GREEN-GO Wireless Guidance

This guide provides deeper insight into the standards used in Green-GO Wireless systems, along with general best practices, helpful tips, and important do's and dont's to ensure optimal performance and reliability.

For detailed guidance on setting up all Green-GO access points and beltpacks, please refer to the official Green-GO manual, available at **manual.greengoconnect.com**

How does Green-GO transmit wireless intercom?

DECT Communication Standard

Green-GO utilizes the DECT standard for its wireless communications. DECT stands for Digital Enhanced Cordless Telecommunications - a communications standard developed by ETSI that is mainly known for being used in cordless telephone systems.
Most countries have a license-free frequency range that can be used for DECT. The amount of carrier frequencies (1,728 MHz spacing) available in each country differs. DECT uses both FDMA (Frequency-Division Multiple Access) and TDMA (Time-Division Multiple Access). Multiple frequencies are available, each with 24 time-slots. Each frequency carries 12 upstream and 12 downstream time slots.

Advantages

- Excellent voice quality; DECT is optimized for voice communication and low latency.
- Dedicated frequency band; Operates in its own reserved frequency band (typically 1880-1900 Mhz in Europe, reducing interference from Wi-Fi, Bluetooth and other 2.4/5 Ghz devices.
- Stable connections; Frequency hopping enables stable wireless connections, making it reliable for critical communications.
- Scalable coverage and reliable roaming; The wireless coverage area can be extended by integrating additional access points into the network. DECT facilitates seamless handover, allowing for uninterrupted roaming across access points that support this feature.
- Low power consumption; In addition to the standard, using DECT enables us to improve battery efficiency by dynamically lowering transmission power when full power is unnecessary, outperforming other wireless protocols in energy conservation.

Downsides

- Spectrum availability varies; DECT bands differ by region (e.g. 1880–1900 MHz in Europe, 1920–1930 MHz in some other regions). In places without a standardized DECT band, you may face regulatory hurdles or interference.
- Limited device capacity; A single DECT RF space typically supports between 4 and 20 wireless Green-GO devices with optimal audio quality, depending on region and available bandwidth. Additionally, the number of simultaneous connections to a single access point is limited.
- Interference at high density; In very crowded DECT deployments, overlapping transmitters may lead to interference and require planning to ensure optimal performance.
- Signal cannot be repeated; Expanding DECT coverage require precisely synchronized access points and cannot be extended as easily as with Wi-Fi repeaters.
- Cellular interference; DECT may suffer from interference by 4G LTE and 5G Low Band transmitters, limiting the usability of the complete DECT RF-spectrum.

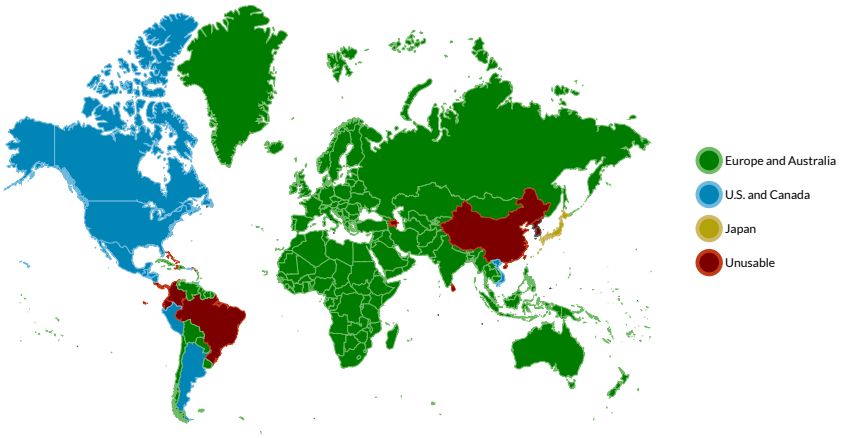
In which regions can Green-GO DECT be used?

