How to install the smart-house wireless modules

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1 SMART-HOUSE WIRELESS SYSTEM INSTALLATION MANUAL

This manual is an integral part of the smart-house system. Please read it carefully, as it contains important information regarding safety.

- The smart-house system must be used only for the usage it has been designed for. Any other kind of usage is potentially unsafe. The manufacturer is not responsible for improper usage.
- The manufacturer is not responsible for the consequences of using non-original spare parts.
- This manual is subject to change without notice.

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1 Introduction

The smart-house wireless system, called WiDup, provides a flexible installation where wiring is not possible.
It is based on the IEEE 802.15.4 wireless protocol. The IEEE is the Institute of Electrical and Electronics Engineers, a non-profit organization dedicated to furthering technology involving electronics and electronic devices. The 802 group is the section of the IEEE involved in network operations and technologies, including mid-sized networks and local networks. Group 15 deals specifically with wireless networking technologies.
The standard is **Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs)**

In a wireless system there is no cable to act as a secure and reliable signal path. The link must be made across free-space, through walls, people and other obstructions. This environment may be constantly changing, such as in a busy working area with people moving around. Furthermore, the environment may already contain other wireless systems that seek to "share" the same airwaves as the system to be deployed. In short, in wireless system deployment, there is usually little or no control over the deployment environment, which can vary widely.
So, care has to be taken when deploying a wireless network. The aim of this manual is to give advice about how to do it.

2 Smart-house wireless system description

WiDup, the wireless smart-house system, is designed to operate in the 2.4 GHz radio band, which is available worldwide. This band, also known as the ISM (Industrial, Scientific and Medical) band, has regulations which allow many different systems to use it at the same time. WiDup may have to share its frequency space with systems such as Wi-Fi, Bluetooth or microwave ovens and, thanks to the 16 channels of the IEEE 802.15.4 standard, this can easily be achieved.
WiDup is generated by the wireless base unit SH2WBU230N, which is connected to the Sx2WEB24 via the high speed bus that is present both on the local bus and on the terminals at the bottom of the bus generators. The distance between two “visible” antennas in ***open space*** is 700m for those modules powered by 230VAC.
By means of routers/repeaters, the operating distance in ***open space*** can reach 2100m from the wireless base unit and the slave modules powered by 230VAC. This data is based on “free-space” radio wave propagation, but in an installation many obstacles could challenge the assumptions.
Up to 7 SH2WBU230N can be connected to one Sx2WEB24 and each SH2WBU230N can handle up to 250 slave modules, such as light switches, window sensors, wireless dimmers, wireless energy meters and wireless relay modules.
The types of data managed by each SH2WBU230N can be divided as described below:

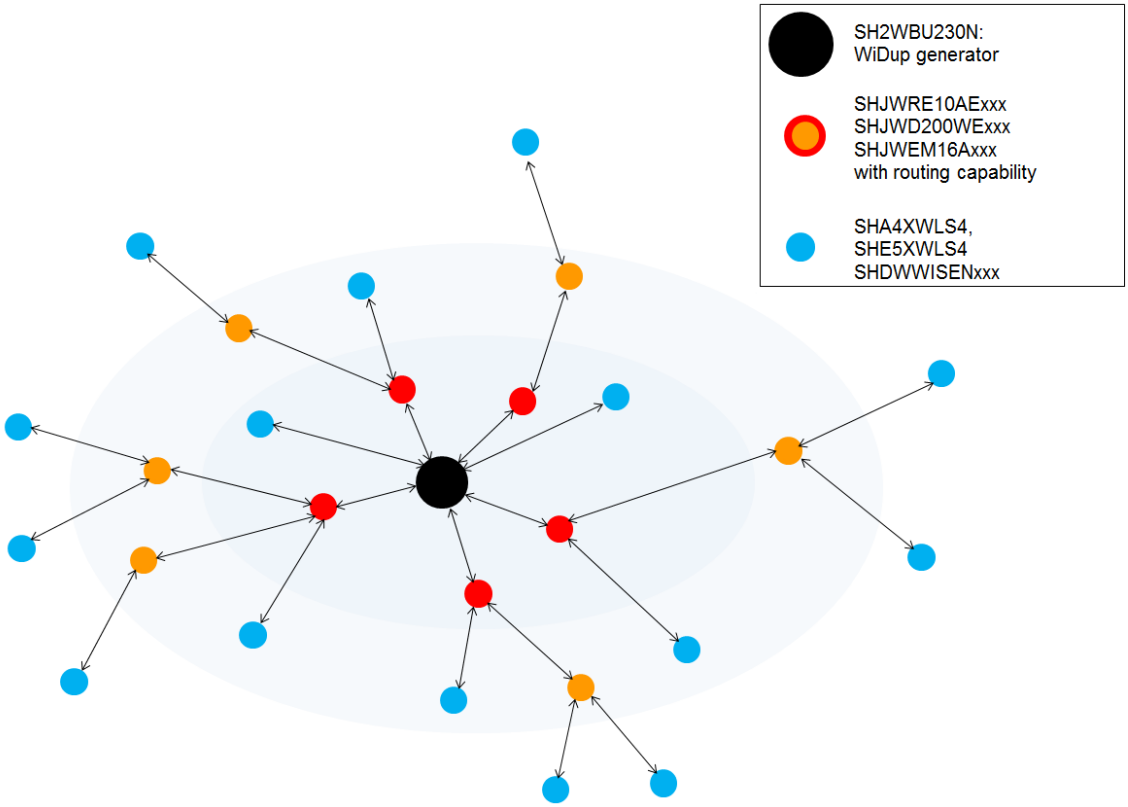
1) Up to 160 digital inputs
2) Up to 160 digital outputs
3) Up to 512 word size variables (e.g. Temperature)

