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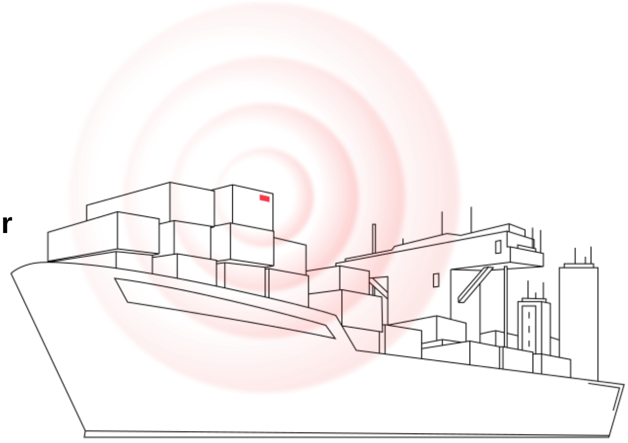
# Asset Tracking Design Guide

STEP BY STEP GUIDE TO INTEGRATE AND OPTIMIZE THE ANTENNA IN YOUR TRACKER.

# ASSET TRACKING DESIGN GUIDE

## ENSURING RELIABLE ANTENNA PERFORMANCE IN YOUR ASSET TRACKER.



**Why is Virtual Antenna® technology your best choice for asset tracking devices?**

- Worldwide coverage with one component.
- High performance enables efficient power consumption and long battery life.
- Small form factor easy to embed into any tracker design.
- Accurate location positioning regardless of the tracker's location or mounting orientation through omnidirectional radiation.

**What is in this Design Guide?**

- Recommended antenna design steps for a typical asset tracking device using cellular IoT and GNSS with examples from simulation, prototype RF laboratory measurements and pre-certification verification of final device.
- Total antenna efficiency impact by PCB size, clearance area and materials in proximity.
- Time to first fix (TTFF) dependency on environment.

**Frequency band configurations used in this design guide:**

- TRIO mXTEND™ is configured for cellular bands operation (typical LTE-M/NB-IoT):
  - 698 - 960 MHz and 1710 - 2200 MHz.
- DUO mXTEND™ for GNNS operation (BeiDou, GPS & Galileo, GLONASS)
  - 1561 - 1606 MHz.

*We know every design is different and unique, to evaluate performance in other frequency and PCB size combinations please use our free digital tool **Antenna Intelligence Cloud™:** https://ignion.io/antenna-intelligence/

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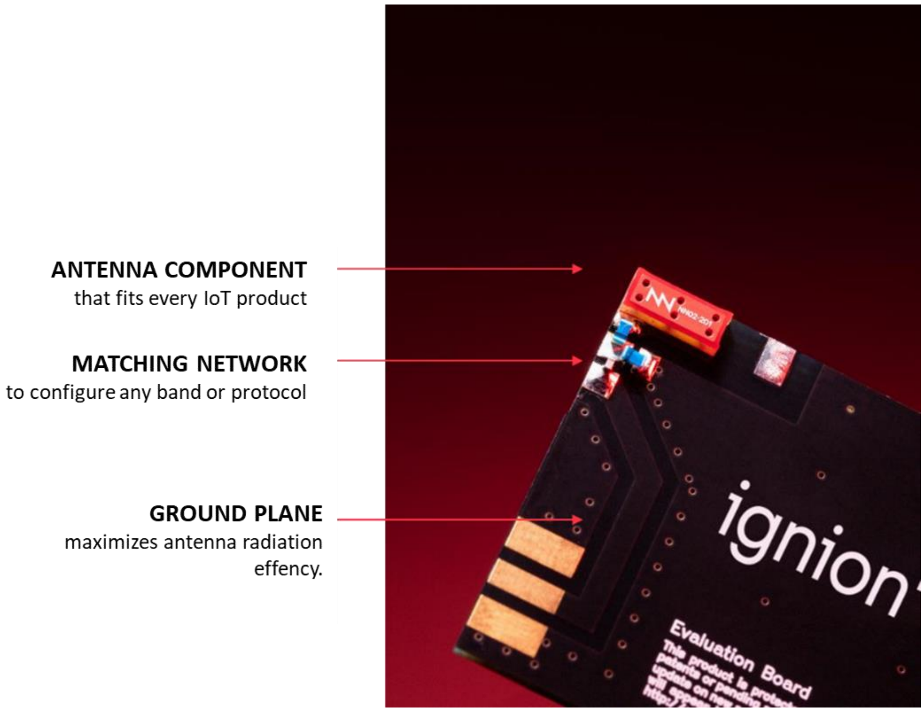
# 1. ASSET TRACKING DESIGN JOURNEY WITH VIRTUAL ANTENNA®

## 1.1. VIRTUAL ANTENNA® TECHNOLOGY

The Virtual Antenna® technology is the smallest and most versatile antenna option available, delivering robust high performance.

The Virtual Antenna® technology consists of 3 main elements:




**Antenna component**: The Virtual Antenna® component is a small, wideband and/or multiband antenna component, also called antenna booster. This non-resonant component is mounted directly on the printed circuit board (PCB) and its role is to maximize the transfer of power from the radio frequency module to the ground plane, and vice versa. This unique capability enables the Virtual Antenna® components to support a frequency range from 698 MHz to 10 000 MHz.

**Matching network:** A series of small low-cost capacitors and inductors placed between radio and antenna component to select required frequencies of operation and maximize RF energy transfer. For any Virtual Antenna® configuration, the matching network is the only component that needs to be modified to change the desired frequencies.

**Ground plane:** Virtual Antenna® component achieves resonance through the combination of the matching network and the PCB ground plane and transmits/receives radio waves for communication through the ground plane. The ground plane dimensions have a direct influence on RF performance.

## 1.2. SIMPLE DESIGN STEPS WITH VIRTUAL ANTENNA® TECHNOLOGY

All the steps in this design guide can be done by any IoT device designer or hardware engineer with the right tools. Additionally, the Virtual Antenna® technology is backed by Ignion customer services where an experienced technical team is ready to assist in all stages of the design.


**Figure 1 –** Virtual Antenna® design journey steps for a successful IoT solution.

**Step 1 - Assess Feasibility (free Ignion service)**: Through the Antenna Intelligence Cloud™ the developer is provided with tailored guidance and digital prototype performance results, including S-parameters, total efficiency, and design recommendations such as antenna placement and clearance area in a bare PCB. In addition, the tailored antenna design files are provided to simply be imported into the PCB design tool.
By using the Antenna Intelligence Cloud™ from the beginning, designers will know if their designs are going to meet their antenna specifications before building any physical hardware and if not apply the design changes needed to achieve them. In this way, designers can take go- or no-go decisions in the early stages of the design cycle minimizing cost, risks, and time to market. Often changes in either antenna component placement, clearance area size or PCB dimensions can easily solve performance issues, that later will be difficult to adjust as the design hardens.

**Step 2 - Build Gerber files**: Building the PCB design files (Gerbers) with optimal antenna performance from the get-go is easy due to the tailored templates automatically provided by Antenna Intelligence Cloud™ along with the tailored design recommendations.

**Step 3 - EM simulation**: Design file validation with an Electro-Magnetic (EM) simulation of the full device considering every component influencing RF performance such as objects in close proximity to the antenna (on board components, batteries, casing etc.) and ensuring RF performance requirements are met. The simulation allows the designer to evaluate potential design changes/requests and their impact on the antenna performance.

**Step 4 - Final Gerber sanity checks (free Ignion service)**: Before initiating the physical prototype production a fast (and free) check is done ensuring that the antenna, matching network layout and key design recommendations are correctly followed. A quick extra set of experienced eyes can catch mistakes and save an extra prototype iteration. The Gerber file is simply sent to the Ignion team which will respond with a short Gerber review report.

**Step 5 - Produce prototype, test and fine-tune**: Verifying that prototype performance results are aligned with expectations, fine-tune if necessary. If needed, a VNA (Vector Network Analyzer) is used to verify the resonance frequency/S1 parameters of the antenna system, and simple adjustments in the matching network values can be done.

**Step 6 - Certification pre-test**: Performing over-the-air (OTA) tests with the antenna system and radio module to ensure the device is meeting certification requirements.

## 1.3. ANTENNA COMPONENTS SELECTED AND DESIGN SPECS

The following Virtual antenna® components are popular in asset tracking systems due to their reliable performance and accurate positioning. The TRIO mXTEND™ (NN03-310) provides cellular connectivity for data transmission, while the DUO mXTEND™ (NN03-320) receives GNSS satellite signals for precise location determination. By utilizing separate antennas optimized for each technology, the performance is maximized while interference is minimized, resulting in a robust tracking system.

Note: it is also possible to cover the cellular and GNSS bands in a single antenna component, but performance will not be optimal.

**TRIO mXTEND™ (NN03-310)**
Component dimensions: 30.0 x 3.0 x 1.0 mm
Can be configured for: 698 – 8000 MHz.
More info.

**DUO mXTEND™ (NN03-320)**
Component dimensions: 7.0 x 3.0 x 2.0 mm
Can be configured for: 1500 – 10600 MHz.
More info.

Virtual Antenna® components and evaluation board features:

- All Virtual Antenna® solutions are linearly polarized and have omnidirectional radiation patterns.
- The manufactured evaluation boards withstand temperatures from -40 to + 125 ºC.
- Impedance: 50Ω.

The design used in this document has the following specs:

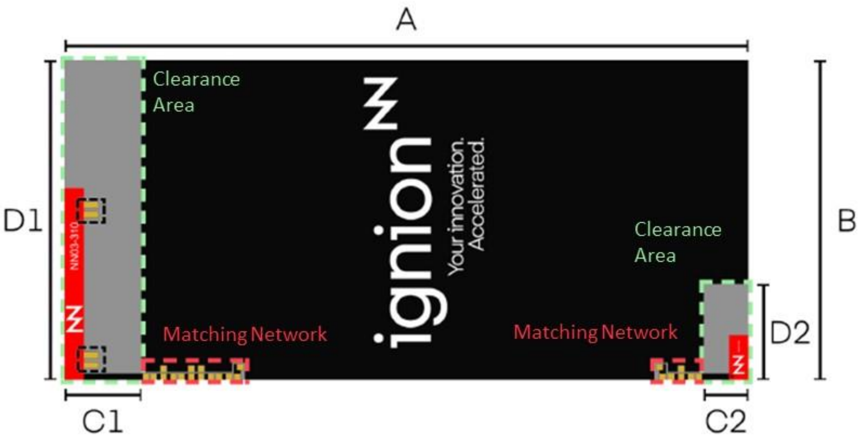
- PCB size of 107 mm x 50 mm (common form factor used in asset trackers)
- Clearance area 12 mm x 50 mm (minimum area to achieve maximum performance in NB-IoT and LTE/CAT-M).
- Covered bands:
    - **Cellular IoT bands:**
        - 698 MHz to 960 MHz: Band 5, 8, 12, 13, 20, 26, 28.
        - 1710 MHz to 2200 MHz: Band 2, 3, 4, 66.
    - **GNSS bands:**
        - 1561 MHz: BeiDou E1.
        - 1575 MHz: GPS L1.
        - 1598 MHz to 1606 MHz: GLONASS L1.

# 2. STEP BY STEP DETAILS AND EXAMPLES

## 2.1. STEP 1: FEASIBILITY – USING ANTENNA INTELLIGENCE CLOUD™

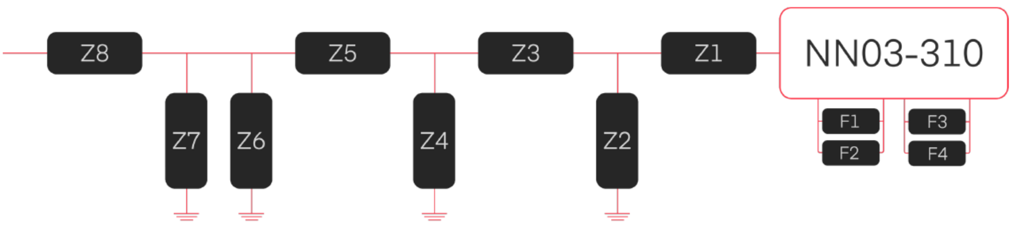
The feasibility evaluation starts with a simple and fast performance estimation on a bare PCB without any other components, casings, batteries, etc. These results are provided by Ignion's Antenna Intelligence Cloud™, a unique tool that delivers antenna performance results, suggested matching network topologies, and BoM (Bill of Materials). By simply filling in the on-line form and choosing the frequency band of operation and desired PCB size, the results are completed in minutes.