Green-GO devices with a DECT module can operate in different frequency ranges, depending on the region the devices are used in. Green-GO currently supports the frequency ranges for the following regions:

- 1880 - 1900 MHz (Europa and Australia)
- 1893 - 1906 MHz (Japan) - reduced bandwidth compared to EU/AU DECT. Antenna X only, not supported by STRIDE yet.
- 1920 - 1930 MHz (US and Canada) - reduced bandwidth compared to EU/AU DECT.

The devices will operate in the frequency range of 1880 - 1900 MHz (Europe and Australia) after being delivered from the factory. This range is also suitable for use in South Africa, much of Asia, Hong Kong and New Zealand.

Legislation regarding frequency usage may vary and is subject to change in each country. The deployment of a Green-GO Wireless system may not be permitted in your region. Always verify the applicable frequency ranges with your local laws and regulations before installation.



Green-GO is designed and manufactured in the Netherlands by ELC Lighting
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Green-GO DECT Access Points (antennas)

There are two DECT-based options to add wireless devices to your Green-GO network:

1. **Green-GO Wireless Antenna X**
   Best for: Small to medium setups
   Technology: DECT-based
   Scalability: Limited, up to 4 beltpacks and 7 antennas
   Roaming: Non-seamless roaming (between 5 – 10s connection loss during handover)

2. **Green-GO STRIDE Antenna**
   Best for: Large-scale and fixed installation
   Technology: DECT-based
   Scalability: Flexible, up to 100 beltpacks and 250 antennas
   Roaming: Full-seamless roaming (PTPv2 synchronization required)

TX- (transmission) Power
All Green-GO DECT access points comply with the same DECT standard and its limitations, meaning they offer identical performance in terms of transmission power.

Antenna Characteristics
All Green-GO DECT access points are equipped with omni-directional transmit (TX) and receive (RX) antennas, meaning they broadcast and receive signals equally in all directions.

To ensure optimal performance, it's important to consider this characteristic when positioning the access points. Ideally, they should be placed in open, central locations to maximize coverage. Avoid positioning them near obstacles or conductive materials, as these may interfere with the signal.

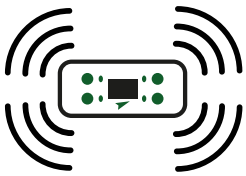
If an access point is receiving intermittent RF signals, we can take advantage of its omni-directional characteristics by physically shielding the side from which the interference is coming.

Green-GO DECT Wireless Devices

Unlike DECT access points, Green-GO DECT wireless devices operate exlusively within their allocated DECT time-slots, defined by both frequency and time synchronization. This time-devision multiplexing significantly reduces the risk of RF interference.

Power Scaling
Additionally, DECT power scaling dynamically adjusts the transmission power based on the device's proximity (determined by the devices received signal strength. This not only minimizes RF spectrum congestion but also optimizes energy efficiency, particularly for battery-power devices.

Antenna Characteristics
All Green-GO DECT wireless devices are equipped with omni-directional antennas as well, meaning they broadcast and receive signals equally in all directions. This also reduces the impact of device orientation on signal performance.



DECT & RF Golden Rules

Antenna placement
Just like with Wi-Fi and other wireless technologies, proper antenna placement is crucial for optimal DECT performance. Keep the following in mind:

- Line of sight is always preferred. Physical obstructions can degrade signal quality.
- When using multiple antennas, maintain a minimum distance of 2 meters between them to avoid interference.
- Avoid placing antennas near large metal objects, thick walls, or other electronic equipment that may cause signal reflection or absorption. Devices and power sources that emit electromagnetic fields (EMF) such as dimmers, power supplies, cable bridges, and LED screens can interfere with RF signals.
- Take into account the omni-directional nature of the antennas when positioning access points, as they transmit and receive signals equally in all directions.

The optimal location for an access point may sometimes seem counterintuitive, especially when minimizing external interference is more critical than maximizing range. In such cases, shielding the access point from disruptive signals can lead to better overall performance, even if it means sacrificing some coverage

Thoughtful placement is key to maintaining a stable and reliable wireless communication environment.

