

KNX Communication

KNX Association

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Definition

The following terms are used as synonyms in KNX literature:

- ✚ Physical address and individual address
- ✚ Communication object and group object

The terms **physical address** and **communication objects** are commonly used in the KNX training documentation as well as in ETS.

1 Basic Method of Operation

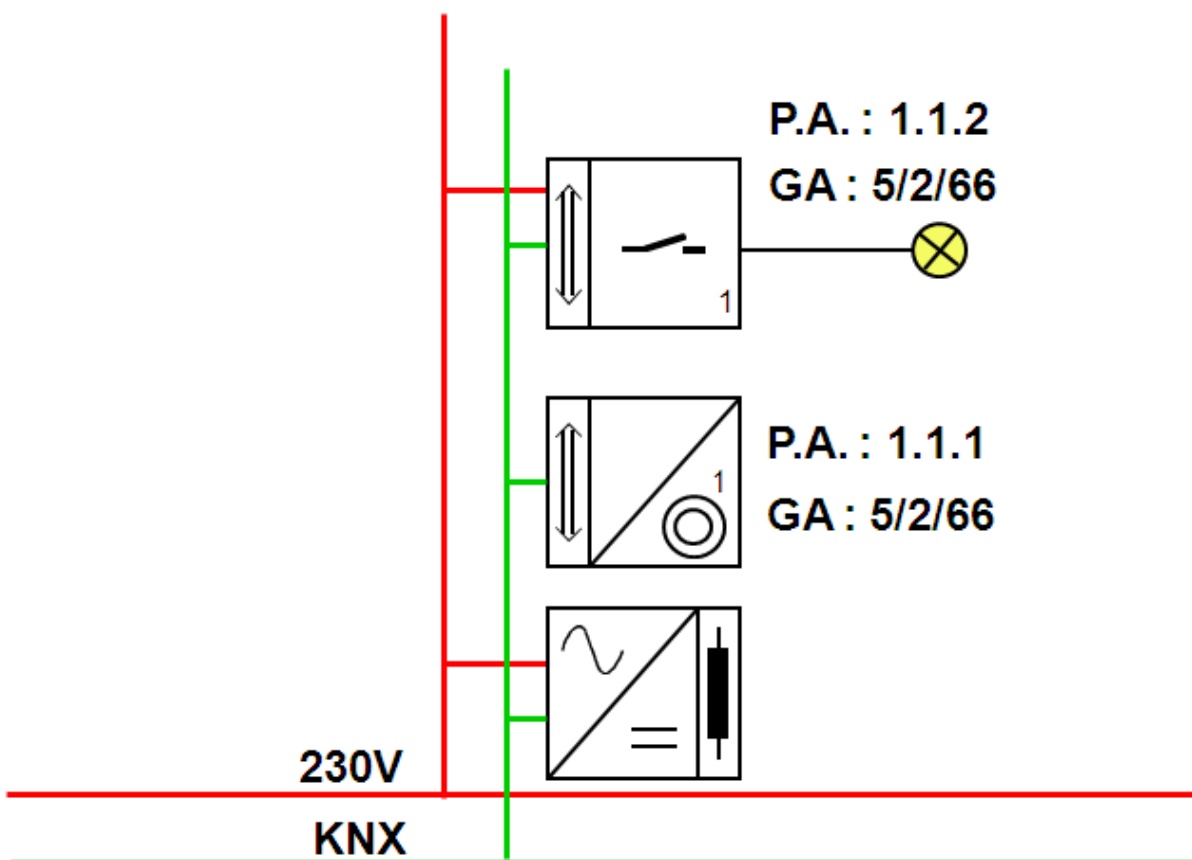


Figure 1: Basic method of operation

A minimum TP1 KNX installation consists of the following components:

- ✚ a power supply unit (DC 30 V)
- ✚ a choke (can also be integrated in the power supply unit)
- ✚ sensors (a single switch sensor is represented in the figure above)
- ✚ actuators (a single switch actuator is represented in the figure above)
- ✚ bus cable (only two wires of the bus cable are required).

After the installation and in the case of S-mode compatible products, a KNX system is not ready for operation until sensors and actuators have been loaded with application software with the help of the ETS™ program. The project engineer must first have carried out the following configuration steps using ETS:

- ✚ assignment of physical addresses to the different devices (for the unique identification of a sensor or actuator in a KNX installation);
- ✚ selection and setting (parameterisation) of the appropriate application software for sensors and actuators;
- ✚ assignment of group addresses (for linking the functions of sensors and actuators).

In the case of E-mode compatible products, the same steps as above have to be applied, whereby:

- ✚ the physical addresses
- ✚ parameterisation of the appropriate application software for sensors and actuators and;
- ✚ the assignment of group addresses (for linking the functions of sensors and actuators)

is done via either local settings or automatically by a central controller.

After the above configuration, the installation could function as follows:

- ✚ If the upper rocker of the single switch sensor (1.1.1) is pressed, it sends a telegram which contains the group address (5/2/66) and the value ("1") as well as miscellaneous data.
- ✚ This telegram is received and evaluated by all connected sensors and actuators.
- ✚ Only the devices with the same group address:
 - send an acknowledgement telegram
 - read the value and behave accordingly. In our example, the switch actuator (1.1.2) will close its output relay.

When the lower rocker is pressed, the same process occurs except that the value is set to "0" this time and the output relay of the actuator is thereby opened.

The respective elements of the KNX system are explained in more detail on the following pages.

2 Physical address

A = Area

L = Line

B = Bus device

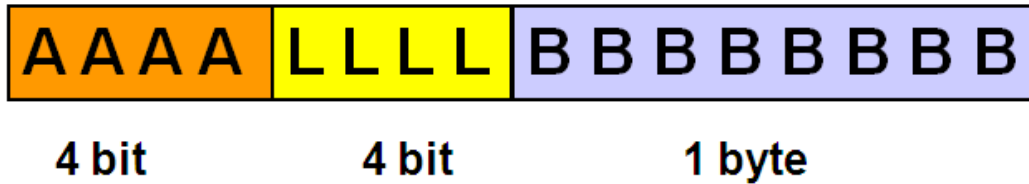


Figure 2: Physical address

A physical address must be unique within a KNX installation. The physical address is configured as described above. It has the following format: Area [4 bit] - Line [4 bit] – Bus device [1 byte]. The bus device is normally prepared for the acceptance of its physical address by pressing a programming button on the bus device. The programming LED is lit during this process. The physical address is also used for the following purposes after the commissioning stage:

- ✚ Diagnosis, error rectification, modification of the installation by reprogramming
- ✚ Addressing of the interface objects using commissioning tools or other devices.

Important: The physical address has no significance during normal operation of the installation.