The topology of a WiDup network is a tree: each slave module communicates either directly with the wireless base unit SH2WBU230N, or passes through one or two wireless routers/repeaters.

The new wireless modules, such as SHJWD200WExxx, SHJWRE10AExxx or SHJWEM16Axxx, can be programmed as routers/repeaters by means of the Sx tool: WiDup implements the routing function up to two levels. The wireless relay module SHDWRE16AE230 can be programmed as a router only for one level.

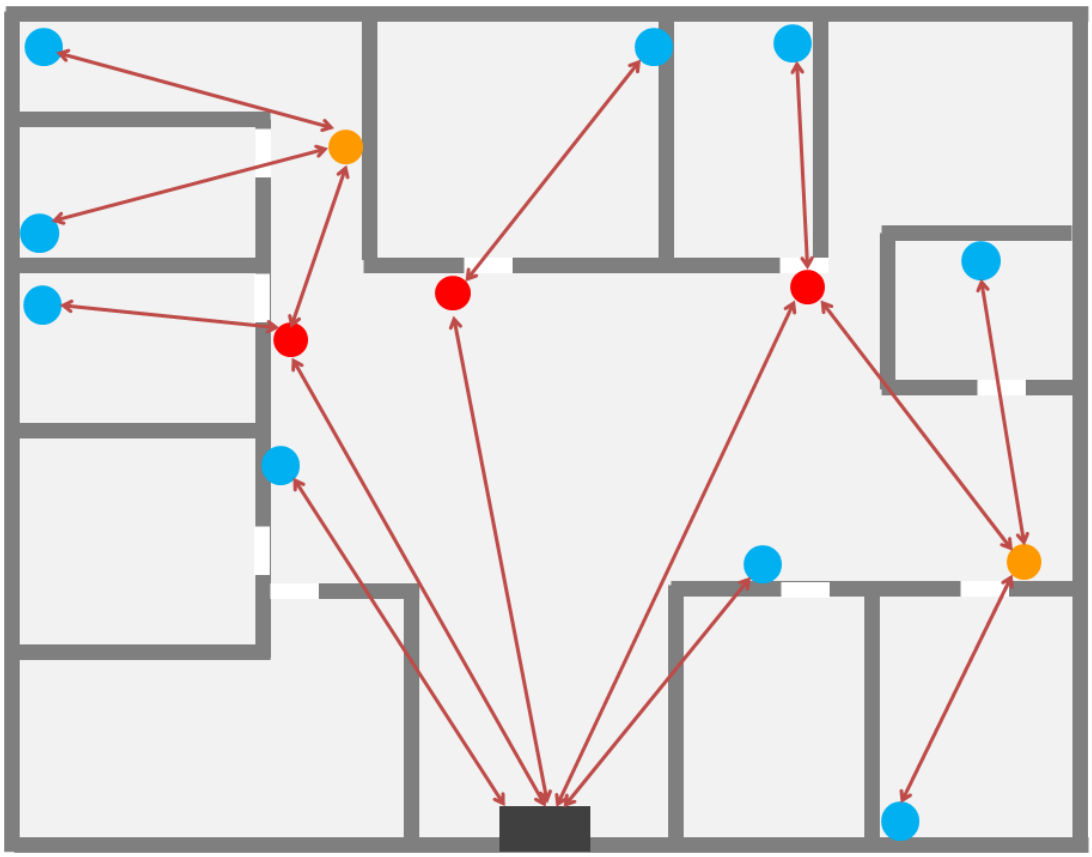
Example:
The modules shown in the inner circle are the wireless modules directly connected to the wireless base unit. The WiDup modules represented by the red dots are those with routing capability and they are used as a first level of routing/repeating to indirectly connect other WiDup modules to the wireless base unit. In the outer circle the modules indirectly connected to the wireless base unit (connected to the first level of routing) are shown. The wireless modules with routing capability are used as a second router and are directly connected to the first router. The more distant modules (beyond the outer circle and represented by the blue dots) are connected indirectly and they use the second router to communicate with the wireless base unit.

Thanks to the two levels of routing/repeating, the maximum distance in an open field is 2100 metres for those modules powered by 230VAC.



When designing the network, care has to be taken to properly assign the slave modules to the relevant router in order to make them visible to the SH2WBU230N.

