AGILE™ RADIO FIRE DETECTION SYSTEM

APPLICATION and INSTALLATION GUIDELINES

CONTENTS

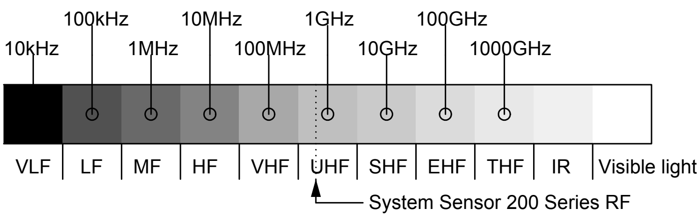
RF BASICS

The RF Waveband

Radio frequency (RF) devices use radio waves to communicate (transmit and receive data) in the form of coded radio signals. The RF waveband (part of the electromagnetic spectrum) ranges from a few kHz to hundreds of GHz and can be divided up into different sections, with different radio characteristics and capabilities.

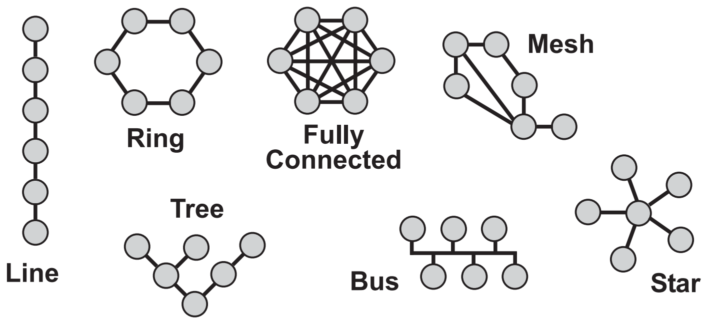
The Agile™ 200 Series RF fire system uses a frequency range based around 868MHz in the UHF region (the lower end of microwaves); that is a wavelength of 346mm.

Short-range, low-power RF Systems are becoming more popular for a wide range of applications; within fire and security products they are often used in temporary installations or situations where building work and unsightly cabling cannot be tolerated.



The RF Network

Agile™ 200 Series RF devices can transmit and receive, they are transceivers. When two devices communicate directly with one another, they have set up a link; the devices at each end of a link are known as nodes. A set of devices (or nodes) communicating together is called a network. There can be a wide range of network topologies, as shown in the examples following:



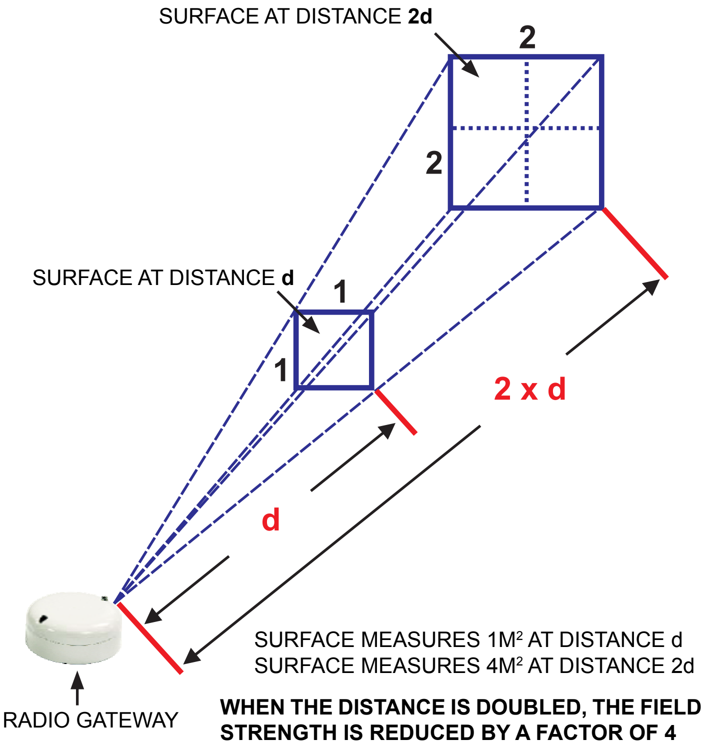
RF Signal Characteristics

Fundamentally radio signals, like light, travel in straight lines. And in the same way as light they can be affected by objects in their path. Forming part of the electromagnetic energy spectrum, they are capable of transmission through some materials, absorption by others and can be reflected, refracted and diffracted. The effects on radio waves caused by different materials are dependent upon the material's properties.

Metallic surfaces are excellent reflectors of radio frequency (RF) energy; water and wet areas may also be good reflectors. Refraction occurs when electromagnetic waves pass across a boundary between materials of different densities (refractive index) and diffraction can occur when signals pass close to large, particularly sharp, objects. Attenuation in different materials (resulting from energy absorption and high frequency scattering) is caused by the material's molecular characteristics, structure and resonances at different wavelengths.

In an open space, the power reduction down a signal path is proportional to the square of the distance from the transmitter *(see Figure 1 following)*.