Below are the results extracted from the Antenna Intelligence Cloud™ submitted for this example project using a 107 mm x 50 mm size PCB board with operation in LTE/Cat-M and GNSS bands. The solution proposed uses two separate antenna components, TRIO mXTEND™ (NN03-310) for LTE/Cat-M and DUO mXTEND™ (NN03-320) for GNSS. The antenna components are separated to minimize the coupling and maximize the performance of both.




| PCB | | NN03-310 | | NN03-320 | |
|---|---|---|---|---|---|
| Measure | mm | Measure | mm | Measure | mm |
| A | 107.0 | C1 | 12.0 | C2 | 7.0 |
| B | 50.0 | D1 | 50.0 | D2 | 15.0 |

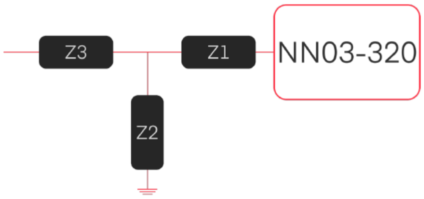
**Figure 2 –** PCB layout from the Antenna Intelligence Cloud™.delivering Cellular coverage with the TRIO mXTEND™ (NN03-310) and GNSS with the DUO mXTEND™ (NN03-320).



| Comm. Standard | Component | Value | Part Number |
|---|---|---|---|
| LTE-Cat M | F1 | 0.4pF | GJM1555C1HR40WB01 |
| | F2 | 15nH | LQW18AN15NG80 |
| | F3 | 0Ohm | |
| | F4 | 0Ohm | |
| | Z1 | 2.6nH | LQW15AN2N6G80 |
| | Z2 | 10nH | LQW18AN10NG80 |
| | Z3 | 1.7pF | GJM1555C1H1R7WB01 |
| | Z4 | 22nH | LQW18AN22NG80 |
| | Z5 | 3.3nH | LQW15AN3N3G80 |
| | Z6 | open | |
| | Z7 | 0.8pF | GJM1555C1HR80WB01 |
| | Z8 | 4.3nH | LQW18AN4N3G80 |

The electronic component values correspond with the Matching Network when implemented on a bare PCB. These values may need further tuning and optimization when additional elements such as batteries, plastic covers, connectors, displays, etc. are added to your final device.

**Figure 3 –** Matching network topology for LTE, and BoM from the Antenna Intelligence Cloud™.




| Comm. Standard | Component | Value | Part Number | Manufacturer |
|---|---|---|---|---|
| GNSS | Z1 | 11nH | LQW18AN11NG80 | Murata |
| | Z2 | 12nH | LQW18AN12NG80 | Murata |
| | Z3 | 9.5nH | LQW18AN9N5G80 | Murata |

**Figure 4** - Matching network topology for GNSS, and BoM from the Antenna Intelligence Cloud™

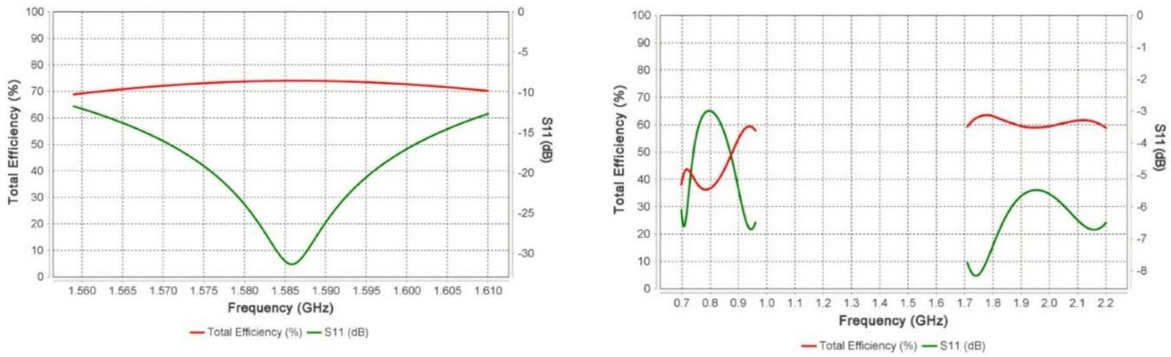



**Figure 5 –** Reflection Coefficient (dB) and Total Efficiency (%) from the Antenna Intelligence Cloud™ of TRIO mXTEND™ (NN03-310) and the DUO mXTEND™ (NN03-320).

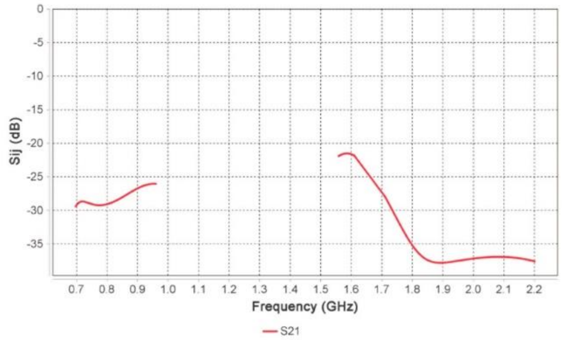



**Figure 6** – Coupling effect from the Antenna Intelligence Cloud™ between TRIO mXTEND™ (NN03-310) and the DUO mXTEND™ (NN03-320).

The results obtained for this first performance assessment show a good starting point on a bare PCB, covering the Cellular IoT bands from 698 MHz to 960 MHz and 1710 MHz to 2200 MHz and GNSS from 1561 MHz to 1606 MHz with results shown in Table 1 and Table 2 below.

| Tot. Eff (%) | 698MHz | 960MHz | 698 – 960MHz AVG | 1710MHz | 2200MHz | 1710 – 2200MHz AVG |
|---|---|---|---|---|---|---|
| **TRIO mXTEND™ (NN03-310)** | 38.1 | 58.1 | **49.2** | 59.2 | 59.8 | **63.1** |

**Table 1 -** Total efficiency simulated and measured for the LTE-M bands with the TRIO mXTEND™ (NN03-310) of a PCB of 107 mm x 50 mm (Figure 2).

| Tot. Eff (%) | 1561MHz | 1606MHz | 1561 – 1606MHz AVG |
|---|---|---|---|
| **DUO mXTEND™ (NN03-320)** | 69.0 | 70.1 | 71.2 |

**Table 2 -** Total efficiency simulated and measured for GNSS with the DUO mXTEND™ (NN03-320) of a PCB of 107 mm x 50 mm (Figure 2).

The Antenna Intelligence Cloud™ results enables evaluation of whether the antenna performance is able to meet the project expectations or if the solution needs some design adjustments. The results obtained can be utilized to assess the feasibility of meeting the Total Radiated Power (TRP) requirements set by the cellular operator. TRP requirements may differ depending on the network carrier and operational region. Employ Equation 1 described in section 2.6, to estimate the TRP based on the antenna's total efficiency and the output power of the RF module. Ensure that the calculated TRP exceeds the minimum TRP requirements specified by the cellular operator.

Configured for GNSS, one of the advantages of the DUO mXTEND™ component is its versatile placement options, allowing it to be positioned at any corner of the PCB or near the center of the long edge. This flexibility enables easy adaptation to hardware layout requirements while optimizing performance. In the case of separate modules for each wireless technology, the Antenna Intelligence Cloud™ recommends placing antennas in opposite corners as the preferred option. This selection is based on extensive analysis and ensures enhanced performance for NB-IoT, LTE/CAT-M, and GNSS.

The next step of the design journey is to perform electromagnetic simulations, but a few modifications are done first in this asset tracking example. The Antenna Intelligence Cloud™ recommended design assumes two separate RF modules and thus recommends placing the two antennas in separate corners. However, as many cellular IoT modules today provide cellular & GNSS in a single RF module the design is modified to make the layout more reasonable to connect the feeding lines to the two antennas with the same RF module. Additionally, for this particular scenario, the clearance area of NN03-310 is expanded from 12 x 50 mm to 16 x 50 mm (Figure 7). This increase in clearance area significantly enhances performance in NB-IoT and LTE/CAT-M, particularly in the low-frequency bands. Consequently, the BOM has been updated to reflect these changes, ensuring optimal antenna performance and overall total efficiency (Ignion's support team is always available to discuss your specific project needs further, after you have received your initial tailored design through the Antenna Intelligence Cloud™).

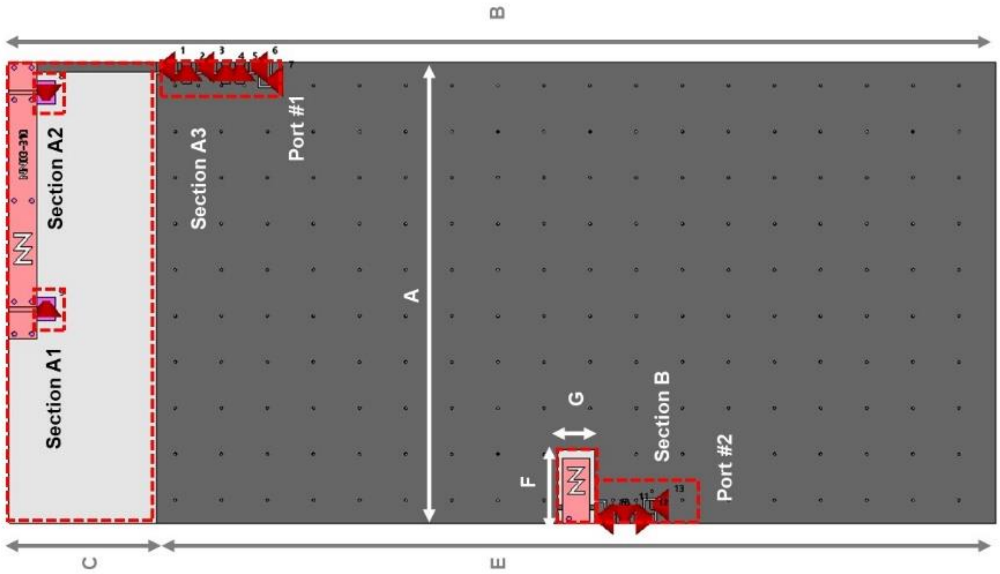
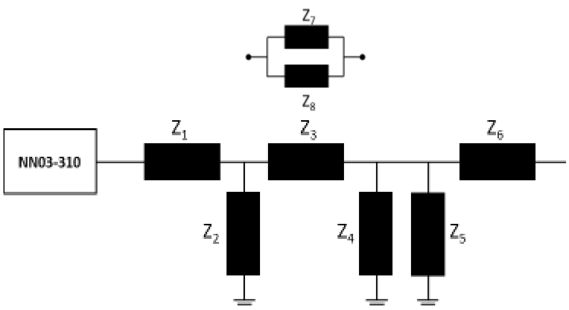
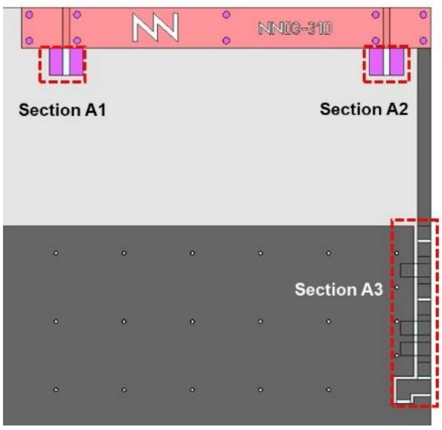



**Figure 7 -** PCB layout with increased clearance area around NN03-310.

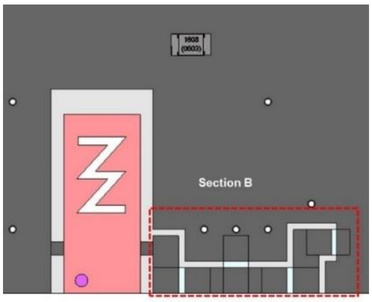



| Measure | mm |
|---|---|
| A | 50 |
| B | 107 |
| C | 16 |
| D | 13 |
| E | 91 |
| F | 8 |
| G | 4 |




| Components | | Part Numbers | Values |
|---|---|---|---|
| Section A1 | Open | - | 0Ω |
| Section A2 | Z7 | LQW18AN13NG80 | 13nH |
| | Z8 | GJM1555C1HR40WB01 | 0.4pF |
| Section A3 | Z1 | LQW15AN3N3G80 | 3.3nH |
| | Z2 | LQW18AN9N1G80 | 9.1nH |
| | Z3 | GJM1555C1H2R1WB01 | 2.1pF |
| | Z4 | GJM1555C1H1R3WB01 | 1.3pF |
| | Z5 | LQW18AN9N9G80 | 9.9nH |
| | Z6 | LQW15AN1N3C80 | 1.3nH |

**Figure 8** - BoM of TRIO mXTEND™ NN03-310 matching network for NB-IoT and LTE/CAT-M (698 – 960MHz and 1710 – 2200MHz).




| Components | | Part Numbers | Values |
|---|---|---|---|
| Section B | Z1 | GJM1555C1H1R1WB01 | 1.1pF |
| | Z2 | GJM1555C1H4R2WB01 | 4.2pF |
| | Z3 | - | 0Ω |

**Figure 9** - BoM of DUO mXTEND™ NN03-320 matching network for GNSS (1561 – 1606MHz).

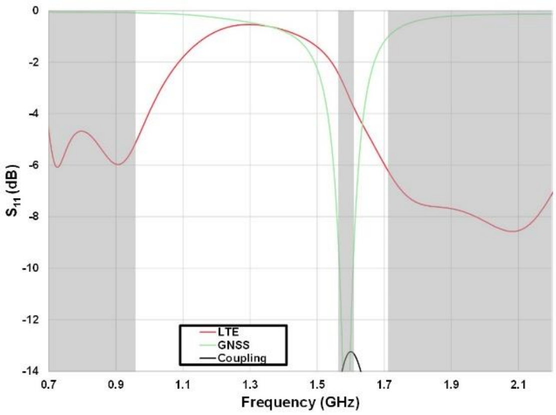



**Figure 10** – Simulated S-parameters of antennas TRIO mXTEND™ and DUO mXTEND™ of solution shown on Figure 7.

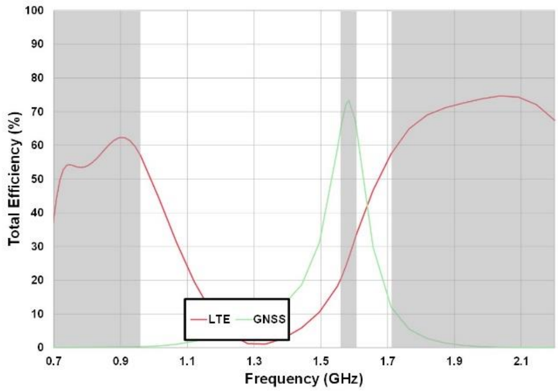



**Figure 11** – Simulated Total Efficiency of antennas TRIO mXTEND™ and DUO mXTEND™ of solution shown on Figure 7.

## 2.2. STEP 2: BUILD YOUR DESIGN FILE

When beginning to work on the device design, it is important to consider the design recommendations provided in the Antenna Intelligence Cloud™ report. Additionally, Virtual Antenna® components design files and tailored templates are provided. For additional resources, please refer to the accompanying files provided in each Antenna Intelligence Cloud™ submission, specifically tailored to address your specific requirements and needs.

