KNX TP1 Installation

KNX Association

Table of Contents

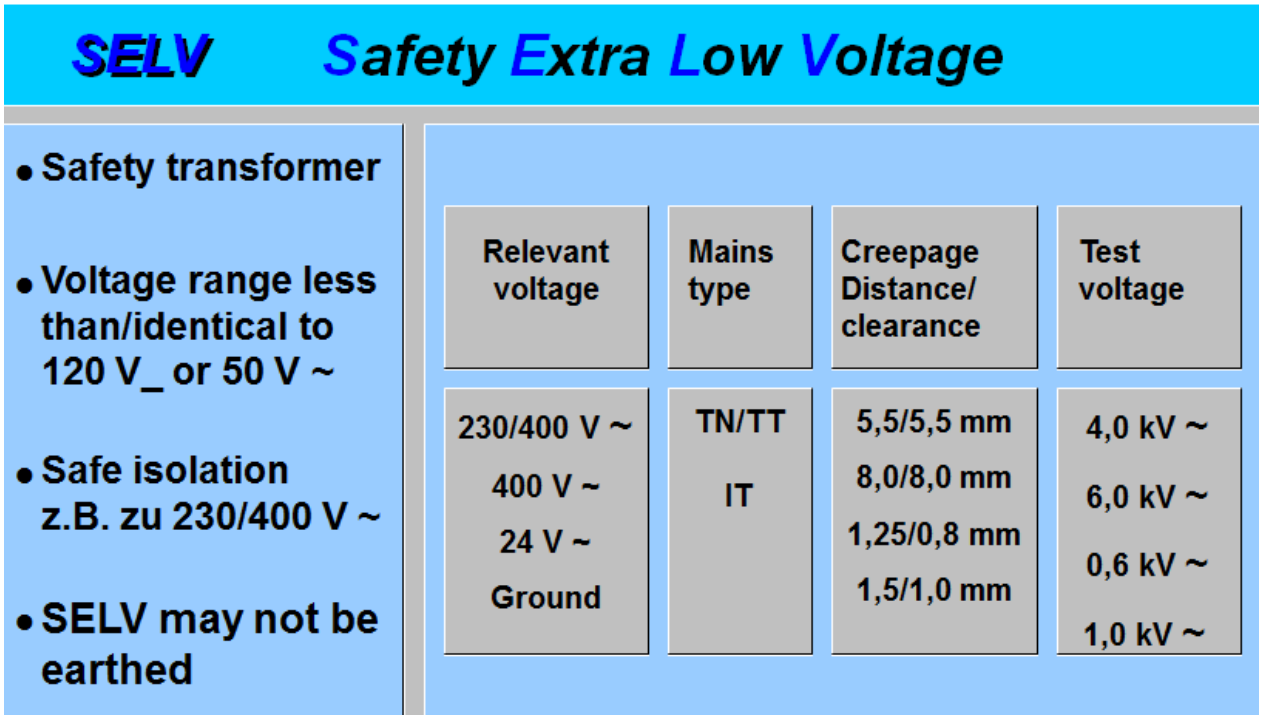


Figure 1: Safety Low Voltage Networks

1 Safety Low Voltage Networks

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

SELV stands for Safety Extra Low Voltage
Clearance and creepage distances:
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

Permitted voltage range:

- Alternating current: ≤ 50 V
- Direct current: ≤ 120 V

No special protection against direct contact if required if the voltages do not exceed 25 V_ or 60 V_.

Earthing:

- A SELV network must not be earthed!

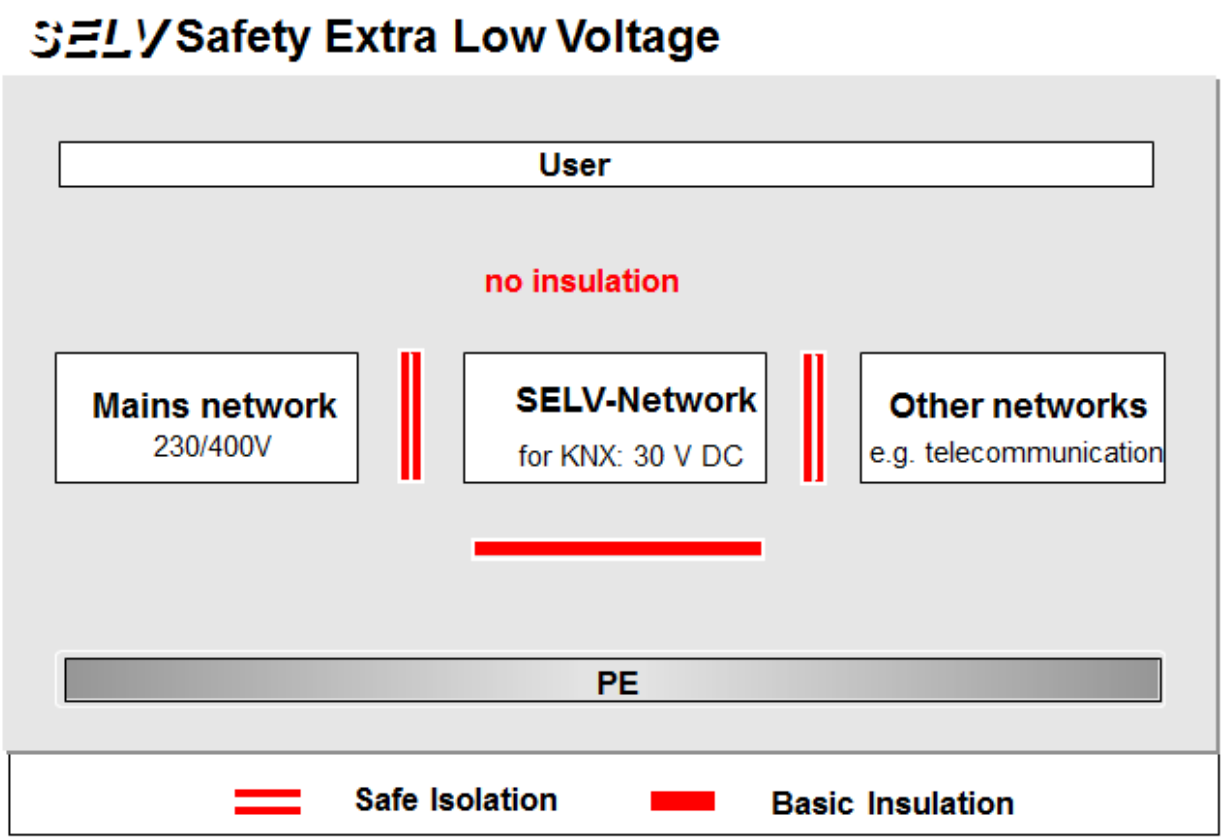


Figure 2: SELV Safety Extra Low Voltage Network

2 SELV Safety Extra Low Voltage Network

A safety transformer generates the SELV voltage for the KNX TP1 Installation Bus.
Voltage used:

- DC 30 V

Insulation:

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

Attention:

- The SELV network must NOT be earthed!
- Cables that are intended for the installation of heavy-current networks may not be used for the installation of TP1 networks!

