

# UPS Application Guide

Digital Energy™ Uninterruptible Power Supply

## 16 NEUTRAL SYSTEMS

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GE imagination at work



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## 16.1 AC POWER DISTRIBUTION SYSTEMS

In electricity supply systems, an earthing system defines the electrical potential of the conductors relative to that of the Earth's conductive surface. The choice of earthing system has implications for the safety and electromagnetic compatibility of the power supply. Note that regulations for earth (grounding) systems vary considerably between different countries.

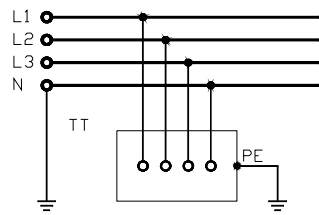
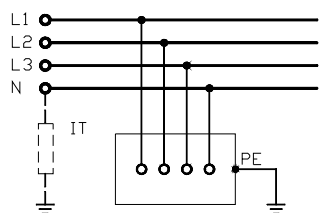
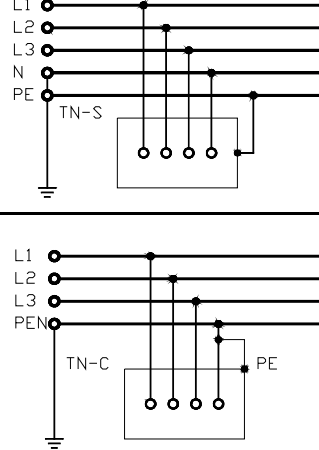
A *protective earth* (PE) connection ensures that all exposed conductive surfaces are at the same electrical potential as the surface of the Earth, to avoid the risk of electrical shock if a person touches a device in which an insulation fault has occurred. It also ensures that in the case of an insulation fault, a high fault current flows, which will trigger an over current protection device (fuse, MCB) that disconnects the power supply.

International standards require that electrical installations implement two types of protection of person against the dangers of electrical currents.

- Protection against **direct contact** with conductive parts that are intentionally live. This protection is provided by barriers or enclosures for which the design and type define the corresponding IP degree protection index.
- Protection against **indirect contact** with conductive parts that are not normally live but which may become live accidentally. This protection is provided by disconnecting the supply of power when the potential difference of these parts becomes dangerous.

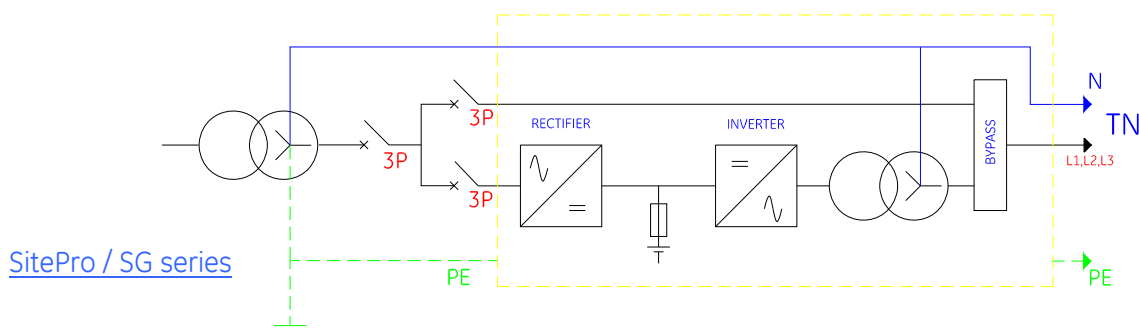
International standard IEC 60364 distinguishes three families of earth arrangements using the two-letter codes **TN**, **TT**, and **IT** (three letter codes only for TN systems)

