Peter Gabler

"Your computer does **not** run on every socket!"

go inside

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Installation guide for protection against undefined system faults as well as surge voltage, lightning and power failure

Issued by
Fachbereich Elektronik und EDV
im Bundesverband öffentlich bestellter
und vereidigter sowie qualifizierter
Sachverständiger e.V.
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Fachbereich Elektronik und EDV im Bundesverband öffentlich bestellter und vereidigter sowie qualifizierter Sachverständiger e.V. (BVS)

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Peter Gabler is an electronics technician and has worked in the areas of hardware and software since 1970. He started with a manufacturer of mainframes and later went on to work as after-sales manager with a nationwide systems house for small and medium companies in selected sectors. During some of these years he was in charge of the central hotline and service marketing for product-oriented services. The focus was on prevention, i.e. fault-free installation and safe operation of PCs and network electronics systems.

He has been a freelance consultant since 1993, advising systems houses in how to design services as marketable products.

He is a publicly certified expert on damage to electronic systems caused by surge voltage.

Contents

Preface

It is a widely spread opinion that PCs, networks and other networked electronics systems can be installed swiftly and easily because there are socket outlets everywhere. But, whenever illogical and undefined faults occur, it transpires that problems can often be ascribed to faults in the cabling (230 V~/data cables).

In the interests of system users, it is important to avoid malfunctions and destruction. The cost of a production outage are much higher than the cost of an electrical installation that does justice to IT requirements or in comparison with the replacement of defective hardware. The overall entrepreneurial risk cannot be insured and is economically not justifiable.

This installation guide is the result of more than 15 years of safety and environmental analyses in the area of PCs, mainframes and networked electronics systems. It was drawn up with great care and attention and has been put to use in innumerable informative talks with end customers and their electrical installation technicians. A large number of installations has been successfully converted in accordance with the contents of this guide. On the one hand, this guide was conceived as lightweight food for thought for interested readers, and on the other hand, as the basis for conducting talks with the user. In this way, users are able to realise that an installation not only involves setting up hardware and loading and configuring software, but begins much earlier.

1 The almost normal daily routine

Undefined faults without any recognisable logical connection

- Just before you finish your day's work, the PC simply stops or the network hangs.
- Without any prompting whatever, the load in the network increases from about 10% to more than 30%. Network performance is poor.
- You enter data on a workstation that gets sent off practically in one packet with a clearly visible delay.
- Several memory errors are recorded in a system's error log.
- In a system's cache, individual status bits are altered, locking access to the hard disks. The data is lost.
- A successful data backup is displayed, despite the fact that the data cannot be accessed in the restore process.
- For no apparent reason, the coupon printer sequence is changed over on a cash register system. The printout is useless.
- New workstations are installed and are integrated into a network. A connection cannot be established until the data transfer rate is reduced from 100 Mbits/s to 10 Mbits/s.
- Read/write errors on hard disks are reported.
- You cannot get to grips with the parameters of an air conditioning system. The temperature falls below the dew point and the valuable stucco "drips" from the ceiling.
- The fire brigade arrives several times as the result of false alarms by the fire alarm system.
- Without any apparent reason, the UPS system switches to bypass and the screen display jitters.

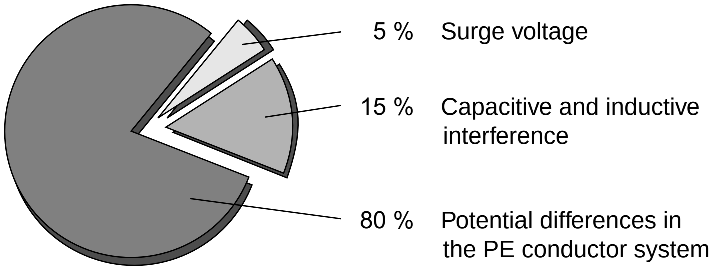
2 Service personnel activities

Defective systems are diagnosed at the service base and found to be faultless

The service technician goes to a location and does not immediately find any faults. A short time later the same symptoms manifest themselves to the technician. Now, hardware is replaced because he has to show that he has done something. The module is deposited at the service base and is placed in intermediate storage. A short time later, the same symptoms appear. The software specialist does not find any faults either. Updates do not bring any improvements.
When computers, printers or modules are tested at the service base, though, no faults appear.

Surveys undertaken with renowned German computer manufacturers have shown that between 70% and 80% of the network cards sent in for module replacement are not defective.

Causes of malfunctions and destruction from an analysis of damage

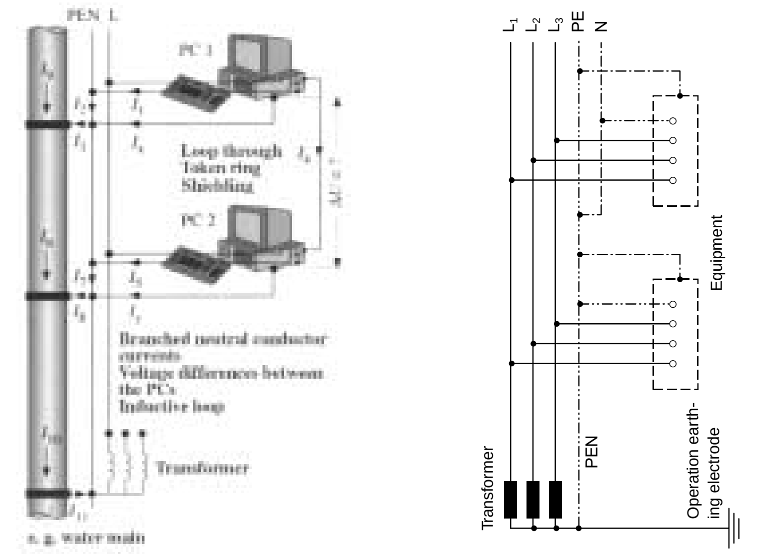


3 The standard electrical installation network configuration TN-C-S

Neutral conductor currents are forced through the PE conductor

Up to now, and still today, the network configuration TN-C-S has been and is usually installed in new buildings. (The network configuration TT is prescribed in a small number of regions in Germany.) The TN-C or TN-C-S network configuration (vertical TN-C/ horizontal TN-S) is the network configuration that is encountered most frequently in the event of malfunctions and destruction of electronics systems. It is therefore referred to in the most recent literature as being unfavourable in terms of EMC. As specified in VDE, in this network configuration the PE and N conductors may be routed in part of the network system as a common PEN conductor provided its cross-section is at least 10 mm² Cu or 16 mm² Al.

