

# KNX Powerline PL 110

KNX Association

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**NOTE:** THIS CHAPTER IS INTENDED TO BE USED AS INFORMATIVE ANNEX TO BASIC COURSES.  
THE CONTENTS IS NOT PART OF THE EXAM AT THE END OF THE BASIC COURSE.

## 1 Introduction

KNX PL 110 allows the transmission of telegrams across the 230/400 V network. A separate bus line is therefore not necessary. Telegram transmission takes place via external and neutral conductors which must be connected to every device. KNX PL 110 is compatible with KNX TP1 components and the corresponding tools. It is possible for instance to plug a flush-mounted application module onto a flush-mounted mains coupler and to load the application software via the 'bus cable' (230/400 V supply line) into the mains coupler.

In spite of the undefined transmission characteristics of the energy supply system (caused by cable types, cable length, type and number of connected devices...), KNX PL 110 ensures a high level of security during telegram transmission. KNX PL 110 works bi-directionally in a half-duplex operation i.e. every device can transmit and receive. Typical KNX PL 110 applications are:

-  control (switching, dimming) of lighting installations
-  motor-driven applications (shutters, opening gates)
-  alarms
-  transmission of analogue values
-  time or central control
-  presence simulation
-  visualisation with touch-sensitive displays

Owing to the undefined network conditions, telegram transmission may be interrupted. For this reason, it is not permitted to realise applications with KNX PL 110 whereby the absence of a telegram can lead to extensive consequential damage. Such applications are for example lift control and emergency devices.

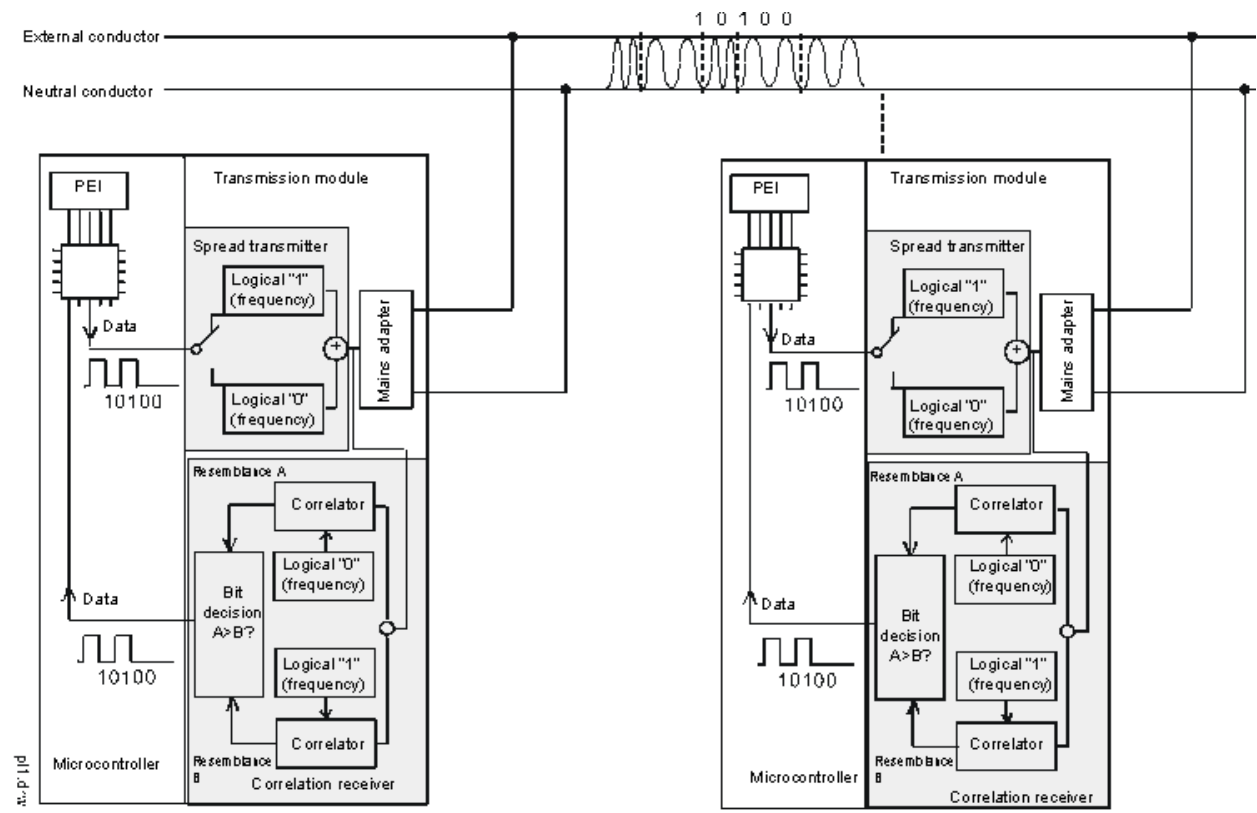
## 2 Standardisation

In Europe, signal transmission via the energy supply system is regulated by the CENELEC standard EN 50065. Part 1 of this standard defines general requirements, frequency ranges, transmission levels and requirements for electromagnetic compatibility (EMC).

KNX PL 110 uses the frequencies 105.6 kHz and 115.2 kHz for transmission.

