Light is networked

Design-in guide for wireless drivers and applications

OSRAM

Contents

1 Why use wireless drivers?

1.1 Advantages of using wireless technology

Modern lighting systems play a vital role in the carbon footprint of public buildings, industrial plants or private homes. Energy-efficient light management is therefore a very effective tool for reducing energy consumption, making the best possible use of daylight and thus lowering the total operating costs.

But light management must not only be efficient, it is also crucial that the entire process – from planning and commissioning to installation and daily use – is intuitive, time-saving, simple and comfortable. This is how the advantages of wireless technology pay off for different target groups: for building owners as well as for architects, lighting designers, installers and end users.

1.2 Benefits for different target groups

Facility managers and building owners

- Easy to **adapt to new space usage** concepts (new tenants)
- **Scalability** for system extensions and buildving/location expansions
- **Reduced downtime during installation/refurbishment** compared to wired installations
- **Robust** and transparent **security concept by design**, including user management
- **Maximum savings** in existing buildings thanks to motion detection and daylight harvesting
- Applicable in infrastructures **not prepared for rewiring** or general changes
- **Maximum flexibility** for new installations and especially for retrofitting or adaption of existing installations

Installers

- **Ease of installation** and simple customization
- **Reduced complexity** during system set-up, no single point of failure, reduced planning effort
- Easily **scalable solution** and less training effort
- Simultaneous **multi-installer commissioning*** to reduce labor time and costs
- **Pre-configuration service*** allows to divide enhanced and basic commissioning work
- Complete **one-stop-shop solution*** offering (hardware and software)

Lighting solution providers

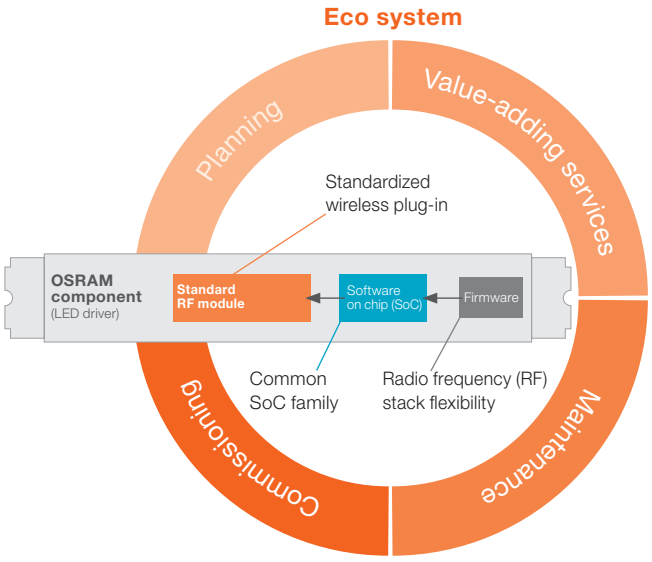
- Real **scalable solution** with less training effort
- **Sustainable investment** due to an open standard
- **New commissioning experience** enables new project opportunities
- **Remote commissioning service*** possible
- Complete **one-stop-shop solution*** offering (hardware and software)

*) These functions are available with certain systems, e.g. HubSense.

1.3 Our OPTOTRONIC wireless strategy – the key to flexibility

Our approach: Future-proof, flexible and customer-centric

- Future-proof platform supporting most relevant standards for lighting
- Flexibility to program different stacks and protocols
- Same wireless module for all drivers, sensors, pushbutton couplers, gateways (wireless2wired) etc.
- Standardized components to ensure availability and cost-efficient wireless connectivity



1.4 Key reasons why you can rely on our wireless LED drivers

Our corporate values:

Strong technical competence

- Strong technical competence
- Multiple global R&D sites with high technical knowledge
- Knowledge and experience in major wireless protocol systems
- Investments in emerging protocols and carriers (e.g. DALI+)

Highly flexible systems and components

- System approach and components fulfillment
- Wireless drivers that fulfill your project demands

Customer-centric

- Capability of developing drivers and integrating protocols based on your project requirements

High-quality technical support

- Customer focus and competent support
- Global team of application engineers
- Support with luminaire design-in, driver positioning, range improvement etc.

