


# Signal Window® Guide for Construction and Renovation



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WINDOW®





The photo shows a Lammi MSE-A window with Signal Window glazing at Tuusula Housing Fair (Lammi-Kivitalot).

## The goal of the guide

The goal of this guide is to address the issue of poor indoor mobile phone reception and network connectivity. It provides practical advice on how to ensure optimal indoor reception quality using Signal Window® windows and doors when constructing or renovating your house. In the last part, the guide explores the existing problems, product selection and positioning through three practical examples (renovation of an old detached house, construction of a new stone house, renovation of an apartment building).

## By reading this guide, you will learn:

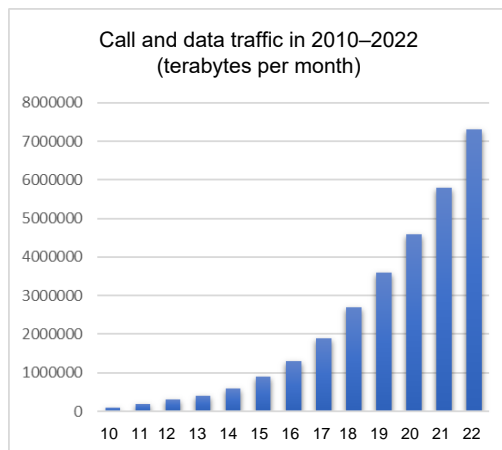
- What causes poor mobile phone reception and internet connectivity indoors
- How Signal Window® windows and doors differ from conventional products
- How the functionality of these products has been studied
- How to choose and position products correctly for your specific site
- How indoor reception can be optimized during renovation and construction

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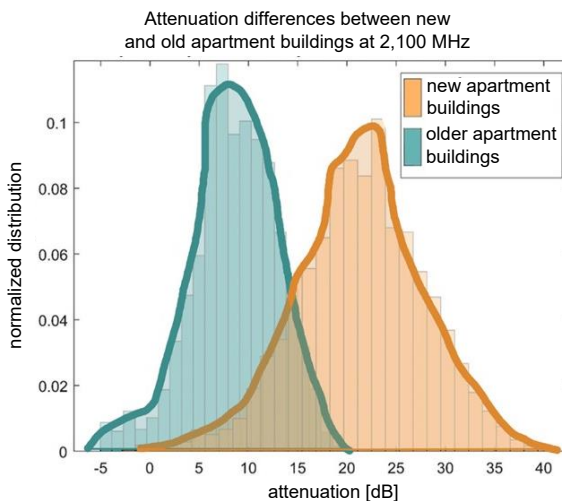
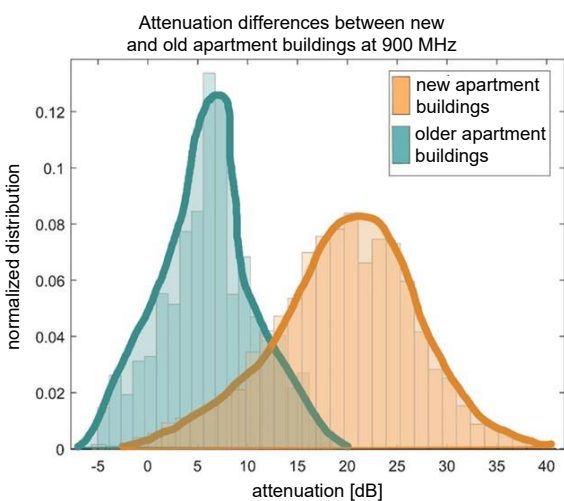
# The phenomenon of poor reception

Over the last decade, the volume of mobile call and data traffic has increased dramatically. At the same time, the focus of the construction industry has shifted to using more energy-efficient building materials and improving the insulation of building envelopes. Windows and doors have also evolved significantly, with notable improvements in thermal insulation (U-value). The chart to the right illustrates the growth in call and data traffic in recent years. (Source: Signal Window webinar of 27 Jan 2021)



