RANGE PLANNING GUIDE FOR SYSTEMS USING THE ENOCEAN RADIO STANDARD

26 May 2026

Observe precautions! Electrostatic sensitive devices!

EnOcean

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REVISION HISTORY

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DISCLAIMER

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1 Introduction

Wireless systems offer significantly simpler installation and provide the flexibility to relocate or expand a system as needed.

This planning guide presents straightforward recommendations to enable successful installation and reliable wireless operation for devices using the 868 MHz (Europe), 902 MHz (North America), or 928 MHz (Japan) variants of the EnOcean radio standard.

In building environments, two primary types of radio system installations are commonly used and are the focus of this planning guide.

1.1 Point-to-point wireless communication (Sender -> Receiver)

In this scenario, one or several senders (for instance, switches or sensors) transmit telegrams that are received by one or several actuators (for instances, relays, dimmer or shutter controllers).

Radio paths between sender (switch or sensor) and receiver (actuator) are usually relatively short as the sender is often in the same room as the receiver. If necessary, a central radio repeater can be installed to forward telegrams to receivers that are further away. Such installations can for instance be found in residential homes.

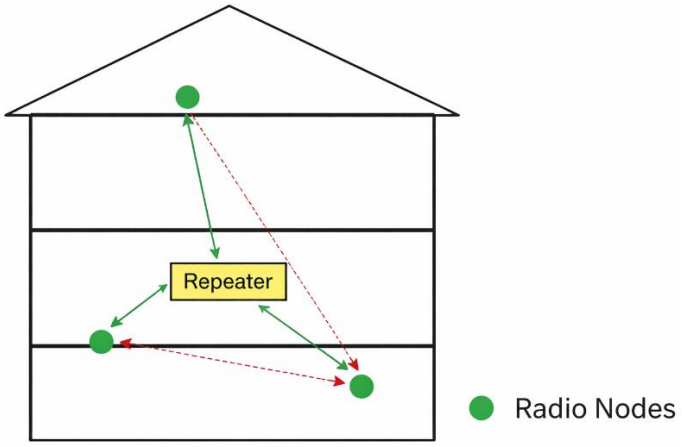

Figure 1: Point-to-point wireless communication

1.2 Hybrid wireless / wired communication

For larger buildings, such as offices or warehouses, there is typically a centralized building management system (BMS) to monitor and control key building parameters. BMS typically use one or several controllers or servers that communicate with all devices throughout the entire building.

Communication is typically implemented using a hybrid wired / wireless approach whereby a wired communication backbone (TCP/IP, BACnet, LON, KNX) is used for building-level communication while communication at "the last mile" (within a room or an area) uses the EnOcean wireless standard.

The bridge between wired and wireless communication is provided by radio gateways that provide radio coverage for the region around them (shown as circles in the illustration below) and use wired communication to forward these signals.

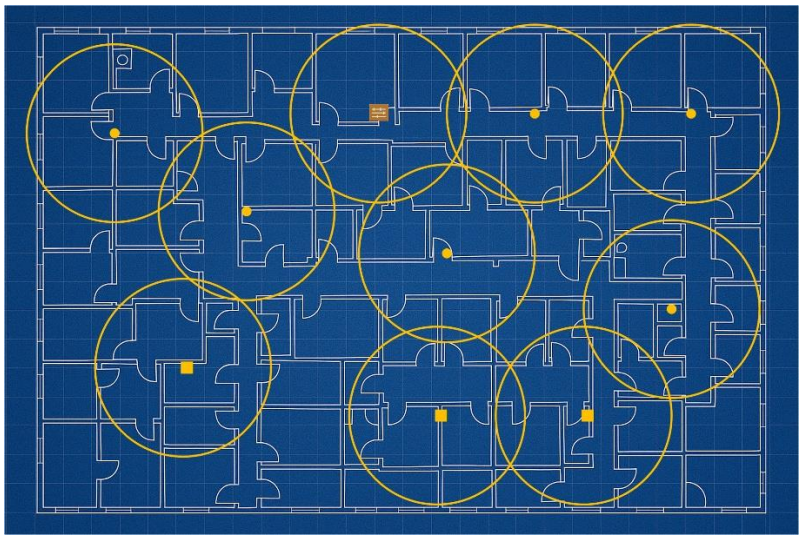

Figure 2: Radio communication in hybrid wired / wireless systems.