2 Wireless communication technology

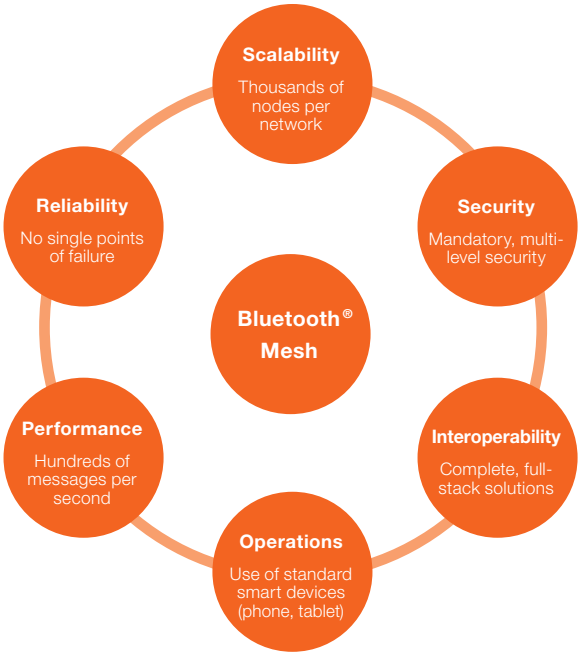
For wireless communication technology, we have decided to use Bluetooth® technology, since most smartphones already have Bluetooth® pre-installed and 35 % of all connected IoT devices rely on Bluetooth® technology.

2.1 Benefits of Bluetooth® wireless technology

Bluetooth® Mesh enables the creation of large-scale device networks. It is ideally suited for control, monitoring and automation systems where hundreds or thousands of devices need to communicate with one another. Bluetooth® Mesh was designed from the beginning to meet the strict requirements of commercial and industrial environments where performance, reliability and security are of the utmost importance.

of all IoT connected devides rely on Bluetooth® technology

Data source: ABI Research, 2022



Please note:
We are a Bluetooth® SIG associate member. More information is provided on www.bluetooth.com

Bluetooth® Low Energy (BLE)
This technology is designed for low-power point-to-point communication between central devices (e.g. PS, smartphone, tablet) and peripheral devices (e.g. headphones, fitness trackers, luminaires). There is no need for a gateway or additional tools. It is often used as an interface for direct communication between Level 1 and Level 3 without the need for a gateway, router or separate controller.

Bluetooth® Mesh (QBM)
This is a robust standard lighting control interface designed to minimize power consumption and to be future-proof for data exchange between multiple nodes in a Qualified Bluetooth® Mesh (QBM) network. There is no single point of failure because the control function is integrated in Level 1 devices. The technology is based on Bluetooth® Low Energy (BLE).

Full-stack solution
Unlike other low-power wireless mesh networking technologies, Bluetooth® Mesh is a complete, full-stack solution that defines everything from the low-level physical radio layer through to the high-level application layer. In addition to enabling easier product development and greater levels of product interoperability, this full-stack approach allows for a faster and smoother evolution of the technology. Bluetooth® Mesh is entirely in control of its own destiny.

Application layer	Bluetooth® Mesh models
Networking layer	Bluetooth® Mesh profile
Radio layer	Bluetooth® Low Energy

Decentralized control
Bluetooth® Mesh has fully embraced the intelligent edge. Control systems based on Bluetooth® Mesh do not require centralized controllers, as intelligence is distributed to all end devices. For example, in a Bluetooth® Mesh lighting control system, switches and sensors do not communicate to a centralized controller which then controls the lights, but instead they communicate directly with the lights. This decentralized control architecture enables systems to achieve significantly greater scale, reliability and performance, as well as lower costs.

Publish/subscribe (pub/sub) addressing
Individual device addressing used by most other wireless mesh communications systems is best suited for wired networks where most traffic is unicast. However, in wireless networks with significant multi-cast traffic, including lighting control systems, it can result in significant scale and performance issues. In addition to individual device addressing, Bluetooth® Mesh supports a unique publish/subscribe (pub/sub) addressing approach for multi-cast traffic. In pub/sub, devices, such as light switches, publish their messages to a group address, like a conference room. All devices that should receive that message, such as the lights in the conference room, subscribe to that group. The pub/sub approach results in significantly lower messaging traffic on the network, leading to greater network scale and performance.

