

ignion<sup>™</sup>

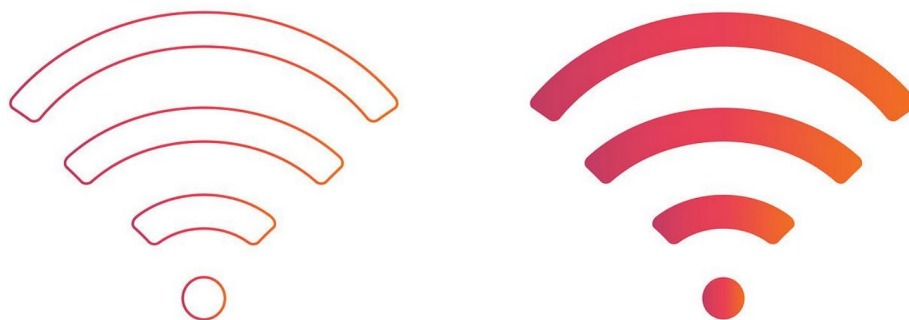
Your innovation.  
Accelerated.

# Miniature antenna for Wi-Fi 6E

APPLICATION NOTE  
ONE mXTEND<sup>™</sup> (NN02-201)

## THE MINIATURE ONE mXTEND<sup>™</sup> FOR Wi-Fi 6E

- **Antenna Component:** ONE mXTEND<sup>™</sup> NN02-201
- **Dimensions:** 7.0 mm x 3.0 mm x 1.0 mm
- **Frequency regions:** 2400-2500 MHz, 5170-5835 MHz, and 5925-7125 MHz



## Wi-Fi 6E

**Design your new Wi-Fi 6E device  
with a tiny, ultra-slim and standard chip antenna  
2.4 GHz + 5.0 GHz + 6.0 GHz**

Design your products with **latest standard** of Wi-Fi, the ground-breaking Wi-Fi 6E. The miniature and ultra-slim ONE mXTEND<sup>™</sup> will enable you to more rapidly design, build and go to market with your devices connected to the world's most prevalent communication technology, Wi-Fi.

Do not worry if you are not ready to use Wi-Fi 6E just yet. Designing your solution with the ONE mXTEND<sup>™</sup> antenna booster means you are ready for both today and tomorrow. The ONE mXTEND<sup>™</sup> antenna booster is a **standard antenna solution that supports all possible frequency coverage combinations of Wi-Fi 5, Wi-Fi 6 and Wi-Fi 6E**. In other words, future proofing!

This means: Wireless engineers, you can eliminate future antenna design worries and effort within your Wi-Fi projects today. This is because the **ONE mXTEND<sup>™</sup> antenna booster can be easily tuned to any standard you need to support your requirements, now or in the future**.

Thanks to its miniature size, only 7.0 x 3.0 x 1.0 mm, this tiny antenna booster fits in just about any platform. Its tiny volume is **only 21mm<sup>3</sup>**. On top of this, the ONE mXTEND<sup>™</sup> antenna will enable to design your products in the smallest of form factors according to your needs, it will be **faster, easier and cheaper** than ever before.

Discover within this application note the new standard of Wi-Fi 6E covered by the ONE mXTEND<sup>™</sup> and its performance in different evaluation board sizes.

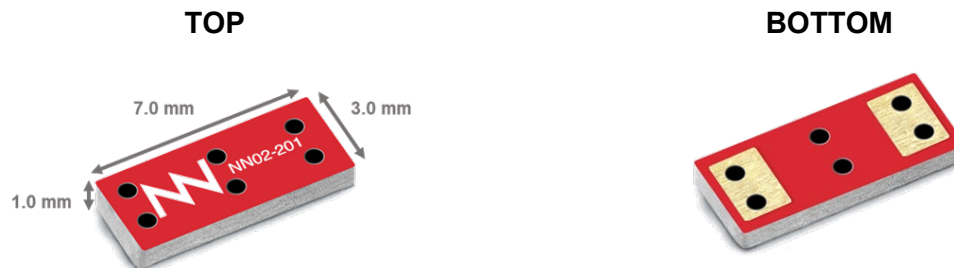
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# 1. PRODUCT DESCRIPTION NN02-201

Wi-Fi 6E has arrived and it is compelling. Higher data rates, reduced spectrum congestion and more reliable connections are just a few of the advantages that Wi-Fi 6E technology has to offer. Most notably, the 6GHz frequency band has been added to the already unlicensed spectrum in the 2.4GHz and 5GHz frequency ranges. This additional frequency band offers more bandwidth with more available channels to improve data speed rates, while preserving coverage and minimizing spectrum congestion in high density environments.

The ONE mXTEND<sup>™</sup>, a multi-band miniature antenna booster, is capable of easy adaption to just about any kind of device. Featuring an extremely small package that requires only a nominal space, the ONE mXTEND<sup>™</sup> is a versatile product capable of operating all the Wi-Fi 6E frequency bands through the same single antenna package. This application note gathers the performance of the ONE mXTEND<sup>™</sup> when mounted onto various sized evaluation boards (EB). The selected sizes have been chosen from the most deployed device types in the Wi-Fi 6E environment, namely routers, gateways, smartphones, and other small tracker devices featuring CR80 size format.



