Product documentation

KNX RF radio converter
Art. No. MK100RF

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1 Product definition

1.1 Product catalogue

Product name:	RF radio converter
Use:	System device
Design:	Installation
Art. No.	MK100RF

1.2 Function

Media couplers are the link between a specific KNX RF environment (RF = Radio Frequency) and a wired KNX TP installation (TP = Twisted Pair). With regard to the routing property of telegrams, media couplers function like standard TP backbone/line couplers. This means that RF devices can communicate with TP devices via a media coupler or (with additional IP area couplers) with IP devices and vice versa.

Media couplers possess filter settings and filter tables. The physical address defines whether a media coupler is a line coupler or a backbone coupler. The exact function of the device is determined by the selected parameterization and by the physical address.

Optionally, the Jung media coupler can additionally or alternatively work as an repeater. A repeater repeats the radio telegrams received in its RF line by retransmitting them immediately. This allows an extension of the range of a KNX RF installation, meaning that it is possible to position RF devices as required in a building, even in the case of difficult transmission and reception conditions.

The Jung media coupler is a device which allows the media type RF on the lower-level line and the media type TP on the higher-level line. As of version 5, the device can be configured and commissioned using the ETS. The device is powered via a KNX TP bus connection (KNX power supply unit) or alternatively, via a suitable external DC power supply unit in repeater operation (see chapter 1.3. Accessories).

1.3 Accessories

Power supply 24 V, for rail mounting	Art. No. NT 2415 REG VDC

2 Installation, electrical connection and operation

2.1 Safety instructions

Electrical devices may only be mounted and connected by electrically skilled persons.

Failure to observe the instructions may cause damage to the device and result in fire and other hazards.

The radio communication takes place via a non-exclusively available transmission path, and is therefore not suitable for safety-related applications, such as emergency stop and emergency call.

2.2 Device components

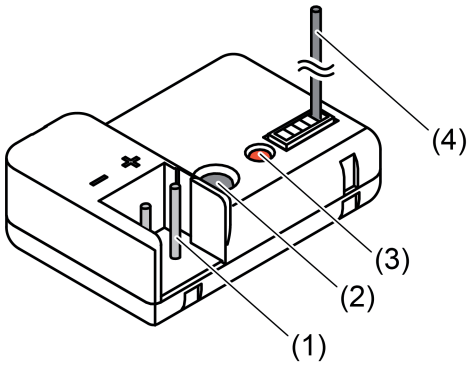

Figure 1: Device components media coupler

(1) KNX TP bus connection

(2) Programming button

(3) Status LED
Lights red: Programming mode active
Flashes red quickly: Filter function not configured (filter table has no function)
Flashes red slowly: Safe-state mode active
Flashes yellow: Parameter-dependent (TP or RF telegram forwarding, telegram traffic)
Short change red -> yellow: Display test after a device restart

(4) Antenna

i Do not shorten or extend the antenna (4), or connect it to an electrical potential!

2.3 Mounting and electrical connection

DANGER!

Electrical shock on contact with live parts in the installation environment.

Electrical shocks can be fatal.

Before working on the device, disconnect the power supply and cover up live parts in the working environment.

General

Mount in suitable flush-mounted or surface appliance boxes.

- In outdoor installations: Use appliance box IP55.
- Do not place the device in small metallic distributors or boxes.

Do not lead any wire or sheathed cables from other power circuits through the appliance box.

Precondition: To ensure good transmission quality, keep a sufficient distance from possible interference sources, e.g. metallic surfaces, microwave ovens, hi-fi and TV sets, ballasts or transformers.

Connect the device and mount it for use as media coupler

The media coupler is connected to and supplied by a KNX bus cable (TP).

Precondition: Ideally, the media coupler is positioned in the centre of an RF installation (domain), to allow low-loss and thus interference-free communication with all the associated RF devices.

- Connect device to a KNX bus cable. For this, use a KNX device connection terminal. Ensure correct polarity.
- If the media coupler is used as a line coupler, the KNX bus cable must be the main line of a TP area. If the media coupler is used as area coupler, the KNX bus cable must be the TP area line (Backbone) of the KNX installation.
- Place the device in the appliance box.
- When laying the antenna, extend the antenna extended as much as possible. If this is not possible, position the antenna behind the device in a circular arrangement.
- When using blank covers, make sure the antenna does not lie directly behind the metal supporting frame.

Connect the device and mount it for use as a repeater (no media coupler function)

If needed, the repeater can be connected to a KNX bus cable (TP) via which it is supplied, as long as the bus cable is the TP line of the associated media coupler. Thus the use of the repeater is especially relevant for retroactive solutions in existing TP systems. Alternatively, a repeater can also be supplied via a separate DC power supply (see accessories), even without KNX bus voltage.

Precondition: The repeater is positioned within radio range of the media coupler and ideally within radio range of another repeater of the same RF domain, to allow low-loss and thus interference-free communication with all the associated RF devices.

- Connect the device to a KNX bus cable or alternatively, to a separate DC power supply. For this, use a KNX device connection terminal. Ensure correct polarity.
- Do not use the unchoked 30 V output of a KNX power supply! The media coupler may heat up to an impermissible temperature.

- When connecting a TP bus cable, after the physical address is programmed, no direct ETS program access to the device on the TP side during repeater operation is possible any longer. Consequently, the repeater can only be programmed and diagnosed (e.g. with the use of suitable KNX RF USB data interfaces or via another media coupler of the same RF domain) via the RF side.
- Place the device in the appliance box.
- When laying the antenna, extend the antenna extended as much as possible. If this is not possible, position the antenna behind the device in a circular arrangement.
- When using blank covers, make sure the antenna does not lie directly behind the metal supporting frame.

2.4 Commissioning

General

Depending on the physical address, the device can be added to the KNX topology either as a media coupler or alternatively, as an RF repeater, and commissioned. Already the physical address assignment and programming define the device function.
The device operates as a media coupler when it is given a physical address in the form x.y.0 (line coupler) or x.0.0 (area coupler) (x = area address, y = line address).
The device operates exclusively as a repeater when it is assigned a physical address in the form x.y.1...255.

In an RF domain, always commission the media coupler first! Only then should any optional additional repeaters and all other participants of the RF installation be programmed.
Ideally, install and connect the repeater after the media coupler has been completely commissioned.

Precondition: An appropriate device must be created and configured in the ETS project. Device has been connected and the power is switched off.

- Project design and commissioning with ETS5 or a more recent version.
- Programming mode is deactivated after the physical address has been successfully programmed, or is generally deactivated by a device test (power failure, ETS programming process of the application program).
  Programming mode is also deactivated automatically after 4 minutes if none of the above events occurs.

Commissioning as media coupler

As delivered, the device can be programmed and commissioned as a media coupler via the TP side (e.g. with the use of suitable USB or IP data interfaces) or via the RF side (e.g. with a KNX RF USB data interface).

- After a successful initial commissioning, access to the device for programming may be restricted because of an active configuration lock (see page 24).
- Press the programming button (2)(figure 1).

  The status LED (3) lights up red. Programming mode is activated.
- Load the physical address into the device. The ETS also automatically loads the domain address of the RF line into the device.

  The red status LED goes out.
- When programming the media coupler via RF: For the programming of the physical address and the domain address to be carried out and completed correctly, the domain address of the RF line must match the domain address of the RF communication interface (e.g. KNX USB RF data interface)! Otherwise, communication errors can be expected.
  The domain address of the KNX RF USB data interface used by the ETS is configured in the general connection settings of the ETS. In an ETS project, the domain address of an RF line or a media coupler is configured in the line properties (separate for each RF line).
- Load the application program into the device using the ETS.
- The filter table is automatically loaded to the device together with the application program via the ETS. Whether or not the filter table is used for routing group telegrams in media coupler operation is defined by the device parameters.
  In pure repeater operation, the filter table has no function.

Commissioning the device as a repeater

The device can only be programmed as a pure repeater (no media coupler function) and commissioned via the TP side to a limited extent (e.g. with the use of suitable USB or IP data interfaces, if the device is connected to the TP line of the associated media coupler).

Programming access to the device via the RF side is always possible with no limitation (e.g. with a KNX RF USB data interface or via a media coupler).

After the physical address is programmed, a repeater can no longer be reached directly via the TP side. As a result, further programming operations using the ETS can no longer be executed on the TP side without the media coupler. Direct access to the device via the TP side is only possible again when the device is reset to delivery state (see page 27).

Program the physical address and the application program always separately.

- Press the programming button (2)(figure 1).

  The status LED (3) lights up red. Programming mode is activated.

- Load the Physical Address to the device via the TP side (if the device is connected to the TP line of the associated media coupler) or the RF side. The ETS also automatically loads the domain address of the RF line into the device.

  The red status LED goes out.

i After the physical address has been successfully programmed, the device can no longer be reached with the ETS via the TP side, because the device's TP transponder is switched off! This feature is necessary because from a topological standpoint, a repeater (without media coupler function) is exclusively assigned to the RF line, and no longer to a TP line. Consequently, afterwards the application program can only be programmed separately via the RF side. To do so, either a programming connection via the media coupler of the RF domain can be used (TP -> RF) or alternatively, a KNX RF USB data interface.
Where necessary, the TP line of the media coupler can be used for power supply to the repeater (see page 7-8).

i When programming the repeater via RF: For the programming of the physical address and the domain address to be carried out and completed correctly, the domain address of the RF line must match the domain address of the RF communication interface (e.g. KNX USB RF data interface)! Otherwise, communication errors can be expected.
The domain address of the KNX RF USB data interface used by the ETS is configured in the general connection settings of the ETS. In an ETS project, the domain address of an RF line or a repeater is configured in the line properties (separate for each RF line).

- Load the application program into the device using the ETS.

i In pure repeater operation, the filter table has no function.

3 Technical data

General	
Test mark	KNX
Ambient temperature	-20 ... +55 °C
Storage temperature	-25 ... +45 °C
Transport temperature	-25 ... +70 °C
Degree of protection	IP 20
Protection class	III
Dimensions L×W×H	44x29x16 mm
Relative humidity	10 ... 100 % (No moisture condensation)
KNX RF	
KNX medium	RF1.R
Commissioning mode	S-mode
Radio frequency	868.0 ... 868.6 MHz
Transmission capacity	max. 20 mW
Transmitting range in free field	typ. 100 m
KNX TP	
KNX medium	TP
Commissioning mode	S-mode
Rated voltage KNX	DC 21 ... 32 V SELV
Current consumption KNX	max. 5 mA
Repeater operation	
Rated voltage	DC 24 V SELV
Data according to EN 300220	
Receiver category	2

4 Software description

4.1 Software specification

ETS search paths: - Radio / System components / RF radio converter
Configuration: S-mode standard

Application:

No.	Short description	Name	Version	from mask version
1	Use as media coupler in the function of area or line coupler (depending on the physical address and configuration). Use as KNX RF repeater possible.	Media coupler / repeater 902011	1.1	2920

4.2 Software "Media coupler / repeater"

4.2.1 Scope of functions

- Use as media coupler in the function of area or line coupler (depending on the physical address)
- Use as KNX RF repeater possible
- Influence on forwarding of group telegrams (routing) by filter function in coupler operation
- Support of the full address range (groups 0-31) for filter function
- Forwarding of group telegrams (TP -> RF, RF -> TP) parameterizable
- Forwarding of physically addressed telegrams (TP -> RF, RF -> TP) parameterizable
- Forwarding of broadcast telegrams (TP -> RF, RF -> TP) parameterizable
- Telegram repetitions in case of transmission errors for group, broadcast and physically addressed telegrams can be set on the TP side
- Telegram confirmation for group and physically addressed telegrams can be separately configured on the TP side
- Configuration lock can be set (programming only via TP or RF)
- Status LED to display device statuses
- Conversion and generation of RF system broadcast telegrams
- Support of long frames
- Safe-state mode to stop the application program (e.g. if the device does not function properly due to errors in the project design or during commissioning)
- Function for reset to delivery state

4.2.2 Notes on software

Restricted ETS programming access in repeater operation

When the device is used as a repeater (physical address = x.y.1...255 / no media coupler function), take note that after the physical address is programmed, a repeater can no longer be reached directly via the TP side. As a result, further programming operations using the ETS (e.g. programming the application program) can no longer be executed on the TP side without the media coupler.

Direct access to the device via the TP side is only possible again when the device is reset to delivery state (see page 27).

4.2.3 Functional description

4.2.3.1 Function as media coupler

Line coupler or area coupler

A media coupler, depending on the physical address, can either be added to the KNX topology as a backbone coupler or, alternatively, as a line coupler. With KNX RF, there is generally no physical limitation of the number of possible bus subscribers as in a TP line (e.g. 64). With KNX RF, the number of subscribers is only limited by the physical addresses assigned in the ETS.

- Media coupler as line coupler
  The media coupler has a physical address in the form **x.y.0** (x = TP area address, x = TP line address / e.g. "1.1.0").
  A KNX RF line can contain up to 256 devices (including media coupler) (figure 2). The media coupler is connected to the main TP line of an area. Additional TP lines can be set up using additional TP line couplers.

i There may only ever be one media coupler in an RF line. Multiple repeaters can be added to an RF line.

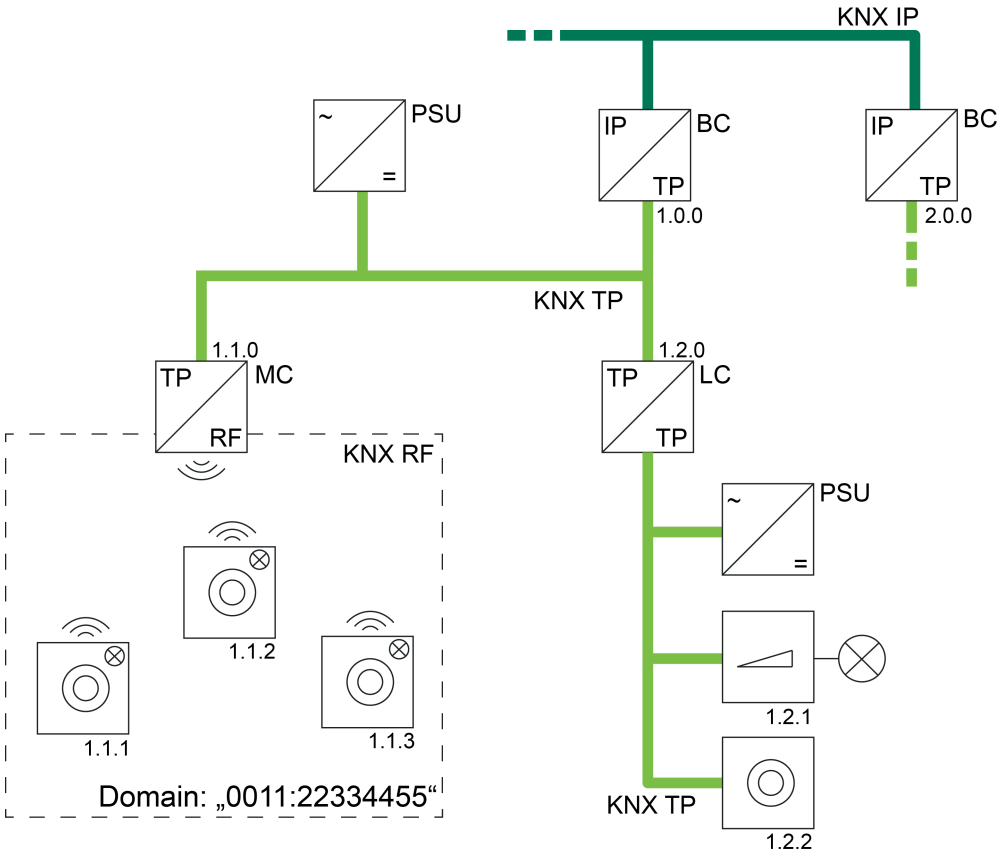

Figure 2: Example of a possible KNX topology with RF, TP and IP lines
Media coupler as line coupler

MC Media coupler as line coupler (TP, RF)
LC Line coupler (TP)
BC Backbone coupler (as IP router / TP, IP)
PSUPower supply (TP)

- Media coupler as backbone coupler
  The media coupler has a physical address in the form **x.0.0** (x = TP area address / e.g. "1.0.0").
  If a media coupler is used as a backbone coupler, then a total of up to 4,081 RF devices (including media couplers) can be integrated into the appropriate area. The RF devices must then divide themselves up on the backbone line and on up to 15 additional subordinate RF lines (figure 3). In the ETS, a maximum of 255 subscribers may exist for each area or line. If the media coupler is a backbone coupler, then the backbone must possess the media type "TP". A KNX IP environment cannot then be implemented (the ETS prevents such a topology)!

i Even in an RF area, there may only be one media coupler (subordinate RF lines do not possess their own media coupler).

i Subordinate RF lines of an RF area always have the same domain address as the area itself.