2.2 Limitations of using wireless technology

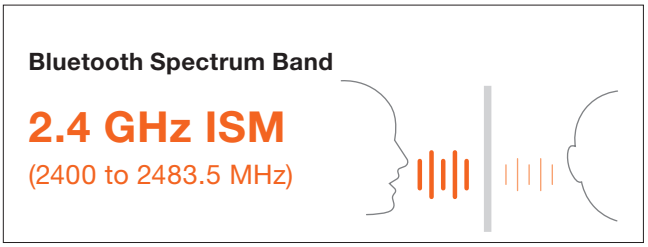
What determines the Bluetooth® range?
The short answer to the question about the range of Bluetooth® technology it is: It depends. If explained in detail, the answer is slightly longer: Unlike other wireless technologies, Bluetooth® technology is designed to support a wide range of achievable ranges between two devices, providing developers tremendous flexibility to create wireless solutions that best meet the needs of their target use case.

Several key factors influence the effective range of a reliable Bluetooth® connection, including the following:

Interference
One of the biggest challenges for any wireless technology in providing reliable data communication is interference. Unlike wired data communications technologies, wireless technologies must share the transmission medium. For example, Bluetooth® technology operates in the same 2.4 GHz ISM frequency band as Wi-Fi and technologies that utilize the IEEE 802.15.4 standard. As a result, it's possible for a packet being transmitted between two Bluetooth® devices to be corrupted or lost if it collides with a packet being transmitted at the exact same time and frequency channel as other in-range Bluetooth®, Wi-Fi, or 802.15.4 devices.

Path loss
Path loss is the reduction in signal strength that occurs as a radio wave propagates through the air. Path loss, or path attenuation, occurs naturally over distance and is impacted by the environment in which the signal is being transmitted. Obstacles between the transmitter and the receiver can deteriorate the signal.

Attenuators can be anything from humidity and precipitation, to walls, windows, and other obstacles made of glass, wood, metal, or concrete, including metal towers or panels that reflect and scatter radio waves. While radio waves can pass through objects, the amount of attenuation and effective path loss varies with the type and density of the obstruction. Think about when you are trying to hear someone in the next room and the difference between the volume and clarity of what you can hear if the wall that separates you is made of wood compared to concrete.



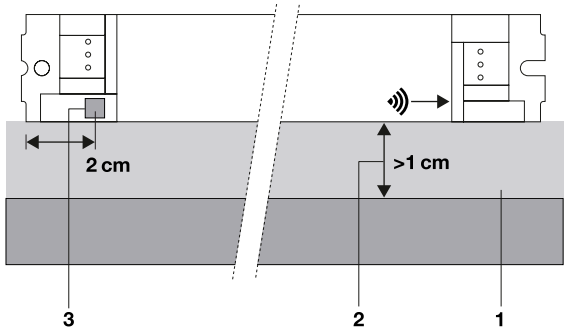
3 Design-in rules for luminaires

3.1 General rules

The following points are general guidelines for control placement to optimize the stability and effective range of the Bluetooth/wireless connection:

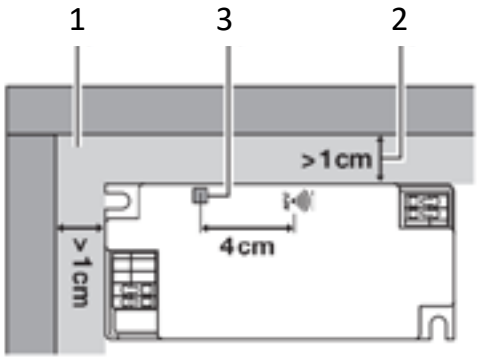
1. Preferable installation on systems free from metal obstructions or materials that significantly weaken the radio frequency signal (e.g. fiber-reinforced plastic).
2. Do not completely enclose wireless LED drivers inside metal boxes!
3. Keep a distance of at least 1 cm between the antenna area and the mounting surface.
4. Do not wire cables (mains voltage, LED supply wires) near the antenna area.
5. Consider an installation height above the furniture and human obstacles (e.g.: 1.6 m from the floor). This is important for the wireless communication range. The wireless range between the controllers is smaller than between a controller and a smartphone because the controllers are partly surrounded by metal housings while the smartphone is not.