We suggest placing all the modules in a map of the installation to verify that they are all covered by the wireless field via a direct connection to the SH2WBU230N or by using the SHJWD200WExxx, SHJWRE10AExxx, SHJWEM16Axxx as repeaters.
In the example shown below, the modules in red are the first level of repeaters, while the modules in orange are the second level of repeaters.



	SH2WBU230N	**WiDup base unit**
	SHJWD200WExxx **SHJWRE10AExxx** **SHJWEM16Axxx**	**with routing capability**
	SHA4XWLS4 **SHE5XWLS4** **SHDWWISENxxx** **SHJWD200WExxx** **SHJWRE10AExxx** **SHJWEM16Axxx**	

Once all the modules are installed according to the suggestions described in the following paragraphs, the network has to be configured via the Sx tool software (http://www.productselection.net/MANUALS/UK/sx_tool_manual.pdf).

WiDup implements the Diagnostic function: the SH2WBU230N regularly checks the presence of the associated modules and monitors the quality of the signal received and the battery level of each module. The diagnostic is also applied to all notification type information: if a digital input (or a variable) is not updated within a certain time, it is flagged as “not present”.

WiDup manages the network configuration (association and device configuration) in the same manner as the Smart Dupline system (it uses the SIN address). The SH2WBU230N transmits, on a fixed service channel, the discovery and the configuration request. Every 2 minutes each module ‘listens’ to check if there is a pending discovery or configuration request.
When a new configuration has to be downloaded, it is necessary to wait for 2 minutes to complete the operation. This time is necessary to reduce battery usage.

3 Wireless network deployment

1.1 Range of radio signals

An important concept in radio networks is “line-of-sight” (LOS): if two antennas see each other, they have a “line-of-sight”. In a wireless network, a LOS link means that the two nodes can "see" each other, but a non-LOS link is also possible where the two nodes cannot physically "see" each other but can still communicate, as is described in the following pages.

Since WiDup follows the standard rules of radio communication, the further the signal has to go, the weaker it becomes. Furthermore, the radio coverage is decreased by the obstacles the signal finds on its way. Even if the radio wave can penetrate walls, the power reduction of the signal depends on the material the walls are made of and the penetration angle.

The table below shows some examples of wall materials and the relevant reduction:

Device Position	Operating Distance
In the open air	Approx. 700m
Plasterboard/wood	Approx. 30 m, max. 5 walls
Tile and cellular concrete	Approx. 20 m, max. 3 walls
Reinforced concrete walls/ceilings	Approx. 10 m, max. 1 ceiling/wall

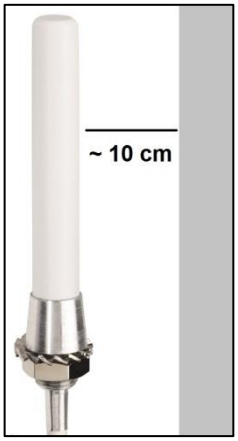
Transmission range is also limited by:

- insulation material with metal foil
- intermediate ceilings with metal or carbon fibre panels
- leaded glass or metal-coated glass
- mounting wall transmitters on metal walls
- people presence
- furniture

The ideal situation is when the two nodes that have to communicate have a clear path between them (the line-of-sight is free): for this reason a good rule is to mount the node at head height when possible. If nodes must be placed in positions very close to the floor, such as a radiator thermostat, then the range may be reduced by between 50% and 90%.

For this reason the mounting position and the orientation of the antenna of a node is also very important.

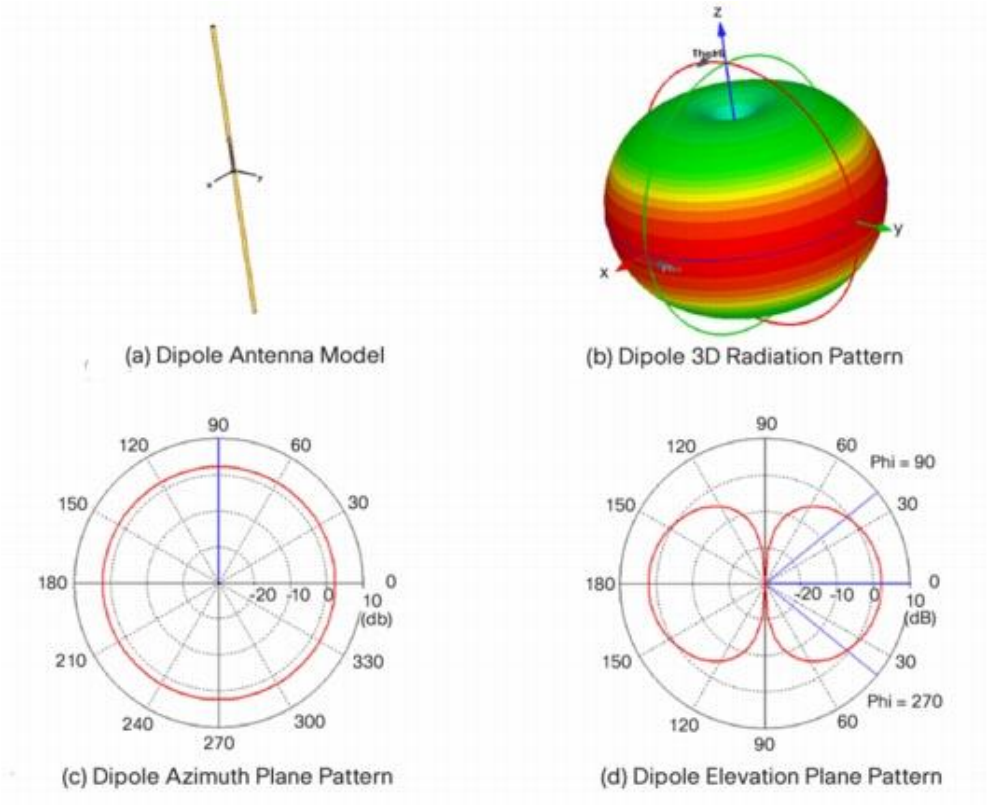
1) SH2WBU230N: the wireless base unit is provided with a “dipole” omni-directional external antenna with 2 metre cable in order to mount it as high as possible outside the cabinet and for indoor usage only. It is better to install the SH2WBU230N in the midpoint of the network area and at a high level in respect to the floor (on the floor level there are more obstacles compared to the ceiling levels). Furthermore, the antenna should be mounted at least 10 cm away from the wall.