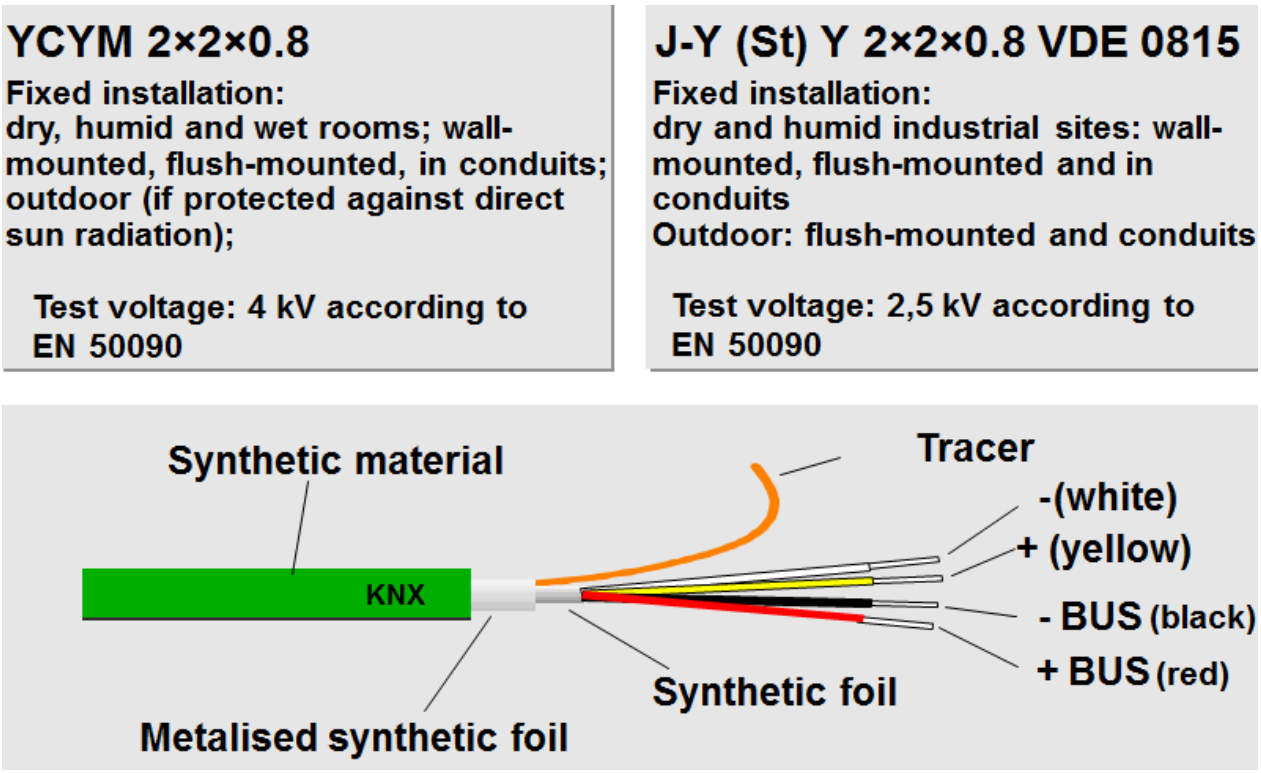


Figure 3: Types of bus cable

3 Types of Bus Cable

Twisted Pair 1 cable which fulfils 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 TP1 design) can be recognised (without KNX logo) or certified (with KNX logo) by KNX Association[1]. Only the standard green KNX TP1 cable guarantees:

- max. cable length of a line
- max. distance between two bus devices on a line
- max. number of bus devices per line

This is based on the loop resistance of 75 Ω and the loop capacitance of 100 nF per 1000 m. For all other cables, the maximum length given in the data sheet of the cable must be observed.

It is not normally necessary to connect the shielding of the installed cable types.

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

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

Used wire pair:

- Red: plus
- Black: minus

Spare wire pair: Permitted use of the spare wire pair:

- no connection at all
- for other SELV low voltage methods

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

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

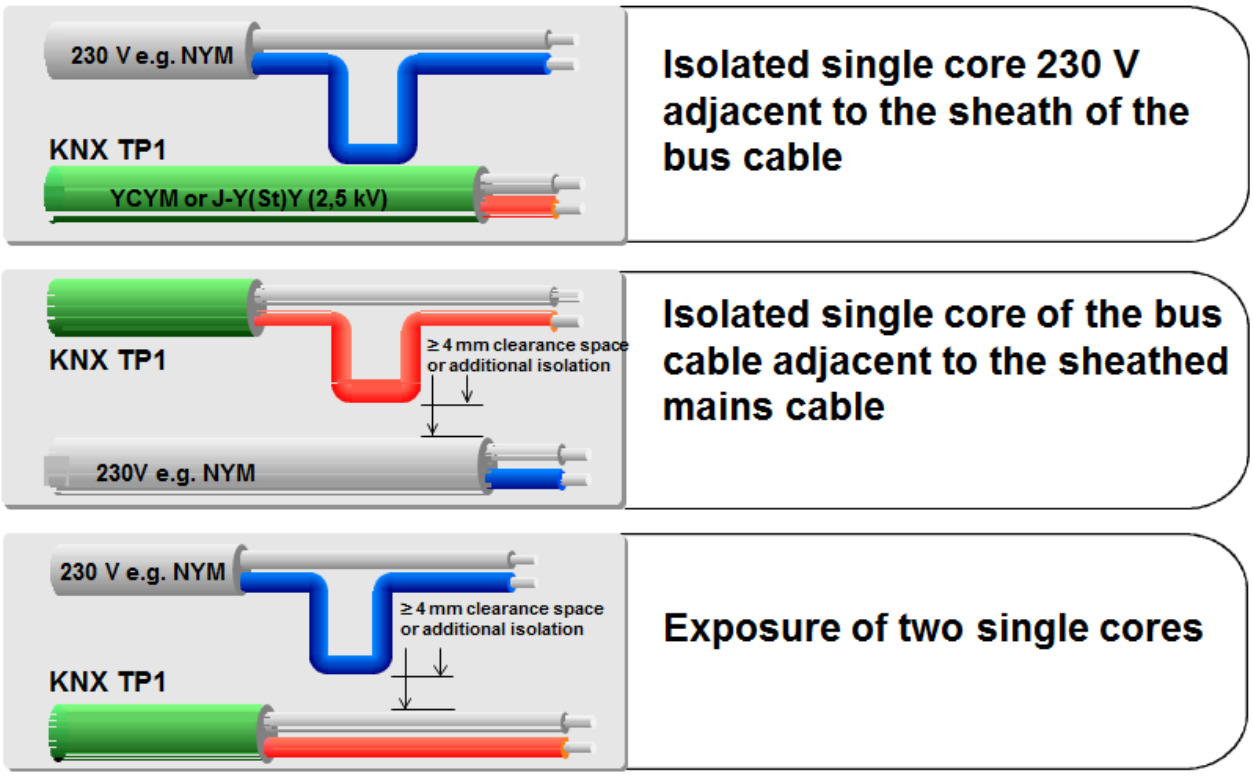


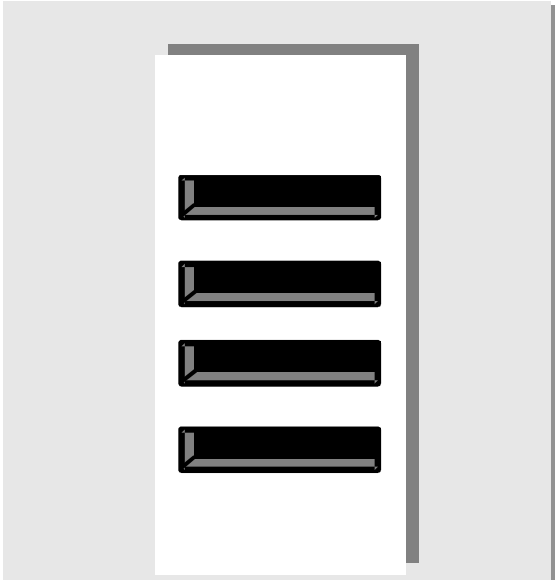
Figure 4: Installation of cables

4 Installation of Cables

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

- Insulated wire cores of sheathed mains cables and KNX TP1 bus cables may be installed next to each other without any clearance space.
- A minimum clearance space of 4 mm must be observed between the insulated wire cores of KNX TP1 bus cables and those of sheathed mains cables. Alternatively, the wire cores must be provided with an equivalent insulation, such as a spacer or insulation sleeving (DIN VDE 0110-1, Basic insulation). 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 arrester) must be ensured.
- All cables should be permanently marked as ***KNX TP1*** or ***BUS*** cables.

A terminating resistor is not required.



- **Use standardised distribution boards**
- **Install bus cables with sheath up to terminals**
- **Cover unused section of data rail**
- **Do not install bus devices above mains devices with significant power losses**

Standardised power distribution boards	Requirements

Figure 5: Bus devices in distribution boards

5 Bus Devices in Distribution Boards

Any commercial, standardised electric power distribution boards equipped with EN 50022 35x7.5mm DIN rails may be used, on which KNX TP1 DIN rail mounted devices can be installed. Some of these KNX TP1 DIN-rail mounted devices use spring contact blocks to a standard data rail glued into DIN rails, others provide the normal bus connector (see later) for connection to the bus.

Unused parts of data rail must be protected by cover strips.
If the mains section is separated from the installation bus, no special installation requirements need to be observed.
If the mains section is not separated from the installation bus, the bus cables must be sheathed up to the terminals.

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

Bus devices should not be mounted above mains devices with significant power losses, as this could cause excessive heat development in the installation.

When a lightning arrester is installed on a DIN rail containing a data rail, the following requirements must be met:

- Overall insulation of the arrester (e.g. do not use any uncovered air sparking gaps).
- As DIN rails may not be used for earthing, arresters must be provided with a separate earthing terminal.

