KNX System overview



KNX Association

Artman Training Center – Iran

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Definition ۱

The following terms are used as synonyms in KNX literature:

Terms used in the KNX training documentation and in ETS	Alternative term
Individual address	Physical address
Group object	Communication object

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Minimal structure of a KNX TP installation ۲

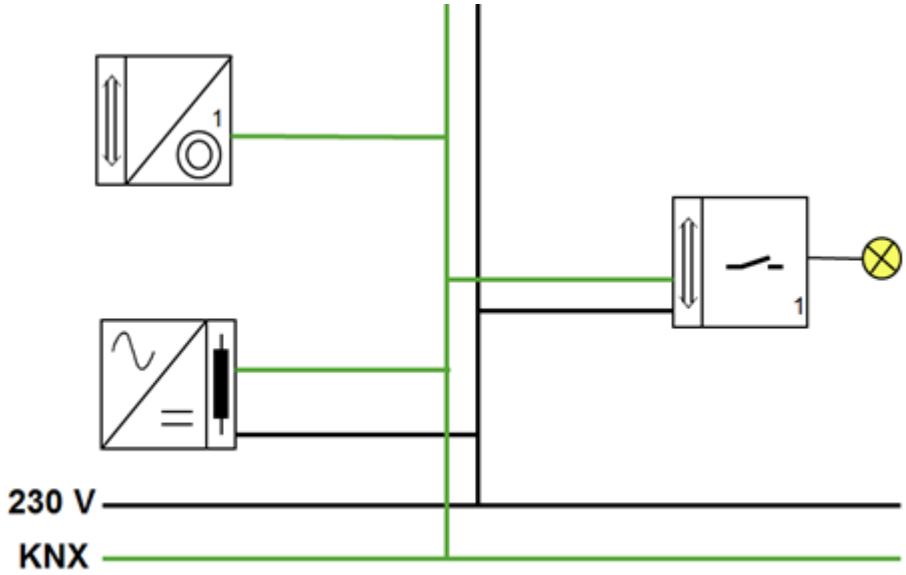


Figure 1: Minimal structure of a KNX TP installation

	A minimum TP KNX installation consists of the following components:
KNX Power supply unit (30 V DC)	
Choke	▪ Is mostly integrated in the power supply unit.
Sensor(s)	▪ A single push button with one rocker or two buttons is represented in the figure above ▪ Sensors usually get their power from the KNX power supply unit.
Actuator(s)	▪ A single switch actuator is represented in the figure above
Bus cable	▪ only two wires of the bus cable are required for transmission of telegrams (data exchange) and in most cases for supplying the bus device with power ▪ In the figure above it is represented as a green line ▪ Connects sensors, actuators and KNX power supply unit. ▪ Can serve for providing ancillary power to bus devices

Addressing ۳

In KNX there are two types of addressing, i.e. the individual addressing and the group addressing.

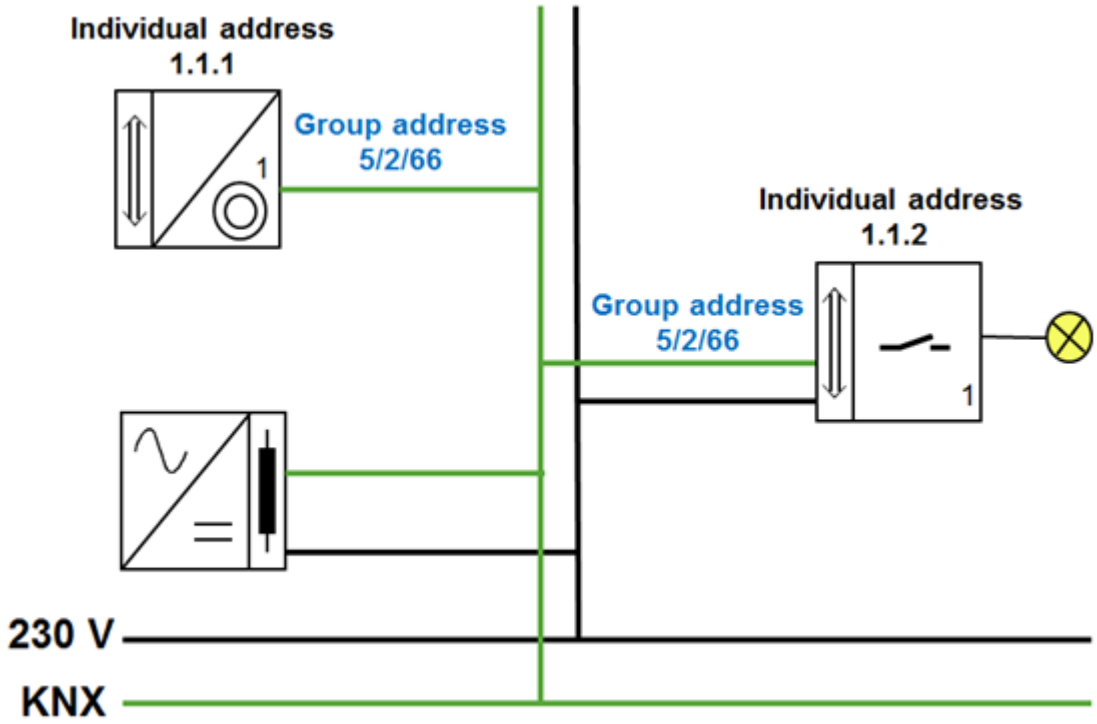


Figure 2: Addressing

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Individual address[1] ۳٫۱

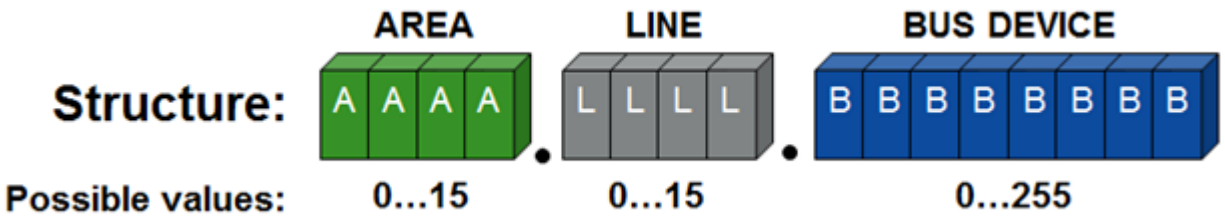


Figure 3: Structure of the individual address

An individual address shall be unique within a KNX installation. Its primary goal is to forward "programming telegrams", new application - / and parameter data via the ETS to the bus device.

The individual address in a telegram has a fixed structure of 16 bits and has the format as shown in the figure above.

In the user interface of ETS and in KNX documentation, individual addresses are represented in decimal format with two separating points.

The bus device is usually prepared for the acceptance of its individual address by pressing a programming button on the bus device. The programming LED is lit during this process.

The individual address is permanently assigned to the bus device by means of ETS. ETS is now able to forward all required data (application, configuration, parameters, group address assignments) via the bus to the device.

If the commissioning including all customization and diagnostic steps have been carried out, the communication (e.g. light on/off) is exclusively done via group addresses.