In a multi-floor installation, we suggest installing an SH2WBU230N in each floor in order to maximise the field strength and have a better coverage of the wireless signals.

Do not flex the antenna cable since this might damage it, reducing the performance of the antenna.

The radio patterns of the antenna are shown below. The maximum transmission power is the red area of the sphere.



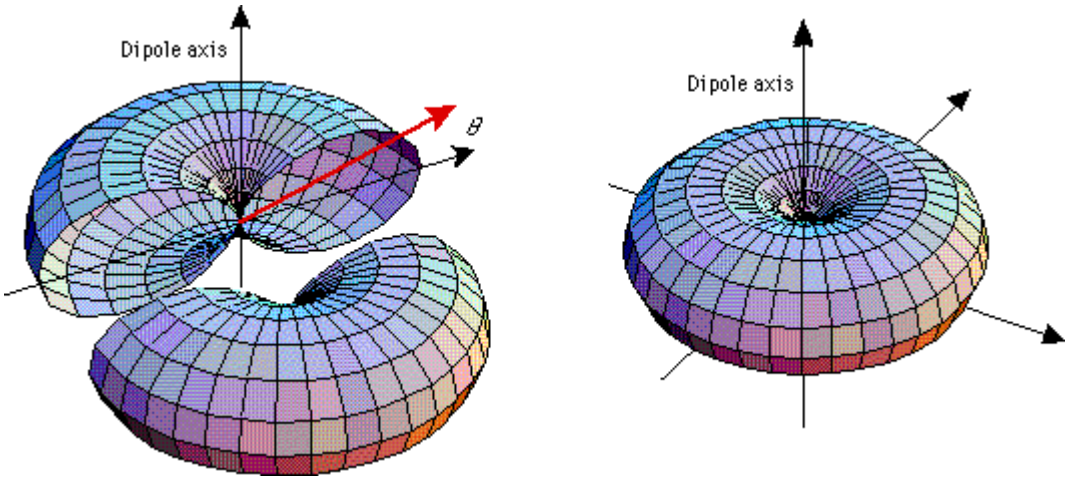
Horizontal pattern

Vertical pattern

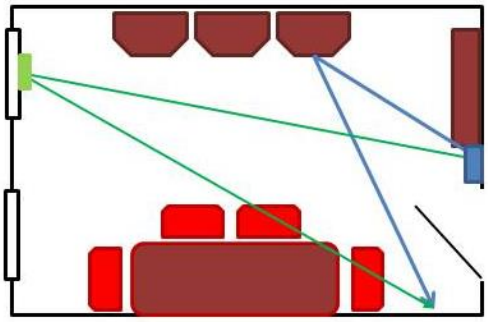
This radiation pattern should be taken into account when designing a WiDup wireless network, in order to ensure that the SH2WBU230N, the SHA4XWLS4, SHE5XWLS4, SHJWD200WExxx, SHJWRE10AExxx, SHJWEM16Axxx in a particular location have coverage on both the vertical and horizontal axes.

- The Horizontal pattern indicates the shape and range of coverage of the WiDup signal, as it radiates from the antenna horizontally. Use this chart to understand what the area of coverage is, around the WiDup nodes.
- The Vertical pattern indicates the shape and range of coverage of the WiDup signal, as it radiates from the antenna vertically. Use this chart to understand what the area of coverage is above and below the WiDup nodes. Note that the Vertical pattern indicates two dead zones around the 0° and 180° positions.

