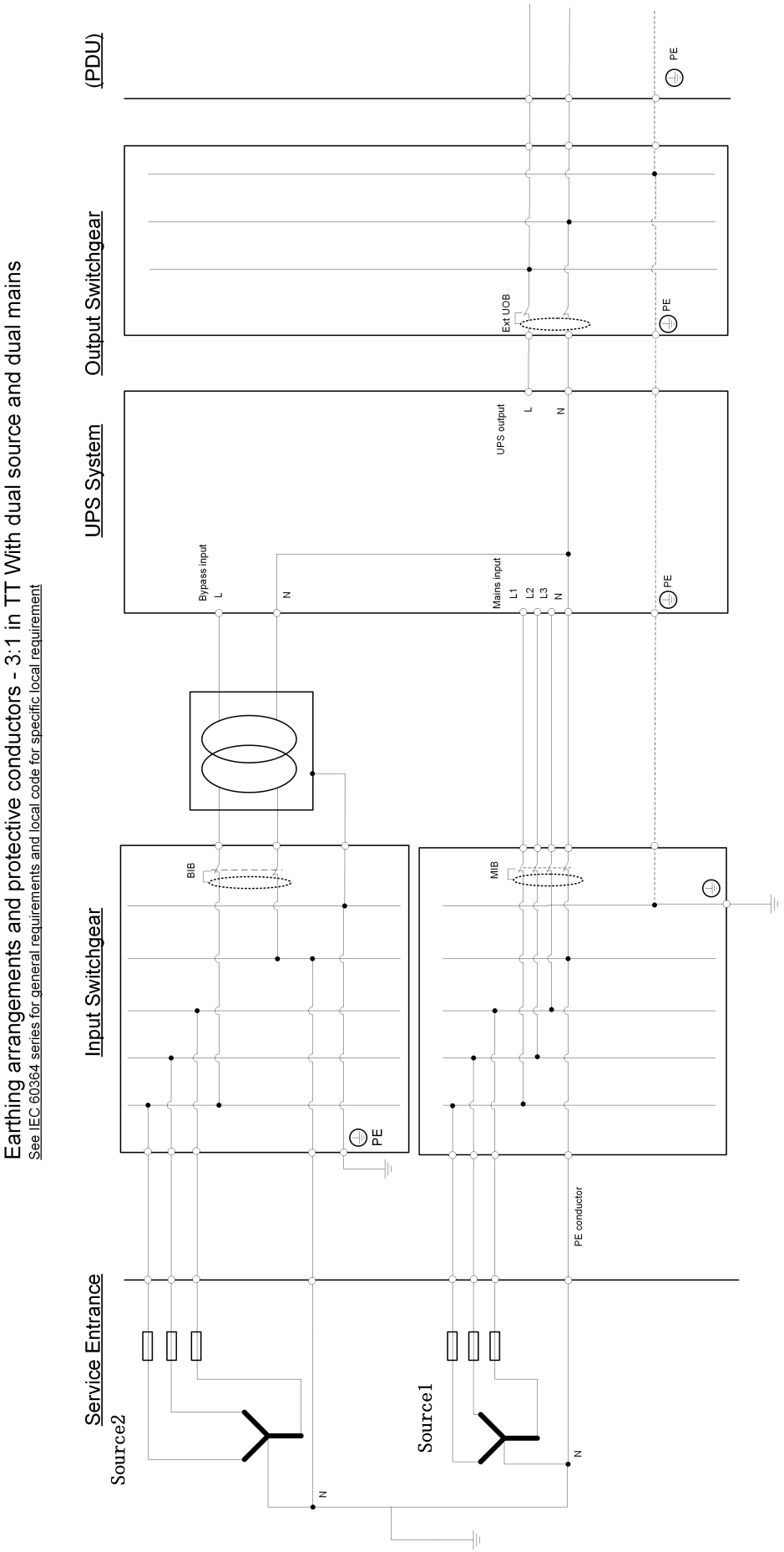
Easy UPS 3L 3:3 TT System with MBP Dual Source Dual Mains



3:1 TT System Single Source



3:1 TT System Dual Source



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 "$R_A \times I_d \leq 50$ V" 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)
2. In installations where the exposed conductive parts are 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:

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

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 conditions:

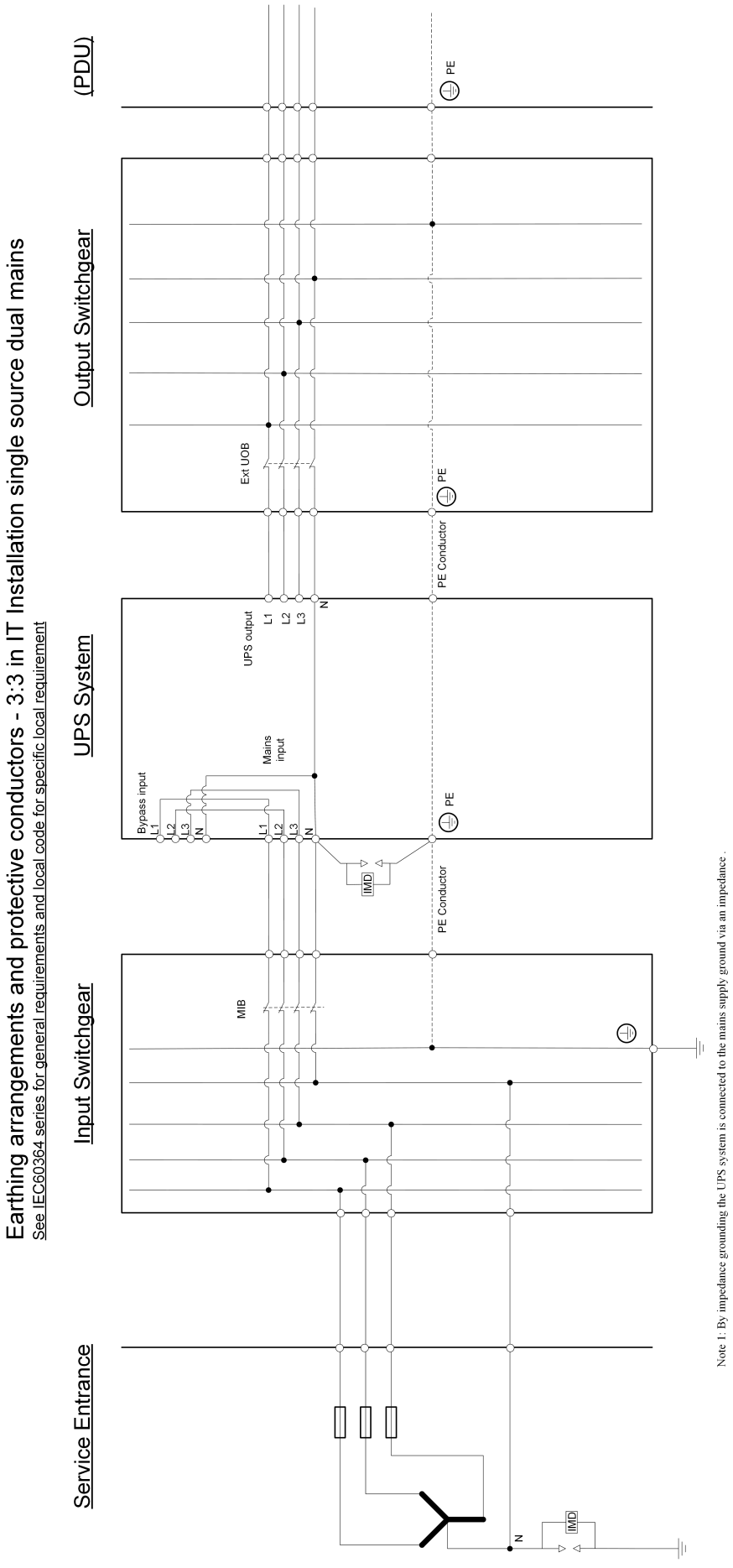
- U_0 is the nominal AC RMS voltage between phase and neutral
- Z_s is the impedance of the fault loop comprising the phase conductor and the protective conductor of the circuit
- Z'_s is the impedance of the fault loop comprising the neutral conductor and the protective conductor of the circuit
- I_a is the operating current of the protective device

