# Wireless Interconnections in Fire Detection and Fire Alarm Systems: Points of Attention for the Installer and the Belgian Application Standard

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## Abstract

The interconnections in fire detection and fire alarm systems (FDAS) are wired for most of the installations. FDAS components embedding means for radio interconnections are now offered on the market since at least 15 years. Opponents to the radio techniques often claim lack of reliability. To the opposite, several advantages in comparison with wired interconnections can be highlighted. The reliability of an FDAS with radio interconnections is certainly based on the quality of the products. Nevertheless the contribution of the installer is also a key point. Specific characteristics of the radio interconnections having direct impacts on the FDAS have been identified. These characteristics lead to points of attention for the installer. The radio coverage has to be preferably simulated in advance or, if not possible, checked on-site before the definitive installation. The used frequency band is shared with other applications. Moreover very high level signals as well as signals transmitted during a large percentage of the time may still disturb the wireless FDAS. Hence the installer has to question the building user about the presence of other transmitters. Wireless components are most often powered by an internal battery, without any mean for recharging. Hence the installer has to consider this constraint when designing the system. The weakest point of the wireless FDAS is probably the variation of signal intensity arriving to the receiver. This variation is produced by changes made on the building construction, on the furniture or on the occupancy (museums, concert halls,…). This characteristic is known as “immunity to site attenuation”. This function is dedicated to the installer who has to use it specifically during the commissioning of the system.

**Keywords:** wireless, radio, FDAS, fire detection system

## Introduction

The interconnections in fire detection and fire alarm systems (FDAS) are wired for most of the installations. The cable remains a proofed technique under control since long. It is for sure its hardware and visible characteristics that make it the preferred interconnection mean: the course of signals can be visibly followed, the damaged parts can be seen, and the connection faults can be found and fixed. On another hand, these last 20 years, the radio techniques have appeared in a lot of professional and private applications. The massive development of the radio interconnections brought an obvious improvement of their performances, miniaturisation of the components, and lowered production costs. The Windsor castle fire disaster in 1992 has certainly been a trigger for the development of radiofrequency links between FDAS components. FDAS components embedding means for radio interconnections are now offered on the market since at least 15 years and the standardisation of this function within FDAS has started in Europe 10 years ago with the standard EN 54-25 [1].

Opponents to the radio techniques often claim lack of reliability. It is true that several drawbacks can be identified: spatial coverage is difficult to predict, the transmission quality may vary from time to time, the link can be disturbed by other transmitters, and the battery has to be periodically replaced. Nevertheless these drawbacks do not mean that the wireless has to be banned from FDAS. To the opposite, several advantages in comparison with wired interconnections can be highlighted: neither bleeds nor cableways are needed (historical buildings), fast installation (loss of exploitation is limited), suitable for temporary installations, no material degradation, and new redundancy techniques (mesh topologies). Hence, advantages and drawbacks have to be duly considered when choosing the technology.

The reliability of an FDAS with radio interconnections is certainly based on the quality of the products. Nevertheless the contribution of the installer is also a key point. ANPI had to recognize that the knowledge of the installers about their role in this topic was very low in Belgium. This situation shouldn't be by far different in the other countries. Very few national application guidelines consider the specific aspects of wireless components. The UK guideline (BS 5839-1 [2]) was the only document including significant consideration to the radio devices.

The present paper explains specific characteristics of the radio interconnections having direct impacts on the FDAS. These characteristics lead to points of attention for the installer. The integration of these considerations into the Belgian application standard is finally explained.

**Product conformity is the starting point**

The conformity of the radio components to all the requirements of the European standard EN 54-25 has to be ensured and preferably certified. Qualitative and reliable products constitute the starting point to ensure qualitative and reliable installations. This is however not the only point of attention. Certified products don't guarantee a good installation, they guarantee that the tools needed by the installer are provided. He has to use them as intended: the installer has to play his role.