To preserve the simulated antenna performance results in the physical prototype the following design recommendations should be followed.

1. **Antenna placement**: Place the antenna as far as possible from other components, such as LCDs, batteries, and connectors, especially those components and covers or housings with metallic characteristics (see suitable placement in Figure 2).

2. **Clearance area:** Keep the clearance area around the antenna component as recommended in Figure 2. The clearance area must be free from electronic components, traces and ground plane in all PCB layers including the underside of the PCB directly underneath the mounted antenna area. As general rule of thumb, the larger the clearance area the better the performance.

3. **PCB layers**: Ensure a continuous ground plane layer in at least one layer of your PCB design. Avoid any ground plane or conductive trace underneath the matching network pads area at a distance shorter than 1 mm from it.

4. **Matching network**: Arrange pads for all the matching networks to host 0402/0603 SMD components if possible. Place pads as close as possible to the antenna feed point and within the ground plane area to enable an effective tuning of the matching networks components throughout your design. Use **high Q and tight tolerance** matching network components.

5. **Transmission line and RF module**: Design your transmission line connecting the matching network to your RF module (see scheme connecting in Figure 3) so that its characteristic impedance is 50Ω. The output impedance of your RF module must be 50Ω as well. Locate your RF module as close as possible to the matching network to reduce the losses introduced by the transmission line.

## 2.3. STEP 3: PERFORM ELECTRO-MAGNETIC SIMULATIONS

In this step, comprehensive Electro-Magnetic (EM) simulations are performed on the entire device, considering all components, including batteries, casings, and other non-RF components. These simulations analyze the influence of these components on antenna performance. To access the necessary design information, you can download the design info pack from the Ignion website, which includes 2D files (such as .dxf and Gerber files), 3D files (such as .stp and CST files), and S-parameter files for Ignion products, including Virtual Antenna® components, Evaluation Boards, and other relevant information for electromagnetic simulations.

In this section, an electromagnetic simulation is presented as an example, focusing on a fully populated board measuring 107 mm x 50 mm. A comparison is made between the reflection coefficient and total efficiency of the fully populated board and the bare PCB simulated in the section before with the same dimensions. It is observed that the metallic components in contact with the PCB, such as the battery and casings, have an impact on the S11 parameter, subsequently affecting the efficiency. For optimal GNSS performance, slight retuning may be necessary due to the presence of components in proximity such as casings, and batteries.

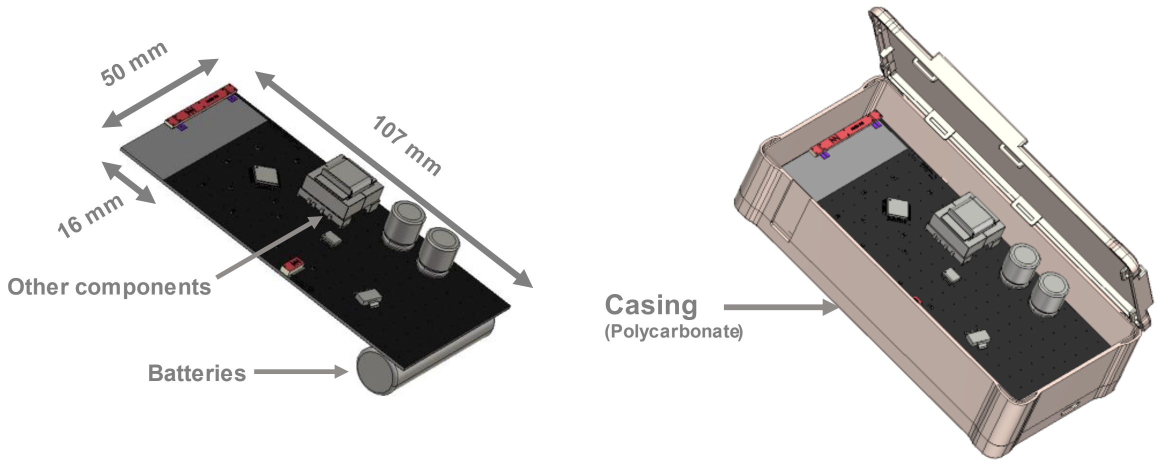
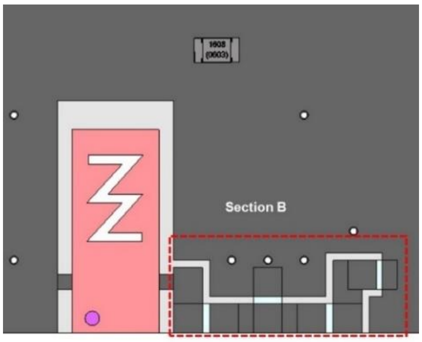



**Figure 12 –** PCB of 107 mm x 50 mm (L x W) full populated example




| Components | | Part Numbers | Values |
|---|---|---|---|
| Section B (Free Space) | Z1 | GJM1555C1H1R1WB01 | 1.1pF |
| | Z2 | GJM1555C1H4R0WB01 | 4.2pF |
| | Z3 | - | 0Ω |
| **Components** | | **Part Numbers** | **Values** |
| Section B (Populated PCB) | Z1 | GJM1555C1H1R1WB01 | 1.1pF |
| | Z2 | GJM1555C1H4R0WB01 | 3.7pF |
| | Z3 | - | 0Ω |

**Figure 13 –** DUO mXTEND™ (NN03-320) PCB layout for GNSS (**left**). BoM of DUO mXTEND™ matching network for GNSS (1561 – 1606MHz) in a Free-Space PCB **(right top).** Adjusted BoM of matching network for GNSS (1561 – 1606MHz) when casings and electronics are present **(right bottom).**

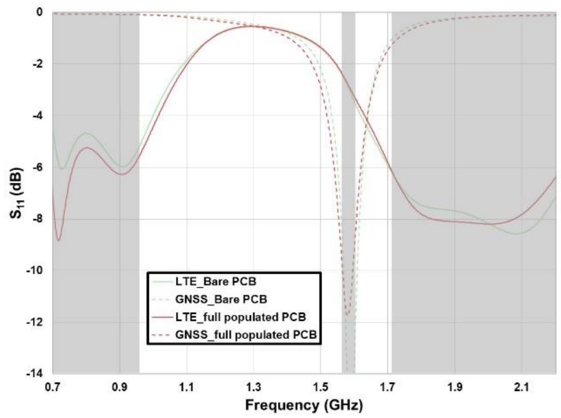



**Figure 14 -** Comparison of Sparam of antennas TRIO mXTEND™ and DUO mXTEND™ between results of a bare PCB of 107 mm x 50 mm and the same but adding electronics and casing**.**

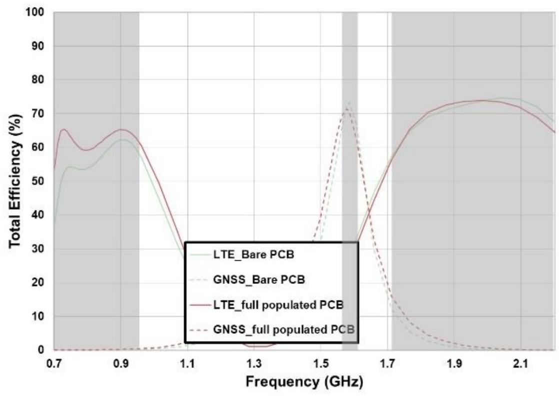
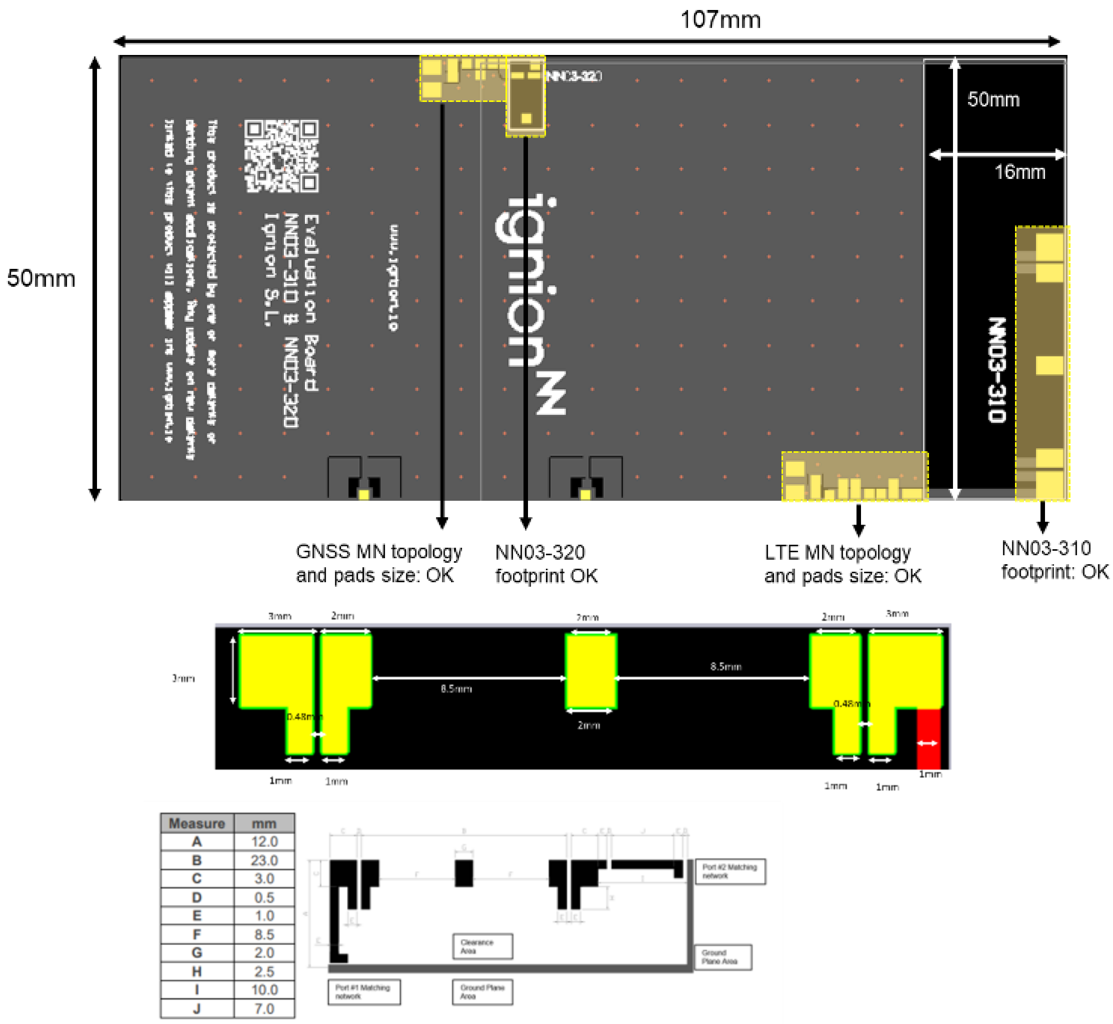



**Figure 15 -** Comparison of Total Efficiency of antennas TRIO mXTEND™ and DUO mXTEND™ between results of a bare PCB of 107 mm x 50 mm and the same but adding electronics and casing**.**

As it can be seen in Figure 14 and Figure 15, losses or other effects induced by surrounding elements in close proximity to the Virtual Antenna® components can be mitigated by adjusting the matching network, particularly for GNSS solutions. However, in the case of Cellular solutions, no fine-tuning of the matching network is required to maintain optimal performance.