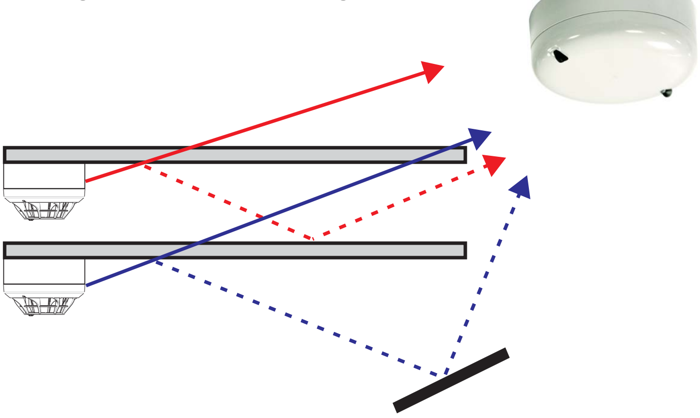
Figure 1: Relationship Between Distance and RF-Power



RF Signal Attenuation

In addition to this square law attenuation, signal strengths inside a building will also vary from place to place owing to destructive and constructive interference caused by signals arriving with different phases, resulting from different path lengths *(see Figure 2)*.

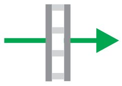
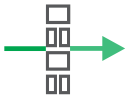
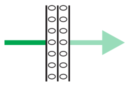
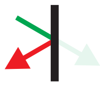
Figure 2: Different RF Signal Paths



The Agile™ 200 Series RF devices have a typical transmission range in free air of up to 500m, but within an office or factory environment, signals can come into contact with many objects in a range of materials such as ceilings, floors and walls at different angles, desks, filing cabinets and a variety of plant and machinery. There are numerous opportunities for reflection, refraction and absorption and all these things will probably reduce the effective range, even in an open plan environment, to not much more than about 100m.

Some common building materials are listed in *Table 1* together with typical energy loss figures which can be expected. A normal double brick wall, for example, can reduce a signal's strength by up to a third or more. All these factors will contribute to the occurrence in a building of areas of varying signal strengths and reception characteristics.

Table 1: Energy Loss with Different Materials

	Material Type	**Energy Loss**
	Wood and plasterboard	0 – 10%
	Solid brick	5 – 35%
	Steel reinforced concrete	30 – 90%
	Metal plates, under floor heating	90 – 100%

Designing and installing an RF system in areas with large radio field absorption, e.g. with metallic lattice partitions, large metal vessels or with tall metallic storage racks may be very challenging.

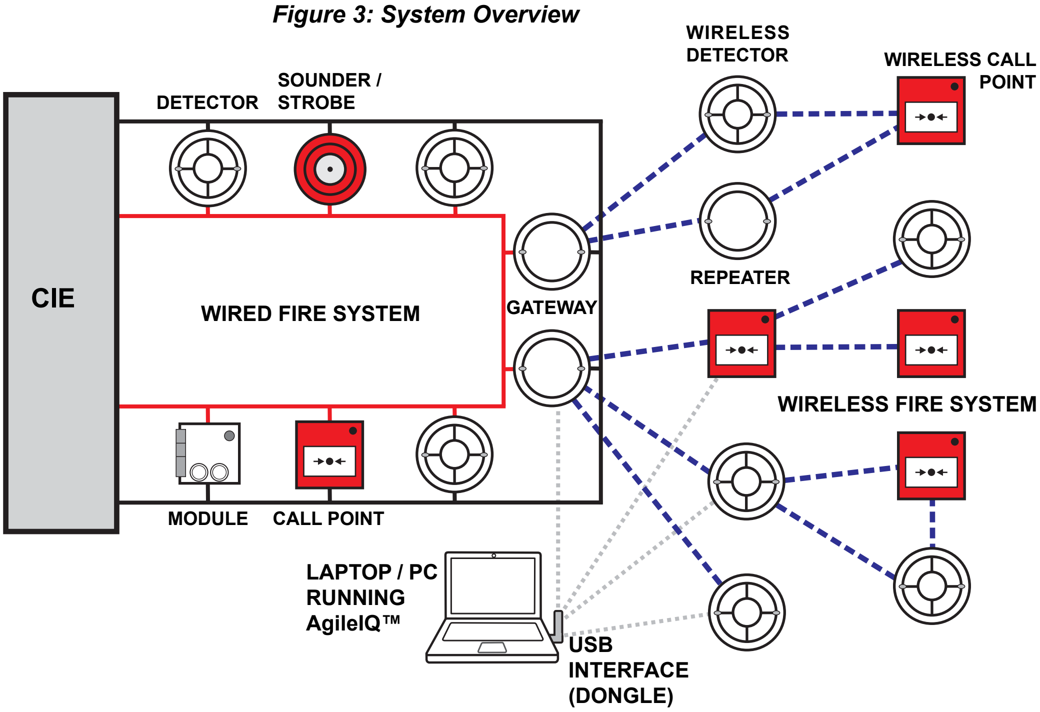
AGILE™ RF FIRE SYSTEM

The Agile™ 200 Series RF fire system is designed for use with compatible intelligent fire systems using the System Sensor 200/500 Series CLIP, Enhanced and Advanced communication protocols. Devices signalling from the radio domain are translated by the RF gateway into addressable loop communication signals recognized by the Control and Indicating Equipment (CIE). Each device has its own physical address on the loop, selected using two rotary switches, which can be manually set in a range between 1 and 99 or 1 and 159 depending on the loop protocol used by the panel.

The system architecture can be characterised as shown in *Figure 3* following.

The red and black lines show the wired loop; the dotted blue lines represent the RF communication. A PC has the ability to communicate with all the wireless devices using a special software application (AgileIQ™) and USB transmit/receive interface dongle.