Due to the middle frequency of 110 kHz, the KNX PL 110 system is sometimes referred to as PL110. As the standard only allows a maximum transmission level of 116 dBµV, the devices are sometimes called 'class 116' devices.

### 3 Transmission Process



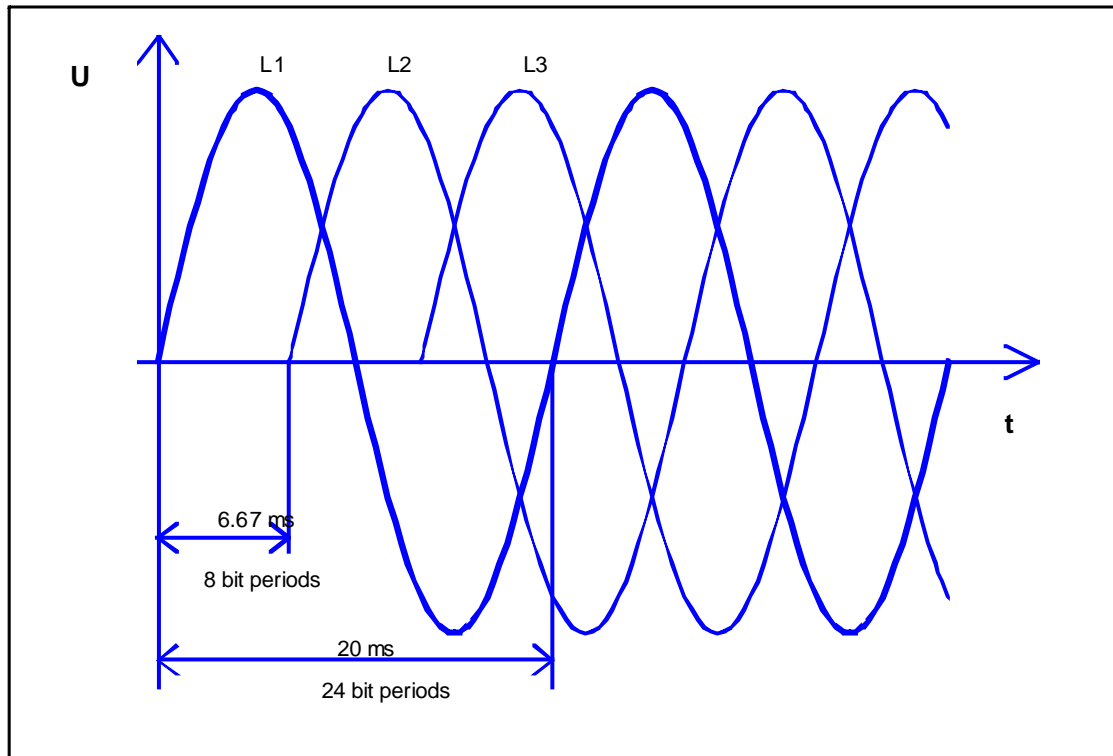
**Figure 1: Transmission process**

Owing to the continuous progress made in the miniaturisation of electronics, it was possible to apply a new transmission process for KNX PL 110 i.e. Spread Frequency Shift Keying or SFSK for short. It functions as follows:

- ✚ If a '0' is transmitted, the transmitter produces a frequency of 105.6 kHz and the supply voltage are superimposed.
- ✚ If a '1' is transmitted, a frequency of 115.2 kHz is used.
- ✚ In order to ensure a safe transmission at the highest possible speed, the rate of 1200 bit/s is set in all mains couplers which corresponds to a bit duration of 833 µs.
- ✚ All mains couplers are permanently in receive mode. A received signal (also noise) is permanently converted into a digital value.
- ✚ This digital value is now fed into two correlators (probability comparators) which compare the received digital value with a stored, digital frequency reference pattern. There are two correlators in each mains coupler: one for the '0' bit and one for the '1' bit.
- ✚ The correlators can differentiate with a calculable probability that:
  - - it is a '0'
  - - it is a '1'
  - - it is undefined (noise) and the bit is therefore rejected.

The combination of bit patterns as well as the specialised error detection methods allows a guaranteed level of telegram recognition.

In addition, a further innovative technique is used, namely the permanent and automatic adaptation of transmission power and receiving sensitivity. This process allows continuous adaptation of the transmission power to the network characteristics, thereby taking into account that the maximum transmission level is never exceeded. All receivers likewise permanently adapt their sensitivity according to the network characteristics. This results in an optimum transmission range even under constantly changing supply conditions.



**Figure 2: Phase coupling**

### 3.1 Phase Coupling

In order to ensure that data is transmitted on all three conductors, the following two possibilities exist:

- ✚ In smaller installations, a passive phase coupling across the connections to devices with more than one phase (e.g. gas heater, electric cooker) can suffice. However, in order to ensure a defined coupling between the three external conductors, the use of a phase coupler is recommended.
- ✚ In larger installations, the integration of a system coupler in the repeater function<sup>1</sup> is recommended. The system coupler has 4 poles (3 external conductors and 1 neutral conductor) and couples signals with the highest possible transmission level on each external conductor.

<sup>1</sup> The repeater has meanwhile been integrated in the system coupler and is no longer available as an individual device. See also the chapter “System Devices: System Coupler”.

Phase couplers and system couplers may not be installed simultaneously in an installation. This means that if a repeater is retrofitted in an installation with an integrated phase coupler, the phase coupler must be removed.