[1] Synonym for "physical address"

Group address ۳٫۲

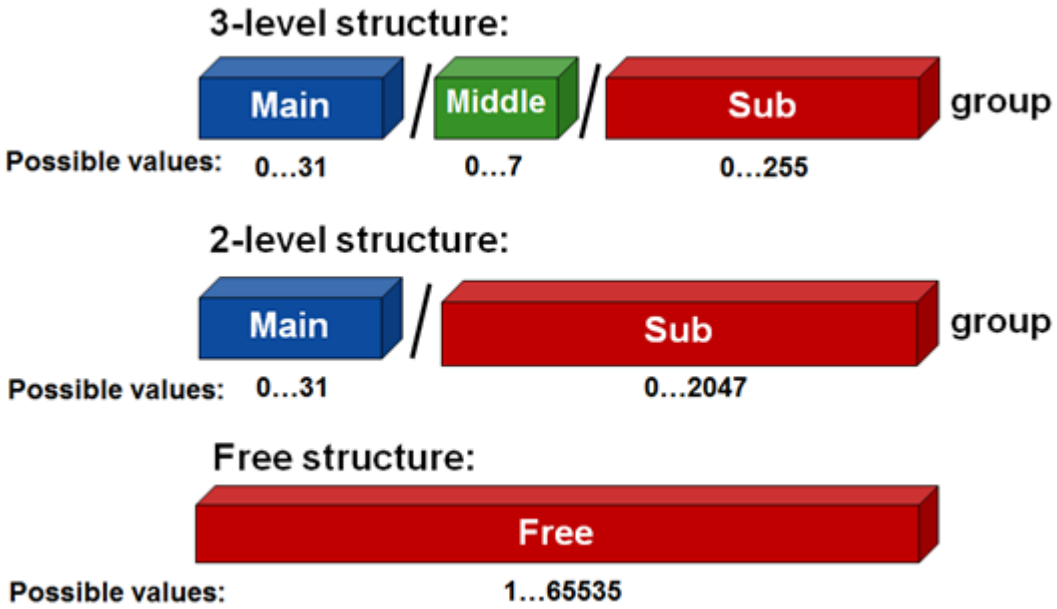


Figure 4: Structure of group addresses

The normal communication between devices in an installation is carried out via group addresses. The project engineer defines for each function in the installation an appropriate group address. He can freely select the group address structure.

65535 group addresses are available[2] in ETS. How many group addresses one can assign to a KNX device, may depend on the KNX system profile, the application program and/or the amount of parameters.

Important: a group address cannot be zero. For an ETS project with 3-level representation this means that '0/0/0' is not allowed and for 2-level that '0/0' is not allowed.

The group address 0/0/0 is reserved (Broadcast). This address is required for assigning and establishing the individual addresses.

[2] Only valid from ETS4 onwards. Until ETS3 the most significant bit was set to 0. Main groups were therefore limited from 0….15. 32767 group addresses were available in total.

For each ETS project it is possible to select the representation of group addresses in a:

3-level structure (main group / middle group / subgroup) ✓

2-level structure (main group / subgroup) ✓

Freely defined structure ✓

The levels only serve for a clearer overview of the functions / group addresses created in ETS.

The default level is the 3-level structure. The level structure can be set for each project in the project properties of ETS.

Example of a 3-level structure:

Room 424, switch light 1	5/2/66
Room 424, switch light 2	5/2/67
Room 424, switch all lights together	5/2/68
Switch lighting building 4	14/2/69
Etc.	

The free-level group address structure offers the most flexible structuring option (see chapter Project planning – Basic).

The meaning of each individual level can be freely defined by the ETS project engineer.

A common structure is however the following:

Main group	Floor number
Middle group	Functional domain (e.g. 1 = lighting, 2 = heating, 3 = Shading, …)
Subgroup	Function of load or group of loads (e.g. Light 1 R424 on/off, Window bedroom open/close, Ceiling living room on/off, Ceiling living room dimming, Blinds room 424 up/down,…)

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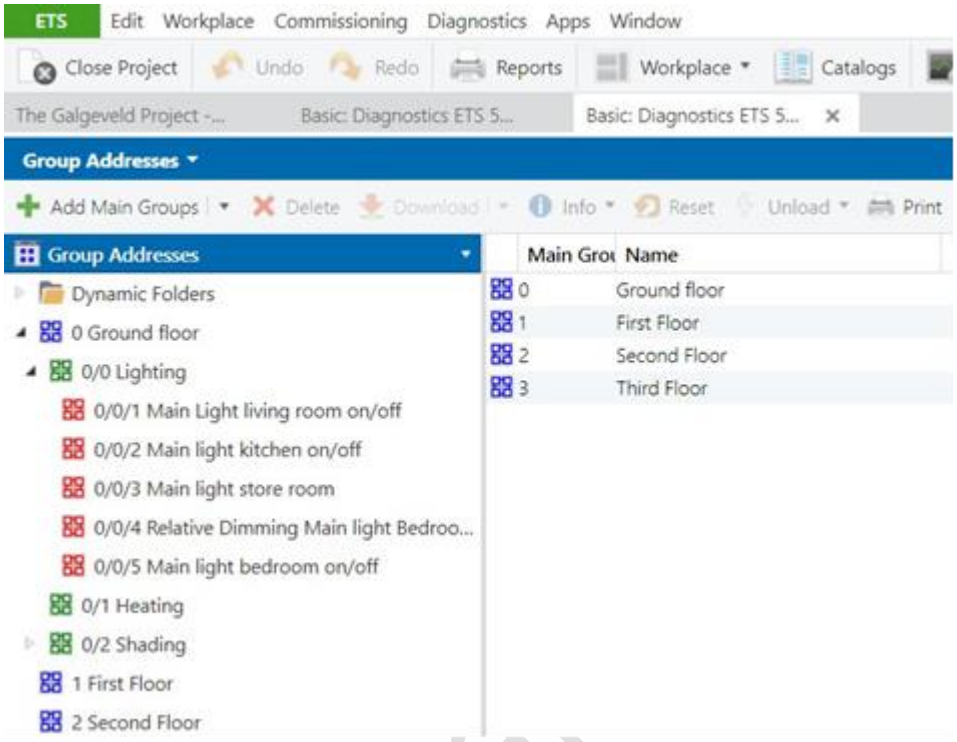


Figure 5: Example: structure of group addresses in ETS

It is recommended to define a company default group address structure and to stick to this structure in all projects in order to facilitate the insight into different projects.

Each group address can be assigned to bus devices at one's discretion, regardless where the device is installed.

The group addresses are assigned to the group objects of the respective bus devices, either with the help of ETS (S-mode) or automatically and invisible in E-mode.

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Summary:

The individual address is important for the commissioning and diagnostic in an installation via ETS (in order to address individual devices).

Group addressing dominates however during “normal operation” of a KNX installation: in that case, the individual address is of a lesser importance.

Address type	Application	See example letter post
Individual address	Destination address in ETS „programming telegrams“ in order to forward to one single bus device new application – / and parameter data.	To John Smith Samplestreet 12 US-12345 Tinseltown
Group address	Destination address in „normal“ operation telegrams like e.g. “Lighting room 424 on/off”	Bulk mail To all households with a photovoltaic installation

Important note[3]:
Actuators can listen / react to several group addresses.
Sensors can however send only one group address per telegram

Note:

Recommendation: Use group addresses with main group 16 or higher only in projects containing the latest devices. ✓

When using main groups 14 to 31 (in two-level + three-level group address structure) in ETS, one should take into account that these group addresses cannot be filtered by TP line -/ backbone couplers from the older generation (before 2003). This could negatively influence the dynamics of the entire bus system. Consequently, for these older generation couplers, these main groups can only be routed or blocked collectively and are primarily to be used for central functions. ✓

The number of group addresses that can be assigned to sensors and actuators is variable and is limited by the memory size of the bus device. ETS will prevent that the available memory space for that specific device is exceeded and will give an appropriate warning to the ETS user. ✓

[3] These rules of thumb have been somewhat simplified. More precisely, one should state: group objects can react to several group addresses, however - after an event (e.g. pressing a rocker) - only the first group address assigned to a sensor object will be used during sending.