Mounting hint



1) Do not place any mains voltage or LED supply wires within or close to this area
2) Recommended minimal distance to metal parts: 1 cm
3) Placement of integrated radio transmitter antenna

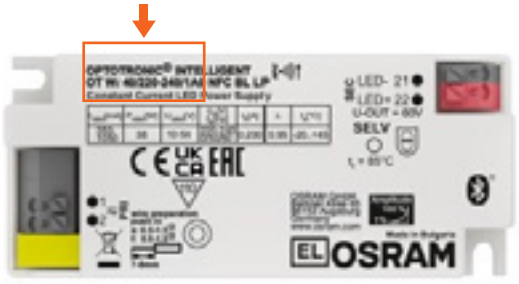
Mounting hint



1) Do not place any mains voltage or LED supply wires within or close to this area
2) Recommended minimal distance to metal parts: 1 cm
3) Placement of integrated radio transmitter antenna

Antenna position for OT Wi **LINEAR** drivers

Antenna position for OT Wi **COMPACT** drivers



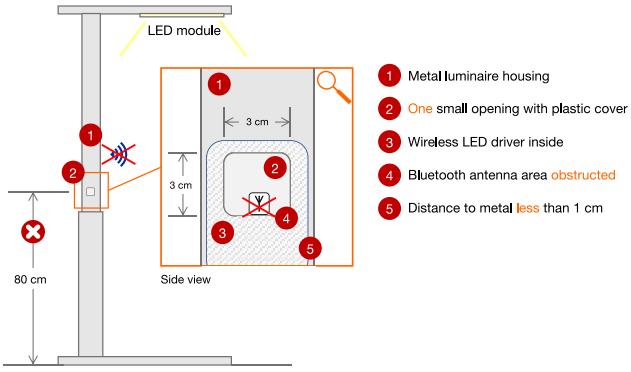
3.2 Dos and don’ts for wireless LED driver design-in

The examples on the following pages present some common mistakes that can be made during the design-in of wireless LED drivers into various types of luminaires. The wrong design is always shown in the left column. In contrast, the column on the right shows what can be done to avoid these mistakes, thus representing examples for correct design-in. Please note that the objective is always to find the optimal solution for achieving an unobstructed radio signal transmission without interferences.

Example 1: Floor-standing LED luminaires communicating wirelessly with each other via Bluetooth

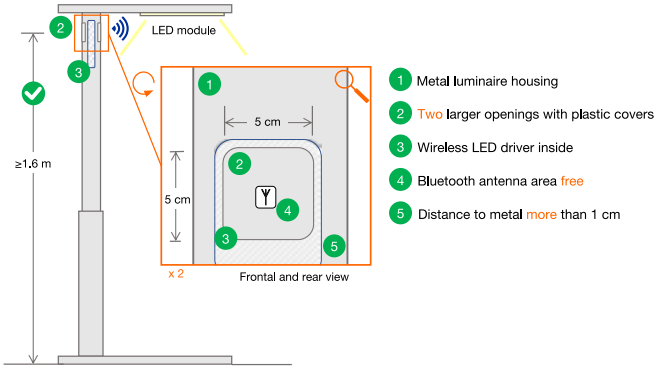
Wrong design

- Radio node placed inside a full metal tube, with only one small square opening with a plastic cover (3 cm x 3 cm) on one side.
- Height of installation from the ground only around 80 cm.



Correct design

- The radio node is placed at a higher distance from the floor (approx. 2 m).
- Two larger openings of about 5 by 5 cm have been made in the antenna zone. This significantly improves the radio signal transmission, especially when luminaires are communicating wirelessly with each other via Bluetooth®.