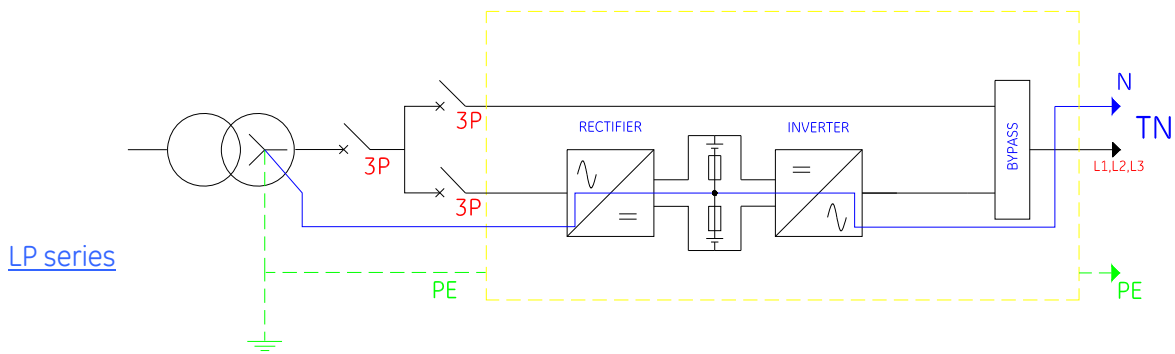
FIRST LETTER <i>connection of the Neutral</i>	SECOND LETTER <i>earthing of the equipment</i>	THIRD LETTER (only for TN systems) <i>protection conductor</i>
<b>T</b>  Direct connecting to the earth of the power distribution	<b>T</b>  Connected to a local earth independent from the power distribution earth	<b>C</b>  Neutral and protective conductor (PEN) are combined in a single conductor
<b>I</b>  Isolated from the earth	<b>N</b>  Connected to the earth of the power distribution	<b>S</b>  Neutral and protective conductor (PE) are distributed separately

<p><b>TT system</b></p> <p>The power distribution system have one point directly earthed:</p> <ul style="list-style-type: none"> <li>the neutral is connected directly to earth</li> <li>the masses are earthed independently of power earthing</li> </ul>	
<p><b>IT system</b></p> <p>The power distribution system is isolated from the earth, except that one point may be connected to earth through an impedance or a voltage limiter:</p> <ul style="list-style-type: none"> <li>the neutral is isolated or connected to earth by an impedance</li> <li>the masses are earthed independently of power earthing</li> </ul>	
<p><b>TN system</b></p> <p>The power distribution system is directly earthed:</p> <ul style="list-style-type: none"> <li>the neutral is connected directly to earth</li> <li>the masses are connected to the same earthing point of neutral</li> </ul> <p><b>TN-S</b> Neutral and protective conductor (PE) are distributed separately.</p> <p><b>TN-C</b> Neutral and protective conductor (PEN) are combined in a single conductor.</p> <p><b>TN-C-S</b> Combination of the two above power distribution systems.</p>	

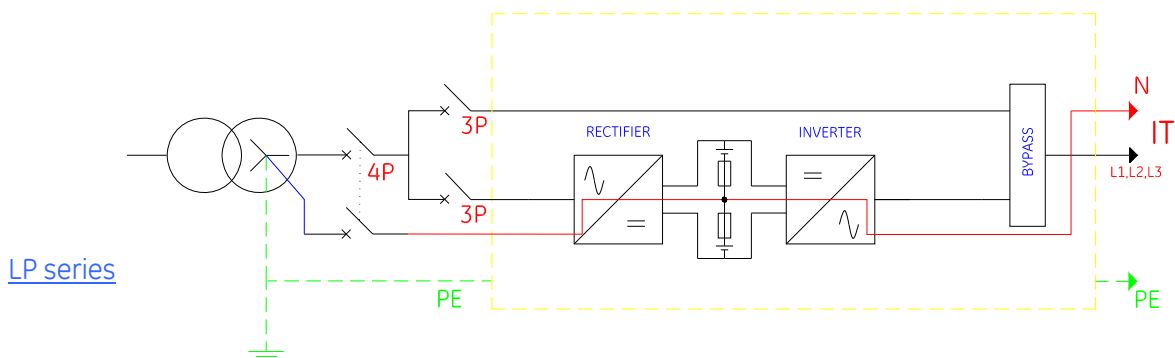
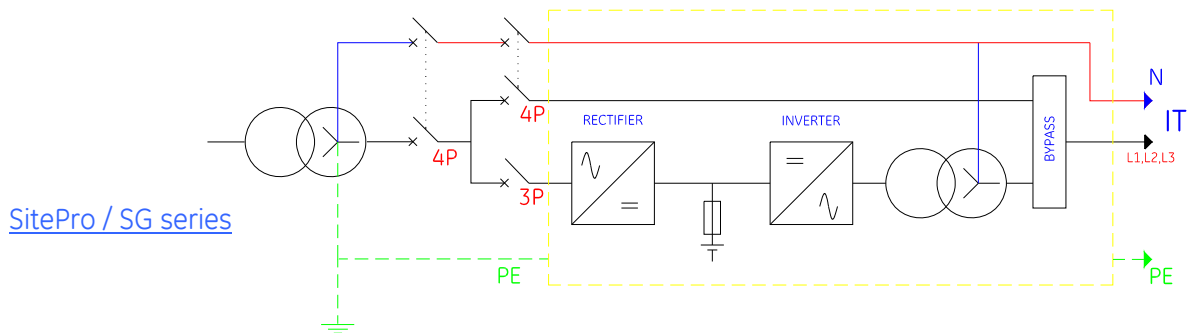
## 16.2 PROBLEMS WITH FOUR POLE BREAKER