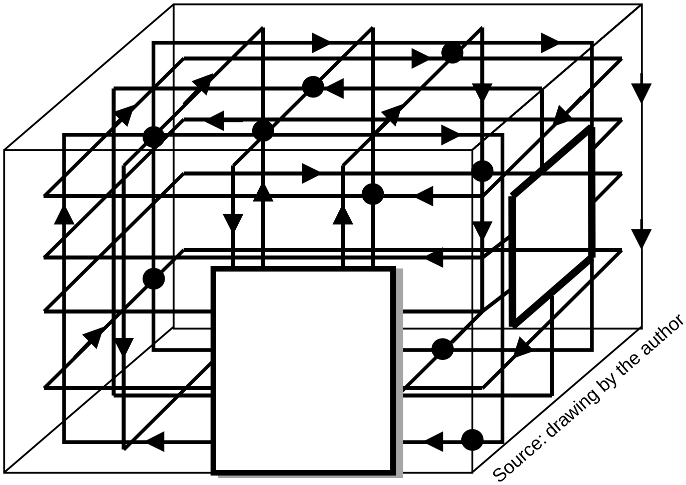
TN-C-System



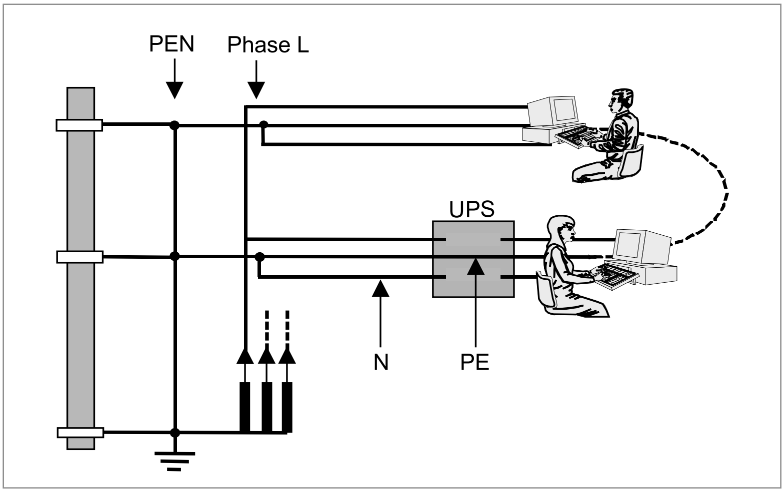
This installation is the cheapest minimum configuration that protects persons if installed skilfully and expertly. Nevertheless, this network configuration cannot by far offer protection for functions. As one PEN conductor is permitted in this network configuration, the neutral conductor currents inevitably flow through the PE conductor.

A multiply earthed PEN conductor, however, is simultaneously connected to the relevant earthing system and generates interference voltages and potential differences between the systems belonging to the various subdistribution boards. These currents are distributed randomly depending on the quality or low impedance of connections.

Possible distribution of current in an equipotential bonding system

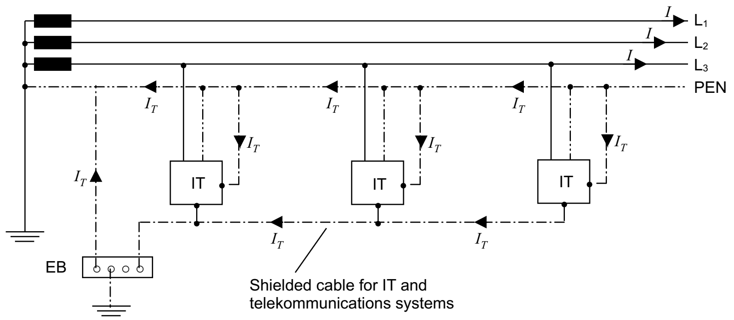


The figure shows the example of a current distribution system in a building as well as its earthing and equipotential bonding system. These currents are able to flow as soon as one PEN conductor is earthed at least twice.



In many cases, an attempt is made to solve the problems with UPS. Despite electrical isolation at N and L, there is no remedy because the PE conductor must be connected through continuously to provide protection against shock hazards. Compensating currents can nevertheless flow.
In this environment, there is no “low-noise equipotential bonding” as stipulated in VDE 0100 Part 540 of November 1991.

No low-noise equipotential bonding



From Kiefer: VDE 0100 und die Praxis, Page 271

Neutral conductor currents in all earthed parts of an IT system

The screen and reference conductor of the signal wires are connected to the PEN conductor. In a system with one or several PEN conductors, the return currents of the N conductor flow on all lines that are connected to the earthed PEN conductor.

What we have just said about the standard installation ensures protection of persons if it is installed skilfully and expertly. In this environment, non-networked standalone devices are also capable of functioning (PC, printer, monitor, copier and fax machine).

If several devices are networked, e.g. across several floors, buildings or subdistribution boards, then a completely different situation suddenly prevails, calling for an improved, PEN-free system environment.

In the buildings, electromagnetic compatibility between the systems must be ensured in conformity with VDE 0100 and its parts.

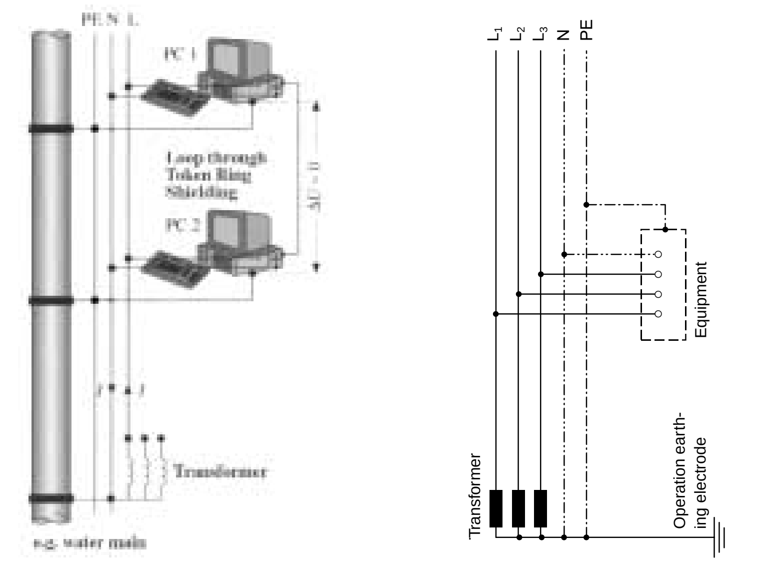
4 The EMC-friendly network configuration TN-S

Since mid 1980, the German Post Office, German Rail and broadcast authorities have prescribed for their internal purposes that the TN-S network configuration must be installed in a building if telecommunications and information processing equipment are installed there.

Since November 1991, VDE 0100 Part 540 has prescribed in Appendix C2 that low-noise equipotential bonding can only be achieved with the TN-S network configuration.

Prerequisite for a clean system environment: network configuration TN-S!