2) SHA4XWLS4, SHE5XWLS4: the wireless light switches are provided with a compact, ceramic antenna internally mounted. The relevant radiation diagram is shown in the picture below.



The obstacles in an indoor installation may cause many reflections that make the signals follow different paths in going from the transmitting antenna to the receiving one (see picture below). Some paths may be direct, but other paths may involve multiple reflections or metal obstructions: for this reason it is advisable to use the router functionality in the WiDup modules with routing/repeating capability if one path is not available anymore. The paths are not predictable, since the radio waves will propagate through brick walls, concrete floors and plasterboard partitions and they are reflected by the obstacles (furniture, people) in the room. All this of course will reduce the power of the signal: however, reflections are useful when there is no “line-of-sight”.

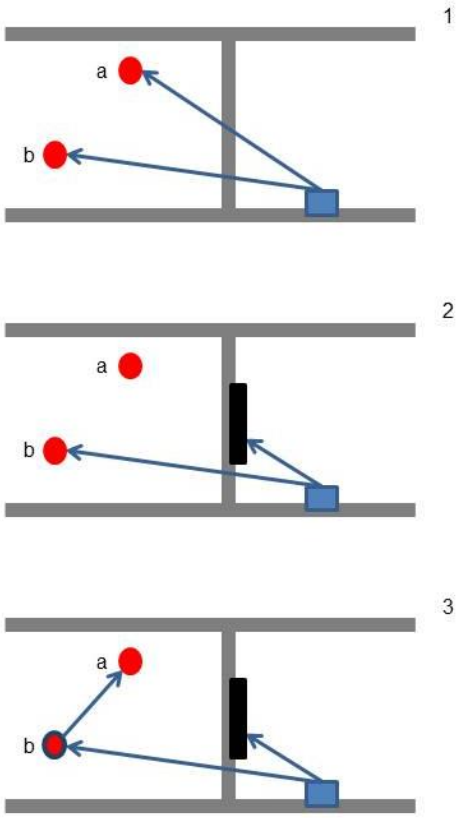


Attention has to be paid to metal panels, metallised glass windows or mirrors, which reflect the majority of the incident power, preventing the signal from passing through. However, some radio power may propagate through small apertures.

1.2 Screening

Large objects made of metal, such as metallic separation walls and metal inserted ceilings, reflect the electromagnetic waves and create what is known as radio shadow. 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 greatly reduced. Mounting an additional repeater at a suitable location can easily provide an optional propagation path.

In the drawings below the following situation is explained: in the beginning both node a) and node b) receive the signal from the transmitter (case 1). Then a metal object is added, which screens the signals so that node a) is in a shadowed position and doesn’t receive commands/data any longer from the transmitter (case 2). But since there is a non-metallic opening, the signal can reach the other room and if node b) is programmed as a repeater it can route the signal to node a) (case 3).



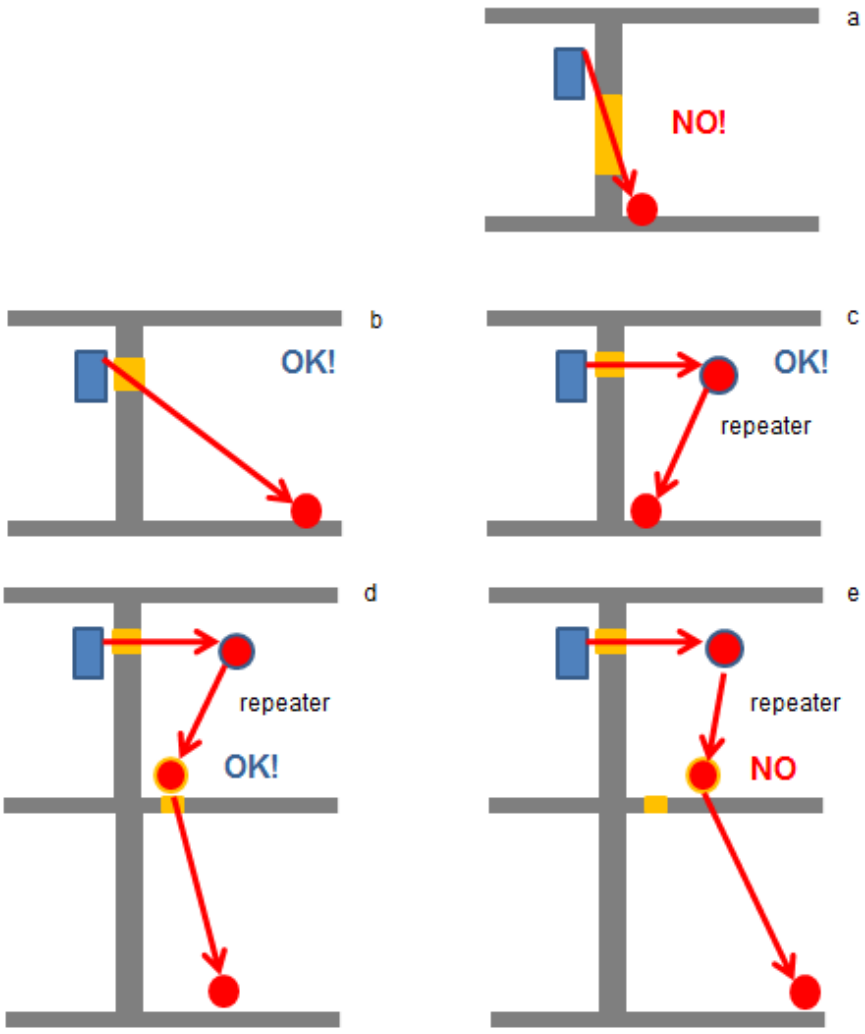
Summing up: objects and factors that decrease or constrain coverage:

- Metal separation walls or hollow lightweight walls filled with insulating wool or metal foil
- Inserted ceilings with panels made of metal or carbon fibre
- Steel furniture, glass with metal coating (typically not used indoors)
- 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 are to be considered as screening.

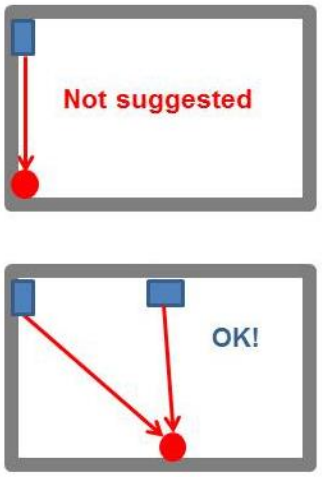
Avoid screening by repositioning the transmitting and/or receiving antenna away from the radio shadow, or by using a repeater.

1.3 Node positioning

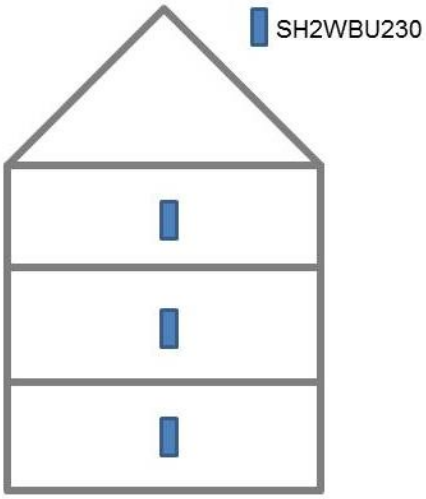
Since the transmission angle, and thus the signal attenuation, is affected by the wall thickness, it is recommended to place the nodes in a way as to have the shortest path through the wall.
The situation shown in figure a) should be avoided, by repositioning the nodes or using a repeater as shown in figures b) and c). When two repeaters are used, please refer to the node positioning shown in figures d) and e).



It is also recommended to place a receiver with an internal antenna on the opposite or connecting wall from where the transmitter is placed: this is because near a wall the radio waves might be subject to dispersions and reflections and also because the two antennas should see each other in order to have line-of-sight and the best radio link possible.
With reference to the figure below, position a) should be avoided.



In multi-floor installations, it is advisable to install a SH2WBU230N wireless base unit on each floor in order to have the best radio coverage and to avoid signal attenuation due to heavily reinforced concrete ceilings or floors.