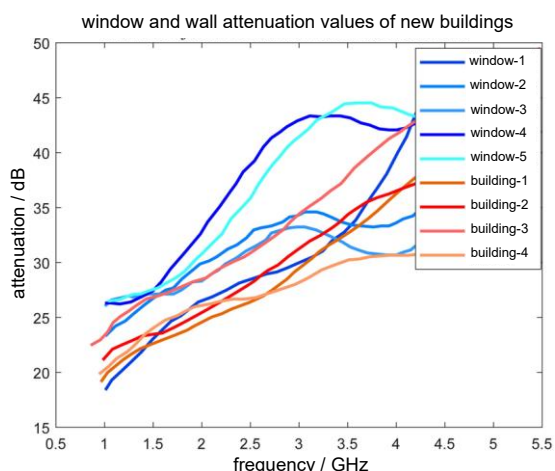
## Indoor reception varies significantly between buildings

Ari Asp, an expert researcher at the Tampere University, has conducted extensive studies on issues related to indoor reception. According to the research, the sound attenuation characteristics of exterior walls differ greatly between old and new buildings. The findings indicate that, compared to older structures, the attenuation capacity of external walls in new buildings is significantly higher. The charts below show the difference in reception attenuation between an old and a new apartment building on two different radio signal frequencies, measured on the decibel scale\*. In older apartment buildings, the average attenuation ranges from 5 to 10 decibels, while in newer buildings it amounts to 20-25 decibels. (Source: Signal Window webinar of 27 Jan 2021)



## Walls and windows attenuate radio signals equally

The same research findings indicate that windows and walls attenuate the passage of radio signals to indoor premises at comparable levels. Consequently, poor indoor reception is a recognised issue that can be addressed by selecting the appropriate type of windows, both during construction and renovation. The chart to the right compares the reception attenuation of five different window types and the walls of four different buildings. (Source: Signal Window webinar of 27 Jan 2021)



# Signal Window® windows and doors

Signal Window ® windows and doors differ from conventional products solely in their glass selection. The glass panes of these windows are patterned using laser technology to facilitate the passage of radio signals. The visibility of the pattern on the glass depends on the background and lighting conditions. You can customize the window model, shape, functionalities, desired colour, and accessories to suit your needs. When placing an order, just remember to specify the Signal Window® feature for your window, and our expert will take care of the rest.

## Signal Window® glass can be chosen for various applications, including:

- Ventilation windows
- The largest glass surface of a window
- The entire glass surface of a window
- Glass apertures of exterior doors
- All-glass balcony or terrace doors



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## Bigger is better



The opening doors in the above photos illustrate how a signal window functions. In the first photo, the slightly open door represents a regular window without the Signal Window® treatment. In the middle photo, the halfway open door represents a window with a small ventilation area treated using our signal technology. The fully open window in the third photo represents a Lammi window with Signal Window® treatment applied to the entire glass surface. The larger the surface treated with the technology, the more effectively signals can reach indoor spaces.

## How much does Signal Window® treatment cost?

The cost of windows and doors with the Signal Window® technology depends on various factors, including the dimensions of the treated surface and the number of products ordered. Pricing is determined on a case-by-case basis, taking into account the customer's entire order. To receive a specific quote, please contact your expert. Here is a tip for those submitting requests for quotation: include the text "Lammin Signal Window or similar" in your request and you will receive a quote with the required details.