2 Principles of Radio Signal Propagation in Buildings

2.1 Range of Radio Signals

Radio signals are electromagnetic waves, so the signal strength decreases the further it travels which limits the achievable communication range. If the signal is weaker than the sensitivity of the receiver, then it can no longer be reliably received, and the achievable communication range has been exceeded.

Radio signal strength (and thereby radio coverage) is additionally reduced by obstacles in the communication path between sender and receiver. For instance, for the same distance between sender and receiver, a signal travelling through a wall will be attenuated more than signals traveling through an open space area without obstacle ("direct line of sight").

The attenuation affecting the signal strength is dependent on the frequency of the signal, the material through which the signal travels and the angle at which the signal hits the material. For the case of walls, Table 1 below provides guidance on range reduction compared to line-of-sight (LoS) scenarios (without a wall) for common materials.

Material	Range reduction vs. LoS
Wood, plaster, uncoated glass, no metal	5 - 10%
Brick, pressed board	10 - 30%
Reinforced concrete	20 - 90%

Table 1: Reduction in Radio Range Caused by Common Indoor Materials.

Radio transmission from a sender to a receiver does not follow a narrow, straight line but rather can be compared to the flow of water from the tap to a sink which fills an area with water.

In the case of radio waves, this area has the shape of an ellipsoid, with the transmitter (Tx) and receiver (Rx) located at its two focal points. The size of this ellipsoid depends on the distance between sender and receiver and the frequency that is used for the transmission. If two EnOcean devices communicate with each other over a distance of 30 metres, then the diameter of the ellipsoid is approximately 10 metres.

Similar to obstacles impacting the flow of water, any obstacle within the ellipsoid will affect radio communication and reduce the range of reliable communication as shown below.

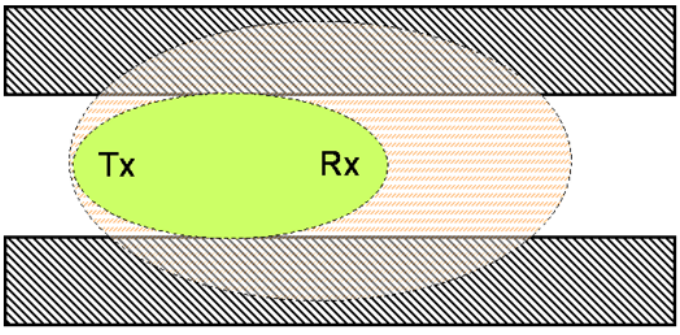

Figure 3: Ellipsoidal Radio Transmission in a Narrow Hallway.

2.2 General guidance on coverage distance for indoor installations

The following coverage distances may be assumed for typical installation scenarios:

- 30 m under ideal conditions
  Large, open rooms, no obstacles, optimal antenna design and positioning

- 20 m in furnished spaces
  Penetration through up to five drywall partitions, two brick walls, or two aerated concrete walls, assuming good antenna design and placement.

- 10 m in constrained conditions
  Receiver mounted on a solid wall or in a corner, using a small internal antenna; switch or whip antenna mounted on a metal surface.

- 1–2 m through metal-reinforced floors at upright penetration angle
  Strongly dependent on reinforcement density and antenna positioning.

Note that the type of antenna installation and its distance to ceilings, floors, and walls have a significant impact on coverage.

Furthermore, the presence of people and objects within the room can reduce the radio range. To maintain system reliability under a combination of challenging conditions, range planning should incorporate an adequate safety margin.

2.3 Screening

Large metallic objects, metal partitions, reinforced walls, and metal foil used in thermal insulation reflect electromagnetic waves, creating areas of radio shadow (“screening”). In contrast, small individual metal studs, such as those found in drywall construction, generally do not cause significant screening.