Checklist	Answer	
Has shielding through metal obstacles been avoided?	No	✗
Has the minimal distance of 1 cm to metal parts been observed?	No	✗
Has care been taken not to wire cables near the antenna area?	No	✗
Has the correct installation height of at least 1.6 m been observed?	No	✗

Checklist	Answer	
Has shielding through metal obstacles been avoided?	Yes	✓
Has the minimal distance of 1 cm to metal parts been observed?	Yes	✓
Has care been taken not to wire cables near the antenna area?	Yes	✓
Has the correct installation height of at least 1.6 m been observed?	Yes	✓

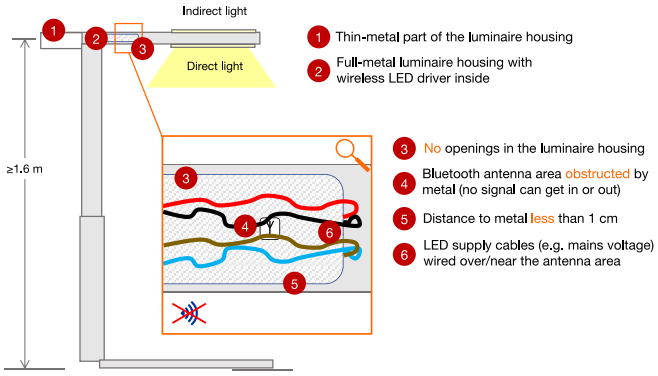
Connection range test results	Answer	
Has the mobile-to-device test shown a connection range of at least 10 m?	No	✗
Has the device-to-device test shown a connection range of at least 10 m?	No	✗

Connection range test results	Answer	
Has the mobile-to-device test shown a connection range of at least 10 m?	Yes	✓
Has the device-to-device test shown a connection range of at least 10 m?	Yes	✓

Example 2: Two-lamp floor-standing LED luminaire with direct and indirect light emission

Wrong design

- The radio antenna is inside a metal tube.
- Installation height: ≥1.6 m

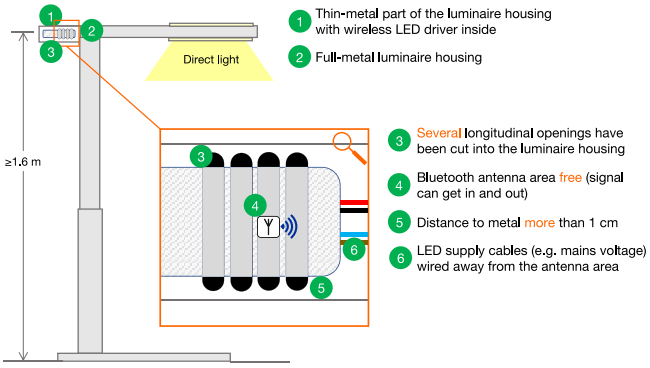


Checklist	Answer	
Has shielding through metal obstacles been avoided?	No	✗
Has the minimal distance of 1 cm to metal parts been observed?	No	✗
Has care been taken not to wire cables near the antenna area?	No	✗
Has the correct installation height of at least 1.6 m been observed?	Yes	✓

Connection range test results	Answer	
Has the mobile-to-device test shown a connection range of at least 10 m?	No	✗
Has the device-to-device test shown a connection range of at least 10 m?	No	✗

Correct design

- The radio antenna has been placed on the back of the luminaire, where the full-metal surfaces are far from the radio antenna.
- In the antenna zone, a set of longitudinal openings (each with a length of 5 cm) has been made to decrease the RF attenuation.



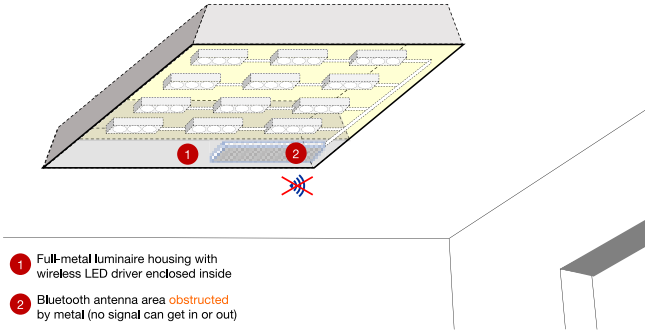
Checklist	Answer	
Has shielding through metal obstacles been avoided?	Yes	✓
Has the minimal distance of 1 cm to metal parts been observed?	Yes	✓
Has care been taken not to wire cables near the antenna area?	Yes	✓
Has the correct installation height of at least 1.6 m been observed?	Yes	✓