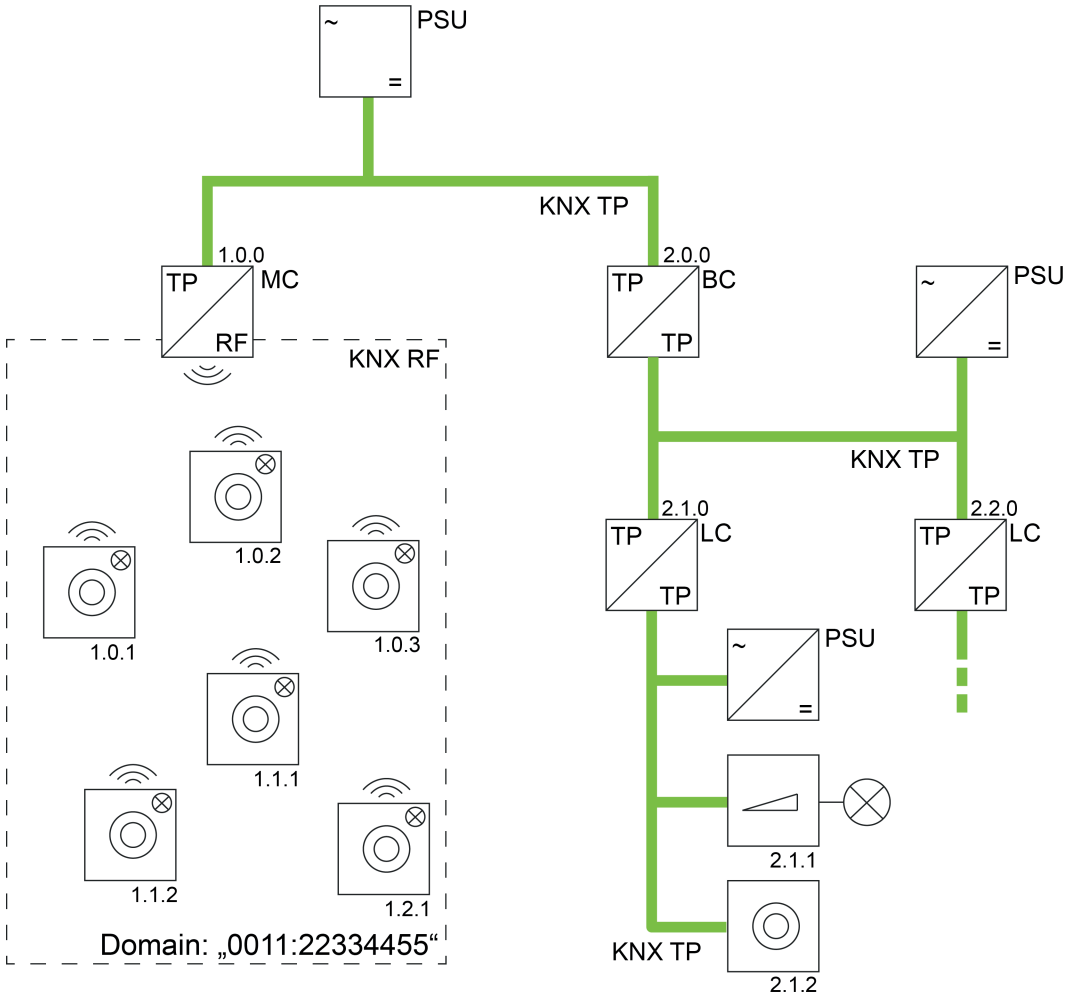

Figure 3: Example of a possible KNX topology with RF and TP lines
Media coupler as backbone coupler

MC Media coupler as backbone coupler (TP, RF)
LC Line coupler (TP)
BC Backbone coupler (TP)
PSUPower supply (TP)

Different RF domains in one KNX installation

Devices in different RF domains must be topologically divided into two different lines or backbones, each with their own domain addresses. These different areas or lines must also contain their own media couplers for the devices to be able to communicate with one another, irrespective of the line. The logical connection between two or more KNX RF environments is thus always made via media couplers and higher-level TP or IP lines (figure 4).

KNX RF USB data interfaces, as used in the ETS, are also assigned to a domain address. In consequence, only RF devices of the same domain can be commissioned directly by radio telegram. Only group telegrams and physically addressed telegrams of the appropriate RF domain are recorded in the group monitor of the ETS (exception: System broadcast telegrams). If other RF devices of another domain are to be contacted with an RF data interface, then communication via media couplers is necessary. If the KNX topology is set up correctly, then such communication takes place automatically via the KNX routing (precondition: media and backbone/line couplers forward the telegrams according to their filter property).

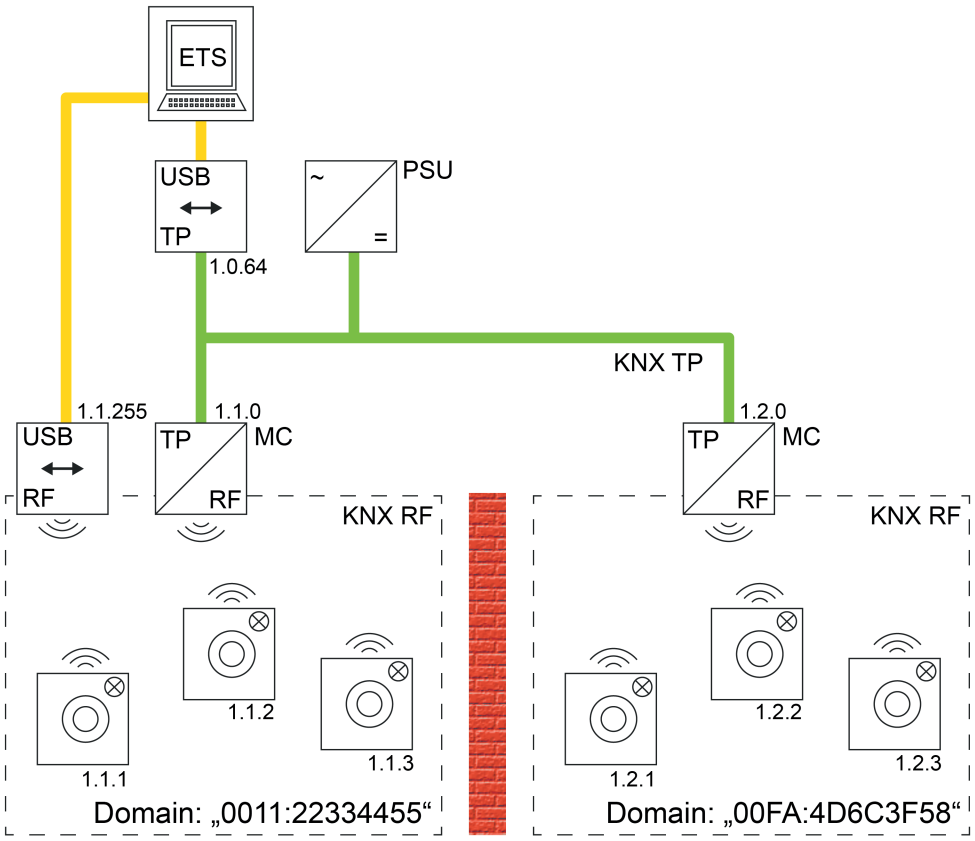

Figure 4: Example of a possible KNX topology with two RF lines and coupling via a TP main line (example)

- In general, multiple media couplers can be used in various lines and areas of a KNX topology. The ETS permits such a configuration. However, media couplers in a shared KNX system can influence each other unfavourably. In particular, during the commissioning of various bus devices using the ETS, radio telegrams may be superimposed, meaning that radio communication is poor or even impossible. Suitable precautions can be taken to avoid such a situation (spatial separation of the RF environments, logical filtering of specific telegrams).
- Media couplers cannot be used to network two or more KNX installations via RF (no proxy function)!

RF areas or lines of a joint KNX installation or of directly adjacent KNX installations in radio range may never have an identical domain address! The ETS offers a function for random assignment of a domain address for RF lines, in order to avoid this improper situation. When the random function is used, the probability of multiple assignment of an identical address is more or less non-existent. A domain address automatically generated by the ETS is characterised by the hexadecimal characters "00FA..." (e.g. "00FA:4D6C3F58").

Routing counter and telegram repeat counter (expert knowledge)

In a TP telegram, the routing counter identifies how often the telegram has already been forwarded by the area or line coupler, or the TP line amplifier. The routing counter is a 3-bit counted measurand (values 0...7) which is reduced by "1" for every forwarding process via the coupler or line amplifier. As soon as a bus device sends out a new telegram, the routing counter is given the value "6". Through the permissible KNX topology with area couplers, line couplers and line amplifiers can, and are permitted to, forward the telegram a maximum of 6 times. Telegrams for which the routing counter is given the value "0" are no longer forwarded via the coupler or TP line amplifier.
The routing counter value "7" is a special case which is not used by normal bus devices. Telegrams with this value are always forwarded. The value is not reduced thereby.

With the KNX RF, the routing counter is replaced by the telegram repeat counter ("RF repeat counter"). When a transmitter sends a new telegram for the first time, it is given the repeat value "6". As soon as a repeater receives this telegram and forwards it, the value is reduced by "1". For each additional repetition process via another repeater in the same RF domain, the repeat value is again reduced by "1". Once the value is "0", the telegram is no longer repeated. With this process, an RF telegram can be forwarded through a maximum 6 repeaters in one domain. Only repeaters are permitted to influence the telegram repeat counter.

During forwarding on the RF side, a media coupler always replaces the routing counter of a received TP telegram with the telegram repeat counter and the value "6". It is irrelevant which value the routing counter has.
Likewise, during forwarding on the TP side, the media coupler always replaces the telegram repeat counter of received RF telegrams with a routing counter and the value "6", regardless of which value the telegram repeat counter had before.

Telegrams that are forwarded via a media coupler via the TP side to the RF side cannot be returned to the TP side by any other media coupler. This is prevented by the "Route-Last" flag, which is set during the forwarding process and forwarded in the RF telegram.
This limitation is important for system broadcast telegrams which are not dependent on any domain. Therefore a system broadcast generated by a media coupler cannot be mistakenly returned to the TP side by other media couplers.

4.2.3.2 Function as repeater

Media couplers with repeater or repeater alone

The media coupler can work as an repeater (also, "retransmitter") in addition to or as an alternative to its function as a coupler. A repeater repeats the radio telegrams received in its RF line by retransmitting them immediately. This allows an extension of the range of a KNX RF installation, meaning that it is possible to position RF devices as required in a building, even in the case of difficult transmission and reception conditions.

The device can only work as a media coupler (see page 15), as a media coupler with repeater or as a repeater alone. The operating mode is defined by the parameter setting and the physical address. The device is exclusively a repeater when it has a physical address which corresponds to a normal participant address of the RF line (e.g. x.y.1 or x.y.200 / x = area address, y = line address).

- Function as media coupler with repeater:

  The device has a physical address in the form x.y.0 and works as a media coupler (see page 15). In addition, the repeater function can be released with the setting "activated" for the parameter "Repeater function for use as media coupler". The parameter "Physical address of the device" must be configured to "x.y.0 (media coupler)".

  Combined operation of the media coupler and repeater function is helpful if, within a radio domain, all the RF subscribers are within radio range of the media coupler but are not however in the radio ranges of other RF subscribers. Here, the repeater integrated in the central media coupler ensures that telegrams from RF subscribers also actually reach all the other RF subscribers of the radio domain.

  Application example (figure 5): Because of the spatial distance, no direct communication between the two RF devices (1.) is possible. The communication route via the media coupler with repeater function (2.), however, enables communication between the two devices without interference.

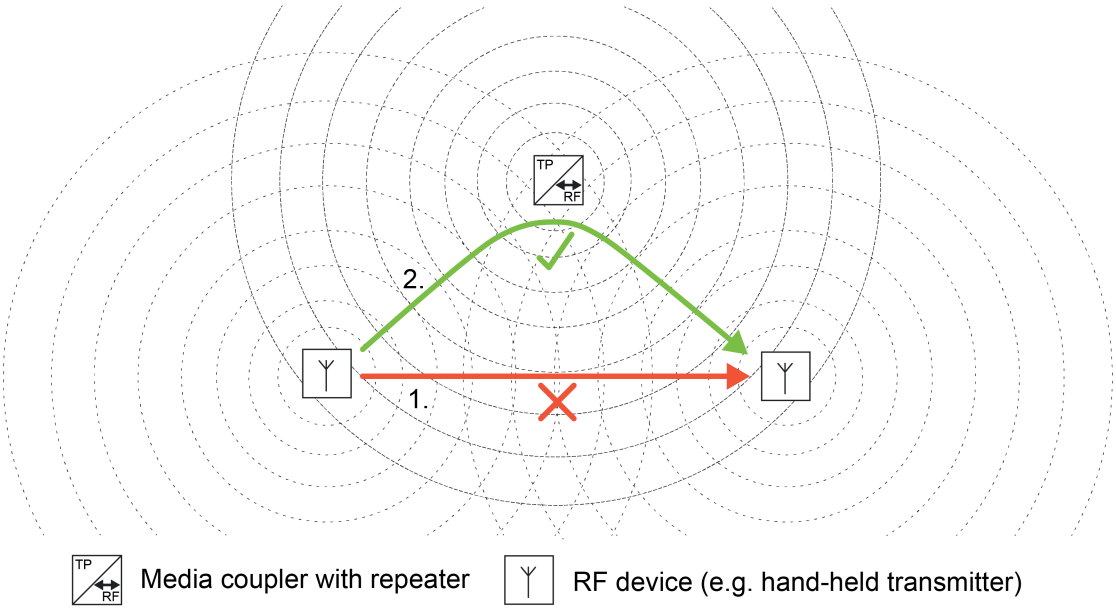

Figure 5: Application example of a media coupler with repeater function

- In combined operation, the repeater function is executed parallel to the media coupler function (routing). The device acts as if the media coupler and the repeater were two separate devices in the same housing and shared the same RF transmitter.
- The integrated repeater does not repeat telegrams which are forwarded to the RF side by the media coupler function and transmitted there.