Metal Partition Walls: Radio transmission can still operate in interiors with metal partition walls due to signal reflection. Walls made of metal or concrete reflect electromagnetic waves, allowing signals to reach adjacent rooms or floors through non-metallic openings such as wooden doors or interior glass windows. However, the local radio range may be significantly reduced.

Installing a repeater in an appropriate location can provide an alternative propagation path.

2.4 Key Objects and Factors That Reduce or Constrain Coverage

The following objects and installation conditions need to be considered when estimating radio coverage:

- Metal separation walls or hollow lightweight walls filled with insulating wool on metal foil.
- Suspended ceilings with panels made of metal or carbon fibre.
- Steel furniture and glass with metal coating (typically not used indoors).
- Switches mounted on metal surfaces (approximately 30% reduction in range).
- Metallic switch frames (approximately 30% reduction in range).

Fire-safety walls, elevator shafts, staircases, and supply areas should be considered as screening obstacles meaning that radio waves will not propagate through them.

Areas that produce screening need to be avoided by placing the transmitting and/or receiving antenna out of the radio shadow or by using a repeater.

Make sure that metal cases, sheets and objects are not placed in the transmission path between the sender and receiver. Ensure that metal objects do not obstruct electromagnetic transmission by positioning receivers and transmitters accordingly.

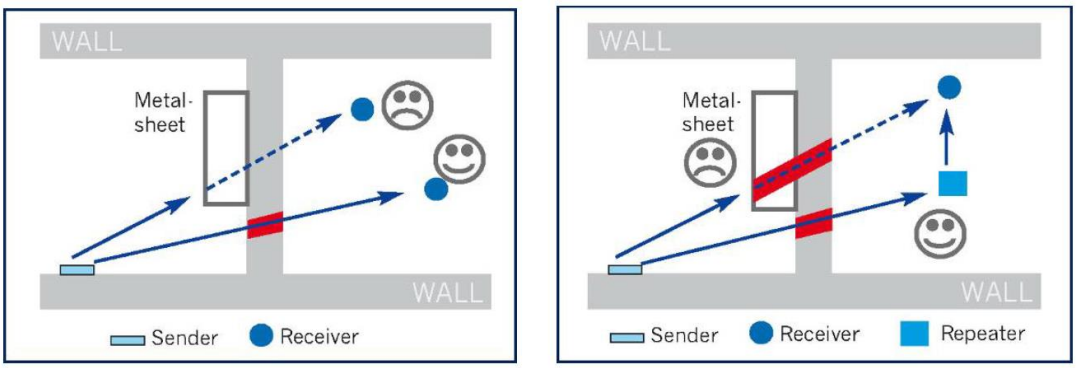

Figure 4: Metal cases placed in the transmission path.

2.5 Penetration Angle

The angle at which the transmitted signal penetrates the wall is very important. The effective wall thickness and the resulting attenuation varies according to this angle.

Signals should propagate as directly as possible (using the shortest possible path) through the wall. The angle measured with respect to the normal to the surface and propagation direction should be close to 0°.

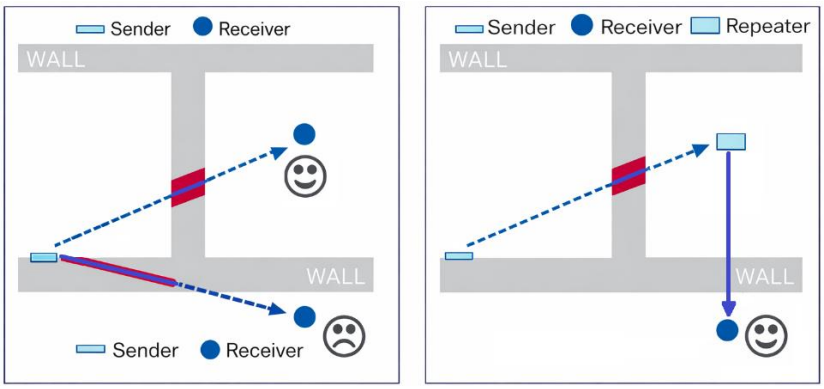

Figure 5: Penetration Angle vs Repeater Use.