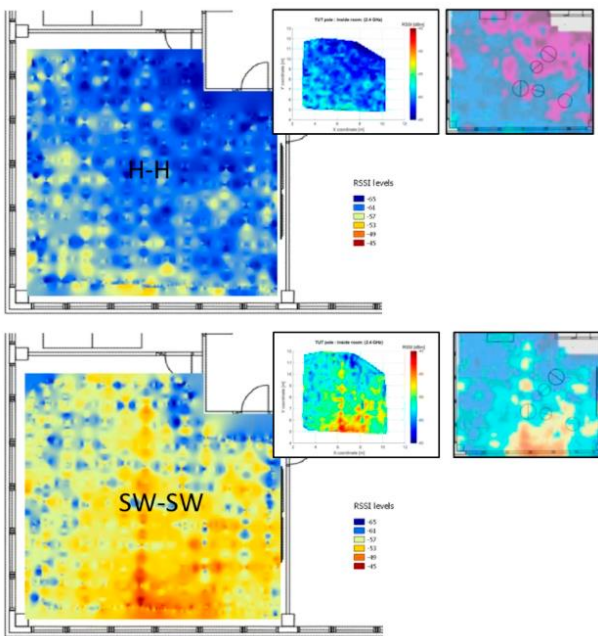
\* The decibel scale is a logarithmic, meaning even small changes in attenuation can have a major impact. This scale enables consistent comparison of measurement results across different radio frequencies, which might otherwise be difficult to calculate.

# Studied and tested technology

The functionality of windows treated with the Signal Window® technology has been studied and tested since 2012, with participation from Finnish universities. Product research has been carried out at Lammin Ikkuna's own test laboratory, with several field tests (e.g., at the Tuusula Housing Fair 2020), and as part of nationwide projects. The most significant project involving our products was the Lux Turrim 5G led by Nokia Bell Labs; in addition to Lammin Ikkuna, the participants included VTT, Aalto University, and the Tampere University of Technology.

## Summary of Signal Window® research results

Lammin Ikkuna currently offers the fourth version of Signal Window® products. According to the latest research findings, Lammi signal windows suppress the passage of radio signals and, consequently, the reception of mobile devices and functionality of the internet indoors by only a fraction as compared to conventional windows. The two diagrams below illustrate the functionality of the technology in practice:

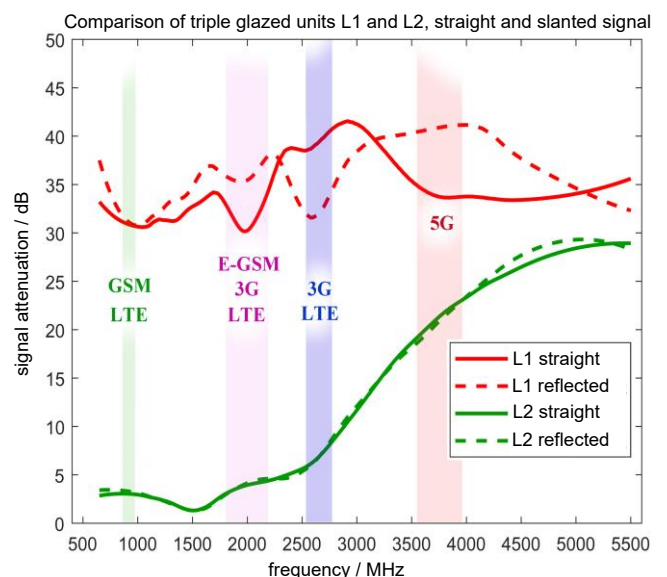


## Lux Turrim 5G project

We tested the functionality of Signal Window® windows as part of the Lux Turrim 5G project, led by Nokia Bell Labs in 2017. The thermal images on the left were taken at the Karaportti office building, where we first tested signal propagation to indoor spaces using a regular triple-glazed opening window. This was later replaced with a Signal Window®. In the image, signal strength was measured at the bottom windows. The deeper the red in the image, the lower the signal attenuation indoors. Therefore, research results demonstrate that the quality of mobile phone reception and internet functionality indoors can be affected by the choice of windows.