## 2.4. STEP 4: GERBER SANITY CHECK

Before producing the physical prototypes, it is recommended to do a fast verification of the design files (Gerber files). This will ensure that the simulated performance results will be aligned with lab measurements. Ignion provides a free and simple Gerber review service for any project.




| Measure | mm |
|---|---|
| A | 12.0 |
| B | 23.0 |
| C | 3.0 |
| D | 0.5 |
| E | 1.0 |
| F | 8.5 |
| G | 2.0 |
| H | 2.5 |
| I | 10.0 |
| J | 7.0 |

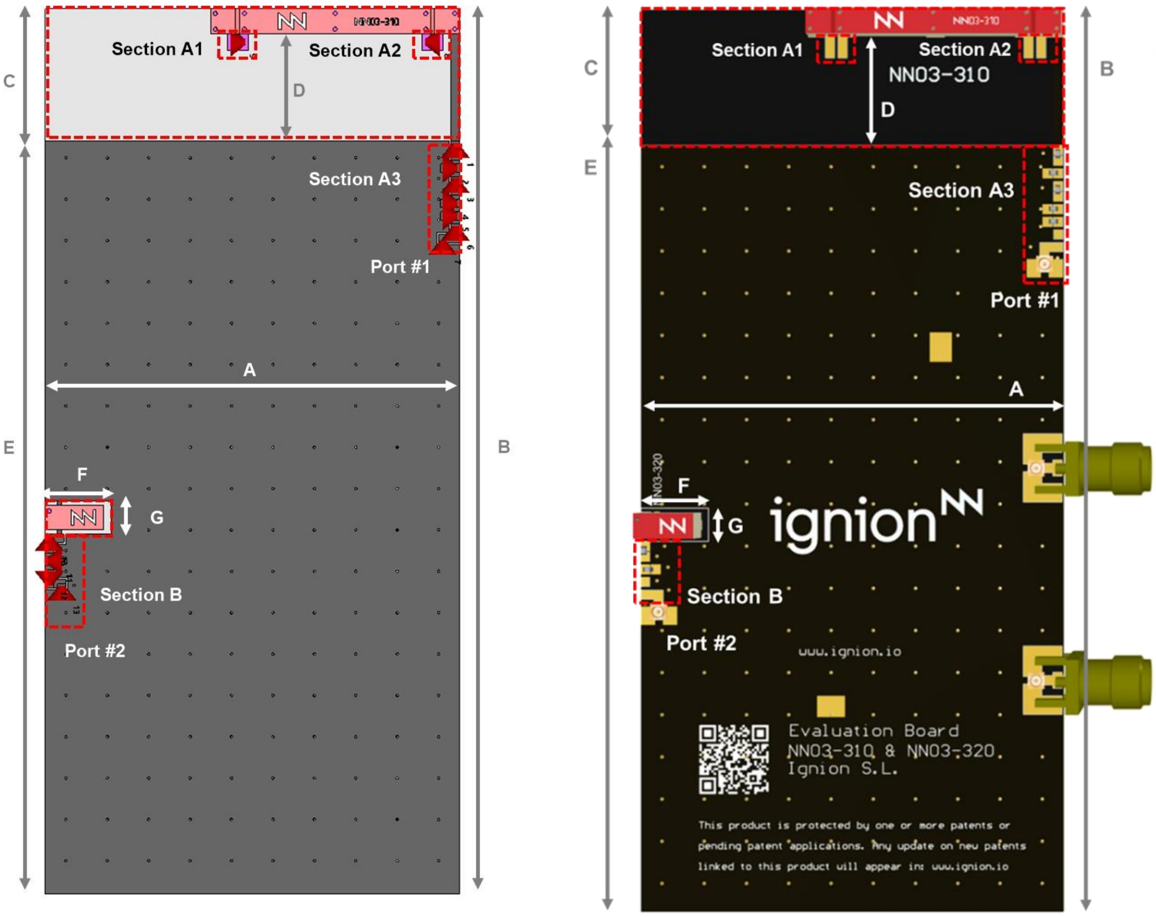
Tolerance: ±0.05mm

**Figure 16 –** Example of Gerber review done and ready for board production.

In the free Gerber review service, an Ignion engineer will review your Gerber design to ensure optimal performance. Key elements to be reviewed include antenna location, clearance area, topologies, feeding lines, transmission lines, and other critical design considerations. This comprehensive review helps identify potential issues and provides valuable insights to optimize the design for maximum efficiency and performance while avoiding costly hardware iterations.

## 2.5. STEP 5: PRODUCE PROTOTYPE AND TEST

The evaluation board is manufactured following the design simulated and reviewed in the previous sections. A comparison of the simulation example PCB and the manufactured PCB is shown in Figure 17. The PCB size is 107 mm x 50 mm, and the clearance area is 16 mm x 50 mm. Figure 18 - Figure 19 show the S-parameters and Efficiency when the simulated matching network is used in the manufactured PCB. On the other hand, Figure 21 - Figure 22 illustrates the same results after the matching network is readjusted (Figure 20) to enhance the performance at both low frequency region (698MHz – 960MHz) and high frequency region (1710MHz – 2200MHz). Results obtained through simulations show good alignment with measured results, particularly in the low-frequency region and GNSS. However, it is important to note that higher frequency losses are not always accurately characterized in simulations. Therefore, after fine-tuning the system based on simulation guidance, further improvements in performance can be achieved, bringing it even closer to the desired targets. This demonstrates the potential of simulations in providing an efficient solution, with the flexibility to easily retune the antenna system if any hardware design changes are introduced, ensuring continued optimal performance.



| Measure | mm |
|---|---|
| A | 50 |
| B | 107 |
| C | 16 |
| D | 13 |
| E | 91 |
| F | 8 |
| G | 4 |

**D**: Distance between the antenna component and the ground plane.
**Material**: The evaluation board is simulated on FR4 substrate. Thickness is 1 mm.

**Figure 17 –** Full-layout of simulation example and manufactured example (PCB size: 107 mm x 50 mm, Clearance area: 16 mm x 50 mm).

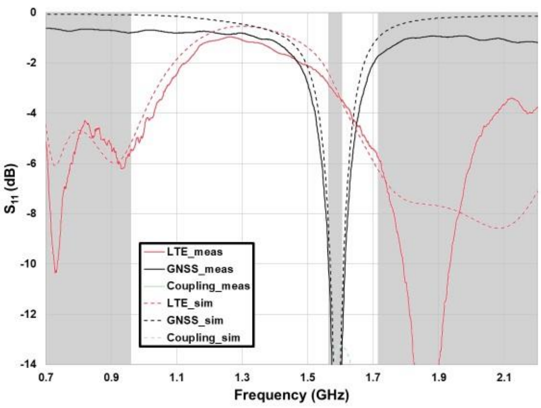



**Figure 18 –** S-parameter Comparison between simulation and measurement of a PCB of 107 mm x 50 mm and clearance area of 16 mm x 50 mm where the same BoM is applied for both.

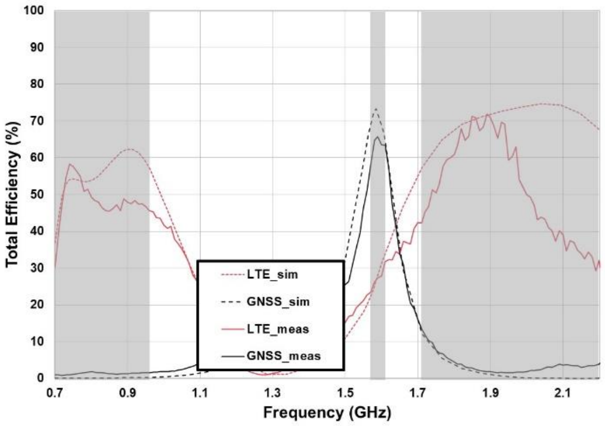
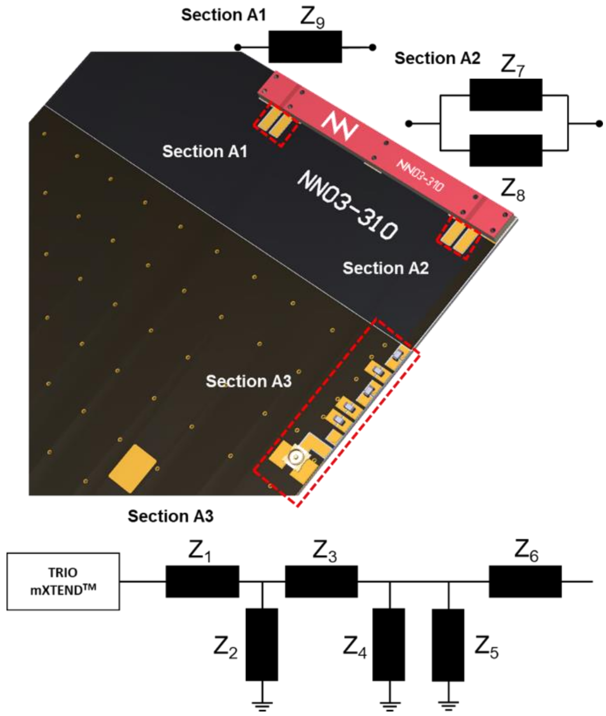


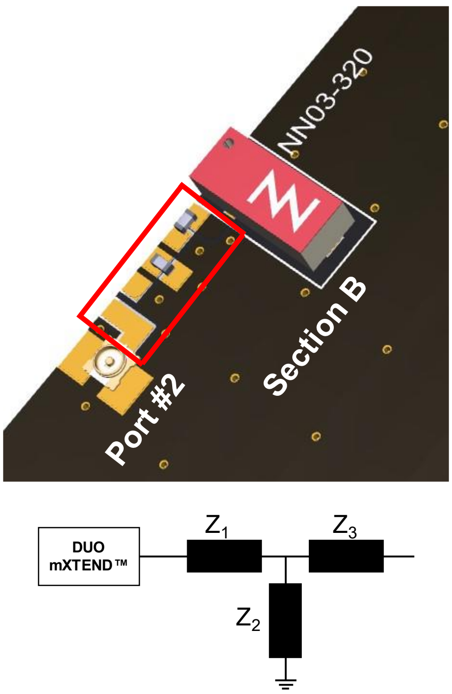

**Figure 19 –** Antenna Efficiency comparison between simulation and measurement of a PCB of 107 mm x 50 mm and clearance area of 16 mm x 50 mm where the same BoM is applied for both.

As mentioned in previous paragraphs, simulations show promising alignment with measured results, especially at lower frequencies and GNSS. However, to address mismatches at higher frequencies, fine-tuning becomes crucial to achieve optimal performance in the overall system.

Figure 20 illustrates the adjustment made to address the mismatch at higher frequencies, while Figure 21 and Figure 22 showcase how the overall system has been successfully aligned with the simulation results, further validating the effectiveness of the fine-tuning process.




| Components | | Part Numbers | Values |
|---|---|---|---|
| Section A1 | Z9 | - | 0Ω |
| Section A2 | Z7 | LQW18AN15NG80 | 15nH |
| | Z8 | GJM1555C1HR30WB01 | 0.3pF |
| Section A3 | Z1 | - | 0Ω |
| | Z2 | LQW18AN7N5C80 | 7.5nH |
| | Z3 | GJM1555C1H2R6WB01 | 2.6pF |
| | Z4 | GJM1555C1H2R0WB01 | 2.0pF |
| | Z5 | LQW15AN6N1B80 | 6.1nH |
| | Z6 | LQW15AN3N0G80 | 3.0nH |




| Components | | Part Numbers | Values |
|---|---|---|---|
| Section B | Z1 | GJM1555C1H1R1WB01 | 1.1pF |
| | Z2 | GJM1555C1H4R8WB01 | 4.8pF |
| | Z3 | LQW15AN3N0G80 | 3.0nH |

**Figure 20** – Matching network readjusted for the manufactured evaluation board (Figure 17) for an optimal performance.

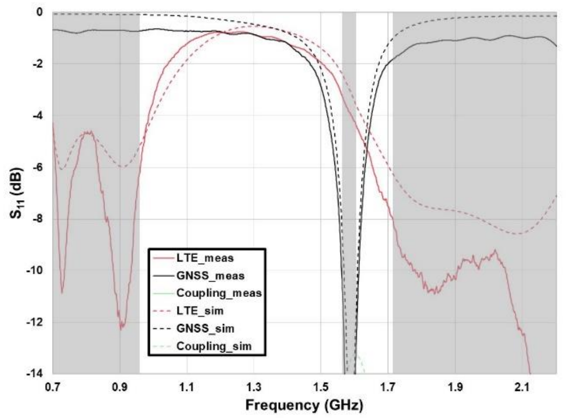



**Figure 21** – S-parameters comparison between simulation and measurement of a PCB of 107 mm x 50 mm and clearance area of 16 mm x 50 mm when fine-tunning is done on the matching network of the real PCB

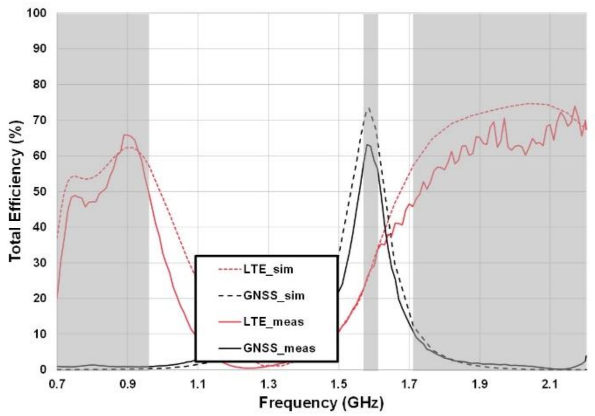



**Figure 22** - Efficiency comparison between simulation and measurement of a PCB of 107 mm x 50 mm and clearance area of 16 mm x 50 mm when fine-tunning is done on the matching network of the real PCB

| Tot. Eff (%) | 698MHz | 960MHz | 698 – 960MHz AVG | 1710MHz | 2200MHz | 1710 – 2200 MHz AVG |
|---|---|---|---|---|---|---|
| **Simulation** | 36.9 | 57.1 | **55.5** | 57.5 | 67.5 | **69.8** |
| **Measurement (MN simulation)** | 30.3 | 45.5 | **48.6** | 43.1 | 30.1 | **51.9** |
| **Measurement (MN readjusted)** | 20.2 | 48.6 | **51.7** | 46.4 | 67.4 | **62.6** |

**Table 3 -** Total efficiency simulated and physical measurement for the NB-IoT, LTE/Cat-M bands with the TRIO mXTEND™ (NN03-310) of a PCB of 107 mm x 50 mm (Figure 17)

| Tot. Eff (%) | 1561MHz | 1606MHz | 1561 – 1606MHz AVG |
|---|---|---|---|
| **Simulation** | 66.1 | 65.5 | 68.9 |
| **Measurement (MN simulation)** | 53.2 | 63.4 | 62.4 |
| **Measurement (MN readjusted)** | 52.9 | 56.7 | 59.7 |

**Table 4 -** Total efficiency simulated and physical measurement for GNSS with the DUO mXTEND™ (NN03-320) of a PCB of 107 mm x 50 mm (Figure 17)

The total efficiency results for the NB-IoT, LTE/CAT-M bands and GNSS, presented in Table 3 and Table 4 respectively, were compared between simulations and physical measurements. Initially, the measurements aligned closely with the simulations in the lower bands and GNSS. After fine-tuning the matching network, the overall performance was further improved and brought into closer alignment with the simulated results also in higher bands. This adjustment resulted in increased total efficiency for both NB-IoT, LTE/CAT-M and GNSS frequencies, indicating that the antenna system was successfully optimized to maximize its performance.

