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Virtual Antenna® Technology

vs.

FPC Antenna

WHITEPAPER

Why Virtual Antenna® Technology is the Superior Choice for Wireless Devices

The Wireless Antenna Challenge

One of the foremost challenges in building successful wireless devices is the choice of antenna. Critical performance features such as connectivity, range, and battery life all depend on an antenna implementation that can deliver the highest quality and most stable, dependable duty in the field.

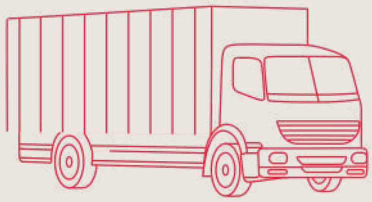
With wireless use cases and deployment numbers growing rapidly throughout countless business sectors, today's deployed devices are expected to be active in the field for years and even decades. With this in mind, it is imperative that developers be certain that the devices they produce will perform as well in the field as in the lab.

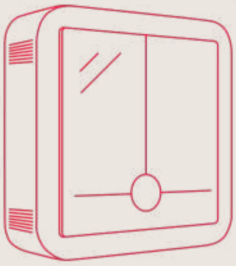
The Key Enabler of the Wireless Mission

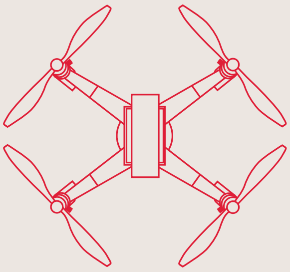
The core value for most wireless device applications is derived from the successful extraction of data sent to the cloud, a task that **demands a reliable and resilient wireless connection**. Today, developers are spoiled with an abundance of connectivity choices. These include a decision between short-range options, such as Bluetooth, Wi-Fi, Zigbee/Thread, or Z-Wave, and longer-range options, such as LTE-M/NB-IoT, LoRa, Wi-SUN, Sidewalk, 3G, or 4G. And the evolution and complexity continue to evolve with new technological opportunities in public and private 5G networks, UWB, and Satellite, the latter moving IoT applications from a LAN (Local Area Network) and WAN (Wide Area Network) to true global coverage.

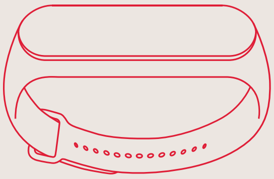
The associated benefits of lower latency and higher-performance connectivity create greater demand for optimized antenna solutions.

Any wireless device, regardless of the wireless protocol used, requires a robust antenna that is capable of **strong, assured connections**. Peak performance must be maintained especially when sensors need to deal with the complexity of multiple frequency bands, and often in changing and even extreme environments.









The Antenna Problema: Solved with Simplicity

The Old Way: Unpredictable FPC Antennas

Historically, a popular antenna choice for wireless devices has been the "sticker antenna" or Flexible Printed Circuit (FPC) with an adhesive backing strip and cable. While FPC antennas perform reasonably well in test environments, they, unfortunately, require manual assembly and precise cable routing.

They are also easily affected by disruptive physical factors when placed into the device casing which makes them unpredictable. These two unavoidable variables often result in **highly degraded wireless performance in the field**; not at all what the product sheet led developers to believe.

The New Way: Reliable Virtual Antenna® Solutions

Today, Virtual Antenna® technology enables developers with a simple path to the two most critical features needed for IoT devices, high performance, and high reliability.

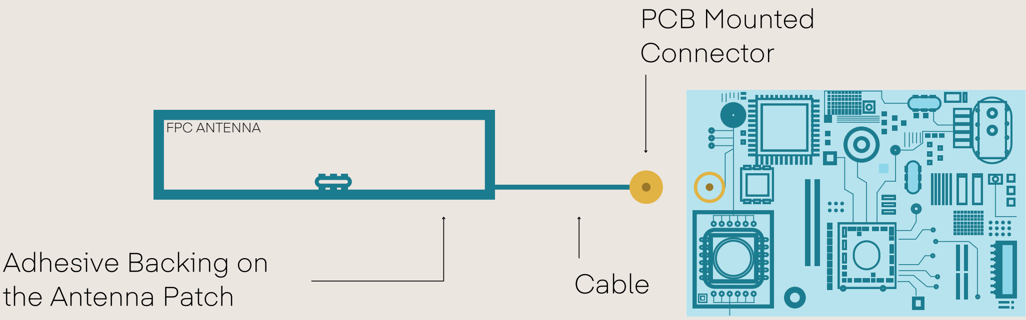
Now application developers have access to an easy-to-implement, cost-effective, multi-band, multi-protocol antenna solution that can be integrated into any design, with an automatic pick-and-place assembly that ensures predictable, repeatable, and reliable performance.