## New results for 2020

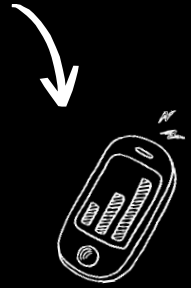
The chart to the right illustrates the results of measurements conducted in 2020 to compare the signal attenuation of a conventional triple-glazed unit (L1) and a Signal Window® glazed unit (L2). The results show that, compared to regular windows, Signal Window® windows attenuate signal penetration to indoor premises many times less (as measured on the decibel scale). The reflected slanted signal demonstrates that signals do not always pass indoors through the window at a right angle. In the test, the slanted signal was measured at an angle of 30 degrees with respect to the glazed unit.



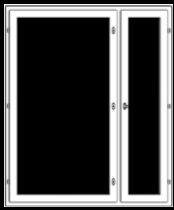
# How signals end up indoors – a simple explanation



A signal from the base station meets the building envelope. The field strength outdoors is expressed in dBm, which indicates the decibel level relative to milliwatts (mW).

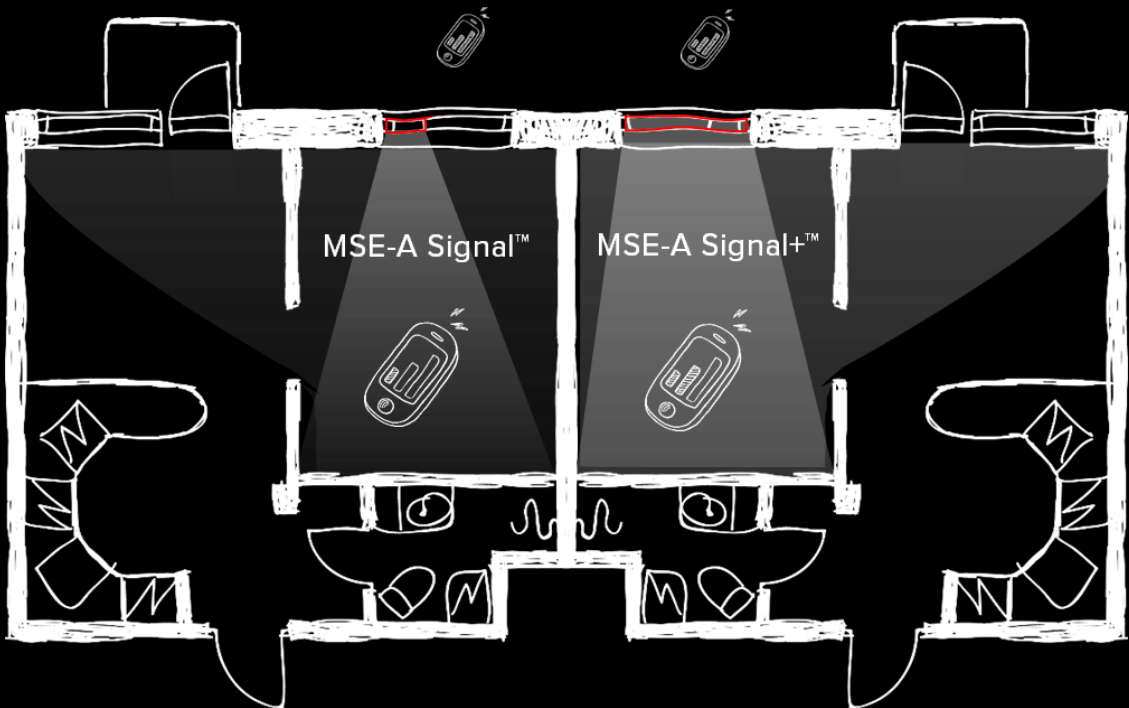


The field in front of a window has a certain power density, which refers to the radiated power (mW/m<sup>2</sup>) within a specific area. Power cannot be increased without additional energy, i.e., amplification.



Signals attempt to penetrate the building envelope. The material of the envelope (e.g., the window glass) attenuates the incoming power.