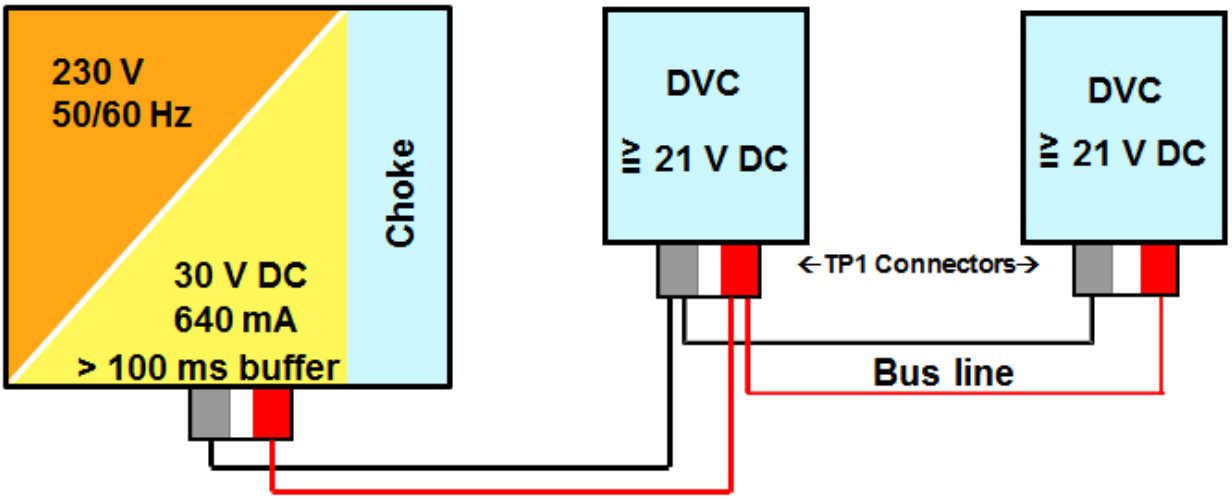


Figure 6: Power supply unit (with TP1 connectors)

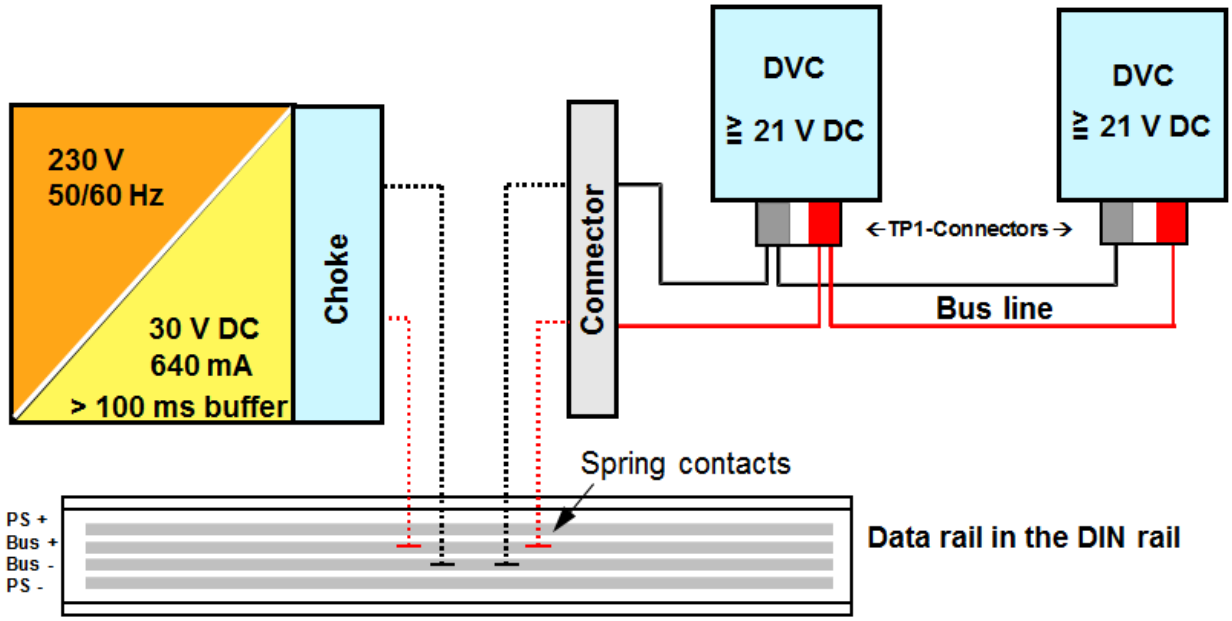


Figure 7: Power supply unit (DIN Rail with data rail)

6 Power Supply Unit

Note: if not explicitly said underneath, the underneath clauses deal with the centralised power supply units.

Power supply units produce and monitor the system voltage of 30 V that is necessary for the operation of a KNX TP1 installation. Each line has its own power supply unit for the bus devices. The power supply unit has an integrated voltage and current control and is therefore resistant to short circuits.

A buffer with a stored-energy time of 100 ms is able to bridge short power gaps.

Bus devices require a minimum of 21 V for safe operation and constitute a load of up to 200 mW on the bus except some devices whose energy requirement should be taken from the data sheet of the respective manufacturer (e.g. heating valves).

With a power supply of e.g. 640 mA, it is possible to connect 64 devices with a maximum capacity of 200 mW and an almost identical distribution on the line.

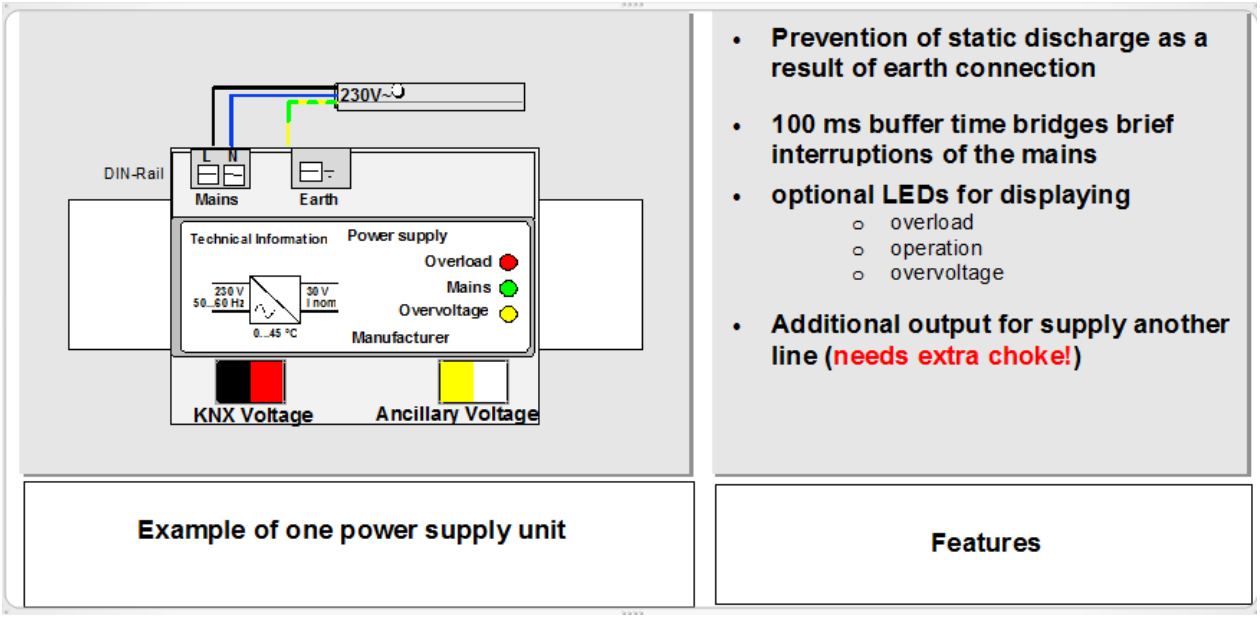


Figure 8: Example and features of a power supply unit (on DIN-Rail without data rail)

