Range Planning Guide for Systmes usind EnOcean Radio Standard

Wireless systems provide much simpler installation as well as the flexibility to relocate or add to a system, compared to wired systems. The easy recommendations in this planning guide are provided to ensure successful installation and reliable operation of robust devices in 868 MHz (for Euroep), 902 MHz (for North America) or 928 MHz (for Japan) band building installations using EnOcean radio standard.

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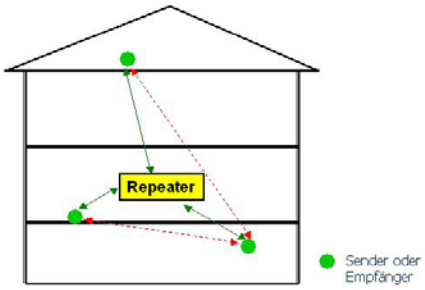
INTRODUCTION

In buildings the following two major types of radio system installations are typically and will be mainly covered by this planning guide:

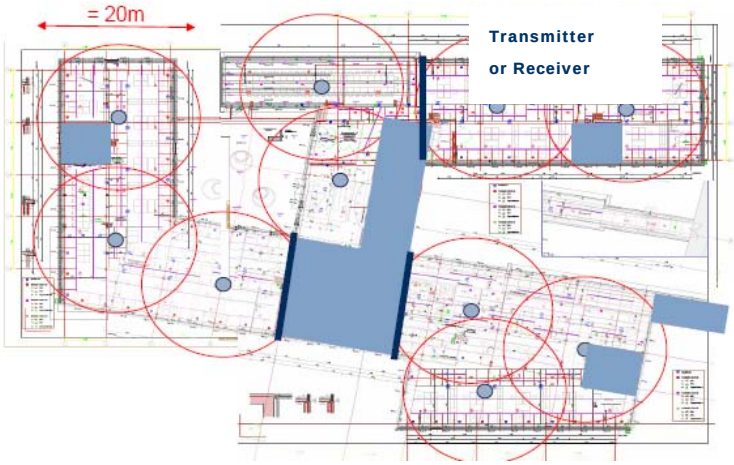
a) Radio Sensors control the actuators directly (RF bus)

In this case the radio paths to be covered are not very long. If needed a central radio repeater is installed for signal amplifying. Such installations are typically for e.g. residential homes:



b) Radio Sensors control the actuators via Automation System

Central placed radio gateways to an established building automation system (e.g. BACnet, TCP/IP, KNX, LON) are typically used in wide-area buildings, e.g. an office building:



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1. PRINCIPLES OF RADIO SIGNALS PROPAGATION IN BUILDINGS

1.1 RANGE OF RADIO SIGNALS

Radio signals are electromagnetic waves, hence the signal becomes weaker the further it travels, the range is limited. The radio coverage is further decreased by specific materials found in the direction of the propagation. While radio waves can penetrate a wall, they are dampened more than on a direct line-of-sight path (LoS), depending on their wavelength (frequency band) and material. In the following please find some examples of different types of wall:

	Material	Range reduction vs. LoS
Tip 1	Wood, plaster, glass uncoated, without metal	5 - 10%
	Brick, press board	10 - 30%
	Ferro concrete	20 - 90%
	Metal, aluminium lining	see 1.2

Figure: Range reduction of some typical in-door materials

Radio transmission shapes an ellipsoid, with Transmitter (Tx) and Receiver (Rx) in its both focal points. Because of that the geometric shape of a room determines the radio range. At 30 m range the theoretical diameter of the ellipsoid would be around 10 m at 868 MHz, 902 MHz or 928 MHz frequency. So narrow floors with thick walls are unfavourable:

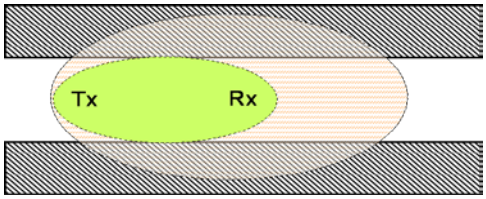


Figure: Radio transmission shapes an ellipsoid

Kind of antenna mounting and antenna distance from ceiling, floor and walls are a major influence for coverage. External antennas typically do have a better radio performance than internal antennas from in-wall receivers. People and other objects within a room also can reduce the radio range. Because of the big amount of different impacts, in practice the common specification of “30 m in-door range” should be considered more precisely. Reserve in the range planning is needed to achieve reliability of the radio system, even in case of several unfavourable conditions combined.

