KNX TP Installation

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KNX Association

Artman Training Center - Iran

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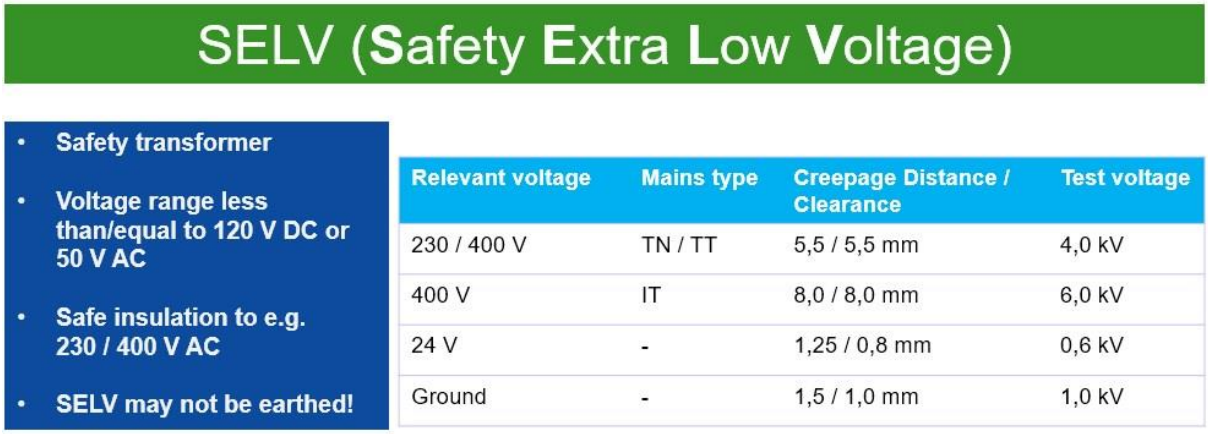
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Safety Extra Low Voltage Networks ١



Relevant voltage	Mains type	Creepage Distance / Clearance	Test voltage
230 / 400 V	TN / TT	5,5 / 5,5 mm	4,0 kV
400 V	IT	8,0 / 8,0 mm	6,0 kV
24 V	-	1,25 / 0,8 mm	0,6 kV
Ground	-	1,5 / 1,0 mm	1,0 kV

Figure 1: Safety Extra Low Voltage Networks

Note: The relevant installation requirements of the respective country shall be observed for the bus and mains installation.

SELV stands for Safety Extra Low Voltage. It is an electrical circuit with lower voltage levels, electrically separated from other circuits carrying higher voltages. Moreover, it is isolated from earth and protective earth conductors of other circuits.

The permitted voltage range in a SELV network is:

- ≤ 50 V for Alternating Current (AC)
- ≤ 120 V for Direct Current (DC)

These levels are too low to provide current that would give a lethal electric shock.

No special protection against direct contact is required if the voltages do not exceed 25 V AC or 60 V DC.

The wiring should be separated from systems or cables with higher voltages as well as from other SELV circuits and from the earth ground. The clearance and creepage distances indicated above apply for:

- Pollution degree 2 (offices)
- Overvoltage category 3 (permanently connected to mains, high availability)
- Insulation material class 3

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SELV - Insulation ۱/۱

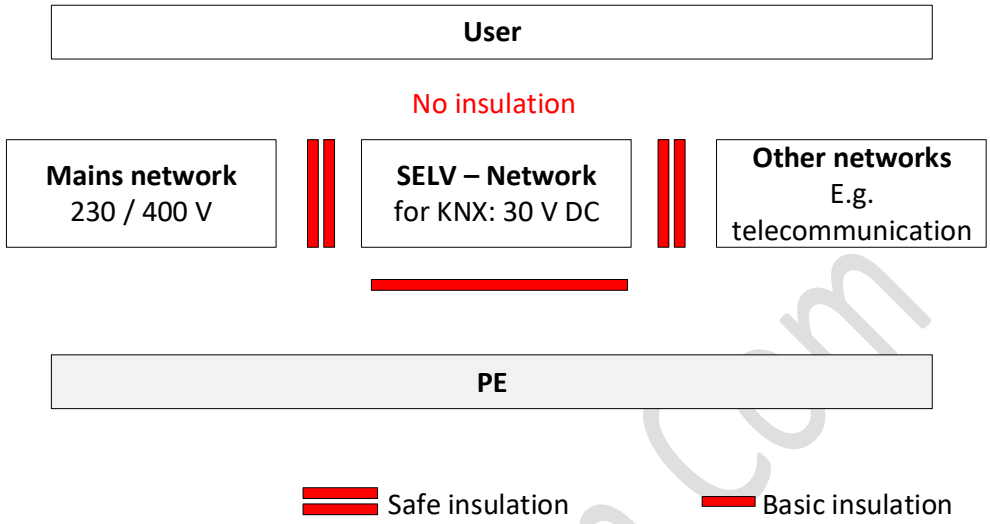


Figure 2: SELV Safety Extra Low Voltage Network

A power supply with secure mains separation generates the SELV voltage for the KNX TP bus.

Voltage used:

30 V DC ✓

Insulation:

Safe insulation from other networks. ✓
Basic insulation to earth. ✓
No insulation on the user's side. ✓

Attention:

The SELV network may not be earthed! ✓
Cables that are intended for the installation of mains networks may not be used for the installation of TP networks! ✓

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Types of Bus cable ۲

YCYM 2×2×0,8

- Fixed installation: dry, humid and wet rooms; wall-mounted, flush-mounted, in conduits;
- Outdoor: If protected against direct sun radiation;
- Test voltage: 4 kV according to EN 50090

J-Y (St) Y 2×2×0,8

- Fixed installation: dry and humid industrial sites; wall-mounted, flush-mounted, in conduits;
- Outdoor: Flush-mounted and conduits
- Test voltage: 2,5 kV according to EN 50090