**Material:** The ONE mXTEND<sup>™</sup> antenna booster is built on glass epoxy substrate.

## APPLICATIONS

- Asset Tracking
- Modules
- IoT Sensors
- Routers and Gateways
- Handsets and smartphones
- Tablets and PCs
- Digital cameras

## BENEFITS

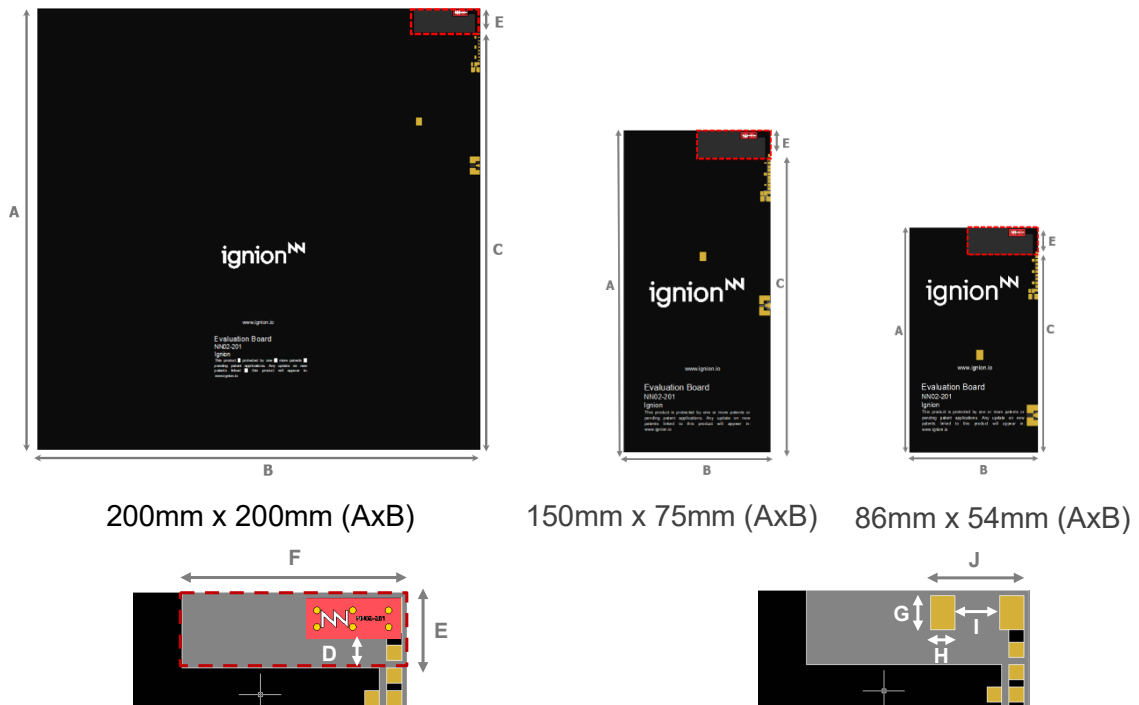
- High efficiency
- Small size
- Cost-effective
- Easy-to-use (pick and place)
- Off-the-Shelf standard product (no customization is required)

The ONE mXTEND<sup>™</sup> antenna booster belongs to a new generation of antenna solutions based upon the Virtual Antenna<sup>™</sup> technology owned by Ignion. This technology replaces conventional and custom antenna solutions with a new class of antenna boosters, delivered in the form of a new range of miniature and off-the-shelf chip antenna components. These new chip antennas are multiband and multipurpose. They fit in a variety of wireless platforms to provide a wireless link at many different communication services. By using a Virtual Antenna<sup>™</sup> component the design becomes more predictable compared to a custom solution, making the whole process **faster, cost effective and easier.**

## 2. PERFORMANCE vs EVALUATION BOARD SIZE

### 2.1. EVALUATION BOARD

The performance of the ONE mXTEND<sup>™</sup> antenna booster operating in the Wi-Fi 6E frequency bands is measured in different EBs featured by different sizes. This application note is intended to illustrate on one hand, how the antenna performance varies according to the ground plane length of any printed circuit board (PCB), and on the other hand, how our ONE mXTEND<sup>™</sup> antenna booster can be easily adapted to the different scenarios by simply adjusting the matching network design. The antenna part remains the same and the operating frequencies can be easily tuned by only properly adjusting the matching network. The following results cover a wide scope of EB sizes (length and width), ranging from 200mm x 200mm down to 86mm x 54mm (Figure 1), representatives of routers, gateways, smartphones, and small tracker or IOT devices.



| Measure | mm       | Measure | mm   |
|---------|----------|---------|------|
| A       | 200 – 86 | F       | 15   |
| B       | 200 – 54 | G       | 2.3  |
| C       | 195 – 81 | H       | 1.65 |
| D       | 2.0      | I       | 3.0  |
| E       | 5.0      | J       | 6.3  |

**Tolerance:** ±0.2 mm

**D:** Distance between the ONE mXTEND<sup>™</sup> antenna booster and the ground plane.

**Material:** The evaluation board is built on FR4 substrate. Thickness is 1 mm.

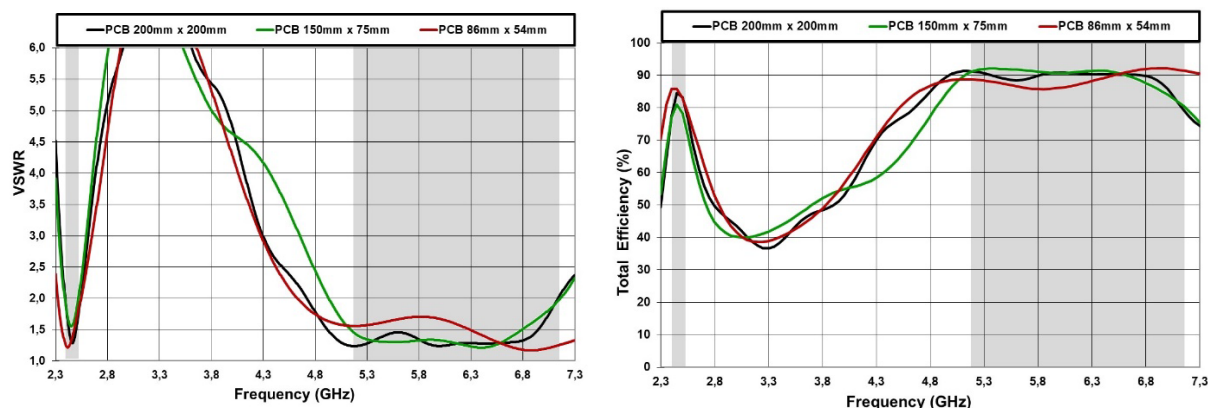
**Clearance Area:** 15 mm x 5.0 mm (FxEx) (indicated in dashed red line)

**Figure 1** – Evaluation boards with different form factors and different ground plane lengths. Detailed image of the ONE mXTEND<sup>™</sup> antenna booster placed in the top right corner of the different sized EBs (left) and its footprint (right).