3 Group Address

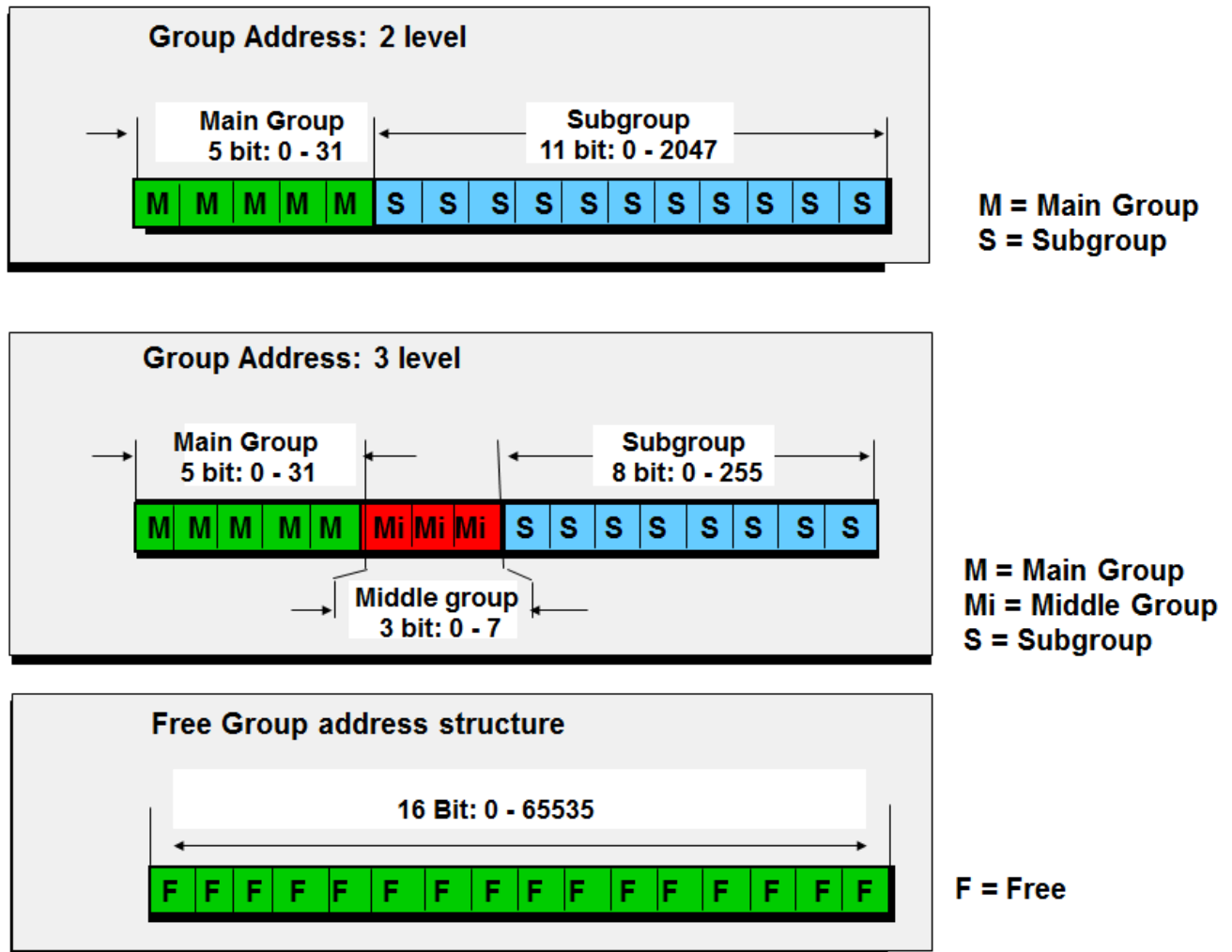


Figure 3: Group Address

Communication between devices in an installation is carried out via group addresses. When setting the group address via ETS, it can be selected as a “2-level” (main group/subgroup), “3-level” structure (main group/middle group/subgroup) or a freely defined structure. The level structure can be changed in the project properties of each individual project.. The group address 0/0/0 is reserved for so-called broadcast messages (telegrams to all available bus devices).

The ETS project engineer can decide how the levels will be used e.g. as in the following pattern:

- ✚ Main group = floor
- ✚ Middle group = functional domain (e.g. switching, dimming)
- ✚ Subgroup = function of load or group of loads (e.g. kitchen light on/off, bedroom window on/off, ceiling living room on/off, ceiling living room dimming,...).

One should stick to the selected pattern of group addresses in all projects.

Each group address can be assigned to the bus devices as required, regardless of where the device is installed in the system.

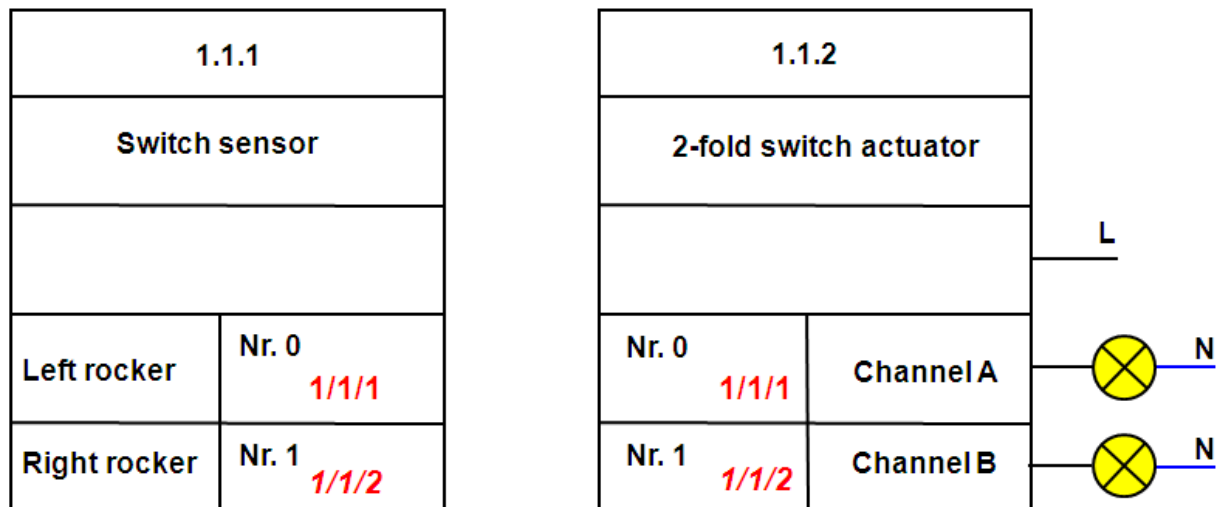
Actuators can listen to several group addresses. Sensors however can only send one group address per telegram.

The group addresses are assigned to the communication objects of the respective sensors and actuators, either by creating and assigning them with the help of ETS (S-mode) or automatically and invisible to the user in E-mode.

Note:

- ✚ When using the main groups 14 resp. 15 or higher in ETS, you should take into account that these group addresses are not filtered by TP1 couplers and could therefore negatively influence the dynamics of the entire bus system.
- ✚ The number of group addresses that can be attributed to a sensor or actuator is variable and depends on the size of the memory.

4 Communication object



Series connection: KNX technology

Figure 4: Communication object

KNX communication objects are memory locations in bus devices. The size of these objects can be between 1 bit and 14 bytes. The size of the communication objects is dependent on its function.

As only two states (0 and 1) are required for switching, 1 bit communication objects are used. The data involved in text transmission is more comprehensive and therefore communication objects with a maximum size of 14 bytes are used.

The ETS only allows to link objects with the same size using group addresses. Several group addresses can be assigned to one communication object, but only one is the sending group address.

An object value is sent on the bus in the following way:

- a) If the upper left rocker is pressed for example, the two-fold switch sensor writes a “1” to its communication object with the number 0. As the communication and transmit flag are set for this object, this device will send a telegram on the bus with the information “Group address 1/1/1, write value, 1”.
- b) All the bus devices throughout the KNX installation that also have the group address 1/1/1 will then write “1” in their own communication object.
- c) In our example, the “1” is written in communication object no. 0 of the actuator.
- d) The application software of the actuator establishes that the value in this communication object has changed and executes the switching process.