Tip 2

Reliable and robust in-door installation can be achieved through sufficient reserve in coverage. Recommendations from practice to provide this are:

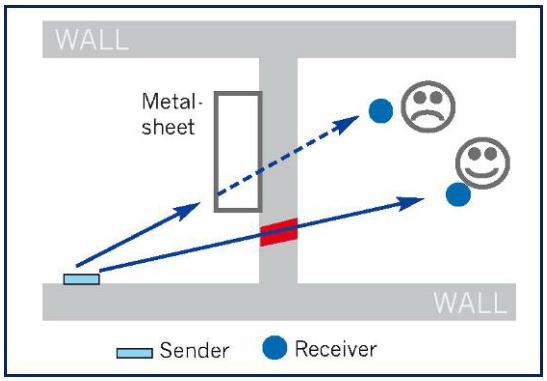
- **> 30 m** under ideal conditions: Broad room, no obstacles, good antenna design and good antenna positions.
- Building is filled with furniture and people. And penetration through up to 5 dry walls or up to 2 brick walls or up to 2 aero concrete walls:
  - **> 20 m** if transmitter and receiver do have good antenna design and good antenna positions.
  - **> 10 m** if receiver is mounted into a massive wall. Or receiver is placed next to a room corner. And a small sized receiver with internal antenna is used. And switch or whip antenna is mounted on metal. Or range along a narrow floor.
- 1-2 metal-reinforced ceilings at upright penetration angle (in strong dependence of reinforcement density and antenna positions).

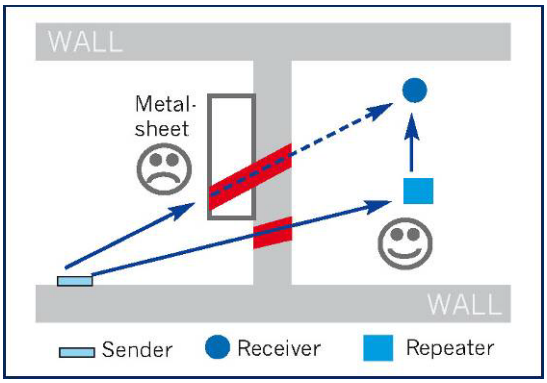
1.2 SCREENING

Massive objects made of metal, such as metallic separation walls and metal inserted ceilings, massive wall reinforcements and the metal foil of heat insulations, reflect electromagnetic waves and thus create what is known as radio shadow. However singularized small metal studs, e.g. the metal studs of a gypsum dry wall, don't show a recognizable screening.

Metal separation walls: It can be noticed that radio transmission even works with metal indoor separation walls. This happens through reflections: Walls made of metal or concrete reflect the electromagnetic waves. The radio waves reach the next room or floor via a non metallic opening, e.g. a wooden door or an indoor glass window. Locally the radio range can be strongly reduced. Mounting an additional repeater at a suited location can easily provide an optional propagation path.

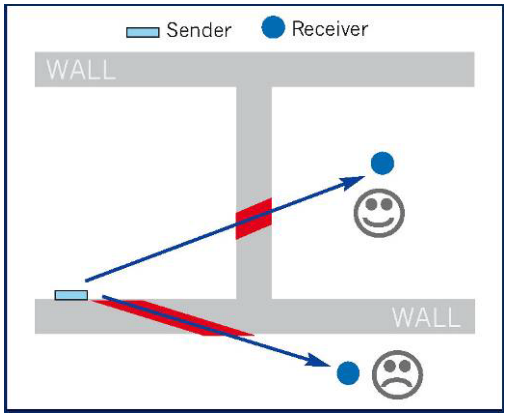
Tip 3	Important objects and factors that decreases or constraints coverage: ■ Metal separation walls or hollow lightweight walls filled with insulating wool on metal foil ■ Inserted ceilings with panels made of metal or carbon fibre ■ Steel furniture, glass with metal coating (typically not used indoor) ■ Switch mounted on metal surfaces (typically 30% loss of range) ■ Use of metallic switch frames (typically 30% loss of range)) Fire-safety walls, elevator shafts, staircases and supply areas should be considered as screening. Avoid screening by repositioning the transmitting and/or receiving antenna away from the radio shadow, or by using a repeater.