One of the foremost challenges in building successful wireless devices is the choice of the optimal antenna, yet there are thousands of options.

Critical performance features such as connectivity, range, and battery life all depend on an antenna implementation that can deliver the **highest quality and most stable, dependable duty in the field**. With wireless use cases and deployment numbers growing rapidly throughout countless business sectors, today's deployed devices are expected to be active in the field for years and even decades. With this in mind, it is imperative that developers can be certain that the devices they produce will perform as well in the field as in the lab.

Breakdown of an FPC antenna solution

An FPC antenna requires both cable and connectors to connect to the ground plane, which adds complexity and cost to the antenna assembly. FPC antennas have an adhesive back strip and require mounting by hand resulting in the risk of human error and unpredictable performance.



(It is worth noting that this adhesive may degrade over time or could be affected by heat. The result, in either case, would be the antenna shifting performance)

Unpredictable Performance from Testing through Production

The testing of an FPC sticker antenna, that is connected to a PCB and laid out side-to-side next to the device PCB, will likely display reasonable performance through the testing process (off-PCB). However, FPC antenna performance changes dramatically and unpredictably when the FPC antenna is placed inside the IoT device enclosure (on-PCB), and even varies substantially depending on how exact the placement is.

Limited Tuning Flexibility and Fixed Bandwidth

FPCs are inherently resonant and designed to operate within specific, limited frequency bands. The operating bandwidth of the antenna is fixed, hence the overwhelming number of options to deal with available protocols and frequency bands, making the right choice based on product specification may well prove to be a real gamble.

Environmental Difficulties

In typical use cases, FPC antennas can operate in environments of up to 85ºC. However, even at these common temperatures, which are often significantly higher inside the actual IoT device enclosure, the adhesive backing on the FPC antenna patch can break down and allow the antenna to slide and move. This dramatically affects performance.

No Fit for Small Device Designs

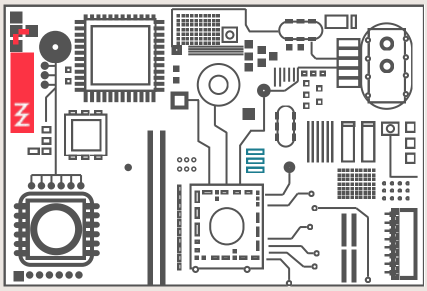
FPCs have a large surface area and require a minimum distance of >20mm to the PCB and are thus difficult to integrate into small IoT product designs such as building sensors, smart meters and asset trackers. Bending or folding the FPC antenna will degrade the performance*.

Increased Cost

FPC antennas are a more expensive antenna solution, even though they are fabricated using standard PCB manufacturing techniques. This is due to the unavoidable need for costly connectors, cables and manual assembly. FPC antennas are always a cumbersome and costly option.

Breakdown of a Virtual Antenna® solution

A powerful, reliable, and cost-effective Virtual Antenna® solution is made up of three key elements: the Virtual Antenna® component, a matching network, and the PCB ground plane of the device.



Predictable Performance from Testing to Production

With Virtual Antenna® technology, devices in production will always be an exact replica of the finished prototype, ensuring predictable performance from the lab to the field, and will not degrade over time due to shifting antenna position within the device.

Reliable Solution in Extreme Conditions

Virtual Antenna® components can operate in temperatures of up to 125ºC, providing a clear advantage over FPC antennas in devices that might be subject to high IoT device enclosure temperatures and more extreme or demanding environments such as automotive.

Cost-effective Solution: Placement by Pick & Place Machinery

The Virtual Antenna® component is a Surface Mount Device (SMD) that is mounted using standard automated pick and place equipment and soldered onto the PCB like any other SMD part. No manual assembly is required. Further, Virtual Antenna® components are more cost-effective than FPC antennas and the same Virtual Antenna® component can be re-used across multiple IoT device designs, significantly simplifying logistics and procurement.