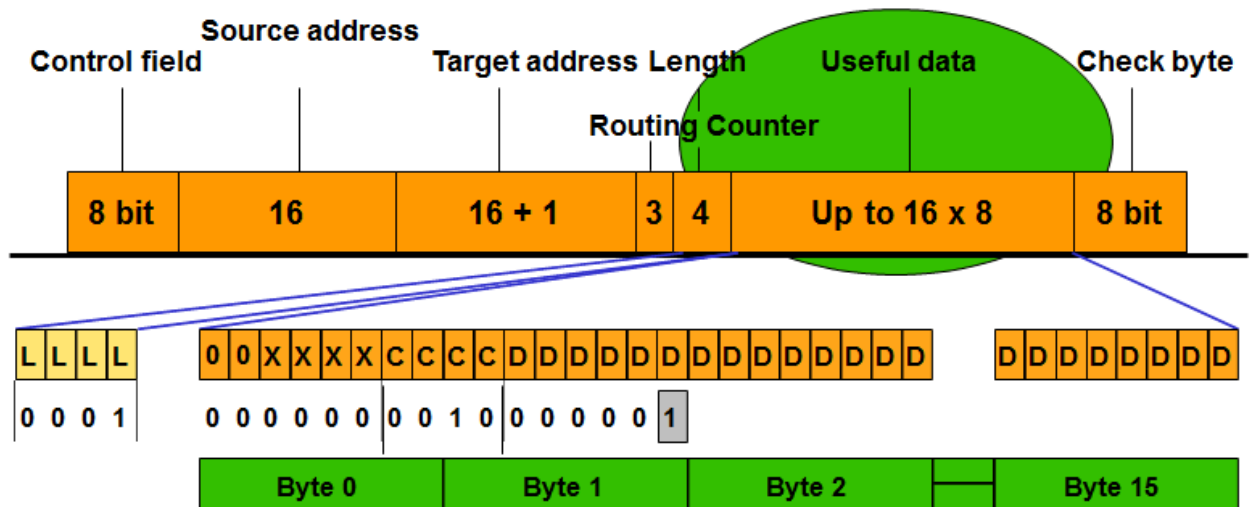
4.1 Flags

Each communication object has flags which are used to set the following properties:

Communication	<input checked="" type="checkbox"/>	The communication object has a normal link to the bus.
	<input type="checkbox"/>	Telegrams are acknowledged. The communication object is not modified.
READ	<input checked="" type="checkbox"/>	The object value can be read via the bus.
	<input type="checkbox"/>	The object value CANNOT be read via the bus.
WRITE	<input checked="" type="checkbox"/>	The object value can be modified via the bus.
	<input type="checkbox"/>	The object value CANNOT be modified via the bus.
TRANSMIT	<input checked="" type="checkbox"/>	A telegram is transmitted when the object value (at the sensor) has been modified.
	<input type="checkbox"/>	The communication object will generate a response only when receiving a read request.
UPDATE	<input checked="" type="checkbox"/>	Value response telegrams are interpreted as a write command. The value of the communication object is updated (always enabled in System 1 devices)
	<input type="checkbox"/>	Value response telegrams are NOT interpreted as a write command. The value of the communication object remains unchanged.
READ ON INIT	<input checked="" type="checkbox"/>	The device independently sends Read value commands for the initialisation of the communication object after return of current (only available on certain masks)
	<input type="checkbox"/>	After return of current the device <i>does not</i> initialise the value of the assigned communication object via Read Value commands

Please note: The default flags should only be changed in exceptional circumstances.

For further information you can consult the topic “Flags” in the chapter “Project Design” of the basic course documentation or the chapter “Flags” in the advanced course documentation.



The actual payload is explained here using the example of a 1-bit telegram.

Legend

- C = Command
- D = Data (dependent on the data point type[DPT])
- L = Length of the useful data (dependent on DPT)
- X = No evaluation

Selected commands

- 0000 Value Read
- 0001 Value Response
- 0010 Value Write
- 1010 Memory Write

Figure 5: Useful data of TP1 telegram

5 Useful Data of a TP1 telegram

The actual payload determines the type of command. The actual payload is explained in the above figure using the example of a 1-bit telegram. In the case of the “write” command the last bit on the right contains a “1” or a “0” for “Switch on” or “Switch off”.

A “read” command requests the addressed communication object to report its status. The reply may be a 1-bit message as in the example of the “write” command, or it can use up to 13 bytes (bytes 2 to 15).

The length of the data is dependent on the datapoint type used.

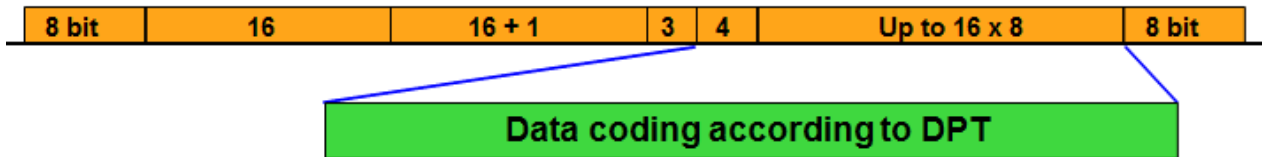


Figure 6: Standardized Datapoint types

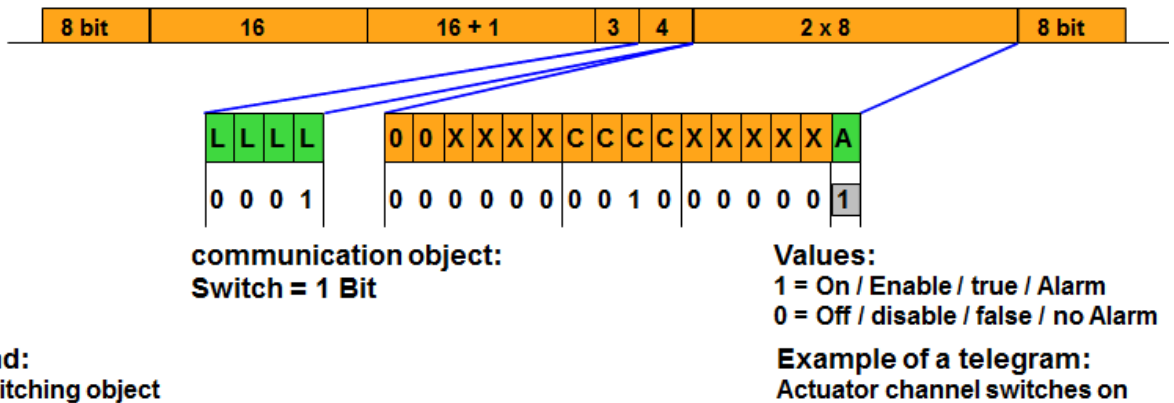
6 Standardized Datapoint Types (DPT)

Datapoint types were standardised to guarantee the compatibility of similar devices from different manufacturers (e.g. dimmers, clock).

The standardisation includes requirements on the data format and structure of the communication objects as well as for sensor and actuator functions. The combination of several standardised datapoint types (e.g. in dimming actuators) is called a functional block.

The designation of a datapoint type is geared towards the application for which it was conceived. This does not always imply that the use of the DPT is limited to this area of application. For example “Scaling” (Type 5.001) can also be used both for setting a dimming brightness or for setting a heating valve position.

A selection of frequently used datapoint types is given on the following pages. The full list of standardised datapoint types can be downloaded from the KNX web site (www.knx.org).



Legend:

- A = Switching object
- C = Command (0010 = write telegram)
- L = Length of useful data (byte 0 to byte 1)
- X = No evaluation

Figure 7: DPT Switch (1.001)

6.1 Switch (1.001)¹

The switch function is used for switching an actuator function. Other one bit datapoint types are defined for logical operations (Boolean [1.002]), Enable [1.003]), etc...).