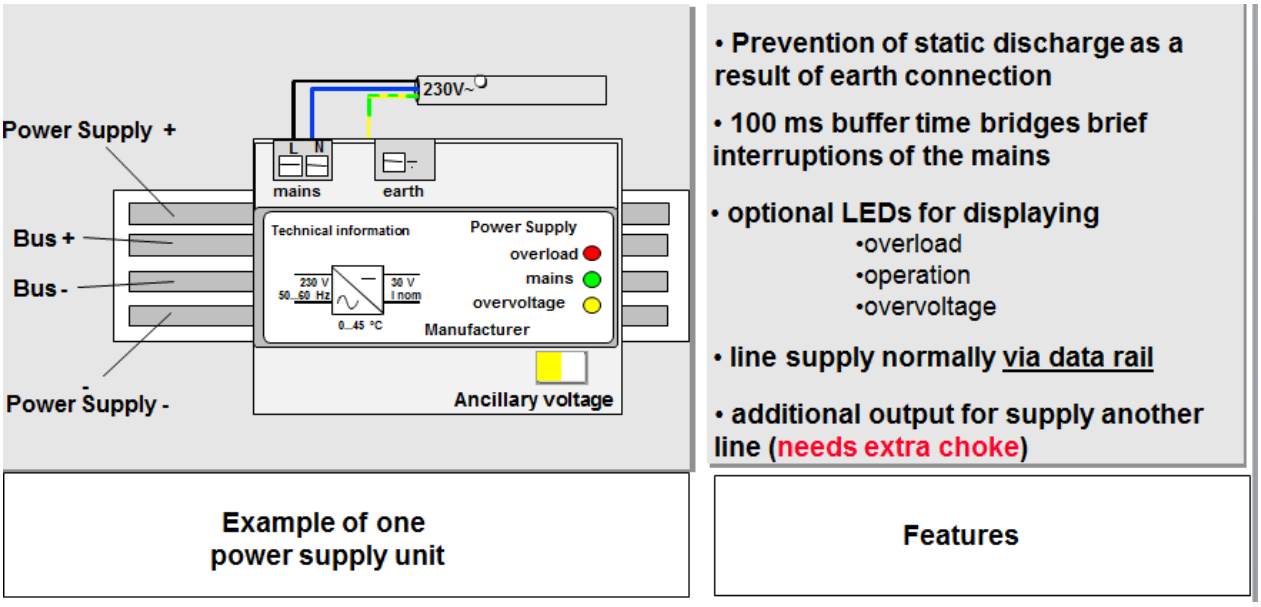


Figure 9: Example and features of a power supply unit (on DIN-Rail with data rail)

To prevent static charges on the bus side, the power supply unit has high ohmic resistances connected from each bus core to earth.

The power supply unit should be earthed. To do so, connect the earth point of the low voltage section to the power supply unit. This connection should be marked yellow/green. It does not have any protective effect according to safety regulations and does not contradict the conditions that apply to SELV networks.

Some power supply types or the external chokes have a reset switch and a red control LED. The connected line can be set to 0 V with this switch.
The chokes prevent the short-circuiting of bus telegrams (alternating voltage 9600 Hz) via the filter or charging capacitor 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)). It goes without saying that the number of installable devices in a line depends on type of 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.

Most of the power supply units are DIN-rail mounted types, whereby only the two outer printed conductors of the data rail make contact with the power supply unit.
Some types have an additional output, with which it is possible to supply other lines using an external choke.
Uninterruptible power supply types 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, maybe due to a short circuit between bus wires.
- Yellow: An external voltage higher than 30 V has been applied to the bus side.

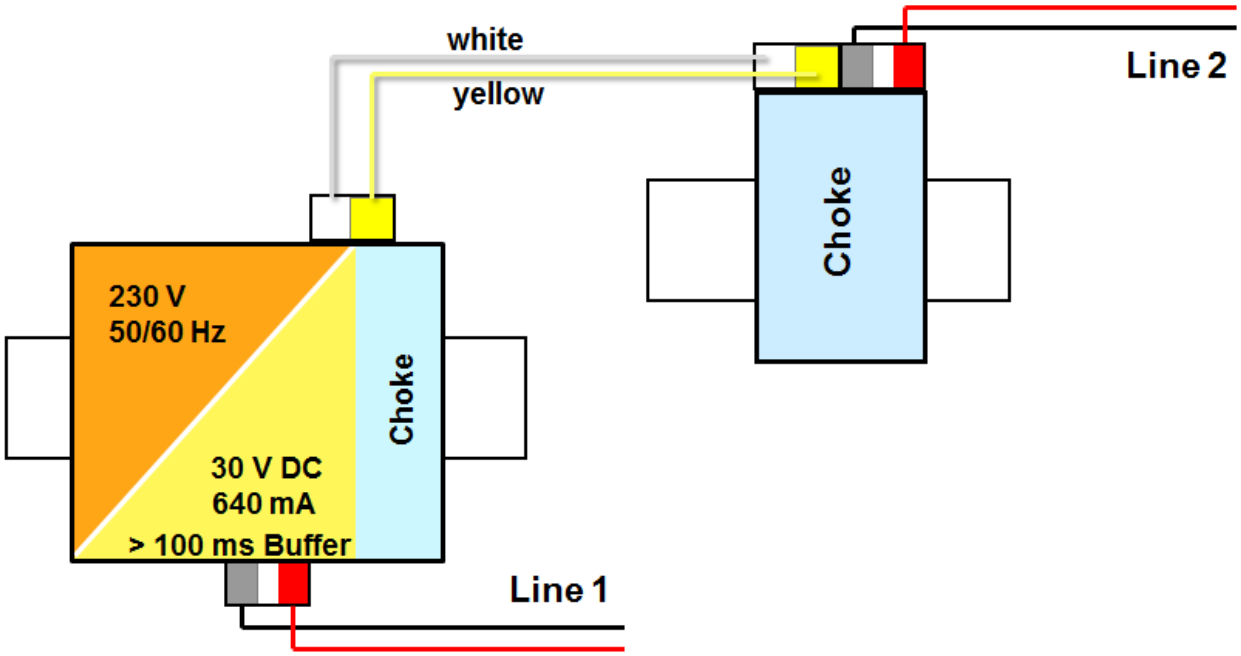


Figure 10: Power supply for two lines (DIN-Rail without data rail)

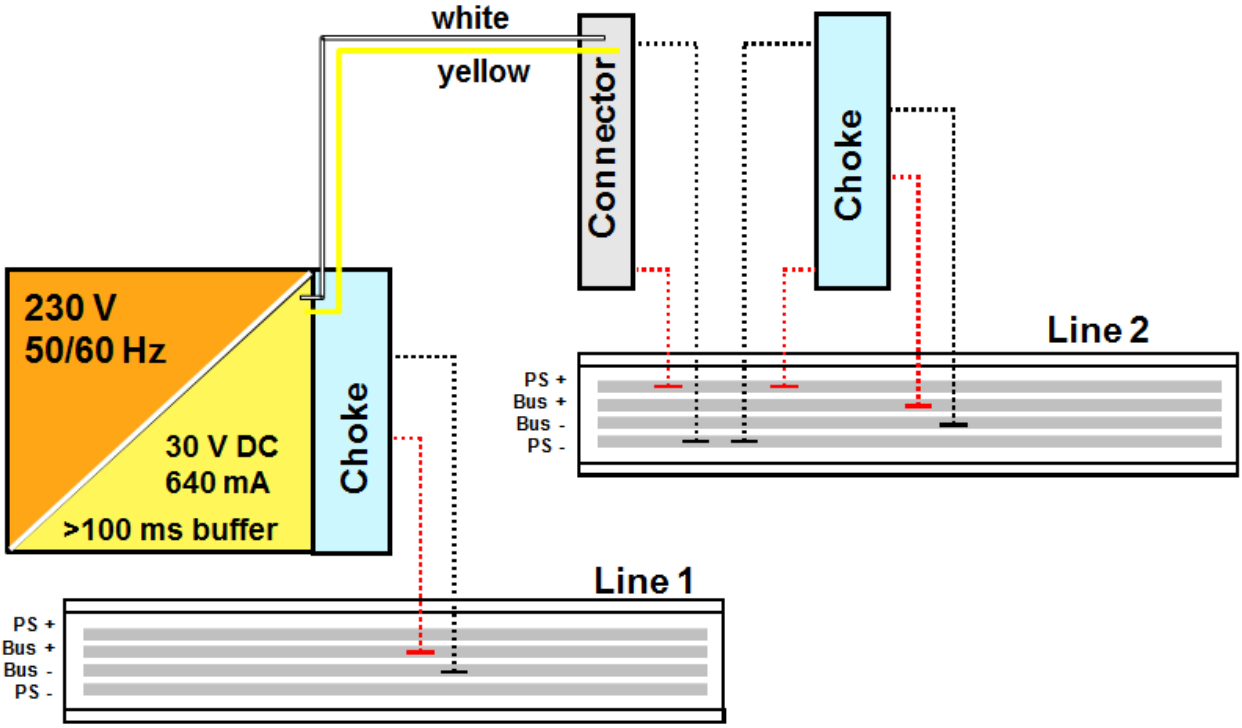


Figure 11: Power supply for two lines (DIN-Rail with data rail)