Regular glazing	-3 dB = -1/2 of the power
1 selective glass pane	-23 dB = -1/100
2 selective glass panes	-39 dB = -1/1000



- Increasing the area leads to a higher signal level throughout the room.
- The larger the area through which signals pass, the more power can be transmitted indoors, and vice versa.
- Radio signals entering through the window are reflected off the walls and dispersed throughout the room.

# Signal Window® product selection and positioning

Product selection and positioning are crucial for indoor reception. When it comes to positioning, two main factors must be considered: obstacles to signal penetration in the form of the building's façade, and the orientation of the network operators' base stations. The following three tips will help guide your choices:

## 1. Contact Lammin Ikkuna for expert assistance and start planning

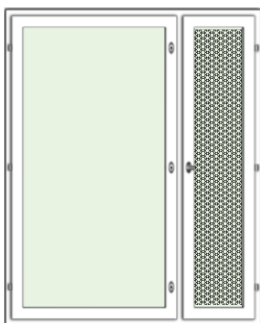
It may be helpful to test internet functionality in different rooms to identify those with the weakest connectivity. Focus on the rooms where mobile phones, computers or other internet-enabled devices are most frequently used. You can also check whether you are within the range of the operators' base stations. Do not hesitate to contact experts at Lammin Ikkuna for help – planning assistance is provided free of charge!



If signal strength outside the building is poor, signal windows or doors will not improve reception. Please note that no signal windows/doors (or antenna windows/doors) generate signals; they only facilitate the passage of existing signals.

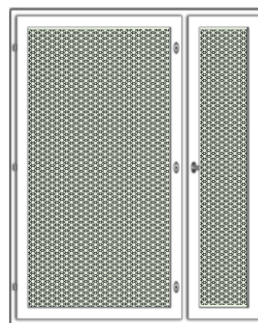
## 2. Choose either cost-effectiveness or maximum reception

You can choose the Signal Window® feature for either the ventilation part or the entire glass surface of a window. The larger the glass area treated with Signal Window® technology, the better the indoor connectivity. Alternatively, you can opt for the cost-effective ventilation window version.



### Lammin MSE-A Signal

- Your choice for a cost-effective, minimal solution
- Signal-transmitting glazing in the ventilation part
- From a functionality standpoint – a regular triple-glazed, wood-aluminium window that can be opened



### Lammin MSE-A Signal+

- Your choice for optimal reception
- Signal-transmitting glazing across the entire window area
- From a functionality standpoint – a regular triple-glazed, wood-aluminium window that can be opened

## 3. Decide where to install your Signal Window® products

Inside the building, the signal strength wanes as the distance from the envelope increases. This is because signal weakens each time it encounters an obstacle (e.g., a wall, mirror, door, or stairs) and is reflected off it. Signal strength is also affected by other parts of the building, such as the roof, frame materials, partitions, and insulation materials. We recommend installing Signal Window® products in the following areas:

- Study rooms, living rooms, and bedrooms
- Any room where mobile devices need to function seamlessly
- At least one product for each cardinal point, as operators regularly re-orient their base stations
- All-glass balcony or terrace doors

## Example: Renovation of an old detached house

In this example, a Finnish couple had purchased an old wooden detached house in Hämeenlinna. They wanted to renovate the windows because the existing ones were in poor condition. The house had double-glazed, opening windows. The internet and mobile phone coverage were good in the old house built in 1940s.

### PROBLEM

During the renovation, the old double-glazed windows (U-value 2.5) were replaced with new triple-glazed windows (U-value 1). After the renovation, the couple noticed that the quality of their internet connectivity and mobile phone reception deteriorated. The cause of the problem was that the new, energy-efficient windows also blocked radio signals more effectively than the old windows.

### SOLUTION

Replacing old windows with more energy-efficient and insulating ones will inevitably lead to poorer passage of radio signals to indoor spaces. When renovating an old, detached house, Signal Window® products can help ensure that the installation of new windows has minimal impact on the reception and connection quality. You can choose these products for areas such as bedrooms, living rooms and study rooms.