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

¹ previously referred to as EIS1

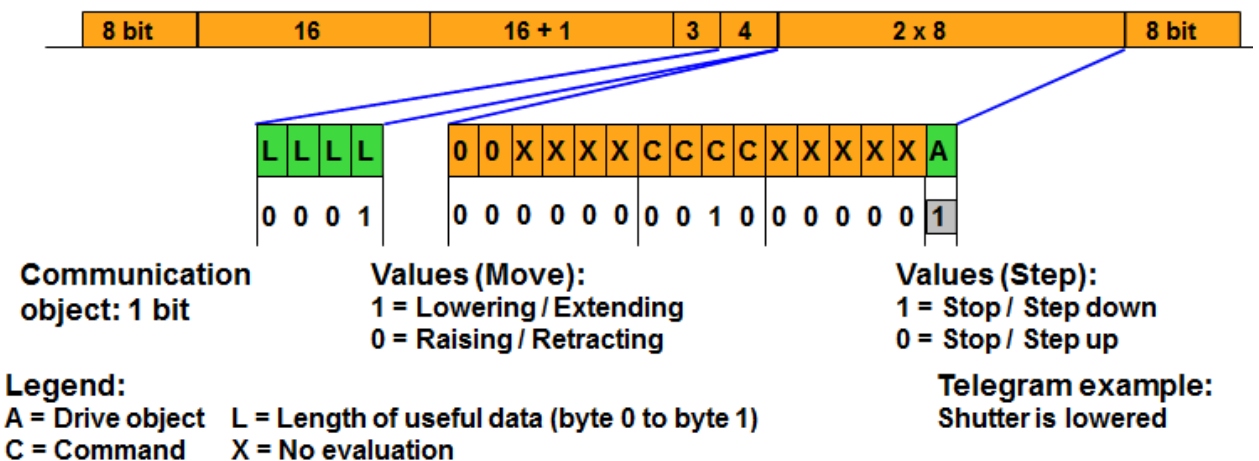


Figure 8: Functional block Shutter Control

6.2 Functional block Shutter Control²

The functional block “Shutter control” is principally used for the control of shutter and blind drive mechanisms and provides at least the following datapoint types as communication objects

- ⬆️ Up/Down (1.008)
- ⬆️ Step (1.007).

By writing on the Up/Down, a drive is set in motion from an idle state or changes direction while moving.

By writing on the Step, a drive which is already in motion is brought to a stop or a halted drive is set in motion for short periods (step-by-step).

Important: Communication objects which use this function should never reply to read requests via the bus as they may unintentionally stop moving drives or set halted drives in motion. The “read” flag should therefore be deactivated in the relevant communication objects – both in sensors as well as actuators. This especially applies for central functions.

² previously referred to as EIS7

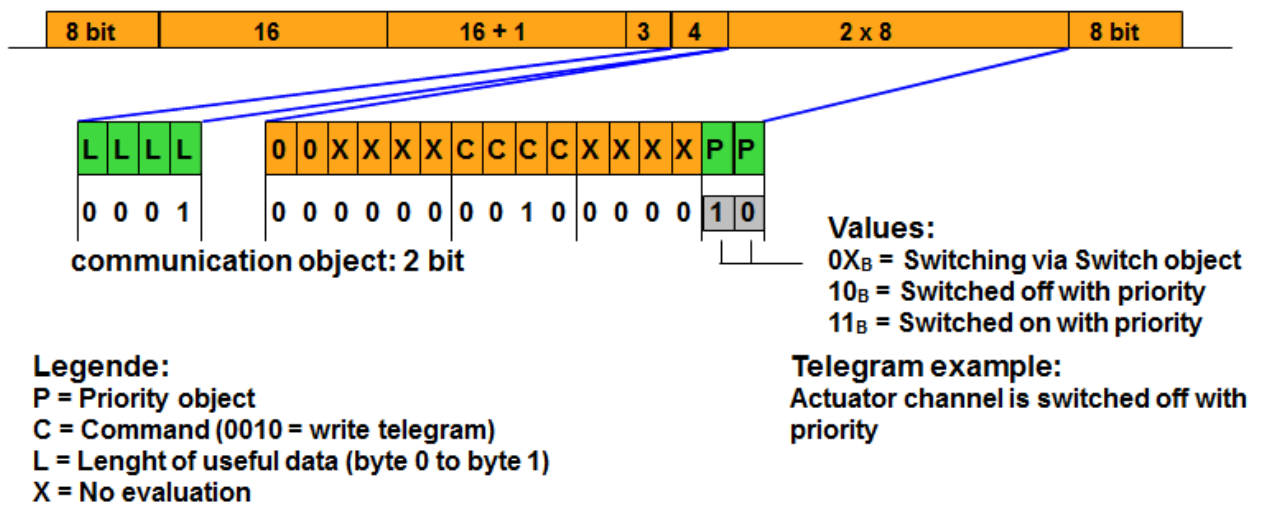


Figure 9: Switch Control (2.001)

6.3 Switch Control (2.001)³

The Switch Control is used to operate actuators – next to the normal operation via the Switch – by a communication object with higher priority.

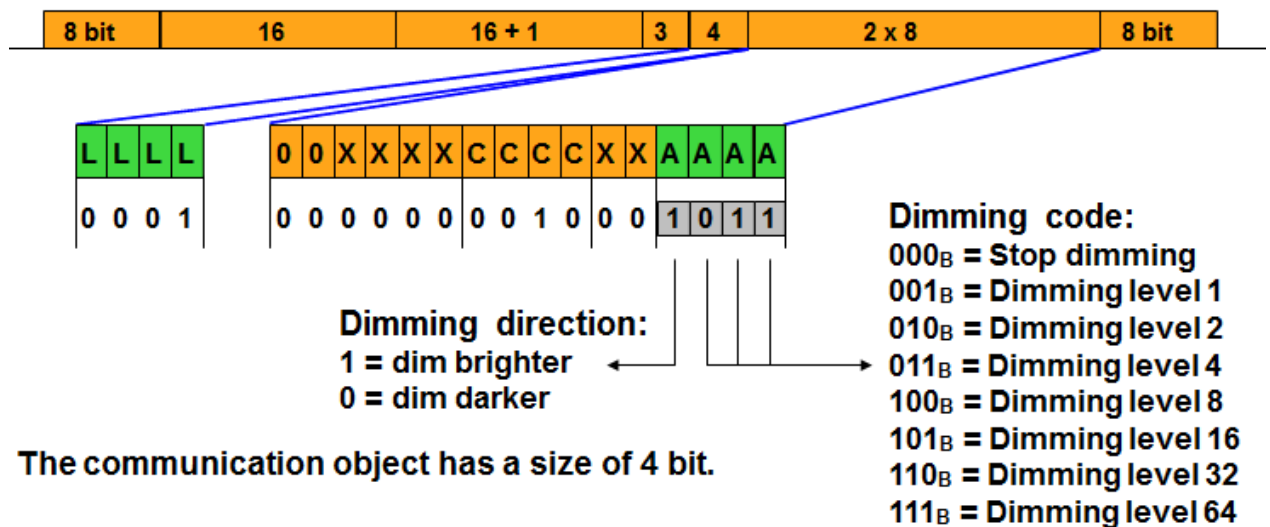
The switching function of a connected device depends on the state of the two communication objects Switch and Switch Control.

The communication object of type Switch Control has a size of 2 bits.

If the value of the 2 bit object is 0 or 1, the connected actuator is controlled via the switching object.

If the value of the priority object is 2, the output is switched off respectively on when the value is 3. The value of the switching object is in both cases ignored.

³ Previously referred to as EIS 8



The communication object has a size of 4 bit.

- Legend:**
 A = Dimming object
 C = Command (0010 = write telegram)
 L = Length of useful data (byte 0 to byte 1)
 X = No evaluation

Figure 10: Functional Block "Dimming"

6.4 Functional Block "Dimming"⁴

Apart from the 4 bit object (Dim Step – 3.007), the functional block dimming consists of at least a switching object (corresponds to Switch) and a value object (corresponds to Scaling – 5.001).