Configuration steps ۳/۴

After mounting the devices, a KNX installation (especially for S-mode compatible products) is not ready for operation until sensors and actuators have been downloaded with the application program via the ETS program. The project engineer first needs to carry out the following configuration steps using ETS:

assigning individual addresses to the different devices (for the unique identification of a sensor or actuator in a KNX installation); ✓

selecting the appropriate **application program** for the bus devices; ✓

Setting the parameters for the bus devices; ✓

Assigning group addresses in order to logically connect sensors and actuators and by doing so realize the desired functions. ✓

In the case of E-mode compatible products, the same steps as above are applied, whereby the settings for:

the individual addresses, but also ✓

the parameters of the bus devices and ✓

the group addresses (for linking the functions of sensors and actuators) ✓

is done either via local settings on the products or automatically or semi-automatically by a central controller module.

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Function after commissioning stage ۳٫۴

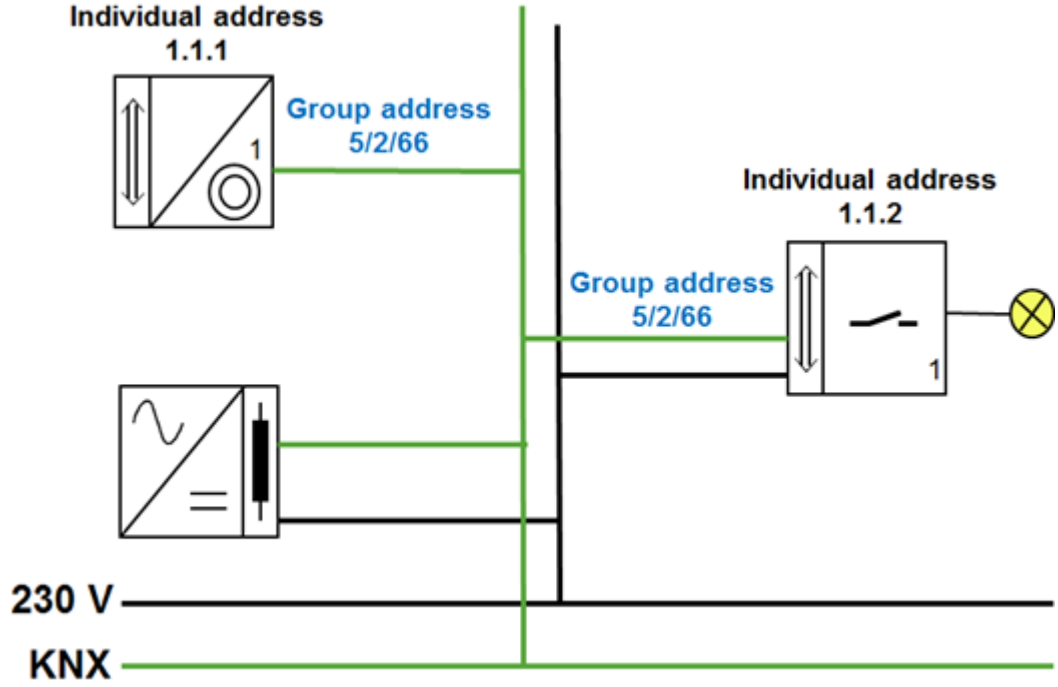


Figure 6: Function after commissioning stage

After configuration, the installation functions as follows:

If the upper rocker of the single push button (1.1.1) is pressed, it sends a telegram containing the group address (5/2/66) and the value (“1” = switch on) ✓

This telegram is **received** and **evaluated** by all connected bus devices. ✓

All devices that have the same group address in their address table will: ✓

- synchronously send an acknowledgement telegram (reception correct / reception incorrect);
- read the value and behave accordingly.

In our example, the switch actuator (1.1.2) will close its output relay because group address 5/2/66 was also assigned to it.

When the lower rocker is pressed, the same happens except that this time the value is set to “0” and the output relay of the actuator is opened.

Group object ۴

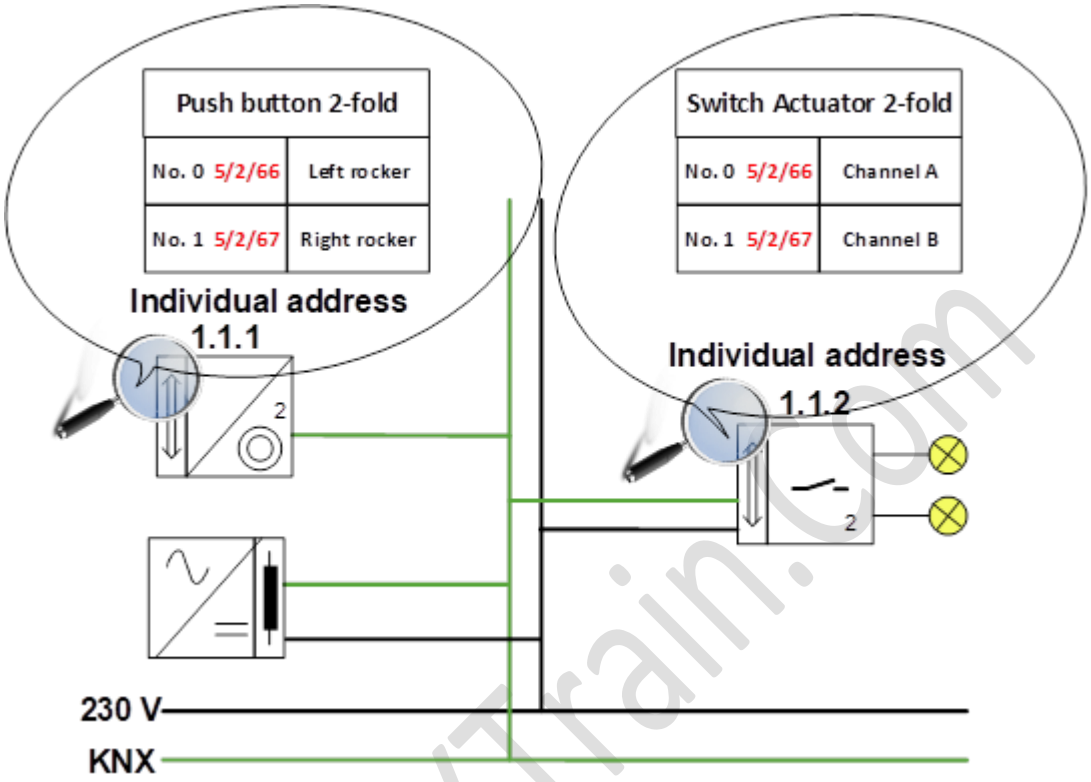


Figure 7: More detailed description of bus devices with group objects

In the previous introduction example, a group address was assigned directly to a bus device (single Push button – single channel Actuator).

In reality, one needs to think one level deeper, as there can be several channels that can communicate in a device. Obviously this is the case when a push button has more than one rocker or when an actuator has more than one switching output.

The individual rockers of a push button or the several switching outputs of an actuator are represented by so-called “group objects”.

KNX group objects represent memory locations in a bus device. The size of these objects can vary between 1 bit and 14 bytes. The size of the group objects is defined by the manufacturer and depends on the related function.

As only two states (0 and 1) are required for switching, 1 bit group objects are used in this example. The data for text transmission is more bulky and therefore group objects with a maximum size of 14 bytes are used. By means of group addresses, ETS only allows linking group objects that have the same size.