6.1 Power Supply for Two Lines

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

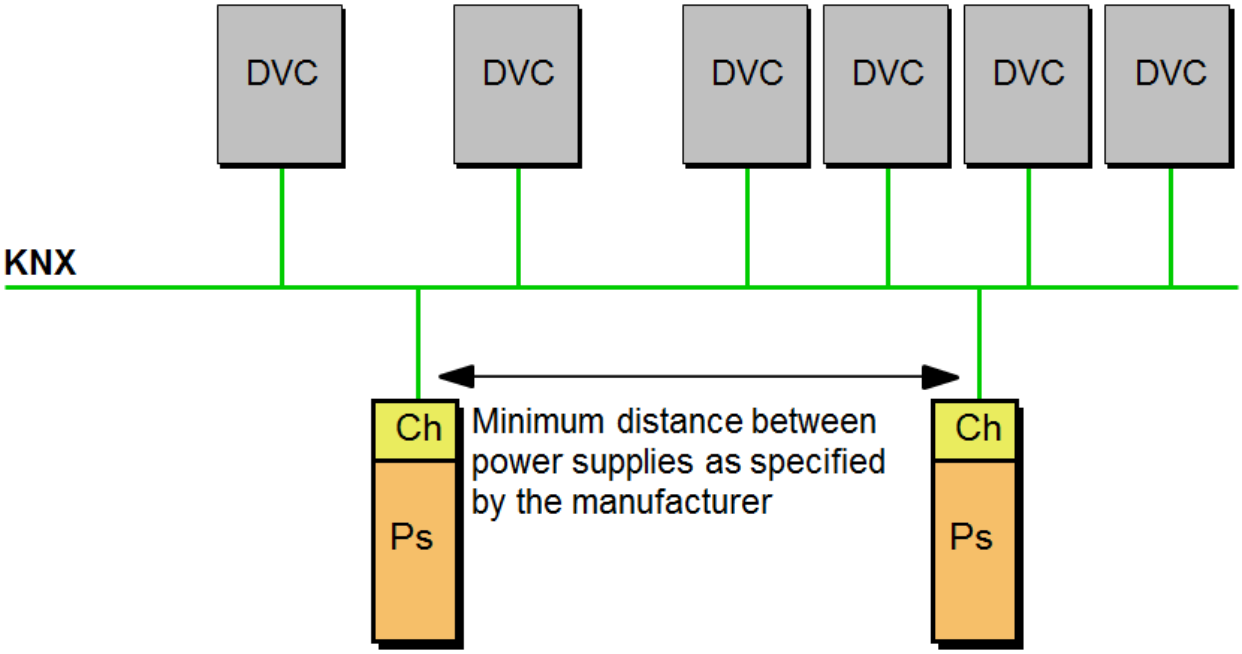


Figure 12: Two power supply units on one line

6.2 Two Power Supply Units on One Line

If more than 30 bus devices are connected within a short distance to each other (e.g. on a distribution board), the power supply unit should be installed in the vicinity of this group.

If an additional power supply unit is to be installed, the minimum distance shall be taken from the product specifications. One line may only have a maximum of two power supply units connected to it.

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

Figure 13: Cable length

7 Distributed power supply

Instead of a centralised bus power supply, the bus is powered in a distributed way by some devices connected to the line containing each a Decentralised 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 supply current (25, 40 and 80 mA).

In most cases, it is possible to combine DPSU with up to two standard central PSUs.
The DPSU can be located at any point in the bus line. There are no limitations concerning minimal distances between two DPSUs or DPSU and standard central PSU.

Up to eight DPSUs can be mounted in one single bus line. More than eight can have a negative effect on the 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 and/or ETS database) shall not exceed 3A.

In most cases it is possible to manually disable the DPSU on the device (e.g. by jumper or configuration of a parameter).
The to be observed cable length in conjunction with the use of central and decentralised power supply units is given in the above figure.

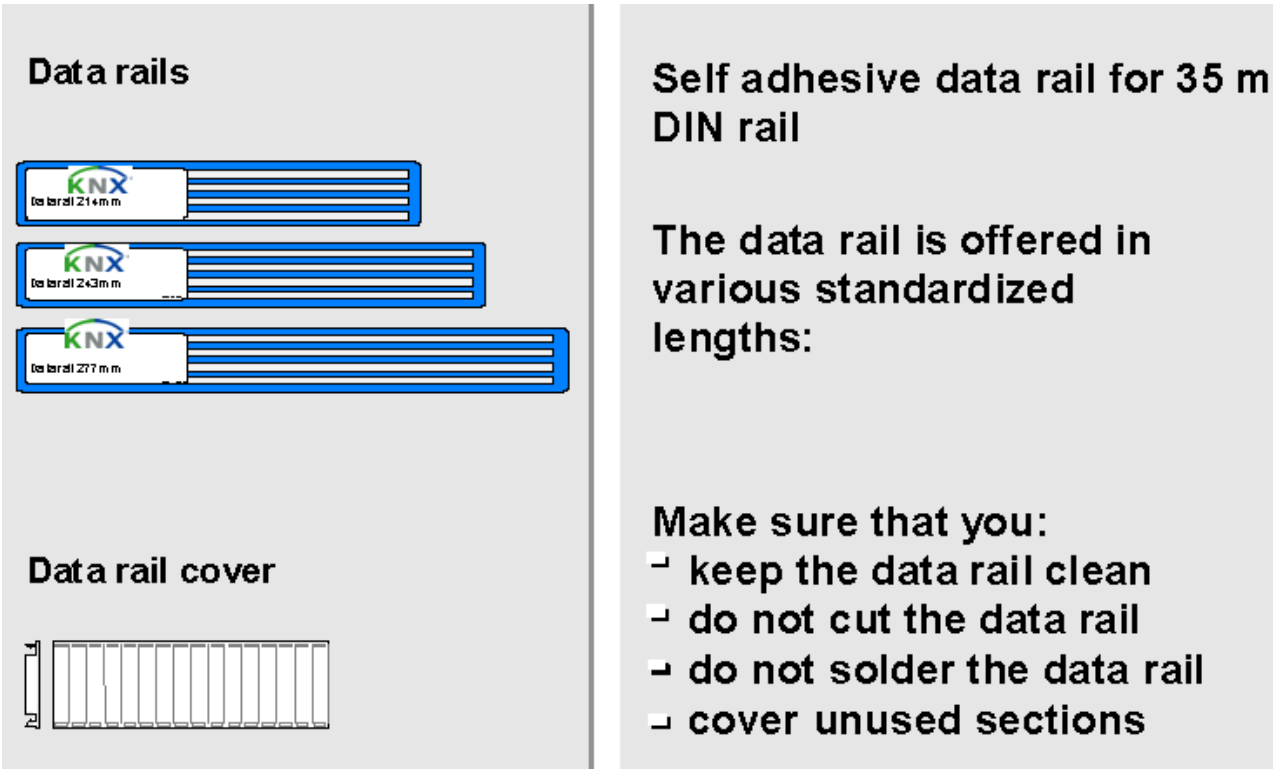


Figure 14: Data rails and data rail covers

8 Data Rails and Data Rail Covers

Some DIN rail type bus devices, such as binary outputs, dimmers, power supply unit etc., use a data rail to connect to the KNX TP1 bus.
The self-adhesive data rail is mounted on the 35 mm DIN rail according to EN 50022.

The lengths of ready-made data rails match the various widths of the standardised electric power distribution boards available. The length of a data rail may not be changed, for instance by cutting it shorter, as this would change the creepage and clearance distances.

When DIN-rail mounted KNX TP1 bus devices use the data rail to connect to the TP1 bus when snapped on the DIN rail, they do so by means of a pressure contact mechanism. In order to protect unused sections of data rail from pollution or from accidental contact with mains cables, they should be covered by a data rail cover.