Figure 3: System Overview



<u>The Agile™ RF Mesh Network</u>

When two devices in a network can communicate directly, they are said to have a ***link***. The devices at each end of a link are known as nodes and a network is made up of a set of nodes and links. For the 200 Series RF system, each RF device can receive and transmit wireless information and hence each RF link has bi-directional communication.

As every RF device is a transceiver the network can be organized to minimize the use of repeaters. This is achieved by allowing each device to receive and re-transmit information from its neighbours on to the master device (the gateway).

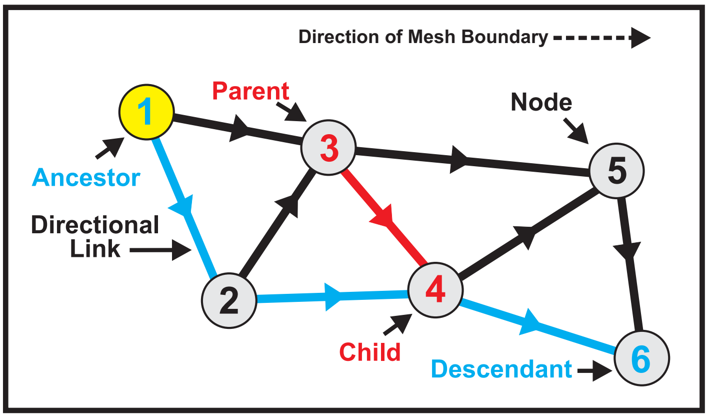
The Concept of Mesh Hierarchy

When there is a direct path between nodes, say from device #1 to device #2, the two nodes are linked. Within the mesh there are the concepts of 'parents' and 'children', and 'ancestors' and 'descendants', moving in the direction from the gateway to the mesh boundary. So, whilst links have bi-directional communication, there is also a concept of link directionality with respect to the order or ranking of each of the devices. This is why links are shown with directional arrows, establishing the hierarchy of the nodes.

In the Agile™ RF system, each node can have up to 6 active links with its neighbours; 2 links going toward the gateway (one from each of its 2 parents) and up to 4 links going toward the network boundaries (i.e.to 4 children). A gateway is a special RF node and can have up to 32 links.

In general, to satisfy the Agile™ mesh protocol criteria in terms of hierarchy and timings, all nodes should be descendents of the gateway, (i.e. there must be a chain of primary links to/from the gateway) and each device will have one primary link to a parent and one secondary link to its other parent. All links from a gateway will be primary links.

Figure 4: Mesh Hierarchy



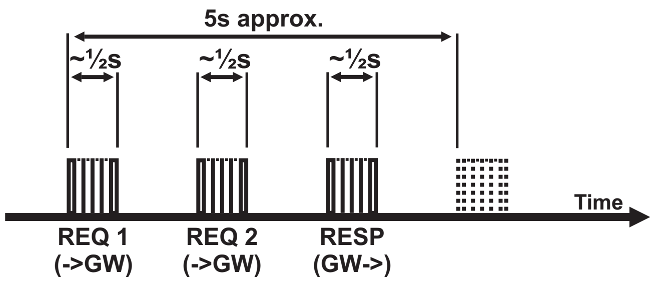
Note the unique and important Back-up Node #2; this has only one parent – the gateway. Its importance in the network is described below.

Network Synchronisation
When Agile™ devices transmit data they require a lot of energy. Therefore, to maintain low battery power consumption, the devices are not in transmit/receive mode all the time; for much of the time they will be in a very low power (silent) mode.

To communicate properly, the devices in the network must all transmit and receive at the same time. To do this, the communicating periods must be synchronised so that devices wake up together from their silent state to move data to and fro before going silent again. This synchronisation of the network is orchestrated by the gateway which maintains a constant 'drum-beat' throughout the mesh system.

In the Agile™ 200 Series RF Fire System, a complete cycle of transmit/receive windows takes approximately 5 seconds including the silent periods.

Figure 5: Synchronised Communication Sequence



The Back-up Node
A mesh network that is operating normally is kept in sync by the Gateway. But if a gateway is removed from a system or is powered off, control of the network will be lost. All the devices will continually try to re-connect with the missing gateway and this will lead to high battery power consumption and significantly reduce the battery life, unless all the batteries are removed from the Agile™ RF devices.

To prevent this situation (for example, during a fire system maintenance period), a special node has been created in the mesh that takes over the network synchronisation role should a gateway go 'missing'. Hence, the network continues to operate, but in a low power (idle) state, minimising battery usage across the system while the gateway is off. Obviously, during this time, the Agile™ RF system will not be providing fire cover.

It can take up to 12 minutes for a backup node to assume control of the network, after the gateway has been switched off. It may take up to 10 minutes for the gateway to reclaim control of the network, when the gateway is re-powered on.

SITE SURVEY

What is a Site Survey?

Great care needs to be taken when assessing a site and choosing the right technology and design layout to use; wireless systems may not be suitable for every situation. Before committing to a design and physical implementation of a wireless fire system it is important to understand and 'visualise' the field strength of the RF network to ensure that vital areas of the building have adequate signal coverage.

A site survey needs to be done to ensure that the RF fire system will work reliably after installation.

A site survey involves the use of the AgileIQ™ Software Tools and Site Survey equipment to carry out RF energy scans and RF link quality checks. The RF energy scan identifies any channel frequencies that are unsuitable and the link quality check ensures that RF communications between nodes is acceptable.

