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NANO mXTEND™ FOR WEARABLES: IGNION'S SMALLEST BLUETOOTH ANTENNA IN DIFFERENT GROUND PLANE FORM FACTORS.

APPLICATION NOTE
NANO mXTEND™ (NN02-101)

NANO mXTEND™ FOR WEARABLES: IGNION'S SMALLEST BLUETOOTH ANTENNA IN DIFFERENT GROUND PLANE FORM FACTORS

- **Antenna Component**: NANO mXTEND™ NN02-101
- **Dimensions**: 3.0 mm x 2.0 mm x 0.8 mm
- **Frequency regions**: 2400 - 2500 MHz

When designing a wearable, the antenna should be small, versatile, and efficient. How can we meet all these requirements and avoid buying a new part for each of the endless list of form factors?

In this application note you can learn how the NANO mXTEND™ gives Bluetooth connectivity to devices with many different form aspects and sizes. Included is a full demonstration of how the antenna behaves in terms of gain and efficiency for different matching networks which are created to help perfectly tune the antenna for optimal performance in any wearable application. Within the note you can also find out where to place the tiny antenna within the different PCB elements regardless of the shape of the device.

The NANO mXTEND™ antenna is the perfect choice for devices that are strictly limited in terms of PCB real estate and overall size. It's our product of choice when looking for a reliable and repetitive antenna solution for Bluetooth.

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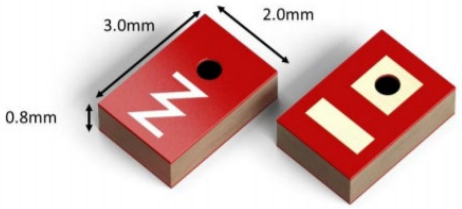
1. PRODUCT DESCRIPTION NN02-101

The market of Internet of Things demands Bluetooth connectivity for diverse PCB form factors. Furthermore, it is fundamental to employ miniature antennas that do not occupy too much space of the PCB, which will be available for other components and purposes. This application note gathers the performance of NANO mXTEND™ (NN02-101) integrated in different kind of platforms. The selected PCB sizes have been chosen from the most common devices, namely pencils, smart watches, air tags, earphones and Bluetooth modules.

The NANO mXTEND™ is the smallest Virtual Antenna™ chip to date. Featuring a size of 3 mm x 2 mm x 0.8 mm, this off-the shelf-chip antenna has been specifically designed to fit almost every IoT device from entry level to high-end products.



Material: The NANO mXTEND™ antenna booster is built on glass epoxy substrate.

APPLICATIONS

- Pencils
- Smartwatches
- Air Tags
- Earphones
- Bluetooth modules

BENEFITS

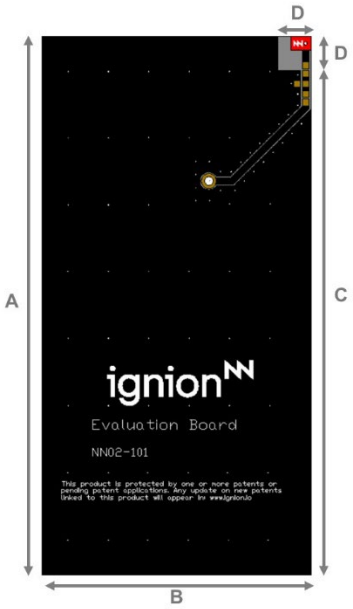
- High efficiency
- Small size
- Cost-effective
- Easy-to-use (pick and place)
- Off-the-Shelf standard product (no customization is required)

The NANO mXTEND™ antenna booster belongs to a new generation of antenna solutions based on the Virtual Antenna™ technology developed by Ignion. The technology is mainly focused on replacing conventional antenna solutions by miniature and standard components.

2. PERFORMANCE vs EVALUATION BOARD size

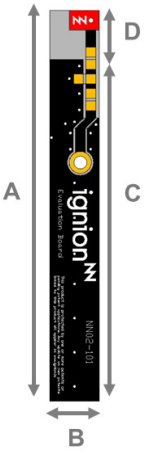
2.1. EVALUATION BOARD

This application note illustrates how the PCB size impacts the antenna performance. PCB sizes of representative applications have been selected.