Connection range test results	Answer	
Has the mobile-to-device test shown a connection range of at least 10 m?	Yes	✓
Has the device-to-device test shown a connection range of at least 10 m?	Yes	✓

Example 3: Ceiling luminaire for offices

Wrong design

- The original OPTOTRONIC linear LED driver has been replaced by an OPTOTRONIC Wireless (OT Wi) linear LED driver.
- Metal surfaces all around the radio antenna embedded in the LED driver.

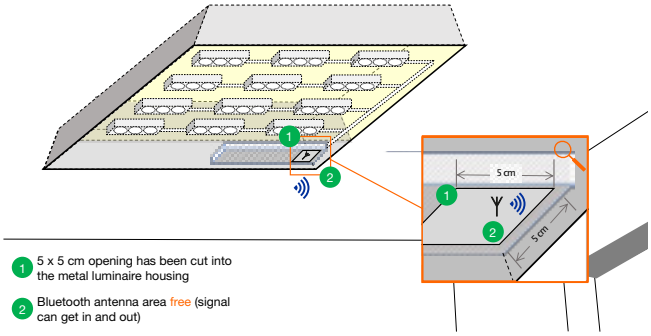


Checklist	Answer	
Has shielding through metal obstacles been avoided?	No	✗
Has the minimal distance of 1 cm to metal parts been observed?	No	✗
Has care been taken not to wire cables near the antenna area?	Yes	✓
Has the correct installation height of at least 1.6 m been observed?	Yes	✓

Connection range test results	Answer	
Has the mobile-to-device test shown a connection range of at least 10 m?	No	✗
Has the device-to-device test shown a connection range of at least 10 m?	No	✗

Correct design

- An aperture of approximately 5 by 5 cm has been made on the metal surface in the antenna zone of the LED driver.



Checklist	Answer	
Has shielding through metal obstacles been avoided?	Yes	✓
Has the minimal distance of 1 cm to metal parts been observed?	Yes	✓
Has care been taken not to wire cables near the antenna area?	Yes	✓
Has the correct installation height of at least 1.6 m been observed?	Yes	✓

Connection range test results	Answer	
Has the mobile-to-device test shown a connection range of at least 10 m?	Yes	✓
Has the device-to-device test shown a connection range of at least 10 m?	Yes	✓

4 Application rules for wireless system solutions

4.1 Wireless system planning and expectations

Wireless project considerations

Although wireless lighting control can be “quick and easy,” it is still recommended to always plan projects in advance, while considering wireless communication requirements.

In many typical cases of wireless node distribution (e.g. “standard” offices) there would likely be very low risk of mesh connection issues, even without any special planning. However, it is always worth reviewing the project plans so you can be aware of potential issues and therefore be prepared for risk mitigation measures. For example, metal-walled elevator shafts or metal-mesh ceiling panels in the application could become a communication blocker requiring work-around measures.

Expectations regarding the wireless range

When it comes to range, as mentioned previously, the first key is to get the strongest signal out of the luminaire/node itself in the first place, which is why careful design-in is very important. But after that, there are other influences on range in the application, such as node specification, density/placement, orientation and on-site environmental effects. Typically, the expected wireless range of individual nodes may be stated as 10 to 15 m. This is generally a quite conservative statement, with many devices on their own achieving a far greater range than this. However, influences in the application, outside of the wireless LED driver and the luminaire itself, can mean the ranges may be heavily affected and in extreme cases even such conservative expectations may not be achieved in reality.

It is recommended for all nodes to be planned to be in range of two other nodes where possible, to both enhance network strength and to provide a backup communication route in case of failure of one of the nodes.