The mains transformer star centre is grounded, thus the neutral has the same potential as the earth. In the below picture it is possible to see how a 3-pole breaker may be used to connect/disconnect the UPS. In this case only three phases will be interrupted; the neutral is always connected to the load. A TN system guarantees either the 3-pole breaker is open or closed.



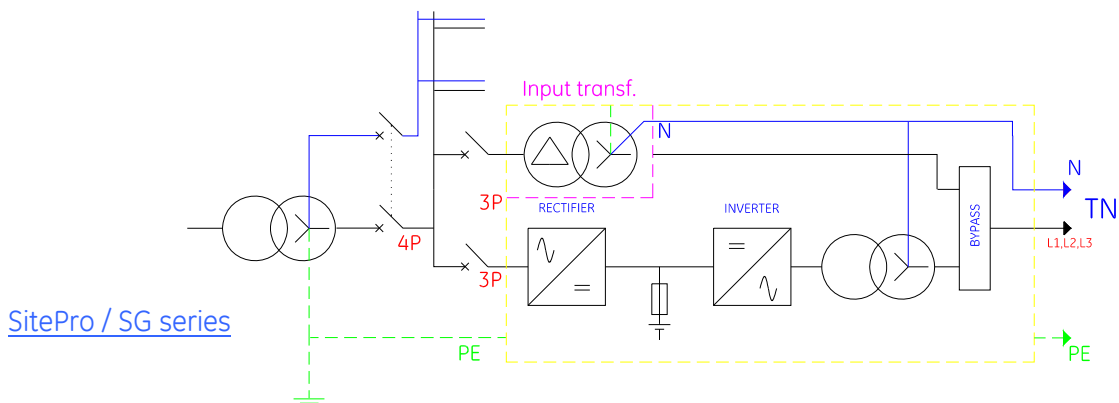


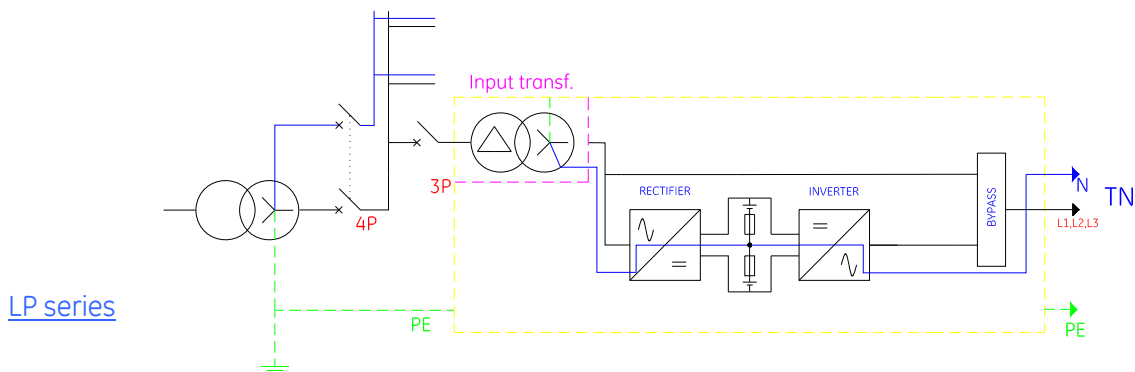
What's happens if a 4-pole breaker is used?



Above, a 4-pole breaker is used and the neutral is interrupted. In this case the output will change from TN into IT system. This is dangerous nearby user safety and safety of the connected load. This type of breaker is used in many electrical systems and it is very important to prevent any unsafe situation.

How is it possible to avoid this problem?