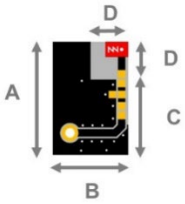


80mm x 40mm (AxB)

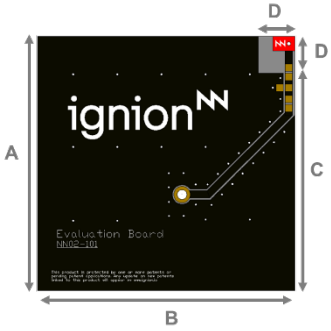
40mm x 20mm (AxB)



40mm x 5mm (AxB)



15mm x 10mm (AxB)

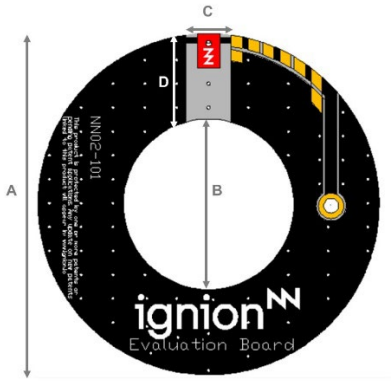


35mm x 35mm (AxB)

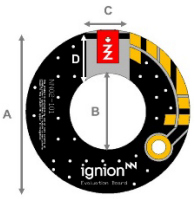
Measure	Mm
A	80.0 – 15.0
B	40.0 – 5.0
C	75.0 – 10.0
D	5.0

Tolerance: ±0.2 mm

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



30mm (A)



15mm (A)

Measure	mm
A	30.0 – 15.0
B	15.0 – 7.0
C	4.0
D	7.6 – 4.3

Tolerance: ±0.2 mm

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

Figure 1 – Evaluation boards analysed with different form factors to cover Bluetooth (2400MHz - 2500MHz).

2.2. VSWR AND EFFICIENCY

VSWR (Voltage Standing Wave Ratio) and Total Efficiency versus Frequency (GHz).

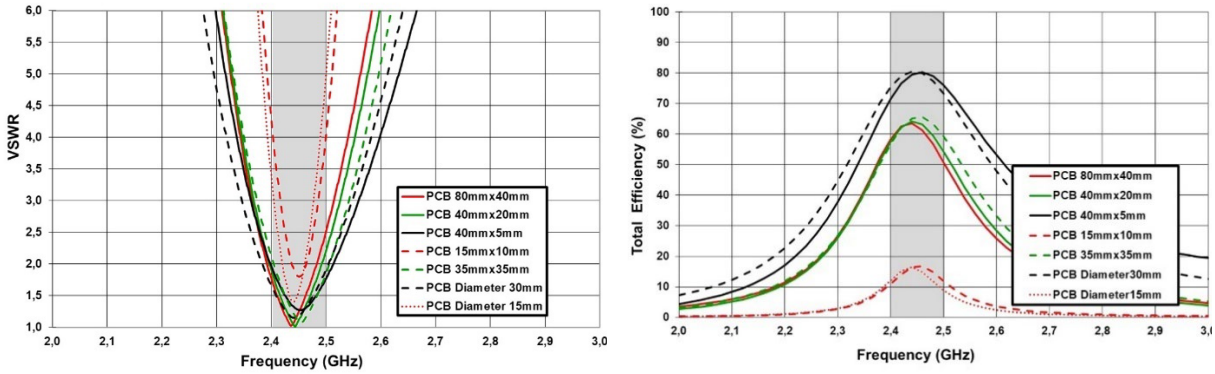


Figure 2 – VSWR and Total Efficiency for the 2400 – 2500 MHz frequency from the evaluation boards (Figure 1).

	BLE (2400 – 2500 MHz)				
Form Factor	**$\eta_{a\ 2400MHz}$**	**$\eta_{a\ 2500MHz}$**	**Min**	**Max**	**Av. η_a**
PCB 80mm x 40mm	58.4	50.9	50.9	63.5	58.9
PCB 40mm x 20mm	57.6	54.3	54.3	64.2	60.2
PCB 40mm x 5mm	71.5	76.0	71.5	80.3	77.1
PCB 15mm x 10mm	11.0	11.9	11.0	16.7	14.2
PCB 35mm x 35mm	56.8	59.3	56.8	65.6	62.0
PCB Diameter 30mm	75.4	73.4	73.4	80.5	77.6
PCB Diameter 15mm	12.2	8.9	8.9	16.4	13.2

Table 1 – Antenna efficiency (%) comparison considering the different clearance lengths.