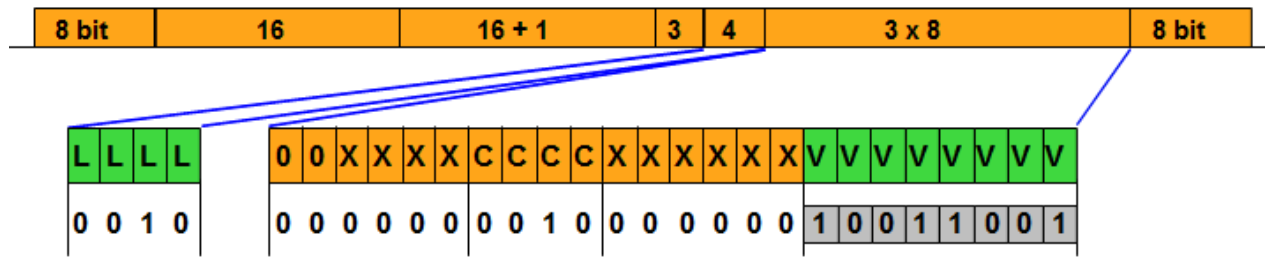
A dimming command, relative to the current brightness setting, is transmitted to the dimming actuator using the Dim Step.

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 range. The area of brightness (0-100%) is divided into 64 dimming levels. The dimming actuator always dims to the next dimming level. For example: a dimming actuator has a brightness level of 30%. If a sensor sends 1011_B as useful data, a dimming brighter command is carried out until the next dimming threshold is reached (or 100% divided by 4 = 25%, i.e. the next level is 50%).

The dimming code 0 (i.e. useful data 00_{HEX} or 80_{HEX}) means "Stop Dimming". The dimming process is interrupted and the current brightness value is retained.

⁴ previously referred to as EIS 2



Legend:
 V = Value
 B = Command (0010 = Write telegram)
 L = Length of useful data (byte 0 to byte 2)
 X = No evaluation

Telegram example:
 Brightness value 60 % (153)

Figure 11: Value object

With the Scaling, a brightness value between 1 (minimum) and 255 (maximum) is set directly.

Depending on the manufacturer’s application, it may be possible to switch on ($1 \leq \text{value} \leq 255$) or off (value = 0) a connected device using this DPT.

The DPT has a size of 1 byte.

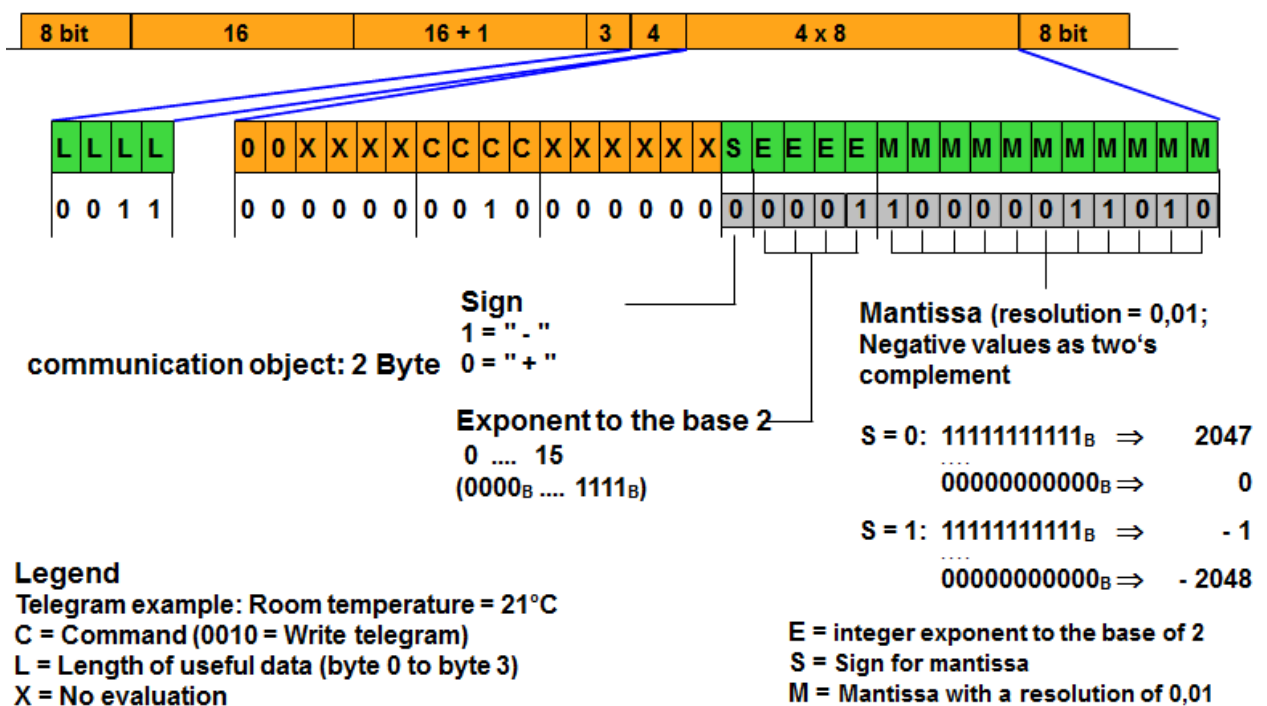


Figure 12: 2 octet Float Value

6.5 2 Octet Float Value (9.00x)⁵

With this data format (which has a number of different datapoint types according to the nature of the sent value, e.g. room temperature °C – 9.001), numbers which represent physical values can be transmitted.

“S” is the sign for the mantissa.

The four-digit exponent “E” is an integer exponent to the base of 2.

A resolution of 0.01 is defined for the mantissa “M”. Positive values (“S” = 0) take the form of normal binary numbers. Negative values (“S” = 1) are coded by the mantissa as two’s complement numbers.

The size of the DPT is 2 bytes.

⁵ previously referred to as EIS 5

„0“ and „1“ are the two logical states a bit can possess.