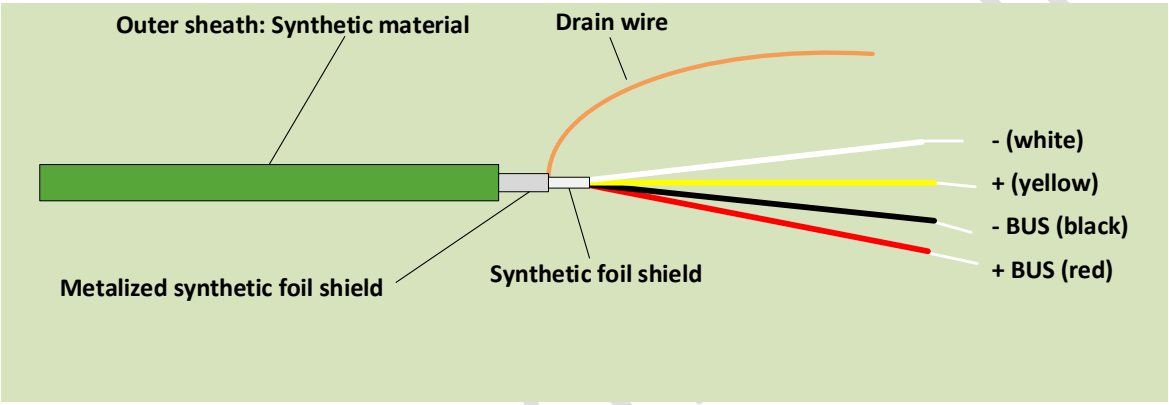


Figure 3: Types of bus cable

Cable fulfilling the KNX requirements in volume 9 of the KNX Specifications (e.g. YCYM 2×2×0,8 or J-Y(St)Y 2×2×0,8 in TP design) can be recognized (without KNX logo) or certified (with KNX logo) by KNX Association[1].

Only the standardized green KNX TP cable guarantees:

That data is transmitted reliably over the total cable length of the line segment (max. 1000 m.) ✓
maximum distance between two bus devices in a line (700 m) ✓
maximum number of bus devices per line (256 devices) ✓

The requirements of a standardized cable for instance include a loop resistance of 75 Ω and a loop capacitance of 100 nF per 1000 m. For all other cables types, the maximum cable length as given in the data sheet of the cable must be observed.

It is not required to connect the shielding of the bus cables to the equipotential bonding bar.

[1] For the current list of KNX recognized/certified cable types, please consult the KNX web site (www.knx.org)

When installing a standardized cable with a test voltage of 4 kV, the following conditions apply.

Used wire pair:

Red: plus ✓
Black: minus ✓

Spare wire pair (white/yellow): Permitted use of the spare wire pair:

no connection at all ✓
for other SELV low voltage networks ✓

Test voltage according to EN 50090:
The specified test voltage must be applied to all connected wire cores (drain wire included) and the outer surface of the cable sheath.

Note: Please make sure that all installed cables are properly identified and marked!

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Installation of cables ۳

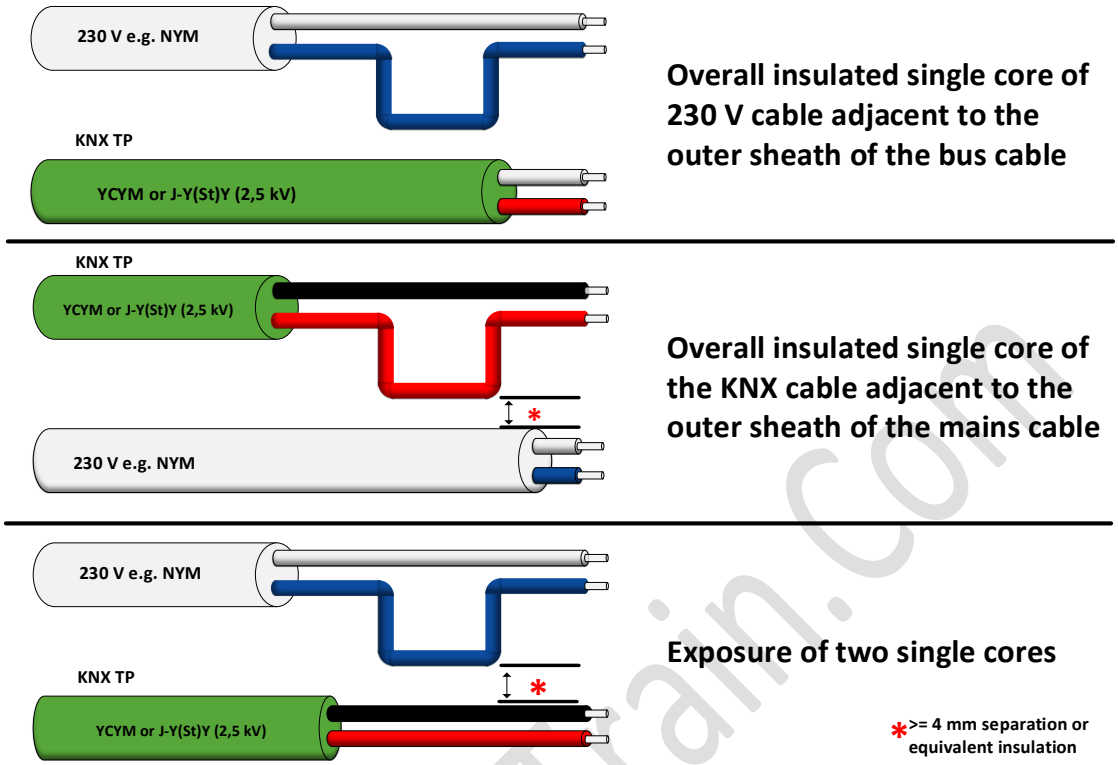


Figure 4: Installation of cables

The requirements for the installation of bus cables are generally the same as for the installation of 230/400 V AC networks.