- Function as a repeater alone:

  The device has a physical address in the form x.y.1...255. In this case, the media coupler function is completely switched off. The device does not perform any routing and thus does not have any parameters for configuring filter properties. The parameter "Physical address of the device" must be configured to "x.y.1...255 (RF repeater)".

  The operation of one or more repeaters is recommended when the range of the RF domain should be deliberately extended in one or more directions (e.g. in trans-property communication), or when a part of a building (e.g. ceilings, walls, metal constructions) which weakens the signal need to be overcome.

  Repeaters can be positioned around the media coupler in a star formation (figure 6), ideally within the radio ranges of other/adjacent repeaters of the same RF domain, or also oriented in a strand configuration (figure 7), e.g for overcoming greater distances in a deliberate direction.

- Using a maximum 2 repeaters in one RF domain (see application examples) is recommended to prevent communication problems due to forwarded telegrams. Communication problems due to forwarded telegrams can occur when repeaters are not positioned to each other within their own reception area, but still affect identical devices (e.g. hand-held transmitters) in the same RF domain independently of each other. In this case, therefore, the radio ranges of the repeaters overlap for some RF devices, but not at the installation location of the repeater. If only two repeaters are used in one RF domain, the likelihood of communication problems due to repeated telegrams is reduced.
  The ETS permits integration of up to 255 repeaters in one domain. Nonetheless, because of the RF data protocol, one RF telegram can only be forwarded a maximum of six times. Thus, use of more than 2 repeaters in one RF domain would be possible in principle.
- After the physical address is programmed, a repeater can no longer be reached directly via the ETS, because the TP transponder of the device is switched off. This feature is necessary because from a topological standpoint, a repeater (without media coupler function) is exclusively assigned to the RF line, and no longer to a TP line. As a result, further programming operations using the ETS can no longer be executed on the TP side without the media coupler. Direct access to the device via the TP side is only possible again when the device is reset to delivery state (see page 27).
  Further information on commissioning is available in the chapter "Commissioning" in this documentation (see page 9).

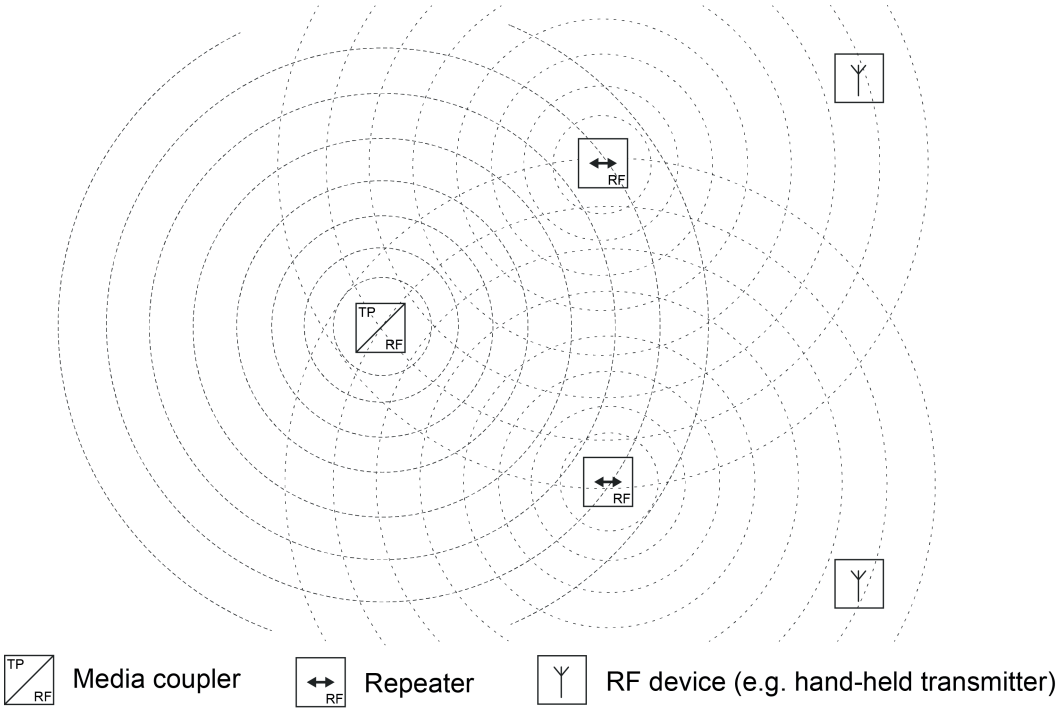

Figure 6: Application example 1: two repeaters in a star configuration

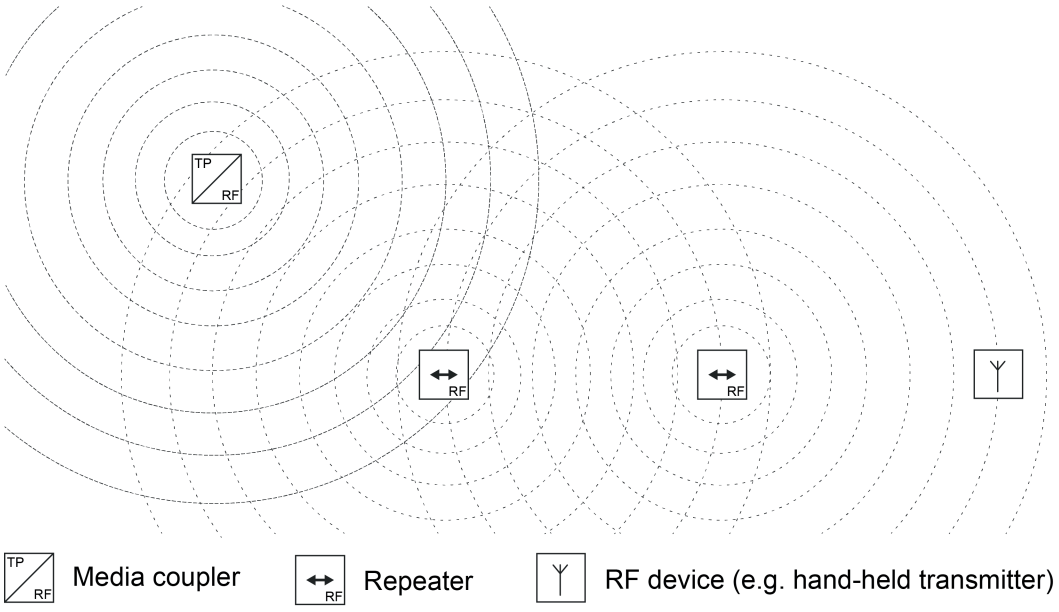

Figure 7: Application example 2: two repeaters in a strand configuration

Function in detail (expert knowledge)

To prevent radio collisions, according to applicable KNX specifications, after an RF telegram has been received repeaters are permitted to retransmit more quickly than normal RF devices

without repeater function (telegram pause time of the repeater = 5...15 ms, normal RF device = 15...30 ms). As a result, repeated telegrams from repeaters persist temporally in the RF medium (as a result, they have a higher transmission priority). Because of the listen-before-talk function, normal RF devices can recognize that repeaters are transmitting repeated telegrams and delay their own transmission requests until the radio channel is free again.
In addition, like all other RF devices, a repeater waits for a short random interval at each transmission request before a radio telegram is actually transmitted and thereby repeated. This random time is of different length for each transmission operation. Consequently, radio collisions in combination with listen-before-talk are largely suppressed to accommodate the possibility that there are several repeaters in one RF domain which, so to speak, want to transmit at the same time. The principle of this collision avoidance is only expedient when all repeaters in one RF domain are positioned within radio range of each other.

One repeater essentially repeats all RF telegrams from its own domain which it has not already transmitted itself, in addition to always repeating all system broadcast telegrams. Telegram repetitions are not forwarded to the TP side via a media coupler if the coupler has already forwarded the original telegram previously. Moreover, repeated telegrams also do not appear in the group or bus monitor of the ETS when telegram recording with a KNX RF USB data interface takes place.
These specific modes of action are made possible by extending the RF telegram structure and evaluating special telegram characteristics, as explained in the following:

On a KNX RF, in addition to the physical and domain addresses of the transmitter, a telegram is also given an LFN (Line layer Frame Number). This LFN is a 3-bit counted measurand (value 0...7) which, starting at "0" for each new telegram, is counted up with value overrun by "1" by each transmitter (example, hand-held transmitter: press ON button -> LFN = 0, press ON button again -> LFN = 1, press OFF button -> LFN = 2 etc.). Repeaters do not change the LFN value when repeating telegrams.

In addition, an RF telegram is also given a telegram repeat counter (similar to the routing counter for a TP telegram / also"RF repeat counter"). When a transmitter sends a new telegram for the first time, it is given the repeat value "6". As soon as a repeater receives this telegram and forwards it, the value is reduced by "1". For each additional repetition process via another repeater in the same RF domain, the repeat value is again reduced by "1". Once the value is "0", the telegram is no longer repeated. With this process, an RF telegram can be forwarded through a maximum 6 repeaters in one domain. Only repeaters are permitted to influence the telegram repeat counter.

Because the last received telegrams and the evaluations of the LFN and the telegram repeat counter for newly received telegrams are saved internally, media couplers and all other RF devices can recognize whether a telegram has already been received and processed or not, despite of its identical user data content. This internal saving also permits repeaters to recognize whether they themselves have already forwarded the received telegram and therefore do not need to do so again.

i The domain address of an RF telegram and the LFN can be displayed in ETS group or bus monitors under "Medium Info".

4.2.3.3 LED display

The media coupler has a two-colour status LED. This LED displays device statuses in normal operation and during commissioning or maintenance.

The following display functions have been implemented:

- LED lights red:
  Programming mode is active. Programming mode is activated by pressing the programming button or by using the ETS. Programming mode is deactivated after the physical address has been successfully programmed, or is generally deactivated by a device test (power failure, ETS programming process of the application program). Programming mode is also deactivated automatically after 4 minutes if none of the above events occurs.

- LED flashes slowly red:
  Safe-state mode is active (see page 25).

- LED flashes red quickly (only in operation as media coupler):
  Filter function has not been configured (filter table has no function). This display is dependent on the parameter settings of the media coupler. If the parameter "Telegrams TP -> RF group telegrams" and/or "Telegrams RF -> TP group telegrams" is configured to "forward unfiltered" and the device is started up with this parameter setting, the status LED flashes red quickly. This is a sign that the filter table has no function.

  i This state should only be configured in a KNX installation within the context of system commissioning. During normal operation of a KNX system after commissioning, it is always recommended to activate the filter function of the group telegrams in both communication directions. This is realised by the parameter settings "filter" (default setting) or "lock".

- LED flashes yellow:
  This display function also depends on the parameter settings. The parameter "Function of the yellow status LEDs" defines how the display acts (see parameter table).

- LED briefly changes between red and yellow:
  Device test at a device restart after power is restored or after an ETS programming process.

The priority of the described display functions is fixed. Programming mode has the highest display priority. As a result, when programming mode is active, the red lighting of the status LED overrides all other display functions.
Safe-state mode has the second-highest display priority. The slow red flashing of the safe-state mode overrides the quick red flashing of the filter function display (third display priority) and this, in turn, overrides the yellow status function (fourth display priority).

4.2.3.4 Configuration lock

Function of the configuration lock

By using the ETS, the media coupler can be programmed and commissioned either via the TP side (e.g. with a suitable KNX TP USB or IP data interface) or as an alternative, via the RF side (e.g. with a KNX RF USB data interface). As needed, it is also possible to prevent programming access to the device depending on the medium and so prevent changes to the configuration. This allows unwanted programming attempts (e.g. for unauthorised manipulation) to be suppressed to a great extent.

- Locking or forwarding group telegrams, physically addressed telegrams and broadcast telegrams (routing) are not affected by the configuration lock. With the safe-state mode, the configuration lock can be temporarily cancelled in media coupler operation (see page 25).
- If the device is working exclusively as a repeater (physical address x.y.1...255), it is only possible to program the application program and read out device information via the RF side! Thus, the configuration lock is always active on the TP side. In this case, the lock cannot even be released in safe-state mode.
  Only changing the physical address back to x.y.0 ends the pure repeater operation and makes the device a media coupler again, whereupon the configuration lock can be configured.
- The configuration lock is deactivated on the device in delivery state.

Setting up the configuration lock

The parameter "Configuration via" determines whether the configuration lock is active and to which media it applies.

- Set the parameter to "TP and RF".

  The media coupler can be programmed and read out for diagnostic purposes from the TP or RF side with no limitation.
- Set the parameter to "only TP".

  The media coupler can only be programmed and read out via the TP side. Physically addressed connections reaching the device via the RF side are not responded to. Nor does the device respond to RF broadcast telegrams.
- Set the parameter to "only RF".

  The media coupler can only be programmed and read out via the RF side of the corresponding domain. Physically addressed connections reaching the device via the TP side are not responded to. Nor does the device respond to TP broadcast telegrams.

4.2.3.5 Safe-state mode

Function of the safe-state mode

If the device does not work as intended, e.g. as a result of errors in the project design or during commissioning, the execution of the loaded application program can be halted by activating the safe-state mode. In safe-state mode, essential functions of the device are deactivated. Only the ETS diagnosis function can be executed, and it is still possible to program the device.

When safe-state mode is active, the device acts as follows:

- No group telegrams, physically addressed telegrams or broadcast telegrams are forwarded (the routing is inactive).
- The repeater function is inactive (no RF telegrams are repeated).
- The configuration lock is inactive.
- The status LED flashes red slowly.

If the device is working exclusively as a repeater (physical address x.y.1...255), it is only possible to program the application program and read out device information via the RF side! Thus, the configuration lock is always active on the TP side. In this case, the lock cannot even be released in safe-state mode.
Only changing the physical address back to x.y.0 ends the pure repeater operation and makes the device a media coupler again, whereupon the configuration lock can be configured.

Activating the safe-state mode

Safe-state mode is activated by pushing the programming button and disconnecting and reconnecting the device power supply.

- Disconnect the device connection terminals or switch off the power supply.
  The device does not function.
- Press and hold down the programming button.
- Reconnect the device connection terminals or switch the power supply back on.
  The device restarts. The status LED lights red briefly and then yellow. Then the status LED flashes red slowly.
- Release the programming button as soon as the status LED starts flashing red slowly.
  Safe-state mode is active.

Deactivating safe-state mode

Safe-state mode is deactivated via the ETS or by disconnecting and reconnecting the device power supply.

Precondition: Safe-state mode is active.

- Reset the device via the ETS (restart).
  or
- Program the physical address with the help of the ETS.
  or
- Disconnect the device connection terminals or switch off the power supply.
- Wait about 3 s.
- Reconnect the device connection terminals or switch the power supply back on.
  Safe-state mode is deactivated.

A programming process of the application program via the ETS does not end the safe-state mode, because there is no automatic restart.