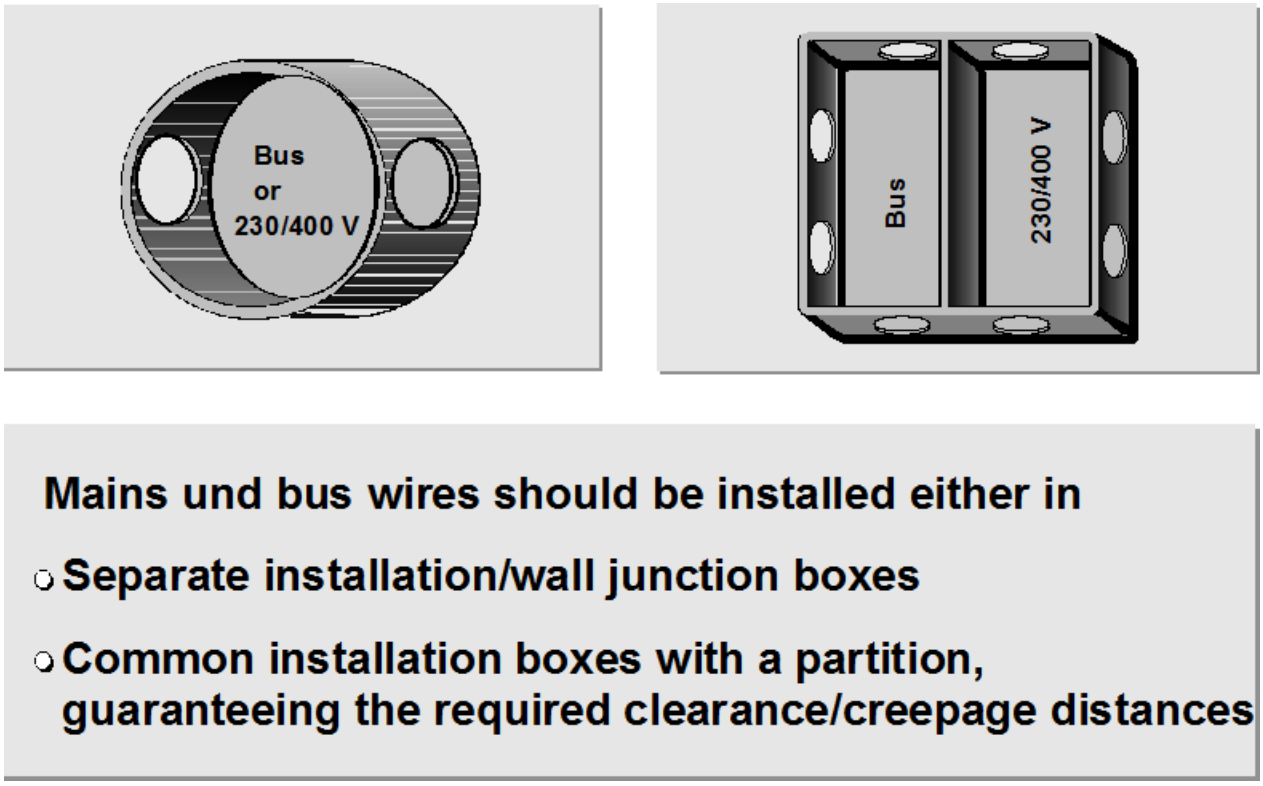


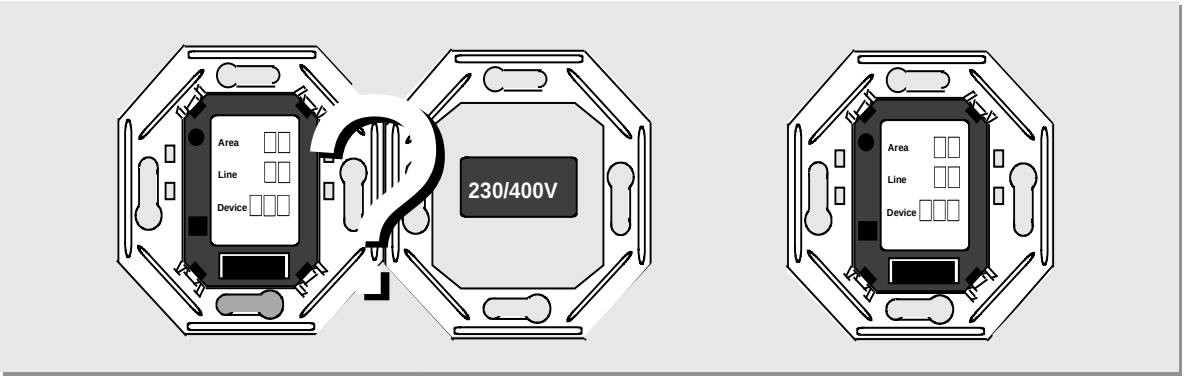
Figure 15: Bus cables in wall boxes

9 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 8 mm clearance and creepage distances e.g. for TN/TT networks in office buildings.



- **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 16: Installation of flush-mounted bus devices

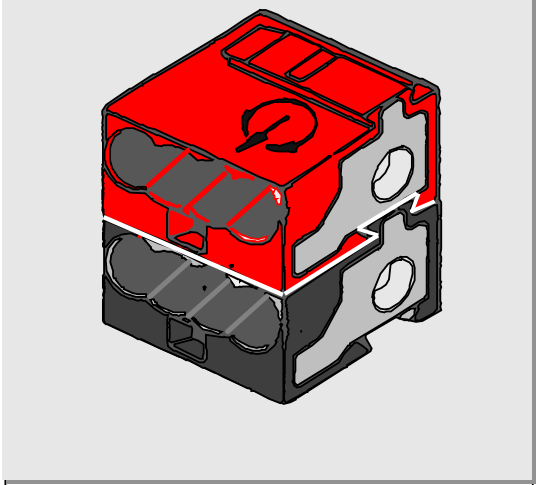
10 Installation of Flush-mounted Bus Devices

Only wall boxes suitable for screw mounting may be used. Clamp mounting is not possible in most cases.
In order to provide sufficient room for cables, wall boxes with a depth of 50 mm, for instance, should be installed.

'Combinations' refer to the use of mains devices (e.g. socket outlets) and bus devices (e.g. pushbuttons) or other electric circuits underneath a common cover.
Both components must be safely isolated from each other. This can be achieved by using basic insulation for the power devices and basic 230 V insulation for the bus device.
Please 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.



Bus connection block

- **Joints, extensions or connections are realised by means of bus connection blocks**
- **Bus cable shall only end either at the device itself or at this terminal**
- **Removal of bus devices without interrupting the bus**
- **Mechanical protection against mismating**

Usage

Figure 17: Bus connection block

11 Standardised TP1 Bus Connection Block

The bus connection block 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 connection block should only be used for the KNX TP1 installation bus.
The bus connection block consists of two parts:

- the PLUS part (red) and
- the MINUS part (grey)

which are mechanically linked by means of a dovetail joint. Up to four bus wires (6 mm stripped) can be connected to each part by means of screwless terminals.

Standardised TP1 bus connection blocks allow the removal of bus devices without interrupting the bus wire.