Special requirements:

- Insulated wire cores of sheathed mains cables and KNX TP bus cables may be installed next to each other without any clearance space. It should be noted that only the KNX certified bus cable (YCYM 2x2x08) may be installed parallel to 230/400 V cables due to the higher insulation resistance, whereas for the cable type JY (St)Y 2x2x0.8 this only applies to 230 V cables. ✓
- A minimum clearance space of 4 mm must be observed between the insulated wire cores of KNX TP bus cables and those of sheathed 230 V AC mains cables. Alternatively, the wire cores must be provided with an equivalent insulation, such as a spacer or insulation sleeving. This also applies to wire cores of other cables that are not part of SELV/PELV circuits. ✓
- An adequate distance to the external lightning protection system (lightning current arrester) must be ensured. ✓
- All cables should be permanently marked as KNX TP or BUS cables. ✓
- If the polarity of the connected bus cable at a certain bus device is incorrect, the wrongly polarized bus device does not function until the fault is rectified. ✓

A terminating resistor is not required.

Bus Devices in distribution boards ۴

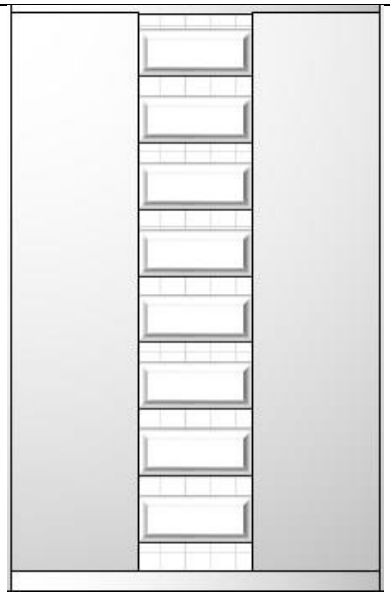
Standardized power distribution boards	Requirements
	▪ Use of standardized distribution boards ▪ Install bus cables with sheath up to the bus connector ▪ Do not install bus devices above mains devices as these could cause excessive heat development in the distribution board

Figure 5: Bus devices in distribution boards

Any commercial, standardized electric power distribution board equipped with EN 50022 35x7.5 mm DIN rails may be used, on which KNX TP DIN rail mounted devices can be mounted.

If the mains section is separated from the bus installation, no special installation requirements need to be observed.

If the mains section is not separated from the bus installation, the bus cables must be sheathed up to the bus connector.

Possible contact between mains cores and bus cable cores must be prevented by adequate wiring and/or mounting.

Bus devices shall not be mounted above mains devices that dissipate heat as the latter could cause excessive heat development in the distribution board.

When a lightning current arrester is installed on a DIN rail, the following requirements shall be met:

Overall insulation of the arrester (e.g. no use of uncovered air spark gaps). ✓
As DIN rails may not be used for earthing, arresters must have a separate earthing terminal. ✓

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Power supply unit ۵

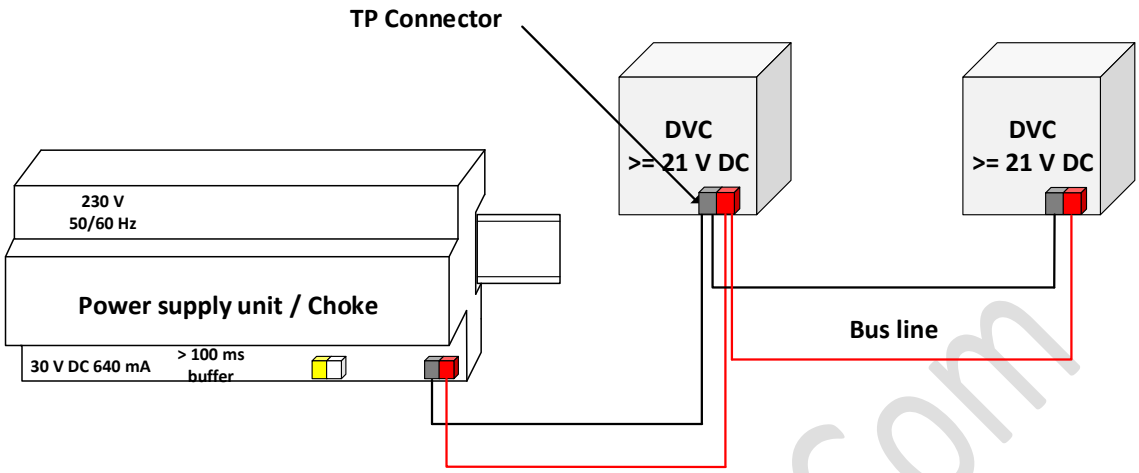


Figure 6: Power supply unit (with TP connectors)

Note: if not explicitly said below, the following applies to centralized power supply units.

Power supply units produce and monitor the system voltage of 30 V DC necessary for the operation of a KNX TP installation.

Each line needs an own power supply unit to supply the connected bus devices.

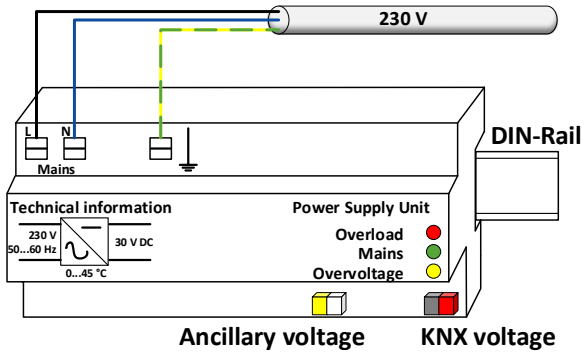
The power supply unit has an integrated voltage and current control and is therefore resistant to short circuits.

The power supply unit is able to bridge short power gaps of minimum 100 ms.

Bus devices require a minimum of 21 V DC for safe operation. The power consumption of the bus devices can be read in the data sheet of the manufacturer.

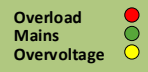
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Example of a power supply unit



Features

- **Earth connection prevents static charges**
- **100 ms buffer time bridges brief interruptions of the mains**
- **Optional LEDs for displaying**



- **Additional output for supplying other line** (needs extra choke !)