4.2.3.6 Delivery state

Function in delivery state

In delivery state, the device is ready for operation as a media coupler. The device works as follows with the configurations below:

- Physical address: 15.15.0
- Domain address: $FF FF FF FF FF FF
- Configuration lock: inactive
- Repeater function during use as media coupler: deactivated
- Function of yellow status LED: deactivated
- Filtering group telegrams (TP -> RF, RF -> TP): Filter (because no filter table has been loaded, group telegrams are not forwarded)
- Filtering broadcast telegrams (TP -> RF, RF -> TP): Forward unfiltered
- Filtering physically addressed telegrams (TP -> RF, RF -> TP): Filter (TP-> RF forwarding physical addresses of line 15.15)
- Repetitions in case of TP transmission errors: yes
- Telegram confirmation on TP line: only if transmitted

Reset delivery state (master reset)

The device can be reset to delivery state at any time, even without using the ETS.

i A reset to delivery state is useful when, for example, the device was mistakenly commissioned with the physical address x.y.1...255, so the repeater is active. In pure repeater operation, the device can no longer be programmed via the TP side. In this case, a reset to delivery state is helpful in allowing the TP to be reprogrammed.

- Disconnect the device connection terminals or switch off the power supply.

  The device does not function.
- Press and hold down the programming button.
- Reconnect the device connection terminals or switch the power supply back on.

  The device restarts. The status LED lights red briefly and then yellow. Then the status LED flashes red slowly.
- Release the programming button as soon as the status LED starts flashing red slowly.

  Safe-state mode is active.
- Press the programming button again and hold it down for 20 s.

  The status LED goes out. The device resets to delivery state.
- Release the programming button.

  The status LED lights red-> yellow briefly. The device is in delivery state.

4.2.4 Parameters

Description	Values	Comment
☐↵ Configuration		
Physical address of device x = area y = line		Depending on the physical address the device can be inserted either as a media coupler or, alternatively, as an RF repeater in the KNX topology. Already the physical address assignment and programming define the device function. The following parameter must also be configured for the appropriate use.
	x.y.0 (media coupler)	The device works as media coupler. Depending on the allocated physical address, the media coupler operates as either an area or a line coupler. The device operates as a line coupler when it has a physical address in the form x.y.0 (x = TP area address, x = TP line address / e.g. "1.1.0"). Then the media coupler is connected to the main TP line of an area. The device operates as an area coupler when it has a physical address in the form x.0.0 (x = TP area address, e.g. "1.0.0"). In this case, the backbone must be media type "TP". ⓘ There may only ever be one media coupler in an RF line.
	x.y.1...255 (RF repeater)	The device operates exclusively as a repeater, without media coupler function. A repeater repeats the radio telegrams received in its RF line by retransmitting them immediately. This allows an extension of the range of a KNX RF installation, meaning that it is possible to position RF devices as required in a building, even in the case of difficult transmission and reception conditions. ⓘ Repeaters working in an identical RF domain must have the same area address (x) and line address (y). Multiple repeaters can be added to an RF line.
Repeater function when used as media coupler	**deactivated** activated	In media coupler function mode, the device can also repeat telegrams from its own RF domain. Like in an independent repeater mode, this allows the range of a KNX RF installation to be extended, meaning that it is possible to position RF devices as required in a building even in the case of difficult transmission and reception conditions.

Function of yellow status LED	**deactivated**	The yellow status function is permanently deactivated.
	flashes on telegram forwarding TP <-> RF	The status LED lights up yellow briefly for each forwarded telegram. This function is only available during operation as media coupler.
	flashes on telegram reception at TP	The status LED only lights up yellow briefly when a group telegram, broadcast telegram or physically addressed telegram is received on the TP side. This function is only available during operation as media coupler.
	flashes on telegram reception at RF (own domain)	The status LED only lights up yellow briefly when a group telegram, broadcast telegram or physically addressed telegram with the domain name of the associated RF domain is received on the RF side.
	Flashes on telegram reception at RF (all domains)	The status LED only lights up yellow briefly when an arbitrary group telegram, broadcast telegram or physically addressed telegram is received on the RF side. In this case, telegrams of all KNX RF domains are displayed. i With the settings "flashes for telegram reception on RF (own domain)" and "flashes for telegram reception on RF (all domains)", the status LED also lights up yellow briefly when system broadcast telegrams are received.
Configuration via		By using the ETS, the media coupler can be programmed and commissioned either via the TP side (e.g. with a suitable KNX TP USB or IP data interface) or as an alternative, via the RF side (e.g. with a KNX RF USB data interface). As needed, it is also possible using this parameter to prevent programming access to the device depending on the medium and so prevent changes to the configuration. This allows unwanted programming attempts (e.g. for unauthorised manipulation) to be suppressed to a great extent.

ⓘ Locking or forwarding group telegrams, physically addressed telegrams and broadcast telegrams (routing) are not affected by the configuration lock. With the safe-state mode, the configuration lock can be temporarily cancelled in media coupler operation (see page 25).

TP and RF — The media coupler can be programmed and read out for diagnostic purposes from the TP or RF side with no limitation.

only TP — The media coupler can only be programmed and read out via the TP side. Physically addressed connections reaching the device via the RF side are not responded to. Nor does the device respond to RF broadcast telegrams.

only RF — The media coupler can only be programmed and read out via the RF side of the corresponding domain. Physically addressed connections reaching the device via the TP side are not responded to. Nor does the device respond to TP broadcast telegrams.

ⓘ If the device is working exclusively as a KNX RF repeater, it is only possible to program the application program and read out device information via the RF side! In this case, the parameter "Configuration via" is permanently set to "only RF".

☐↵ Selection

Telegrams TP -> RF

Group telegrams — This parameter determines whether group telegrams are forwarded from the higher-level TP line to the lower-level RF line (routing TP -> RF).

transmit unfiltered — All group telegrams will be transmitted. The filter table will be disregarded. This setting influences the behaviour of the red status LED. As soon as this parameter is set to "forward unfiltered", the status LED flashes red quickly.

		ⓘ This setting should only be selected in a KNX installation within the context of system commissioning. During normal operation of a KNX system after commissioning, it is always recommended to activate the filter function of the group telegrams in both communication directions. This is realised by the parameter settings "filter" (default setting) or "lock".
	block	All group telegrams will be blocked. No group telegram can pass the media coupler from TP to RF.
	filter	In accordance with the filter table generated and programmed in the ETS, group telegrams are either transmitted or blocked selectively.
Broadcast telegrams		This parameter determines whether broadcast telegrams are forwarded from the higher-level TP line to the lower-level RF line (routing TP -> RF).
	transmit unfiltered	All broadcast telegrams are transmitted.
	block	All broadcast telegrams are blocked. No broadcast telegram can pass the media coupler from TP to RF.
physically addressed telegrams		This parameter determines whether physically addressed telegrams are forwarded from the higher-level TP line to the lower-level RF line (routing TP -> RF).
	transmit unfiltered	All physically addressed telegrams are transmitted.
	block	All physically addressed telegrams are blocked. No physically addressed telegram can pass the media coupler from TP to RF. This means no RF devices in the media coupler domain can be programmed via the TP side!
	filter (depending on target & coupler address)	Only physically addressed telegrams with a target address matching the media coupler area or line address are forwarded. All other physically addressed telegrams are blocked.
Telegrams RF -> TP		
Group telegrams		This parameter determines whether group telegrams are forwarded from the

		lower-level RF line to the higher-level TP line (routing RF -> TP).
	transmit unfiltered	All group telegrams will be transmitted. The filter table will be disregarded. This setting influences the behaviour of the red status LED. As soon as this parameter is set to "forward unfiltered", the status LED flashes red quickly. i This setting should only be selected in a KNX installation within the context of system commissioning. During normal operation of a KNX system after commissioning, it is always recommended to activate the filter function of the group telegrams in both communication directions. This is realised by the parameter settings "filter" (default setting) or "lock".
	block	All group telegrams will be blocked. No group telegram can pass the media coupler from RF to TP.
	filter	In accordance with the filter table generated and programmed in the ETS, group telegrams are either transmitted or blocked selectively.
Broadcast telegrams		This parameter determines whether broadcast telegrams are forwarded from the lower-level RF line to the higher-level TP line (routing RF -> TP).
	transmit unfiltered	All broadcast telegrams are transmitted.
	block	All broadcast telegrams are blocked. No broadcast telegram can pass the media coupler from RF to TP.
physically addressed telegrams		This parameter determines whether physically addressed telegrams are forwarded from the lower-level RF line to the higher-level TP line (routing RF -> TP).
	transmit unfiltered	All physically addressed telegrams are transmitted.
	block	All physically addressed telegrams are blocked. No physically addressed telegram can pass the media coupler from RF to TP. This means no TP or IP devices can be programmed via the RF side (media coupler domain)!
	filter (depending on target & coupler address)	Only physically addressed telegrams with a target address which does not match the media coupler area or line

address are forwarded. Physically addressed telegrams with a target address matching the media coupler area or line address are blocked.

Repetitions in case of TP transmission errors

Group telegrams — no **yes**

A group telegram transmitted by the media coupler on the TP side is checked for transmission errors. This parameter determines whether the forwarded telegram is to be repeated up to three times when a BUSY or a NACK confirmation signal is received, or when there is no ACK confirmation signal on the higher-level TP line.

Broadcast telegrams — no **yes**

A broadcast telegram transmitted by the media coupler on the TP side is checked for transmission errors. This parameter determines whether the forwarded telegram is to be repeated up to three times when a BUSY or a NACK confirmation signal is received, or when there is no ACK confirmation signal on the higher-level TP line.

physically addressed telegrams — no **yes**

A physically addressed telegram transmitted by the media coupler on the TP side is checked for transmission errors. This parameter determines whether the forwarded telegram is to be repeated up to three times when a BUSY or a NACK confirmation signal is received, or when there is no ACK confirmation signal on the higher-level TP line.

i Deactivating the telegram repetition if there are transmission errors reduces the bus load, but also reduces the transmission security!

Telegram confirmation on TP line

Group telegrams

At this point, it is possible to define when the media coupler confirms the group telegrams received on the higher-level TP line.

	always	The media coupler always confirms, on the higher-level TP line, every group telegram received.
	only if transmitted	The media coupler confirms, on the higher-level TP line, only those group telegrams forwarded on the lower-level RF line.
physically addressed telegrams		At this point, it is possible to define when the media coupler confirms the physically addressed telegrams received on the higher-level TP line.
	always	The media coupler always confirms, on the higher-level TP line, every physically addressed telegram received.
	only if transmitted	The media coupler confirms, on the higher-level TP line, only the physically addressed telegrams forwarded on the lower-level RF line.

i Broadcast telegrams are always confirmed on the TP line by the media coupler when they are received.

5 Appendix

5.1.1 The KNX RF system

Introduction

The Jung KNX RF system (RF = Radio Frequency) is based on a manufacturer-independent KNX radio standard (868 MHz), with which existing KNX systems can be refitted or new installations can be expanded simply using RF components. Mobile hand-held transmitters allow easy operation of the intelligent KNX building functions via "remote control". KNX radio wall transmitters can be mounted anywhere in which a control panel is required, no matter whether that is on stone, concrete, wood or glass walls or on the surfaces of furniture.
KNX RF devices can be connected to wired KNX installations using media couplers. Additionally or alternatively, suitable RF actuators can be activated and evaluated directly by RF transmitters. Whilst TP or RF actuators are located where cables are present, cables are not relevant during the mounting of KNX radio wall transmitters and hand-held transmitters, as these Jung RF transmitters are battery-operated.
KNX RF components possess a transmit and receive module and are thus bidirectional. This means that it is possible, for example, to implement status displays on the RF control panels, in addition to the operating function, or to allow status feedback for actuators. In addition, bidirectional communication makes ETS commissioning possible.

Jung KNX RF hand-held transmitters and KNX radio wall transmitters are battery-operated. To prolong the life of the battery, the devices possess an energy-saving mode. After the last operation or after an ETS programming operation, the devices switch automatically to the energy-saving mode (semi-bidirectional operation) after a settable time. The devices temporarily have no function. If an RF device is in energy-saving mode, this mode must be actively terminated before a programming operation by the ETS is possible. This can usually be done by pressing a button or the programming button. The same applies to the unloading of the application program or reading out of the device information by the ETS.

i If energy-saving mode is active, the receiver of a semi-bidirectional RF device is switched off. In consequence, the device cannot receive any telegrams, meaning that status changes of group addresses cannot be tracked. In the case of hand-held transmitters or radio wall transmitters which are configured to the button function "Switching - TOGGLE", it can thus be necessary to press the button up to twice for the switching command (ON -> OFF / OFF -> ON) to be switched correctly.

i The ETS requires the user to press the programming button if no direct access to the devices is possible due to an active energy-saving mode.

Jung KNX RF devices correspond to the KNX standard "KNX RF1.R S-Mode". Devices of other manufacturers, which meet the same standard, are intercompatible. Frequently, for marketing reasons, different names or product designations are used for the same KNX RF system. The designations named below usually indicate, if necessary also in combinations, products of the same KNX standard.

- KNX RF1.R S-Mode
- KNX RF Ready S-Mode
- KNX RF 868 MHz
- KNX RF+

Approval and frequency use

KNX RF (KNX RF1.R) uses a frequency from the Europe-wide SRD band (SRD = Short Range Device). Low-power radio applications are used in this approval-free frequency range. Besides KNX RF, these include, for example, radio remote controllers, wireless microphones and headphones or other simple data transmission systems. KNX RF devices are generally approved and can thus be used in all the states recognising the standards and directives of the European Union. In general, these include the EU and EFTA states.

The frequency band at 868 MHz as used by the KNX RF has good characteristics in buildings with respect to the signal distribution, since the attenuation due to walls, concrete reinforcements and metal parts keeps within reasonable limits.

Frequency	Transmission capacity	Application (example)
26.9 ... 27.2 MHz	≤ 10 mW	PC devices, babyphones, model radio
40.6 ... 40.7 MHz	≤ 10 mW	Model radio
433.05 ... 434.79 MHz	≤ 10 mW	Motor vehicle remote controls, headphones, weather stations
446.0 ... 446.2 MHz	≤ 500 mW	PMR radio equipment
868.0 ... 868.6 MHz	**0.5 ... 25 mW**	**KNX RF**

Overview of standard SRD frequency bands

Besides the SRD frequency bands, there are additional frequency ranges provided for other radio services from different areas of application (e.g. analogue and digital audio and video transmission systems, Wi-Fi, Bluetooth). The division into frequency ranges according to the approved application is required for the range of different radio services to coexist and not interfere with one another.
The frequency range used by KNX RF is not exclusively available to the KNX radio service. In this frequency range too, there may be radio systems existing in parallel in a building, which have an influence on signal transmission. Through the joint use of a frequency range, it is possible that interference between the various radio services can occur, meaning the loss of transmitted information.

i Besides available third-party radio services, other devices emitting electromagnetic waves (e.g. electrical machines, electronic ballasts and lighting, microwave ovens) may be potential sources of interference for KNX RF systems. This is then particularly problematic when the named devices are located in direct proximity to KNX RF devices.
For this reason, sources of interference in immediate proximity to KNX RF devices during the planning of the electrical installation are to be avoided as far as possible.

Frequency	Transmission capacity	Application (example)
868.0 ... 868.6 MHz	≤ 25 mW	Including radio alarm systems, garage door openers, eNet
2.40 ... 2.48 GHz	≤ 100 mW	WLAN, Bluetooth
5.725 ... 6.875 GHz	≤ 1,000 mW	WLAN

Overview of standard radio services in the same and neighbouring frequency ranges to KNX RF (also not SRD)

With KNX RF1.R, the mean frequency is specified as 868.3 MHz. Transmission power in the range 0.5...25 mW is possible. The system makes a communication channel available for all devices. The transmission time of each device (Duty-Cycle) is 1 % (maximum transmission time 0.6 seconds in one minute). This avoids continuous transmissions, meaning that the transmission channel is not permanently blocked.