Please note that the ONE mXTEND™ is a versatile antenna solution that is able to cover other frequency ranges besides those covered in this document. If your device is to operate in any other band, please contact to [support@ignion.io](mailto:support@ignion.io) for assistance. We are here to help.

## 2.2. VSWR AND EFFICIENCY

This section explains the antenna performance in terms of VSWR (Voltage Standing Wave Ratio) and Total Efficiency results versus frequency (GHz) for the Wi-Fi 6E frequency bands.



**Figure 2** – VSWR and Total Efficiency for the 2.400 – 2.500 GHz frequency range and for the 5.170 – 7.125 GHz frequency range considering the different EB sizes (Figure 1).

| 2.400 – 2.500GHz |                  |                  |      |      |              |
|------------------|------------------|------------------|------|------|--------------|
| B x C (mm)       | $\eta_a$ 2400MHz | $\eta_a$ 2500MHz | Min  | Max  | Av. $\eta_a$ |
| 200 x 200        | 77.6             | 83.3             | 77.6 | 84.6 | 81.8         |
| 150 x 75         | 77.2             | 78.3             | 77.2 | 81.8 | 78.9         |
| 86 x 54          | 85.8             | 83.0             | 83.0 | 85.9 | 84.9         |

**Table 1** – Antenna efficiency comparison considering the different EB sizes for 2.400 – 2.500GHz frequency range (Figure 1).

| B x C (mm) | 5.170 – 5.835GHz |                  |      |      |              | 5.925 – 7.125GHz |                  |      |      |              |
|------------|------------------|------------------|------|------|--------------|------------------|------------------|------|------|--------------|
|            | $\eta_a$ 5170MHz | $\eta_a$ 5835MHz | Min  | Max  | Av. $\eta_a$ | $\eta_a$ 5925MHz | $\eta_a$ 7125MHz | Min  | Max  | Av. $\eta_a$ |
| 200 x 200  | 91.3             | 90.3             | 88.5 | 91.3 | 89.7         | 90.6             | 79.3             | 79.3 | 90.9 | 89.0         |
| 150 x 75   | 90.7             | 91.0             | 90.7 | 92.1 | 91.6         | 90.9             | 80.5             | 80.5 | 91.5 | 88.7         |
| 86 x 54    | 88.8             | 85.8             | 85.8 | 88.8 | 87.3         | 85.8             | 91.5             | 85.8 | 92.2 | 89.6         |

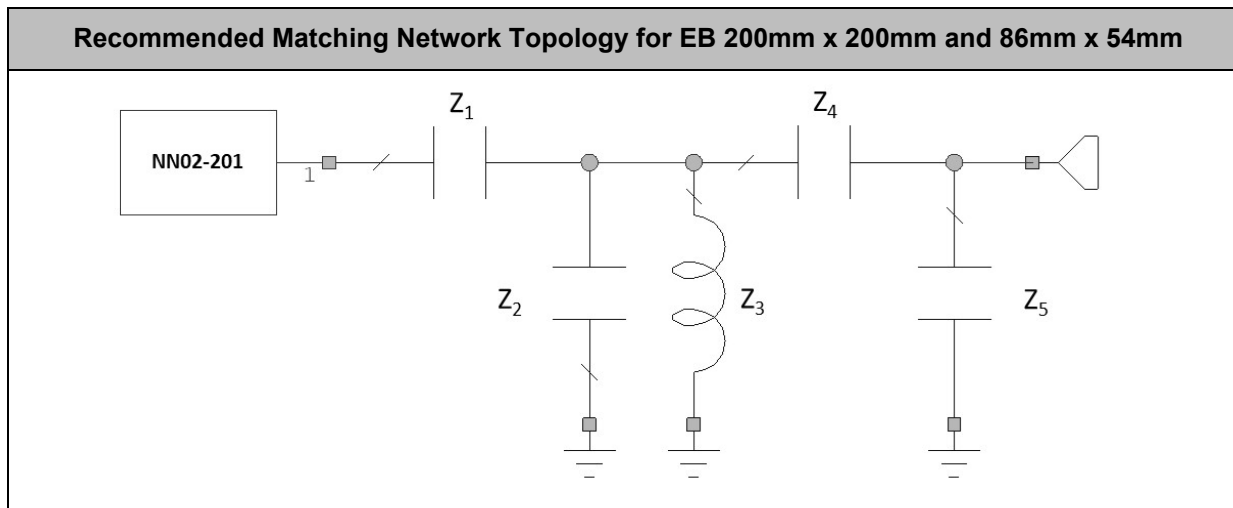
**Table 2** - Antenna efficiency comparison considering the different EB sizes for 5.170 - 5.835GHz and 5.925 – 7.125GHz frequency ranges (Figure 1).

ONE mXTEND™ operates the required Wi-Fi 6E frequency spectrum with high efficiency values. Please note that its performance can be maintained high across different sized EBs by simply adjusting the matching network design.