Figure 7: Example and features of a power supply unit

To avoid static charges on the bus side, the power supply unit is fitted with high ohmic resistances connected from each bus core to the earth connection of the PSU. In order to divert these static charges, this connection shall be connected to the protective conductor system, more specifically to the earth electrode of the low-voltage installation. This connection should be marked yellow/green. This does not result in protective effects according to safety regulations and does not contradict the conditions that apply for SELV networks.

Some power supply types or external chokes have a reset switch and a red control LED by means of which the connected line can be set to 0 V. As a result, all connected bus devices will be reset. The chokes prevent the short-circuiting of bus telegrams (alternating voltage 9600 Hz) by the DC controller of the power supply unit.

Many types of power supply units are available, depending on the supplied output current (160 mA, 320 mA, 640 mA, 1280 mA). It goes without saying that the number of installable devices in a line depends on the type of the power supply unit (PSU) used and the individual power consumption of the devices in that line. Some PSU types have an integrated choke; some need an additional external choke.

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Modern power supply units are DIN rail mounted, whereby the bus voltage is available via the bus connector. Some other types have an ancillary voltage output with which it is possible to supply other lines using a separate choke. Uninterruptible power supply units are also available. Some PSU types have a floating relay output providing information about normal operation/mains failure for evaluation purposes. Most of the PSU types have LEDs, indicating the operating mode of the power supply unit, e.g.

- Green: The power supply is active. ✓
- Red: The power supply unit is overloaded, possibly due to a short circuit between bus wires. ✓
- Yellow: An external voltage higher than 30 V has been applied to the bus side. ✓

Most PSUs do not have an application program. Some PSUs with application programs exist containing standardized datapoint types that allow e.g. to transfer malfunction messages and operating data etc. over the bus.

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Power supply for two lines ۶

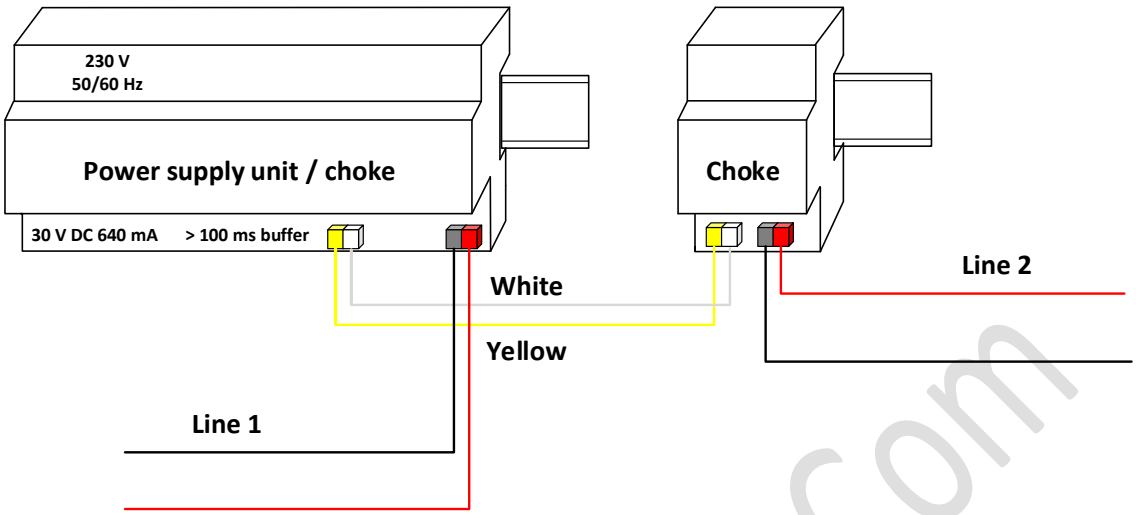


Figure 8: Power supply for two lines

If additional current is needed and depending on the load, one power supply unit can feed two lines. An additional choke may be required for the second line depending on the type of power supply unit.

The bus voltage is available via the dark grey/red bus connector and the ancillary power via a white/yellow connector.

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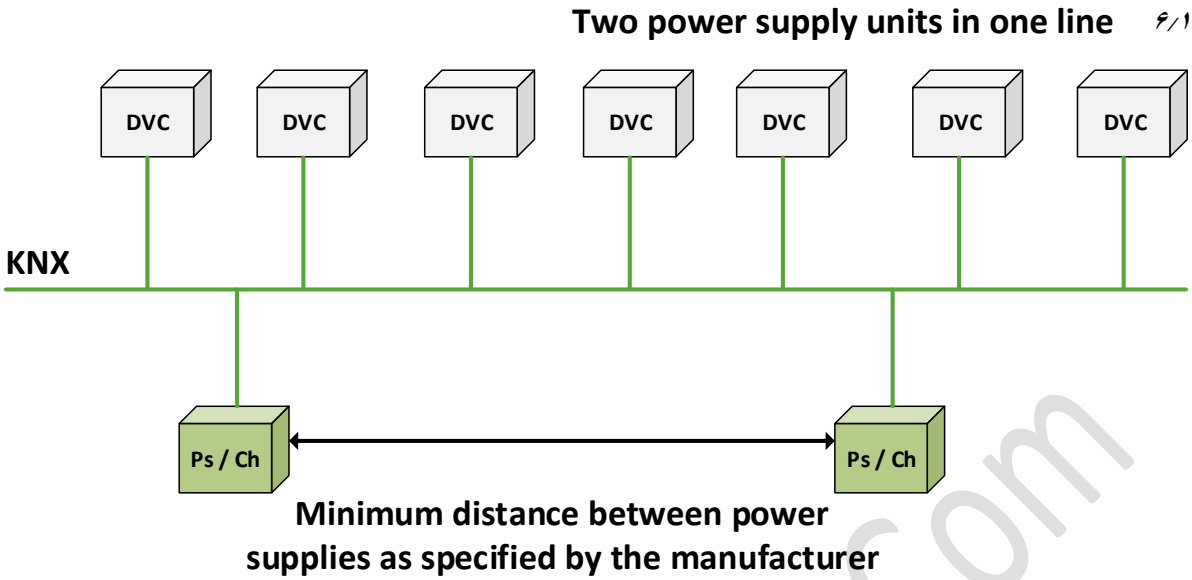


Figure 9: Two power supply units in one line

If more than 30 bus devices are connected at a short distance from one other (e.g. in a distribution board), the power supply unit should be installed near this group of devices.