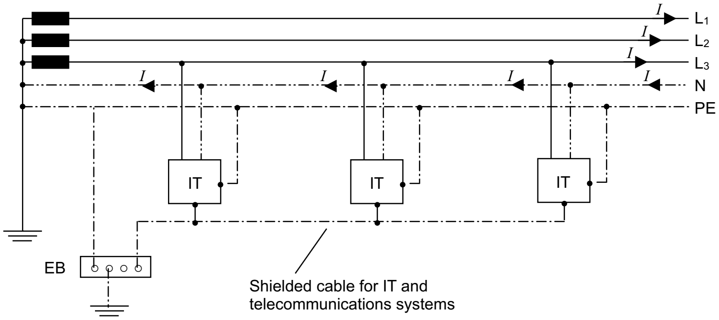
TN-S-System



In principle, this means that the N and PE conductors are routed separately as from the transformer or the feeding point and a continuous 5-conductor network L_1/L_2/L_3/N/PE must exist in the building up to the last socket. In principle, throughout the installation the N conductor must be handled and routed like an insulated phase conductor. In the entire building, the N conductor must no longer be connected anywhere to the PE conductor (no PEN jumpers). The aim of this is to ensure that no operational working currents are able to flow through the PE conductor.

5 Low-noise equipotential bonding

Low-noise equipotential bonding



From Kiefer: VDE 0100 und die Praxis, Page 271

No neutral conductor currents in earthed parts of an IT system

In this system, the (retur)N currents are isolated in the N conductor. No relevant currents flow through the PE and reference conductor system. The vector sum of the phase currents to the loads and the N conductor return current are equal. No differential currents occur and therefore also no electromagnetic fields.

5.1 Practical implementation

Implementation of the TN-S network configuration is described below with reference to practical examples.

1 The building transfer point
This example shows implementation in a building with a connection to the public power supply. This installation does not contain a separate transformer.

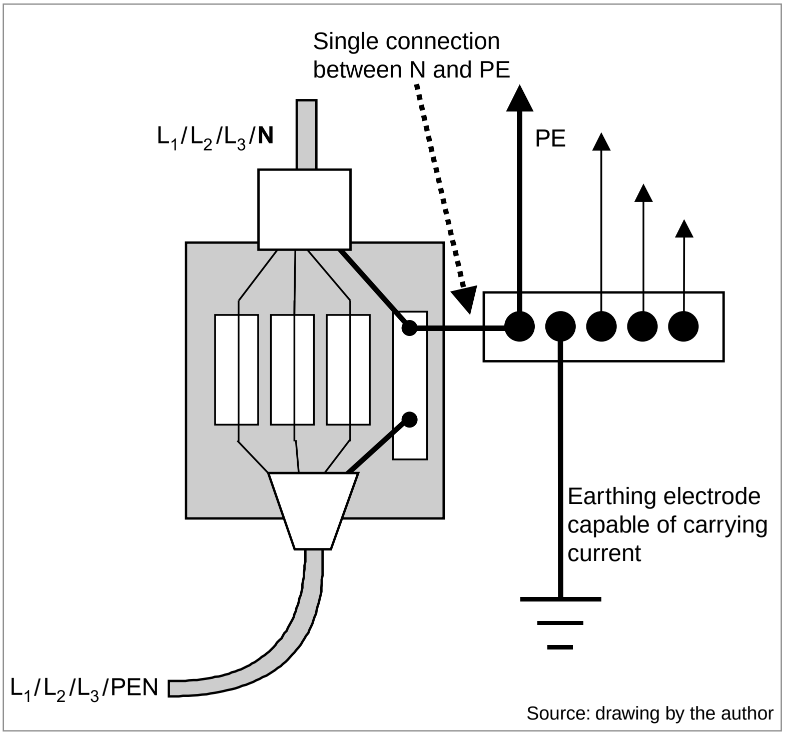
2 Power supply via one single transformer
This second example shows the installation with a transformer, a subsequent low-voltage main distribution board and subsequent subdistribution boards.

3 Power supply by transformer, an emergency generating system and an uninterruptible power supply.

TN-S network configuration as from the building transfer point

Point 1: Building transfer point

Normally, there is a 4-conductor connection TN-C at the building entry point $L_1/L_2/L_3$/PEN.

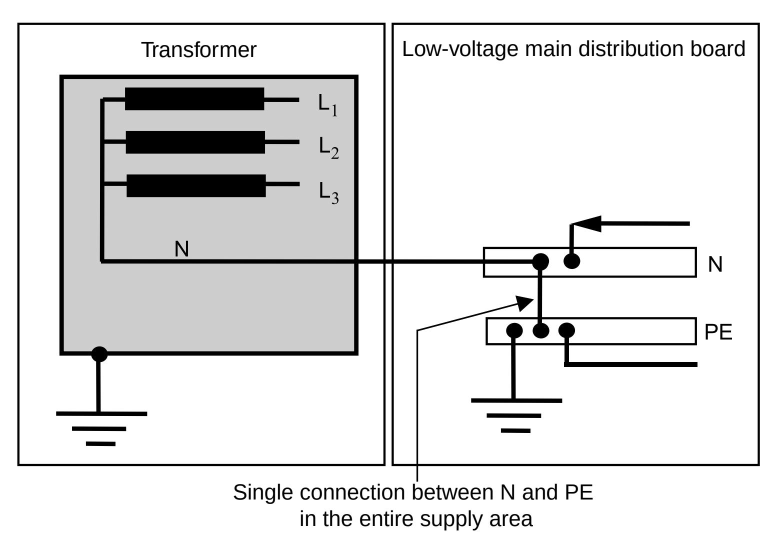


Source: drawing by the author

After the building transfer point, the PEN conductor is split into one N and one PE conductor and these are routed separately in the entire installation. The single connection between N and PE is at the PEN bar. There is also no connection via the meter positions and in the subsequent distribution boards, junction boxes, lamps and sockets.