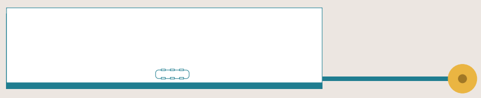
Market-leading Flexibility and Tuning to Any Frequency

The Virtual Antenna® technology turns antenna design into RF circuit design. By simply adjusting the matching network of a few passive components, the operating frequency of the antenna can be tuned, switched to a different frequency/radio technology or even support multiple bands with one antenna. The SMD component always remains the same, and no redesign of the PCB is needed. Thanks to the Virtual Antenna® technology, hundreds of different antenna options for different frequencies can be optimally served by a single antenna that can satisfy all use cases, regardless of protocol or radio technology

High-performance even in Small Designs

Thanks to its size advantage and the fact that the Virtual Antenna® solution uses the PCB as its radiating part, the Virtual Antenna® component will fit in almost any board size. It requires only a fraction of the space within a design, compared to an FPC antenna

Virtual Antenna® Vs. FPC Pros and Cons



PROS

- Little PCB design work needed.
- Simple to integrate with UFL connector.
- Decent efficiency in a lab environment, off-PCB.

CONS

- Large antenna area and cable difficult to fit in small devices.
- Efficiency drops when overlapping the PCB, or cable routed with a mm accuracy.
- Need mounting at minimum > 20mm distance from the PCB board.
- Manual mounting process, prone to human error, costly.
- High efficiency variation (+/-5dB).
- Operates up to only 85ºC.

PROS

- Small component size fits in almost any device, even extremely thin designs.
- Predictable and repeatable high antenna efficiency.
- Emedded on device PCB. Pick & Place machine mounting.
- Simple Cloud-based prototype design and performance simulation.
- Cost-effective solution, same component used across multiple devices.
- Operates up to 125ºC.