Control of media access

When it wishes to transmit a KNX telegram, each KNX RF transmitter checks whether the radio channel is already occupied by another RF transmitter (LBT: Listen Before Talk). If this is the case, the RF transmitter waits with the required radio transmission. It transmits its own telegram as soon as the radio channel is free again.
In addition, each RF transmitter waits for a short random interval on each transmission request, before the radio telegram is actually transmitted. This random time is of different length for each transmission operation. This suppresses to a great extent radio collisions between devices which actually wish to transmit simultaneously (e.g. media couplers, which have received a group telegram to be forwarded via the TP side), in combination with LBT.

The described transmission method for controlling media access generally prevents radio collisions in a KNX RF environment, but cannot exclude them completely. For example, it may occur that, in the case of a transmission between an RF transmitter (A) and an RF receiver (B), there is an additional RF transmitter (C), which is located within the range of the RF receiver, but cannot reach the other RF transmitter due to the spatial distance (figure 8). In such a case, the two RF transmitters are unable to detect when the other transmits radio signals (Hidden Station Problem). In consequence, radio collisions can occur on the receiver located in the range of the two RF transmitters.

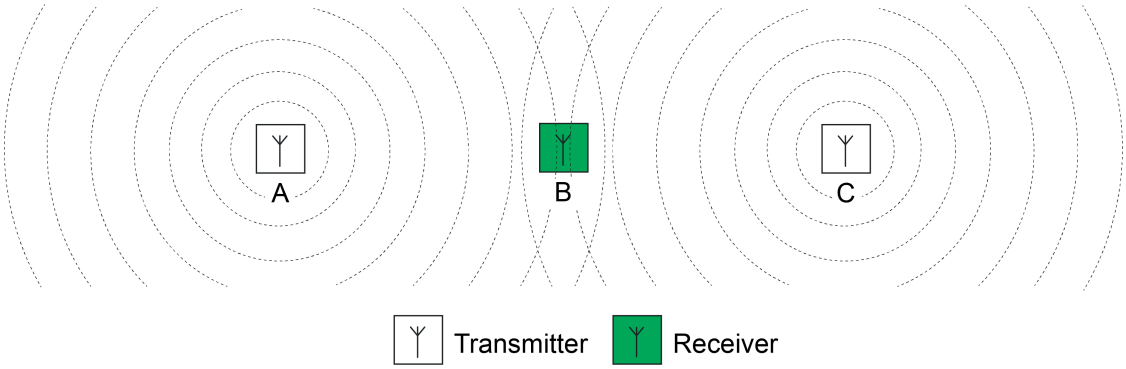

Figure 8: Radio collisions on the receiver due to the transmitter being too far away

The described effect is system-dependent and can be a particular problem when there are two or more media couplers in a KNX system. If the media couplers are out of the other's range, then they cannot detect whether another media coupler is already transmitting a group telegram. However, the KNX subscribers in the various RF lines can be located in such a way that they are in the overlap areas of the RF domains of the couplers. In consequence, the subscribers receive the colliding telegrams of multiple media couplers (figure 19).

This circumstance must already be taken into account during the planning of a KNX RF system.

- If possible, position media couplers in such a way that they are within direct reception range of each other.
- Structurally decouple RF domains in such a way that their subscribers are only positioned in their own RF environment.
- Use repeaters instead of media couplers, if this is wise from a structural and topological point of view. Repeaters should be located within the range of the media coupler and also within the ranges of other repeaters.

i If complete separation of RF domains or the integration of media couplers into their radio ranges cannot be guaranteed structurally, then it may be better to create only one radio domain instead of multiple media couplers and to work with repeaters.

Expert knowledge:
With KNX TP (TP = Twisted Pair), the bus access of a subscriber is controlled by the CSMA/CA method (Carrier Sense Multiple Access/Collision Avoidance). This bus access method avoids telegram collisions. In addition, received telegrams are confirmed by each addressed TP bus subscriber (telegram confirmation through LinkLayer-Confirm: Ack, Busy, Nack). This allows transmitters of KNX messages to detect whether potential receivers have understood the message or whether telegram repetitions are necessary due to transmission or processing errors.
These security mechanisms are not available within a KNX RF1.R radio domain, due to the specifications. If there are transmission errors, media couplers, which forward RF telegrams to the TP side, can repeat telegrams up to three times. Telegrams forwarded on the RF side are only transmitted once.
Media couplers can perform a telegram confirmation on the TP line for received telegrams. As described, this is not possible for telegrams received on the RF side.

5.1.2 Basic physical principles

Electromagnetic wave

Radio waves are waves of coupled electrical and magnetic fields (figure 9). Electromagnetic waves are emitted by antennas into the surrounding area as free progressive waves. They do not require a special medium for radiation. In a vacuum, radio waves radiate at the speed of light. The radiation is always slower in other media. Like light, electromagnetic waves are subject to deflection, refraction, reflection, polarisation and interference.

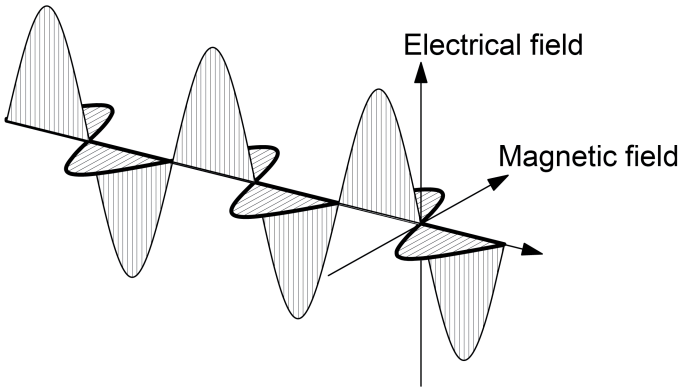

Figure 9: Model of an electromagnetic wave in an open space

Electromagnetic waves radiate out in a straight line in every direction. If multiple electromagnetic waves meet, then they will be superimposed. With KNX RF, the radio signals come from almost every direction (through the positioning of the transmitters and due to reflections). If KNX RF radio waves are superimposed, then noise is created (signal with an unspecific frequency spectrum) in the communication channel, which can no longer understood by any KNX RF receiver. This can cause transmitted information to be lost.
Therefore, when planning a KNX RF environment, various specifications must be taken into account. The chapter "Building structure and RF topology" in this documentation provides more detailed information on this.

Information transmission with radio signals

An electromagnetic wave of a constant amplitude and frequency does not yet carry any information. To make this possible, the transmitter must change the amplitude or the frequency of the wave continuously according to an agreed method and the carrier signal must modulate the information in this manner. With KNX RF, the modulation type "Frequency key shifting" (FSK = engl. Frequency Shift Keying) is used (figure 10). Frequency key shifting is a variant of frequency modulation (FM) and suitable for the transmission of digital information. Two time-coded signals of a different frequency are transmitted, in order to inform the receiver of the logical states "0" and "1". Frequency key shifting is impervious to interference. Even major transmission losses in signal amplitude do not have a negative effect on the demodulation of the transmitted information.

For KNX RF, the data rate is 16.384 kBit/s. Manchester encoding is used to apply the "0" and "1" information to the radio signal. This allows very easy synchronisation of the transmitter and receiver.

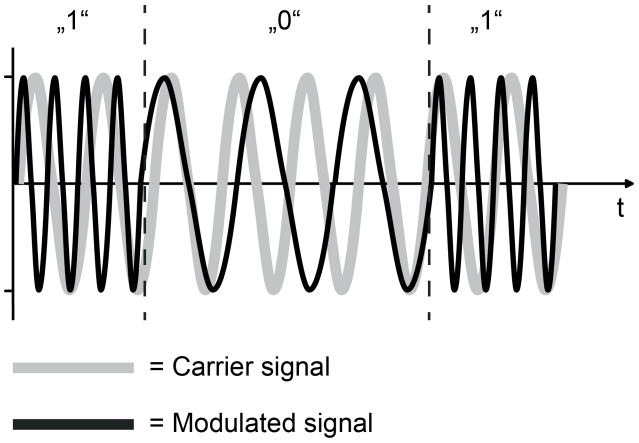

Figure 10: Frequency key shifting as a modulation method (FSK = Frequency Shift Keying)

Radiation and attenuation of radio signals in buildings

Radio waves with a frequency used for KNX RF can penetrate ceilings or walls in a building. Depending on the mass (thickness) and conductivity (metallic component, humidity), this is connected with a greater or lesser energy loss. This loss of transmission energy is also called attenuation (ratio of transmitted and received radio radiation power).
Radio signals are attenuated by various influences on their journey between the transmitter and receiver. The precondition for comprehension between the transmitter and receiver is, of course, that the radio signals of the transmitter still have sufficient energy on reaching the receiver for the receiver to be able to evaluate the signals.

Almost ideal radiation conditions for electromagnetic radio signals exist in the free-field. The term "Free-field" refers to a free area, in which radio waves can radiate out more or less unhindered and interference effects from structures or obstacles have no influence.
If walls and ceilings must be penetrated on the transmission path, then the attenuation - and thus the radio range - is primarily dependent upon the number, type and consistency of the construction materials to be penetrated and on the effective wall and ceiling thicknesses. Part of the incidental radio radiation is reflected on the limit areas and a further part is absorbed. Moist materials, as is found in new buildings or recently renovated rooms (newly-papered or plastered) attenuate electromagnetic radio waves to a greater extent.

Material (dry)	Material thickness	Transmission
Wood, plaster, plasterboard *, glass **	< 30 cm	90...100 %
Brick, chipboard plates	< 30 cm	65...95 %
Reinforced concrete	< 30 cm	10...70 %
Metal grid	< 1 mm	0...10 %
Metal, aluminium cladding	< 1 mm	0 %

*: no metallic stand
**: without metallisation or wire inlay, no leaded glass

Take the attenuation factors of a building into account when selecting the mounting locations of KNX RF devices (hand-held transmitters, radio wall transmitters, media couplers). Take into account too that each KNX RF device is both a transmitter and a receiver on account of the bidirectionality (e.g. hand-held transmitters with or without LED status display and media couplers are transmitters and receivers in the same way).

Position of transmitters (e.g. hand-held transmitter, pushbutton sensor)

Position of possible receivers (e.g. media coupler)

In reception field

Not located favourably in reception field

Not in reception field

Attenuated signal path

Figure 11: Attenuation of the radio signal in buildings through walls and ceilings
Example 1: "Edge position of the transmitter" (simplified depiction)

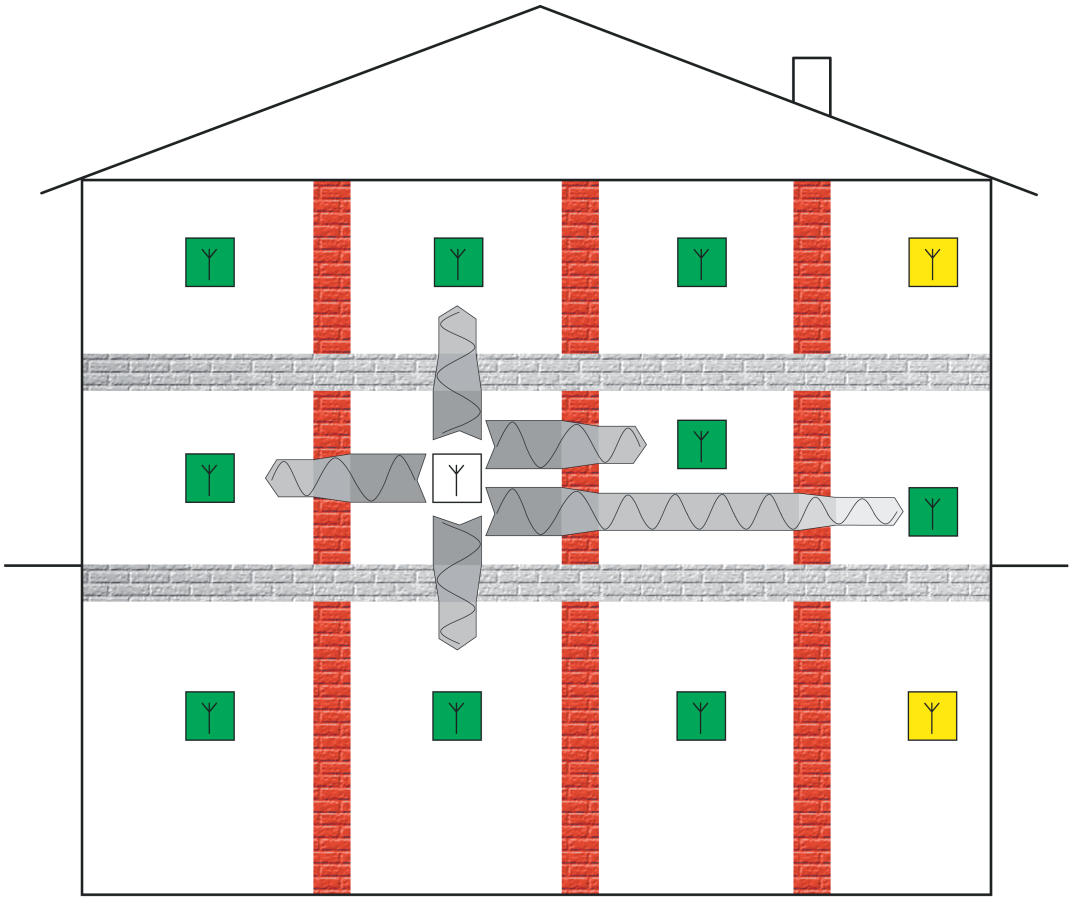

Figure 12: Attenuation of the radio signal in buildings through walls and ceilings
Example 2: "Central position of the transmitter" (simplified depiction)

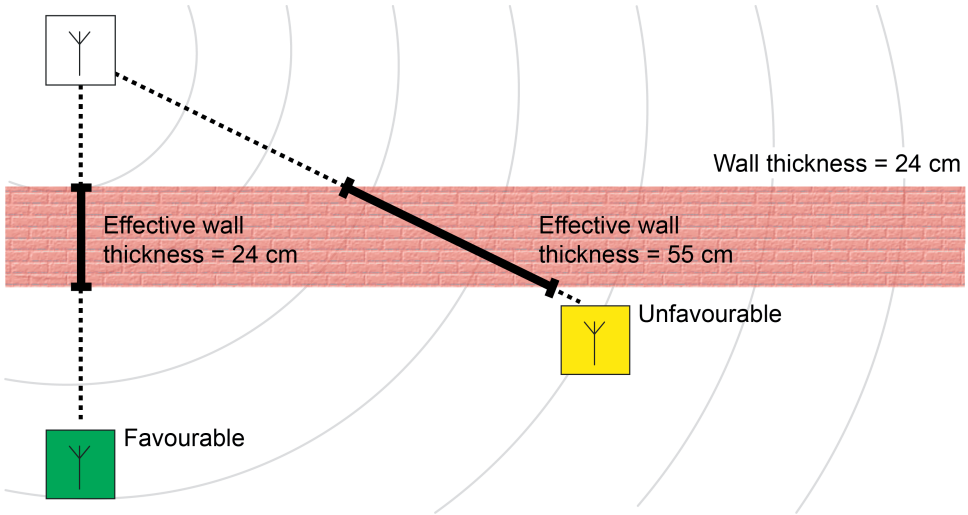

Figure 13: Attenuation through effective wall or ceiling thickness

- Care is required when a building is equipped with shielding materials to reduce electromagnetic waves. Flush-mounted appliance boxes with a conductive coating are not usually suitable for radio products. Special shielding plasters and plasterboard protection plates, into which conductive fibres are worked, reduce the permeability of radio waves by up to 95%. The same applies to stands, into which high level of metallic components (e.g. supporting parts, metallise insulation material) are integrated.
- Due to the wide range of influences, it is difficult to evaluate radio sections in buildings. Eventually a manufacturer of radio products - also of other systems such as Wi-Fi - cannot make any binding statement on the range of radio transmission in buildings. For this reason, the free-field range is always stated, which refers to an uninterrupted radiation of the radio waves and optimally aligned antennas. Provided that there are no special measures for shielding in buildings, this means that targeted radio transmission should be possible.