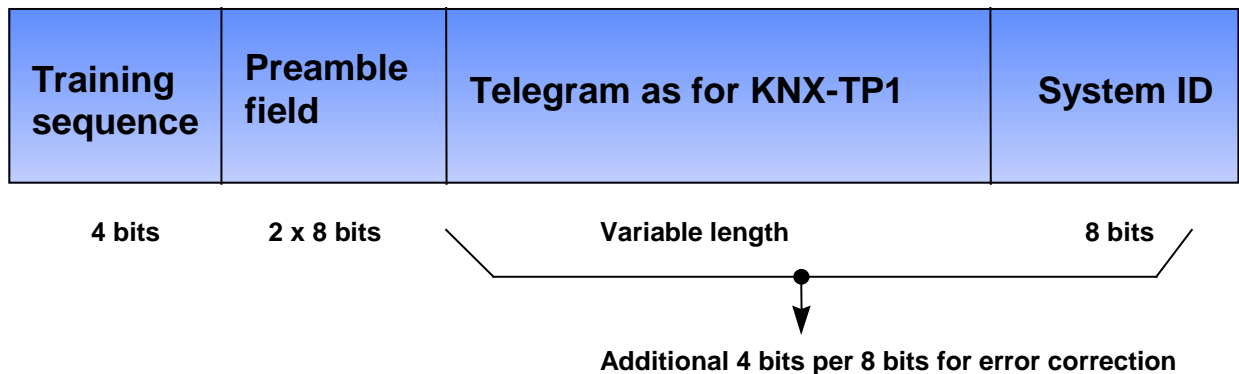


Figure 3: Telegram transmission

## 3.2 Telegram Transmission



Compared to the KNX-TP1 telegram, KNX PL 110 requires additional information during the transmission of data.

### 3.2.1 Training Sequence

The training sequence acts as the automatic reception adjustment of the receivers (thus of all mains couplers except those that are transmitting). The receivers adjust their reception to the network conditions.

### 3.2.2 Preamble field

The preamble field has two functions:

-  It marks the start of the transmission.
-  It controls the bus access.

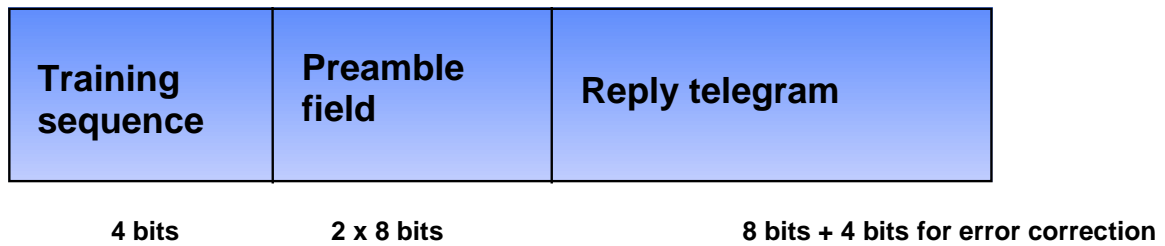
### 3.2.3 Telegram

After this the actual telegram is transmitted (as on KNX-TP1), in which four additional bits of test data are added to every transmitted byte. With the help of this test data, one bit errors can be corrected and multi-bit errors can be detected.

### 3.2.4 System ID

Each telegram is terminated by a field which contains the System ID. The System ID consists of 8 bits (with an additional 4 bits of test data) and can be set by the project engineer of the installation between 1 and 254. The System ID is reserved for information to all devices.

The objective of the System ID is to prevent KNX PL 110 installations that are positioned in close proximity from influencing each other. For this purpose, a distinct System ID is attributed to each KNX PL 110 installation. As the System ID is transmitted in the telegram, each receiver can establish whether the telegram belongs to its installation and then react accordingly.