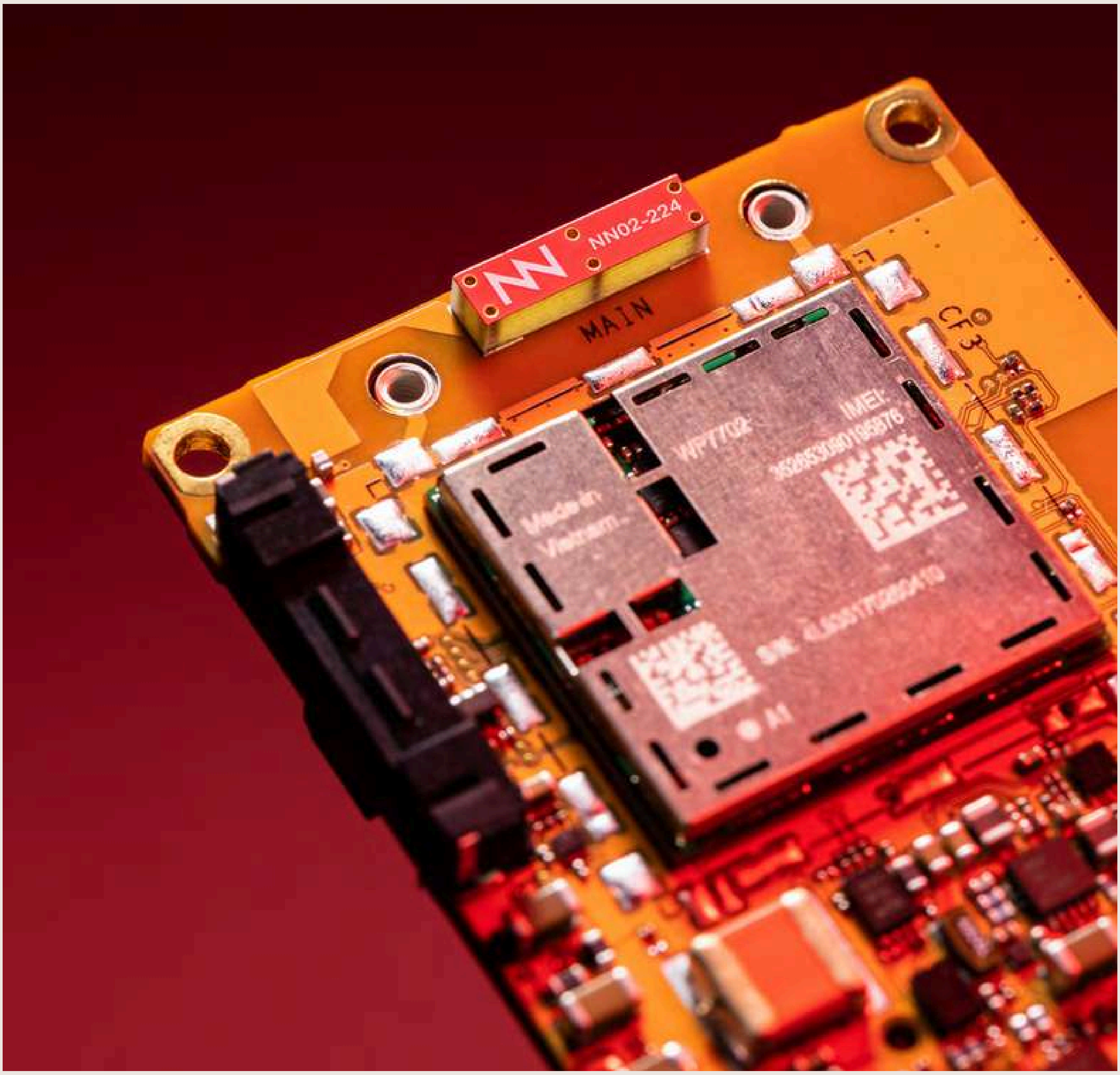
CONS

- Needs to be implemented early in the PCB design process.
- Efficiency of any embedded antenna is dependent on PCB ground plane dimensions.

Antenna efficiency test: FPC vs Virtual Antenna® solution

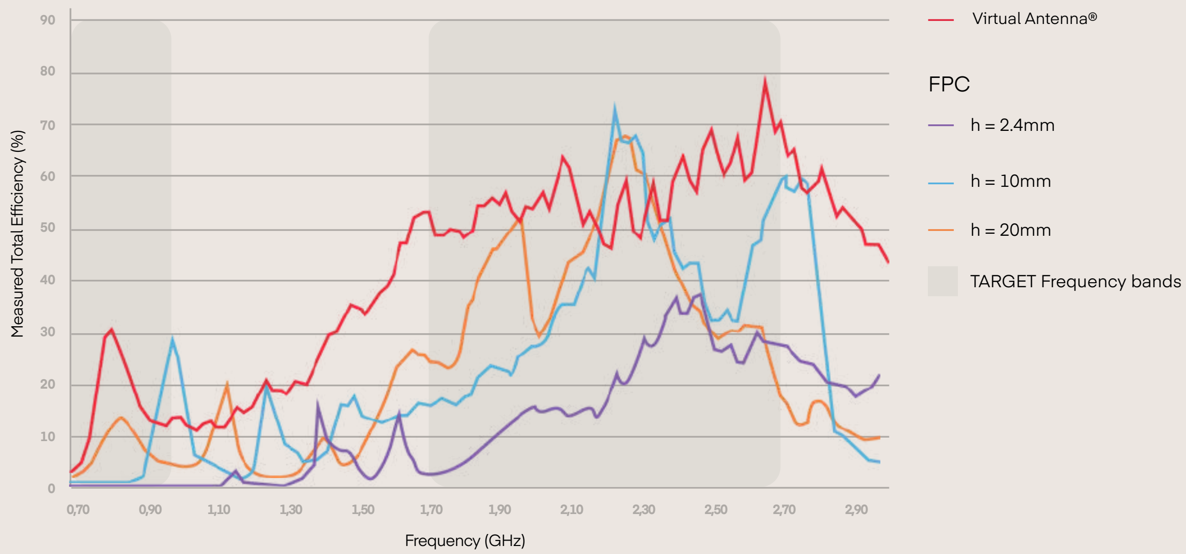
A performance test using an FPC antenna and Virtual Antenna® solution was carried out to produce a head-to-head comparison**. The lab analysis was performed using a popular FPC antenna in the **frequency bands of 698-960 MHz / 1710-2690 MHz,** and an Ignion Virtual Antenna® technology using the Sierra Wireless mangOH®.

Yellow platform. This platform features both a UFL connection for an FPC antenna and an onboard Virtual Antenna® component tuned for the following frequency bands: 698-960 MHz / 1710-2690 MHz, typically used for cellular wireless such as NB-IoT and LTE-M.



Comparison test results

The efficiency measurements presented below clearly demonstrate the superior performance of the Virtual Antenna® solution in comparison to the FPC across the entire frequency spectrum. Particularly in the target low-frequency bands, the FPC antenna does not perform well and becomes detuned when mounted overlapping the PCB. The graph shows the antenna efficiency for the Virtual Antenna® system (red line), compared to an FPC antenna both using the same size PCB board with a dimension of 65 x 42 mm in a casing of 3 different heights. The FPC antenna is mounted on the lid of the casing, on the opposite side of the PCB. The results are shown in purple (2.4mm), blue (10 mm) and orange (20 mm) given the distance between the PCB and the FPC antenna. On average in the target low-frequency bands, the Virtual Antenna® technology delivers >17% efficiency and >56% in the higher bands, compared to the FPC antenna solution only reaching 7% and 40% respectively. **In a real-world use case, this would mean the difference between passing or failing cellular wireless certification.**



	Total Efficiency (%)		698 MHz	960 MHz	Average	1710 MHz	2690 MHz	Average
VA FPC ANTENNA**		HEIGHT 2.4 mm	0.3	0.3	0.5	2.6	27.6	18.4
		HEIGHT 10 mm	0.8	27.6	4.0	15.4	47.5	35.6
		HEIGHT 20 mm	2.8	12.4	7.0	24.8	30.6	40.8
VA		ON PCB	3.7	12.4	17.1	53.6	68.1	56.5

(**) The FPC antenna is placed in a structure simulating a real device with different distances to the ground plane.