Why is it Necessary?

A site RF survey is a critical element in the process of designing and installing a wireless communications network in an office or building. The survey will determine the best placement of the sensors and manual call points to comply with the coverage and positional requirements of the fire regulations in the designated location.

In the UK, the Code of Practice for system design, installation, commissioning and maintenance of fire detection and alarm systems (BS5839-1: 2002) specifically addresses the need to carry out an RF site survey. Section 27.2 states that installation of a radio-linked system should only take place after a comprehensive radio survey has been undertaken to ascertain the following:

- *There are no other potentially interfering radio sources*
- *There is adequate signal strength for communication*

The Code also requires that only radio survey test equipment approved by the manufacturer should be used and records of signal readings should be kept for future reference.

When doing a site survey, give adequate consideration to how the site will be used when the Agile™ RF system is working. For example, make sure that doors and windows are closed when signal strength measurements are being taken.

And when installing an Agile™ RF system, it is important to ensure that there have been no changes to the areas within a building, such as new internal walls or partitions, the introduction of tall metal enclosures or the introduction of other wireless systems since the original site survey was carried out. Any changes to the system design or the building may require an extra site survey to confirm the wireless fire system will still work reliably.

How to Plan a Site Survey

The RF energy and link quality tests are important as they ensure the RF fire system will work reliably in the building where it is installed.

It is preferable to preplan how the tests will be carried out during the site survey visit. Use a plan-view of the building to identify the likely positions of devices with respect to customer requests, local regulations and fire systems requirements. Identify each device location with a device type and unique code. Consider how the RF mesh network will provide coverage across the site, being mindful of the potential attenuation that walls and other objects can cause.

Site layout drawings can be marked up manually to show the planned positions of devices, or an electronic copy of the site layout drawings can be loaded into the Agile IQ™ Software Application to assist with a site survey. Using the Agile IQ™ design feature, it is possible to draft a layout diagram of the Agile™ RF devices, create a mesh network and generate a list of RF links associated with the network.

Be sure to note or mark up any changes to position of devices, or the introduction of new devices, created during the survey.

NOTE: Do not run more than one RF interface (dongle) at a time in an area during a site survey.

What to take to a Site Survey

The following equipment is the minimum that will be required to carry out an RF site survey.

- PC/Tablet running the AgileIQ™ RF PC Tools software application
- USB RF interface (Dongle)
- Two Agile™ radio sensors in RF bases
- Set of Duracell 123 batteries

System Sensor can supply a range of additional equipment to assist with the site survey.

Available options are:

- *POLE HWKIT - 1.5m – 5.2m Telescopic pole*
- *CUP HWKIT – Cup to hold Agile™ radio device and base in position on pole*
- *SOLOADAPT HWKIT – Adaptor that allows the CUP HWKIT to be connected to a SOLO* access pole*
- *BAG RF HWKIT – Survey bag to store and carry poles and cups etc.*

* Available from Detection Testers/No Climb.

Note: The USB interface may need a mini-USB adaptor to be used with a Notebook/Tablet.

The picture shows a device holder (CUP HWKIT) mounted on an extension pole (POLE HWKIT).

Summary of Basic RF Site Survey Principles

1) **Site diagram:** Obtain or create a facility diagram or floor plan drawing that depicts the location of walls, walkways, etc.
2) **Visual inspection:** Walk through the facility to verify the accuracy of the facility diagram. Add any potential barriers that may affect the propagation of RF signals such as metal racks and partitions, items that are not shown on the floor plan.
3) **Device positions:** Determine the preliminary location of devices; be certain to consider mounting options. Make sure all doors and windows etc are closed when the survey measurements are taken.
4) **Verify RF link quality:** Take note of signal readings at the different device locations, moving through the site. (In a multi-level facility, perform signal checks on the floors above and below.) Based on the results of the testing, it may be necessary to relocate some devices and redo any affected tests. Where appropriate, introduce an additional device or a repeater to form a bridge between two locations with a weak link.
5) **Document the findings:** Once satisfied that the planned location of devices will have adequate link quality, identify them clearly on the facility diagrams and add all relevant notes to the project; the installers will need this information. Also, provide a log of signal readings for reference and as support for any future network additions or redesign.

The use of the Agile IQ™ software application will provide a high level of assistance in accomplishing these tasks quickly and efficiently.

Agile™ System Coverage

When designing and installing a System Sensor Agile™ radio mesh network, consideration should be given to the following.

Agile™ RF radio devices appear as wired elements to a fire panel. Check to ensure the maximum number of combined wired and wireless devices on a loop has not been exceeded (198 in CLIP or 318 in AP)

Confirm that detector types and spacing requirements, sounder and strobe coverage and exits that need manual call points have been identified as required by national and local regulations (for example in the UK, the recommendations of the Code of Practice BS5839 Part 1 should be followed).

The Agile™ radio system can have up to 8 Gateways operating in the same area. There is also a maximum limit of 32 devices allowed per Gateway. In the UK, ensure the radio system associated with a gateway does not cover more than one zone as defined by BS5839 Part 1.

Consider the best location for the gateway with respect to both its connection to the wired loop and its need to control a group of radio devices. See section headed ***Do's and Don'ts***.

Identify any radio device locations that may have difficulty communicating with at least 2 other devices in the mesh. It may be necessary to introduce additional nodes to bridge poor links (see ***RF Signal Attenuation*** section). It is important to note that RF signals will be attenuated differently depending on the type and construction of any obstructions.