Protective devices in IT systems

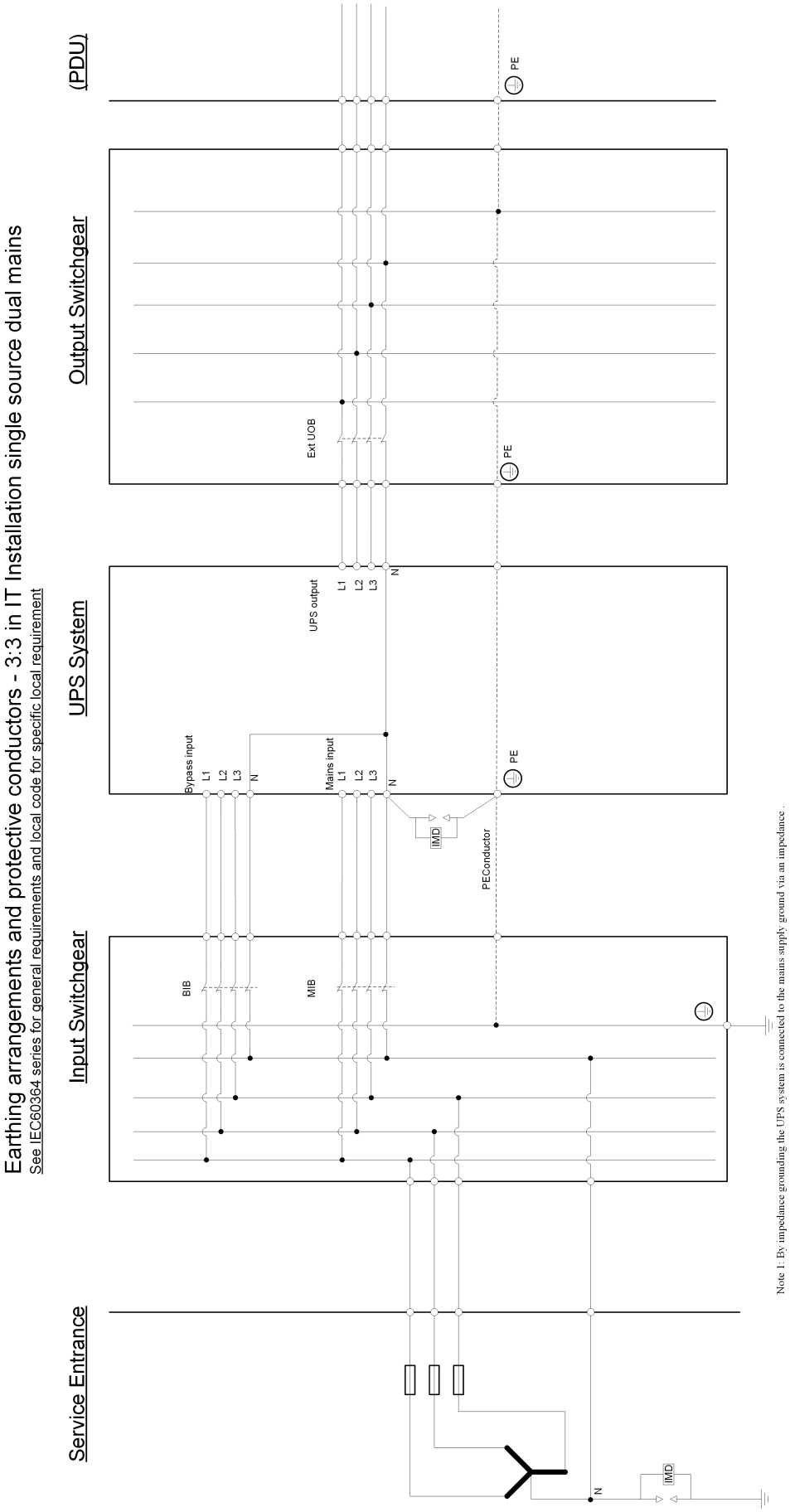
The following protective devices are recognized in IT systems:

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

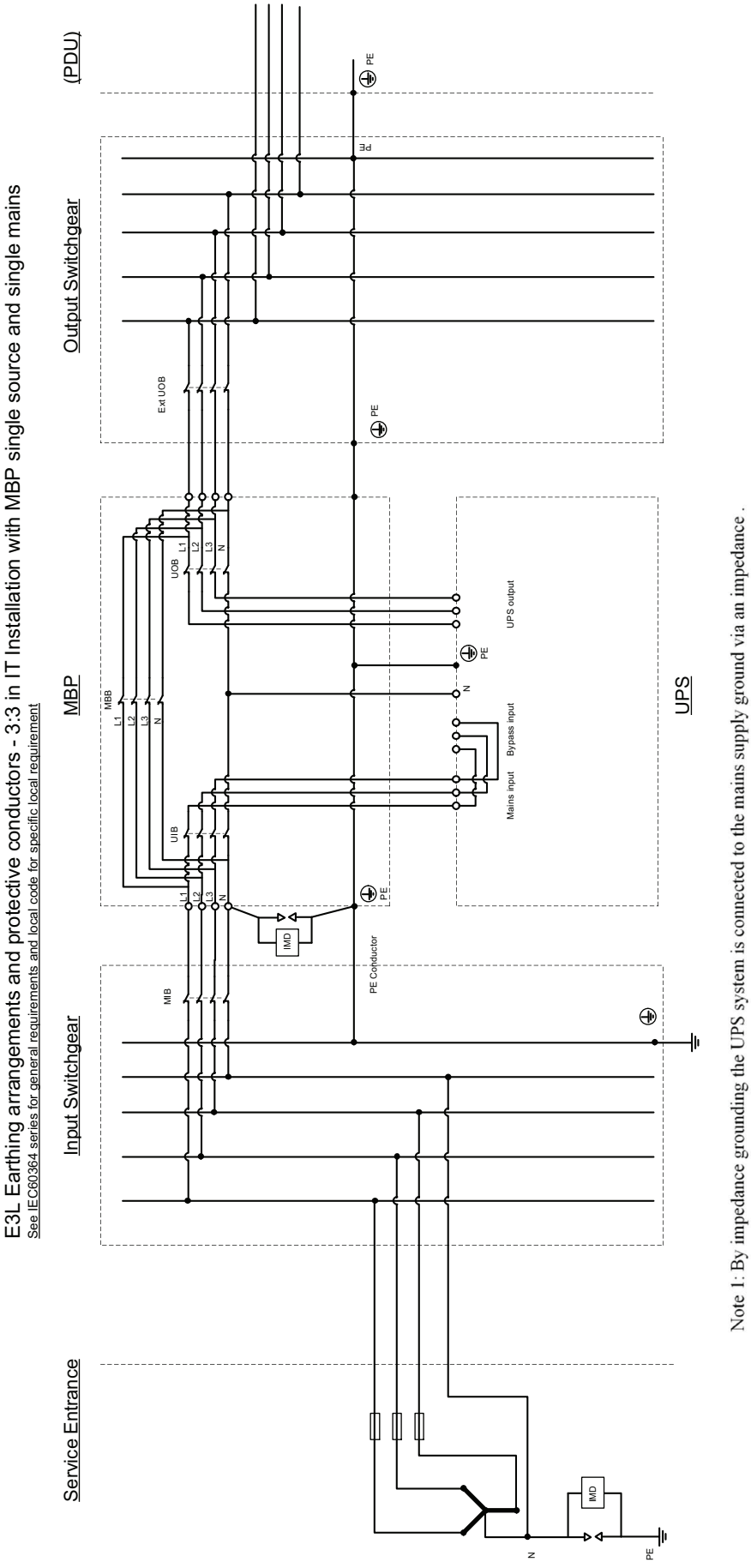
3:3 IT System Single Source and Single Mains