Point 2: Power supply via one single transformer

The first possibility:



This variant is possible if the transformer and low-voltage main distribution board are not far removed

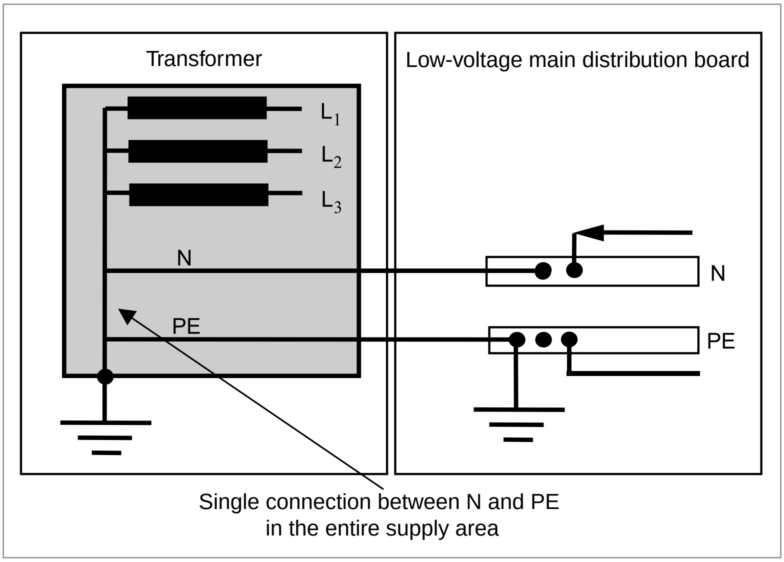
Important prerequisite: there is a separate N and PE bar in the low-voltage main distribution board. If not, it must be added.

In the transformer station, the star point is not earthed. The N conductor arriving in the low-voltage main distribution board is connected to the isolated N bar. From here, a connection is established to the PE bar. From the PE bar, a connection is established to the equipotential bonding bar or to the foundation earth.

All conductors with an N function must be connected to the N bar and all conductors with a PE function must be connected to the PE bar. Further connections between N and PE throughout the low-voltage installation that are supplied with energy from the low-voltage main distribution board are not permitted. All cross-sections of the L_1/L_2/L_3/N conductors are the same. The cross-section of the N conductor must not be reduced.

The second possibility:

Large distances between transformer and low-voltage main distribution board

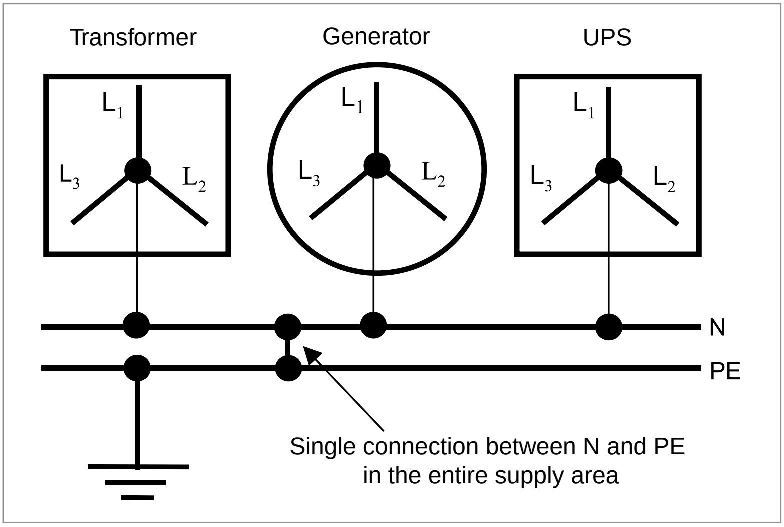


Important prerequisite: There is a separate N and PE bar in the low-voltage main distribution board. If not, it must be added.

As from the transformer's star point, identical cross-sections of the $L_1/L_2/L_3$ and N conductors are laid. The PE may be reduced. Preferably cables (e.g. NYCWY) should be laid, not single wires.

N and PE are single jumpered at the transformer. There are no further PE end jumpers in the installation.

Point 3: Power supply by transformer, emergency generating system and uninterruptible power supply



Set up the N bus system!

The star points must not be earthed if these components are combined in a power supply concept. Every incoming star point conductor must be connected to the N bar in the low-voltage main distribution board. This meets the requirement for the TN-S network configuration according to which the star point must only be earthed once and therefore connected only once to PE.

In this case also, the earthing electrode should be capable of carrying currents which, in cases of doubt, must be measured throughout.

As far as possible, the connections from the energy sources to the low-voltage main distribution board should not consist of single wires, but of twisted cables.

All N conductors have the same cross-section as the phase conductors.

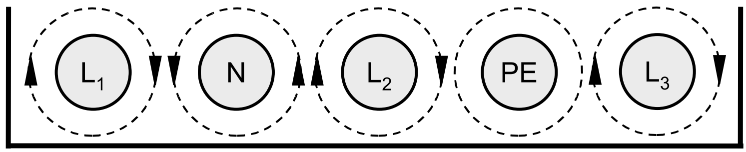
5.2 Single wire versus twisted cables

Avoid single wires and use multiple-conductor cables

As already shown in relation to the transformer connections to the low-voltage main distribution board, the connections from the low-voltage main distribution board to the subsequent subdistribution boards should not consist of single wires (e.g. NYY-0), but of twisted cables (e.g. NYCWC). Several twisted cables should be connected in parallel if the cross-section of one cable is not sufficient for the load.

Reason: if several single wires are lying in parallel on a cable rack, the individual wires' magnetic fields can no longer cancel each other out. This results in substantial interference of monitors that are located one floor above the rack or in a room next to it, for example.

The magnetic fields cannot cancel each other out

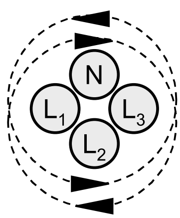


Values from practice: in an establishment, approximately 700 A rms flowed per subdistribution board and phase. In an office room directly behind, a magnetic field strength of 20 µ Tesla could still be measured at a distance of about two meters.

Important note: a monitor image begins to flicker at about 0.7 to 1 µ Tesla.

The magnetic fields cancel each other out

If the wires in a cable are twisted, the magnetic fields of the total currents in the phase conductors to the load and the return current in the N conductor can cancel each other out if the amount is the same and the sign is inverted.

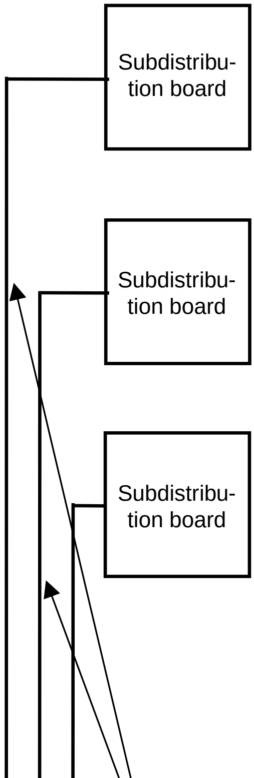


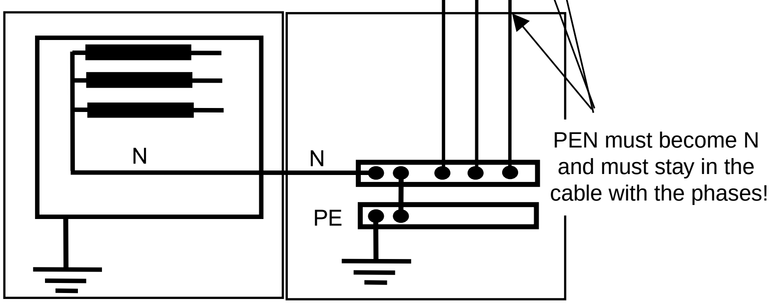
5.3 Converting an existing TN-C-S installation to TN-S

An existing TN-C-S installation can be converted to a TN-S installation.