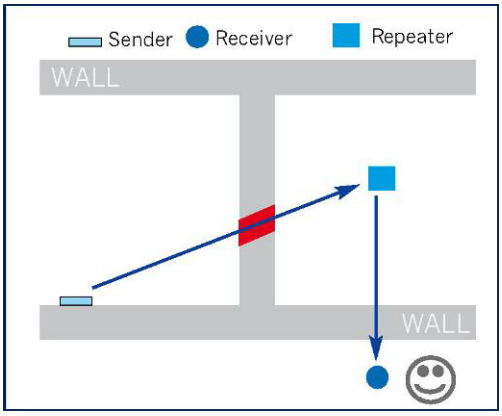




1.3 PENETRATION ANGLE

The angle at which the transmitted signal hits the wall is very important. The effective wall thickness – and with it the signal attenuation – varies according to this angle. Signals should be transmitted as directly as possible through the wall. Wall niches should be avoided.

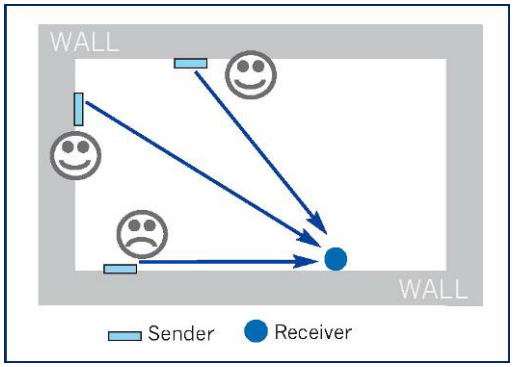




Tip 4	Avoid an unfavourable penetration angle by repositioning the transmitting and/or receiving antenna, or by using a repeater.

1.4 ANTENNA INSTALLATION

When using devices with an internal receiving antenna, the device should not be installed on the same side of the wall as the transmitter. Near a wall, the radio waves are likely to be subject to interfering dispersions or reflections. Consequently, the position of the antenna has to be on the opposite or connecting wall. When using devices with an external antenna, the ideal antenna installation place is a central location in the room. Where possible the antenna should be at least 10 – 20 cm away from the wall corner or concrete ceiling.



Tip 5	Avoid radio propagation along a wall (also given in a long narrow floor).

ACTIVE ANTENNA: A so-called active antenna is a radio unit with integrated antenna that communicates with the actuator unit via a simple multi-line cable (e.g. RS485). Thus no shielded antenna cable is needed, which would loose performance with increasing length and could be folded during installation. So an active antenna allows very simple failure test.

PASSVE ANTENNA: This kind of antenna is connected with the radio unit via a dedicated shielded antenna cable. A "**Magnetic Antenna**" needs to be placed on a large metallic surface to create an adequate anti-pole. A magnetic antenna can be very easily mounted at metallic objects, e.g. at an air tube behind a false ceiling. However a flat "**Patch Antenna**" (planar antenna) must be mounted away from metallic objects, e.g. onto a false ceiling made of gypsum or into a dry wall by using a wall box with a suited size (see picture). The patch antenna must not be mounted directly onto concrete which behaves similar to metal. Exception is the 868 MHz Metal Patch Antenna **"MCA 1890MP**" from Hirschmann. Unobtrusively this flat antenna can be directly glued also onto a metal ceiling. More details about selection of suited passive antennas and antenna connectors can be found in the EnOcean Application Note „**AN103 External Passive Antennas"**.

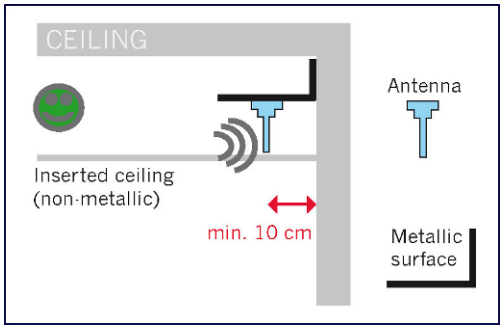


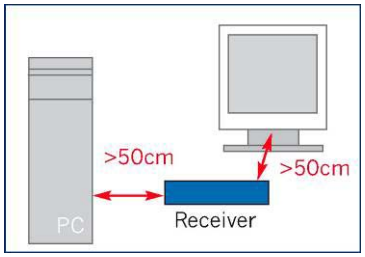
Figure: Mounting a Magnetic Antenna

Figure: Mounting a Patch Antenna

Tip 6	Do never flex a shielded antenna cable during installation. This can result in irreparable damage (performance reduction through change of impedance level)

1.5 DISTANCE BETWEEN RECEIVER AND SOURCES OF INTERFERENCE

The distance between **EnOcean receivers** and other transmitters (e.g. GSM / DECT / WLAN) or high-frequency sources of interference (computers, audio/video equipment) should be at least 50 cm. However, **EnOcean transmitters** can be installed next to any other high-frequency transmitter without any problem.