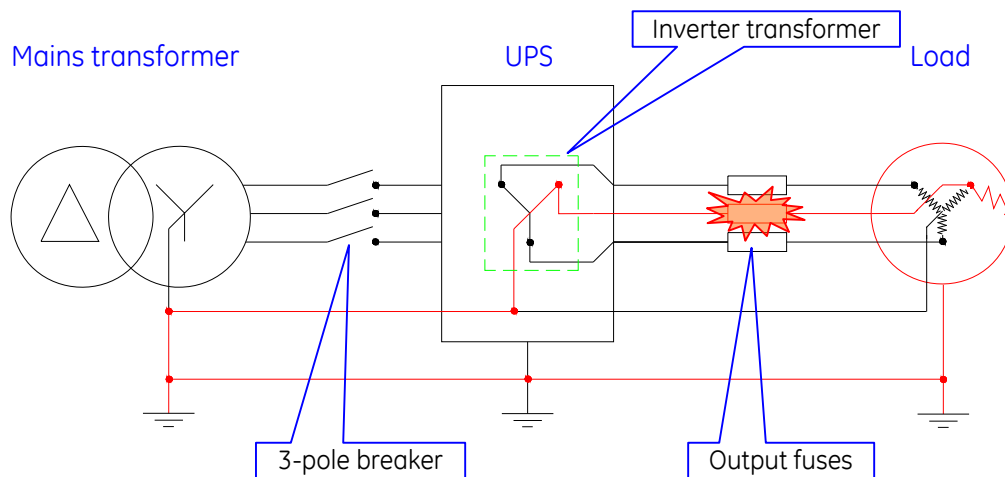


By adding an INPUT BYPASS TRANSFORMER a TN system is maintained whilst a 4-pole breaker opens the neutral of the electrical source. With this transformer a new neutral is created. For SitePro & SGseries UPS, this TX is fixed on the bypass line because the rectifier can operate without neutral and normally the UPS works in VFI mode (rectifier + inverter) thus there will be no losses added by the input transformer. For LPseries this transformer must feed both rectifier and bypass (input neutral conductor is mandatory for LP rectifier).

**NOTE: INPUT TRANSFORMER STAR CENTRE MUST BE STRONGLY CONNECTED TO THE EARTH !!!**

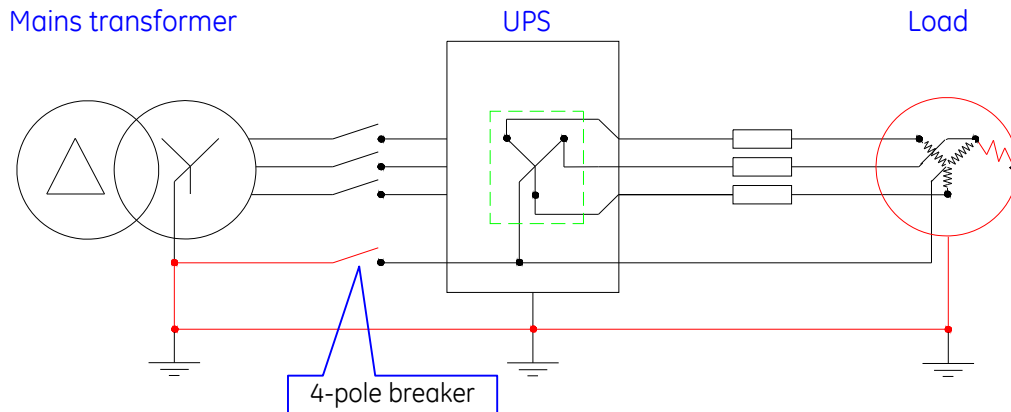
**What's happens if a load phase fault to earth?**

#### **Case 1: 3 pole-breaker used (SP & SG)**



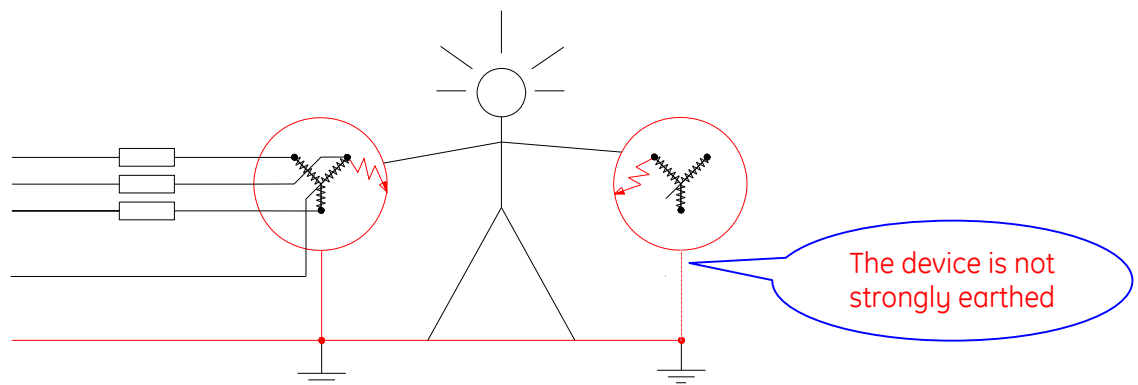
In the above picture, due to an internal isolation problem, one load phase faults to earth. Following the red line it is possible to note that a loop is achieved. Thanks to the neutral-earth connection, current can flow through the inverter output transformer star centre and reach the line fuse. This will cause a high current to blow. Using a strong neutral-earth connection and a properly size fuse, will guarantee safety.