2.3. MATCHING NETWORK

The specs of a Ignion standard product are measured in their evaluation board, which is an ideal case. In a real design, components nearby the antenna, LCD's, batteries, covers, connectors, etc. affect the antenna performance. This is the reason why 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. Do it in the ground plane area, not in the clearance area. This provides a degree of freedom to tune the NANO mXTEND™ antenna booster once the design is finished and taking into account all elements of the system (batteries, displays, covers, etc.).

Please notice that different devices with different ground planes and different components nearby the NANO mXTEND™ antenna booster may need a different matching network. To ensure optimal results, the use of high Q and tight tolerance components is highly recommended (Murata components). Please, if you need assistance contact support@ignion.io for more information related to the antenna booster matching service.

MN for PCB 80mm x 40mm, 40mm x 20mm, 40mm x 5mm, 15mm x 10mm, 35mm x 35mm

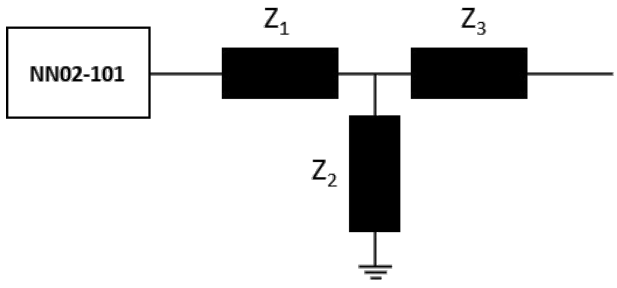


Figure 3 – Topology of matching network mounted at the solutions: PCB 80mm x 40mm, 40mm x 20mm, 40mm x 5mm, 15mm x 10mm.

MN for PCB Diameter 30mm and Diameter 15mm

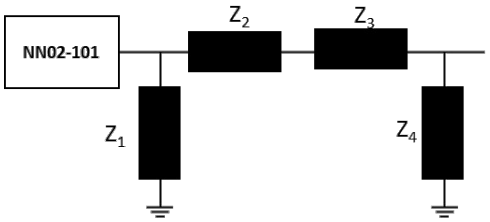


Figure 4 - Topology of matching network mounted at the solutions: PCB Diameter 30mm and Diameter15mm.

Form Factor	Z_1	Z_2	Z_3	Z_4
PCB 80mm x 40mm	9.1nH	8.7nH	6.1nH	-
PCB 40mm x 20mm	9.1nH	8.7nH	6.1nH	-
PCB 40mm x 5mm	9.1nH	8.7nH	6.1nH	-
PCB 15mm x 10mm	8.7nH	8.7nH	10nH	-
PCB 35mm x 35mm	9.1nH	8.7nH	6.1nH	-
PCB Diameter 30mm	OPEN	8.7nH	2.4nH	1.0pF
PCB Diameter 15mm	OPEN	2.2nH	18nH	23nH

Table 2 – Values of the components for each form factor.

Value		Part Number
Z1	9.1nH	LQW18AN9N1G80
	8.7nH	LQW18AN8N7G80
Z2	8.7nH	LQW18AN8N7G80
	2.2nH	LQW18AN2N2C80
Z3	6.1nH	LQW15AN6N1G80
	10nH	LQW18AN10NG80
	2.4nH	LQW18AN2N4C80
	18nH	LQW18AN18NG80
Z4	1.0pF	GJM1555C1H1R0WB01
	23nH	LQW18AN23NG80

Table 3 – Values and part numbers of the components used for the matching networks for the the different form factors.

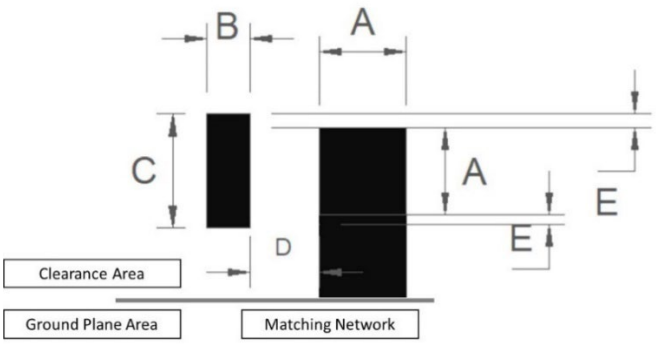
For additional information, please visit www.ignion.io or contact info@ignion.io.