To prevent an undesirable penetration angle, consider repositioning the transmitting and/or receiving antenna, or use a repeater.

2.6 Installation Guidelines for Antennas

Do not install transmitting devices with integrated antenna on the same side of the wall as the receiving device. Radio waves near a wall are prone to interference from dispersion and reflection. Therefore, position the device on the opposite wall or a connecting wall.

For devices with an external antenna (that can be placed freely), the ideal location is the centre of the room. Antennas should be placed 10–20 cm away from wall corners or concrete ceilings. Avoid routing radio signals along a wall surface.

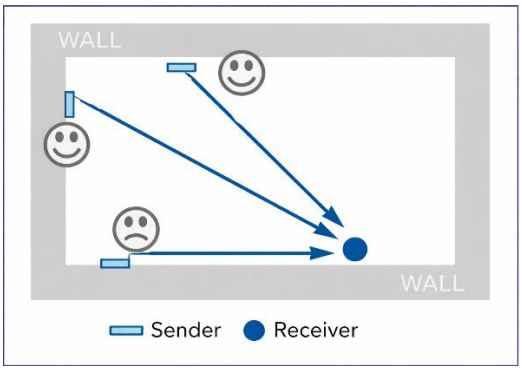

Figure 6: Signal Propagation Parallel to Floors or Walls.

2.7 Antenna Types

Active Antenna

An active antenna is a radio unit that integrates the antenna and communicates with other units (e.g., actuator units) using a wired (IP, USB, RS485, …) connection. This eliminates the need for shielded antenna cables, which can degrade performance when covering long distances or for cases where the cable is bent during installation.

Passive Antenna

A passive antenna connects to the radio unit using a dedicated shielded cable. The following guidance should be considered:

- Magnetic Antenna
  Requires a large metallic surface to create an adequate counter-pole. It can be easily mounted on metallic objects, such as an air duct behind a false ceiling.

- Patch Antenna (Planar)
  Must be mounted away from metal surfaces, for example on a gypsum ceiling or inside a drywall using a suitable wall box. Do not mount directly on concrete, as it behaves like metal.

- Antenna Cable
  Never bend a shielded antenna cable during installation, as this can cause permanent damage.

Further details on passive antennas and connectors are available in EnOcean Application Note AN103: External Passive Antennas.

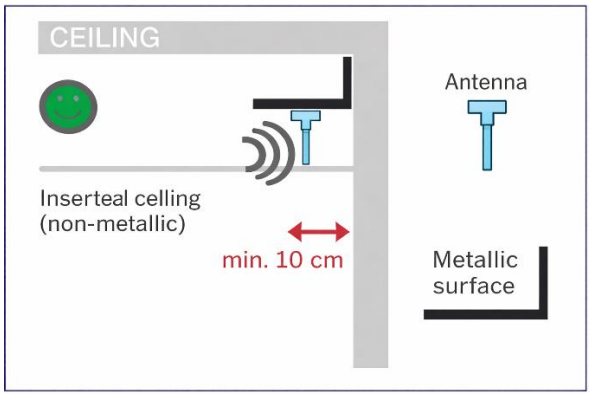

Figure 7: Recommended Mounting Positions for Magnetic Antennas.

2.8 Distance Between Receiver and Interference Sources

Maintain a minimum distance of 50 cm between EnOcean receivers and other transmitters (such as GSM, DECT, WLAN) or high-frequency interference sources (e.g., computers, audio/video equipment).