Additional attenuation in a building or in a more or less free field (outdoors) is created when the antenna of the transmitter or receiver is mounted at a low ground height. KNX RF radio sensors and actuators should therefore be mounted as far from the ground as possible.
The mounting of a transmitter or receiver in the ground (e.g. in a suitable installation box) should be avoided, particularly outdoors. The radio range would be restricted to such an extent that radio transmission would scarcely be possible.

- We recommend installing KNX radio wall transmitters at a standard mounting height of 1.05...1.50 m.

Electrically conductive materials cannot be penetrated by electromagnetic waves. Metallic components of buildings, e.g. furniture or steel reinforcement rods in concrete (figure 14), but also metallic design frames or design parts with metallic coatings thus have a shielding effect. Metallic shieldings can also be used consciously to keep an area free of radio waves.

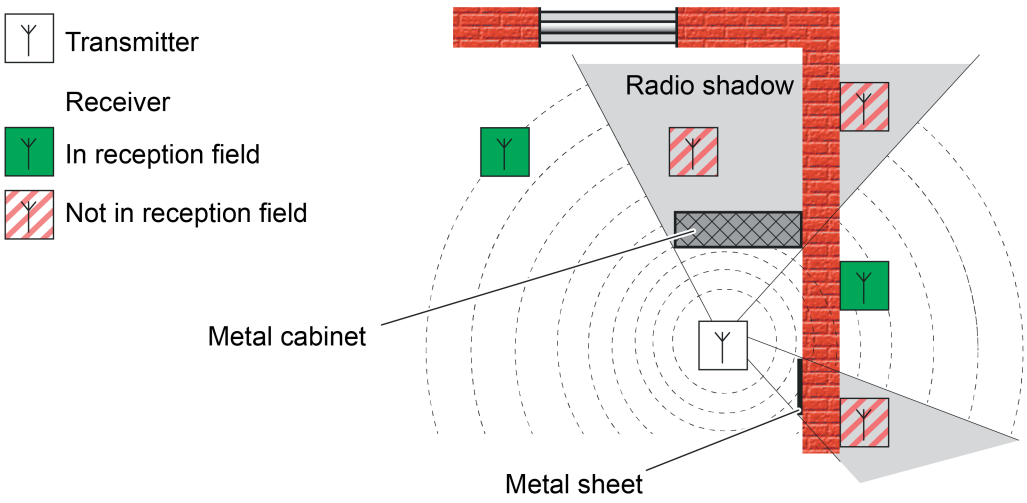

Figure 14: Radio shadow in a building due to metallic parts (idealised)

Radio waves reach the receiver both directly (through the air) and also via diversions (multiple route radiation). Such diversions are created by reflections of the radio waves at boundary layers to other materials, e.g. on the surfaces of walls or ceilings. Radio waves of an identical

source are at the receiver with a differing phase location. In many cases, the reflected radio power is too small to influence the direct path of the radio wave in any significant way. A receiver can then receive the signal of the transmitter without any interference (figure 15).

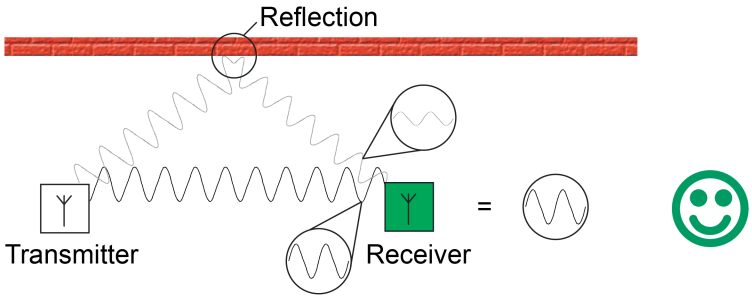

Figure 15: Interference has no effect on the receiver

However, in the worst case, the waves received directly and via reflection are superimposed unfavourably at the target location, creating a signal which receivers can no longer evaluate reliably (figure 16). Positive and negative superposition of radio waves pointing the same way is also termed interference.

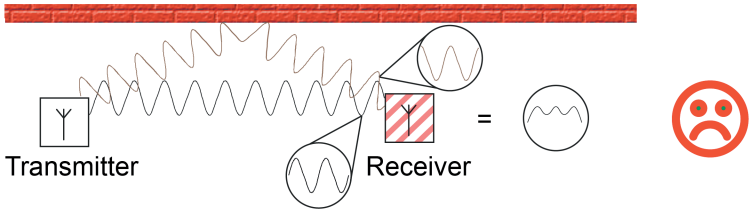

Figure 16: Interference at the receiver prevents reception

Effects from reflections can also be used positively in a building. If possible, RF devices, or their transmission and reception antennas, can be installed horizontally or vertically in the same alignment, as the radio wave also swings in the appropriate direction (polarisation). If antennas are aligned in different ways, then the signal available at the receiver is weakened and thus the maximum radio range is reduced. The weakening of the signal can be of such magnitude that a receiver can no longer receive any output radiated directly from the transmitter. However, in practical terms, reflections may cause a rotation of the polarisation direction, meaning that the reflected signal reaches the receiver in a weakened form and can also be understood there (figure 17).

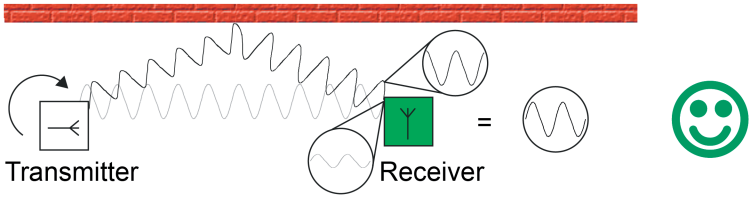

Figure 17: Reflection allows reception through a change of polarisation

In practice, reflection and interference effects can frequently be changed or used beneficially through a slight change in the installation location or the installation environment.

i With KNX radio wall transmitters, only vertical mounting of the device on walls or objects ensures the alignment of the internal antenna. If all the radio wall transmitters are mounted in the same way, then, in consequence, all their antennas are aligned to one another.

Influence of KNX RF on the human body

For many decades, radio waves have been used intensively for radio and global communication. In particular, the new communication media for wireless telephony (UMTS, LTE, DECT) and network communication (Wi-Fi, Bluetooth) are now being used widely in homes and in industry. However, other electrical devices radiate electromagnetic waves, e.g. microwave ovens.
The use of radio waves is regulated by the state. The assignment of frequency ranges and the specification of limit values ensure that there are no health impacts for people and different radio services do not influence one another. In particular, with regard to the number of electrical applications, wireless computer networks, mobile radio telephones and radio services, it must be established that the radio load of multiple KNX RF installations in parallel remains negligible.

Selecting installation location

If possible, the mounting locations of KNX RF devices must be evaluated during the planning of the electrical installation. Concrete ceilings with metal reinforcements attenuate radio radiation to a greater extent than wooden ceilings. The same applies for mineral plasters or hollow walls on the basis of a metallic stand. Room use should also - if known - be taken into account, because a living room in an existing building offers fewer obstacles to radio radiation than an office with metallic cabinets.

A KNX RF media coupler should ideally be positioned in the centre of an RF installation (domain) to allow low-loss and thus interference-free communication with all the corresponding RF devices. The housing of the media coupler is compact, meaning that it can be installed simply in standard flush-mounted appliance boxes (ideally in cavity walls) or surface-mounted appliance boxes (e.g. in suspended ceiling constructions).

General rules on the mounting of KNX RF devices (transmitters, receivers and media couplers).

- Avoid shadows, reflections, extinguishing of radio signals as far as possible. For this, note the structural conditions (supporting metallic parts, metal reinforcements, metallic wall and ceiling panelling, metal-coated panes of glass / heat protection glazing).
- Do not mount the transmitter and receiver near the earth or ground.
- Align unmoveable devices to each other as identically as possible, so that the internal transmission and reception antennas are polarised identically.
- Position the antenna of the media couplers so that they are as straight (stretched out, unkinked) or as circular as possible in the box.
- Ensure a distance to larger metallic surfaces, e.g. doors, frames, aluminium shutters, ceiling panelling, distribution cabinets, insulating films, ventilation grilles, is maintained.
- Ensure the penetrations of walls and ceilings are as short as possible.
- Do not place KNX RF devices in small metallic distributors or appliance boxes.
- Maintain a distance to electromagnetic interference, e.g. electronic ballasts, motors, Tronic transformers, microwaves.
- Maintain a distance to other radio sources, e.g. wireless telephones, radio headphones, WiFi routers.

i During mounting, particularly of media couplers, ensure that the devices are accessible after this.

5.1.3 Building structure and RF topology

Introduction

KNX RF1.R makes a shared communication channel available for all devices. Radio communication, which only has one transmission and reception channel available, can be subject to interference by third-party radio services in the same frequency range or by the same system. Even a second KNX RF line in the same or a neighbouring KNX installation can invoke communication faults in a building. The transmission methods used for KNX RF (LBT: Listen Before Talk) are not always sufficient for ensuring interference-free communication in every case.

A communication fault can occur, for example, when two or more RF environments exist in a building, which do not have an identical radio range and only overlap. For example, in installations with two or more media couplers where the couplers are at some distance from one another. If the media couplers are out of the other's range, then they cannot detect whether another media coupler is already transmitting a group telegram. However, the KNX subscribers in the various RF lines can be located in such a way that they are in the overlap areas of the RF domains of the couplers. In consequence, it is possible that subscribers will receive the colliding telegrams of multiple media couplers. On RF devices, a symptom of such a fault could be that individual telegrams are lost (e.g. control command is not received, there is no status feedback).

- Usually, the random delay in transmitting RF telegrams ensures that media couplers on the same TP backbone or main line are unable to simultaneously transmit telegrams to their RF lines during forwarding. Jung media couplers guarantee this function.
  However, media couplers of other manufacturers can be used, which forward a group telegram received from the TP side to the appropriate RF lines almost simultaneously due to their filter properties, after the couplers have determined that the radio channel is free. In these cases, telegram collisions occur very frequently during the operation of a KNX RF system. For this reason, we recommend you always use Jung media couplers.
- Simultaneous transmission of radio telegrams when multiple Jung wall transmitters or hand-held sensors are actuated is not possible, as these devices always keep to a varying random time when transmitting. A telegram collision is only excluded by device operation in normal operation, even if a button-press takes place almost simultaneously on multiple control panels.
  An absolutely simultaneous reaction to system telegrams (broadcast) or group read telegrams (Read flag set on more than just one subscriber) is not possible on Jung KNX RF devices.

With more than two RF lines in a KNX installation, communication problems can become so great that secure data transmission, and thus a fault-free function of the KNX system, is not possible, either temporarily or continually. For this reason, key conditions are to be checked already during building planning and the planning of the KNX topology and the requirements for the installation and configuration of the KNX RF devices are to be taken into account.
This chapter describes in detail all the key aspects to do with the building structure and the ETS integration of KNX RF devices.

Building structure

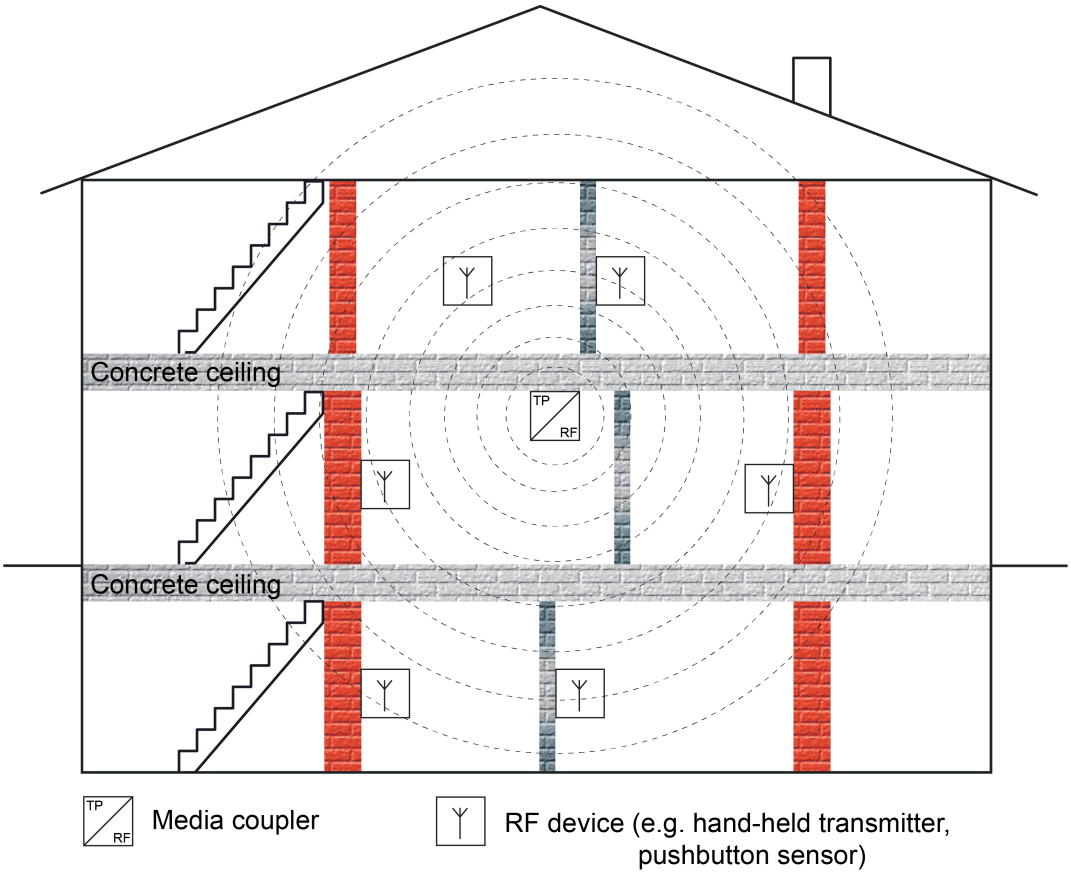

Figure 18: Building with a KNX RF line (example)

The frequency band at 868 MHz as used by the KNX RF has good signal radiation in buildings, since the attenuation due to walls, concrete reinforcements and metal parts close to the transmitter keeps within reasonable limits. This is positive when - for example in a detached house - one storey or even multiple storeys are to be covered with one and the same RF line. The media coupler should then be positioned as close to the centre of the building as possible(figure 18).

The good signal radiation may be a disadvantage in real estate if the RF lines influence each other physically, are only partially within their radio ranges due to a small spatial distance or through insufficiently large attenuation due to wooden ceilings or thin walls (figure 19). Here, it is wise not to create two or more RF lines (each with their own media couplers), but to use repeaters which increase the radio range of one RF line (figure 20). Here too, the media coupler should be positioned as close to the centre of the building as possible.
Repeaters should ideally be located on the edges of the building although still within the range of the media coupler and also within the ranges of other repeaters.