Tip 7	The distance of the EnOcean receiver to different high-frequency transmitters should be at least 50 cm, the transmitter position is not critical. Avoid using 868 MHz power RFID readers and 868 MHz EnOcean receivers in the same room.

1.6. USE OF REPEATERS

In case of poor reception, it may be helpful to use repeaters. EnOcean repeaters do not require any configuration (e.g. programming) and are put into operation simply by connecting them to the supply voltage. The various possibilities of use are shown by the illustrations in the chapters “Screening” and “Penetration”.

Tip 8	While planning, it may be worth considering retrofitting the system with an optional repeater (power supply available). Do not use too many repeaters as this is counterproductive (higher costs, telegram collisions).

A poor radio signal is then received, refreshed and transmitted again, so nearly a double radio range can be achieved. 1-level EnOcean repeaters cannot be cascaded; telegrams once repeated are not repeated again. EnOcean repeaters which can be switched to 2-level function allow two repeaters to be cascaded, which should be needed in extreme cases only. In this case, every 2-level configured repeater behaves as 1-level repeater for original, unrepeated telegrams, respectively as 2-level repeater for already 1-level repeated telegrams.

1.7. FIELD INTENSITY METER

A mobile field intensity meter, such as Probare P10 (www.vicos.at/en/probare) enables the installer to determine the ideal mounting positions for sensors and receivers. Furthermore, faulty connections of devices already installed can be checked.

Figure: EnOcean field intensity meter Probare P10

Tip 9	Even after careful planning, an adequate tool like e.g. the Probare P10 should be used to verify proper reception at the receiver position during installation. It can be used for on-site determination of the ideal mounting position and for identification of an interfering transmitter (also see chapter 4 “Radio System Debugging”).

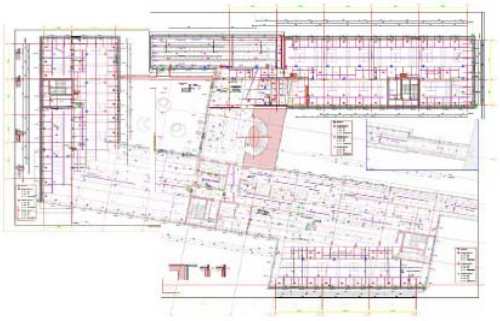
2. GENERAL PLANNING GUIDE RULES FOR BUILDINGS

The radio coverage in commercial buildings is usually restricted by fire safety walls that must be considered as screening. Inside the fire protected sections lightweight or glass partition walls are used with good radio wave propagation properties (except for metal reinforcements or metalized walls!) The following are two common installation architectures

- **Radio Sensors control the Actuators directly (RF bus)**
  Usually, the radio paths to be covered are not very long ("cubicle installation").

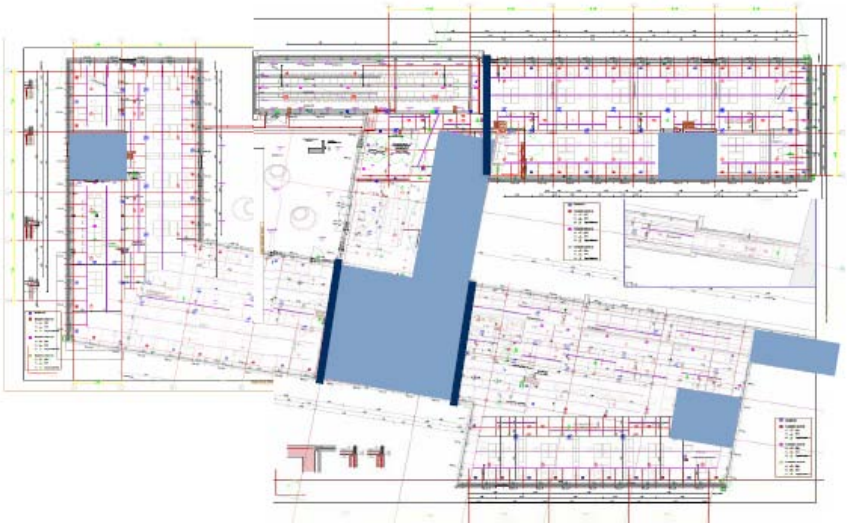
- **Radio Sensors control the Actuators via Automation System**
  Central placed radio Gateways to the Building Automation System (e.g. BACnet, TCP/IP, LON, EIB) are used for system coverage. In the following a reliable radio planning is shown that can be done in quick time and using simple tools only:

STEP 1: Take a Building Floor Plan and a Drawing Circle



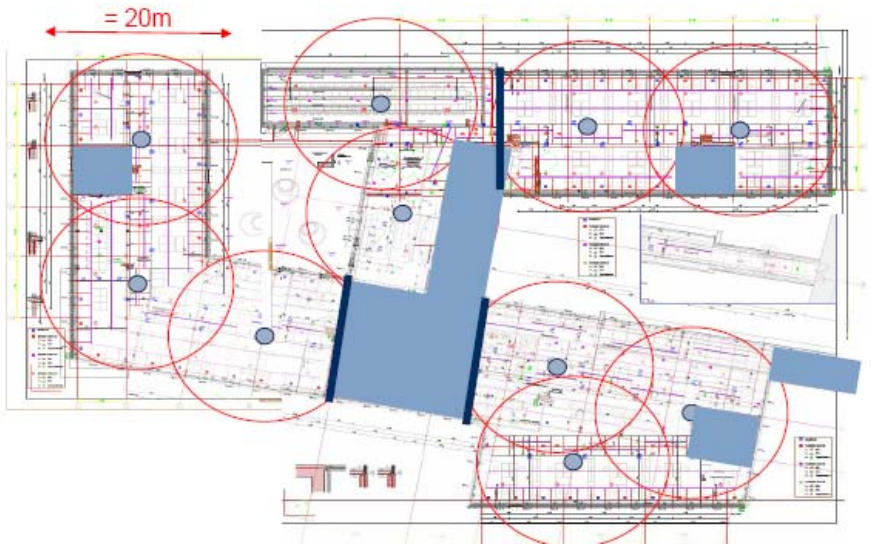
STEP 2: Mark relevant Radio Shadings into the Floor Plan:

- Fire Protection Walls
- Lavatories, Staircases, Elevator Shafts, Supply Areas



STEP 3: Draw circles area wide

- The circle centre points are the ideal positions of the radio gateways (condition: power line).
- The gateways should be positioned in such a way that no screens block the radio connection to any corner inside the fire safety section (potential sensor positions).



Tip 10	For reliable range planning a sum of unfavourable conditions have to be assumed. The lessons learned from practice shows that planning with 10-12 m range offers extensive reserve to avoid most typical bad conditions. Bad conditions also often come from later changes of the ambient (room filled with people, alteration of partition walls, furniture, room plants, etc.). Also a typical realization of the sensors or gateway real positions of 1 meter more or less against the plan doesn't matter because of sufficient reserve.

Tip 11	For a highly robust radio transmission system it is advisable to implement a redundant radio receiver path. To do so, program two next nearby located gateways for parallel reception of the corresponding radio transmitters.

Tip 12	Even after careful planning, range tests should be done during installation with radio level meter to verify proper reception at the receiver positions. Unfavourable conditions can be improved by changing of antenna position or using a repeater.

3. PLANNING GUIDE FOR RESIDENTIAL BUILDINGS

For applications restricted to one or two rooms (e.g. when retrofitting a switch or an awning) the direct transmission range is usually adequate. For applications “throughout” a building, the following differentiations must be made:

Installation in Multi-room Flat or One-family House of up to 400 sqm

- Larger residential units should be fitted with a repeater. The repeater should be centrally placed, e.g. in the centre of the middle floor. The exact repeater position is noncritical.
- EnOcean repeaters are designed in such a way that a second repeater can be added in case of heavy ceiling reinforcement or other screening. Please note that using too many repeaters is counterproductive (higher costs, telegram collisions).