## Example: Construction of a new stone house

A family of four from Lahti ordered a kit house from a Finnish stone house manufacturer. After many years of living in rented terraced houses and apartment buildings, the family had long considered either building a new house or renovating an old one. They were drawn to the modern aesthetic and appeal of stone houses. The house was completed on schedule in 2019–2020.

### PROBLEM

Stone houses present well-known challenges related to mobile phone coverage and network connectivity. The envelope of a stone building contains a lot of insulating material, and there are several iron elements inside and between the blocks. Combined with modern energy-efficient windows, these almost completely block radio signals from entering the indoor space.

### SOLUTION

When selecting windows and doors for stone houses, you should carefully consider the choice and positioning of Signal Window® products. To ensure maximum connectivity in this new stone house, the products were installed in each cardinal direction and in rooms where devices are most frequently used. The Signal Window® treatment was applied to the entire glass area of the windows rather than limited to the ventilation part.



# Example: Renovation of the façade of a residential apartment building

The general meeting of a residential apartment building in Southern Finland voted in favour of comprehensive façade renovation. One of the key objectives of the renovation project was to replace the building's windows and balcony doors with modern energy-efficient alternatives. They chose Lammin Ikkuna Oy as their window and door supplier.

## PROBLEM

Renovating the façade of a residential building is a large-scale project that requires careful consideration of both product cost-effectiveness and the seamless passage of radio signals into the interior. Such projects often involve replacing hundreds or even thousands of windows and doors, leading to substantial expenses. In apartment buildings, the positioning of products is equally crucial, as densely populated residential areas often have neighbouring buildings that further block radio signals from reaching the apartments.

## SOLUTION

For apartment buildings, significant cost savings can be achieved by limiting the Signal Window® treatment to ventilation windows only. However, the housing association might opt for more targeted product positioning – such as installing a single signal window per apartment. A third cost saving option is to choose Signal Window® glazing for all-glass balcony doors.



## Additional information and links

Below are some links to Signal Window-related publications. We encourage you to explore the topic further and reach out to the sales department of Lammin Ikkuna with any inquiries or when planning window or door renovations.

### Videos:

[Webinaaritalenne: Radiosignaalien ja mobiiliyhteyksien huomiointi rakentamisessa ja remontoinnissa 1.2.2021](#)

[Signal Window Tuusulan asuntomessuilla 3.8.2020](#)

[Signal Window -herättelyvideo 22.7.2020](#)

[Signal Window -esittelyvideo 12.10.2016](#)

### Articles:

[Rakennuslehti: "Laajakaistaikkuna" voi ratkaista kännykän kuuluvuusongelmat – uudenlaisen ikkunan valmistamiseen miljoonapanostus 3.7.2019](#)

[Uusiteknologia.fi: 5G-verkko näkyy pian paremmin 20.12.2018](#)

[Yle: Kännyköiden kuuluvuusongelmat ärsyttävät uusissa taloissa – ikkunafirma uskoo keksineensä ratkaisun 11.4.2017](#)

[Eurofins: Lammin Ikkunan polku puusepänerästä teknologiayritykseksi – Signal Window tuo ikkunaan uuden ulottuvuuden 14.2.2017](#)

### Publications:

[Lammin antenni-ikkuna esite/tuotekortti 2020](#)

[Signal Window tekninen esite 2017](#)

## Lammin Ikkunat ja Ovet

Founded in 1969, Lammin Ikkuna is one of Finland's leading companies in the woodworking industry. We offer window and door products, custom-made in Finland, to consumers, housing associations, and companies. While primarily serving the Finnish market, we also export our products to Sweden and other countries. Employing approximately 100 people, Lammin Ikkuna was the first to introduce the market to a proven and functional signal window.

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