Why Virtual Antenna® technology is the ideal choice for wireless applications

Given the complexity and challenges inherent in RF design and antenna implementation, the Virtual Antenna® technology from Ignion provides a welcome solution to many "makers". It is a multi-band, multi-protocol solution that can be factored into any product design from the beginning and can be predictably redeployed across different radio technologies or frequencies with always-optimal performance.

Virtual Antenna® Technology: Always Optimal Performance

The lab testing and competitive analysis prove that Virtual Antenna® technology consistently performs better than FPC in an RF design for a product within the selected frequency bands of 698-960 MHz and 1170-2690 MHz in a device with 65 x 42 mm PCB dimensions. Additionally, the Virtual Antenna® solution is easily tuned to optimize performance in almost any desired frequency band.

Reliable Wireless Designs

The Virtual Antenna® technology, with its embedded components, provides foolproof reliability for IoT designs. The advantage of the pick and place assembly process ensures end-to-end stability throughout mass production. The Virtual Antenna® solution becomes the reliable alternative to an FPC antenna, where mounting and exact position of the antenna in the IoT device introduces unnecessary risks in performance and longevity.

Predictable Design from the First Stage: OXION™

Any changes to a device's specification used to force designers back to the drawing board for enhanced performance due to detuning. Flexibility in these circumstances is critical to business agility. Complementing the Virtual Antenna® hardware component, Ignion offers a highly defined support package that ranges from early design and feasibility using Oxion™ service, and review of the board layout, to the fine-tuning of the matching network, through a full 3D simulation of the antenna performance with the actual board in an enclosure, with plastics and batteries.

These preparatory tools significantly speed up productivity and reduce risks throughout the design phase, even if requirements change. With Virtual Antenna® technology, the company building the device does not have to worry about extensive testing and quality assessment of the antenna and can focus instead on its core expertise, which is developing an IoT application that can extract data in a predictable and high-performance manner.

CUSTOMER SUCCESS STORY

Virtual Antenna® technology chosen over FPC: The Hallsten Innovations Experience

Jim Beckford is a Senior RF/Analog Engineer at Hallsten Innovations, a custom electronic product design, software solutions, and engineering services company with an wireless-focused development team. He has long experience using FPC antennas but says that for Hallsten's applications, the enclosures are usually so small that there is much difficulty in finding available space. Further, the installation of the FPC antenna is a manual step that requires the adhesion of the antenna and connection to the PCB.

With Virtual Antenna® technology technology, Beckford immediately understood and embraced the technical and business advantages. "Once tuned, we have a consistent antenna due to its board mounting, and there's no real manufacturing variation. Assembly is consistent, always placing the antenna in the same location. There is no cable to detach as with an FPC antenna. The antenna simply disappears into the background and does its job," he says.

For Hallsten's use case, the size of the Virtual Antenna® systems and the comprehensive support from Ignion were the two critical elements. Says Beckford, "We are using the TRIO mXTEND™ because it requires the smallest board real estate of any other chip-type antenna for cellular that we considered. But the real clincher was the factory support."

Ultimately, application developers need to remember that when testing FPC antenna performance, they may realize adequate or even impressive results in the lab. However, when the antenna is manually bent or folded into the production casing of the device, efficiency will degrade significantly. Once in the field and exposed to real-world environmental conditions, the FPC antenna is also subject to additional performance and reliability risks through heat inside and outside the casing.

The Virtual Antenna® component in tandem with the cloud-based digital twin design tool, Oxion™, are the innovations that wireless device makers have long needed to make RF design faster, easier, and much more reliable than designing with traditional FPC antennas.

HALLSTEN
INNOVATIONS

*Ignion's technical study reference: Anguera, J; Fernández, A; Puente, C; Andújar, A; Groot, J. Antenna Boosters versus Flexible Printed Circuit Antennas for IoT Devices; Signals: MDPI, 2022. Available at https://www.mdpi.com/2624-6120/3/2/21/pdf?version=1653314611