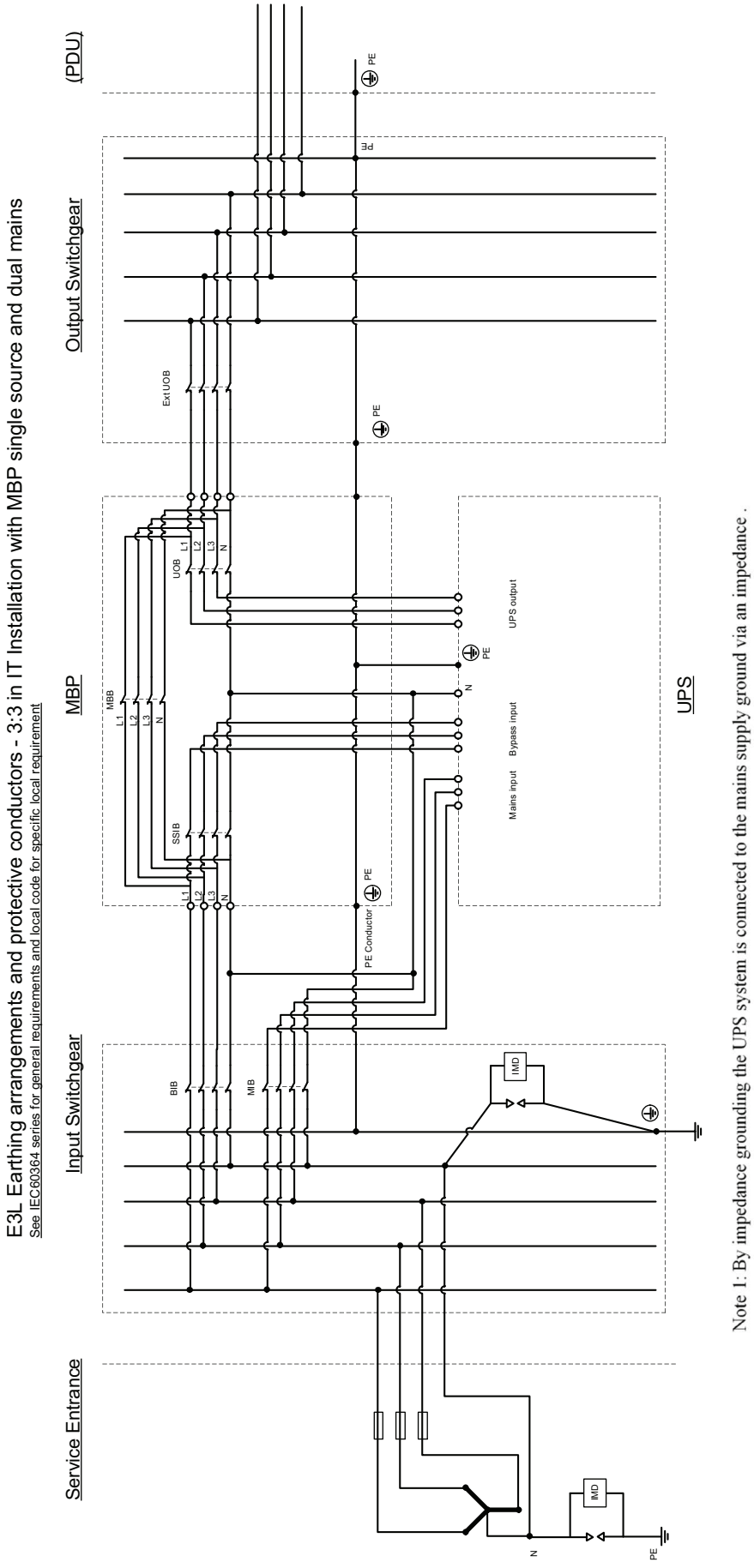
3:3 IT System Single Source and Dual Mains



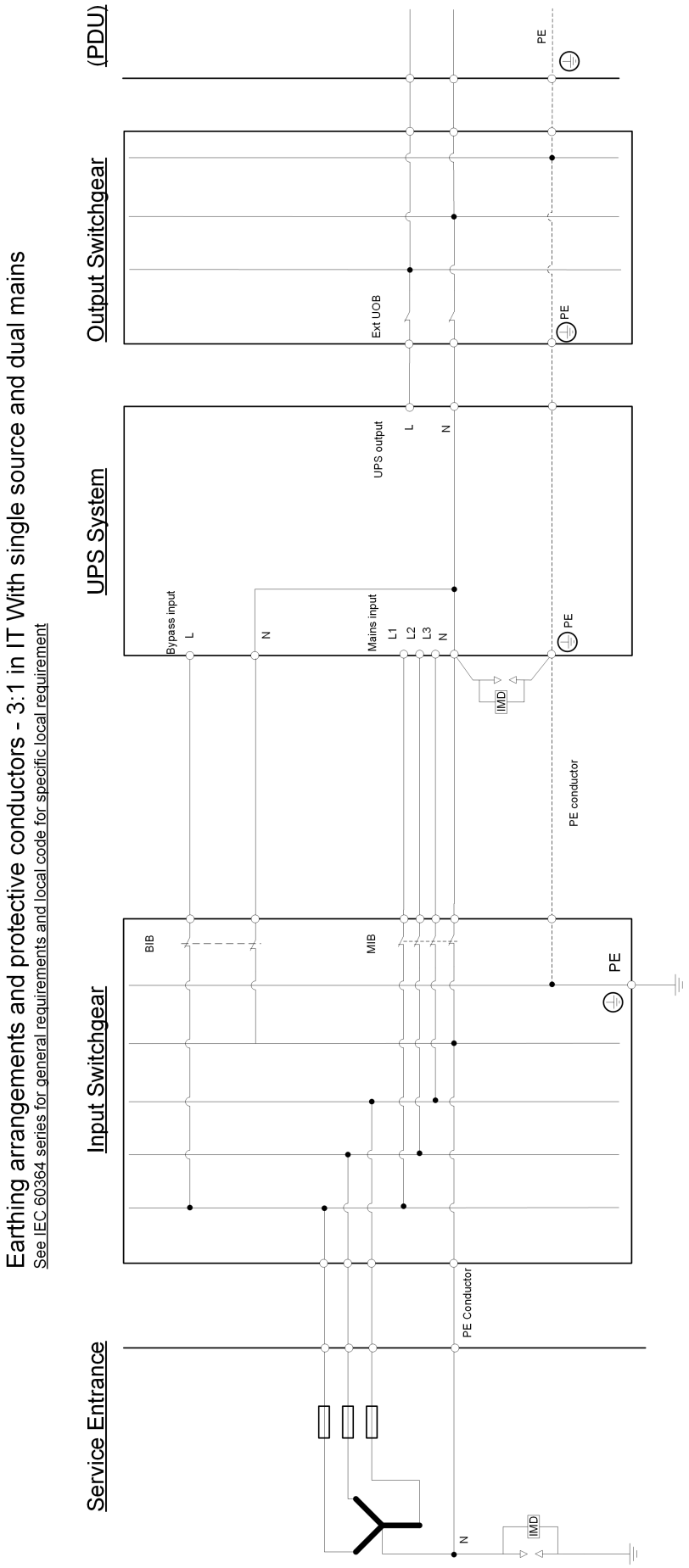
Easy UPS 3L 3:3 IT System with MBP Single Source Single Mains