If an additional power supply unit needs to be installed, the minimum distance between the two power supply units shall be taken from the PSU specifications of the manufacturer.

It is not allowed to have more than two power supply units in one line.

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Distributed power supply ۷

Cable length	Type of bus power supply			
	Decentralised bus power supply with number of DPSU power feeding devices			Central bus power supply unit (PSU)
	1	2	3 ... 8	
Max. total cable length	350 m	700 m	1000 m	1000 m
Max. distance between two bus devices	350 m	700 m	700 m	700 m
Max. distance between non-power feeding device and power supply	350 m	350 m	350 m	350 m
Min. distance between two power supply units	No minimal cable distance between two DPSU or between DPSU and standard central PSU			As specified by the manufacturer

Figure 10: Cable lengths when using a DSPU and a PSU

In this case, instead of a centralized bus power supply, the bus is powered in a ***distributed*** way by some devices connected to the line containing each of them a Decentralized Power Supply Unit (DPSU) with integrated choke module. Stand-alone DPSU (non-communicating) devices are also possible.

A DPSU is especially intended for small installations with few devices. Different types of DPSU exist, depending on the output current (25, 40 and 80 mA).

In most cases, it is possible to combine DPSU with up to two standard centralized PSUs.

The DPSU can be located at any location in the bus line. There are no limitations concerning minimal distances between two DPSUs or a DPSU and a standardized central PSU.

Up to 8 DPSUs can be mounted in one single bus line. More than eight can have a negative effect on communication. In case of mounting up to 8 DPSUs in a single line together with a central PSU, the maximum resulting short circuit current of these devices (as given in the product data sheet) shall not exceed 3 A.

In most cases it is possible to manually disable the DPSU on the device (e.g. by means of a switch or configuration of a parameter).

The cable length that needs to be observed in conjunction with the use of centralized and decentralized power supply units is given in the above figure.

Bus cables in wall boxes





Mains and bus cables should be installed either in:

- **Separate installation / wall junction boxes or;**
- **Common installation boxes with a partition, guaranteeing the required clearance / creepage distances**

Figure 11: Bus cables in wall boxes

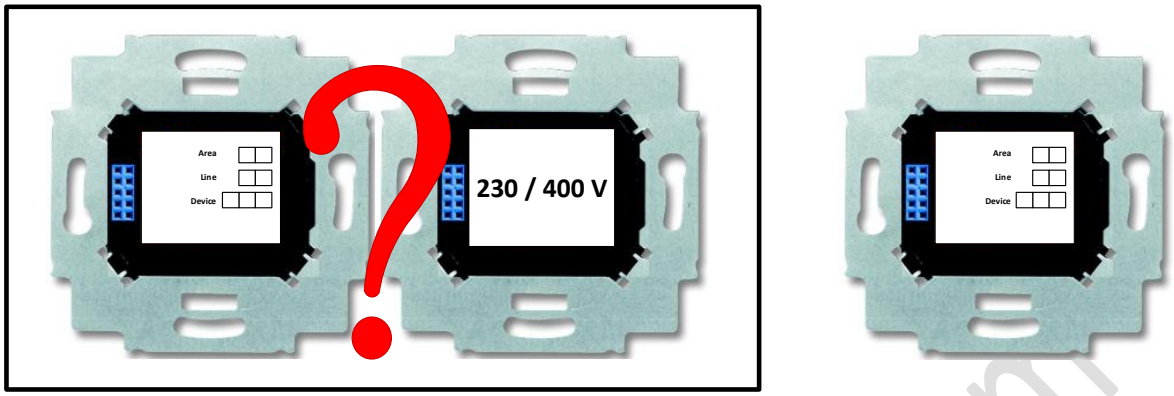
SELV circuits require double or reinforced insulation (protective separation) between mains and bus cables, i.e. unsheathed bus cable cores should never be in contact with mains cables. Junctions can be installed:

in separate boxes or ✓

in a common box with a partition, ensuring 5,5 mm clearance and creepage distances e.g. towards 230 V / 400 V AC TN/TT networks in office buildings. ✓

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Installation of flush-mounted bus devices ۹



- **Use of wall boxes for screw mounting**
- **Permitted use of flush-mounted devices in combination with mains devices depends on the environmental conditions and the design of the bus devices (e.g. pollution degree, overvoltage category).**

Figure 12: Installation of flush-mounted bus devices

Only wall boxes suitable for screw mounting may be used. Clamp mounting is in most cases not possible.
In order to provide sufficient room for cables, wall boxes with e.g. a depth of 66 mm should be installed.

"Combinations" refer to the use of mains devices (e.g. wall socket) and bus devices (e.g. push buttons) or other electric circuits underneath a common cover.

Both components must be safely insulated from each other. This can be achieved by using basic insulation for the power devices and basic 230 V insulation for the bus device.

Do not forget to enquire with the manufacturer of the bus device whether this particular device may be installed together with power devices.

Please note:

The installation of a bus device in combination with power devices must be explicitly approved by the manufacturer of the bus device! ✓
The manufacturer may specify certain bus installation requirements, which must be strictly observed (e.g. connection of the frame to the protective earth conductor). ✓
Mains devices must at all times be protected against accidental contact, even when the common box cover is removed. ✓

Standardized TP Bus connector ۱۰

Bus connector	Usage
	▪ Branching cable, extending cable or connecting cables are realized by means of bus connectors ▪ Bus cable shall only end either at the device itself or at this bus connector ▪ Removal of bus devices without interrupting the bus ▪ Mechanical protection against reverse polarity

Figure 13: Bus connector

The bus connector is used for

- branching the bus cable ✓
- extending the bus cable ✓
- protecting the bus cable ends ✓
- connecting the bus cable to bus devices ✓

To avoid confusion with other electrical circuits, the bus connector should only be used for KNX TP.