**Radio coverage**

The radio signals are not visible. Their presence, their intensity and their propagation across the building cannot be assessed by a simple inspection. Furthermore the spatial coverage is influenced by a large set of parameters. The building configuration (concrete screed, walls, partition walls, doors, windows, furniture) and the materials (reinforced concrete, metals, bricks, functional glasses) will disturb the propagation of the waves and make the coverage apparently unpredictable. This is a pure installation related issue. The best radio product can't get round it. The signal strength arriving from the transmitter to the receiver has to be checked during the design step to ensure that received signal strength (RSS) is sufficiently above the receiver threshold. Specific tools are needed to proceed. Software tools are usually used to predict the radio coverage. These can be used even before the erection of the building (Fig. 1). The drawback is the need for a full description of walls, floors, ceilings, doors, and windows. Otherwise on-site measurements can be performed. The building has, in this case, to be already erected. A transmitter is placed at the expected location of the detector and the RSS is measured at the location of the receiver. The installer has to question the system manufacturer about the available tools for the determination of the radio coverage.

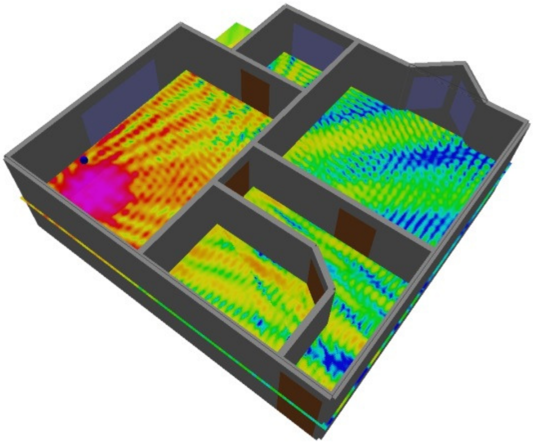

Fig. 1. Example of software prediction of coverage (RSS).

In case of insufficient RSS a radio repeater has to be installed between the detector and the receiver or a mesh configuration (Fig. 2) has to be considered. In case this check is not performed beforehand the RSS coming from some detectors could be too low. This would then lead to an enrolment failures during the commissioning or loss of communication faults when the FDAS is into service.

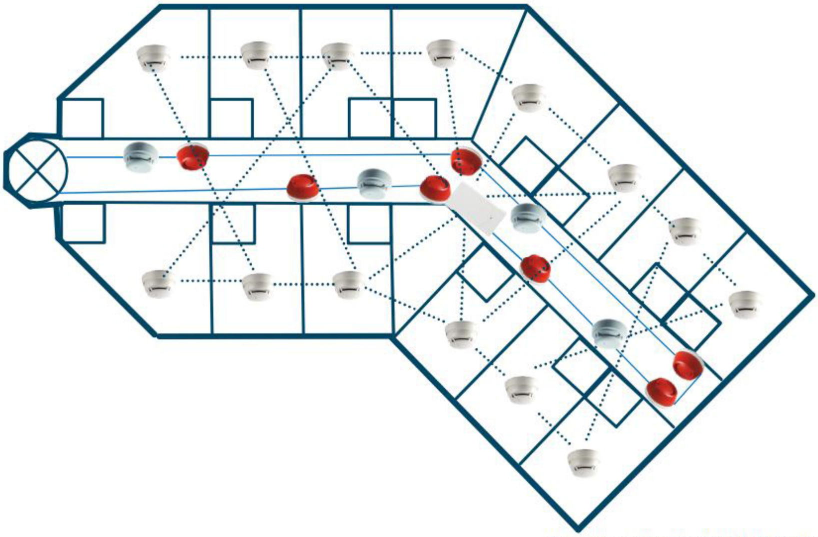


Fig. 2. Mesh configuration allowing each radio component to be a node of a complete network.

**Disturbance by other transmitters**

The use of the electromagnetic spectrum is strictly regulated. Each frequency band has its own rules: allowed application, licensed or unlicensed, maximum signal bandwidth, duty-cycle, maximum radiated power, etc. The aim is to reduce the risk for interferences. The two bands most frequently used by the alarm components are around 433 MHz and around 868 MHz. The latter is now more popular than the former for compactness reasons and also for a reduced risk of interferences. The band around 433 MHz is allocated to the non-specific short range devices. Its advantage with regard to the 868 MHz band is a better propagation range. On the other hand it is open to a wide range of other applications: wireless headsets, any kinds of remote controls, domotic applications, etc. It is moreover included inside a band used by radio amateurs (430 – 440 MHz). The situation in the 868 MHz band is about the same. Most of the alarm products work between 868.0 and 868.6 MHz which is also allocated to non-specific short range devices. Its advantage is to be not included inside a radio amateurs band. Three bands of the frequency spectrum are allocated to radio alarm devices. Nevertheless, in Europe, most the components offered on the market don't use them and transmit in the two "generic" bands described above. This is due to the very low limit for the transmitted power (and consequently the propagation range), the duty-cycle, and the bandwidth allowed in the alarm bands. These considerations explain the risk for interferences within the band used by the wireless FDAS.