Jung media couplers can only work as media couplers, as media couplers and repeaters or only as repeaters. The operating mode is defined by the parameter setting and the physical address of the media coupler. The functional description of the media coupler describes this in more detail.
Combined operation of the media coupler and repeater function is helpful if, within a radio domain, all the RF subscribers are within radio range of the media coupler but are not however in the radio ranges of other RF subscribers. Here, the repeater integrated in the central media coupler ensures that telegrams from RF subscribers also actually reach all the other RF subscribers of the radio domain.

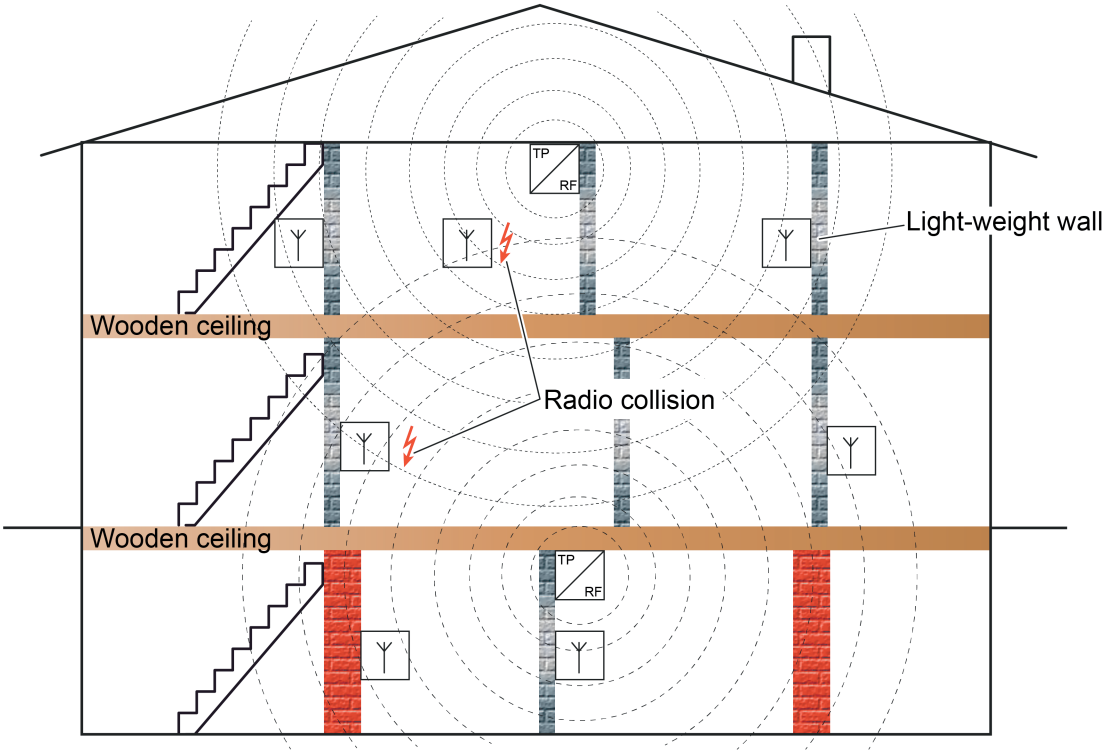

Figure 19: Building structure with two KNX RF lines, disadvantageous influence (example)

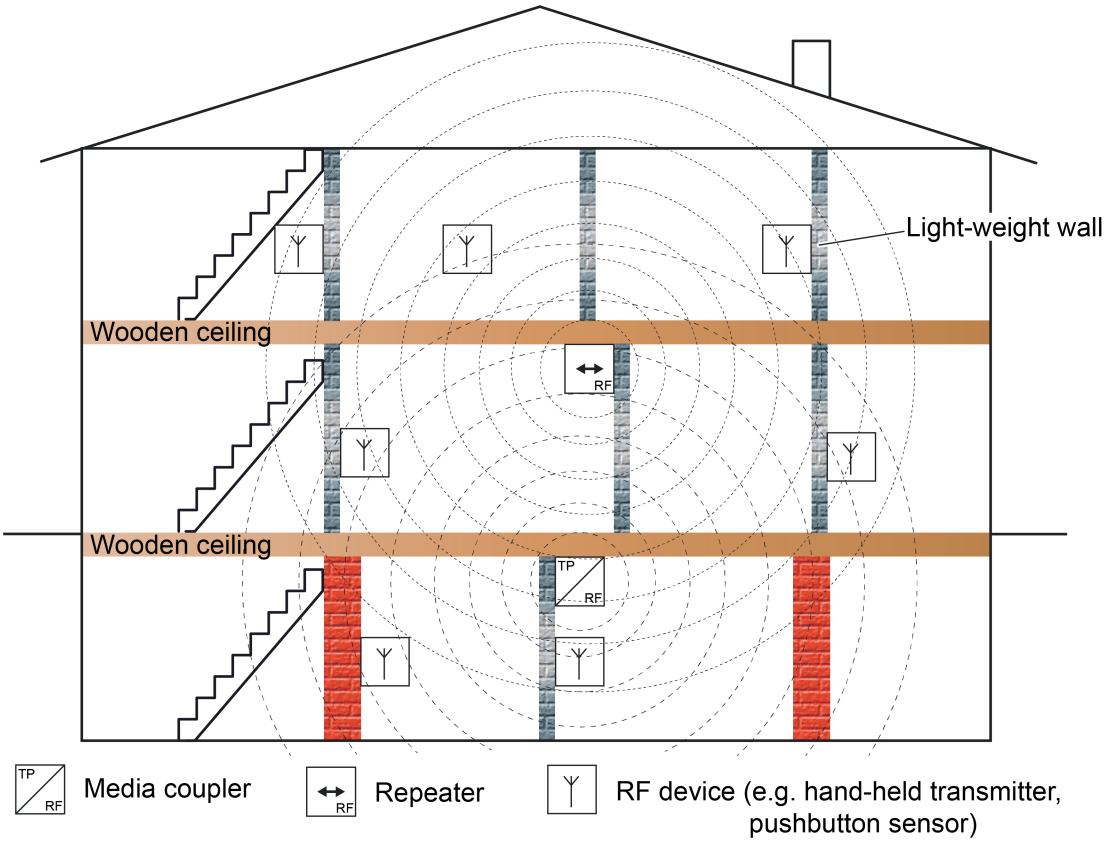

Figure 20: Building structure with one KNX RF line and repeater (example)

The use of more than one RF line is wise in large or extensive buildings or building sections, as the RF lines can then be separated sufficiently from one another, meaning that they no longer have a negative influence on one another. Different RF lines, each with their own media couplers, can also be used in smaller buildings (e.g. detached houses) or in apartment buildings, if the building structure and the consistency of the ceilings and walls shields the individual RF areas sufficiently (figure 21). Underfloor heating can, for example, provide sufficient attenuation of the radio signals in the vertical direction. In the long-distance range, solid, supporting walls can make a positive contribution to achieving sufficiently large attenuation of the radio signals.

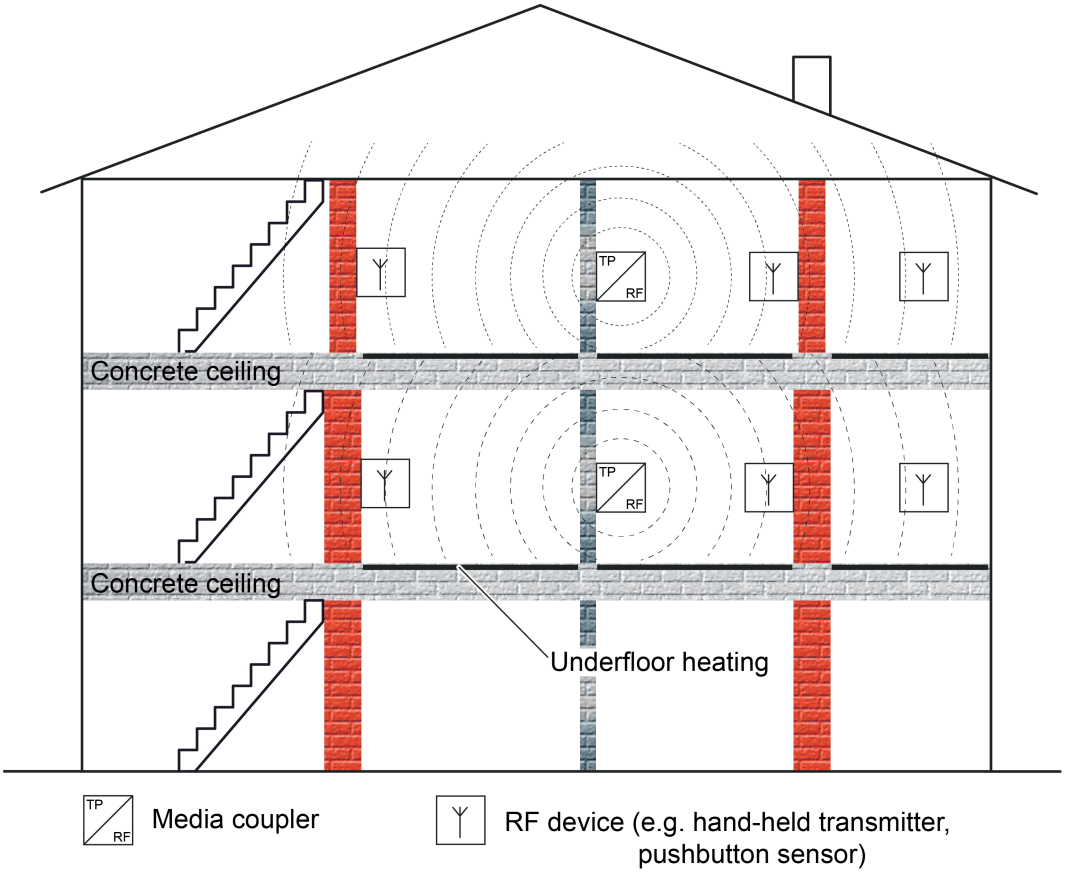

Figure 21: Building structure with two KNX RF lines, which do not influence each other negatively due to the building consistency (example)

A media coupler can also be used outdoors (if necessary as a repeater) in a suitable installation socket (ideally plastic AP WG), in order to make the KNX RF signals available directly between buildings or to amplify them. This means that KNX RF devices can be used outdoors - if the consistency of the buildings allows it - or in separate buildings (e.g. shed) (figure 22).

Ideally, a repeater can also be used for signal amplification and the elimination of radio shadow through metallic furnishings or substances in the interior of the building.

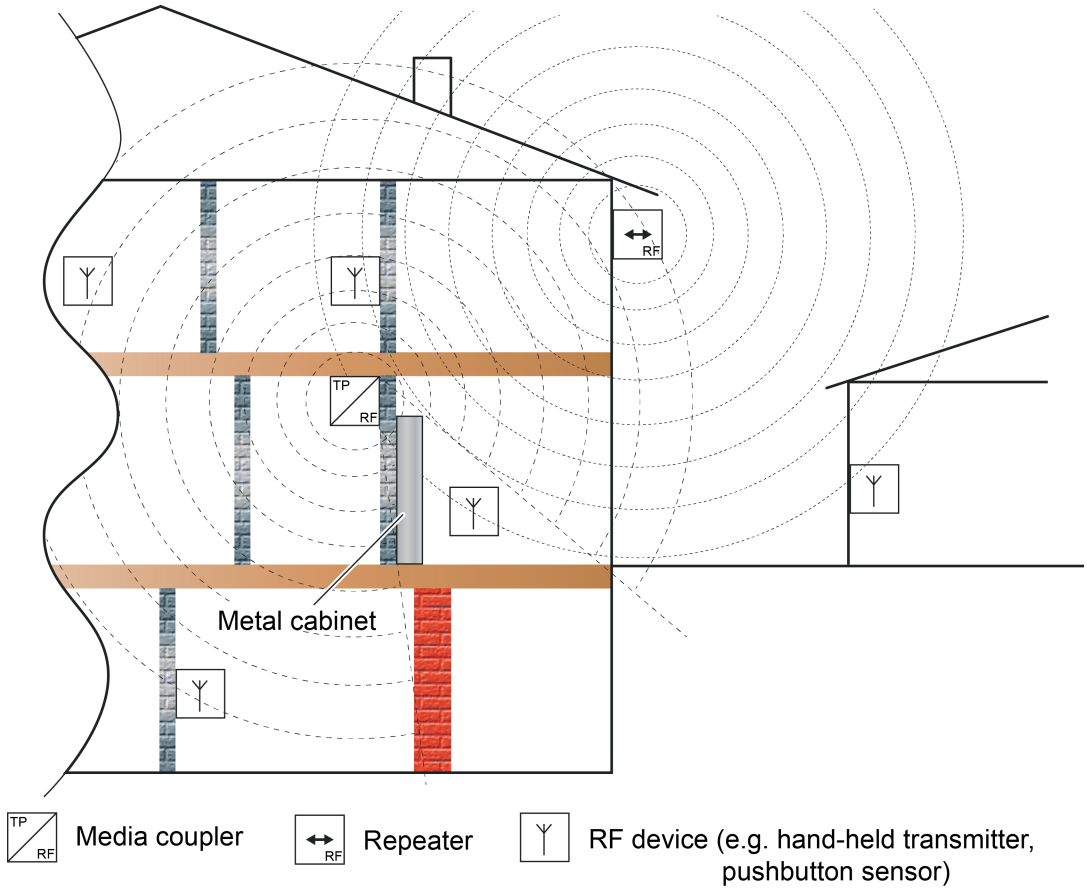

Figure 22: Use of a media coupler as a repeater for signal amplification and elimination of radio shadow for indoor and outdoor applications

Domain address for KNX RF

The radio range of KNX RF devices cannot be determined exactly in spatial terms. KNX RF telegrams cannot be limited to one specific KNX installation. Radio telegrams pass through the borders of buildings and plots of land and can be received by devices installed in neighbouring KNX systems. For this reason, it is important that different KNX RF installations are delimited topologically and thus logically from one another. The domain address helps here.

In accordance with the topology defined in the ETS project, devices assigned to the RF lines also always receive a domain address, in addition to the physical addresses. Only devices with the same domain address can communicate with each other within an RF environment. As a result, a media coupler must always have the same domain address as all the devices in its subordinate RF line.

i The domain address is defined in the ETS for each RF line or for each RF area. If an area is set to the media types "RF", then all the subordinate RF lines automatically receive the same domain address in the ETS.
The ETS programs the domain address automatically into the RF devices when the physical address is programmed.

i A domain address is 6 bytes long and is entered in the ETS in hexadecimals or generated automatically. After the first 2 bytes, the input notation requires a colon (when read from the left). For example, a domain address could look like this: "0011:22334455" or "00FA:4F5B3122".

i KNX RF systems always influence each other physically when they are spatially located in each other's radio range and two or more transmitters transmit more or less simultaneously, which is perfectly possible. Radio telegrams can be superimposed. In this case, the receivers can no longer evaluate the affected radio telegrams. For more information on the transmission property and superposition of RF telegrams, refer to the chapter "Basic physical principles" in this documentation.