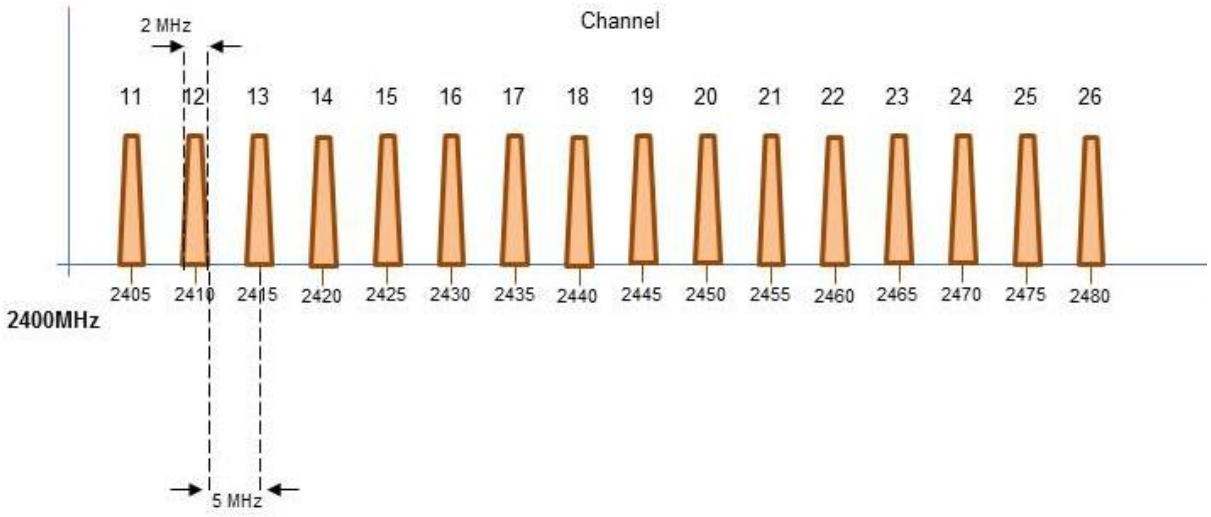


4 Coexistence of WiDup with other systems in the 2.4GHz –ISM band

The 2.4 GHz ISM band is licence-free and it is used not only by the standard IEEE802.15.4 on which WiDup is based, but also by many other very popular systems such as Wi-Fi networks (based on the standard IEEE 802.11b) and Bluetooth, and devices such as microwaves ovens. So when deploying a wireless network, care has to be taken to limit the collateral effects of these different communication systems.
In the following paragraphs, the band occupancy of these systems is described in order to explain how to choose the right transmission channels to reduce overlapping.

1.4 WiDup – based on IEEE 802.15.4 LR-WPAN

IEEE 802.15.4 is a Low-Rate Wireless Personal Area Network that uses 16 channels at 2.4GHz, numbered from 11 to 26. The bandwidth is 2MHz and the channel separation is 5MHz, as shown in the figure below.



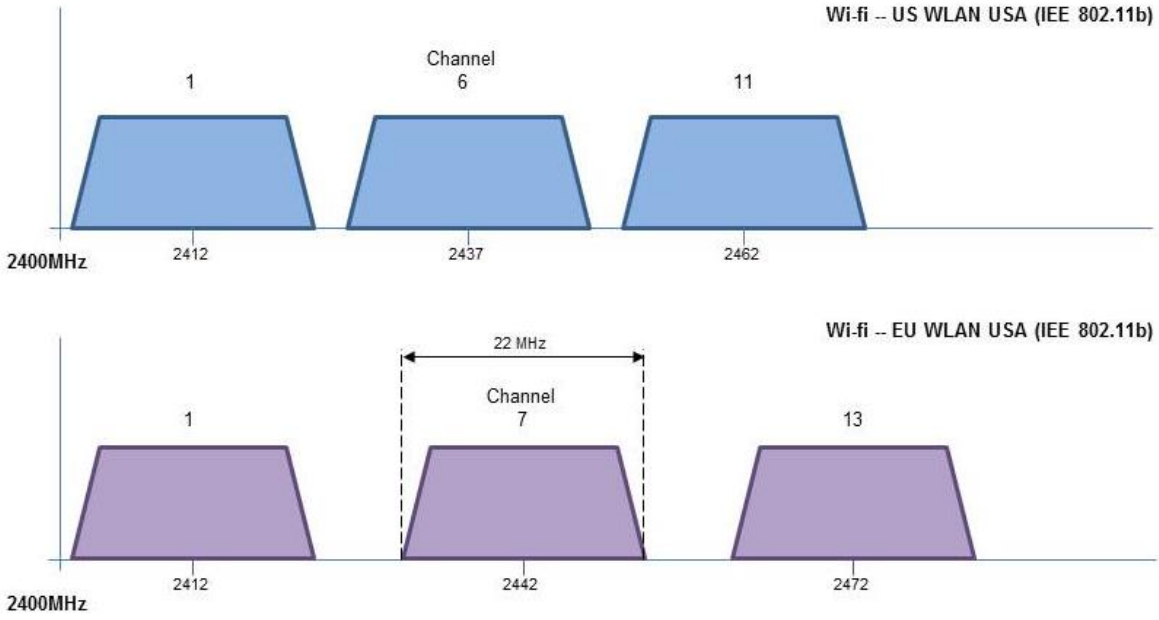
WiDup uses channel 15 to scan the wireless network to find the slave modules and it is fixed, while the working channels can be set from 11 to 26 according to the presence of other systems working at 2.4 GHz.
This selection has to be made by means of the Sx tool.

If more than one SH2WBU230N is used, it is advisable to program them by working on different channels, so that they do not interfere with each other.