Figure 7 shows the relation using a push button 2-fold and a switch actuator 2-fold as an example.

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A group communication in detail:

If e.g. the upper left rocker of a 2-fold push button is pressed, it will write a “1” to its group object (a with the number 0. Consequently, the firmware in the device ensures that a telegram is sent on the bus with the information “Group address 5/2/66, write value, Value = “1”.

All bus devices mounted in the KNX installation, to which the group address 5/2/66 have been (b assigned (and thus listen to 5/2/66) will then take over the “1” in their own group object. In our example, the actuator will take over the value “1” in its group object with number 0.

The application software of the actuator establishes that the value in this group object has changed (c and executes the switching process.

Useful data of a TP telegram ۵

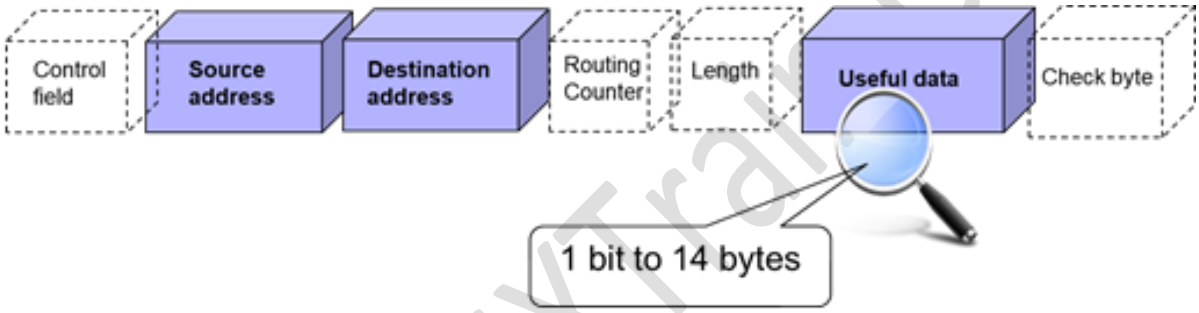


Figure 8: Useful data of a TP telegram

The length of the data depends on the data point type used and can vary between 1 bit and 14 bytes.

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Standardized datapoint types ۶

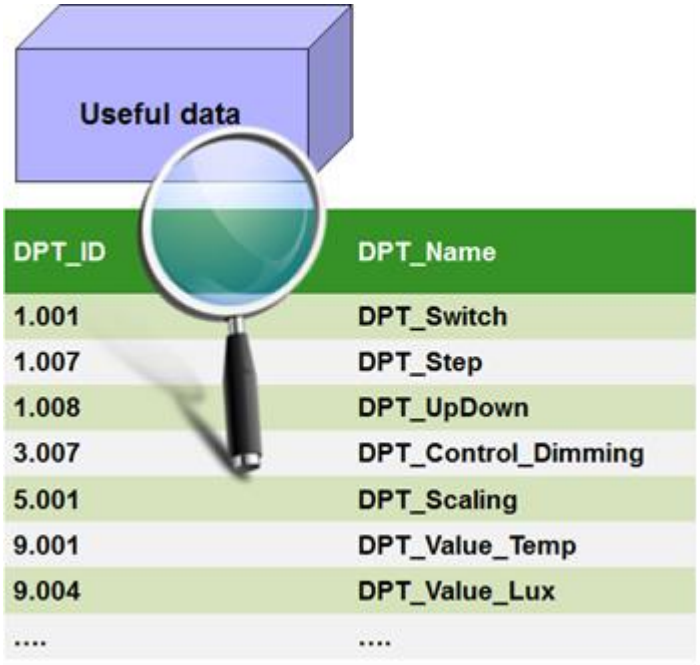


Figure 9: Standardized datapoint types (selection)

Several datapoint types were standardized to guarantee compatibility of similar devices from different manufacturers (e.g. dimmer, clock…).

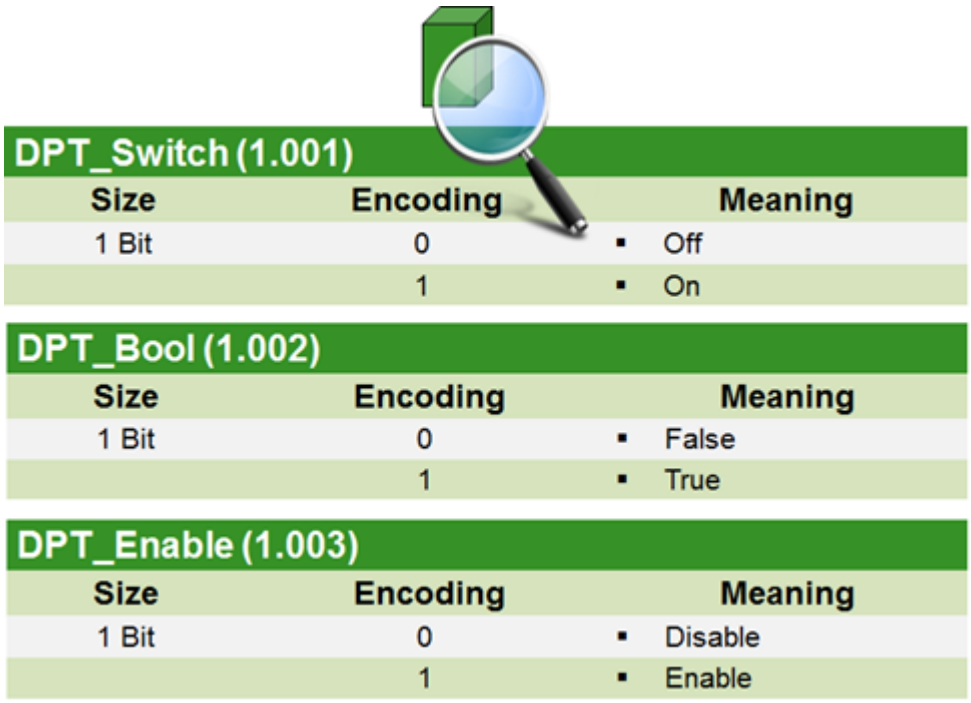
Both the data format as well as structure of the group objects both for sensor and actuator functions is part of the data point standardization.

The combination of several standardized datapoint types is called a functional block.

The name of a group object can be freely decided by the manufacturer. For instance, a DPT_Step is sometimes, depending on the manufacturer, referred to as short operation or as blind operation. This does however not imply that the use of the DPT is limited to this area of application. For example, “Scaling” (Type 5.001) can be used both for setting a dimming brightness or for setting a heating valve position.

In the following pages examples of a number of data point types are presented. The full list of all approved datapoint types can be downloaded from the KNX Association’s web site (https://www.knx.org/wAssets/docs/downloads/Certification/Interworking-Datapoint-types/03_07_02-Datapoint-Types-v02.01.02-AS.pdf).