**Figure 4: Reply telegram**

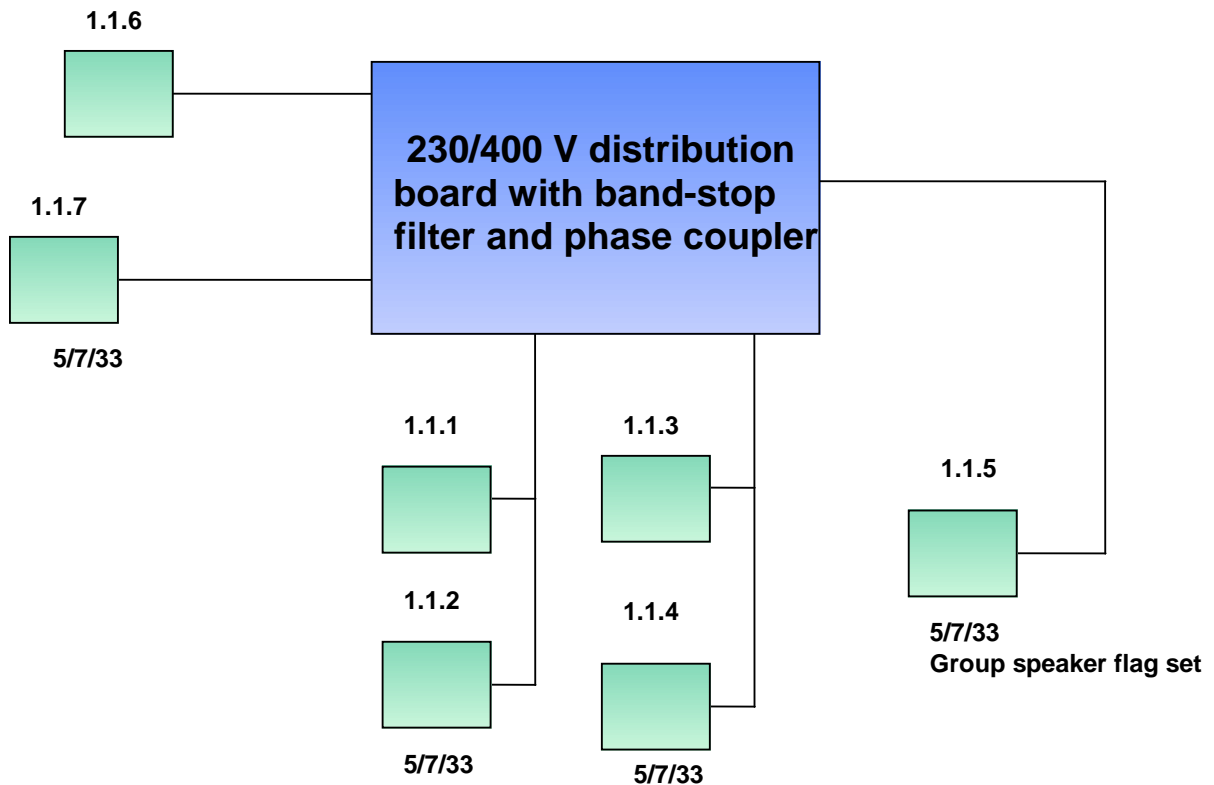
### 3.2.5 Reply Telegram

The reply telegram is produced as a result of the received telegram and must reach the transmitter after a certain period of time. Compared to KNX-TP 1, only two reply telegrams are transmitted:

- ✚ ACK: Transmission was successful.
- ✚ NACK: Transmission was not successful. This reply telegram is only used by the system coupler.

If the reply telegram is not sent, the telegram is repeated. The further process is dependent on whether the system contains a system coupler or not.

The reply telegram may not be sent by all addressed devices but only by one actuator per group address. For this purpose, one group object must be configured as the 'group speaker' during the planning stage.



**Figure 5: Installations without system coupler**

### 3.3 Installations without System Coupler

In the example above, the device 1.1.7 is a KNX PL 110 sensor while all the other devices are KNX PL 110 actuators. The sensor is activated. The following occurs:

- ✚ The sensor transmits a telegram with group address 5/7/33.
- ✚ All actuators receive and analyse it.
- ✚ Only the actuator 1.1.5 transmits the ACK reply telegram because the project engineer has set the group speaker flag at the corresponding group object for the group address 5/7/33.

The following applies:

- ✚ Only one ACK flag may be set per group address (for a group object which is linked to this address).
- ✚ The group speaker flag shall be set at the actuator which is furthest away.

If the telegram of 1.1.5 is either not received or received incorrectly e.g. due to a mains disruption, the actuator will not send a reply telegram. The sensor repeats the telegram once.