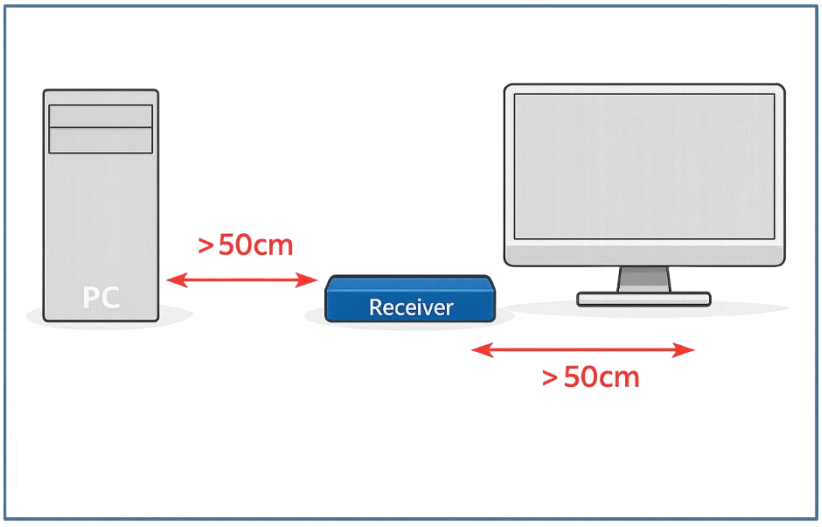

Figure 8: Required Separation Between EnOcean Receiver and Transmitters.

Avoid installing 868 MHz RFID readers and 868 MHz EnOcean receivers in the same room, as they operate on the same frequency band and can cause severe interference.
EnOcean transmitters, however, can be installed close to other high-frequency transmitters without issue.

2.9 Use of Repeaters

If signal reception is weak, installing a repeater can help. A repeater receives a weak radio signal and retransmits it, effectively almost doubling the range. EnOcean radio systems may use two types of repeaters:

- Level 1 Repeaters
  Extend telegram range by one repetition ("one hop"). Once a telegram has been repeated, it cannot be repeated again. This is the recommended repeater mode.

- Level 2 Repeaters
  Extend telegram range by two repetitions ("two hops"). In this mode, each repeater acts as both as repeater for original, unrepeated telegrams (Level 1 Repeater) and as repeater for telegrams that were already repeated once (Level 2 Repeater).
  This mode should only be used in exceptional cases as it significantly increases the number of telegrams and thereby the likelihood of telegram collisions.

Repeater functionality is often available in EnOcean actuators, and no additional equipment is required in this case.

3 General Planning Guidelines for Radio Coverage in Buildings

Reliable radio communication in commercial buildings requires careful planning because building structures can significantly affect signal propagation. The following guidelines provide a practical approach for designing robust radio coverage using simple tools and proven methods.

3.1 Understanding Building Constraints

Radio signals are often restricted by fire safety walls, which act as strong barriers and must always be treated as screening elements during planning. These walls divide the building into fire-protected sections, and each section needs its own coverage strategy.

Inside these sections, lightweight or glass partition walls typically allow good radio wave propagation. However, be cautious of metal reinforcements or metalized surfaces, as they can severely block or reflect signals, reducing reliability.

3.2 Step-by-Step Radio Planning Process

You can achieve reliable coverage quickly using a building floor plan and basic drawing tools:

Step 1: Prepare the Floor Plan
Obtain a detailed floor plan of the building.
Use a drawing compass or circle template to represent coverage areas.