# 2.6. STEP 6: MEETING CERTIFICATION REQUIREMENTS

The Virtual Antenna® technology enables developers to ensure meeting certification requirements from the beginning of the IoT device design journey. If any changes in certification requirements appear after the initial design, the antenna solution can be easily tuned to any desired frequency band without needing to change the antenna component.

## 2.6.1. IDENTIFY CERTIFICATION REQUIREMENTS

The certification requirements are obtained from the cellular operator and vary both by region as well as per device operation characteristics. For this example, we consider TRP requirements from AT&T for a device operating on LTE/Cat-M bands (Source: AT&T: Radiated Performance Requirements version 1.6).

| Band | Minimum TRP Requirement Power Class 3 | Minimum TRP Requirement Power Class 5 |
|---|---|---|
| 2 | +12.0 dBm | +9.0 dBm |
| 4 | +12.0 dBm | +9.0 dBm |
| 12 | +10.0 dBm | +7.0 dBm |

**Figure 23** – LTE/Cat-M requirements for small form factors **under** 107 mm in the longest direction: Free-Space.

| Band | Minimum TRP Requirement Power Class 3 | Minimum TRP Requirement Power Class 5 |
|---|---|---|
| 2 | +20.0 dBm | +17.0 dBm |
| 4 | +20.0 dBm | +17.0 dBm |
| 12 | +18.0 dBm | +15.0 dBm |

**Figure 24 –** LTE/Cat-M requirements for large form factors **above** 107 mm in the longest direction: Free-Space.

## 2.6.2. ESTIMATE TOTAL RADIATED POWER (TRP) AND COMPARE TO CERTIFICATION REQUIREMENT

The estimated TRP results are calculated using Equation 1 below considering 23dBm (Power class 3) of output power from the RF module.

$$\textit{Estimated TRP}\ (dBm) = \textit{Output power}\ (dBm) + \textit{Total Efficiency}\ (dB)$$

**Equation 1 -** Estimated TRP (dBm) calculated from RF Module output power (dBm) combined with antenna solution Total efficiency (dB).

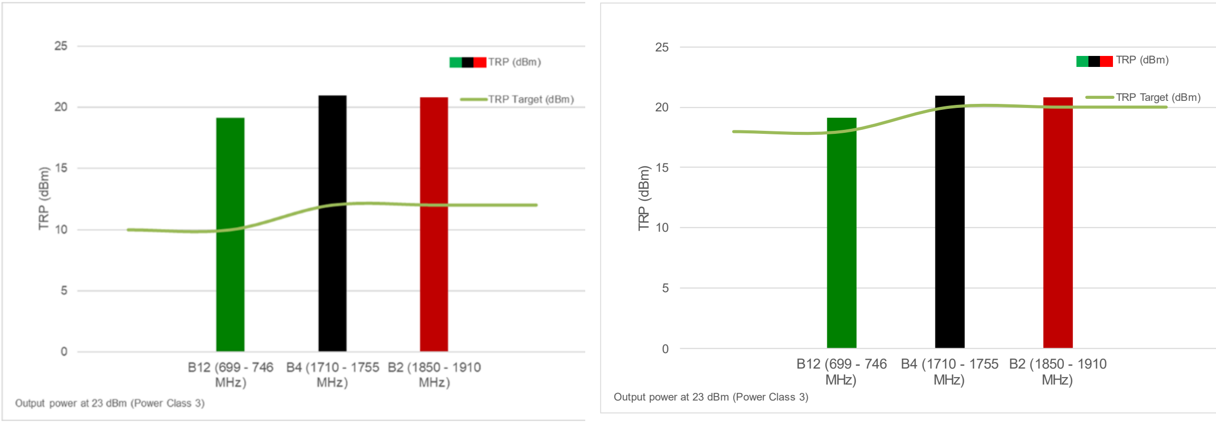



**Figure 25** – Estimated TRP (dBm) from the Evaluation Board (Figure 17). On the left TRP requirements for small form factor devices and on the right TRP for devices having a length larger than 107 mm.

As demonstrated, the current design example exceeds the certification targets with a significant margin on the small form factor requirements, indicating that it is expected to effortlessly pass certification tests.

### 2.6.3. PRE-CERTIFICATION LAB TEST - VERIFY YOUR DEVICE TRP PERFORMANCE

On the final physical prototype, perform OTA (Over-the-Air) test measurements of conducted power, conducted sensitivity, Total Radiated Power (TRP) and Total Isotropic Sensitivity (TIS) to prepare and ensure the device will pass the official certification tests.

At Ignion we offer pre-certification tests and consultation to ensure that your device meets the required targets.

# 3. OPTIMIZING YOUR ASSET TRACKER

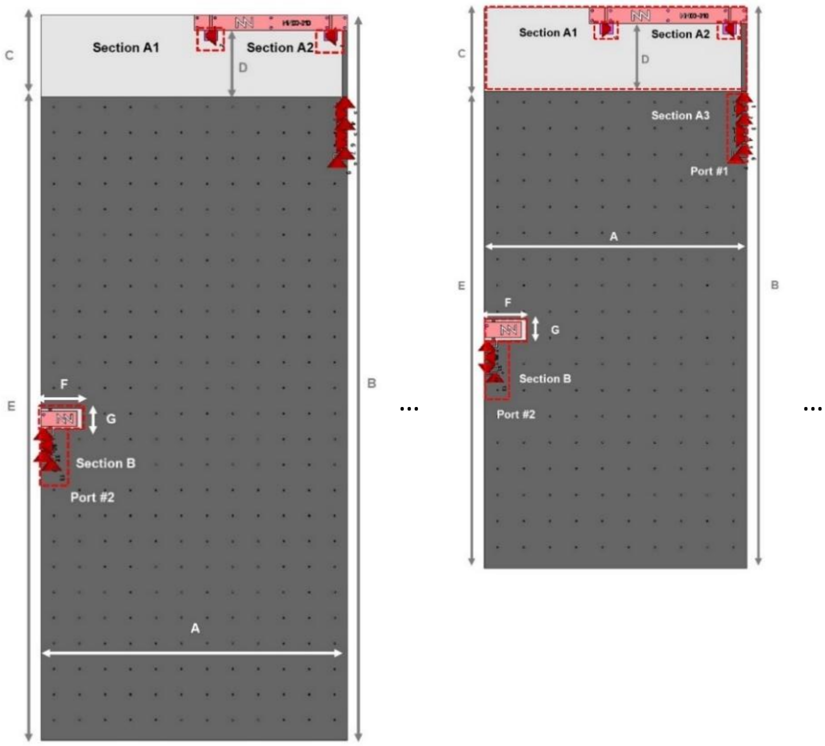
## 3.1 PCB SIZE & CLEARANCE AREA

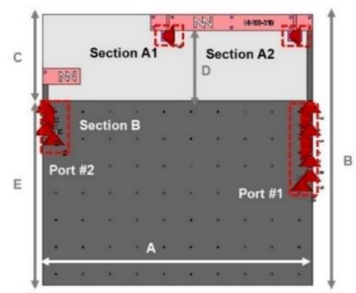
The PCB size, the clearance area and the total efficiency are directly correlated, and the impact each parameter's design has over the antenna performance will be gathered in this section. First, a parametric analysis study is presented to show the impact of the length of the PCB. Next, a similar study is carried out but this time to evaluate the impact of the width of the PCB. Finally, the impact of the clearance area on performance is evaluated.

### 3.1.1. PCB LENGTH: PARAMETRIC ANALYSIS

Six different PCB sizes are analyzed (Figure 26). The clearance area of TRIO mXTEND™ and DUO mXTEND™ always remains the same: 16 mm x 50 mm and 8 mm x 4 mm respectively. Generally, the DUO mXTEND™ is placed in the middle to minimize the effect of coupling between this antenna and the TRIO mXTEND™, except for the smallest form factor where DUO mXTEND™ is located close to top left corner. All these design considerations have been selected to maximize the performance at both NB-IoT and LTE/CAT-M (698-960 MHz and 1710-2200 MHz) and GNSS (1561 – 1606MHz) for each case. The main goal of this study is to evaluate the impact of the PCB length on the final performance.

| 142 mm x 60 mm | 120 mm x 50 mm | 107 mm x 50 mm | 100 mm x 50 mm | 75 mm x 50 mm | 50 mm x 50 mm |
|---|---|---|---|---|---|




| Measure | mm |
|---|---|
| A | 50 |
| B | 142 - 50 |
| C | 16 |
| D | 13 |
| E | 126 - 34 |
| F | 8 |
| G | 4 |

**D**: Distance between the chip antenna component and the ground plane.
**Material**: The evaluation board is simulated on FR4 substrate. Thickness is 1 mm

**Figure 26** – Evaluation boards with different simulated PCB length, ranging from 142 mm x 60 mm down to 50 mm x 50 mm squared form factor, providing operation from 698 MHz to 960 MHz and from 1710 MHz to 2200 MHz with the TRIO mXTEND™ and GNSS band (1561 - 1606 MHz) with the DUO mXTEND™.

The S-parameters and the total efficiency (%) of each of the PCBs shown in Figure 26 are gathered in. Notice that the total efficiency for NB-IoT and LTE/CAT-M is higher, especially in the low frequency region, when the PCB is longer (Figure 27 - Figure 28 and Table 5). On the other hand, the GNSS total efficiency is very similar at all PCB length dimensions (Figure 29 - Figure 30 and Table 6). Then it can be concluded that PCB length has a greater impact at the low frequency region of NB-IoT and LTE/CAT-M and less at the high frequency region and GNSS.

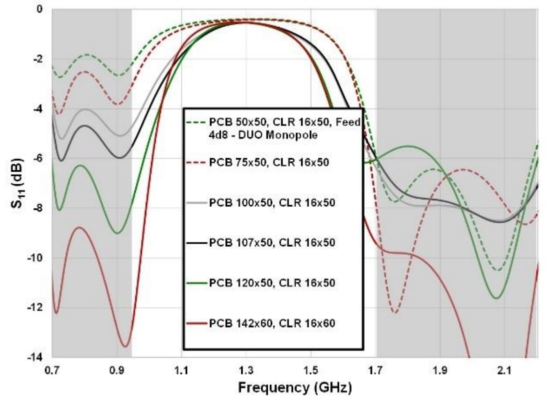



**Figure 27** – S-parameters of the different evaluation boards ranging from PCB142 mm x 60 mm, CLR (Clearance) 16 mm x 60 mm to PCB50 mm x 50 mm CLR for NB-IoT and LTE/CAT-M.

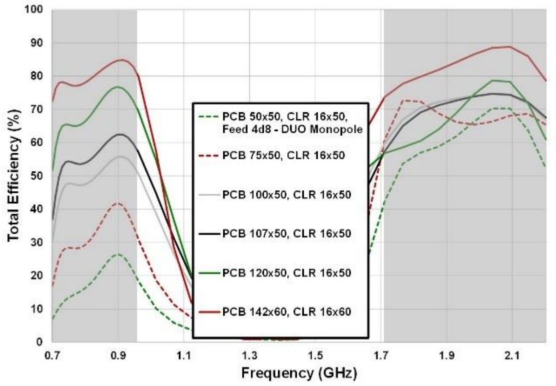



**Figure 28** – Total efficiency of the different evaluation boards ranging from PCB142 mm x 60 mm, CLR16 mm x 60 mm to PCB50 mm x 50 mm CLR for NB-IoT and LTE/CAT-M.

| Tot. Eff (%) | 698MHz | 960MHz | 698 – 960MHz AVG | 1710MHz | 2200MHz | 1710 – 2200 MHz AVG |
|---|---|---|---|---|---|---|
| **142x60** | 72.5 | 79.8 | **79.8** | 73.7 | 78.6 | **82.6** |
| **120x50** | 51.7 | 69.4 | **68.6** | 56.8 | 61.0 | **67.3** |
| **107x50** | 36.9 | 57.1 | **55.5** | 57.5 | 67.5 | **69.8** |
| **100x50** | 30.6 | 50.6 | **48.8** | 60.0 | 66.8 | **70.4** |
| **75x50** | 17.0 | 30.9 | **31.9** | 61.0 | 65.4 | **67.5** |
| **50x50** | 7.0 | 18.3 | **17.9** | 42.5 | 52.3 | **59.7** |

**Table 5** – Total efficiency for the LTE/Cat-M bands with the TRIO mXTEND™ (NN03-310)

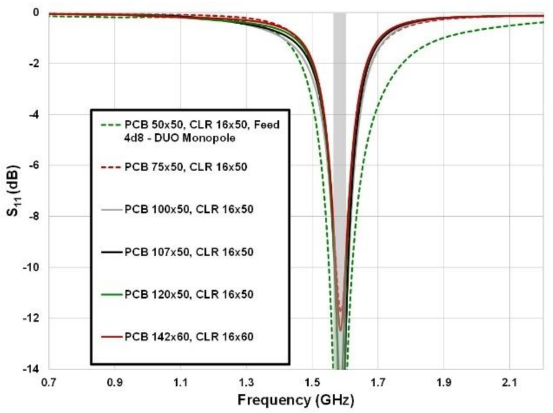



**Figure 29** – S-parameters of the different evaluation boards ranging from PCB142 mm x 60 mm, CLR16 mm x 60 mm to PCB50 mm x 50 mm CLR for GNSS.