Therefore, a system design should take into account obstructions and the level of signal attenuation caused by:

- Wall type and thickness
- Structural supporting beams
- Tall metal cabinets (such as those that are from floor to ceiling and IT equipment in tall metal enclosures)

A system design should also consider the site operating conditions, like:

- Strong local interferences (such as from certain types of communications devices and RFID readers)
- Site changes, such as construction of new internal walls
- Placement of large metal objects, water storage tanks etc.
- Areas where large objects move regularly, loading bays, lift shafts, goods storage
- Possible reflections from close-by buildings or other objects where attenuation may vary with the environment (e.g. rain)
- Whilst Agile™ devices are designed to be omni-directional in performance, note any significant signal strength variation with device rotation; use the mark on the detector base as a reference

Remember that radio signals travel in 3 dimensions, for example, upwards or downwards as well as forward/backwards directions.

Note that the RF Link Quality may be good between devices on adjacent floor levels as well as between devices on the same floor level. This is dependent on the construction of floor and ceiling.

Figure 6 shows the arrangement that may be suitable where the floor construction prevents RF signal between floor levels, while Figure 7 may be suitable where the RF signal can be strong (good) between floor levels.

Figure 6: Arrangement Where the Floor Construction Prevents RF Signal Between Floor Levels

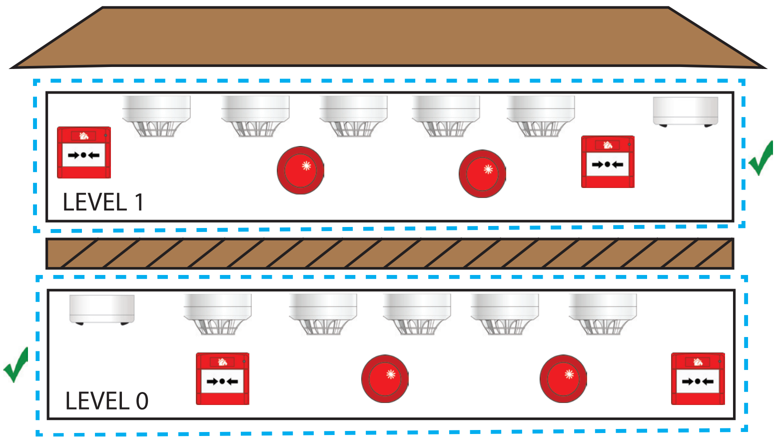
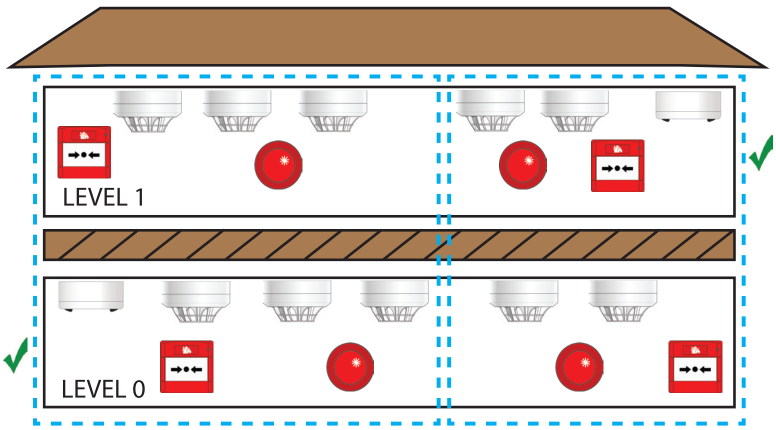


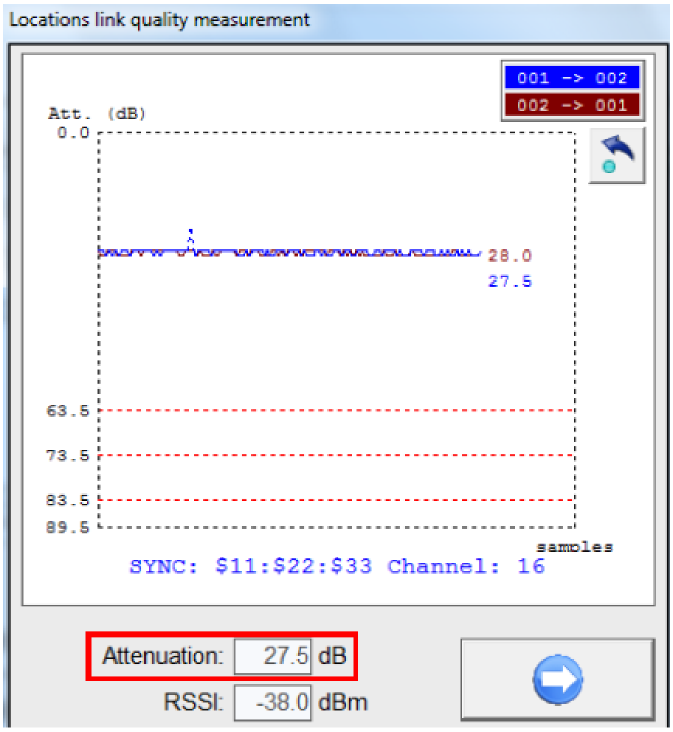
Figure 7: Arrangement Where the RF Signal can be Strong (Good) Between Floor Levels



Measuring Wall Attenuation

The following method can be used to record the actual RF signal attenuation caused by a wall.