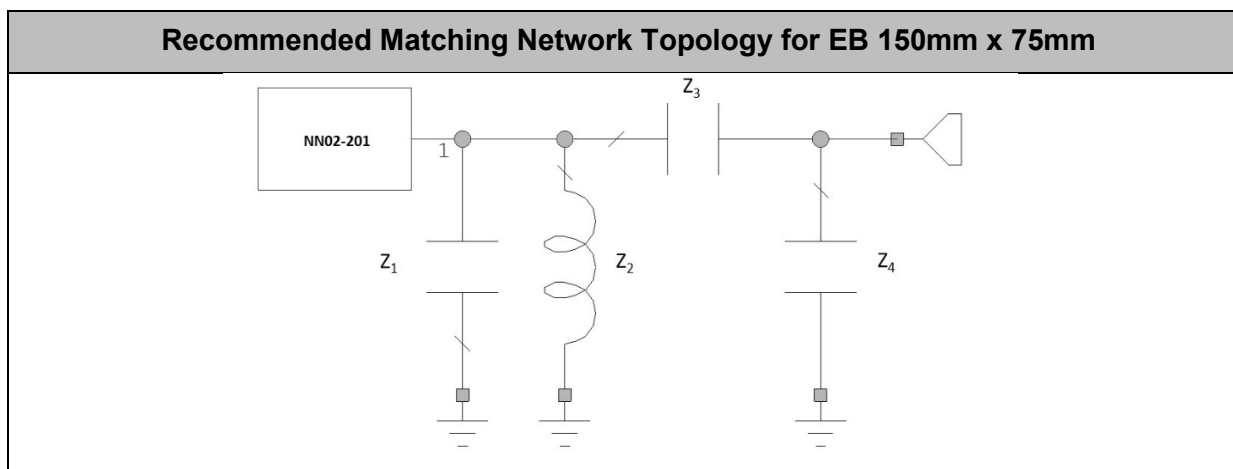
## 2.3. MATCHING NETWORK

The ONE mXTEND<sup>™</sup> antenna booster needs a matching network to connect to your Wi-Fi 6E transceiver. This section describes the recommended matching network topologies and values (Figure 3, Figure 4, Table 3 and Table 4) for the different sized EBs (Figure 1).

Thanks to its versatility the ONE mXTEND<sup>™</sup> antenna booster can be easily tuned to cover Wi-Fi 6E spectrum in different sized platforms through just the proper adjustment of the matching network. The excellent tuning capabilities of the ONE mXTEND<sup>™</sup> makes it ideal to avoid unnecessary product redesigns each time your product specifications and operating frequencies vary. It allows you to easily adapt your design to different applications, market segments, and devices through just the proper design of the matching network by maintaining the same antenna part.



**Figure 3** – Topology of the matching network mounted at the solutions: 200mm x 200mm and 86mm x 54mm (Figure 1).



**Figure 4** - Topology of the matching network mounted at the solution: 150mm x 75mm (Figure 1).

The matching network topology (Figure 3) remains equal for the cases 200mm x 200mm and 86mm x 54mm and just the values of the matching network components must be adjusted to tune the antenna performance to the required operating frequency bands. A different matching network topology is recommended for the 150mm x 75mm case (Figure 4). The recommended matching network component values for operating the Wi-Fi 6E standards ranging from 2400 – 2500MHz and 5170 – 7125 MHz are shown in Table 3 and Table 4.

| A x B (mm)    | Z <sub>1</sub> | Z <sub>2</sub> | Z <sub>3</sub> | Z <sub>4</sub> | Z <sub>5</sub> |
|---------------|----------------|----------------|----------------|----------------|----------------|
| 200mm x 200mm | 4.0pF          | 0.3pF          | 2.3nH          | 0.4pF          | 0.3pF          |
| 150mm x 75mm  | 0.3pF          | 2.6nH          | 0.4pF          | 0.3pF          | -              |
| 86mm x 54mm   | 2.4pF          | 0.2pF          | 2.7nH          | 0.4pF          | 0.2pF          |

**Table 3** - Values of the matching network components for the different EB sizes (Figure 1).

| Value |       | Part Number       |
|-------|-------|-------------------|
| Z1    | 4.0pF | GJM1555C1H4R0WB01 |
|       | 0.3pF | GJM1555C1HR30WB01 |
|       | 2.4pF | GJM1555C1H2R4WB01 |
| Z2    | 0.3pF | GJM1555C1HR30WB01 |
|       | 2.6nH | LQW15AN2N6G80     |
|       | 0.2pF | GJM1555C1HR20WB01 |
| Z3    | 2.3nH | LQW15AN2N3G80     |
|       | 0.4pF | GJM1555C1HR40WB01 |
|       | 2.7nH | LQW15AN2N7G80     |
| Z4    | 0.4pF | GJM1555C1HR40WB01 |
|       | 0.3pF | GJM1555C1HR30WB01 |
|       | 0.4pF | GJM1555C1HR40WB01 |
| Z5    | 0.3pF | GJM1555C1HR30WB01 |
|       | 0.2pF | GJM1555C1HR20WB01 |

**Table 4** - Values and part numbers of the components used for the matching networks for the different EB sizes.

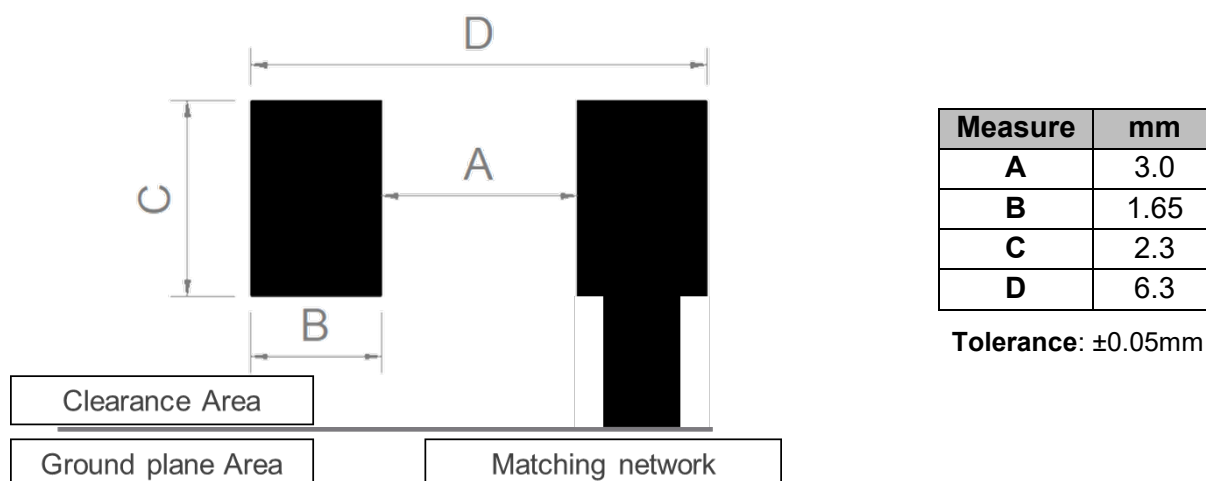
The antenna performance is always conditioned by its operating environment. Different devices with different printed circuit board sizes, components nearby the antenna, LCD's, batteries, covers, connectors, etc. may need a different matching network. Accordingly, it is highly recommended placing pads compatible with 0402 and 0603 SMD components for a matching network as close as possible to the feeding point of the antenna element in the ground plane area, not in the clearance area. This provides a degree of freedom to tune the ONE mXTEND™ antenna booster once the design is finished and takes into account all elements of the system (batteries, displays, covers, etc.). To ensure optimal results, the use of high-quality factor (Q) and tight tolerance components is highly recommended (e.g. Murata components (Table 3 and Table 4)).