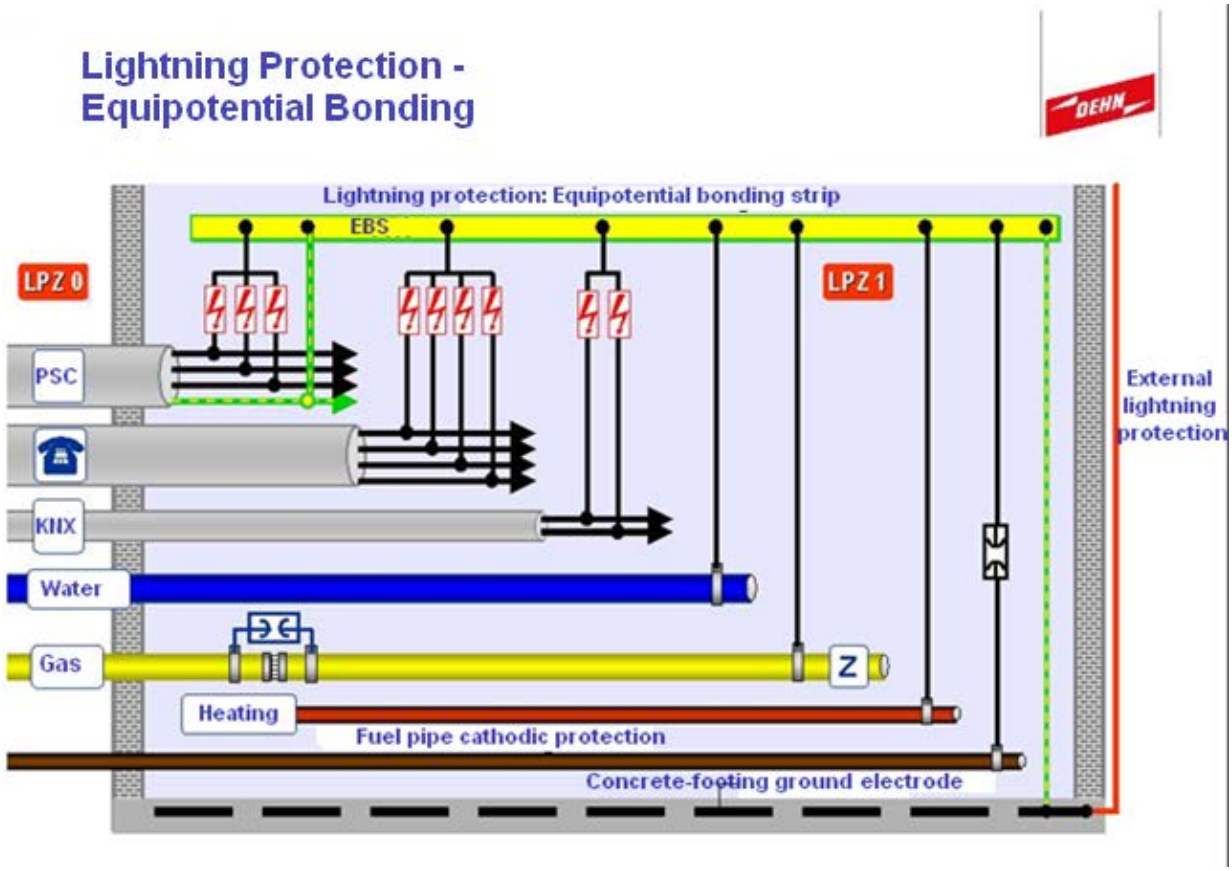


Figure 18: Lightning protection measures

12 Lightning Protection Measures

The KNX TP1 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 (e.g. in Germany of the federal states);
- a risk analysis of the construction (e.g. in Germany according VDE 0815 part 2)
- a requirement from an insurance company (in Germany according VdS 2010).

In general, lightning protection measures are required for buildings which can be easily struck by lightning or to which lightning can inflict heavy damage. These especially include conference rooms, public buildings 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 strip (EBS). In the currently valid guidelines (DIN VDE 0185 Part 1 to 4, IEC 1024-1, IEC 61312-1), the lightning protection equipotential bonding strip is a binding requirement also for active conductors; they must be indirectly connected by means of lightning surge arresters. This is referred to as ‘primary protection’.

Primary protection is achieved by using:

- For the AC 230/400 V 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 EN 61643-11:2001
- 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 D1 according 61643-21:2002

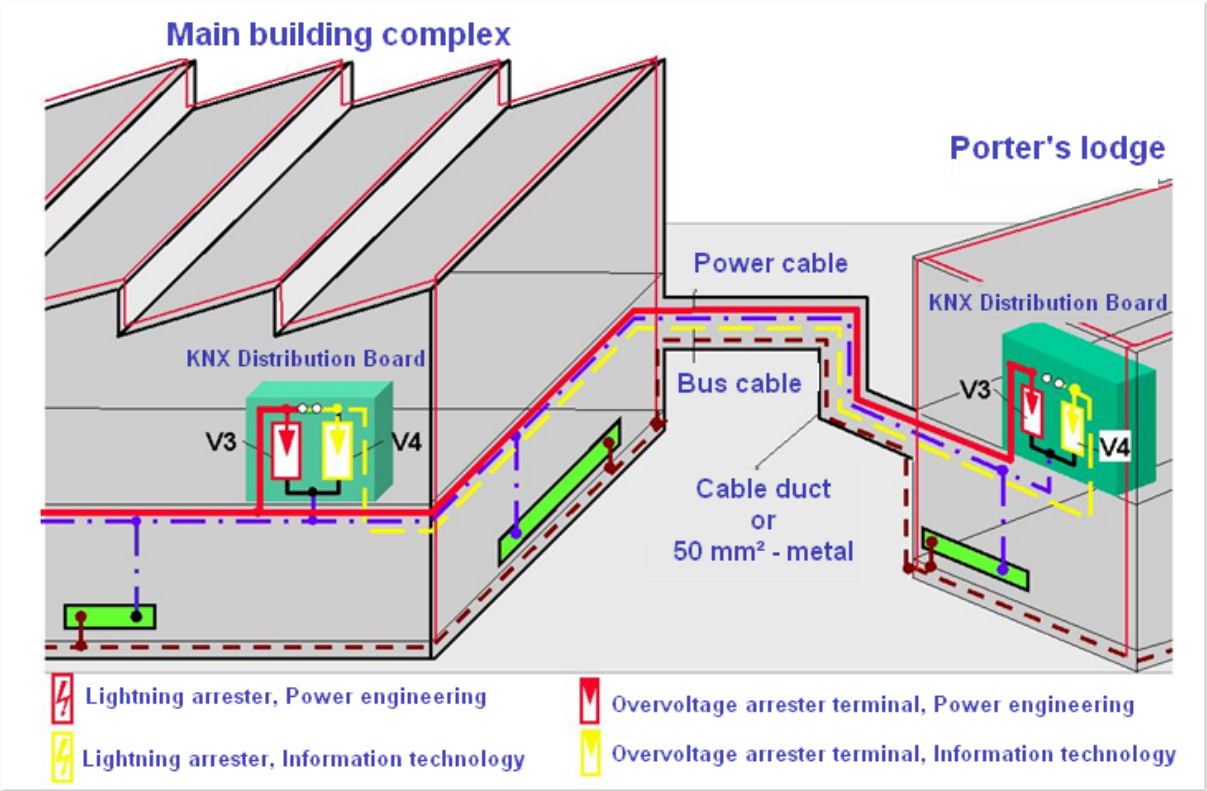


Figure 19: Bus cables installed between buildings

13 Bus Cables Installed between Buildings

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 metal conduit or 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 VDE 0185 part 3.
In either case, the connected bus devices in the building should be connected to an overvoltage arrester terminal for secondary protection. The bus devices and the overvoltage arrester terminal should be mounted apart at a distance of some (cable) metres to make sure that the overvoltage arrester terminal is not forced to accommodate parts of the primary protection.

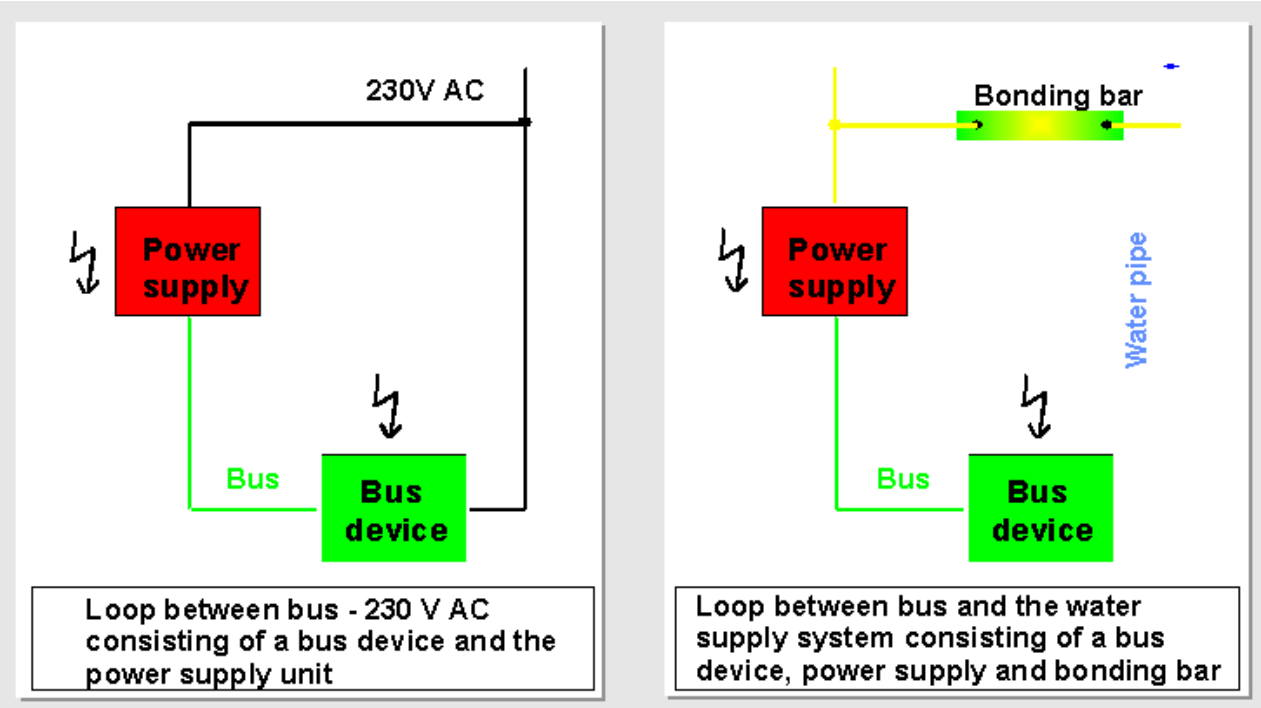


Figure 20: Prevention of loops

14 The Prevention of Loops

As a consequence of the impact of lightning, major overvoltages are generated in loops, which can cause flash-overs in bus devices. The larger the loop area, the larger the (peak) overvoltage 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 strip.
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 TP1 installation, it may not be possible to program the installation under certain circumstances.