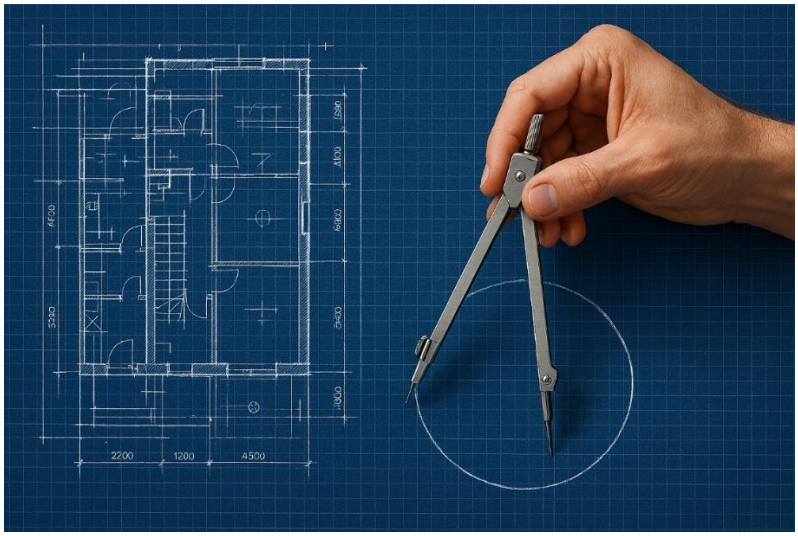

Figure 9: Floor Plan and Drawing Circle.

Step 2: Identify and Mark Radio Barriers
On the floor plan, mark areas that typically block radio signals:

- Fire protection walls
- Lavatories
- Staircases
- Elevator shafts
- Supply and storage areas

These elements create radio shadows that must be considered when positioning gateways.

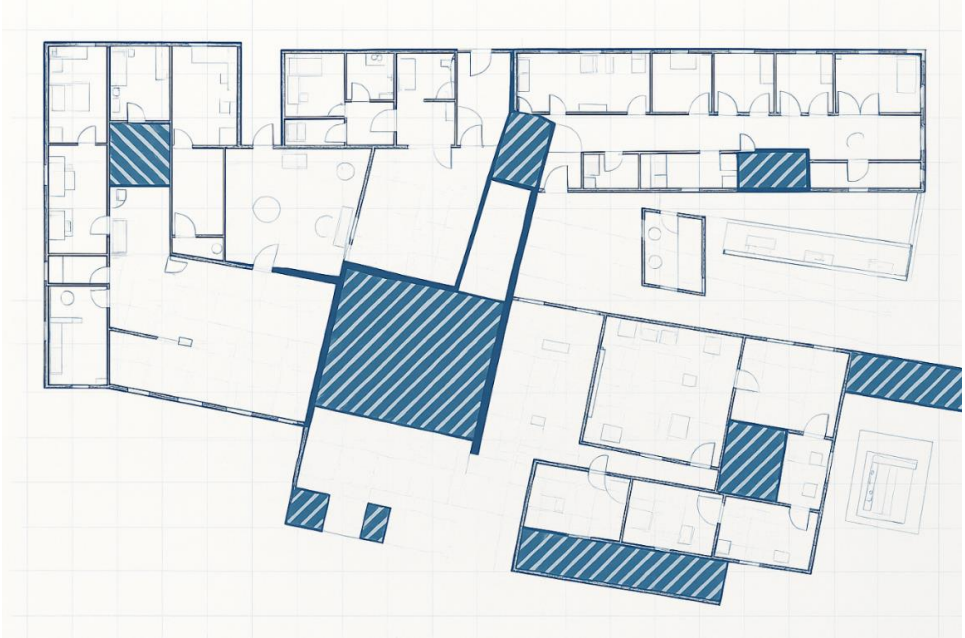

Figure 10: Radio Barriers on Floor Plan.

Step 3: Draw Coverage Circles

Place circles across the floor plan to represent the coverage area of each gateway. The centre of each circle indicates the ideal position for a radio gateway (ensure power supply availability). Position gateways so that no major barriers block the signal to any corner within the fire safety section, where sensors may be installed.