If you need assistance to design your matching network beyond this application note, please contact [support@ignion.io](mailto:support@ignion.io), or if you are designing a **different device size** or a **different frequency band**, we can assist you in less than 24 hours. Please, try our free-of-charge<sup>1</sup> [Antenna Intelligence Cloud](#), which will get you a complete design report including a custom matching network for your device in 24h<sup>1</sup>. Additional information related to NN's range of R&D services is available at: <https://ignion.io/rdservices/>

## 2.4. RECOMMENDED ANTENNA FOOTPRINT FOR NN02-201

The ONE mXTEND<sup>™</sup> antenna booster (NN02-201) must be placed as close as possible to a corner of the PCB. See below the recommended footprint dimensions when it is placed close to a corner of the PCB with the feeding line aligned with the longest side of the board according to the Evaluation Board (Figure 1).

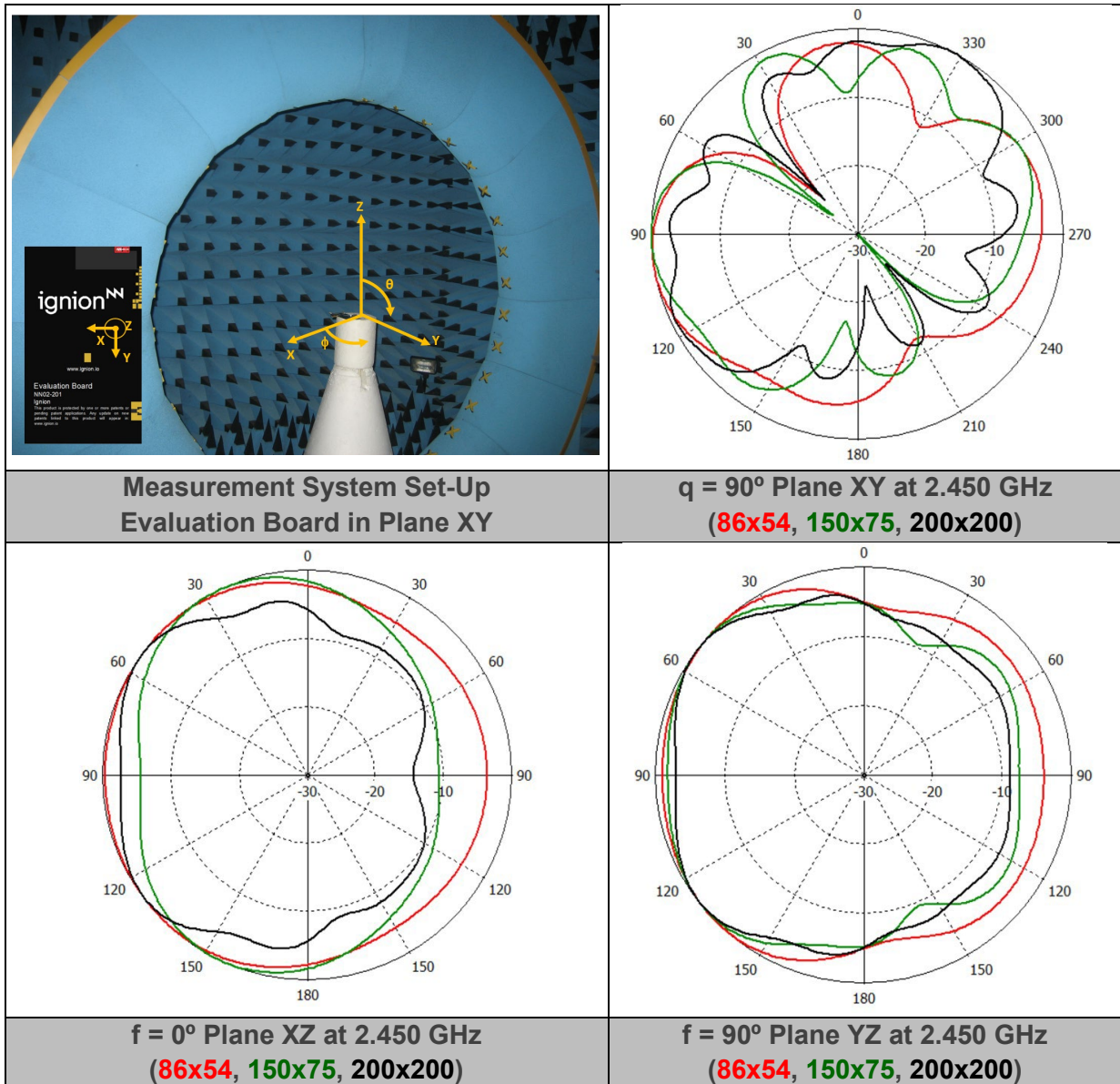


**Figure 5** - Footprint dimensions for the ONE mXTEND<sup>™</sup> (NN02-201) antenna booster.

<sup>1</sup> See terms and conditions for a free Antenna Intelligence Cloud service in 24h at: <https://www.ignion.io/antenna-intelligence/>

## 2.5. RADIATION PATTERNS (2.400 - 2.500 GHz), GAIN, AND EFFICIENCY

This section describes the different radiation patterns, gain and efficiency of the ONE mXTEND<sup>™</sup> antenna booster depending on the different evaluation board sizes.