### Case 2: 4 pole-breaker used (neutral disconnected) (SP & SG)



Opening a neutral conductor by a four pole breaker, means the current cannot flow through the circuit; therefore the fuse doesn't blow. UPS will continue to work whilst a critical safety condition is in action.

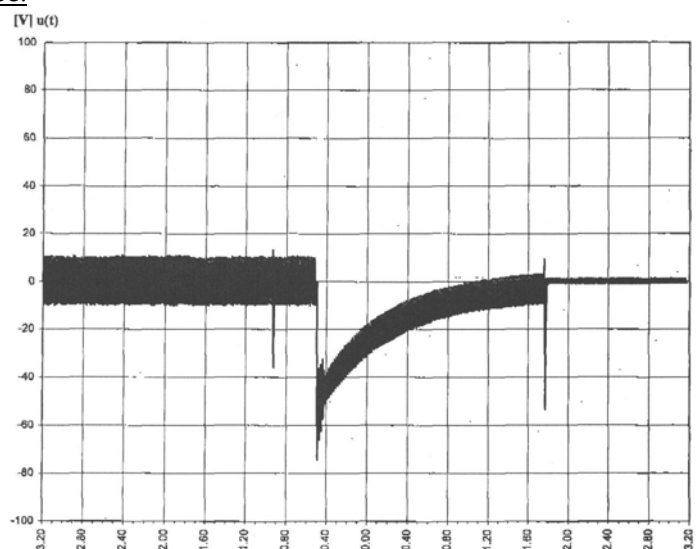
### Case 3: two load beside fault to earth



Above the risk of achieving an IT system is shown with a simple picture. In case another device (not strongly earthed) near the first one fails to earth, and the operator is touching both, an electrical shock will occur.

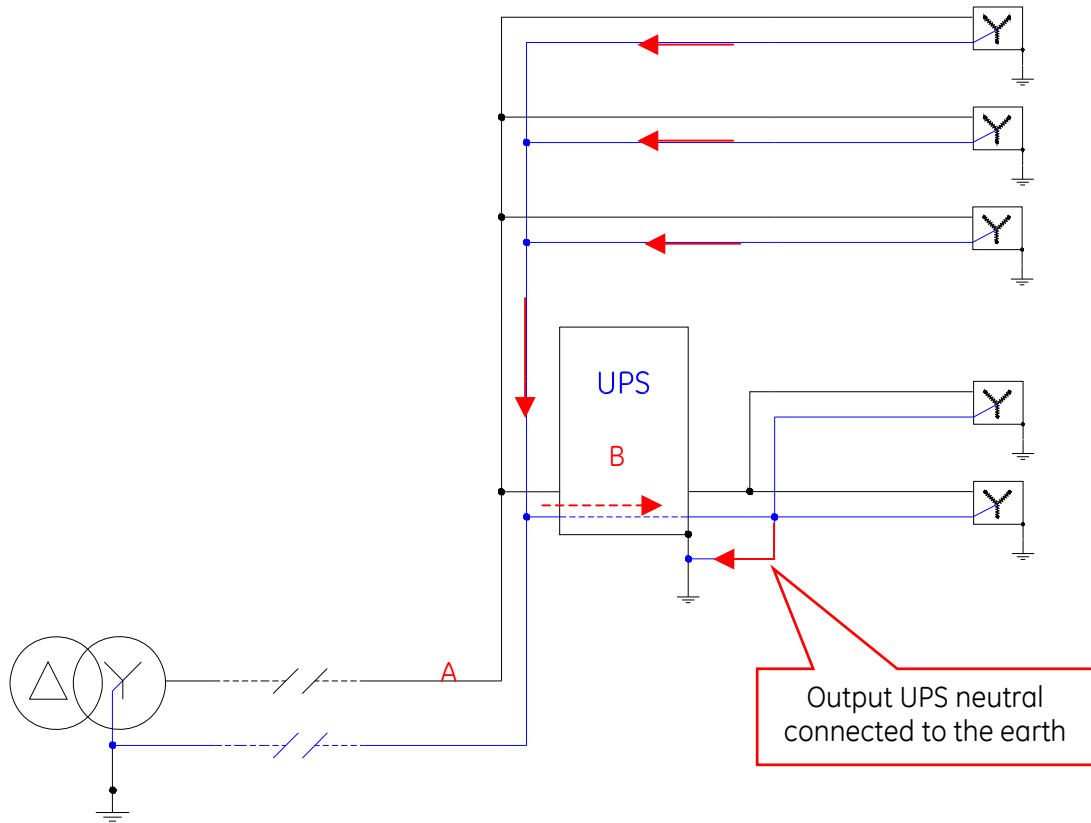
Note: using a four pole breaker upstream a transformerless UPS (LP), the system behaviour will be the same as SP or SG. The only one difference is that LP could be switched off automatically due to the fact that batteries central point will lose zero reference.