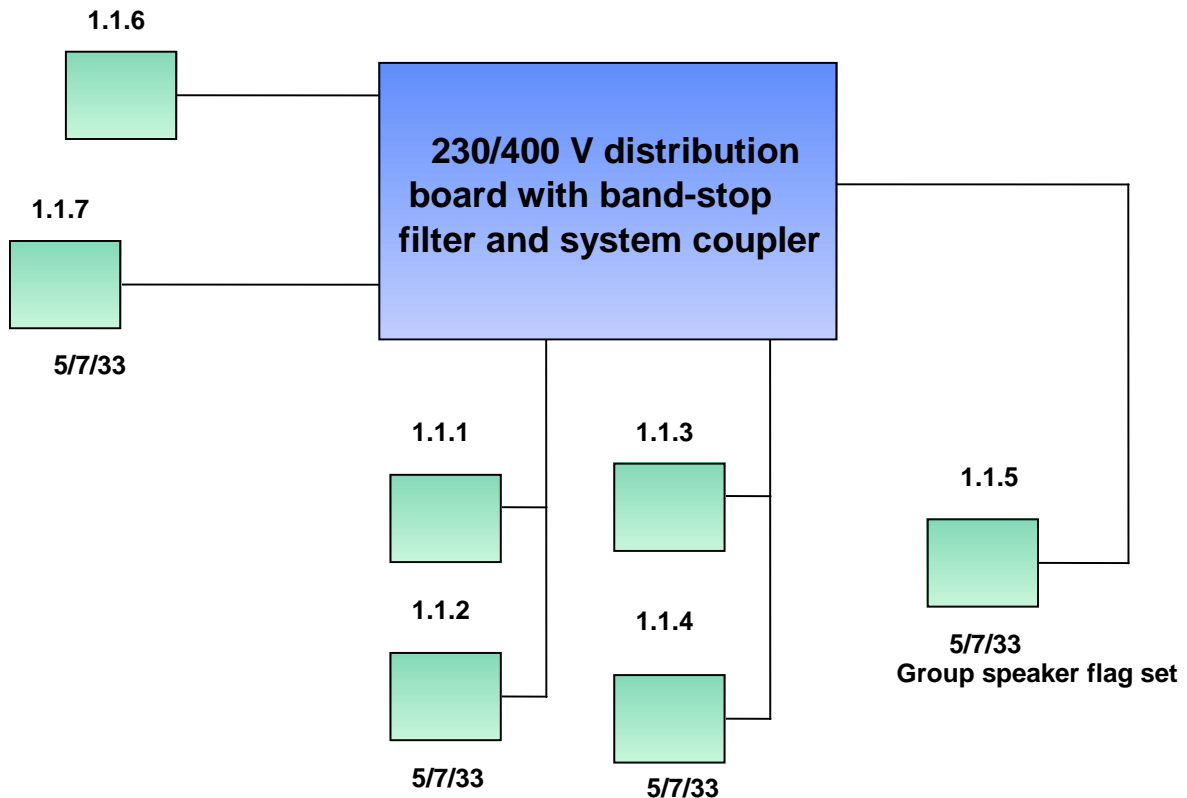


Figure 6: Installations with system coupler

### 3.4 Installations with System Coupler

The example is identical to the one described in section 3.3 but a system coupler has now been installed in the distribution board. The presence of the system coupler is reported to all the devices during programming. If a system coupler is retrofitted in the installation, all the devices must be reprogrammed.

It is not necessary to press the programming button again because the individual address is retained and only the application or base conflict byte, which contains information about a possible system coupler in the installation, is overwritten.

The sensor is activated. If the device 1.1.5 receives the telegram correctly, it sends an ACK telegram. The process is completed and the system coupler does not come into play.

However, if the device 1.1.5 does not receive the telegram or receives it incorrectly, the following occurs:

- ✚ The system coupler registers that the ACK telegram has not been transmitted and repeats the telegram.
- ✚ The device 1.1.5 now receives the telegram and transmits an ACK. The process is thus completed.
- ✚ If 1.1.5 still does not receive the telegram (no ACK from 1.1.5), the system coupler sends a NACK.
- ✚ The sensor receives the NACK and the process is completed.

The following applies:

- ✚ There may only be one group speaker for each group address. The setting is carried out via the ACK flag for one of the group objects that is linked with the group address.
- ✚ The group speaker flag shall be set at the actuator which is furthest away.
- ✚ If a repeater is retrofitted, the following must be carried out:
  - Integrate the repeater in the ETS project:  
The new repeater status is automatically set for all the PL 110 devices in the project.
  - Download repeater status:  
All the devices must be informed about the new repeater status by downloading the application software. Only once the download is concluded are all the devices aware that a system coupler with repeater function has been integrated into the installation.
  - The mains couplers are now aware of the existence of a system coupler in the installation.
  - A transmitting mains coupler will now no longer repeat the telegram, should the reply telegram not be sent.
- ✚ The system coupler must be installed in a central point of the installation (in the distribution board).
- ✚ Only one system coupler per installation is permitted. If a larger KNX/EIB installation is implemented, in which there are several KNX Powerline areas, a system coupler with its own System ID must be installed in each KNX Powerline area.

### 3.5 Bus Access Procedure

As in KNX-TP1, a bus access procedure is also necessary for KNX PL 110 in order to prevent collisions.

Owing to the high level of background noise on the 230/400 V supply system, bus access cannot be related to the voltage level.

The collision problem has been resolved by the use of special time slots i.e. every mains coupler may only transmit during specified periods. However, if several mains couplers try to start transmission simultaneously, the following applies:

The mains couplers detect a collision and determine a new random priority for the transmission of telegrams.