1) In the room containing the wall to be measured, take a *Link Quality* measurement across an open part of a room. Set up the two measuring devices with device #2 nearest to the wall to be checked. The dongle should be within range (a few metres) of device #1.
2) When satisfied that the measurement is stable, ***STOP*** the recording and make a note of the attenuation value.



3) Move device #2 to the other side of the wall, ensure it is in the same orientation as before and take a second measurement, again noting the attenuation value.
4) Subtract the first attenuation value from the second attenuation value; the result is the attenuation in signal strength resulting from the wall. This figure can be used for the wall attenuation in the design simulation and should be entered into the ***Edit Wall*** information box as a *Custom* value.

Not able to generate a Network

If the mesh wizard cannot simulate a reliable RF network from the data it has, the ***Not possible to create a mesh*** message appears. The wizard will give a brief reason for the failure where possible.

The design layout and/or RF criteria will need to be amended to realise an acceptable system. Some possible changes that may help to find a suitable network include:

- Move the gateway to provide wider connectivity with the Agile™ RF devices
- Re-arrange the Agile™ RF devices to minimise link lengths
- Allow longer links or repeaters to be used
- Add a repeater (or another Agile™ RF device) to a marginal or poor link
- Consider if the wall attenuation is set too high and can be reduced

How to Resolve a Poor Link Quality in General

Where possible, re-position RF devices to improve the line-of-sight between two linked devices which have a poor link signal. If this is not possible consider the use of a repeater.

How to Resolve a Poor Link Quality in a Long Corridor

To provide a resilient RF system, the mesh is designed to have multiple communication paths back to the gateway. Each device must have at least two links to other devices. In a long corridor this is sometimes difficult to achieve and some long links may suffer from poor signal strength. The solution may be to include one or more repeaters in, or adjacent to, the corridor.

How to Resolve a Poor Link Quality through Walls

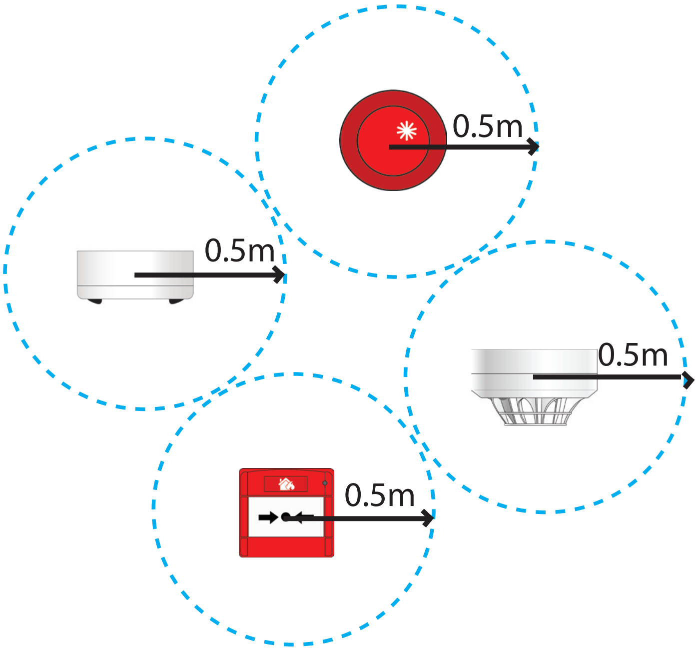
Walls can significantly reduce RF signal strength and hence the link quality between nodes. If the link quality through a wall is poor, the solution may be to include one or two repeaters on either or both sides of the wall between the nodes in question. (See also *Measuring Wall Attenuation*.)

In all these suggestions, any Agile™ RF device can be substituted to act as a repeater.