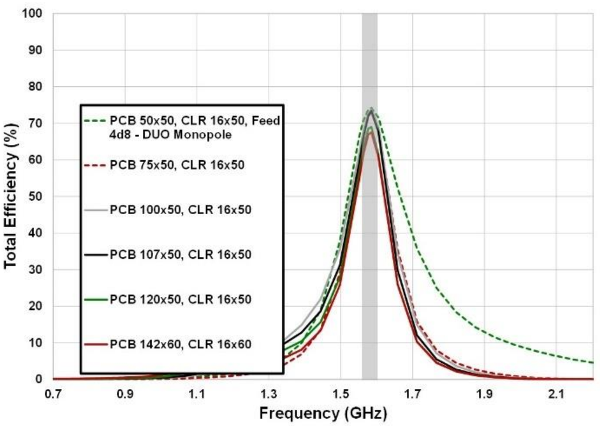


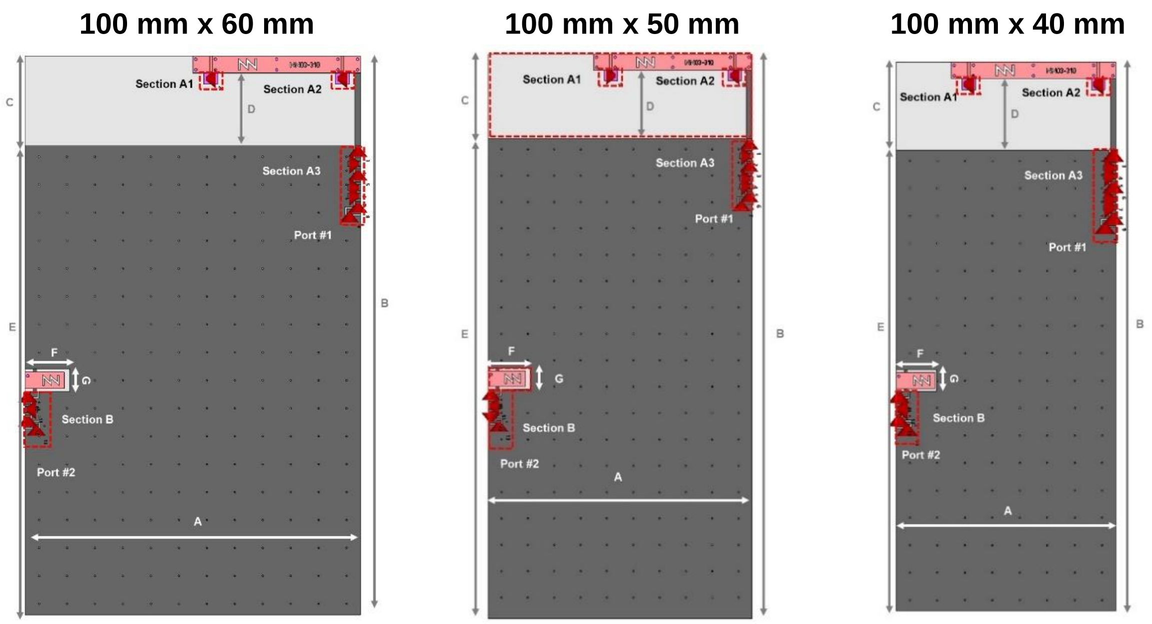

**Figure 30** - Total efficiency of the different evaluation's boards ranging from PCB142 mm x 60 mm, CLR16 mm x 60 mm to PCB50 mm x 50 mm CLR for GNSS.

| Tot. Eff (%) | 1561MHz | 1606MHz | 1561 – 1606MHz AVG |
|---|---|---|---|
| 142x60 | 61.6 | 58.7 | 63.1 |
| 120x50 | 63.4 | 59.3 | 64.3 |
| 107x50 | 66.1 | 65.5 | 68.9 |
| 100x50 | 67.8 | 67.4 | 70.2 |
| 75x50 | 66.9 | 66.8 | 69.4 |
| 50x50 | 70.8 | 70.7 | 72.2 |

**Table 6 -** Total efficiency for GNSS with the DUO mXTEND™ (NN03-320).

### 3.1.2. PCB WIDTH: PARAMETRIC ANALYSIS

Three different PCB sizes of varying width are analyzed: 100 mm x 60 mm, 100 mm x 50 mm, and 100 mm x 40 mm (Figure 31). The goal of this analysis is to evaluate the impact of changing this dimension in the final antenna performance. The clearance area and PCB length do not change.




| Measure | mm |
|---|---|
| A | 60 - 40 |
| B | 100 |
| C | 16 |
| D | 13 |
| E | 84 |
| F | 8 |
| G | 4 |

**D**: Distance between the antenna component and the ground plane.
**Material**: The evaluation board is simulated on FR4 substrate. Thickness is 1 mm.

**Figure 31 -** Evaluation boards with different simulated PCB width, ranging from 100 mm x 60 mm down to 100 mm x 40 mm, providing operation from 698 MHz to 960 MHz and from 1710 MHz to 2200 MHz with the TRIO mXTEND™ and GNSS band (1561 - 1606 MHz) with the DUO mXTEND™.

Notice that the total efficiency for NB-IoT and LTE/CAT-M is higher at the high frequency region when the PCB is wider (Figure 32- Figure 33 and Table 7), whereas the performance in the low frequency region is very similar. Additionally, it can be observed that the GPS performance tends to decrease when the PCB width is reduced (Figure 34 - Figure 35 and Table 8).

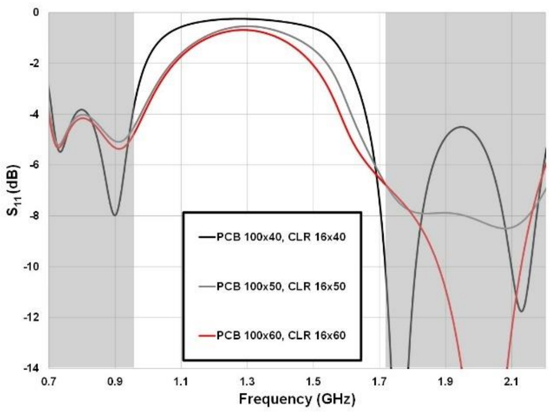



**Figure 32 –** S-parameters of the different evaluation boards ranging from PCB100 mm x 60 mm, CLR16 mm x 60 mm to PCB100 mm x 40mm CLR16 mm x 40 mm for NB-IoT and LTE/CAT-M.

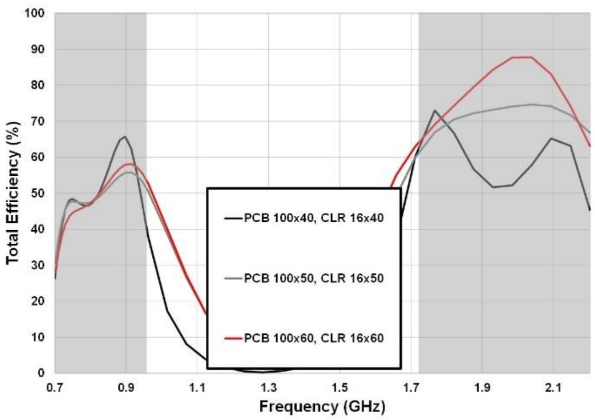



**Figure 33 –** Total efficiency of the different evaluation boards ranging from PCB100 mm x 60 mm, CLR16 mm x 60 mm to PCB100 mm x 40 mm CLR16 mm x 40 mm for NB-IoT and LTE/CAT-M.

| Tot. Eff (%) | 698MHz | 960MHz | 698 – 960MHz AVG | 1710MHz | 2200MHz | 1710 – 2200 MHz AVG |
|---|---|---|---|---|---|---|
| **100x60, CLR16X60** | 27.9 | 52.7 | **48.6** | 63.0 | 63.2 | **76.6** |
| **100x50, CLR16X50** | 30.6 | 50.6 | **48.8** | 60.0 | 66.8 | **70.4** |
| **100x40, CLR16X40** | 26.3 | 38.0 | **50.1** | 60.2 | 45.4 | **59.2** |

**Table 7 -** Total efficiency for the LTE/Cat-M bands with the TRIO mXTEND™ (NN03-310).

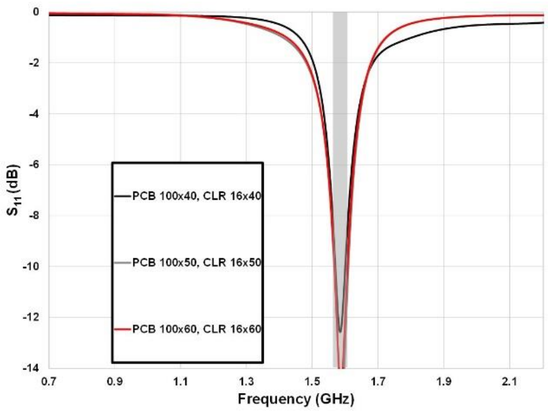



**Figure 34 –** S-parameters of the different evaluation boards ranging from PCB100 mm x 60 mm, CLR16 mm x 60 mm to PCB100 mm x 40 mm CLR16 mm x 40 mm for GNSS.

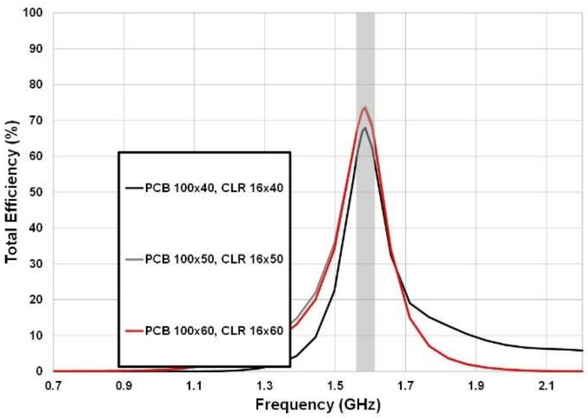



**Figure 35 –** Total efficiency of the different evaluation boards ranging from PCB100 mm x 60 mm, CLR16 mm x 60 mm to PCB100 mm x 40 mm CLR16 mm x 40 mm for GNSS.

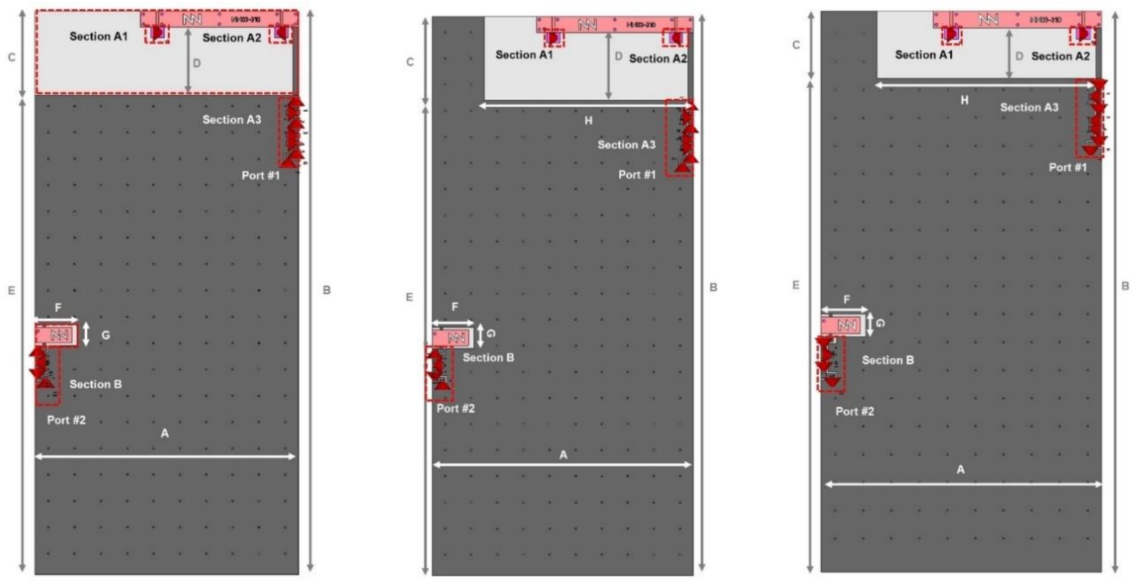
| Tot. Eff (%) | 1561MHz | 1606MHz | 1561 – 1606MHz AVG |
|---|---|---|---|
| **100x60, CLR16X60** | 67.8 | 66.3 | 69.6 |
| **100x50, CLR16X50** | 67.8 | 67.4 | 70.2 |
| **100x40, CLR16X40** | 61.0 | 60.7 | 63.8 |

**Table 8-** Total efficiency for GNSS with the DUO mXTEND™ (NN03-320).

### 3.1.3. CLEARANCE AREA: PARAMETRIC ANALYSIS

In this section, the clearance area of TRIO mXTEND™ is analyzed showing how this dimension can impact the performance of NB-IoT and LTE/CAT-M (Figure 36). On the contrary, PCB dimensions and clearance area of DUO mXTEND™ remain the same.