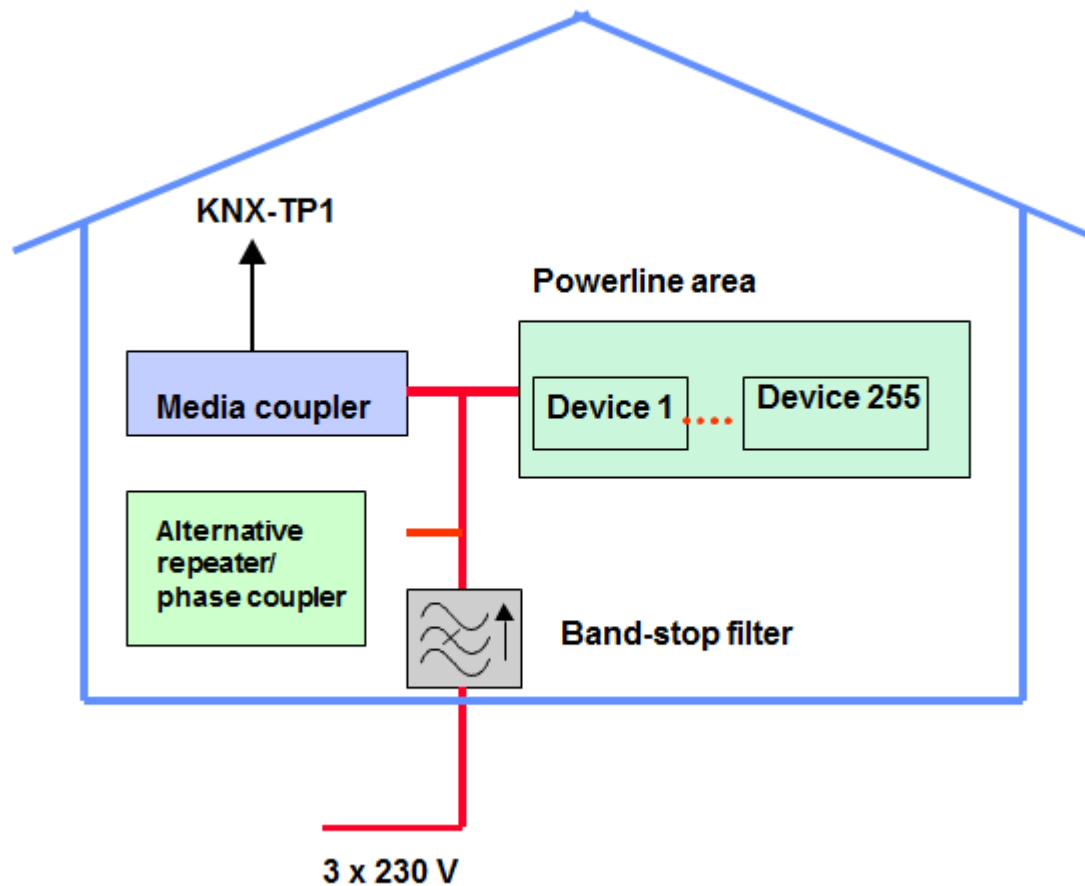


Figure 7: Topology / Addressing

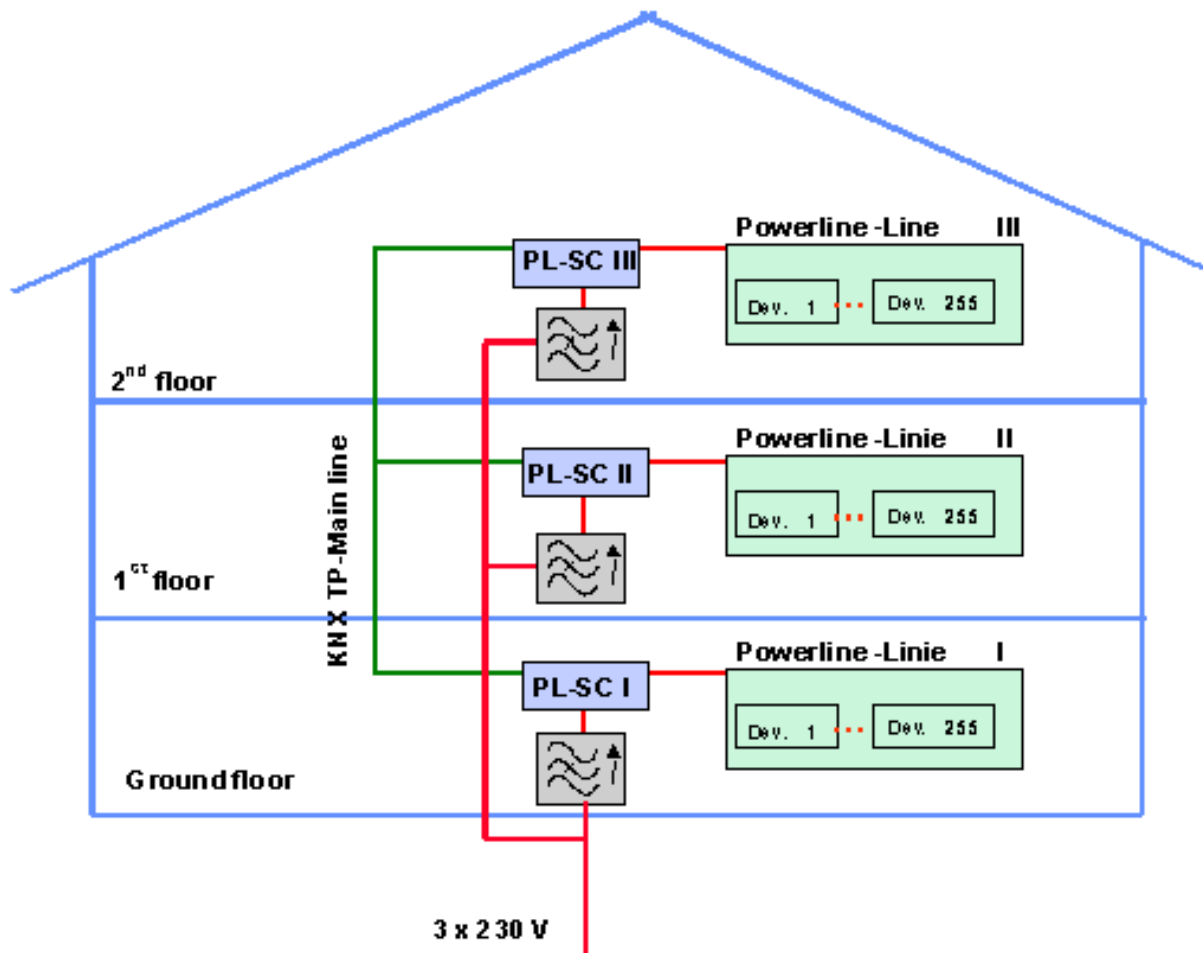
## 4 Topology / Addressing

The logical addressing of KNX-PL 110 is compatible with KNX-TP1. A maximum of 8 areas (compared to 15 for KNX-TP1) can be addressed, each with 16 lines of 256 devices.