Condition: in the supply lines from the low-voltage main distribution board to the subdistribution boards, the previous PEN conductor at least has the same cross-section as the phase conductors (no reduced cross-section of the PEN). In this case, it can be converted to an N conductor. The previous blue phase conductor is marked black at both ends and over its entire visible length and the previous yellow/green PEN is marked blue at both ends over its entire visible length. A yellow/green PE conductor can be pulled to the outside. This is permitted by Section 5.1.4 of VDE 0100 Part 510, February 1996.
A reduced PEN in a cable must not be converted to a PE because the magnetic fields of the phase currents can no longer cancel each other out owing to the missing N current. The differential current is inductively impressed into the PE.

Converting a PEN conductor to an N conductor





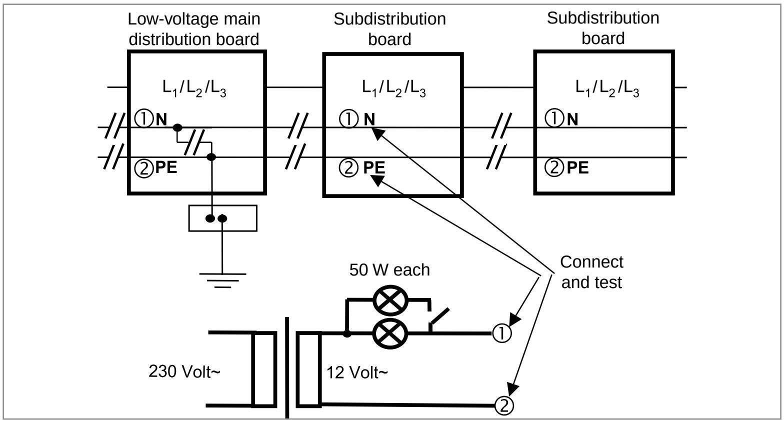
PE can be pulled to the outside

5.4 Connections between N and PE

In each subdistribution board, the incoming N conductor must be connected to the N bar (or N terminal block) and the PE conductor must be connected to the PE bar (or PE terminal block). The PEN jumpers must be removed in each subdistribution board.

Remove all PEN jumpers

This reconnection work, where the entry has to be opened for safety's sake (fuse, master switch, disconnector), should be used to "measure into the load system". Here, measurement is possible with a VDE-approved insulation meter, better with an impressed current from an auxiliary transformer. To measure, deactivate the mains entry, e.g. into the low-voltage main distribution board, disconnect the incoming N conductor and then temporarily remove the PEN jumper. Now establish the connection to the meter (see drawing). The two halogen lamps light up provided there is a connection between N and PE in the subsequent distribution boards. The transformer is operated in the short-circuit mode and, at the same time, the current is limited by the two halogen lamps. Once all jumpers have been removed, the disconnected connections and the PEN jumper are reinstalled. The mains entry is then connected again. Separate routing of the N and PE conductors must be maintained up to the last junction box and socket and to every lamp.



Monitoring the systems after conversion

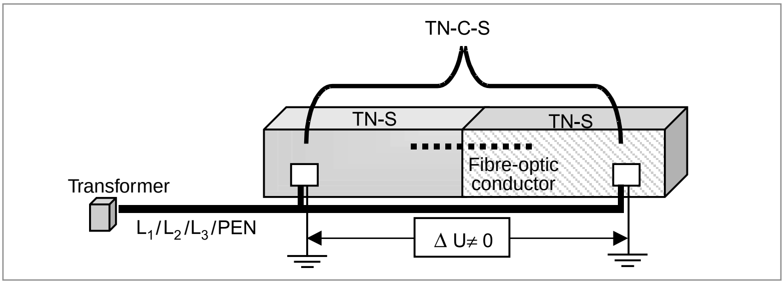
After completing testing, success of your work should be monitored on a permanent basis. To this end, earth fault monitors RCMs (residual current monitoring) should be installed in all important distribution boards (e.g. from Bender, 35305 Grünberg and Doepke, 26506 Norden).

5.5 Avoiding earth loops

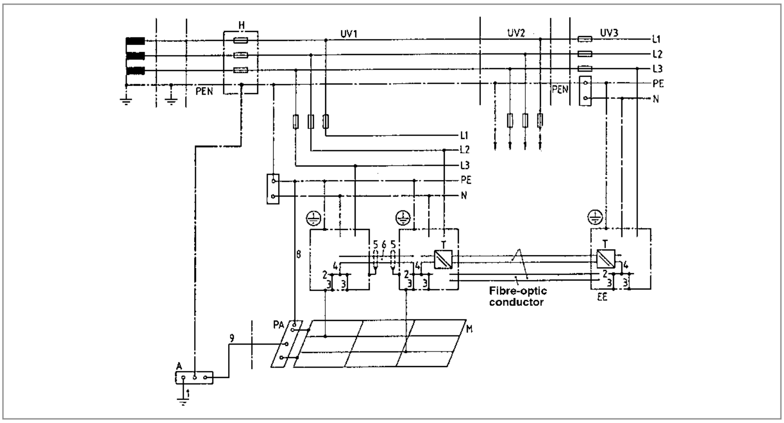
For IT systems, the power supply should be structured in such a way that all components connected to the system are powered from one point (*single point earthed* principle).

Caution: despite TN-S segments, the overall system consists of TN-C-S

In the following example, two power supply segments within one building are structured in accordance with the TN-S network configuration. As both low-voltage distribution boards have an entry with a PEN conductor, the TN-C-S network configuration is realised in the overall installation. Owing to the return current in the (PE)N conductor, at any one time the voltage or potential difference is ≠ 0. If use is made of data cables with shielding that are connected to the relevant earthing system, then compensating currents flow through these signal lines that will lead to malfunctions and destruction of terminal devices.



For such cases, VDE 0800 Part 2 stipulates the use of fibre-optic conductors.

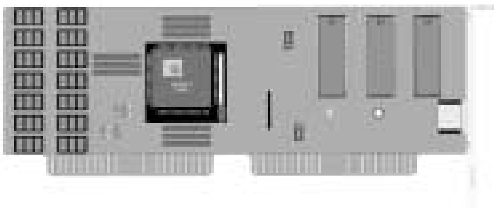
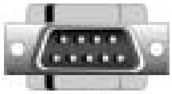
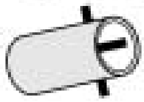


In practice, this means that the data cabling in the supply segments in which a clean TN-S network is installed with an unloaded PE can consist of copper data cable. Then, a fibre-optic cable must be used at the transition from one power supply segment to the other to avoid malfunctions and destruction.