RF Blockers
Several materials and objects can interfere with DECT signals. Be aware of the following potential blockers:
- Curtains and fabrics: Even soft materials can begin to degrade signal strength.
- Glass with metal coating, concrete walls, metal structures, and dense furniture can significantly reduce signal quality.
- Water: Human bodies can also absorb DECT signals, especially in crowded environments.

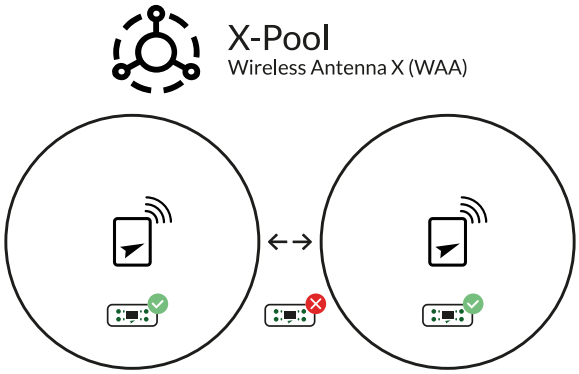
Please take these potential signal-blocking materials into account when using Green-GO Wireless in combination with costumes, stage props, and theatrical decorations.

Roaming

Roaming using Green-GO Wireless Antenna X's
Roaming between Antenna X's (GGO-WAA) is supported using "X-Pools", but it is not designed to be a seamless experience like with cellular networks. When a device reaches a certain received signal strength (RSSI) threshold, it will disconnect from its current access point. This threshold can be adjusted either directly in the device settings or remotely via Green-GO Control.

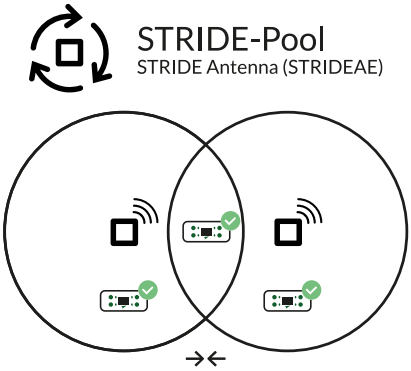
After the disconnection, it will attempt to reconnect to the strongest available signal at that moment. This reconnection process usually takes between 5 – 10 seconds, during which no communication is possible.

For best results ensure that there are clear zones between antennas where the signal from one antenna drops out before the next is picked up. Overlapping coverage areas can cause instability, delays in switching or causing the wireless device to reconnect with its initial access point.



Seamless-roaming using Green-GO Wireless STRIDE Antennas
Seamless-roaming between STRIDE Antennas is supported using "STRIDE-Pools". These access points make use of the PTPv2 time synchronization protocol to synchronize their signal transmission. This ensures there are no noticeable dropouts when a handover between access points occur.

In contrast to the Antenna X, it is recommended to maintain some overlap between STRIDE Antennas. This overlap helps prevent dead zones that could otherwise lead to connection drops, ensuring more stable roaming and continuous communication coverage.

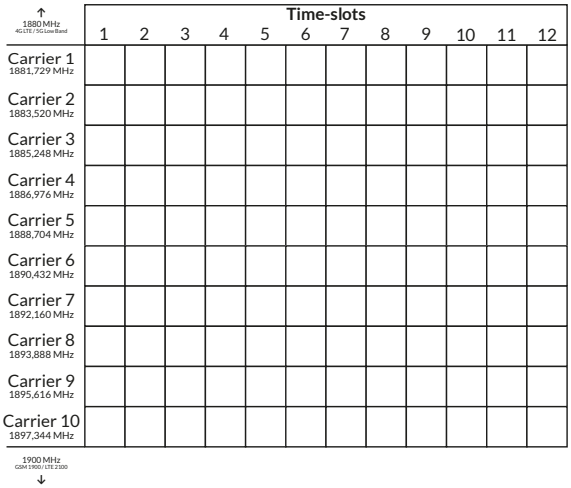


DECT Time-slots and Carriers Explained

In most parts of the world, a 20 MHz frequency band is used between 1880 and 1900 MHz. This band is divided into 10 channels (or carriers), each spaced 1,728 MHz apart.