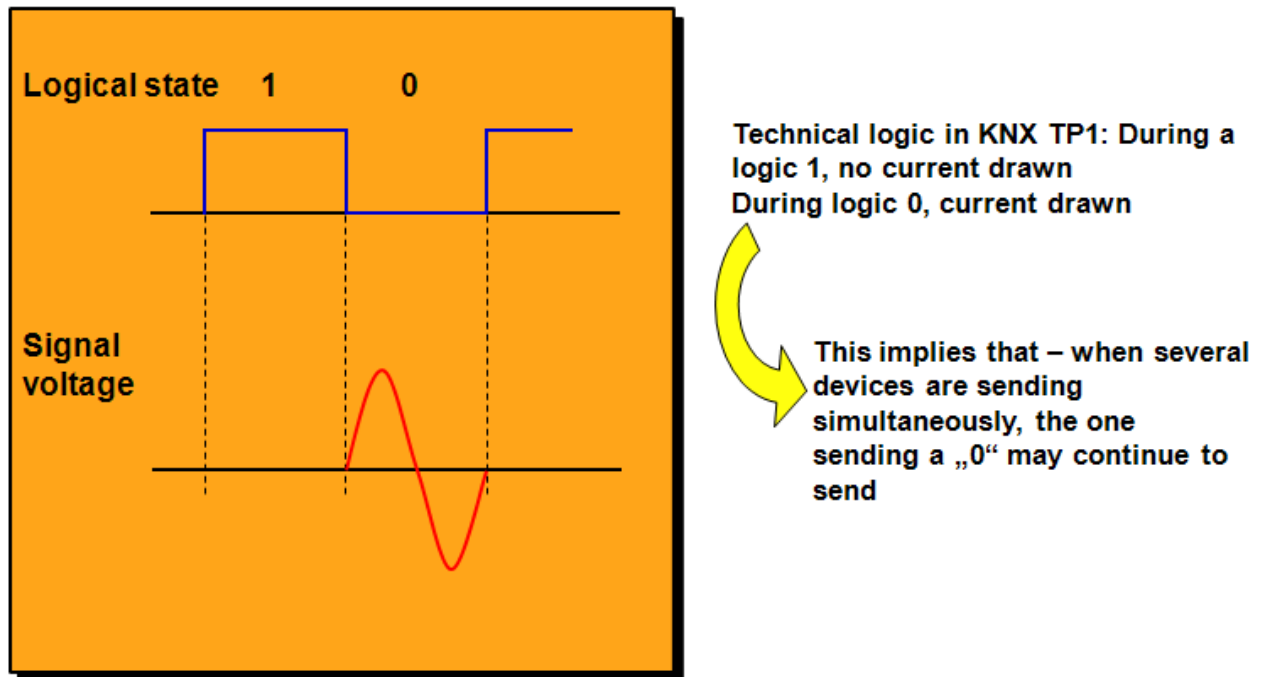


Figure 13: TP1 bit structure

7 TP1 Bit Structure

“0” and “1” are the two logical states a bit can possess.

Technical logic in KNX TP1:

- ✚ During logical state “1”, no signal voltage is available
- ✚ During logical state “0”, signal voltage is available

If several bus devices transmit simultaneously, the logical state “0” prevails!

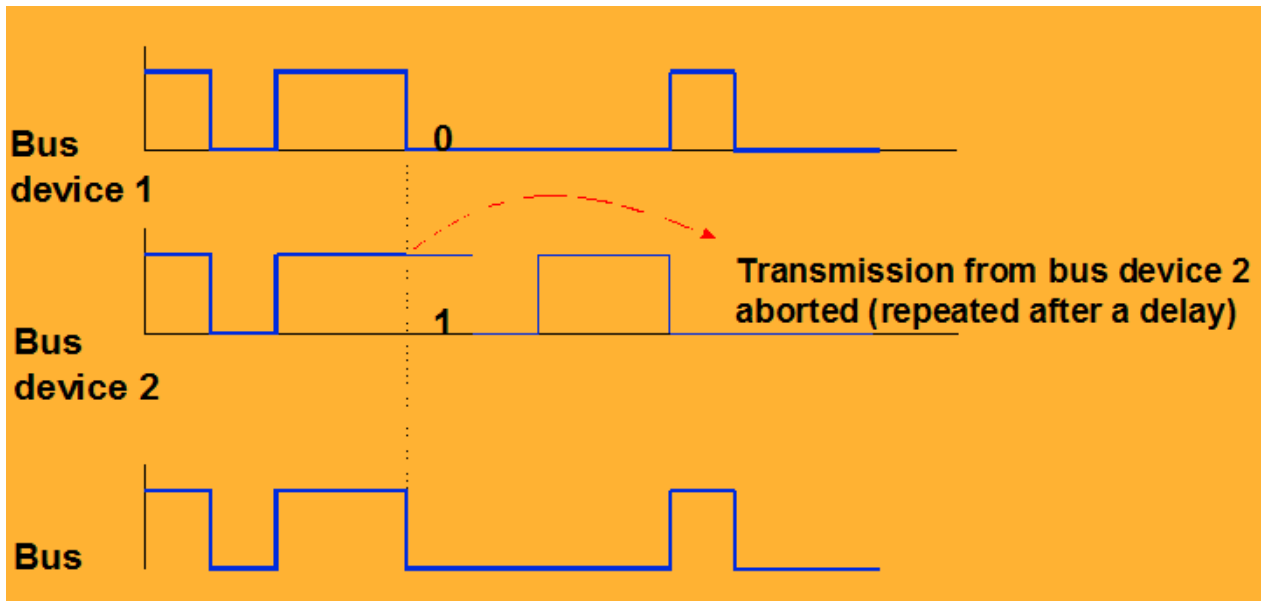


Figure 14: TP1 Telegram Collision

8 TP1 Telegram Collision

A bus device with data to transmit may start transmission immediately if it finds the bus unoccupied.

The simultaneous sending request of several bus devices is controlled by the CSMA/CA procedure (Carrier Sense Multiple Access with Collision Avoidance).

The bus devices listen to the bus while transmitting. 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 to listen to the network to await the end of the telegram transmission and then retries its transmission.

In this way, if several bus devices are attempting to transmit simultaneously, the CSMA/CA procedure ensures that only one of these bus devices can terminate its transmission uninterrupted. The data throughput is therefore not reduced.

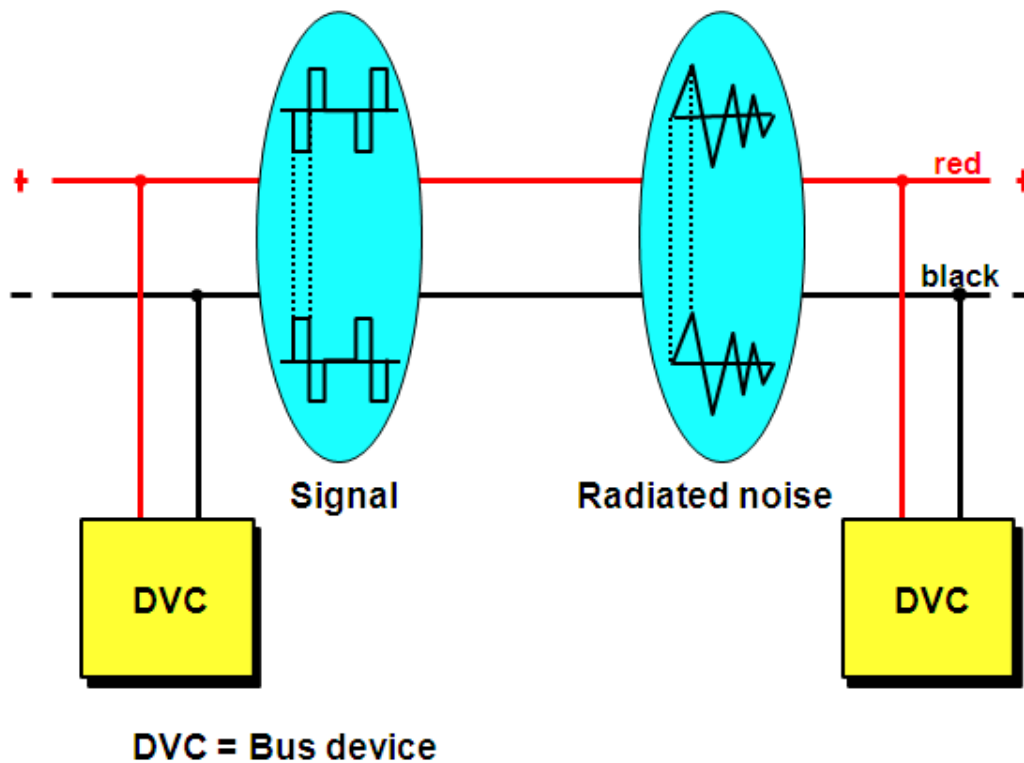


Figure 15: TP1 Symmetrical Transmission

9 TP1 Symmetrical Transmission

The data is transmitted symmetrically over the pair of cores. Bus devices evaluate the difference in voltage between the two cores.

As radiated noise affects both cores with the same polarity, it has no influence on the difference in the signal voltage.