On/Off (1.001) ۶٫۱



DPT_Switch (1.001)		
Size	**Encoding**	**Meaning**
1 Bit	0	▪ Off
	1	▪ On

DPT_Bool (1.002)		
Size	**Encoding**	**Meaning**
1 Bit	0	▪ False
	1	▪ True

DPT_Enable (1.003)		
Size	**Encoding**	**Meaning**
1 Bit	0	▪ Disable
	1	▪ Enable

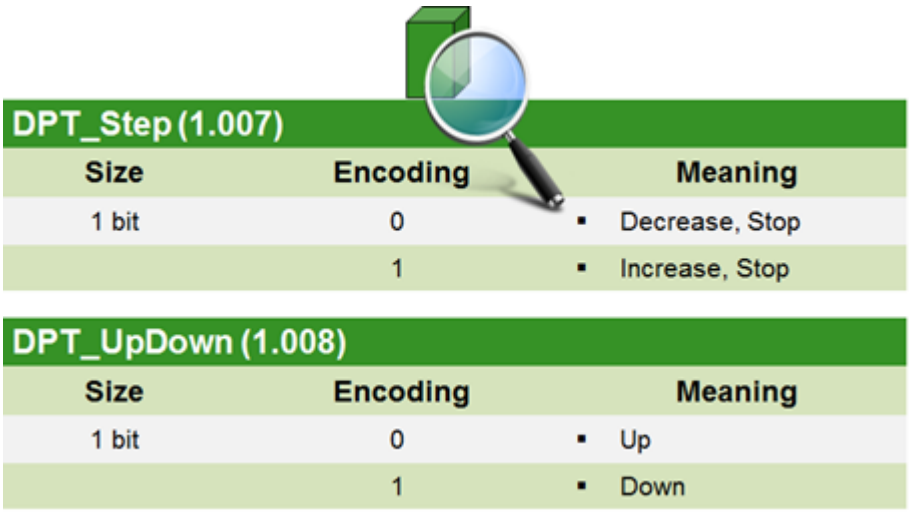
Figure 10: DPT On/Off (1.001),...

DPT_Switch (on/off) is used for switching an actuator function. Other one bit datapoint types are defined for logical operations (Boolean 1.002), for Enable/Disable (1.003), etc....

Other functions or extensions to the pure switching function (inversion, time delay and toggle switch functions etc.) are not part of the datapoint type, but are parameters of the functional block specification, in which this DPT is used (e.g. functional block light switch).

A switching function can additionally have a status or feedback object to report the switching state (on or off) of an actuator. For this, you need to create a group address that links the status object of the rocker with the feedback object of the actuator relay. Both the status object and the feedback object have a data length of 1 bit.

Functional block „Shutter and blinds actuator - basic“ ۶٫۲



DPT_Step (1.007)		
Size	**Encoding**	**Meaning**
1 bit	0	▪ Decrease, Stop
	1	▪ Increase, Stop

DPT_UpDown (1.008)		
Size	**Encoding**	**Meaning**
1 bit	0	▪ Up
	1	▪ Down

Figure 11: Functional block "shutter and blinds actuator - basic"

The functional block “Shutter and blinds actuator –basic” is especially used for controlling shutter and blind drive mechanisms and consists of two group objects with the underneath mentioned datapoint types:

Up/Down (DPT 1.008) (long operation of rocker) ✓

Step/Stop (DPT 1.007) (short operation of rocker). ✓

By writing on the object with “Up/Down”, a shutter or blind is set in motion from an idle state or changes direction while moving.

By writing on the object “Step/Stop”, a shutter or blind already in motion is brought to a stop or if the blind is not in motion, the slats position of the blind will be adjusted for short periods (step-by-step).

Important: Group objects using this function should never reply to read requests via the bus as they may unintentionally stop moving blinds or shutters or set halted blinds or shutters in motion. The “Read” flag should therefore be deleted in the relevant group objects – both in sensors as well as actuators. This especially applies for central functions. Also, a sensor generally does not know the exact position of a shutter or a blind.

Note: Although DPT_Switch (on/off) and DPT_Step or DPT_UpDown (or any 1 bit DPT) use the same 1 bit information (and could in fact be linked in ETS), they should only be linked if the linking is meaningful, e.g. with the function: Lighting off, move up sun shading (DPT_Switch and DPT_UPDown).

Functional block „Dimming“ ۶٫۳

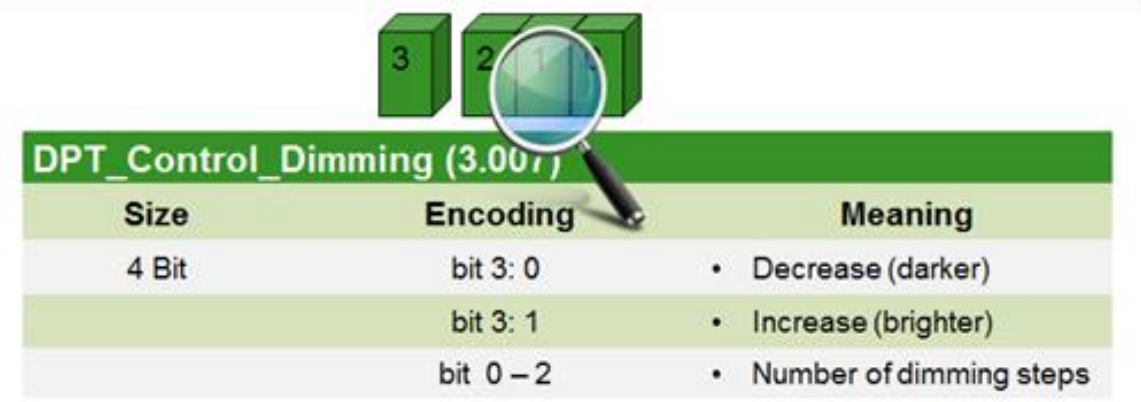


Figure 12: Functional block Dimming

Apart from the 4-bit object (Relative dimming - DPT_Control_Dimming [3.007]), the functional block dimming consists of at least a switching object (corresponds to DPT_Switch [1.001]) and a value object (corresponds to DPT_Scaling – [5.001]).
A dimming sensor supports at least the group objects DPT_Switch [1.001] and DPT_Control_Dimming [3.007] whereas a typical dimming actuator **additionally** supports the DPT_Scaling [5.001] group object.

Switching - On/Off (1.001) ۶٫۳٫۱

Explained in § ۶٫۱.

Relative dimming (3.007) ۶٫۳٫۲

A dimming command, relative to the current brightness setting, is transmitted to the dimming actuator using the relative dimming object DPT_Control_Dimming.

Bit 3 of the useful data determines whether the addressed device dims down or up compared to the current brightness value.

Bits 0 to 2 determine the dimming step. The smallest possible dimming step is $1/64^{th}$ of 100 % (1 % in the ETS group monitor).

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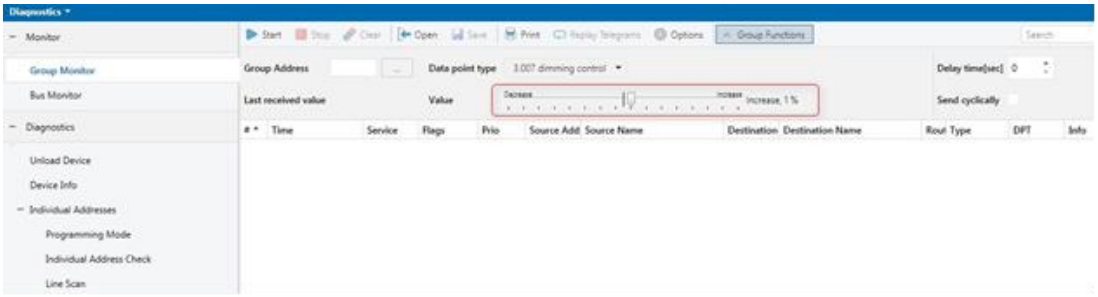


Figure 13: Dimming steps in ETS

Absolute dimming – Scaling (5.001) ۶٫۳٫۳



Figure 14: Scaling - Absolute dimming

With “Absolute dimming” (DPT_Scaling [5.001]), a brightness value between 0,4 % (minimum) and 100 % (maximum) is set directly.