If you need assistance to design your matching network, please contact support@ignion.io, or try our free-of-charge[1] **Antenna Intelligence Cloud** design service, you will get your chip antenna design including a custom matching network for your device in 24h[1]. Other information related to Ignion's range of R&D services is available at: https://www.ignion.io/rdservices/

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

2.4. RECOMMENDED ANTENNA FOOTPRINT FOR NN02-101

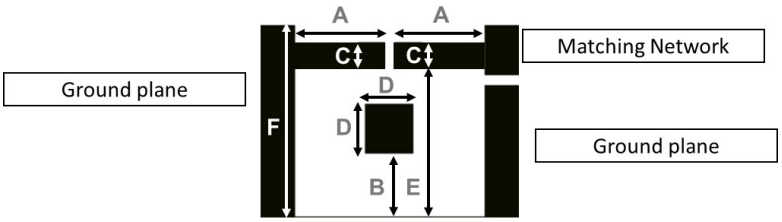
See below the recommended footprint dimensions for the NANO mXTEND™ antenna booster NN02-101 on the corner (Figure 5).



Measure	mm
A	1.0
B	0.5
C	1.3
D	0.8
E	0.15

Figure 5 - Footprint dimensions for the NANO mXTEND™ (NN02-101) antenna booster (on the corner).

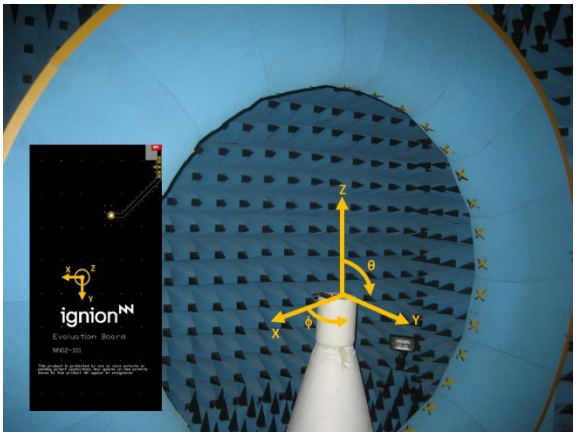
See below the recommended footprint dimensions for the NANO mXTEND™ antenna booster NN02-101 in the middle (Figure 6).



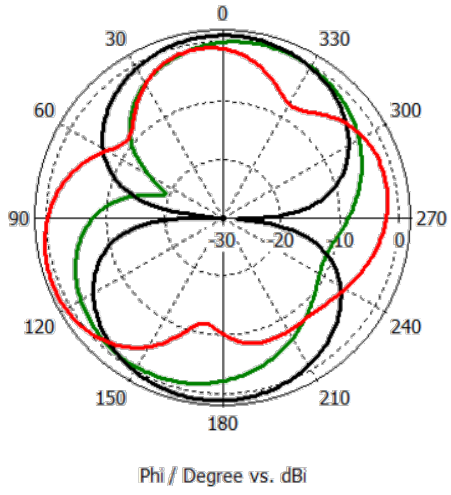
Measure	mm
A	1.875
B	4.85 -1.35
C	0.5
D	1
E	6.9 – 3.8
F	7.6 – 4.2
G	4

Figure 6 - Footprint dimensions for the NANO mXTEND™ (NN02-101) antenna booster (in the middle).