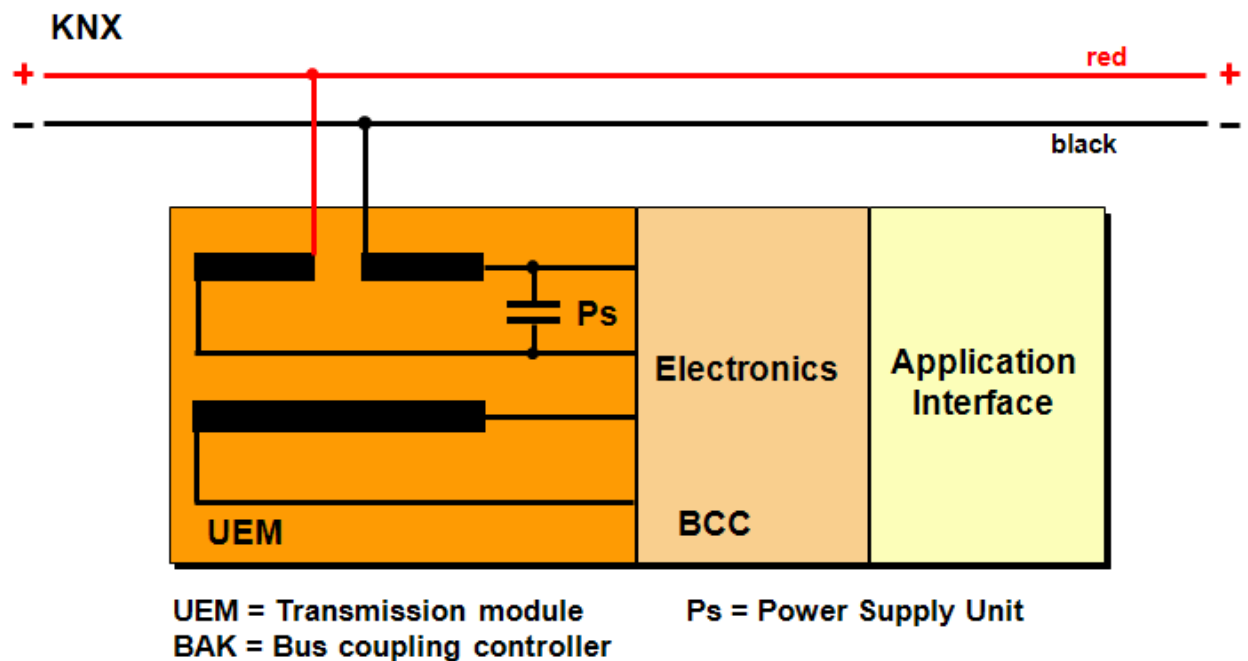


Figure 16: Superimposing Data and Supply Voltage

10 Superimposing Data and Supply Voltage

Data is transmitted in the form of a.c. voltage. The capacitor reacts with a low resistance to a.c. voltage, i.e. it acts as a conductor and closes the circuit on the primary side. When acting as a transmitter, the transformer sends the data to the primary side (in the form of a.c. voltage) where it is superimposed onto the d.c. voltage.

When acting as a receiver, the transformer sends the data to the secondary side where it is separately available from the d.c. voltage.

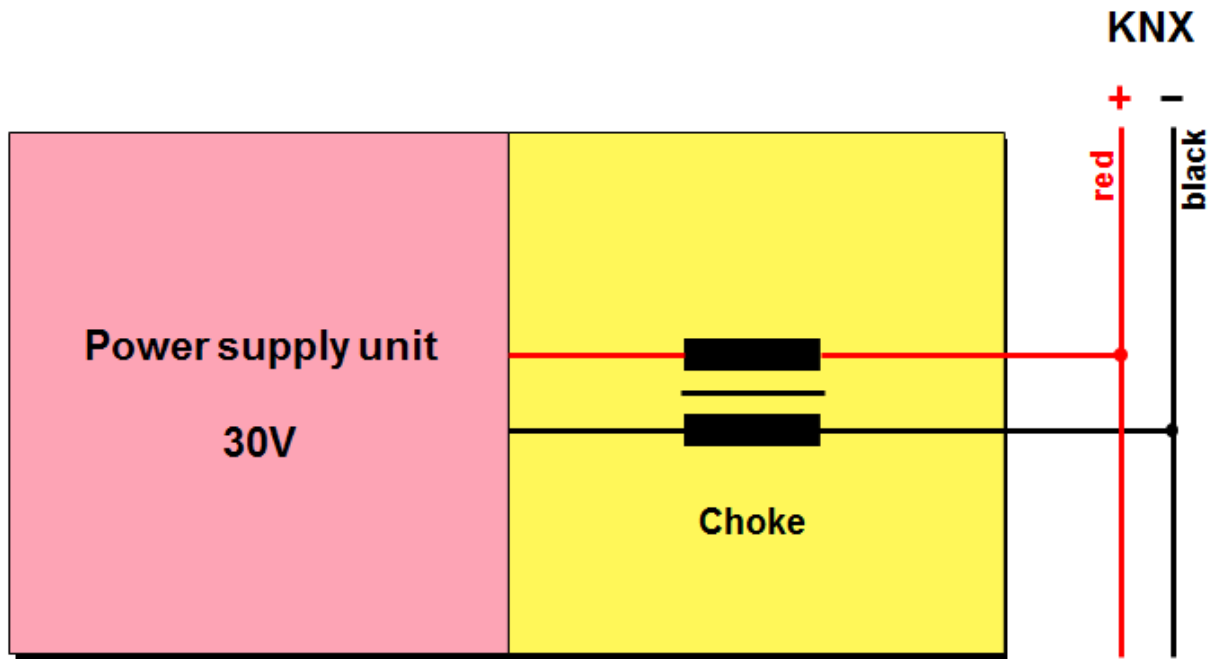


Figure 17: Connection of Power supply to TP1 bus

11 Connection of the Power Supply Unit to the TP1 Bus

The power is supplied to the installation bus via a choke.

When d.c. voltage is supplied, the choke reacts with low resistance (as the frequency is equal to 0 Hz). The data is transmitted in the form of a.c. voltage (frequency is not equal to 0). The choke reacts with high resistance to a.c. voltage.

Hence the power supply unit's influence on the data is negligible.