Depending on the manufacturer‘s application, it may be possible to switch on (0,4 % <= value <= 100 %) or off (value = 0) a connected device using this DPT.

This group object has a size of 1 byte.

2-octet float value (9.0xx) ۶٫۴



Figure 15: 2-octet float value (9.0xx)

With this data format positive or negative float values with a maximum resolution of 0,01 can be transmitted. This data format is used in many datapoint type definitions e.g. for transmitting room temperatures in DPT „Temperature (°C) [9.001]" or wind speed in the DPT „Speed (m/s) [9.005]".

Group objects with this data format have a size of 2 bytes.

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TP bit structure ۷

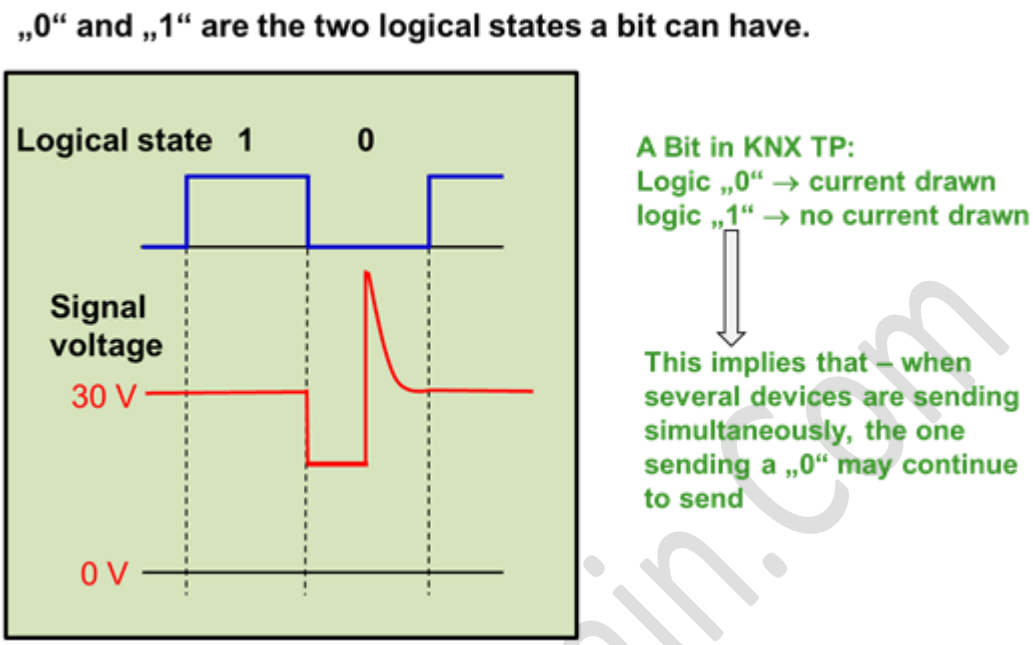


Figure 16: TP bit structure

A “bit” can have two logical states, i.e. “0” and “1”.

Technical logic in KNX TP:

During logical state “1”→ no signal voltage. There is no current flowing. ✓

During logical state “0” → signal voltage. Current is flowing. ✓

This means that if several bus devices transmit simultaneously, the logical state “0” will prevail!

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Bus access – Telegram collision

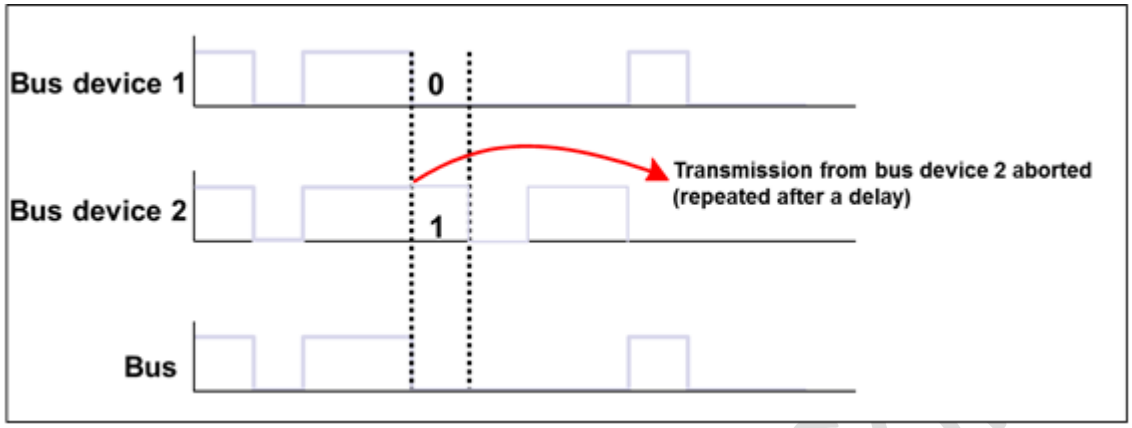


Figure 17: Telegram collision

In KNX TP, bus access is not controlled centrally according to the master/slave principle.

A bus device with data to transmit can start transmission immediately if it detects that the bus is unoccupied. This access happens randomly with no fixed time slots.

The simultaneous sending request of several bus devices is controlled by the **CSMA/CA** procedure (**C**arrier **S**ense **M**ultiple **A**ccess with **C**ollision **A**voidance).

The bus devices listen to the bus while transmitting, if they are not sending themselves a logical 0. This means: As soon as a bus device with the logical state “1” detects the logical state “0” (= flow of current on the line), it stops transmitting to give way to the other sending device.

The bus device that terminated its transmission continues however to listen until the end of the telegram transmission, evaluates it and tries once again to send its own telegram.

In this way, if several bus devices attempt to transmit simultaneously, the **CSMA/CA** procedure ensures that only one of these bus devices can terminate its transmission without interruption (if simultaneously sent, the telegrams will be sent in parallel until a collision is detected). The data throughput is therefore not reduced.

Note: if a bus device cannot send its telegram due to another telegram with a higher priority, it will wait until the telegram with the higher priority has finished and then it will make another attempt to send its telegram.

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Symmetrical signal transmission ۹

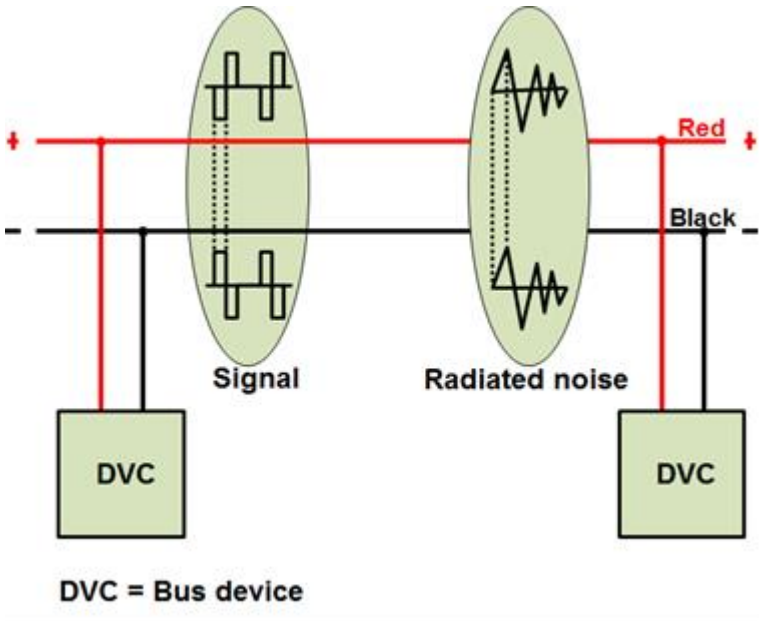


Figure 18: Symmetrical signal transmission

The data is transmitted symmetrically over the pair of wires. None of these wires are connected to the ground or PE, nor are they connected to a fixed potential.