|                                       |            |  |                  |
|---------------------------------------|------------|--|------------------|
| LFR<br>Wi-Fi 6E<br>2.400-<br>2.500GHz | Gain       | Peak Gain <small>(86x54)</small>                                   | 3.2 dBi          |
|                                       |            | Average Gain across the band <small>(86x54)</small>                | 3.2 dBi          |
|                                       |            | Gain Range across the band (min, max) <small>(86x54)</small>       | 3.1 <--> 3.2 dBi |
|                                       | Efficiency | Peak Efficiency <small>(86x54)</small>                             | 85.9 %           |
|                                       |            | Average Efficiency across the band <small>(86x54)</small>          | 84.9 %           |
|                                       |            | Efficiency Range across the band (min, max) <small>(86x54)</small> | 83.0 – 85.9 %    |

**Table 5** - Antenna gain and total efficiency from the Evaluation Board of 86mm x 54mm (Figure 3) for 2.400GHz – 2.500GHz with the matching network of Figure 3. Simulated results obtained with CST.

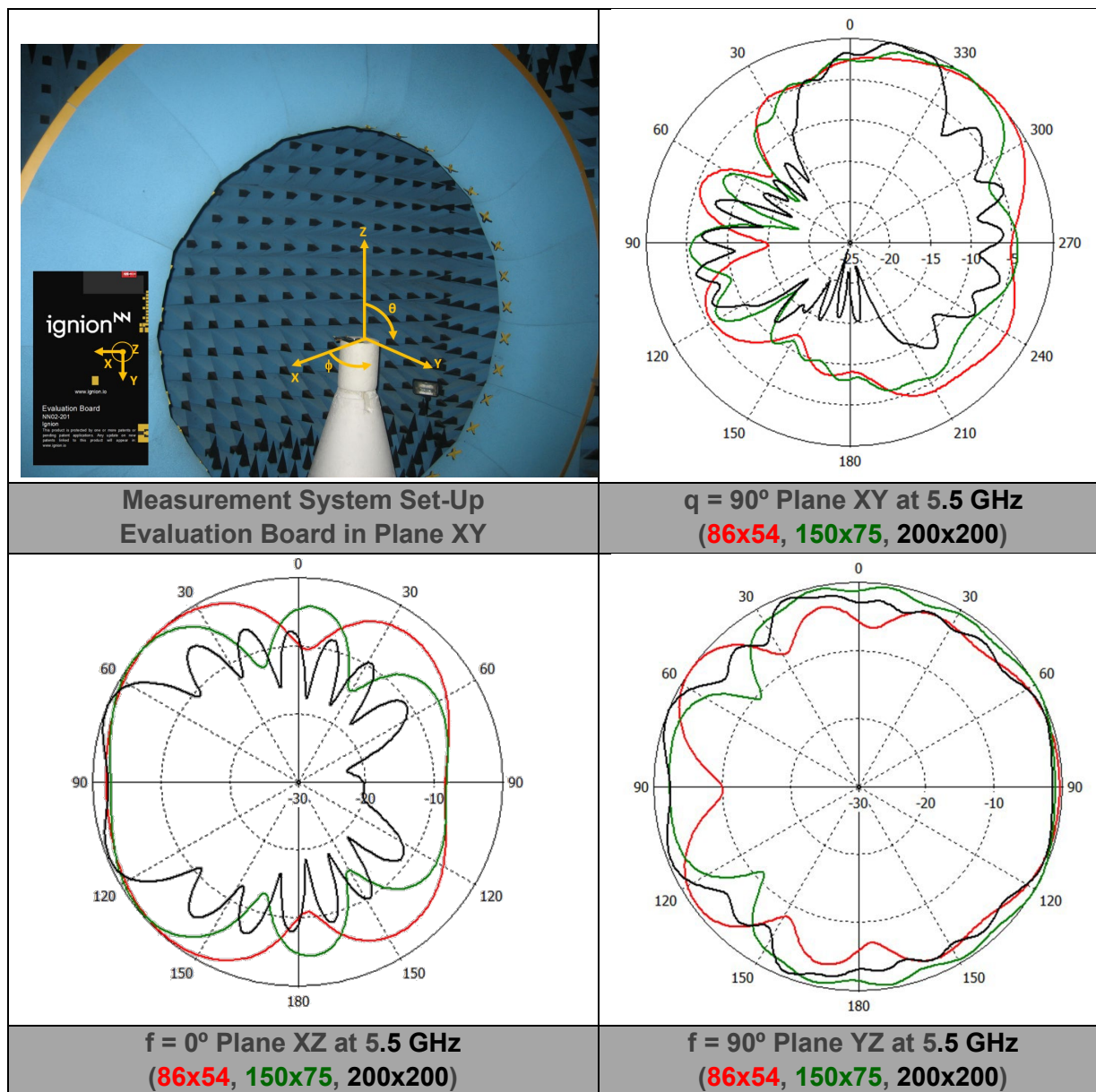
|                                      |            |   |                  |
|--------------------------------------|------------|---|------------------|
| LFR<br>WiFi 6E<br>2.400-<br>2.500GHz | Gain       | Peak Gain <small>(150x75)</small>                                   | 4.1 dBi          |
|                                      |            | Average Gain across the band <small>(150x75)</small>                | 4.0 dBi          |
|                                      |            | Gain Range across the band (min, max) <small>(150x75)</small>       | 3.8 <--> 4.1 dBi |
|                                      | Efficiency | Peak Efficiency <small>(150x75)</small>                             | 81.1 %           |
|                                      |            | Average Efficiency across the band <small>(150x75)</small>          | 78.9 %           |
|                                      |            | Efficiency Range across the band (min, max) <small>(150x75)</small> | 77.2 – 81.1 %    |

**Table 6** - Antenna gain and total efficiency from the Evaluation Board of 150mm x 75mm (Figure 4) for 2.400GHz – 2.500GHz with the matching network of Figure 4. Simulated results obtained with CST.

|                                       |            |  |                  |
|---------------------------------------|------------|--|------------------|
| LFR<br>Wi-Fi 6E<br>2.400-<br>2.500GHz | Gain       | Peak Gain <small>(200x200)</small>                                   | 5.2 dBi          |
|                                       |            | Average Gain across the band <small>(200x200)</small>                | 5.1 dBi          |
|                                       |            | Gain Range across the band (min, max) <small>(200x200)</small>       | 4.8 <--> 5.2 dBi |
|                                       | Efficiency | Peak Efficiency <small>(200x200)</small>                             | 84.6 %           |
|                                       |            | Average Efficiency across the band <small>(200x200)</small>          | 81.8 %           |
|                                       |            | Efficiency Range across the band (min, max) <small>(200x200)</small> | 77.6 – 84.6 %    |

**Table 7** – Antenna gain and total efficiency from the Evaluation Board of 200mm x 200mm (Figure 3) for 2.400GHz – 2.500GHz with the matching network of Figure 3. Simulated results obtained with CST.