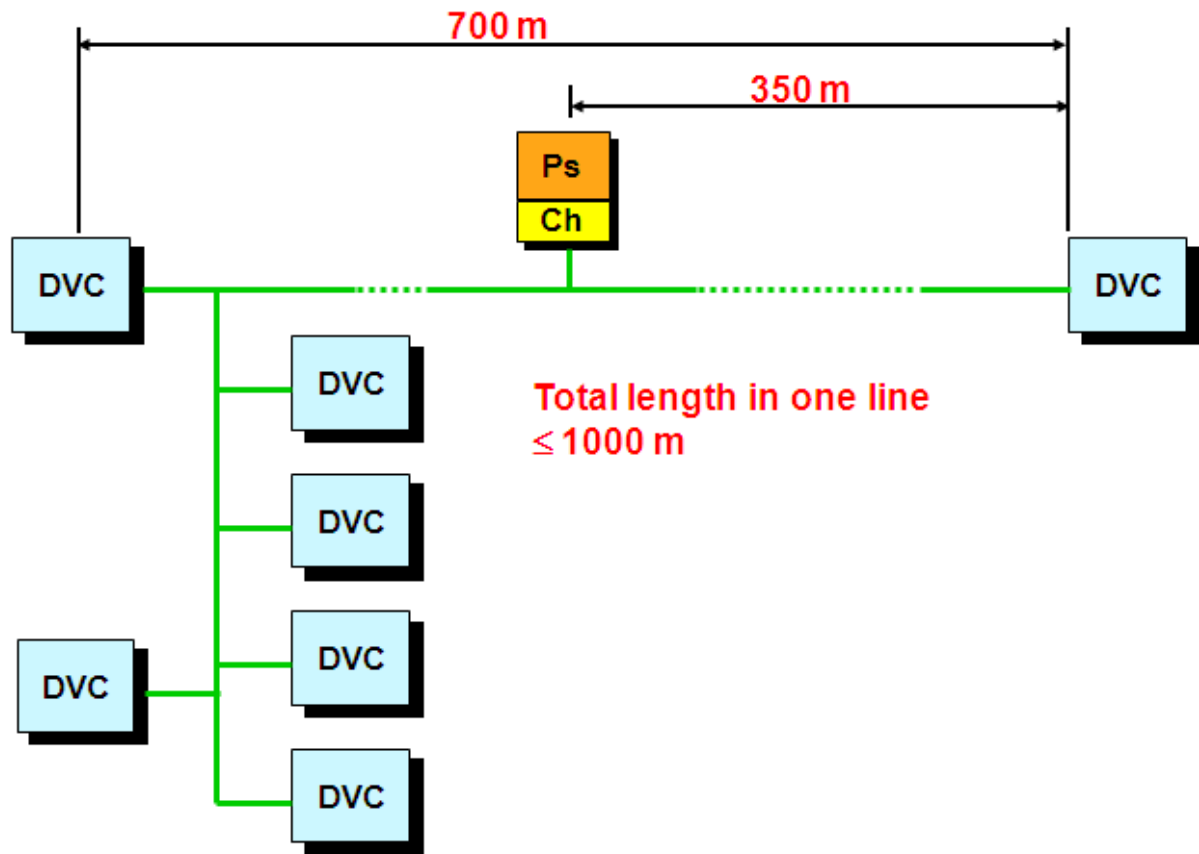


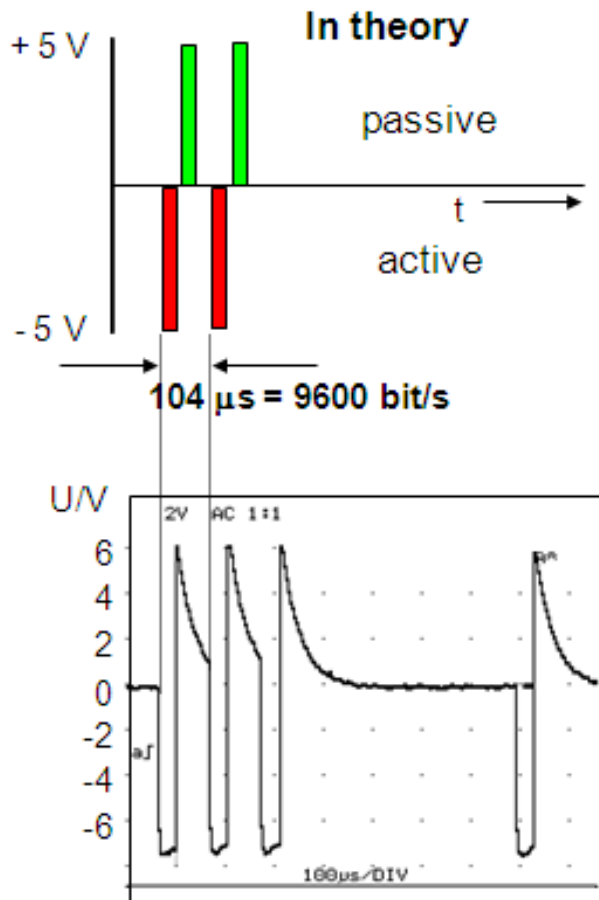
Figure 18: TP1 Cable lengths

12 TP1 Cable Lengths

Within a bus line, the following cable lengths are permitted:

- Power Supply Unit - Bus device..... max. **350 m**
- Bus device - Bus device..... max. **700 m**
- Total bus line length..... max. **1000 m**
- Distance between 2 power supply units in one line...**As specified by the manufacturer**

When using a decentralised power supply, please check the chapter 'installation'.



Alternating voltage between the two cables

Figure 19: Cable Length between TP1 power supply unit and TP1 bus device

12.1 Cable Length between TP1 Power Supply Unit and TP1 Bus Device

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

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

As the choke has a major part in the forming of the equalisation pulse, the bus devices may be installed up to 350 m cable length away from the choke (power supply unit).

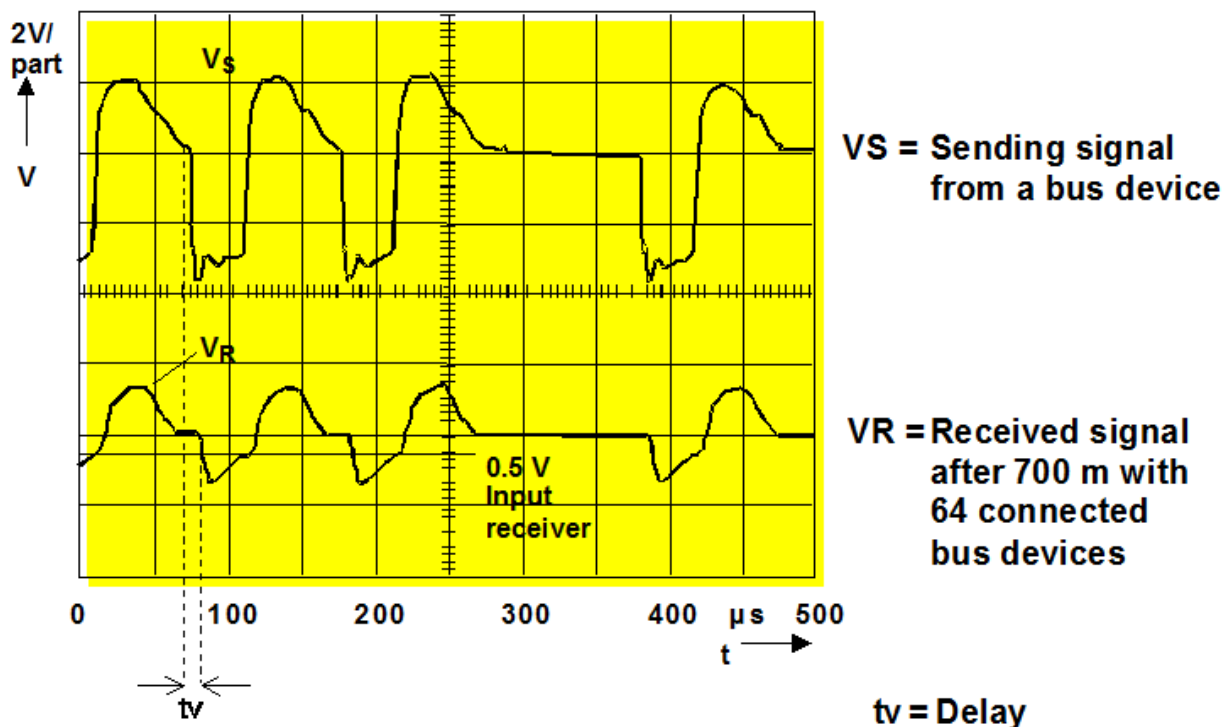


Figure 20: Cable lengths between two TP1 bus devices

12.2 Cable Lengths between two TP 1 Bus Devices

A telegram transmission over the cable requires a certain transit time. If several bus devices try to transmit simultaneously, the occurring collision can be resolved up to a distance of 700 m (delay time of the signal $t_v = 10 \mu s$).

12.3 Total Cable Length per TP 1 Line Segment

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) of the signal.

To enable the data to be reliably transmitted despite these two effects, the total cable length per line segment may not exceed 1,000 m and the maximum number of devices per line segment may never exceed 64 (regardless of the used power supply unit type).