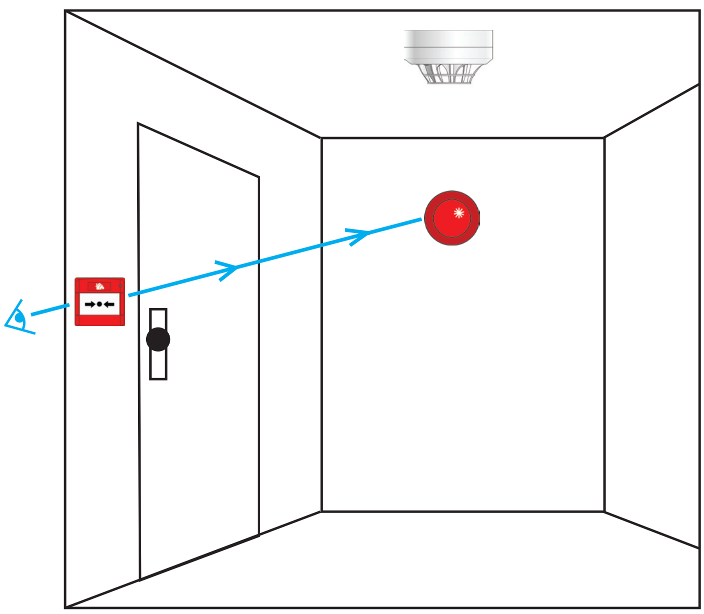
RF DO'S AND DON'TS

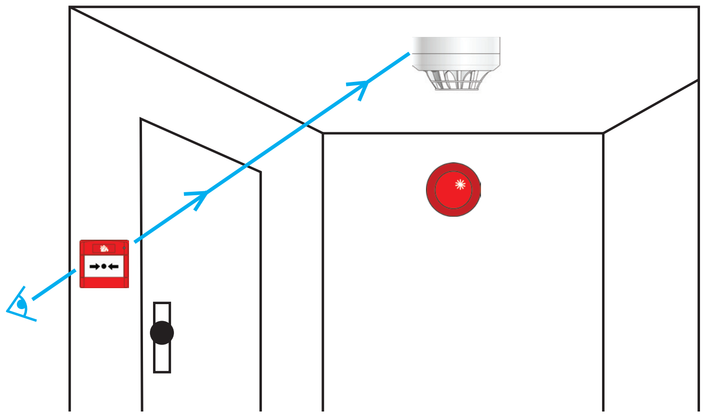
Do's

- **Do** ensure there are sufficient loop addresses to account for all the RF devices
- **Do** ensure a minimum separation distance of 1m exists between neighbouring RF devices in all directions



- **Do** perform a Site Survey and create detailed and clear *Link Quality* and *RF Energy Scan* reports
- **Do** locate a gateway at or greater than 1.8m height from floor level, best away from busy areas where there is constant movement of people, such as near stairs. Also away from areas where metallic obstructions exist, such as near lifts and escalators
- **Do** ensure that gateways are accessible for maintenance
- **Do** ensure where possible the RF devices are positioned in a **line-of-sight**. A simple way to check is just to look from a device and see if the other devices are in view.





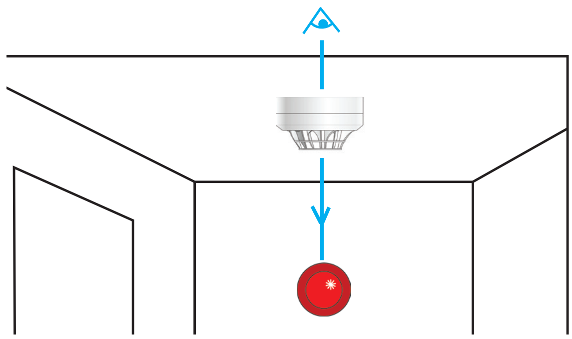
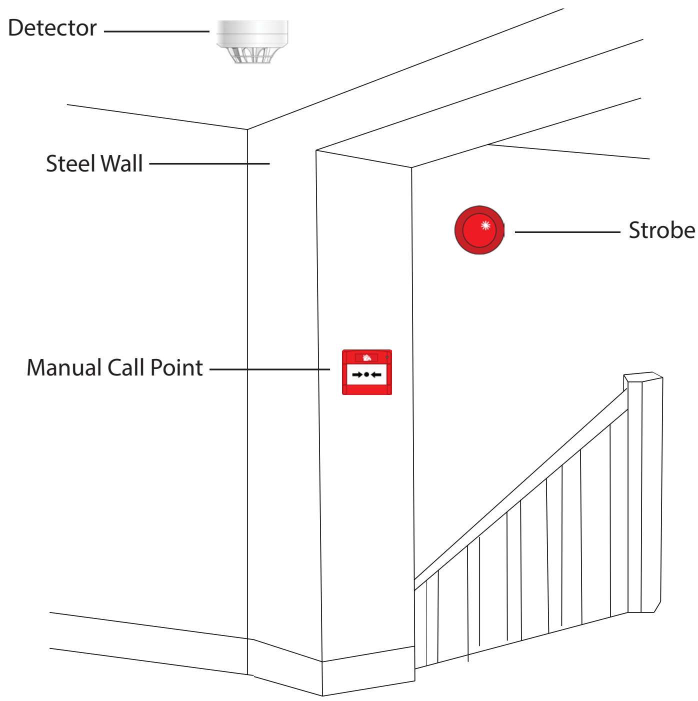


Figure 8: Example of Using the Line-of-Sight Technique



In this arrangement the sounder-strobe could have been located on the wall opposite to the manual call point at a required height.

By making this change the sounder strobe would have had a clear line-of-sight to the manual call point as well as to the detector (and the strobe light would probably be more visible.)

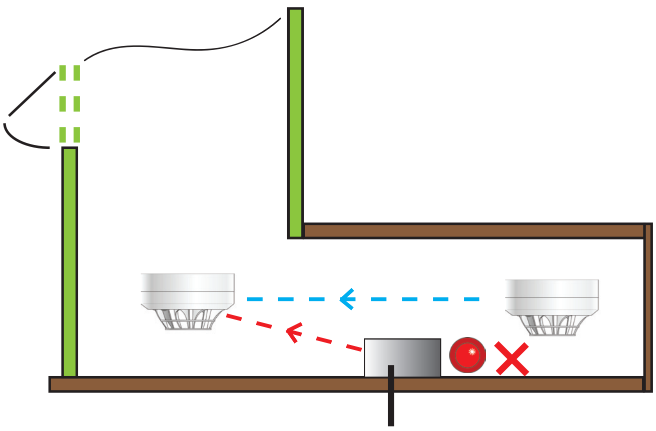
- **Do** ensure other wireless devices (like RFID readers) operating at 868MHz are at least 5m away from any RF devices

[An RFID is an alternative to optical bar code technology that uses radio waves to capture data from product tags. These tags may be in concealed locations and transmit data wirelessly via antenna to an RFID reader]