## 2.6. RADIATION PATTERNS (5.170 - 5.835 GHz), GAIN, AND EFFICIENCY



|   |                   |   |             |
|---|-------------------|---|-------------|
| <b>HFR</b><br><b>Wi-Fi 6E</b><br><b>5.170-</b><br><b>5.835GHz</b> | <b>Gain</b>       | <b>Peak Gain</b> <sup>(86x54)</sup>                                   | 3.3         |
|   |                   | <b>Average Gain across the band</b> <sup>(86x54)</sup>                | 3.1         |
|   |                   | <b>Gain Range across the band (min, max)</b> <sup>(86x54)</sup>       | 2.9 – 3.3   |
|   | <b>Efficiency</b> | <b>Peak Efficiency</b> <sup>(86x54)</sup>                             | 88.8        |
|   |                   | <b>Average Efficiency across the band</b> <sup>(86x54)</sup>          | 87.3        |
|   |                   | <b>Efficiency Range across the band (min, max)</b> <sup>(86x54)</sup> | 85.8 – 88.8 |

**Table 8** - Antenna gain and total efficiency from the Evaluation Board of 86mm x 54mm (Figure 3) for 5.170GHz – 5.835GHz with the matching network of Figure 3. Simulated results obtained with CST.

|   |                   |  |             |
|---|-------------------|--|-------------|
| <b>HFR<br/>Wi-Fi 6E<br/>5.170-<br/>5.835GHz</b> | <b>Gain</b>       | <b>Peak Gain</b> <small>(150x75)</small>                                   | 5.1         |
|   |                   | <b>Average Gain across the band</b> <small>(150x75)</small>                | 5.0         |
|   |                   | <b>Gain Range across the band (min, max)</b> <small>(150x75)</small>       | 4.7 – 5.1   |
|   | <b>Efficiency</b> | <b>Peak Efficiency</b> <small>(150x75)</small>                             | 92.1        |
|   |                   | <b>Average Efficiency across the band</b> <small>(150x75)</small>          | 91.6        |
|   |                   | <b>Efficiency Range across the band (min, max)</b> <small>(150x75)</small> | 90.7 – 92.1 |

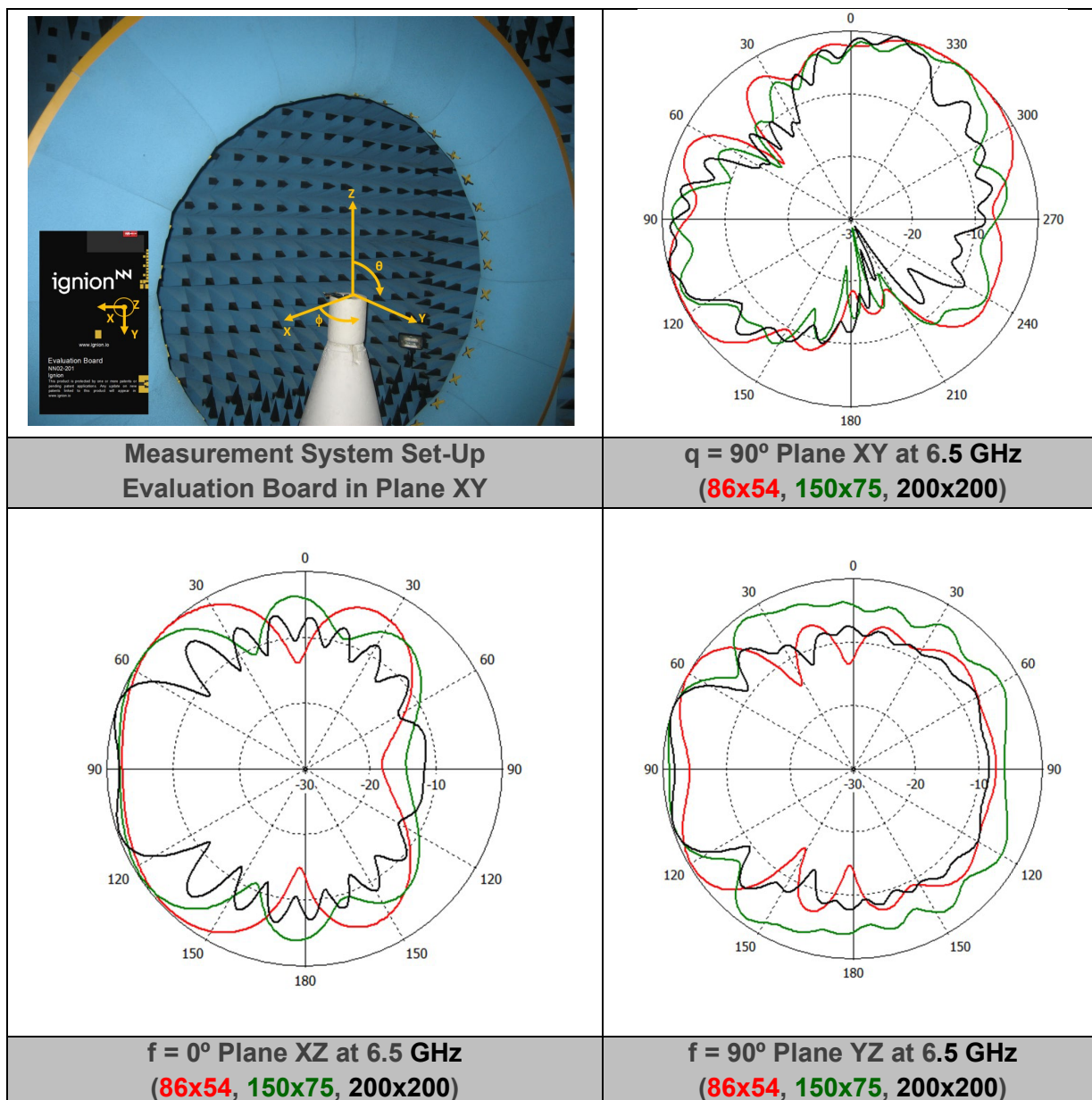
**Table 9** - Antenna gain and total efficiency from the Evaluation Board of 150mm x75mm (Figure 4 for 5.170GHz – 5.835GHz with the matching network of Figure 4. Simulated results obtained with CST.