1.5 Wi-Fi - based on IEEE 802.11b/g

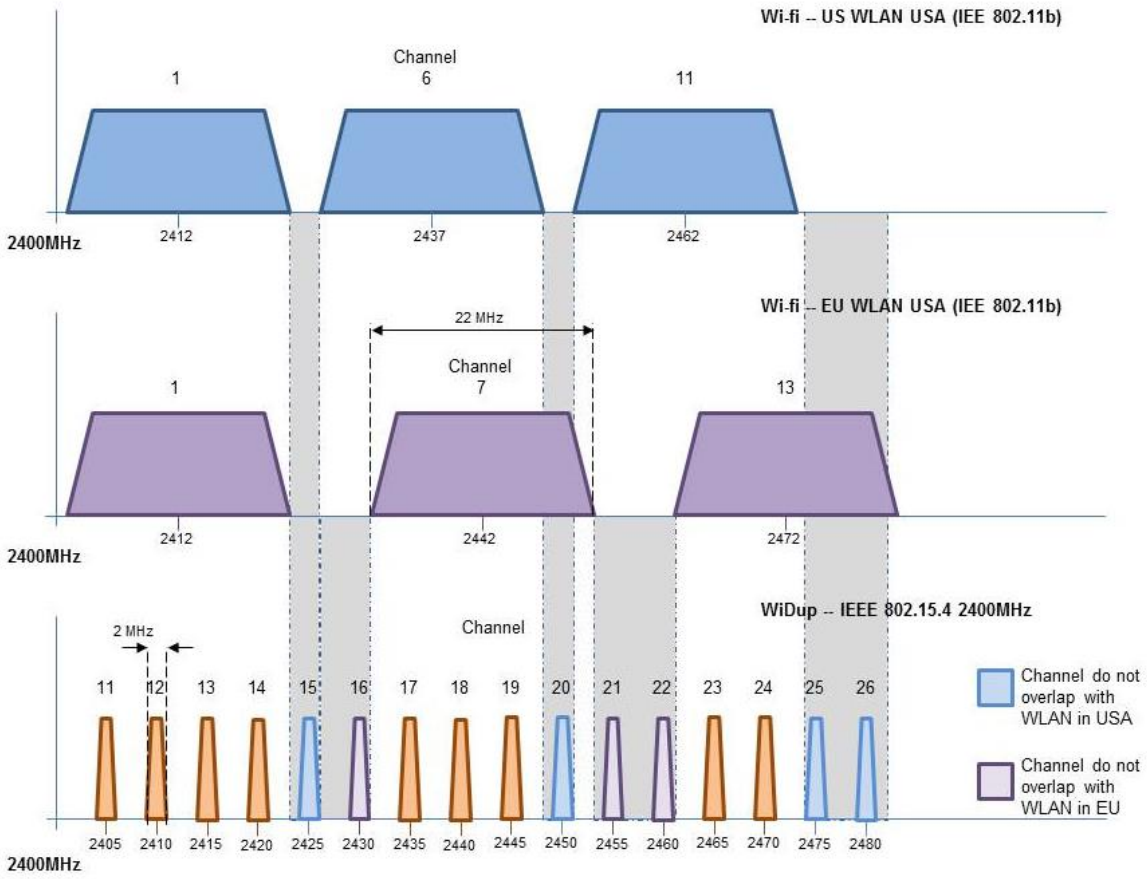
Wi-Fi networks are WLAN, Wireless Local Area Network, based on the IEEE 802.11b standard that operates on a total of 14 channels at 2.4MHz: the channels are numbered 1 to 14, each with a bandwidth of 22 MHz and a channel separation of 5MHz.
Since the IEEE 802.11b standard recommends the use of non-overlapping operating channels, in the USA channels 1, 6 and 11 are used, while in Europe channels 1, 7and 13 are used. See figure below.

The selection of the working channel can be made by changing the Wi-Fi router settings.



1.5.1 Band sharing between WiDup (IEEE 802.15.4) and Wi-Fi (IEEE 802.11)

If the two systems happen to co-exist in the same place, bandwidth allocation should be made following the figure below, where the non-overlapping channels are indicated.



Since channel 15 of WiDup is not overlapping the Wi-Fi bands either in the USA or Europe, it is used by the smart-house system to look for the wireless slave modules present in the field. As for the working band, according to the Wi-Fi channel set in the router, a non-overlapping WiDup channel should be selected: for example, if the router is working on channel 1, channels from 15 to 26 can be selected for the operation of the SH2WBU230N.
WiDup channels 15, 20, 25 and 26 (light blue ones in the figure above) never overlap with the American bands, while channels 15, 16, 21 and 22 (purple ones in the figure above) never overlap with the European bands: these are good choices, since for sure they operate clear of Wi-Fi interference according to the relevant region (USA or EU).

If, for any reason, a channel separation is not possible between WiDup and Wi-Fi and co-channel operations are not avoidable, a physical separation from the WiDup and Wi-Fi access points (SH2WBU230N and routers) of 8-10 m is recommended.

Note: The effects of WiDup on WLAN can effectively be ignored.

1.1 Bluetooth

Another widely used system that shares the ISM band at 2.4 GHz is Bluetooth. Used mainly for headsets and some peripheral connections, the Bluetooth system rapidly hops across most of the 2.4 GHz band. This may disrupt an IEEE 802.15.4 (WiDup) network, but degradation in performance would be gradual. In any case, considering the short operating distance of Bluetooth devices and the packet retry mechanism employed by IEEE 802.15.4 that ensures re-transmission of packets corrupted by Bluetooth interference, to achieve satisfactory IEEE 802.15.4 performance in the presence of Bluetooth interference, a separation distance of 2 m is recommended.

1.2 Microwave ovens

Microwave ovens operate at around 2.45 GHz. Although they should be covered by a Faraday cage, it is still possible for some leakage to occur around the doors. This is increased when mechanical abuse or simple ‘wear and tear’ causes door seals to become less effective. For these reasons, microwave ovens are a potential source of interference for WiDup, but the reality is that microwave ovens cause very little interference if they are placed at a minimum distance of 1 m.