To allow multiple devices to use the same channel, each channel is further divided into 12 time slots using Time Division Multiple Access (TDMA). Each device is assigned a specific time-slot during which it can transmit or receive. By separating transmission and reception in time, devices avoid interference, enabling multiple simultaneous connections on the same frequency.

Combining the 10 frequency channels with 12 time slots per channel results in a total of 120 time-slots, theoretically allowing up to 120 simultaneous connections within the same RF spectrum.



DECT Capacity and Audio Bandwidth Trade-Off

In an ideal, interference-free DECT environment, up to 120 time-slots (12 time-slots across 10 carriers in DECT region Europe & Australia) are available for Green-GO Wireless devices. By default, WBPX-beltpacks use double-width time slots to achieve 7 kHz wideband audio quality.

However, to connect more devices, it's possible to switch to narrowband mode, which reduces usage to a single time-slot per device. This significantly increases capacity but comes at the cost of audio quality, which may sound robotic, though still suitable for mission-critical communication.

Due to external RF interference and the inherent characteristics of radio frequency propagation (reflection, diffraction, scattering and attenuation), the full spectrum is rarely entirely available for Green-GO systems. As a result, the number of devices that can reliably operate in "wideband" mode is typically limited to approximately 20 devices, depending on the local RF environment and spectrum availability.

Devices cannot be fixed to a specific time-slot, devices will hop to their most ideal slot and carrier.
When setting up a connection or powering on beltpacks, ensure that a sufficient amount of access points are available and within range to establish and maintain stable wireless connections.

Range

Just like the maximum number of devices that can be connected within a single RF environment, the effective wireless range is highly dependent on the specific deployment conditions. Factors such as radio frequency (RF) propagation, physical obstructions, RF blockers and interference from other devices operating in or near the DECT band can significantly affect performance.

RF propagation is influenced by environmental elements such as walls, ceilings, metal structures, and even human bodies, which can reflect, diffract, scatter, or attenuate the signal. These effects may reduce signal strength or cause multipath interference, leading to unstable or degraded communication.

As a result, the actual range between a Green-GO access point and a wireless device may vary considerably typically between 30 – 50 meters indoors and 300 meters outdoors (line of sight) depending on the layout, materials, and RF noise present in the area.

To ensure optimal performance:
- Position access points to maintain clear line of sight where possible.
- Avoid placing access points near RF blockers or sources of RF interference.
- Perform a site survey to identify potential RF challenges before deployment.
- Ensure sufficient access point coverage for the number of devices and the size of the area.

Proper planning and awareness of RF behavior are essential for achieving reliable and high-quality wireless communication in Green-GO systems.

RF Analysis / Site Surveying

It is considered best practice to perform a radio frequency (RF) analysis before deploying any DECT system, especially for permanent installations or in environments where RF interference is suspected. A thorough analysis helps ensure optimal performance and minimizes communication issues caused by overlapping signals or environmental noise.

The Green-GO STRIDE Antenna offers valuable insight into the DECT spectrum when operated in monitor mode. In this mode, the antenna disables its access point functionality, allowing it to passively scan and receive signals across the entire DECT frequency range.
Within the Green-GO Control software, the monitor view presents a dynamic grid visualization of the DECT spectrum. This view displays detected RF levels in their corresponding time slots, helping users identify areas of potential interference or congestion.

For even deeper analysis, spectrum analyzers capable of scanning frequencies between 1000 MHz and 2000 MHz can provide real-time visibility into the DECT spectrum and adjacent bands. These tools are especially useful for identifying neighboring interference sources that may impact DECT performance.