In addition, a transmitter working outside the assigned band with a particularly high power may also interfere with the FDAS signals via intermodulation.

The European standard EN 54-25 does partly cover this issue. Very high level signals as well as signals transmitted during a large percentage of the time may still disturb the wireless FDAS. Hence the installer has to question the building user about the presence of high power transmitters. The concern is about broadcasting signals (over kilometres) e.g. radio amateurs or private mobile radio (PMR, UHF and VHF). In industrial environments care shall be taken to high power radio sources like induction heating, microwave heating, arc welding, etc. WiFi, Bluetooth, GSM picocell, and DECT devices shouldn't interfere provided they are located at least 1 meter from the alarm component. Measurements can also be undertaken to detect the presence of potentially interfering signals, knowing that the measures will only reveal the signals actually transmitted during the measurement. The installer has to question the system manufacturer about the available tools for such a site survey. In case the system is commissioned without any care about this issue there is a risk of loss of communication faults when into service.

**Limited power source**

Wireless components are most often powered by an internal battery, without any mean for recharging. The minimum autonomy imposed by EN 54-25 is 36 months. Furthermore there is a requirement to signal a low battery level at least 1 month before the component is unable to work as expected. Hence the installer has to consider this constraint when designing the system. At least 3 questions have to be answered: accessibility of the components for the replacement of the battery, the periodicity of the general maintenance versus the periodicity of the battery replacement, and the use of the system during the evacuation practice (how long the fire alarm devices will sound or flash during the exercise?).

**Variability of the transmission quality**

The weakest point of the wireless FDAS is probably the variation of signal intensity arriving to the receiver. This variation is produced by changes made on the building construction, on the furniture or on the occupancy (museums, concert halls,…).

As an example, insulation materials often bring a metallic foil which will impair the propagation of the radio waves. In order to explain the issue, Fig. 3 depicts 3 different cases. In Case 1 the signal strength received by the receiver (e.g. the CIE or the radio gateway) from the transmitter (e.g. a detector) is far above the sensitivity threshold of the receiver. In such a situation the interconnection remains operational even in case of strong degradation of the propagation of the radio signal. In Case 2 the signal strength received by the receiver is below the sensitivity threshold of the receiver. In such a situation the radio interconnection doesn't work and the problem will be detected during the commissioning. In Case 3 the margin between the received signal and the threshold is narrow. The radio interconnection will work during the conditioning without warning the installer about the high risk for loss of transmission in the future (Fig. 4).

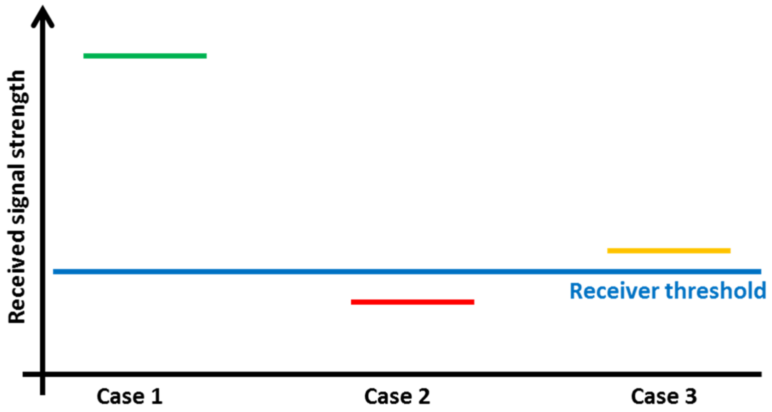


Fig. 3. Margin between received signal strength and receiver threshold: 3 cases.