Areas containing PL signals must be separated from the general supply system via band-stop filters. The band-stop filters are however no longer required uniformly by all suppliers. If in doubt, you should check the local Technical Connection Requirements.

The system coupler forms the interface to KNX-TP1 in combined installations.

In a detached house it is not strictly necessary to split up the devices into lines and areas via corresponding couplers, provided that the number of PL 110 devices does not exceed 256. All PL 110 devices can exchange data across all 3 external conductors via the 230 V installation network, once a phase coupler or system coupler has been installed.



**Figure 8: Topology / Addressing**

Note: The 24 V supply of the TP main line can be taken from a system coupler.

In larger installations, the bus load is reduced via a logical and physical classification of the KNX-PL 110 installation into a maximum of 8 areas with up to 15 lines (with up to 255 PL 110 devices per area).

The physical separation of the individual areas is achieved using band-stop filters.

Data can be transmitted from one line to another via the known KNX-TP1 main line between the system couplers. The area coupling is likewise established as a KNX-TP1 main line between the system couplers. The active phase coupling on the PL 110 side is carried out by the system coupler. The physical separation and the filter table of the system coupler allow a selective transmission of telegrams into the neighbouring area. The bus load in the entire system is thus considerably reduced.

## 5 KNX PL 110 System Devices<sup>2</sup>

### 5.1 Mains Coupler

There are four types of mains couplers:

- ✚ flush-mounted design for installation in standard flush-mounted wall boxes
- ✚ surface-mounted design for installation in surface-mounted housing
- ✚ DIN rail design for mounting on standard DIN rail
- ✚ adapter

Each mains coupler has its own integrated power supply unit. The power consumption on the d.c. side is:

- ✚ In 'receiving' state: 5 V/30 mA and 24 V/1 mA => 174 mW
- ✚ In 'transmitting' state: 5 V/30 mA and 24 V/10 ... 60 mA  
=> 390 mW ... 1.59 W, depending on mains impedance
- ✚ Leakage loss: 0.5 to 1.5 W.

#### 5.1.1 Mains Coupler and Compact Devices in Flush-mounted Design

Characteristics of this mains coupler:

- ✚ It can be built into a wall box but the box must have screws to secure the mains coupler onto the retaining ring.
- ✚ It has a standard 10-pole physical external interface (PEI) which is fitted according to SELV specifications.
- ✚ The mains connection is carried out by two screw terminals, whereby a conductor cross section of 2.5 mm<sup>2</sup> can be connected.
- ✚ The mains supply terminals are marked 'L' and 'N'.

Characteristics of compact devices:

- ✚ Compact devices are mains couplers with integrated actuators e.g. switch, dimming or shutter actuator.

#### 5.1.2 Surface-mounted Design

Characteristics of this mains coupler:

- ✚ It can be inserted in flush-mounted or surface-mounted housing
- ✚ It has a standard 12-pole PEI which is however **not isolated from the 230/400V supply**. If necessary, the device developer must carry out this separation.
- ✚ The mains connection for the device developer is achieved by a 2-pole connection post on the printed circuit-board. The mains connection for the installer is manufacturer-specific.

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<sup>2</sup> PL devices do not require a PE connection. A corresponding terminal connection is necessary for looping through the PE conductor (as in a conventional switch).

### 5.1.3 DIN Rail Mounted Design

Characteristics of this mains coupler:

- ✚ It can be mounted on standard DIN rails.
- ✚ It has a width of 1.5 modules.
- ✚ It has a standard 12-pole PEI which is fitted according to SELV specifications.
- ✚ The mains connection is achieved by four screw terminals (two terminals each for L and N), whereby a conductor cross section of 2.5 mm<sup>2</sup> can be connected.
- ✚ The mains supply terminals are marked 'L' and 'N'.

### 5.1.4 Adapter

Characteristics of this mains coupler:

- ✚ It is inserted in the Schuko socket.
- ✚ It is available as a switch and universal dimming actuator.

## 5.2 Phase Coupler

- ✚ Design: DIN rail, 1 module wide
- ✚ Three-phase connector without neutral conductor
- ✚ Passive capacitive coupling
- ✚ Used in small installations without a system coupler
- ✚ Fused with a circuit-breaker

## 5.3 System Coupler

- ✚ Design: DIN rail mounted, 4 modules wide
- ✚ Three-phase connector + neutral conductor
- ✚ Ensures active phase coupling and telegram repetition
- ✚ Only one system coupler permitted per installation
- ✚ All mains couplers must be informed about the integration of a system coupler into an installation
- ✚ It can also be used as a media or backbone coupler

### Media Coupler:

- Used for coupling KNX-TP1 and KNX-PL110 installations
- Full repeater functionality on PL110 side
- Used in the project in the same way as a line coupler
- KNX-TP1 side is primary, PL 110 side is secondary
- Dynamically organised buffer for up to 256 telegrams
- The following parameters are available:
  - Telegram routing similar to the line coupler. The parameters for blocking, routing and filtering can be set for both directions.
  - Telegram acknowledgement for routed telegrams on KNX-TP1 side.
- Repetitions in the event of transmission errors on KNX-TP1 side

**Backbone Coupler:**

- Used for coupling PL areas and for configuring a structured topology in larger installations
- Full repeater functionality in PL area to which it is assigned
- Data cable of backbone coupler must be supplied internally with 24 V
- The same parameters are available as for the media coupler
- Repetitions in the event of transmission errors on the data cable of the backbone coupler.