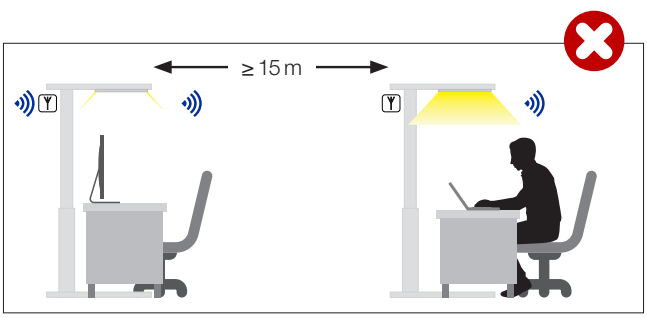
Checks and risk mitigation measures

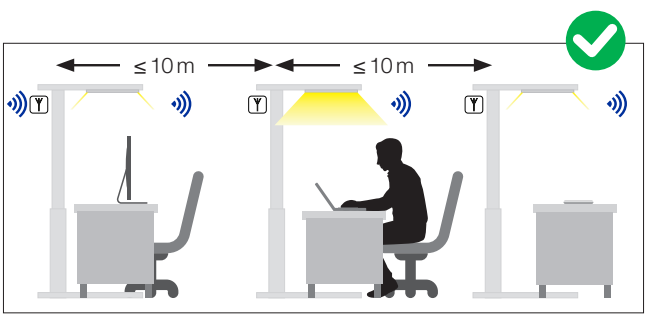
Thanks to the Bluetooth® Mesh functionality, the signal transmission between mesh nodes is given even with a faulty node in between. Nevertheless, it is always recommended to check the mesh quality during and at the end of the commissioning process by simply testing the signal transmission between mesh nodes. If mesh quality is not perfect across the entire mesh, it may not necessarily be a problem for basic functionality as long as there is good mesh quality within each control group and no functional linking to groups is showing poor mesh quality. However, this does not exclude that there still may be some functionality issues. It is always best to check and improve mesh quality as much as possible. The different wireless systems have differing options that you can use to improve performance in case of (potential) issues.

While some systems automatically repeat to transmit messages across nodes – but thereby create additional network traffic – others only use selected nodes for this repeating action to minimize the traffic. Repeater nodes can be vital for working around on-site elements that would otherwise block signals (e.g. elevator shafts). Specifically, multiple repeaters can be placed/activated so that the wireless signal can “hop” around obstacles. Moreover, repeater nodes can also be desirable/appropriate to enhance functionality in long and narrow application areas, such as corridors, where the radio signal transmission range is very quickly used up, or where the mesh needs to link between separate areas within a project (e.g. between building floors)

Some systems may have the option to select different radio frequencies if there is an interference problem on the original frequency, or even to boost the output of the nodes, if possible, but that always happens at the expense of additional power. However, there may be some elements of “trial and error” with frequency selection to get the best results.

The inclusion of additional nodes as “passive repeaters” that are only there to allow enhanced mesh range/quality can also be considered. These could be nodes with no other active function in the system (e.g. not part of a luminaire or sensor). They are only there to allow the messages in the system to be passed on.





4.2 Wireless system testing and troubleshooting

Getting the wireless signal out of the luminaire is key for the proper functioning of the system. The better you do this, the lower the risk that the system will not work properly due to external influences.

If you do encounter issues, proceed as follows:

- Try to connect from your smartphone to one luminaire. Also try various orientations of the luminaire to understand any directionality of the arrangement.
- Place two luminaires in a line of sight (start with a low distance) and try to control both, then test again with different orientations.
- Gradually increase the distance and re-test.
- Try using the smartphone from different locations (e.g. perpendicular to the luminaires, in line with the luminaires).
- Repeat with more luminaires to understand how well the signal is hopping.
- Perform mesh quality tests during and after commissioning to detect weaker areas.
- Check the saturation of the 2.4 GHz frequency band with an app, e.g. “Nordic nRF Connect”.

Be aware that in applications with very high levels of interference, other wireless traffic, or where signal strength between nodes is poor (etc.), it should be expected that, on rare occasions, a given node may “miss” a transmitted message and therefore not respond. This does not suggest any fault of the system, merely a physical result of the difficulty of transmitting the signals to all subject nodes, given the wireless environment conditions. A simple re-sending of the command will often correct the problem, e.g. by pushing the manual control button again or by re-triggering a sensor. While this is actually rarely an issue, customer expectations should still be considered and managed correspondingly.

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