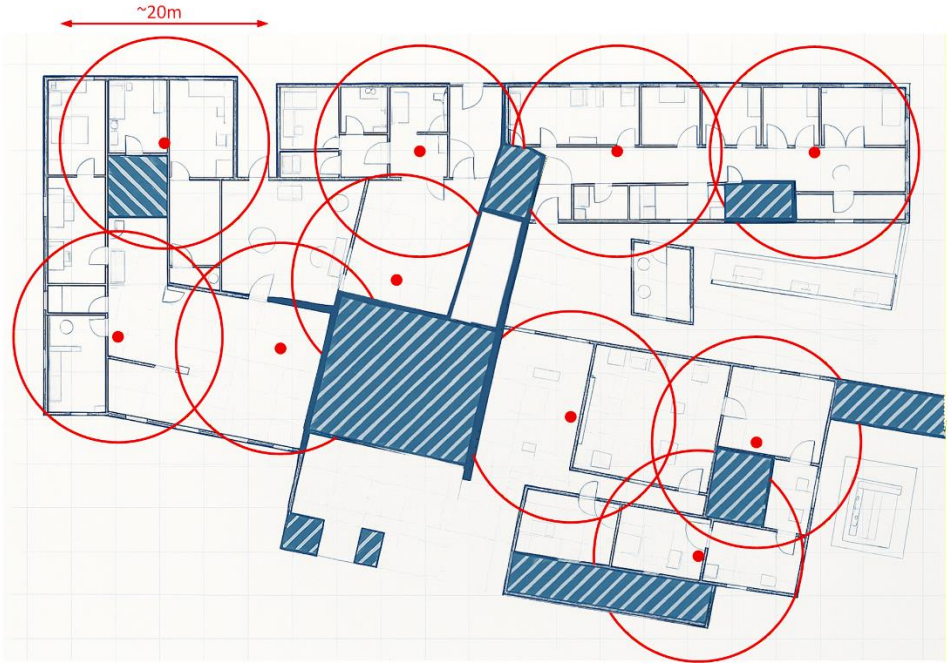

Figure 11: Coverage Circles on Floor Plan.

3.3 Practical Design Considerations

Plan for worst-case conditions as the installation environment may change over time. The presence of furniture, plants, partitions, and people will affect the signal strength.

To ensure reliability, plan for a 10–12 m range per gateway. This provides a safety margin for changes in the environment (furniture, partitions) and for crowded rooms.

Add redundancy for robustness - for critical applications, configure two nearby gateways to receive signals from the same transmitter. This creates a redundant receiver path, improving reliability.

Deploy and verify - even with careful planning, always perform range tests using a radio level meter during installation. If reception is poor, adjust the antenna position or add a repeater to extend coverage.

Planning Recommendations

- Fire safety walls are the main barriers; plan coverage per section.
- Use simple tools (floor plan and circles) for quick planning.
- Assume worst-case conditions and include redundancy for reliability.
- Always validate coverage with on-site tests.

4 Planning Guide for Residential Buildings

Radio coverage in residential environments depends on the size and structure of the building. For small applications limited to one or two rooms—such as retrofitting a light switch or an awning—the direct transmission range of EnOcean devices is usually sufficient.
For installations that span an entire building, the following guidelines apply:

Installation in Multi-room Flats or Single-family Houses (up to 400 m²)

- Use a Repeater for Larger Units
  Larger homes should include at least one repeater to ensure reliable signal coverage.
  - Position the repeater centrally, ideally on the middle floor.
  - The exact location is not critical, as long as it is roughly central.

- Add a Second Repeater if Needed
  EnOcean repeaters allow the addition of a second repeater when signal quality is affected by heavy ceiling reinforcement or other structural barriers.
  - Avoid installing too many repeaters, as this can lead to higher costs and telegram collisions, reducing system efficiency.

Installation in Multifamily Units or High-rise Buildings

- Separate Systems per Flat
  Each apartment should have its own independent radio system to prevent interference.

- Gateway for Building Automation
  One radio gateway per flat can be used to connect to a building automation system (e.g., BACnet, KNX, LON, TCP/IP), enabling integration across the property.

4.1 Small Residential Unit (up to 3 walls, 1 ceiling)

For very small installations—such as a single room or a small area with up to three walls and one ceiling—the direct transmission range of EnOcean devices is typically sufficient.
No repeater is required unless there are metallic barriers or other unusual screening conditions.