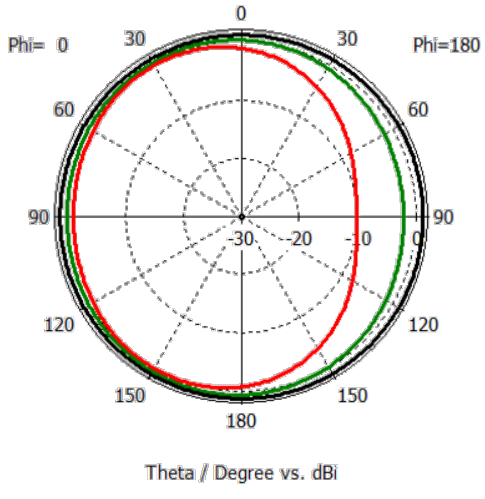
2.5. RADIATION PATTERNS (2.400 - 2.500 GHz), GAIN, AND EFFICIENCY



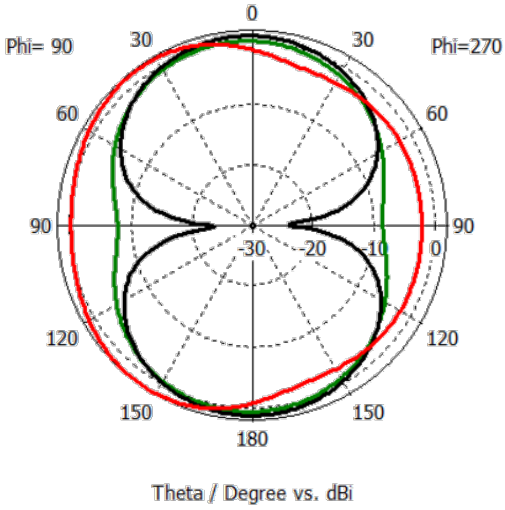
Measurement System Set-Up Evaluation Board in Plane XY



θ = 90º Plane XY at 2.44 GHz (80x40, 40x20, 40X5)



ϕ = 0º Plane XZ at 2.44 GHz (80x40, 40x20, 40X5)



ϕ = 90º Plane YZ at 2.44 GHz (80x40, 40x20, 40X5)

PCB80x40	**Gain**	**Peak Gain**	1.8 dBi
		Average Gain across the band	1.5 dBi
		Gain Range across the band (min, max)	0.8 dBi – 1.8 dBi
	Efficiency	**Peak Efficiency**	63.5%
		Average Efficiency across the band	58.9%
		Efficiency Range across the band (min, max)	50.9% – 63.5%

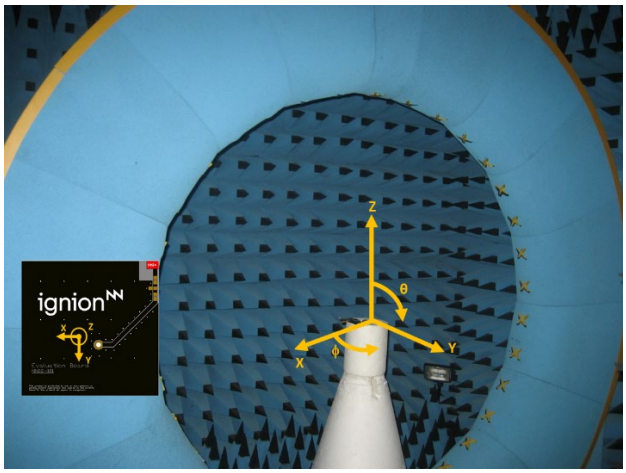
Table 4 - Antenna gain and total efficiency from the Evaluation Board of 80mm x 40mm (Figure 1) for BLE (2400 MHz - 2500MHz). Simulated results obtained with CST.

PCB40x20	**Gain**	**Peak Gain**	0.6 dBi
		Average Gain across the band	0.3 dBi
		Gain Range across the band (min, max)	-0.1 dBi – 0.6 dBi
	Efficiency	**Peak Efficiency**	64.2%
		Average Efficiency across the band	60.2%
		Efficiency Range across the band (min, max)	54.3% – 64.2%

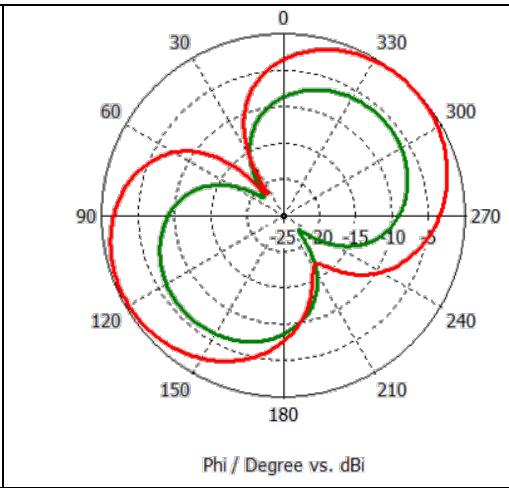
Table 5 - Antenna gain and total efficiency from the Evaluation Board of 40mm x 20mm (Figure 1) for BLE (2400 MHz - 2500MHz). Simulated results obtained with CST.