When a connection is established between a Green-GO access point and a WBPX beltpack, you can take advantage of the beltpack's built-in signal analyzer. This feature provides real-time feedback directly on the beltpack, showing both the signal strength and the currently connected access point.

This tool is especially useful for:
- Identifying areas with weak reception.
- Determining the effective range of an access point.
- Locating handover zones, where the beltpack transitions between antennas while roaming.

While these diagnostic tools are not typically required for standard Green-GO wireless system setups, they are considered best practice in environments where signal issues are anticipated or where optimal coverage is critical.

Note: When surveying a venue, keep in mind that measurements taken without an audience present may differ significantly from those taken during a live event. Audience presence can introduce additional RF noise, physical obstructions, and environmental changes that affect signal propagation and system performance.
For the most accurate results, consider conducting RF analysis under conditions that closely resemble actual usage. In such cases, transmission from the access point to the Green-GO WBPX-beltpack may still function, but the access point's ability to receive return signals is compromised on most of the time-slots. This leads to one-way communication, severely impacting system reliability.

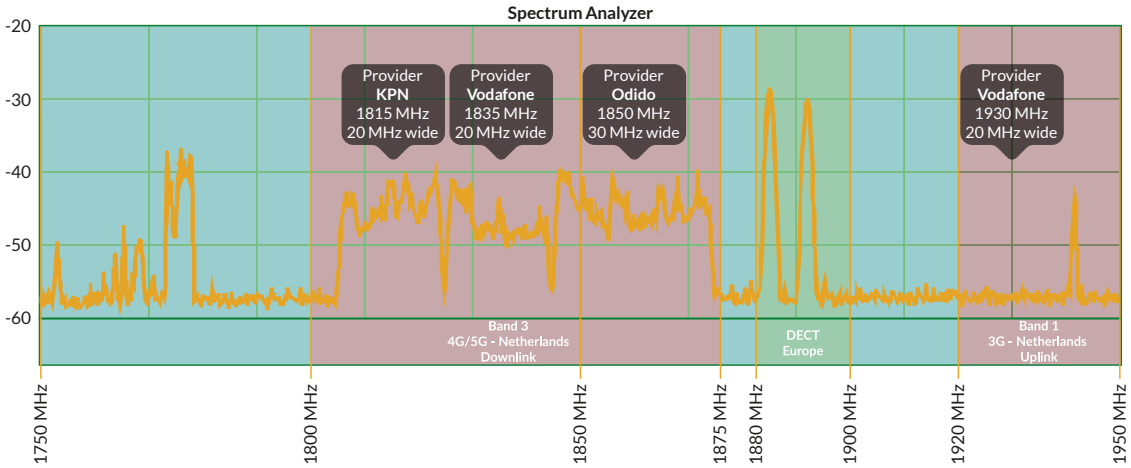
Interference Challenges in High-RF Environments

One of the primary challenges with DECT access points arises when they are exposed to high levels of RF interference, even from signals outside the DECT frequency band, such as nearby 4G LTE or 5G Low Band transmissions. These external signals can overwhelm the receiver, making reliable two-way communication difficult.

In such cases, transmission from the access point to a Green-GO WBPX wireless device may still occur, but the return signal from the beltpack to the access point can be disrupted. This results in one-way communication, which severely limits system functionality.

These conditions often occur in environments like sports stadiums, which are often equipped with numerous LTE repeaters, and festival grounds, where temporary cellular support masts are deployed to accommodate large crowds. These setups create a dense and unpredictable RF environment, significantly complicating the performance and reliability of DECT systems.

Example:



This example illustrates a challenging RF environment where a Dutch telecom provider is transmitting 4G LTE signals very close to the DECT frequency band, leaving only a narrow 5 MHz gap between them. As a result, the DECT antenna becomes overstimulated, preventing it from properly receiving signals across the full DECT spectrum.

Such occurrences have become increasingly frequent since the global expansion of 5G networks began in 2019, with rapid growth between 2020 and 2022. This development introduced new RF dynamics and potential sources of interference.