The bus connector consists of two parts:

- the plus part (red) and ✓
- the minus part (dark grey) ✓

which are mechanically linked by means of a dovetail joint (Attention: danger of reverse polarity). Up to 4 bus wires (6 mm stripped) can be connected to each part by means of these screwless connectors.

Standardized TP bus connectors allow the removal of bus devices without interrupting the bus line.

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Lightning protection measures (Primary Protection) ١١

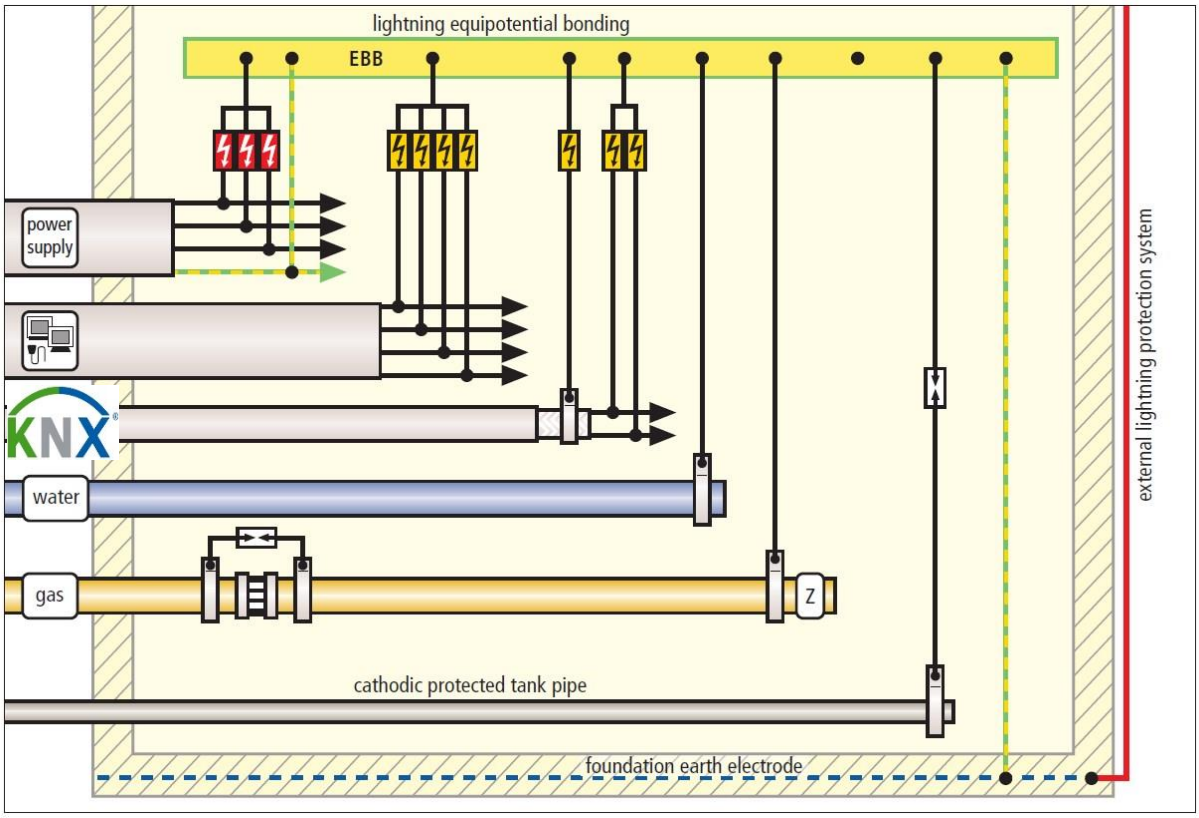


Figure 14: Lightning equipotential bonding according to IEC 62305-3 (www.dehn.de)

The KNX TP bus network should be integrated into the protection measures of the mains power network.

The need for lightning protection for buildings may be the result of:

- the local building regulations; ✓
- a risk analysis of the construction in accordance with IEC 62305 ✓
- a requirement from an insurance company. ✓

In general, lightning protection measures are required for buildings that can be easily struck by lightning or to which lightning can inflict heavy damage. These especially include conference rooms, public buildings, hospitals etc.

The internal lightning protection constitutes the most indispensable part of a lightning protection system. Its most significant component is the **lightning protection equipotential bonding bar**.

All conducting elements or systems, such as the water supply system, gas pipes, central heating system, metal walls, etc. must be connected to the equipotential bonding bar. In the currently valid guidelines (IEC 62305-x series), the lightning protection equipotential bonding bar is a binding requirement also for active conductors; they must be indirectly connected by means of **lightning current arresters**. This is referred to as **'primary protection'**.

Primary protection is achieved by using:

- ✓ For the 230/400 V AC mains:
  - nominal discharge current at least 12,5 kA (10/350 µs) per conductor
  - protection level: < 4 kV
  - Surge protection device (SPD) Type 1 according IEC 61643-11:2012
- ✓ For the bus line
  - nominal discharge current at least 2,5 kA (10/350 µs) per conductor
  - protection level: < 600 V
  - Surge protection device (SPD) Category Type 3 according to IEC 61643-11:2012

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Bus cables installed between buildings ۱۲