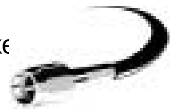
This is why interfaces and the devices connected to them frequently suffer damage:

The most frequent failures occur at interfaces

- Serial interfaces and units RS232/422/485
- Time recording, access control, production data acquisition hardware

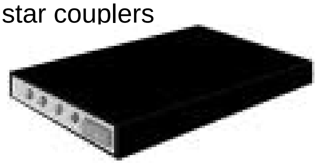




- Network cards and components
- Twinax and toke
- Ethernet



- Parallel interfaces and printers

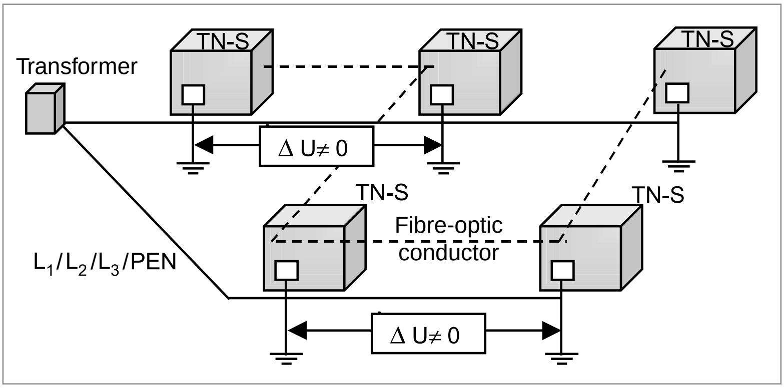

- Modems, active hubs, star couplers
- PLCs




- etc.

5.6 Examples of electrical isolation

An establishment consists of several buildings, an office, production, logistics and a warehouse. Production control, production data acquisition, access control and time recording facilities are installed in these buildings. To some extent, office workplaces with networked PCs and production machines are accommodated in such buildings.
These buildings are connected to the power supply via a 4-conductor cable. The basic prerequisite is that the TN-S network configuration is realised in the individual buildings. If these devices are connected to one another via copper data lines, then the TN-C-S network configuration is realised in the overall installation thanks to the PEN conductor. Earth loops inevitably occur.



Fibre-optic conductors help to avoid problems

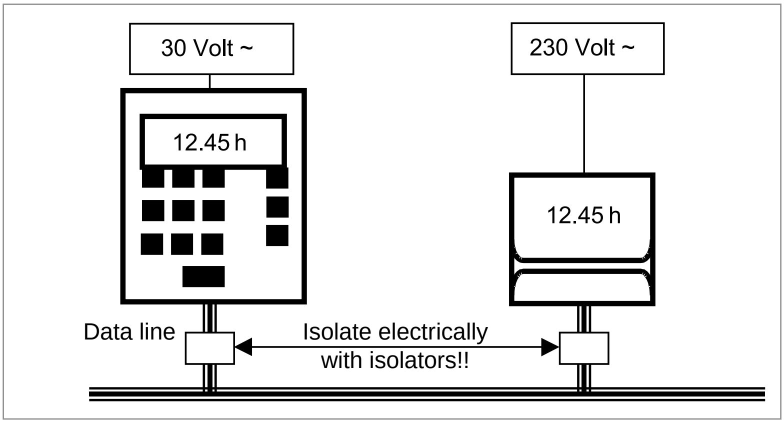
Therefore, solutions containing fibre-optic cables should be used here to avoid the occurrence of earth loops and to prevent compensating currents from flowing.

Possible alternatives
Electrical isolation by means of an isolator can be realised if the network office communication is concentrated in one building and only one time recording unit is installed in each further building, for instance. These isolators must be chosen according to the interface type, the data protocols and cable lengths.
The same principle should also be applied to access control devices.

Otherwise, current probes on the data lines must be used to measure the presence of currents.

Example: time recording and access controls

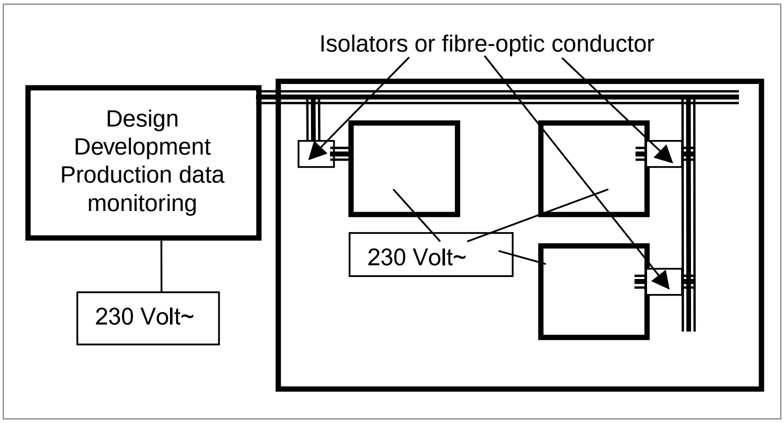
Every device is connected once only to the PE conductor



Example: design area and PPS systems

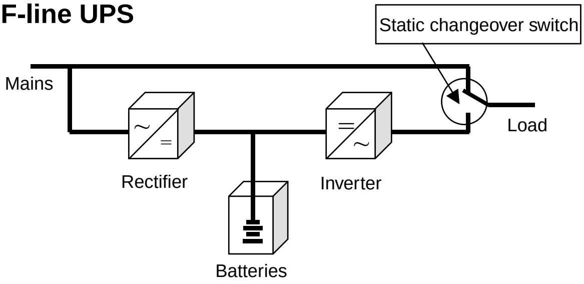
There are areas where the design department is connected directly to the machining centres in production. If these two areas are powered via different subdistribution boards that receive their entry via a 4-conductor network (TN-C-S network), fibre-optic cables should be used in this area or the data link to the machining centers should be isolated electrically by means of isolators.

Avoiding earth loops with the aid of fibre-optic conductors or isolators



6 Uninterruptible power supplies (UPS)

The OFF-line UPS



OFF-line UPS systems are not uninterruptible!

Operating principle: this kind of UPS device registers the power failure and switches over to internal battery operation electronically or electromechanically. During normal operation, the load is connected directly to the mains and the batteries are charged.