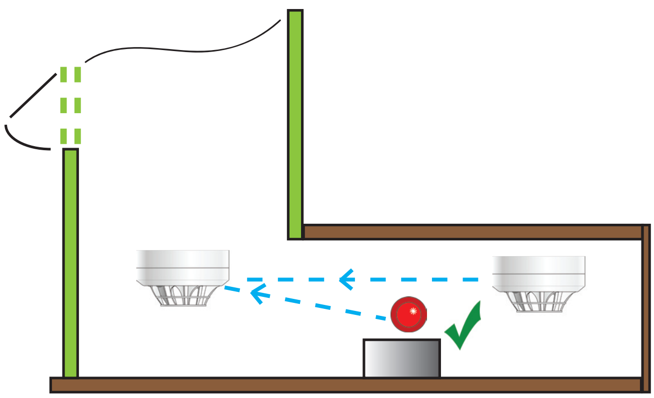
- **Do** place test devices in a site survey as close as possible to the final device positions. A site survey kit is available to assist with this
- **Do** Consider doors as shut in any design and have them shut during a site survey link measurement
- **Do** check critical links for directional dependency by rotating devices during a survey. Directional information can be entered into the device information option in the Agile IQ™ tool
- **Do** ensure when using multiple gateways in an area, that the main communication channels for the different networks are not on adjacent channel numbers. It is recommended that they are separated by at least one channel to avoid any possible crosstalk. The quality of any separating channels is not important in this respect
- **Do** always use 4 batteries in devices
- **Do** set the device address before inserting the batteries
- **Do** check an installed, operating system for *Fire* and *Fault* events before leaving the site. A fire can be simulated with a test magnet on an Agile™ detector (see device installation instructions for details) and a fault can be created in a system by removing a device from its base (*Tamper Fault*)

Don'ts

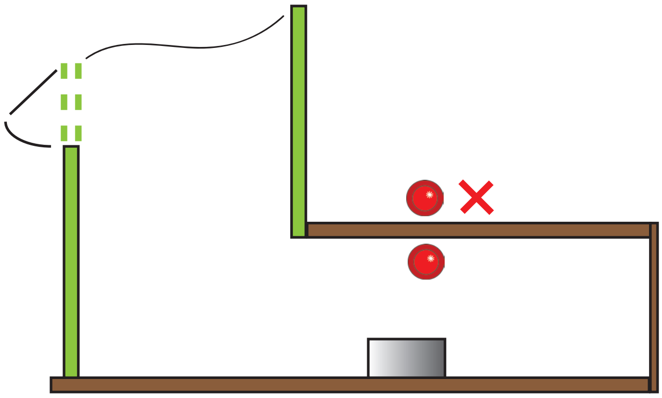
- **Don't** locate RF devices behind obstructions that can weaken RF signal and cause poor link quality



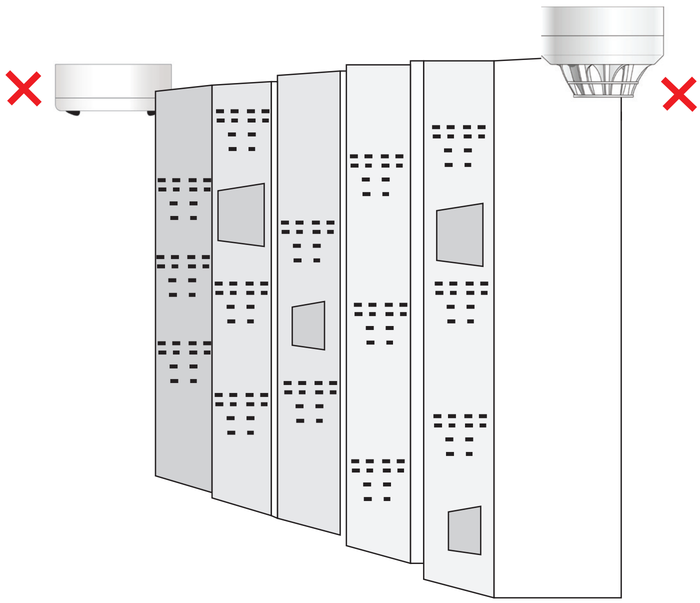
Boxed metal structural beam (floor to ceiling)



- **Don't** locate Agile™ RF devices back to back where there is little or no attenuation, as 1m separation is required between RF devices



- **Don't** install gateways or Agile™ RF devices near electrical switch gear



- **Don't** choose the main and the backup RF channels next to one another in the frequency spectrum to have the best chance of avoiding possible channel blocking
- **Don't** use any RF channels that are categorised as ***UNSUITABLE*** in the RF energy scan table
- **Don't** use RF channels that are categorised as ***Marginal*** unless this is unavoidable, and then preferably only use them for the back-up channel
- **Don't** accept any RF links that are categorised as ***UNSUITABLE*** in a Link Quality measurement
- **Don't** leave the batteries in a detector that is not part of a mesh, or being used in a site survey

And finally…

- **Don't** leave an installed site without first testing the working system for ***Fire*** and ***Fault*** events. On the Agile™ 200 Series RF Fire System, a fire can be simulated with a test magnet on an Agile™ detector (see device installation instructions for details) and a fault can be created in a system by removing a device from its base (to generate a tamper fault)

SYSTEM SENSOR EUROPE
Pittway Tecnologica S.r.l.
Via Caboto 19/3
34147 TRIESTE
Italy
www.systemsensoreurope.com