**100 mm x 50 mm, CLR 16 mm x 50 mm** | **100 mm x 50 mm, CLR16 mm x 40 mm** | **100 mm x 50 mm, CLR 12 mm x 40 mm**

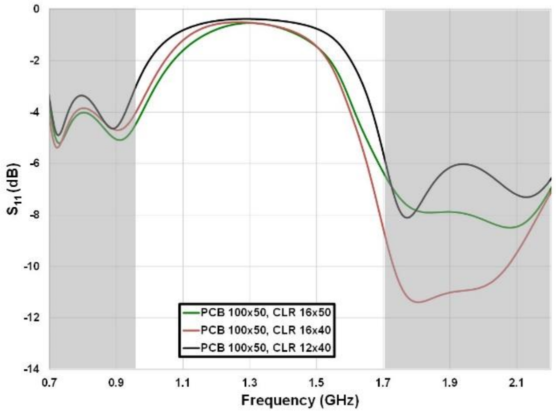



| Measure | mm |
|---|---|
| A | 50 |
| B | 100 |
| C | 16 - 12 |
| D | 13 - 9 |
| E | 88 - 84 |
| F | 8 |
| G | 4 |
| H | 40 |

**D**: Distance between the chip antenna component and the ground plane.
**Material**: The evaluation board is simulated on FR4 substrate. Thickness is 1 mm.

**Figure 36 -** Evaluation boards with different simulated clearance area, ranging from 100 mm x 50 mm, CLR 16 mm x 50 mm down to 100 mm x 50 mm, CLR 12 mm x 40 mm form factor, providing operation from 698 MHz to 960 MHz and from 1710 MHz to 2200 MHz with the TRIO mXTEND™ and GNSS band (1561 - 1606 MHz) with the DUO mXTEND™.

Notice that the total efficiency of NB-IoT and LTE/CAT-M is higher when the clearance area of the TRIO mXTEND™ is larger (Figure 37 - Figure 38 and Table 9). This is especially true for low frequencies.



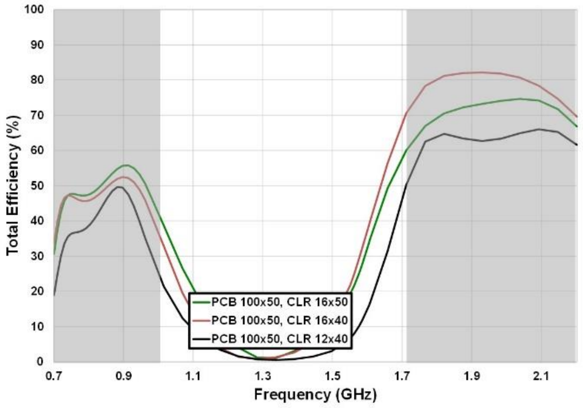
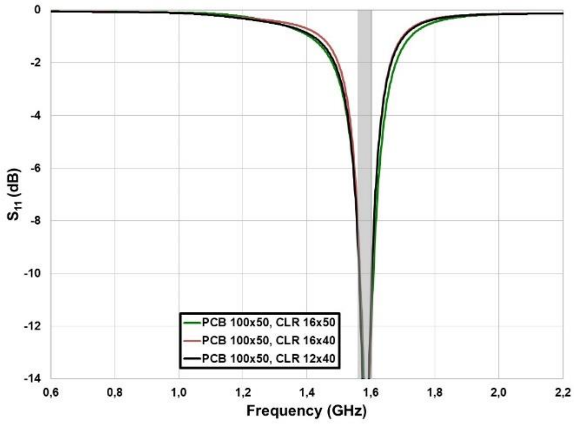




**Figure 37 –** S-parameters of the different evaluations boards ranging from PCB100 mm x 50 mm, CLR16 mm x 50 mm to PCB100 mm x 50 mm CLR12 mm x 40 mm for NB-IoT and LTE/CAT-M.

**Figure 38 –** Total efficiency of the different evaluations boards ranging from PCB100 mm x 50 mm, CLR16 mm x 50 mm to PCB100 mm x 50 mm CLR12 mm x 40 mm for NB-IoT and LTE/CAT-M



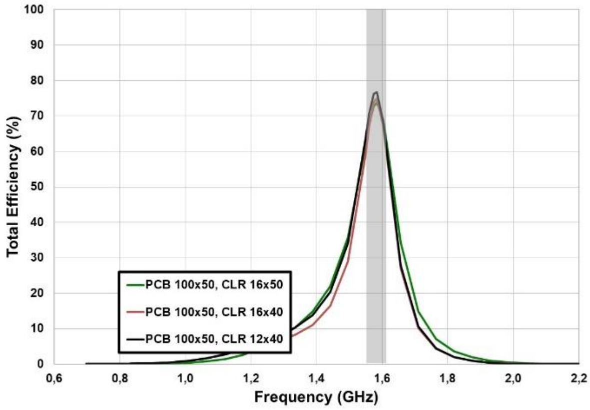




**Figure 39 –** S-parameters of the different evaluations boards ranging from PCB100 mm x 50 mm, CLR16 mm x 50 mm to PCB100 mm x 50 mm CLR12 mm x 40 mm for GNSS.

**Figure 40 -** Total efficiency of the different evaluations boards ranging from PCB100 mm x 50 mm, CLR16 mm x 50 mm to PCB100 mm x 50 mm CLR12 mm x 40 mm for GNSS.

| Tot. Eff (%) | 698MHz | 960MHz | 698 – 960MHz AVG | 1710MHz | 2200MHz | 1710 – 2200 MHz AVG |
|---|---|---|---|---|---|---|
| **100x50, CLR16X50** | 30.6 | 50.6 | **48.8** | 60.9 | 66.8 | **70.4** |
| **100x50, CLR16X40** | 33.5 | 45.9 | **47.3** | 70.6 | 69.6 | **77.9** |
| **100x50, CLR12X40** | 18.9 | 35.2 | **39.7** | 50.2 | 61.6 | **62.5** |

**Table 9 -** Total efficiency for the NB-IoT, LTE/Cat-M bands with the TRIO mXTEND™ (NN03-310).

## 3.2. TIME TO FIRST FIX

Time to First Fix (TTFF) is used to evaluate tracking systems and it measures the time it takes for a GNSS navigation device to acquire satellite signals and navigation data for position calculation. Lower TTFF results in faster position calculation and reduced battery consumption.

The DUO mXTEND™ Virtual Antenna® component delivers omnidirectional GNSS performance enabling flexible mounting and orientation options ensuring an enhanced satellite reception regardless of the tracker's orientation and position. An omnidirectional antenna can effectively receive signals from multiple satellites, facilitating a rapid fix, whereas traditional patch antennas require a distinct orientation to operate.

The set-up used for the example measurements in this section consists of the selected 107 mm x 50 mm evaluation board (Figure 17), with DUO mXTEND™ as the best Virtual Antenna® component for GNSS performance, a high-gain Low-Noise Amplifier (LNA), and a u-blox M8 GNSS Evaluation Kit (EVK-M8N-0).

Different **positions in a vehicle** (Figure 41) and scenarios have been tested while driving in multiple locations including **highway, city, and forest** (Figure 42). The most favorable position for the GNSS antenna is the car dashboard facing upwards, while the worst is under the seat. The best scenario for low TTFF is on the highway with no obstacles to interfere with satellite signals, whereas the city and the forest are the most challenging scenarios due to the obstacles present.

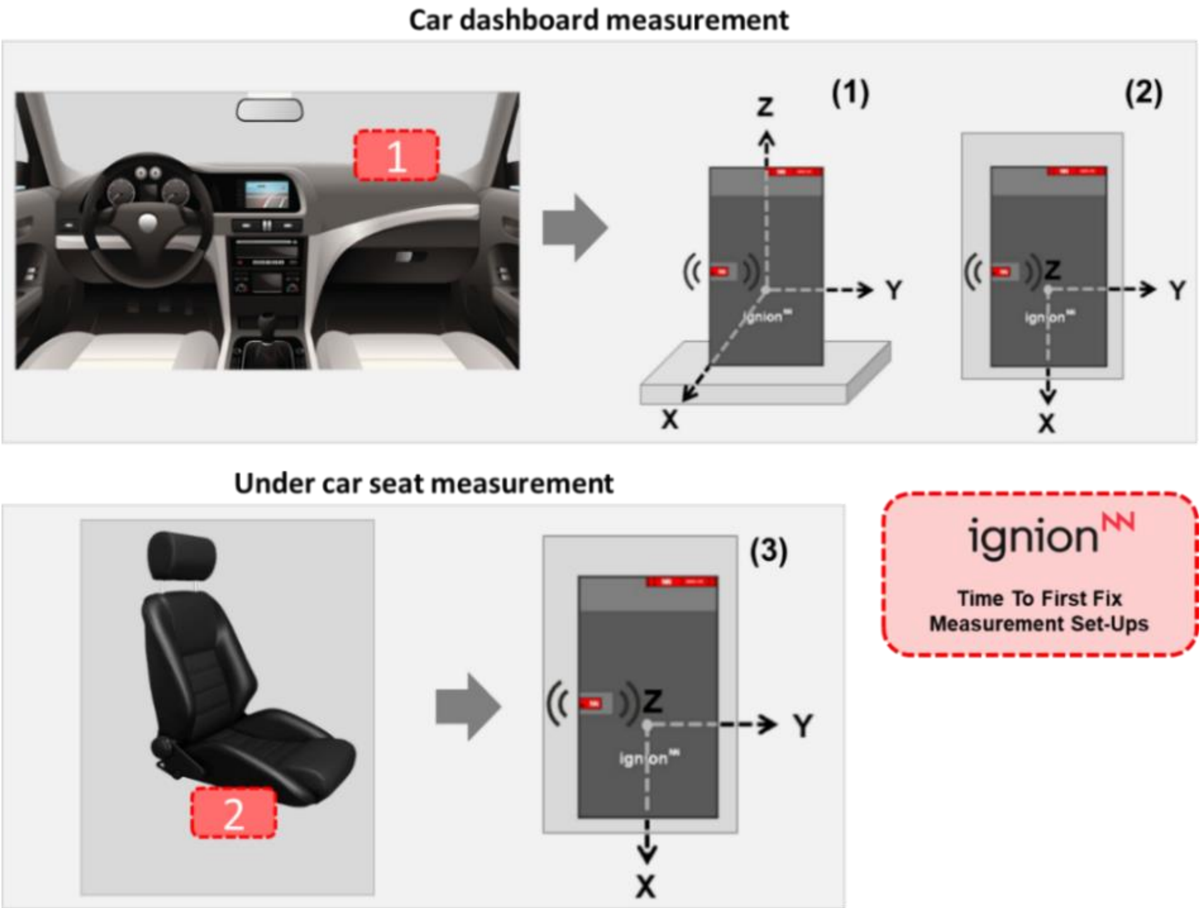



**Figure 41** – Measurements were taken from different positions in the vehicle to evaluate tracking performance. Position 1 involved two measurements on the car dashboard with the PCB in a stand-up (1) and face-up (2) orientation, while position 2 involved a single measurement under the car seat (3) with the PCB in a face-up orientation.

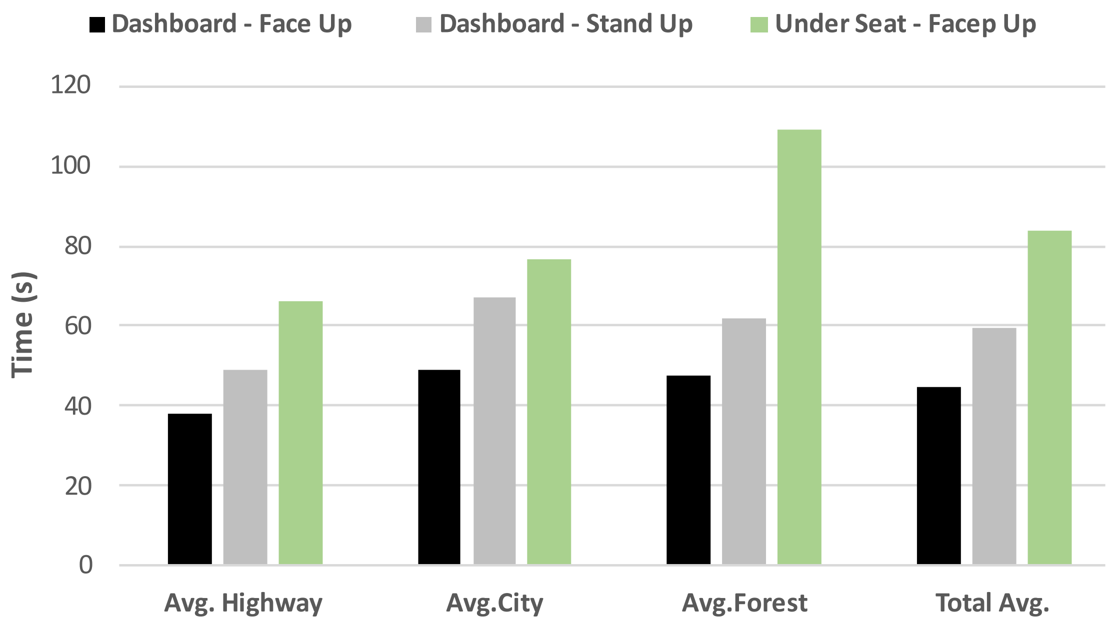


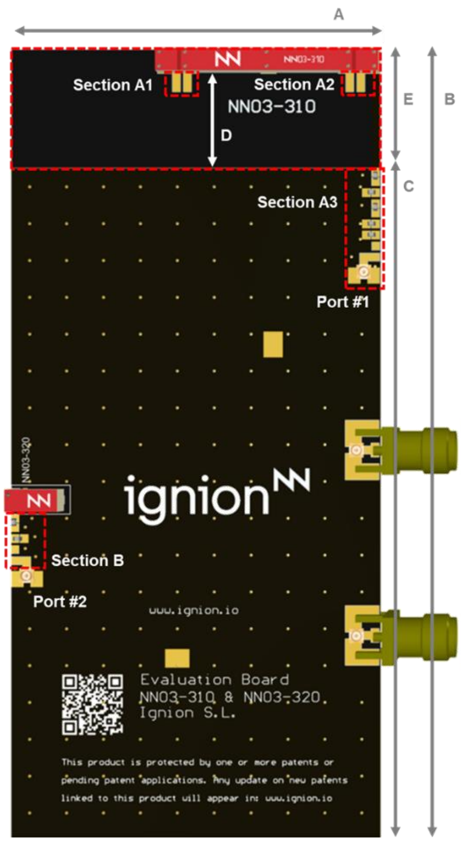

**Figure 42** – Time to first fix of a PCB of 107 mm x 50 mm (Figure 17) in highway, city and forest under different conditions: Face Up, Stand Up and Under Seat (faced-up)

A faster TTFF is generally preferred as it allows for quicker and more efficient positioning, leading to improved power efficiency. The acceptable TTFF threshold varies depending on specific application requirements, such as accuracy needs and battery life.