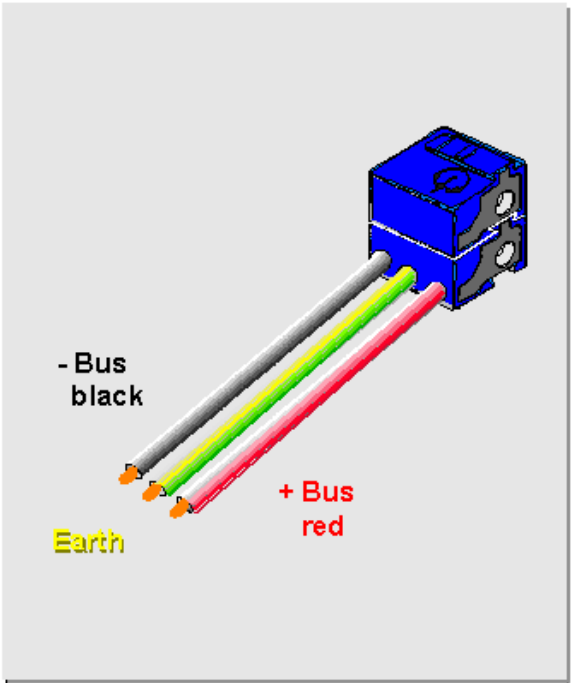
15 Basic Immunity of Bus Devices

The basic immunity of bus devices is tested according to the standard EN 50090-2-2 by applying a 2 kV surge voltage core to earth. As a consequence, bus devices are protected against overvoltages often caused by switching operations.
In general this provides sufficient protection.
More significant interference can however be caused:

- when bus cables and powerful 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.

16 Bus Devices on Cable Ends

In this case, additional secondary protection should be provided.



Bus overvoltage arrester

- To bus devices with 230 V mains connection
- To line and area couplers on both lines
- To bus devices installed in conductive walls or in the vicinity of water pipes, gas pipes etc
- To bus cable ends
- At the edge of buildings

Recommended usage

Figure 21: The overvoltage arrester terminal

17 The Overvoltage Arrester Terminal

The overvoltage arrester terminal 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 arrester terminal 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 not suitable for this purpose.

Via the connection wires sticking out of the bus overvoltage arrester (which have an identical colour marking as the bus cable, i.e. red and black), the arrester can be connected by means of a conventional bus connection block to the bus cable or directly to a bus device. However, the bus overvoltage arrester cannot be used to branch the bus cable. The third green 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 arrester terminal is directly connected to the bus device instead of using a bus connection block. In this case, the connection between wires is ensured by means of an externally mounted bus connection block.
The arrester terminal also replaces the bus connection block when couplers are to be connected in the main line.
In the case of DIN rail mounted bus devices in general, e.g. power supply units and secondary lines of couplers, the overvoltage arrester terminal should be connected to a data rail 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.

18 Recommendations to the use of overvoltage arresters

The use of overvoltage arresters is recommended for:

- bus devices with protection class 1
- bus devices with more connections than just bus (AC 230/400 V respectively conduits of the heating system)

In distribution boards, it is sufficient to equip each bus line with one overvoltage arrester. In this case also the outer conductor and the neutral conductor with overvoltage arresters. For luminaries with built-in switching actuators the installation of overvoltage arresters is only necessary when the bus and the mains form large-surface loops.

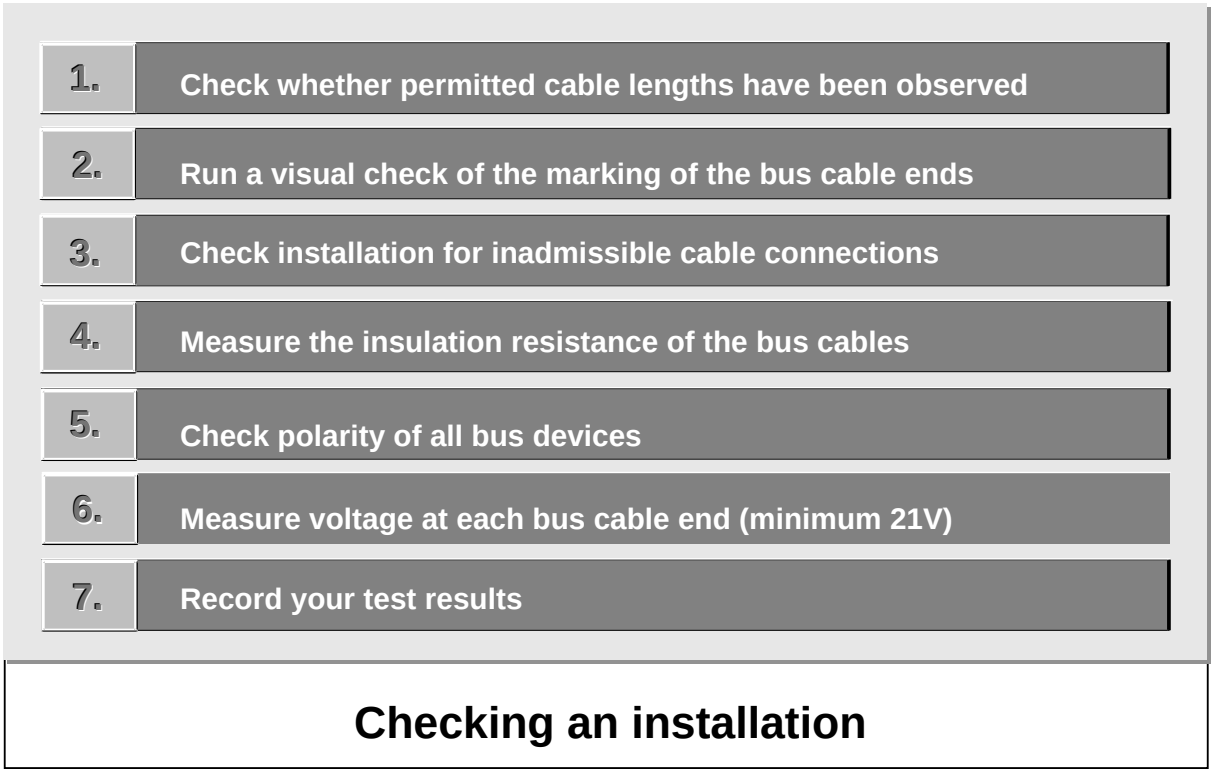


Figure 22: Checking the installation

19 Checking the Installation

1) Voltage drops and telegram run times occur due to the ohmic resistance, the capacity and inductance of the bus cables. This produces the physical limits of a KNX TP1 installation as outlined below.

Length of a line segment	**max. 1000 m**
Distance between power supply unit and 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.

2. The ends of the bus cables should be clearly identified as KNX TP1 installation bus cable by marking them *KNX TP1* or *BUS*. An extra indication of the area and line will make it easier to locate a specific bus cable for test, commissioning or maintenance.

3. Bus cables from different lines may never be linked 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.

4. The measurement of the isolation resistance of the bus cable should be carried out at DC 250 V (DIN VDE 0100 T600). The isolation resistance shall be at least 500 kΩ. The measurement is carried out as conductor against PE and not conductor against conductor.
   Please note: Overvoltage arrester terminals should always be removed before carrying out the test so that the measurement is not influenced and the overvoltage arrester is not damaged.

5. A polarity check should be carried out on all bus devices. To do so, set the bus device to the 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 pushbutton again. This switches the bus device back to normal operating mode and resets the programming LED.

6. 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.

7. Record all test results and add them to the documents of the KNX TP1 installation.