The bus device only evaluates the difference of the AC voltage between both wires.

Radiated noise affects both wires with the same polarity and hence have no influence on the difference in the signal voltage.

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Superimposing data and supply voltage ١٠

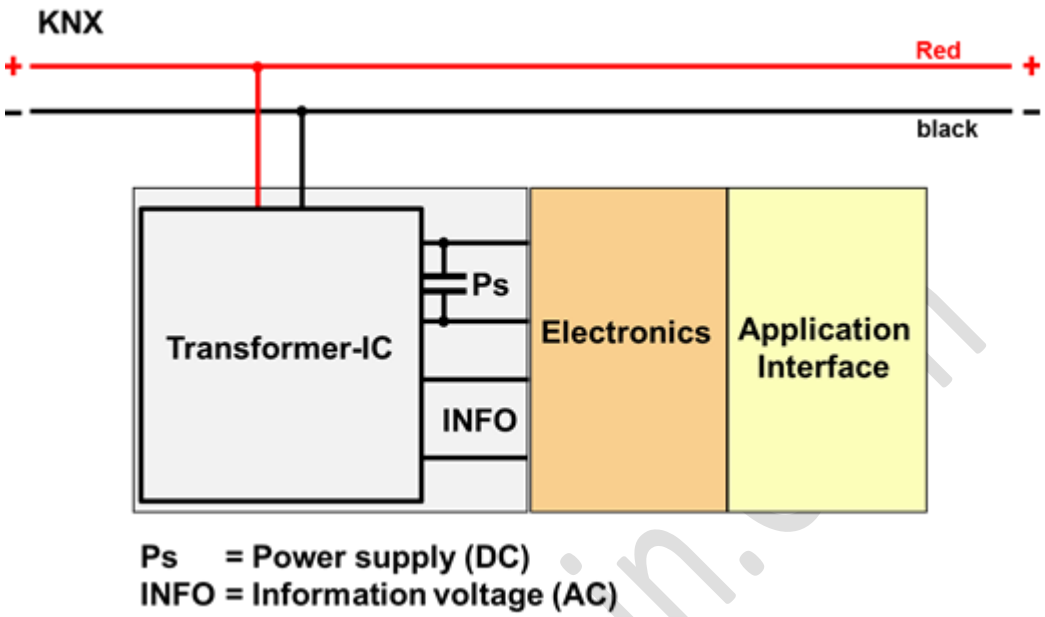


Figure 19: The transformer-IC in the bus device separates DC supply voltage and AC information voltage

Data is transmitted in the form of AC voltage. It is superimposed onto the DC supply voltage. Both voltage parts are separated by the transformer-IC.

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Connection of the power supply unit to the TP bus ١١

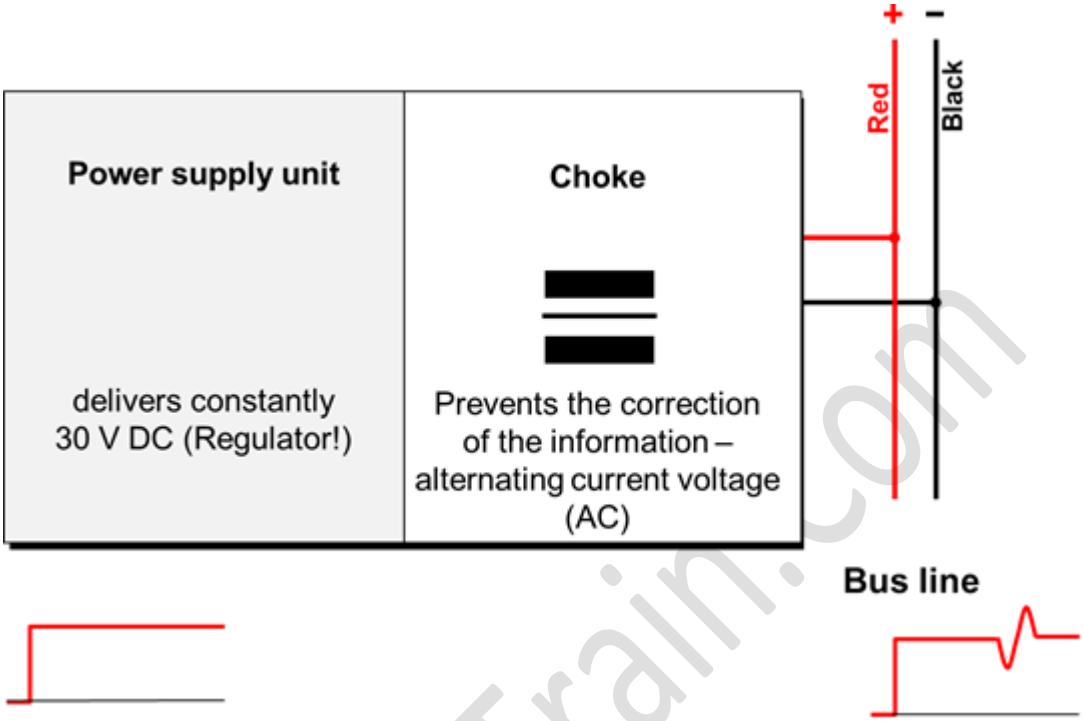


Figure 20: Connection of power supply to TP bus

The power supply feeds the bus via the choke. A voltage regulator is included in the power supply, which tries to immediately correct deviations in the 30 V nominal voltage. If the installation were connected directly to the power supply, the voltage regulator would try to also correct the AC information voltage. This would result in a “tug of war” between the sending bus device and the regulator included in the power supply.

The choke with its inductance brings some “inertia” into the system.

It allows short-time deviations to the 30 V voltage and at the same time allows the regulation of the DC supply voltage.

The second task of the choke is the generation of the second (positive) half of the AC voltage pulse. Only the first (negative) half is generated by the sending bus device. The cooperation between bus device and choke results in an AC signal voltage without a DC part. This is important for the correct signal evaluation in receivers.