RF topology and ETS

Media couplers are the link between a specific KNX RF environment and a wired KNX TP installation. With regard to the routing property of telegrams, media couplers function like standard KNX TP backbone/line couplers. This means that RF devices can communicate with TP or IP devices and vice-versa.
Media couplers possess filter settings and filter tables. The physical address defines whether a media coupler is a line coupler or a backbone coupler.

Optionally, the Jung media coupler can additionally or alternatively work as an repeater. A repeater repeats the radio telegrams received in its RF line by retransmitting them immediately. This allows an extension of the range of a KNX RF installation, meaning that it is possible to position RF devices as required in a building, even in the case of difficult transmission and reception conditions.

i The Jung media coupler is a device which allows the media type "RF" on the lower-level line and the media type "TP" on the higher-level line.

As with all other KNX components with S-Mode commissioning, KNX RF devices are configured and commissioned using the ETS. In consequence, RF devices also possess a physical address, parameters and communication objects. In addition, a unique domain address is assigned to each RF line in the ETS. Only devices with the same domain address can communicate with each other.

i Addressing, configuration and diagnostics of KNX RF devices are only implemented in the ETS of Version 5 or higher. Older versions of the ETS do not possess manufacturer-independent KNX RF support.

KNX RF systems are addressed, configured and diagnosed in the normal fashion via the ETS data interfaces.

- Use of a KNX RF USB data interface (figure 23):
  All the devices of an RF line or an RF area can be programmed and diagnosed directly via the KNX RF USB data interface. It is important that the KNX RF USB data interface has a valid physical address of the RF line or the RF area and is configured with the same domain address.
  In addition, all the other devices of the KNX installation can be programmed using a media coupler with an identical domain address. A wired data interface is not essential for this.
  If necessary, the KNX RF USB data interface can also be used in the group or bus monitor of the ETS5, in order to record RF telegrams of the corresponding RF domain.

i In the group monitor, a KNX RF USB data interface only displays group-addressed telegrams of the same RF domain. In addition, the interface displays physically addressed telegrams, provided that it is also used as the ETS programming interface. In the bus monitor, a KNX RF USB data interface only displays group-addressed telegrams.

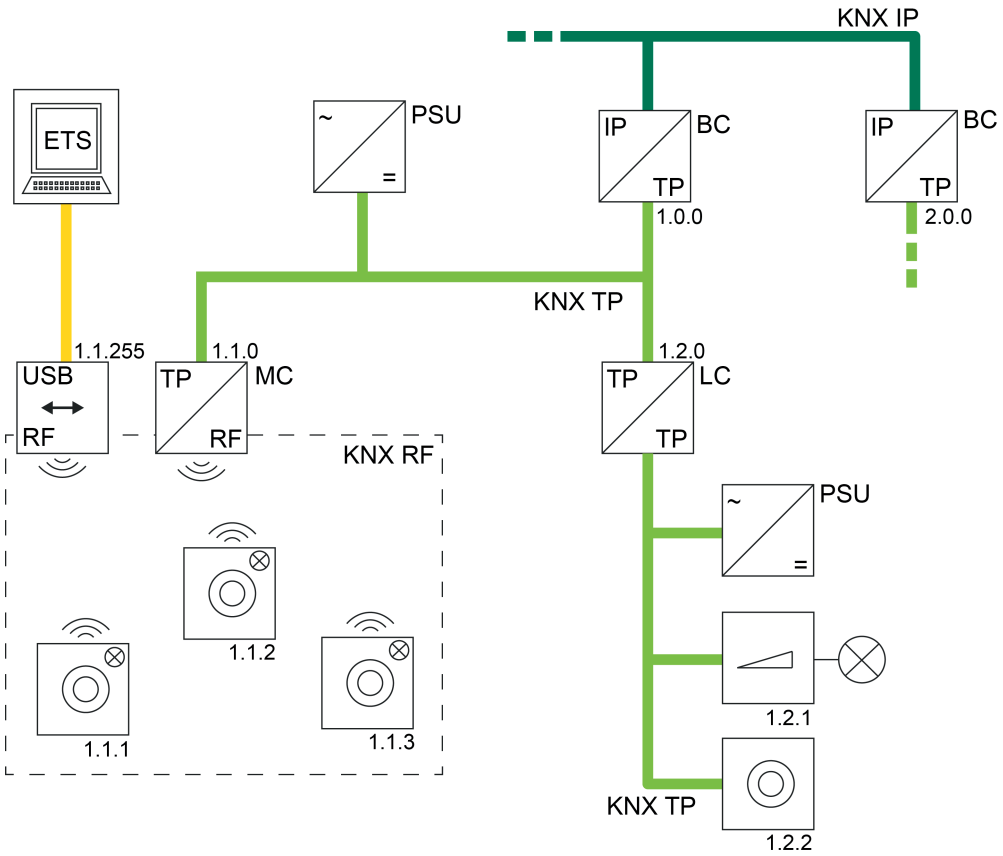

Figure 23: Example of a possible KNX topology with a KNX RF USB data interface

- Use of a KNX TP USB data interface (figure 24):
  RF devices can only be commissioned and diagnosed using a KNX TP USB data interface when a media coupler is also available. It is irrelevant in which line the KNX TP USB data interface is located so long as the topology of the KNX system is structured according to regulations (all the couplers and the data interface itself must have correct physical addresses and also guarantee telegram forwarding).

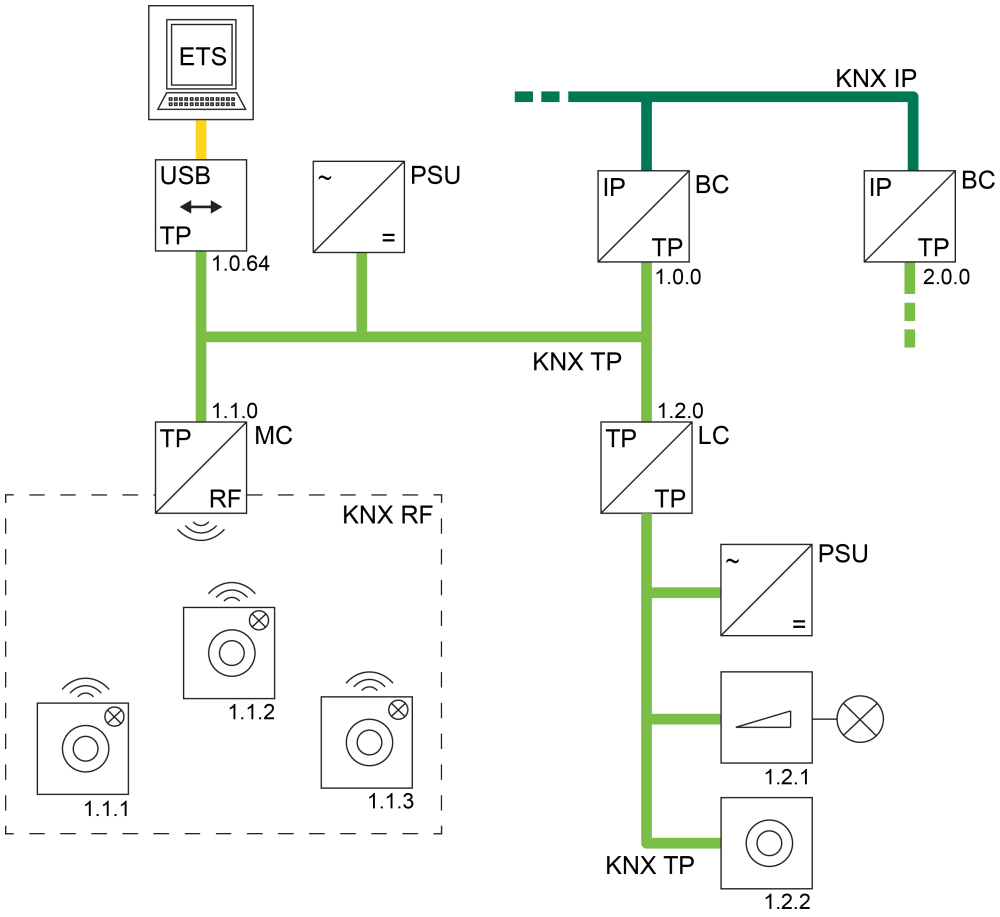

Figure 24: Example of a possible KNX topology with a KNX TP USB data interface

- Use of a KNX IP data interface (KNXnet/IP) (figure 25):
  An IP connection of the ETS can also be used to commission or diagnose devices in a KNX RF environment. Here too, it is essential that a media coupler is available, which first connects the appropriate RF line in the correct manner with a TP line (main line of a TP area) and then with the IP environment (IP backbone) via a suitable IP router or an IP data interface.
  If the media coupler is a backbone coupler, then the backbone must possess the media type "TP". A KNX IP environment cannot then be implemented (the ETS prevents such a topology)!

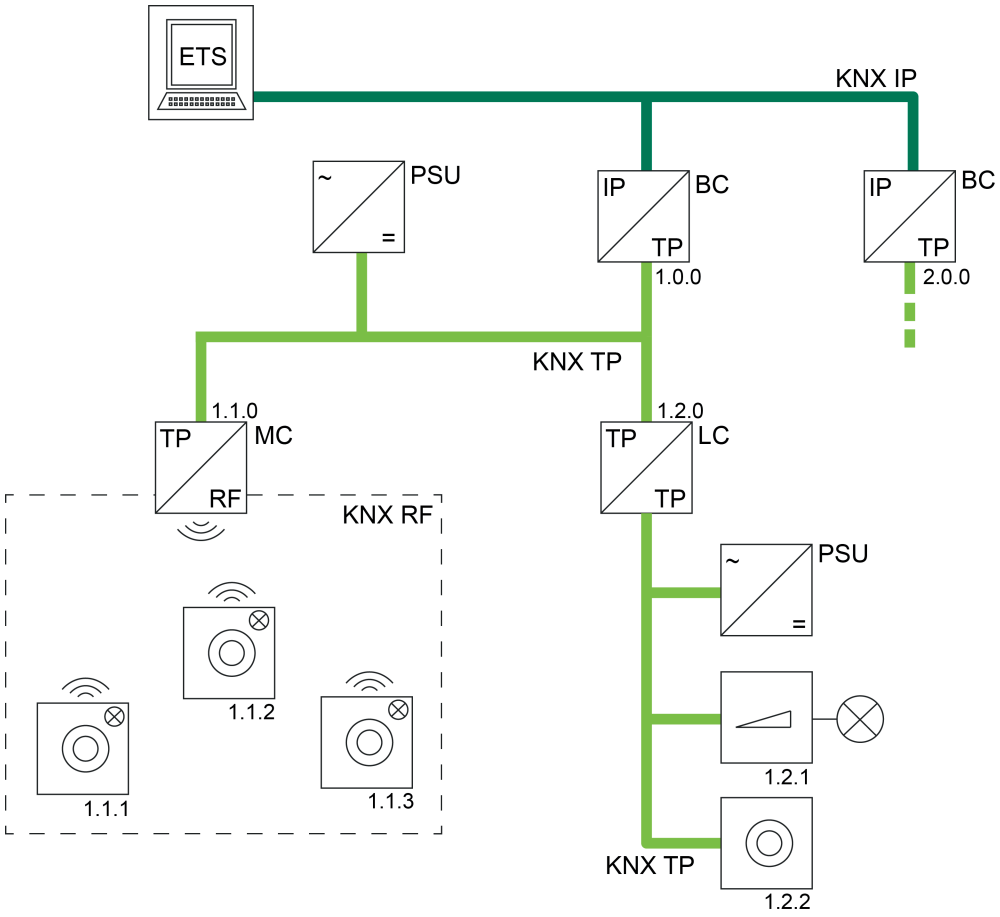

Figure 25: Example of a possible KNX topology with one KNX IP connection of the ETS (KNXnet/IP)

RF addressing types (expert knowledge)

As with all KNX media, the payload data is also transmitted on the KNX RF using group telegrams (Multicast). A group telegram (e.g. to switch on the light) can be received from multiple bus subscribers simultaneously, provided that the communication objects of the devices are linked with identical group addresses. Besides the actual group address (2 bytes-long), the domain address (6 bytes-long) is also transmitted in an RF group telegram in accordance with "KNX RF1.R S-Mode". This means that the recipients of the group telegrams can immediately detect whether they are addressed by the group address, are located in the same RF domain and thus whether they have to react to the group telegram. A media coupler inserts the required domain address into the group telegrams automatically, provided that they were received on the TP side and were transmitted to the RF environment in accordance with the filter setting. In the same way, a media coupler removes the domain supplement when a group telegram is received on the RF side and transmitted to the TP side.

A special type of group telegrams are broadcast telegrams (address 0/0/0). Broadcast telegrams always address all the bus subscribers in an RF environment or in the entire KNX system simultaneously. Such telegrams are used, for example, by the ETS, in order to program physical addresses or domain addresses or to read out which bus devices are in programming mode. Only in RF environments is a distinction made between simple broadcast telegrams and system broadcast telegrams. Only the latter are domain-independent and generated by media couplers as required, if the ETS, for example, has to program or diagnose RF devices via media couplers (TP -> RF). The ETS controls the available media couplers as necessary, so that the conversion of TP broadcast to RF system broadcast telegrams takes place in a targeted manner

and these system telegrams are forwarded.
In the same way, a media coupler converts system broadcast telegrams to normal broadcast telegrams on the TP side. Here too, the ETS automatically controls the function of the routing of such system telegrams in media couplers as required.
The ETS can generate direct system broadcast telegrams when it communicates via an RF USB data interface.

Besides broadcast telegrams, the ETS also uses physically-addressed telegrams in the RF system to program RF devices (Unicast).

i Group telegrams, broadcast telegrams and physically addressed telegrams can be filtered independently of each other in the media coupler as required or can even be disabled completely. This allows RF lines to be decoupled logically from the rest of the KNX system, according to requirements.

5.2 KNX Data Secure compatibility and updateability

5.2.1 KNX Data Secure compatibility

The device is KNX Data Secure compatible from version "V01". KNX Data Secure offers protection against manipulation in building automation and can be configured in the ETS project. Detailed specialist knowledge is required.

Overview of device versions

- Devices marked "V00": No KNX Data Secure compatibility. Secure commissioning of other devices via media coupler is not possible with this device version (Information concerning an Update from V00 to V01 see paragraph 5.2.2.).
- Devices with marking from "V01" on: KNX Data Secure compatibility as of ETS5.7.3. Secure commissioning of other devices is possible without restrictions via media couplers as of this device version.

5.2.2 Running updates

The device can be updated. Firmware updates (e.g. from device version V00 to V01) can be performed in existing installations with the ETS and a special update application program.

It is recommended to update media couplers individually and sequentially.

Procedure for performing an update:

1. Contact the JUNG customer support to get the special update application. The update application is provided in an ETS test project.

2. Import the received test project into ETS (usable from ETS5.7.3). Open the test project and the project with the media coupler to be updated.

3. Copy the device contained in the test project with the application name "Update application media coupler/repeater" into the project in which the update is to be performed. Copy the device with the update application into the line containing the media coupler to be updated.

4. Temporarily park the physical address of the media coupler originally present in the ETS project (e.g. "1.1.0" -> "1.1.-")

5. Set the physical address of the update device to the address of the original media coupler (for example, "1.1.0").

6. Program the application program of the update device with the ETS.

7. After successful programming, delete the update device from the project.

8. Set the media coupler originally present in the ETS project back to the previous physical address (e.g. "1.1.0").

9. Program the application program of the original device.

10. Update process completed.

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