Advantage:

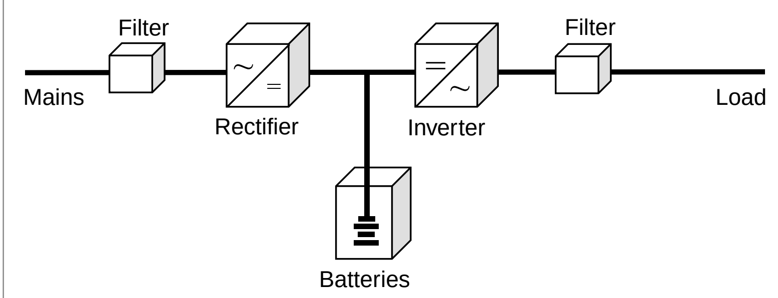
- A considerable material saving and thus a lower price are possible in comparison with an ON-line UPS.

Disadvantage:

- Response and changeover times by sensors and electronic or electromechanical changeover facilities amounting to 10 ms and more are sufficient for some loads, but not for all.
- The power supply units of connected devices cannot always bridge failure times.
- During normal operation, unfiltered mains voltage generally reaches the loads.
- In the battery mode, OFF-line units frequently supply square-wave or trapezoidal output voltages. Owing to their great technical complexity, devices that supply sinusoidal output voltages and have a filtering effect are in the price category of the ON-line devices.
- The tolerance of the input voltage is lower, with the result that the UPS switches over in the event of small-scale mains fluctuations, making more frequent use of the batteries. This shortens battery service life.
- Defects in the area of the inverter and/or battery are not noticed until a power failure occurs.

Check whether the UPS and a computer match each other

ON-line UPS is really uninterruptible!



Operating principle: the mains voltage is filtered and rectified on the input end. On the one hand, the DC voltage charges a battery and, on the other hand, it serves as the input voltage for an inverter. This generates an AC voltage similar to a sine wave, which is then stepped up to an rms value of 230 V~. If the mains should fail, only charging of the batteries is suspended.

Disadvantage:

- The price is slightly higher, but provides safety!

Advantage:

- Filters in the input and output areas; malfunctions are eliminated.
- Input voltage tolerance from +10% to –15%.
- Output voltage approximately ±1% of the rated value.
- No changeover times (really uninterruptible).
- Batteries are constantly charged under control.
- The charge is monitored.
- Capable of withstanding overloads.

Consult your UPS vendor

No matter what expressions are used in the sales brochures, the only decisive thing is whether changeover at the output of the UPS takes place or not at the moment when the mains voltage fails. You must ask your UPS vendor this question. Use should only ever be made of UPS units that **do not** switch over at the output.

6.1 Tips on how to choose a UPS

Crest factor

Computers represent a non-linear load and draw a high peak value out of the mains in relation to the rms value. This ratio is referred to as the crest factor, which may differ from one computer to another. Therefore, ask your system supplier about the crest factor of the computer or computers (typically 3) that is or are to be connected to the UPS. The UPS must at least provide this power at the moment of switching over. If it does not, the system will crash at that moment. Therefore, the crest factor is an important variable that describes the performance of a UPS (see also rated power).

Stored energy time

The stored energy time during which the loads are powered solely by the batteries used in the UPS should be coordinated. On the one hand, it may depend on the organisational needs of the operational process and, on the other hand, it may depend on the time a system needs to reliably close all files and save them on the hard disk. Typical times are 5 to 15 minutes.

Rated power

The rated power of the UPS must be coordinated to the needs of the powered system. The average rms current and peak current values of the system are related to the UPS's crest factor. Depending on the result, it may be that a UPS with a rated capacity of 20 KVA, for example, may only be loaded with a maximum of 80%, i.e. a maximum of 16 KVA. If this ratio has not been observed, failures may already occur during normal operation. The peak current must not be confused with the power-on surge current that occurs when the system is switched on.

Communication

Communication equipment (interfaces/software) between the UPS and the system is available for almost all UPSs (standard/option). Such equipment ensures a controlled shutdown, i.e. backing up of the data and shutdown of the system. Have the reliable process for your configuration demonstrated. If, for organisation reasons, you should additionally need automatic system restarting, then have this process demonstrated.

Further tips

UPS temperature

The UPS must only be operated within the boundaries of the maximum limits stated in the specifications. If ambient temperatures are below theses maximum limits, the reliability of a system, e.g. in the event of an overload, is increased. Air conditioning may be necessary if a UPS is operated in a room that does not have windows.

Temperature of batteries

In most cases, the permissible ambient temperatures for batteries are below the temperatures for the UPS system. It is imperative to keep to these values. Capacity is reduced if temperatures are too low over a prolonged period of time. Lifetime is shortened if temperatures are too high.

Setting up

UPS systems produce dissipated heat and noise. This should be taken into account when choosing a location. Small to medium-sized units should not be placed directly in front of a wall, where the warm outgoing air cannot flow off unobstructed.
The actual space requirement of the UPS and no-problem transport to the installation location should be checked. Access should be available for maintenance personnel. If separate areas are planned for the UPS and the batteries, attention must be paid to the regulations that are applicable to handling acids.

Maintenance/remote maintenance

In the case of medium to large systems and depending on the minimum availability of a UPS system, it is possible to obtain information about the performance capabilities of a UPS by means of an online diagnosis. Periodic tests can be arranged by contract partners. These include a status report containing an up-to-date status description.

Future capacity

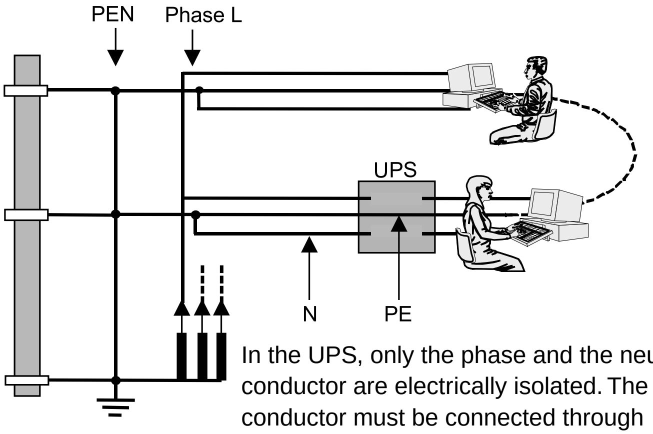
Plan for system expansions in good time. You can assume that future electronics systems will consume less power than nowadays. Some UPS systems are based on a modular structure and are able to grow with the required power.

6.2 The consequence

If the symptoms described on Page 8 occur during the “normal daily routine”, an attempt is frequently made to get to grips with the problems by using a UPS system. Almost without exception, interference from the 230 V~ network is spoken of, which can be eliminated by means of electrical isolation.
System faults that can be ascribed to vagabond currents in the PE and reference conductor system cannot be eliminated by a UPS.

The UPS is no panacea for occurring problems.