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Cable lengths ۱۲

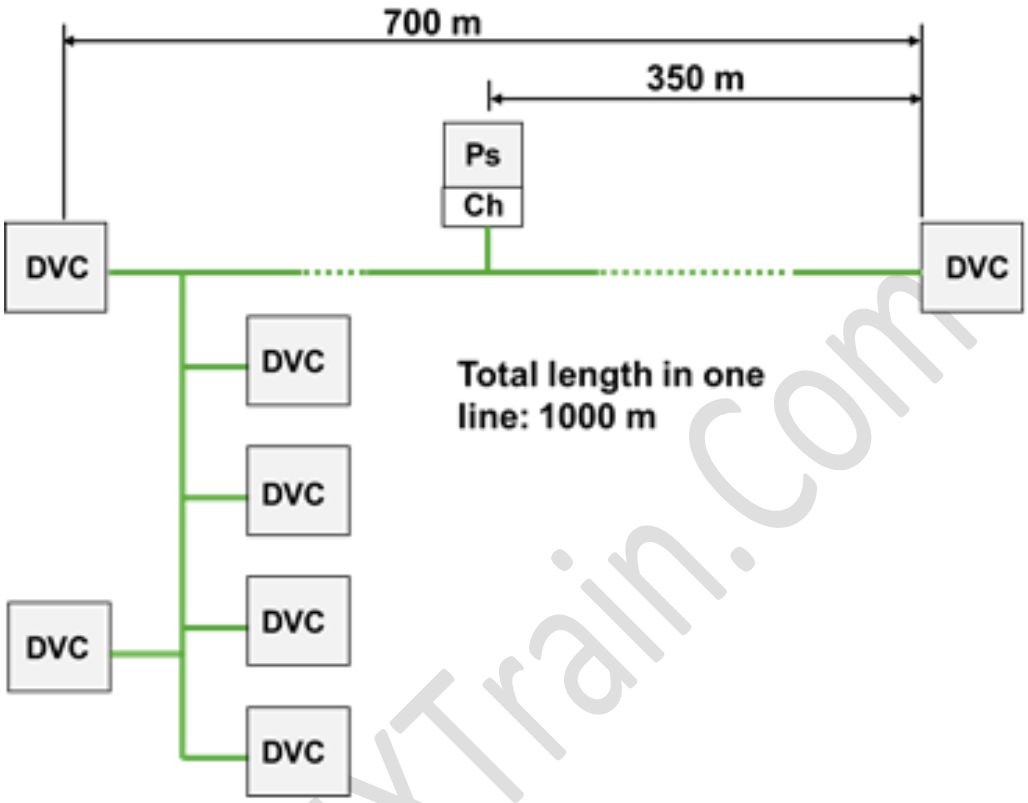


Figure 21: cable lengths

max. **350 m**..... Power Supply Unit - Bus device

max. **700 m**..... Bus device - Bus device

max. **1000 m** .....Total bus line length

Distance between 2 power supply units in one line……**See manufacturer instruction**

Irreproducible data transmission problems can occur if the maximum total bus length in a TP line segment is exceeded.

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Cable length between TP power supply unit – TP bus device ۱۲/۱

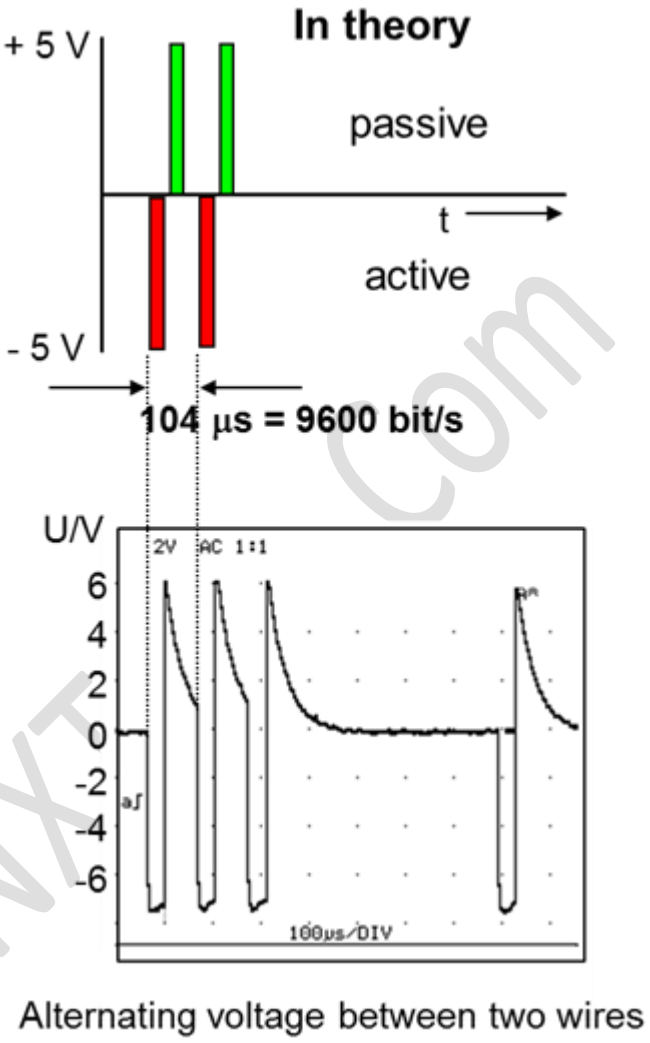


Figure 22: Cable length between TP power supply unit - TP bus device

A bus device only transmits a half wave (shown in the picture as the negative half wave at the positive wire).

The choke as part of the power supply unit produces - together with the transformers of the bus devices - the positive equalization pulse.

As the choke plays a significant role in the forming of the equalization pulse, the bus devices may only be installed up to 350 m cable length away from the choke (power supply unit).

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Cable lengths between two TP bus devices ۱۲٫۲

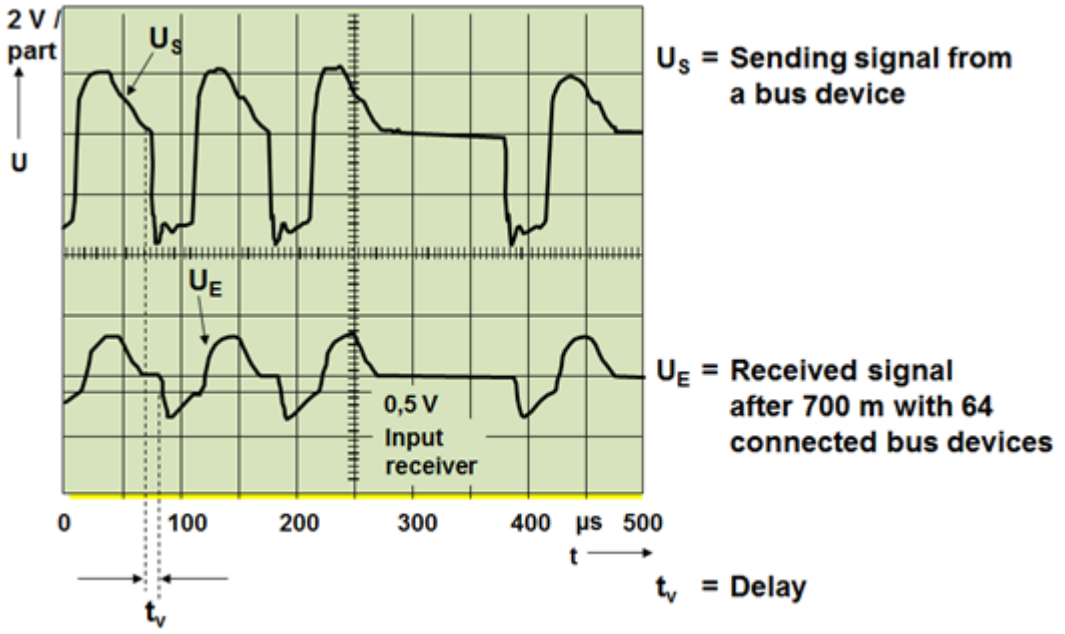


Figure 23: Cable lengths between two TP bus devices

A telegram transmission over the cable requires a certain transit time.

If several bus devices try to transmit simultaneously, a possible collision can only be resolved up to a distance of 700 m (delay time of the signal t_v = 10 µs).

Total cable length per TP line segment ۱۲٫۳

The signal of the sending bus device will be damped by the continuous loading and unloading of the cable capacity. At the same time, the signal edges are rounded by the cable capacity. The signal level drops due to the resistive load (bus cable and device).

To ensure that data is reliably transmitted despite these two effects, the total cable length per line segment may not exceed 1,000 m. The maximum number of devices per line segment depends on their total power consumption: In newer installations, more devices per line segment can be installed (see chapter Topology for more information).