The figure explain what's happen during a opening or closing of neutral conductor. The voltage level between neutral and heart can increase up to 100V. This system behaviour could switch off all the sensitive equipment (Radio/TV equipments) connected to the UPS output.



## 16.3 PROBLEMS BY CONNECTING OUTPUT NEUTRAL TO THE EARTH

To connect the output neutral conductor to the earth is strongly prohibited, a UPS failure high risk can occurs. It's also not allowed to perform the same connection before the UPS. Neutral conductor must be fixed to earth only in the mains distribution transformer.



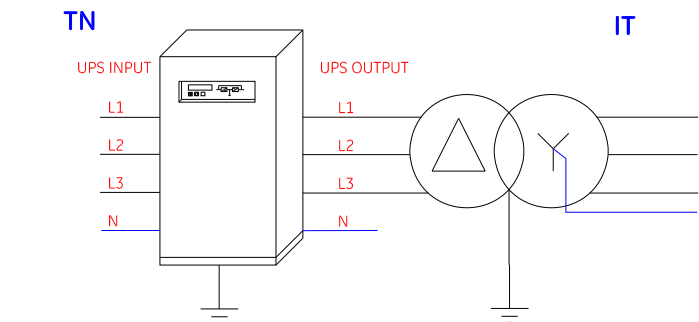
The above picture represents an example of system distribution where the output UPS neutral is been connected to the earth conductor. We need to consider that inside our UPS, neutral conductor is common with both input and output connections. Supposing that neutral system line point "A" has a higher impedance respect point "B", all the neutral current of the remaining circuit will flow to the internal UPS neutral and will close the circuit to the earth. This means that UPS internal neutral conductor could burns and damages the UPS.



## 16.4 UPS NEUTRAL REQUIREMENT

- Our UPS are designed to operate supplied by a: **TN power distribution system with a solidly grounded neutral.**
- Our UPS use the **same neutral** for input and output connections.
- A **three-pole protection device** shall be used as UPS input protection devices.
- UPS input neutral shall be **not interrupted** to avoid IT distribution system when battery mode is operating.
- In case of a 3-wire distribution without neutral, a local neutral shall be realized by adding an UPS **input bypass transformer** .
- It's possible to install a UPS in a **TN-C system** (neutral and earth connected).
- EN and IEC standards recommend:
  - o for standard user safety (protection against direct and indirect contact), the max voltage difference between PE and Neutral shall never exceed 50Vac rms.
  - o for user safety in critical ambient (outside or humid rooms), the max voltage difference between PE and Neutral shall never exceed 25Vac rms.
- For UPS application we have tested:
  - o up to 2Vac rms: no problem for UPS and all kind of criticals load
  - o from 2Vac rms to 5Vac rms: possible (rare) problems for UPS and very critical loads
  - o more than 5Vac rms: should never be accepted!

- To achieve an **IT system**, a delta/star transformer is needed. The output UPS neutral conductor is not used.
- The transformer star centre will recreate a new neutral isolated from the earth.



- **It's strongly prohibited to connect neutral and earth conductor together to the UPS output** (it's only allow for SitePro and SG series used as frequency converter)
- **SP and SG rectifiers** can work without neutral conductor (**neutral conductor is mandatory for bypass**). LP models **must have** input neutral to both rectifier and bypass.
- Inside UPS cabinet neutral and earth conductor are not connected together.
- For all our UPS: internal Neutral wiring rating is two times the phase current.

Before a UPS purchase, carefully check your electrical plant.