Installation in Multifamily Unit or High-rise Building

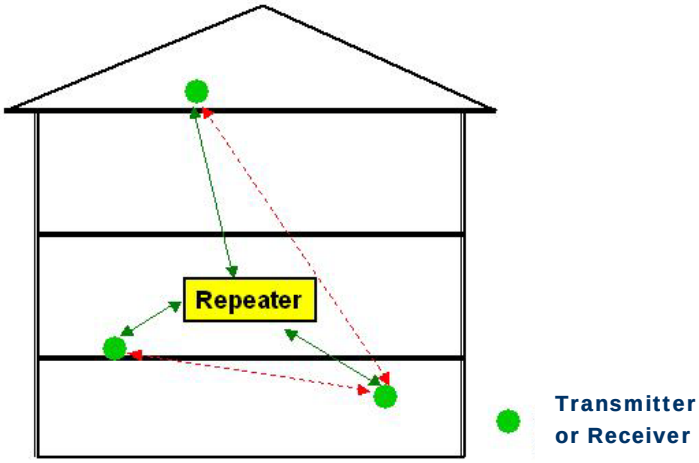
- Use separate radio systems for each flat.
- One radio gateway per flat can be used for cross-property connection via an established automation system (e.g. BACnet, KNX, LON, TCP/IP, etc.).

3.1 SMALL RESIDENTIAL UNIT (up to 3 walls, 1 ceiling)

Transmitter or Receiver

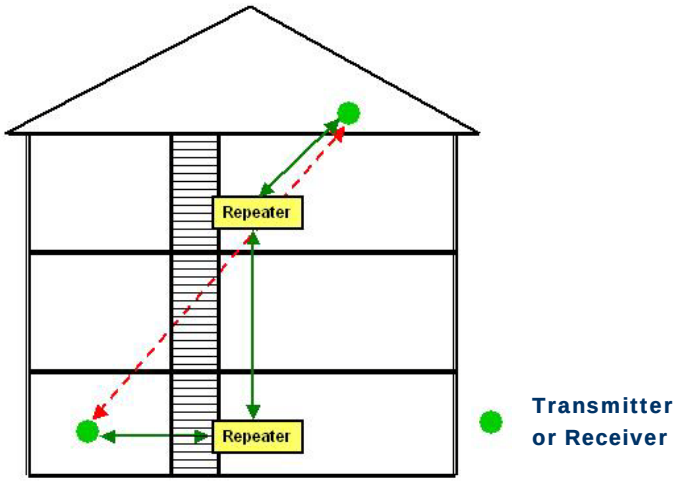
Tip 13	For bedsits or up to 2 floors in a townhouse the direct transmission range is usually adequate.

3.2 MULTI-ROOM FLAT AND ONE FAMILY HOUSE (more than 3 walls, more than one ceiling)



Tip 14	In a larger residential unit, it is generally advisable to install a central repeater to ensure radio coverage.

3.3 EXTREME EXAMPLE IN A ONE-FAMILY HOME



Tip 15	In rare cases of heavily reinforced concrete ceilings or thick basement walls a second repeater may be necessary to ensure full coverage (both repeaters must be switched to 2-level function, see information in chapter 1.6).

4. RADIO SYSTEM DEBUGGING

The foregoing information on selecting the ideal place of installation for transmitters and receivers has been provided to ensure a smooth operation of the devices. If, however, you still have experience radio transmission problems, please refer first to the following table for troubleshooting:

	Possible Cause and Remedy
Transmitter received not at all	**Transmitter fails to send.** Check the transmitter. Where necessary, ensure sufficient light for solar-operated transmitters (for a quick functional test, briefly expose to daylight or place under a bright lamp).
	Transmitter is installed outside the receiver range (or transmitter is removed or maybe exchanged). Reposition transmitter or receiver antenna. Follow the notes given in chapter 1.
	a) Transmitter not programmed or wrong transmitter programmed. Reprogram transmitter into the receiver. **b) Receiver does not receive.** Check the receiver and the installation of the antenna and the antenna cable.
	a) Low-power jammer near receiver. Move jammer (telephone, PC etc.) at least 50 cm away from EnOcean receiver. **b) High-power jammer present.** Remove jammer.
	a) Receiver is placed at the limit of the transmitter's range. Remove transmitter or receiver antenna, or use Repeater. Follow the notes given in chapter 1. **b) Transmitter not installed at the expected position (or wrong assignment Sender/Receiver).** Assign correctly. **c) The place of installation of the transmitter changes occasionally (e.g. transmitter not fitted).** Choose a place of installation for the transmitter within the range of reception.
Transmitter intermittently not received	**Receiver does not receive.** Check the receiver and the installation of the antenna and the antenna cable.
	Jammer present. Remove jammer

DISCLAIMER

The information provided in this document describes typical features of the EnOcean radio transmission system and should not be misunderstood as specified operating characteristics. No liability is assumed for errors and / or omissions. We reserve the right to make changes without prior notice. For the latest documentation visit the EnOcean website at **www.enocean.com**.