## 5.4 Band-stop Filter

- ✚ Design: DIN rail mounted, 2.5 modules wide, single-phase connection + neutral conductor
- ✚ Max. load: 63 A with an operating temperature up to 25 °C
- ✚ Connection of the external conductor: via screw terminals up to 25 mm<sup>2</sup>
- ✚ Connection of the neutral conductor: via screw terminal up to 2.5 mm<sup>2</sup>
- ✚ In installations with a nominal current between 63 A and 125 A and a conductor cross section exceeding 25 mm<sup>2</sup>, it is permitted to install two band-stop filters per phase in parallel using main branching terminals.
- ✚ Each band-stop filter must be secured according to its nominal load.
- ✚ As the effectiveness of the band-stop filter is dependent on direction, the current flow direction must be observed in the direction of the printed arrows during installation (connection below: supply cable, connection above: KNX PL 110 installation).
- ✚ The supply cable to the band-stop filter and the cable leading from it should be placed as far apart as possible (recommended minimum interval: 10 cm) in order to prevent unwanted signal interference.
- ✚ Attenuation: 40 dB
  - Used to weaken signals:
    - to separate various installations in a building for example
    - to filter out interference
- ✚ It must always be installed to meet existing regulations or any regulations in development (e.g. technical connection conditions of the electricity board).
- ✚ A band-stop filter must be installed per external conductor.
- ✚ Installation site: normally in the distribution board directly behind the main fuse or the fault current switch.
- ✚ A band-stop filter can be omitted if the installation has its own transformer area.

## 5.5 Mains Cables

- ✚ All standard 230/400 V cables can be used. However, shielded cables where the shield has been earthed should not be used due to signal attenuation.

## 6 Information for Planners, Project Designers and Installers

- ✚ The integration of PL 110 installations can be carried out without any limitations in the residential sector.
- ✚ PL 110 installations should however be 'enclosed' signal areas e.g.:
  - installations behind the electricity meter e.g. in detached houses or multiple dwellings
  - separate supply systems in larger buildings e.g. lighting or shutter control installations in administration buildings
- ✚ KNX PL 110 does not function or cannot be used:
  - Across a transformer substation
  - In networks with deviating parameters (e.g. 110 V/60 Hz)
  - In networks in which other carrier-frequent systems have already been installed for supply data transmission in the frequency band 95 kHz – 125 kHz.
  - In networks with insufficient noise suppression (according to regulations). Problems are caused by mains parallel capacitors, inverters, UPS installations and insufficiently suppressed industrial machines (cranes, welding machines, eroding machines etc.). In these cases, separate cables or band-stop filters are used to isolate the devices causing interference.
  - For signal transmission between houses and buildings due to regulations.
  - For safety-related applications e.g. installations for monitoring sustaining and life-saving functions as well as for functions whose failure can lead to extensive damage.
- ✚ A prerequisite for the operation of PL 110 is the effective interference suppression of all the electrical loads used in the installation. This can nowadays be assumed due to the legal regulations and norms for these devices. When a variety of electromotive and frequency-controlled loads are used, this factor should be checked (CE mark of the devices).
- ✚ Practical experience shows that the interference caused by electronic ballasts and electronic transformers is largely dependent on whether these devices are installed correctly. The appropriate requirements should be obtained from the operating instructions of the manufacturers.
- ✚ Installation functions and customer requirements should be established as for KNX-TP1.
- ✚ The system coupler should be installed in the central point of the installation to achieve the highest possible ranges.
- ✚ Transmission speed: 1200 bit/s => approx. 6 telegrams per second can be transmitted.

- ✚ Bus devices should not be commissioned in such a way that they transmit cyclical telegrams in short intervals (shorter than a minute).
- ✚ Do not use any unshielded 230/400 V cables (with shield potential to ground).
- ✚ Cable routing: as required (but in the case of band-stop filters, incoming and outgoing cables should not be laid in parallel).
- ✚ If there are several installations in one building, avoid running cables in parallel in order to avoid cross-talk between installations.
- ✚ Circuit-breakers and protective switches with a nominal current smaller than 10 A shown a high level of signal attenuation. These devices should therefore not be installed between two transmitting devices. If necessary, cut-out fuses should be used in this case.
- ✚ Always use one band-stop filter per external conductor (exception: own transformer area), even when the transmission is limited to one phase. Pay attention to the heat dependency of the load capacity of the band-stop filter. If necessary, divide electrical circuits across several band-stop filters.
- ✚ Overvoltage protection: The regulations for 230/400 V installations apply.
- ✚ A PL 110 installation is commissioned in the same way as for KNX-TP1.
- ✚ If a system coupler is retrofitted in an installation as a repeater (or removed), it also has to be reconfigured (removed) in ETS. All bus devices then need to be reprogrammed accordingly so that they know that the installation has a new repeater status.
- ✚ A bus reset in a PL 110 installation can only be achieved by triggering the appropriate circuit-breaker.
- ✚ When using KNX-PL 110 in installations with devices known for causing interference (e.g. inverters, UPS installations), the separation of the load and signal circuit can already be taken into account at the planning stage.