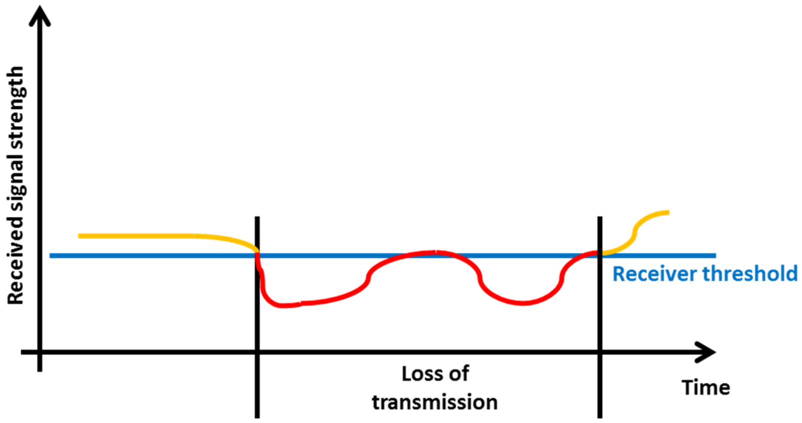


Fig. 4. Variation of the received signal strength and loss of transmission during some period.

To overcome this known phenomenon the EN 54-25 imposes to provide the product with a mean to simulate the degradation of the signal propagation. This characteristic is known as “immunity to site attenuation”. This function is dedicated to the installer who has to use it specifically during the commissioning of the system. The installer has to question the system manufacturer about the available tools and verification criteria. The process is depicted in Fig. 5. This example considers that the manufacturer has implemented a mean to artificially reduce the power transmitted by the detector. Two cases are presented. In Case 1 the received signal strength is sufficient with the nominal transmitted power and remains sufficient (above the threshold) when the power is artificially reduced. Hence there is a margin allowing the interconnection to work even in case of degradation of the propagation. In Case 2 the received signal strength is sufficient (above the threshold) with the nominal transmitted power but falls below the threshold when the power is artificially reduced. Hence the margin is too narrow and doesn’t allow the interconnection to work in case of degradation of the propagation.

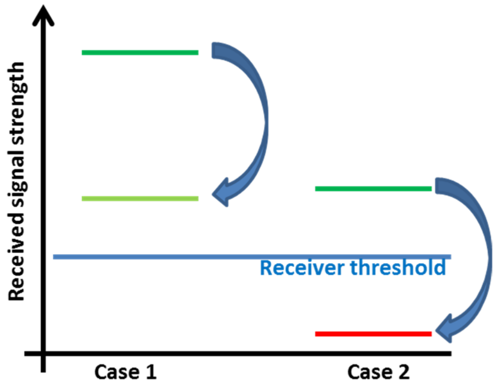


Fig. 5. Principle of test for immunity to site attenuation.

According to EN 54-25 this artificial reduction mean shall be at least 26 dB at 433 MHz and 29 dB at 866 MHz but could be limited to 10 dB if other mitigation techniques are provided.

In case this verification is not done during the commissioning there is a risk of loss of communication faults when into service. When this fault happens too often the temptation to disable the link supervision function appears. This is the worst reaction and unfortunately the one that happens very often.

**Wireless FDAS and the Belgian application standard**

The Belgian application standard for FDAS (NBN S 21-100-1 [3]) has been recently revised in order to add specific requirements related to wireless components. The deliberate approach has been to avoid any exclusion about the types of sites where the radio technology can be used and to promote expected performances of the radio link characteristics. Hence it incorporates some specific milestones for the designer, the installer and the user at the different steps of the project: risk analysis and assessment of the needs, detailed study, commissioning, controls, and verification and maintenance. The considerations given in the present paper have been implemented at the adequate place in this future application standard. This new version is presently under enquiry.

## Conclusion

The wireless FDAS are neither the ideal solution for any case nor a rubish technology to be banned. It has to be considered as a technology different to the wires with its own characteristics, advantages, and drawbacks. Its characteristics have to be properly understood and this is the purpose of the present paper.

After having got a sufficient understanding, its advantages have to be used where wireless technology offers a higher level of safety than wired technology or the same level at a lower cost. Its drawbacks have to be adequately addressed to reduce their impact on the reliability of the system.

Provided these conditions are fulfilled, wireless FDAS may be considered as providing the same level of reliability than wired FDAS. This was the philosophy behind the revision of the Belgian application standard NBN S 21-100-1.

## Acknowledgement

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## References

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[2] BSI, "*BS 5839-1 Fire detection and fire alarm systems for buildings. Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises*", BSI, 2013.

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