A TN-C-S system



In the UPS, only the phase and the neutral conductor are electrically isolated. The PE conductor must be connected through continuously!

Consequently, this means:
Always first set up the EMC-friendly TN-S network configuration. The principle of the closed circuit must be realised. Neutral conductor currents must be returned to the feeding source in the neutral conductor. They must not be fed into the earthing system. Insofar as this is concerned, and as already described, TN-C and TN-C-S systems with PEN conductors are highly problematic in buildings from the point of view of EMC and must be consistently avoided.

Only then can and should a UPS be installed, not vice versa.

7 Conditions for setting up office computers

These setting up conditions can be found with almost identical wording in the documentation issued by all renowned PC and computer manufacturers.

1 Introduction

Proper setting up and installation are an essential prerequisite for the operating reliability of PCs and networks. This is why the applicable setting up conditions must be observed. In conformity with our general terms and conditions of business, we are not liable for damage resulting from failure to observe our setting up conditions.

2 Safety rules

The electrical installation of the system power supply must be set up and maintained in accordance with the generally recognised electrotechnical regulations and the accident prevention regulations. The technical connection conditions of the local electricity supply companies also apply.

3 Setting up and installation

Only our service employees are entitled to set up, commission, repair and maintain the computer systems including peripherals. The electrical installation must be created by electricians in conformity with the applicable VDE and DIN regulations. The location must be chosen so as to ensure that the system, including all peripheral devices, is protected against vibrations, dust, moisture and direct sunlight. Attention must also be paid to ensuring that neither the heating nor a ventilation window will have an influence on the cooling system.

Climate: the room temperature and air humidity are two essential factors when it comes to static charges.
Room temperature: 21 ± 4°C
Temperature gradient: < 5°C/hour
Room humidity: 40-60% rH
The room air must be humidified in accordance with the evaporation principle because the spring principle involves scale deposits. The distance from radiators must be > 50 cm.

Electrostatic charges: functioning of computer systems may be disturbed by static electricity, or they may even be destroyed. This is also a nuisance to operating personnel.
The occurrence of static electricity primarily depends on air humidity in conjunction with the flooring and the soles of shoes worn by persons. Operators' clothing and chairs also have an influence on the occurrence of static charges. Therefore, the following notes apply to the avoidance of static charges:

- Reduce the electrical resistance of the flooring.
- Keep to a relative humidity of 40-60% rH.

Power supply: as specified in VDE 0100, the power supply must be installed by an electrician. The computer system must be connected to a building or storey distribution board. This IT network supplies all devices belonging to the system (single point earthing concept). No other components may be connected. A phase must be chosen that has as low a load as possible and which is noise-free.
Operating voltage: 230 V ± 10%
Operating frequency: 50 Hz ± 1%
Harmonic distortion: max. 5% of the rated voltage, harmonic component < 3%.
Mains voltage drops > 5 ms are not acceptable.

4 Notes on networked systems

All mains connections leads must be connected to permanently installed shock proof sockets (IT network). Screened network and data cables are laid together. Cable connection lies within the responsible of the customer.

Protective system earthing: the earthing must be set up so as to ensure that all IT devices are connected to one earthing point. Corresponding cable cross-sections must be planned. The formation of earth loops must be avoided. The PE system must be unloaded (prove by measurement!).

5 Regulations

VDE 0100: regulations for the erection of power installations
VDE 0800 Part 2: regulations for equipment and operation of telecommunications systems including information systems.

8 Requirements for a reliable IT power supply

- Create a low-impedance earthing system that is capable of carrying current
- No operating currents from the PE/equipotential bonding (verify!)
- No multiple earthing of N in the event of a multiple entry; earth N once only!
- Do not allow any reduced cable cross-sections for N
- Design cable cross-sections for harmonics loads
- No single wires from the transformer to the low-voltage distribution board and then to the subdistribution board
- Do not permit any PEN conductors anywhere in the building
- Install surge voltage protectors for compensation systems
- Use residual current monitoring units
- Introduce permanent energy monitoring of all parameters
- Set up systems in such a way as to allow testing – make test points accessible
- Documentation and marking of cables and systems
- Reliably mark wires
- Permanent learning
- Maintain systems expertly; network technology continues to develop

9 Final remarks

The relationships described in this installation brochure are basic prerequisites that should be urgently created for a functioning electronic IT system.

From the point of view of EMC, it is imperative to avoid a flow of operating currents in the earthing system.

This creates favourable prerequisites because not only can operating currents at the basic frequency of 50 Hz be avoided, but also currents with harmonics and sub-harmonics of 150 Hz and more in the PE system.

If these currents still flow through the PE conductor and the equipotential bonding system, then they flow in all parts of the system that are earthed or which are connected to one another via an equipotential bonding system.
Practical experience has shown that interference and destruction can be ascribed to these currents in the earthing system.

Even when potential has been boosted by atmospheric discharges (indirect lightning discharges), it has been possible to observe that, if a TN-S network is set up properly, no damage at all or only very slight damage occurs, even when no surge protection equipment is installed.

Surge voltage protection in low-voltage main distribution boards and subdistribution boards that is planned in a targeted fashion and which is used conscientiously is capable of dissipating occurring surge voltages that penetrate into installations through mains feeders.

This installation guide has not discussed the issue of harmonics. Refer to VDE 0839 and its parts, Compatibility Levels in Low-Voltage Networks, Medium-Voltage Networks and Industrial Installations.

10 Literature

VDE 0100 Part 300
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Prof. Dr. -Ing. habil Friedheim Noack: Blitzstörbeeinflussung in Niederspannungsnetzen
Siemens; Technische Mitteilung 08/1997 TM 6014, Überspannungsschäden durch ungünstige Netzkonstellation
Wißner: Tela CD

It is a widely spread opinion that PCs, networks and other networked electronics systems can be installed swiftly and easily because there are socket outlets everywhere. But, whenever illogical and undefined faults occur, it transpires that problems can often be ascribed to faults in the cabling (230 V~/data cables).

In the interests of system users, it is important to avoid malfunctions and destruction. The cost of a production outage are much higher than the cost of an electrical installation that does justice to IT requirements or in comparison with the replacement of defective hardware. The overall entrepreneurial risk cannot be insured and is economically not justifiable.

This installation guide is the result of more than 15 years of safety and environmental analyses in the area of PCs, mainframes and networked electronics systems. It was drawn up with great care and attention and has been put to use in innumerable informative talks with end customers and their electrical installation technicians. A large number of installations has been successfully converted in accordance with the contents of this guide. On the one hand, this guide was conceived as lightweight food for thought for interested readers, and on the other hand, as the basis for conducting talks with the user. In this way, users are able to realise that an installation not only involves setting up hardware and loading and configuring software, but begins much earlier.

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