|   |                   |   |             |
|---|-------------------|---|-------------|
| <b>HFR<br/>Wi-Fi 6E<br/>5.170-<br/>5.835GHz</b> | <b>Gain</b>       | <b>Peak Gain</b> <small>(200x200)</small>                                   | 7.8         |
|   |                   | <b>Average Gain across the band</b> <small>(200x200)</small>                | 7.5         |
|   |                   | <b>Gain Range across the band (min, max)</b> <small>(200x200)</small>       | 7.3 – 7.8   |
|   | <b>Efficiency</b> | <b>Peak Efficiency</b> <small>(200x200)</small>                             | 91.3        |
|   |                   | <b>Average Efficiency across the band</b> <small>(200x200)</small>          | 89.7        |
|   |                   | <b>Efficiency Range across the band (min, max)</b> <small>(200x200)</small> | 88.5 – 91.3 |

**Table 10** - Antenna gain and total efficiency from the Evaluation Board of 200mm x200mm (Figure 3) for 5.170GHz – 5.835GHz with the matching network of Figure 3. Simulated results obtained with CST.



## 2.7. RADIATION PATTERNS (5.925 - 7.125 GHz), GAIN, AND EFFICIENCY



|   |                   |  |             |
|---|-------------------|--|-------------|
| <b>HFR<br/>Wi-Fi 6E<br/>5.925-<br/>7.125GHz</b> | <b>Gain</b>       | <b>Peak Gain</b> (86x54)                                   | 5.0         |
|   |                   | <b>Average Gain across the band</b> (86x54)                | 4.3         |
|   |                   | <b>Gain Range across the band (min, max)</b> (86x54)       | 2.9 – 5.0   |
|   | <b>Efficiency</b> | <b>Peak Efficiency</b> (86x54)                             | 92.2        |
|   |                   | <b>Average Efficiency across the band</b> (86x54)          | 89.6        |
|   |                   | <b>Efficiency Range across the band (min, max)</b> (86x54) | 85.8 – 92.2 |

**Table 11** - Antenna gain and total efficiency from the Evaluation Board of 86mm x 54mm (Figure 3) for 5.925GHz – 7.125GHz with the matching network of Figure 3. Simulated results obtained with CST.

|   |                   |  |             |
|---|-------------------|--|-------------|
| <b>HFR<br/>Wi-Fi 6E<br/>5.925-<br/>7.125GHz</b> | <b>Gain</b>       | <b>Peak Gain</b> <small>(150x75)</small>                                   | 4.8         |
|   |                   | <b>Average Gain across the band</b> <small>(150x75)</small>                | 4.5         |
|   |                   | <b>Gain Range across the band (min, max)</b> <small>(150x75)</small>       | 4.2 – 4.8   |
|   | <b>Efficiency</b> | <b>Peak Efficiency</b> <small>(150x75)</small>                             | 91.5        |
|   |                   | <b>Average Efficiency across the band</b> <small>(150x75)</small>          | 88.7        |
|   |                   | <b>Efficiency Range across the band (min, max)</b> <small>(150x75)</small> | 80.5 – 91.5 |

**Table 12** - Antenna gain and total efficiency from the Evaluation Board of 150mm x 75mm (Figure 4) for 5.925GHz – 7.125GHz with the matching network of Figure 4. Simulated results obtained with CST.

|   |                   |   |             |
|---|-------------------|---|-------------|
| <b>HFR<br/>Wi-Fi 6E<br/>5.925-<br/>7.125GHz</b> | <b>Gain</b>       | <b>Peak Gain</b> <small>(200x200)</small>                                   | 7.3         |
|   |                   | <b>Average Gain across the band</b> <small>(200x200)</small>                | 6.7         |
|   |                   | <b>Gain Range across the band (min, max)</b> <small>(200x200)</small>       | 6.5 – 7.3   |
|   | <b>Efficiency</b> | <b>Peak Efficiency</b> <small>(200x200)</small>                             | 90.9        |
|   |                   | <b>Average Efficiency across the band</b> <small>(200x200)</small>          | 89.0        |
|   |                   | <b>Efficiency Range across the band (min, max)</b> <small>(200x200)</small> | 79.3 – 90.9 |

**Table 13** – Antenna gain and total efficiency from the Evaluation Board of 200mm x 200mm (Figure 3) for 5.925GHz – 7.125GHz with the matching network of Figure 3. Simulated results obtained with CST.

**Do you need more help with your antenna for your device?**

Use our **Antenna Intelligence Cloud service** and get your ready-to-test antenna design especially simulated for your platform **free of charge**<sup>1</sup>, and in **24 hours**.

<https://www.ignion.io/antenna-intelligence/>

The ONE mXTEND<sup>™</sup> antenna booster and other Ignion products are based upon proprietary Virtual Antenna<sup>™</sup> technology that are protected by one or more of the following <https://ignion.io/files/Patent-list-NN.pdf>

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Ignion is an ISO 9001:2015 certified company. All our antennas are lead-free and RoHS and REACH compliant.

ISO 9001: 2015 Certified





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