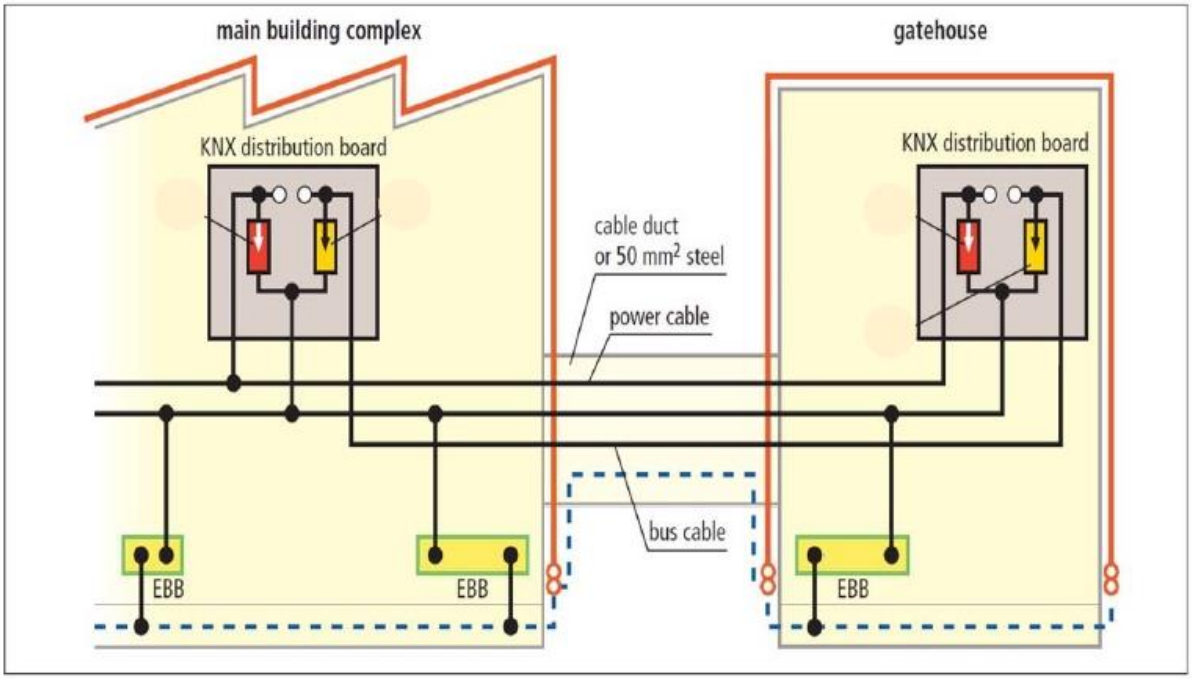


Figure 15: Lightning and surge protection for cabling systems installed between buildings with interconnection of the foundation earth electrodes (www.dehn.de)

If lightning protection measures have been installed, special measures **must** be taken if the installation contains bus cables that extend over more than one building. It is recommended to take these measures even if such lightning protection systems are not installed.

Either a lightning current arrester should be installed at the next corner of the building (which should be connected to the main equipotential bonding), or the bus cable should be installed in-between the buildings in a steel cable duct, which should be connected to earth on both sides, at the entrance to the building. In order to discharge parts of the lightning current, a minimum cross-sectional area of 16 mm^2 CU or 25 mm^2 Al or 50 mm^2 FE is required according to IEC 62305-3.

In either case, the connected bus devices in the building should be connected to an overvoltage protector e.g. together with the line couplers for **secondary protection**. The bus devices and the overvoltage protector should be mounted apart at a distance of some (cable) meters to make sure that the overvoltage protector is not forced to accommodate parts of the primary protection.

The prevention of loops ۱۳

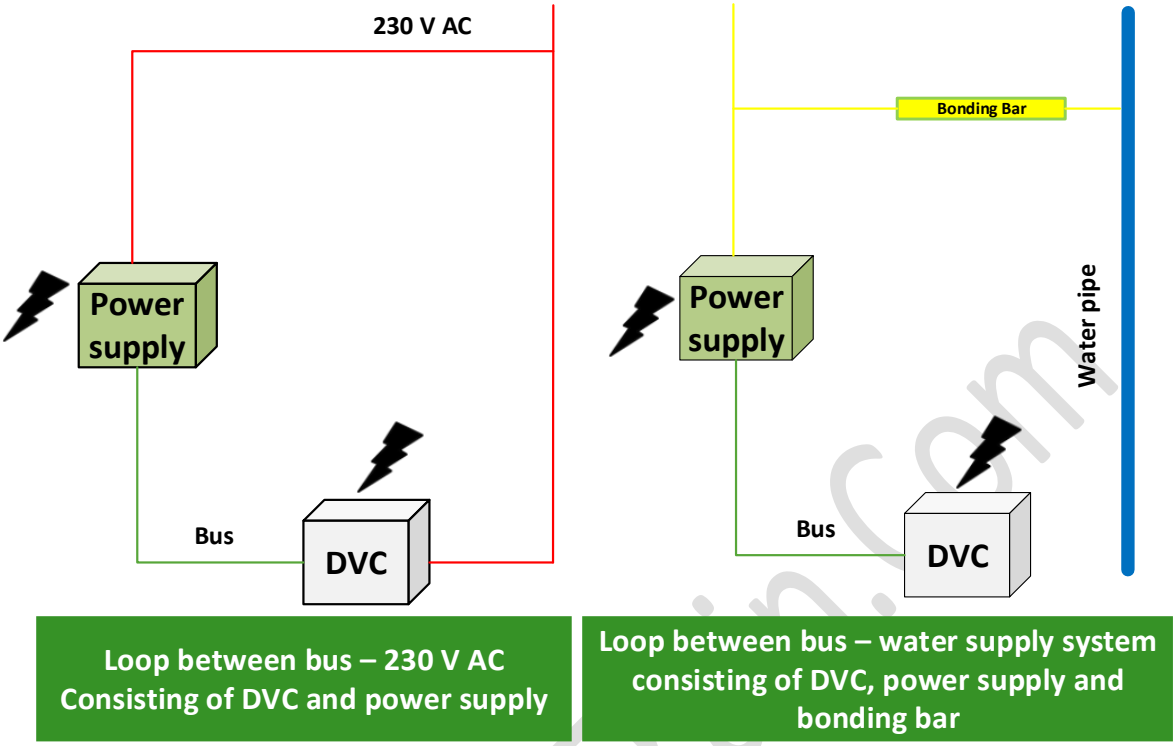


Figure 16: Prevention of loops

Because of the impact of lightning, major surges are generated in loops, which can cause flashovers in bus devices. The larger the loop area, the larger the (peak) surge to be expected.

Loops are created when for instance both the bus cable and the 230 V cable are connected to one bus device, as in this case also the power supply unit is connected to both networks. Both devices are therefore at risk when struck by lightning.

However, loops are also created when a connection is made to the water supply system, the central heating system, metal walls etc. The loop is closed by means of the equipotential bonding bar.