PCB40x5	**Gain**	**Peak Gain**	1.1 dBi
		Average Gain across the band	1.0 dBi
		Gain Range across the band (min, max)	0.6 dBi – 1.1 dBi
	Efficiency	**Peak Efficiency**	80.3%
		Average Efficiency across the band	77.1%
		Efficiency Range across the band (min, max)	71.5% – 80.3%

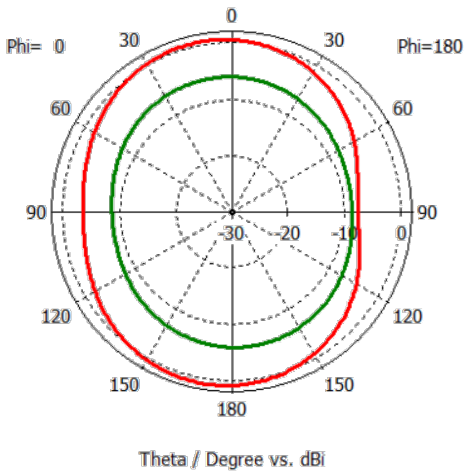
Table 6 - Antenna gain and total efficiency from the Evaluation Board of 40mm x 5mm (Figure 1) for BLE (2400 MHz - 2500MHz). Simulated results obtained with CST.



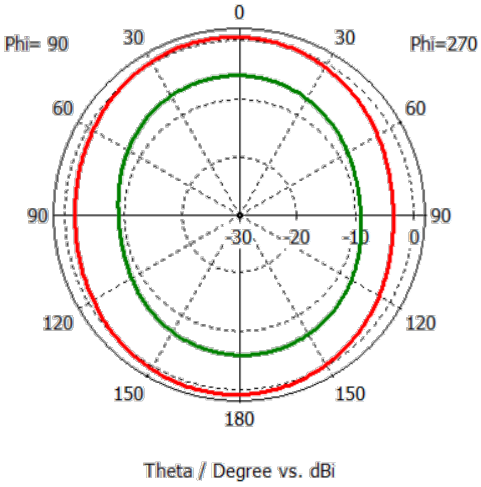
Measurement System Set-Up Evaluation Board in Plane XY



θ = 90º Plane XY at 2.44 GHz (35x35, 15x10)



ϕ = 0º Plane XZ at 2.44 GHz (35x35, 15x10)



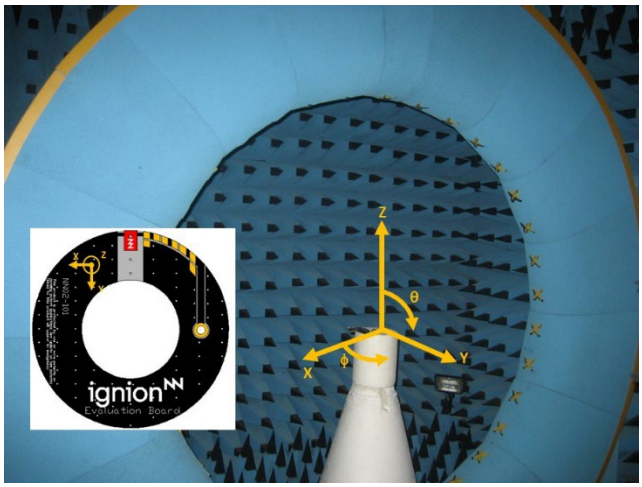
ϕ = 90º Plane YZ at 2.44 GHz (35x35, 15x10)

PCB35x35	**Gain**	**Peak Gain**	0.8 dBi
		Average Gain across the band	0.6 dBi
		Gain Range across the band (min, max)	0.1 dBi – 0.8 dBi
	Efficiency	**Peak Efficiency**	65.6%
		Average Efficiency across the band	62.0%
		Efficiency Range across the band (min, max)	56.8% – 65.6%

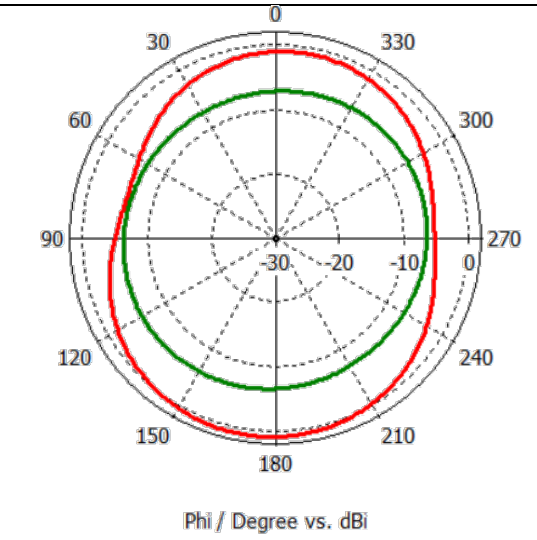
Table 7 - Antenna gain and total efficiency from the Evaluation Board of 35mm x 35mm (Figure 1) for BLE (2400 MHz - 2500MHz). Simulated results obtained with CST.