If you need to deep dive into more details, please visit: www.mdpi.com/1996-1073/15/24/9623

## 3.3. SURROUNDING MATERIALS

This section explores the impact of different environmental conditions on the performance of NB-IoT and LTE/CAT-M and GNSS antenna components in IoT applications. The study uses a reference PCB with dimensions of 107 mm x 50 mm (LxW) and clearance areas of 16 mm x 45 mm (LxW) for TRIO mXTEND™ and 8 mm x 4 mm for DUO mXTEND™ (Figure 43). The PCB is positioned at distances of 20 mm and 0 mm from wood, body phantom, and metal surfaces (Figure 44 and Figure 45), which are common materials found around asset tracking devices. These PCB dimensions are commonly used in current trackers, and the results can be applied to PCBs of similar sizes. It's important to note that the results presented here are based on direct measurements conducted in a laboratory setting.




| Measure | mm |
|---|---|
| A | 50 |
| B | 107 |
| C | 91 |
| D | 13 |
| E | 16 |

D: Distance between the TRIO mXTEND™ antenna component and the ground plane.

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

**Figure 43 –** PCB employed to evaluate the impact of materials in NB-IoT and LTE/CAT-M (698MHz – 960MHz, 1710MHz – 2200MHz) and GNSS (1561MHz – 1606MHz).

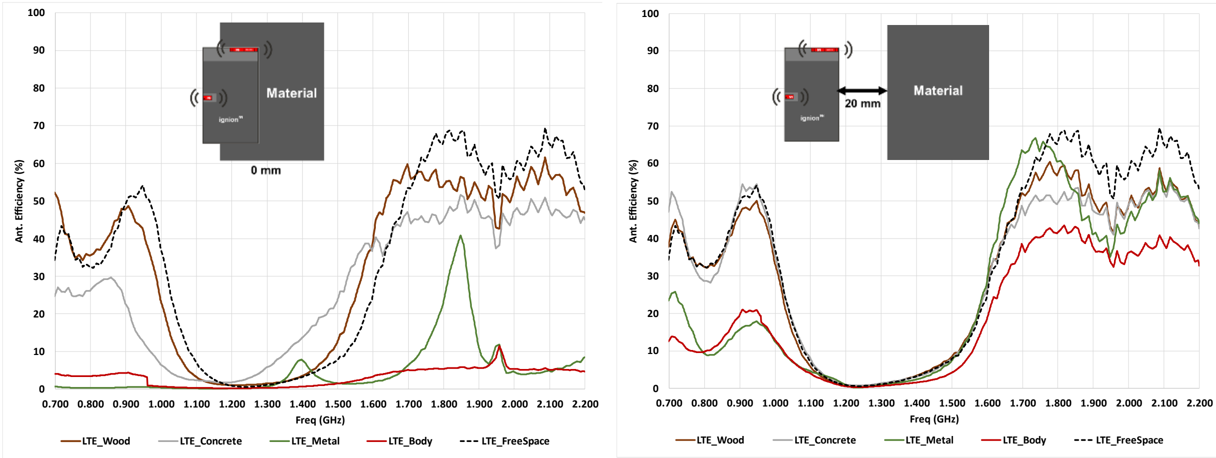



**Figure 44 –** Summary of antenna performance variation in different environmental conditions for NB-IoT and LTE/CAT-M with the TRIO mXTEND™ (NN03-310) when the PCB analyzed is deployed at 20 mm **(right)** and at 0 mm **(left)** from the analyzed materials (Wood, Concrete, Metal, and Body) with a PCB of 107 mm x 50 mm (Figure 17).

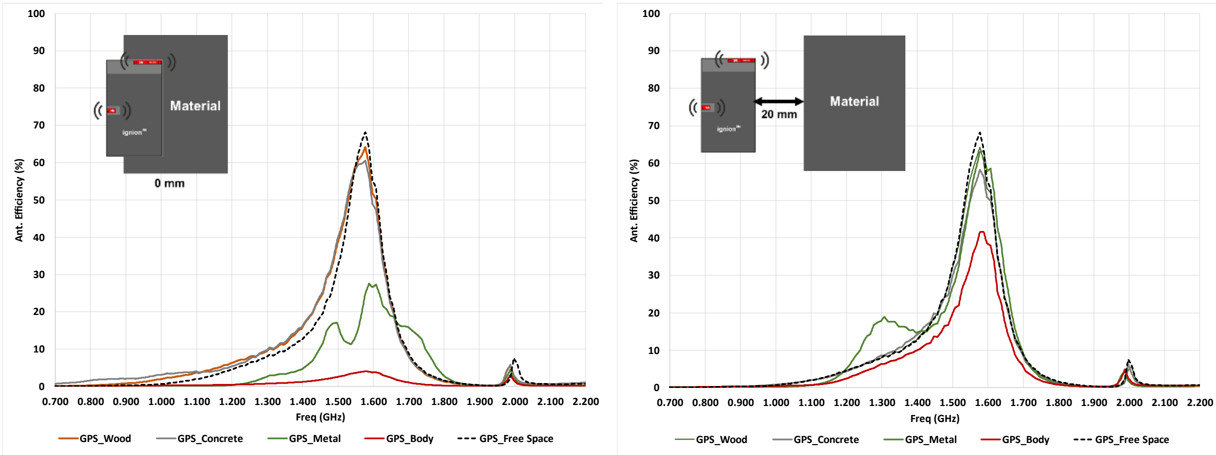



**Figure 45 –** Summary of antenna performance variation in different environmental conditions for GNSS with the DUO mXTEND™ (NN03-320) when the PCB analyzed is deployed at 20 mm **(right)** and at 0 mm **(left)** from the analyzed materials (Wood, Concrete, Metal, and Body) with a PCB of 107 mm x 50 mm (Figure 17).

| **Total Efficiency (%)** | | **Cellular** | | **GNSS** |
|---|---|---|---|---|
| | | **Avg (698 – 960MHz)** | **Avg (1710 – 2200MHz)** | **Avg (1561 – 1606MHz)** |
| **Free-Space** | | 39.6 | 62.1 | 67.5 |
| **Wood** | **0mm** | 41.0 | 54.3 | 63.6 |
| | **20mm** | 38.8 | 52.8 | 63.4 |
| **Concrete** | **0mm** | 25.2 | 46.5 | 60.3 |
| | **20mm** | 39.9 | 49.9 | 57.4 |
| **Metal** | **0mm** | <1.0 | 12.4 | 23.6 |
| | **20mm** | 14.9 | 51.5 | 61.9 |
| **Body phantom** | **0mm** | 3.7 | 5.7 | 4.0 |
| | **20mm** | 13.5 | 38.6 | 40.6 |

**Table 10 –** Summary of antenna performance variation in different environmental conditions for NB-IoT and LTE/CAT-M with the TRIO mXTEND™ (NN03-310) and GNSS with the DUO mXTEND™ (NN03-320) of a PCB of 107 mm x 50 mm (Figure 17).

This section shown the impact of proximity to various materials on antenna performance. Materials such as walls, containers, animals, and pallets commonly encountered in logistics can affect wireless performance.

- The antenna performance in presence of **wood** hardly changes.
- **Concrete** in proximity causes a drop in efficiency, especially at high bands, but no shifting in frequency, so there is no need of a readjustment of the matching network.
- **Human/animal body** in proximity has significant impact on the antenna performance, especially at the lower bands. The further the antenna is from the material the higher the antenna performance.
- **Metal** is probably the most challenging material when placed close to an antenna. A reconfiguration/retuning of the matching network is recommended to adjust to the specific distance between the device and the metal.

# 4. ADD WI-FI IN YOUR ASSET TRACKER

Combining Cellular with Wi-Fi in a single IoT device offers benefits for several application areas. For example, switching between cellular and Wi-Fi technologies to cover on-site and off-site data transfer or location tracking capability expanded by using Wi-Fi access points, enables seamless logistics and asset tracking operations using just one IoT device. The flexible capabilities of the Virtual Antenna® technology easily enables the addition of using Wi-Fi. This functionality is supported by the Ignion products shown in Table 11.

| Ignion Product | Antenna Features | Application Note |
|---|---|---|
| DUO mXTEND™ (NN03-320) | Thanks to its multiport nature, it can combine GNSS and Wi-Fi or Bluetooth and Wi-Fi in a single package. | ignion.io/files/ NN03-320 |
| ONE mXTEND™ (NN02-210) | Small but powerful. The ONE mXTEND™ delivers operation up to Wi-Fi 6E. | ignion.io/files/ NN02-210 |
| NANO mXTEND™ (NN02-101) | The smallest Virtual Antenna® ever. The NANO mXTEND™ antenna is the perfect choice when devices are strictly limited in terms of real estate and overall size. | ignion.io/filesNN02-101 |

**Table 11** - Ignion product portfolio enabling Wi-Fi functionalities.

Assess the performance of your multiple radio IoT device adding Wi-Fi functionalities through the Antenna Intelligence Cloud™. In addition, if you are designing a device with a different size or operating frequency than shown above, you can assess the performance of this solution using our free-of-charge Antenna Intelligence Cloud™ tool at ignion.io/antenna-intelligence/ providing a complete design report, including expected performance and tailored design guide, within 24 hours.

For additional information about Ignion's range of R&D services, please visit: ignion.io/resources-support/engineering-support/. If you require further assistance, please contact support@ignion.io.

# 5. SUMMARY

To optimize the design of an asset tracker and ensure its performance, the following recommended steps should be followed:

1. Utilize the Antenna Intelligence Cloud™ as a starting point to gain insights into the expected performance and anticipate potential issues, while getting a head start with tailored design files.
2. Adhere to the provided design guidelines for the PCB design to guarantee optimal performance.
3. Understand the impact of PCB size and clearance area on the overall performance and adjust if needed.
4. Study the impact of materials such as wood, body, metal, and concrete to assess the effects on performance.
5. Conduct a comprehensive simulation of the fully populated PCB, considering all integrated elements of the final device, to obtain accurate RF performance results.
6. Produce hardware prototype and compare simulated results to assess the need for fine-tuning of the matching network for potential further maximizing of the antenna performance.
7. Enjoy the optimized performance of your new asset tracking device, passing cellular certification and delivering short Time to First Fix (TTFF).

By following these steps, designers can ensure that their tracker device is optimized for performance and meets the desired requirements.

# 6. DO YOU NEED MORE HELP? OVERVIEW OF IGNION SUPPORT SERVICES

Virtual Antenna® technology makes antenna optimization accessible for any electronics engineer, however if need of support during the product development, the Ignion team is ready to help in every step of the design journey.

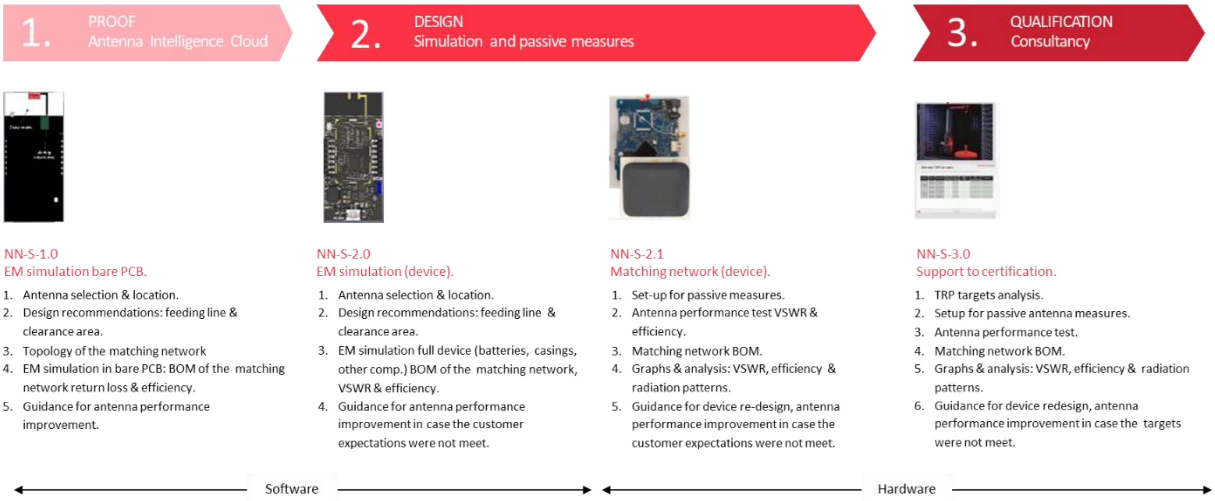



**Figure 46** Ignion services for antenna integration.

The TRIO mXTEND™ and the DUO mXTEND™ antenna components and other Ignion products based on its proprietary Virtual Antenna® technology are protected by one or more of the following Ignion patents.



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

ISO 9001: 2015 Certified

RoHS 2002/95/EC

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Accelerated.

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