If possible, care should be taken as early as the planning stage to prevent the creation of loops. Bus and mains cables should be installed as close to each other as possible. An appropriate distance should be observed from the water supply or central heating system, etc. If line-crossing loops occur in a KNX TP installation, it may under certain circumstances not be possible to properly program the installation.

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Basic immunity of bus devices ۱۴

The basic immunity of bus devices is tested according to the standard IEC 63044-3 by applying a 2 kV surge voltage core to earth. Consequently, bus devices are protected against surges often caused by switching operations.

In general, this provides sufficient protection. A more significant interference can however be caused:

- when bus cables and high-power mains are installed in parallel over a longer distance, ✓
- in the vicinity of lightning rods and arresters, ✓
- when bus lines and conductive parts of an installation (through which lightning current can flow) are installed in parallel, ✓
- in loops, ✓
- in bus devices connected to conductive sections such as metal walls, central heating pipes etc. ✓

Bus devices on cable ends ۱۵

In this case, additional secondary protection should be provided.

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The overvoltage protector with KNX bus connector design (Secondary protection) ۱۶

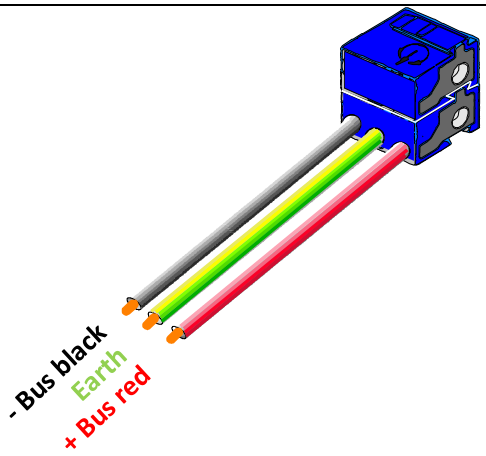
Overvoltage protector with KNX bus connector design	Recommended usage
	▪ To bus devices with 230 V mains connection ▪ To line and backbone couplers on both lines ▪ To bus devices installed in conductive walls or near water pipes, gas pipes etc. ▪ To bus cable ends ▪ At the edge of buildings

Figure 17: The overvoltage protector with KNX bus design

The overvoltage protector should be used as a secondary protection and shall meet the following requirements:

nominal discharge current at least 5 kA (8/20 µs) ✓
protection level: < 350 V ✓
KNX certified ✓

The overvoltage protector with KNX bus connector design is a symmetrical safety device discharging both bus wires, thus preventing large voltage differences. Single pole arresters should not be used. Due to their higher capacity, varistors are also not suitable for this purpose.

Via the connection wires sticking out of the overvoltage protector (which have an identical color marking as the bus cable, i.e. red and black), the arrester can be connected by means of a conventional bus connector to the bus cable or directly to a bus device. However, the overvoltage protector cannot be used to branch the bus cable. The third green/yellow connection wire is the earthing conductor, which should be connected to the nearest earthing point of the installation (i.e. protective earth conductor).

In the case of flush-mounted bus devices and couplers, the overvoltage protector is directly connected to the bus device instead of using a bus connector.

In this case, the connection between wires is ensured by means of an externally mounted bus connector.

The earthing conductor of the distribution board must be connected to the protective earth conductor (PE) by means of a **non-earthed** DIN rail terminal.

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Recommendations to the use of overvoltage protectors ۱۶/۱

The use of overvoltage arresters is recommended for:

- ✓ bus devices with protection class 1
- ✓ bus devices with more connections than just bus (230/400 V AC and/or pipes of the heating system)

In distribution boards, it is sufficient to equip each bus line with one overvoltage protector. In this case, also the outer conductor and the neutral conductor need to be equipped with overvoltage protectors.

For luminaries with built-in switching actuators the installation of overvoltage protectors is only necessary when the bus and the mains form large-surface loops.

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Checking the installation ۱۷

Checking an installation
1. Check whether permitted cable lengths have been observed
2. Run a visual check of the marking of the bus cable ends
3. Check installation for inadmissible cable connections
4. Measure the insulation resistance of the bus cables
5. Check polarity of all bus devices
6. Measure voltage at each bus cable end (minimum 21 V)
7. Record your test results
8. Hand over the ETS project to the client together with the project documentation

Figure 18: Checking the installation

۱. Voltage drops and increase of the transmission duration of telegrams are the result of ohmic resistance, capacity and inductance of bus cables. This again causes the physical limits of a KNX TP installation as outlined below.

Length of a line segment	**Max. 1000 m**
Distance between power supply unit - bus device	**Max. 350 m**
Distance between two power supply units, including chokes	**As specified by the manufacturer**
Distance between two bus devices	**Max. 700 m**

It may be helpful to measure the loop resistance of the bus line under test.

۲. The bus cables ends should be clearly identified as KNX TP by marking them KNX TP or BUS. An extra indication of the area address and line address will make it easier to locate a specific bus cable for testing, commissioning or maintenance purposes.

۳. Bus cables from different lines may never be connected together. Inadmissible connections between the individual lines can be checked by switching off the power supply unit of the line under test. If the power LED of the line coupler continues to light, an inadmissible connection has been detected.

۴. The measurement of the insulation resistance of the bus cable should be carried out at 250 V DC. The insulation resistance shall be at least 500 kΩ. The measurement is carried out as conductor against PE and not conductor against conductor.

Please note: Overvoltage protectors should always be removed before carrying out the test, so that the measurement is not influenced and the overvoltage protector is not damaged.

۵. A polarity check should be carried out on all bus devices. To do so, set the bus device into programming mode by pressing the programming button. If the programming LED lights up, the bus device is correctly connected. To finish the check, press the programming button again. This switches the bus device back to normal operating mode and resets the programming LED.

۶. After having mounted all bus devices, check the bus voltage at the end of each bus cable using a voltmeter. The voltage should be at least 21 V DC.

۷. Record all test results and add them to the documents of the KNX TP installation.

۸. Hand over the ETS project to the client together with the project documentation

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