Keep in mind that this example reflects a situation in Europe, where challenges occur around 1880 MHz frequency band. Conditions may vary by region due to country-specific frequency regulations.

Interference:

1880 MHz (4G LTE / 5G Low Band)	Time-slots 1	2	3	4	5	6	7	8	9	10	11	12
Carrier 1 1881,729 MHz	-63	-63	-63	-63	-63	-63	-63	-63	-63	-63	-63	-57
Carrier 2 1883,520 MHz	-57	-63	-60	-63	-63	-63	-63	-63	-63	-60	-66	-51
Carrier 3 1885,248 MHz	-60	-66	-57	-60	-63	-63	-63	-63	-60	-57	-60	-57
Carrier 4 1886,976 MHz	-60	-63	-57	-54	-63	-63	-57	-63	-60	-60	-63	-51
Carrier 5 1888,704 MHz	-57	-63	-60	-60	-63	-63	-57	-63	-60	-60	-63	-54
Carrier 6 1890,432 MHz	-57	-63	-57	-60	-63	-63	-57	-60	-57	-57	-63	-54
Carrier 7 1892,160 MHz	-51	-63	-54	-57	-63	-60	-57	-63	-57	-57	-54	-54
Carrier 8 1893,888 MHz	-54	-63	-54	-57	-63	-63	-54	-63	-54	-54	-63	-54
Carrier 9 1895,616 MHz	-54	-63	-54	-54	-54	-63	-54	-63	-54	-54	-63	-54
Carrier 10 1897,344 MHz	-54	-48	-66	-48	-48	-54	-66	-63	-54	-54	-63	-60

1900 MHz (GSM 1900 / LTE 2100)

Typical:

1880 MHz (4G LTE / 5G Low Band)	Time-slots 1	2	3	4	5	6	7	8	9	10	11	12
Carrier 1 1881,729 MHz												-75
Carrier 2 1883,520 MHz			-77									
Carrier 3 1885,248 MHz												
Carrier 4 1886,976 MHz												
Carrier 5 1888,704 MHz												
Carrier 6 1890,432 MHz												
Carrier 7 1892,160 MHz												
Carrier 8 1893,888 MHz												
Carrier 9 1895,616 MHz			-80									
Carrier 10 1897,344 MHz												

1900 MHz (GSM 1900 / LTE 2100)

Time-slot is considered free and usable.

Time-slot in use by Green-GO wireless device

RF levels detected from unknown/un-synchronised source. Time-slot might be re-usable.

RF levels detected from unknown/un-synchronised source. Time-slot not usable for utilization of Green-GO wireless devices.

Dummy time-slot containing broadcast antenna information, enabling Green-GO wireless devices to detect and connect to available DECT access points.

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In such cases, transmission from the access point to the Green-GO WBPX beltpack may still function; however, the access point's ability to receive return signals is compromised on most time-slots. This results in one-way communication, significantly reducing overall system reliability and responsiveness.

The compromised reception prevents the access point from effectively receiving clear data back to the beltpack. As a result, the system may appear to be working from the access point's perspective, while in reality, the user is unable to communicate.

This degradation leads to a severely limited signal range, sometimes as little as 10 meters under extreme conditions, and frequent signal dropouts. Such limitations can have a major impact in critical communication environments, where consistent two-way audio is essential for coordination and safety.

Possible methods to remedy this:
- Taking control of the 4G LTE transmitters by getting in to contact with the providers. This may be a viable option for permanent installation.
- Shielding the access point from nearby 4G LTE transmitters can help reduce interference. Since the receiver is omnidirectional, blocking one side with RF-absorbing material may reduce unwanted signals, especially if the interference source is known.
- (External) RF-filtering. Applying external filters to the access points to filter out unwanted RF-frequencies.

If no solution seems possible, please contact your distributor to explore further options. It may be that an alternative to DECT is better suited for your application.