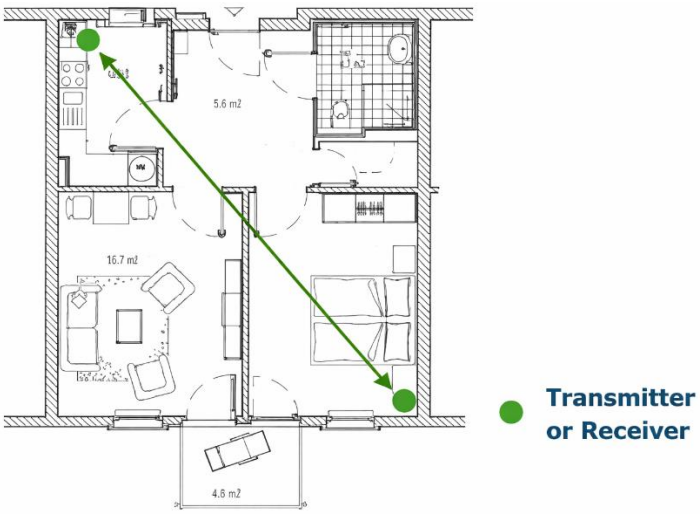

Figure 12: Small Residential Unit with Single Transmitter and Repeater.

For bedsits or townhouses with up to two floors, the standard direct transmission range is generally sufficient for reliable operation.

Key Recommendations

- Plan for structural barriers such as reinforced concrete or metalised walls.
- Use repeaters sparingly—only when necessary for coverage.
- For multi-unit buildings, isolate radio systems per flat to avoid interference.
- Always verify signal strength during installation and adjust positions if needed.

4.2 Extreme Example in a One-Family Home

In rare cases where ceilings are heavily reinforced with concrete or basement walls are exceptionally thick, a second repeater may be required to achieve full coverage.
Both repeaters must be configured for two-level operation (see details in Chapter 2.9).

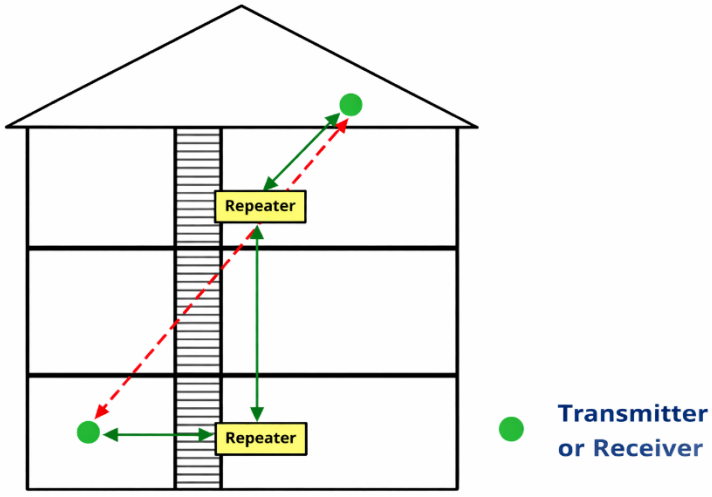

Figure 13: Example of a Single-Family Home Installation.

5 Radio System Debugging

The previous sections explained how to select the ideal installation locations for transmitters and receivers to ensure smooth operation.

If you still experience radio transmission issues, refer to the troubleshooting table below.

Problem	Possible Cause and Solution
No telegrams received	**Transmitter not sending** • Check the transmitter • For solar-powered devices, ensure there is sufficient light. A quick test is to expose the transmitter to daylight or a bright lamp. **Transmitter out of range or replaced** • The transmitter or receiver antenna should be repositioned. • Refer to the installation guidelines in Chapter 2. **Receiver malfunction** • Inspect the receiver, the antenna installation and the antenna cable
Some telegrams are not received	**Low-power interference near receiver** • Relocate any nearby devices (e.g. telephones or PCs) to at least 50 cm away from the EnOcean receiver. **High-power interference or Jammer present** • Identify and remove the interfering device. **Receiver positioned at range limit** • Adjust the antenna placement or install a repeater **Position of transmitter or receiver has changed** • Correct the position of sender and receiver • Mount sender and receiver in a fixed position within reception range. **Receiver performance has degraded** • Check the antenna installation and the antenna cable

Table 2: Radio Communication Troubleshooting