PCB15x10	Gain	Peak Gain	-6.0 dBi
		Average Gain across the band	-6.7 dBi
		Gain Range across the band (min, max)	-7.8 dBi – -6.0 dBi
	Efficiency	Peak Efficiency	16.7%
		Average Efficiency across the band	14.2%
		Efficiency Range across the band (min, max)	11.0% – 16.7%

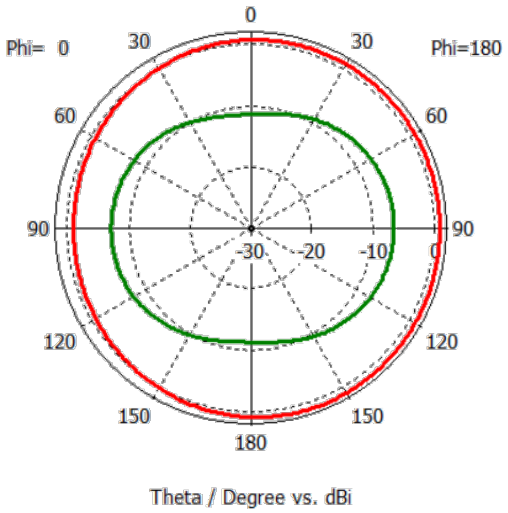
Table 8 - Antenna gain and total efficiency from the Evaluation Board of 15mm x 10mm (Figure 1) for BLE (2400 MHz - 2500MHz). Simulated results obtained with CST.



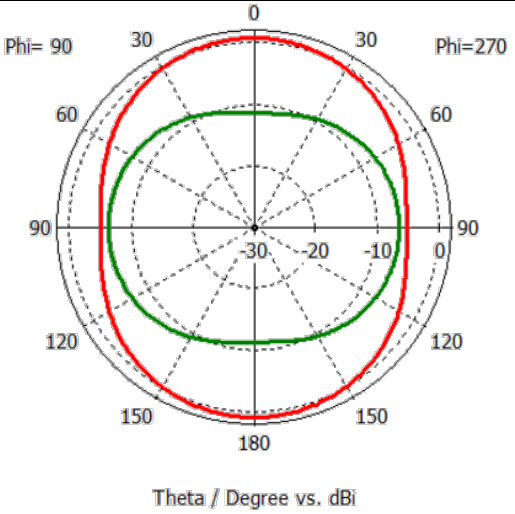
Measurement System Set-Up
Evaluation Board in Plane XY



θ = 90º Plane XY at 2.44 GHz
(Diameter30, Diameter15)



ϕ = 0º Plane XZ at 2.44 GHz
(Diameter30, Diameter15)



ϕ = 90º Plane YZ at 2.44 GHz
(Diameter30, Diameter15)

PCBDiameter 30	**Gain**	**Peak Gain** (150x75)	1.0 dBi
		Average Gain across the band (150x75)	0.8 dBi
		Gain Range across the band (min, max) (150x75)	0.6 dBi – 1.0 dBi
	Efficiency	**Peak Efficiency** (150x75)	80.5%
		Average Efficiency across the band (150x75)	77.6%
		Efficiency Range across the band (min, max) (150x75)	73.4% – 80.5%

Table 9 - Antenna gain and total efficiency from the Evaluation Board of diameter 30mm (Figure 1) for BLE (2400 MHz - 2500MHz). Simulated results obtained with CST.

PCBDiameter 15	**Gain**	**Peak Gain** (150x75)	-6.0dBi
		Average Gain across the band (150x75)	-7.0 dBi
		Gain Range across the band (min, max) (150x75)	-8.7 dBi – -6.0 dBi
	Efficiency	**Peak Efficiency** (150x75)	16.4%
		Average Efficiency across the band (150x75)	13.2%
		Efficiency Range across the band (min, max) (150x75)	13.2% – 16.4%

Table 10 - Antenna gain and total efficiency from the Evaluation Board of diameter 15mm (Figure 1) for BLE (2400 MHz - 2500MHz). Simulated results obtained with CST.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 674491

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

ISO 9001: 2015

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