Easy UPS 3L 3:3 IT System with MBP Single Source Dual Mains



3:1 IT System Single Source and Dual Mains



Dimensioning

Cross-Sectional Area of Protective Conductors

NOTE: The following section deals with dimensioning of the Protective Conductor (the PE conductor).

Reproduced Articles from IEC 60364-5-54

543 Protective Conductors

543.1 Minimum cross-sectional areas

543.1.1 The cross-sectional area of every protective conductor shall satisfy the conditions for automatic disconnection of supply required in clause 413.1 of IEC 60364–4–41 and be capable of withstanding the prospective fault current.

The cross-sectional area of the protective conductor shall either be calculated in accordance with 543.1.2, or selected in accordance with table 54.3. In either case, the requirements of 543.1.3 shall be taken into account.

Terminals for protective conductors shall be capable of accepting conductors of dimensions required by this subclause

Cross-sectional area of line conductor *S* mm²	**Minimum cross-sectional area of the corresponding protective conductor mm²**	
	If the protective conductor is of the same material as the line conductor	**If the protective conductor is not of the same material as the line conductor**
$16 \leq S$	S	$\frac{k_1}{k_2} \times S$
$16 < S \leq 35$	16^a	$\frac{k_1}{k_2} \times 16$
$S > 35$	$\frac{S^a}{2}$	$\frac{k_1}{k_2} \times \frac{S}{2}$

where

k_1	is the value of *k* for the line conductor, selected from table A.54.1 or from the tables in IEC 60364–4–43, according to the materials of the conductor and insulation;
k_2	is the value of *k* for the protective conductor selected from tables A.54.2 to A.54.6 as applicable
a	For a PEN conductor, the reduction of the cross-sectional area is permitted only in accordance with the rules for sizing of the neutral conductor (see IEC 60364–5–52).

543.1.2. The cross-sectional areas of protective conductors shall not be less than the value determined either

- in accordance with IEC 60949;
- or by the following formula applicable only for disconnection times not exceeding 5 s:

$$S = \frac{\sqrt{I^2 t}}{k}$$

where

S is the cross-sectional area, in mm^2

I is the value (r.m.s) in A of prospective fault current for a fault negligible impedance, which can flow through the protective device (see IEC 60909–0);

t is the operating time of the prospective device for automatic disconnection in s;
NOTE 1 Account should be taken of the current-limiting effect of the circuit impedances and the limitation of I^2t of the protective device.

k is the factor dependent on the material of the protective conductor, the insulation and other parts and the initial and the final temperatures (for calculation of k, see annex A).

If application of the formula produces non-standard sizes, conductors of a higher standard cross-sectional area shall be used.

NOTE 2 For limitations of temperatures for installations in potentially explosive atmospheres, see IEC 60079–0.

NOTE 3 As the metallic sheaths of mineral insulated cables according to IEC 60702–1 have an earth fault capacity greater than that of the line conductors, it is not necessary to calculate the cross-sectional area of the metallic sheaths when used as protective conductors.

543.1.3 The cross-sectional area of every protective conductor which does not form part of the cable or which is not in a common enclosure with the line conductor shall be not less than

- 2,5 mm^2 Cu/16 mm^2 Al of protection against mechanical damage is provided
- 4 mm^2 Cu/16 mm^2 Al of protection against mechanical damage is not provided

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