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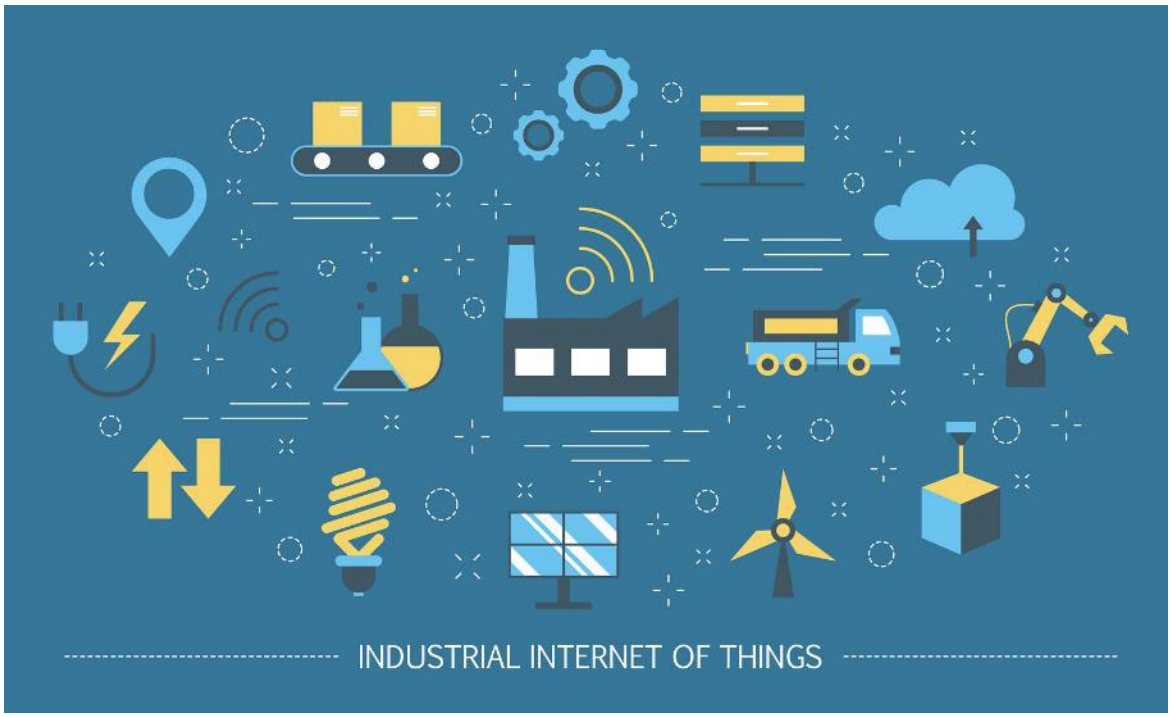
ISM and Bluetooth® in a single antenna

APPLICATION NOTE
RUN mXTEND™ (NN02-224)

RUN mXTEND™ – GO IoT ORIENTED: ISM & BLUETOOTH, ALL IN ONE PIECE

- **Antenna component:** RUN mXTEND™ NN02-224
- **Dimensions :** 12.0 mm x 3.0 mm x 2.4 mm
- **Frequency regions:** 863 – 928MHz and 2400 – 2500MHz



To make cost-effective oriented the **industrial**, **scientific** and **medical IoT** we have compacted the **ISM** bands (LoRa, LoRaWAN, Sigfox, Simphony, ZigBee) including **Bluetooth** within the same antenna component.

The application of the IoT technologies has arrived at the industrial sector. The industrial, scientific and medical traditional applications, covering with the ISM bands need to grow with the IoT environment and features: the need of having a **wireless connection saving cost**, **time-to-market** and **space**.

Within this application note you can check how you can build different devices: a smart grid platform, any wireless sensor or a medical device by using a **tiny**, **multipurpose** and **pick & place assembly** antenna component, the **RUN mXTEND™**.

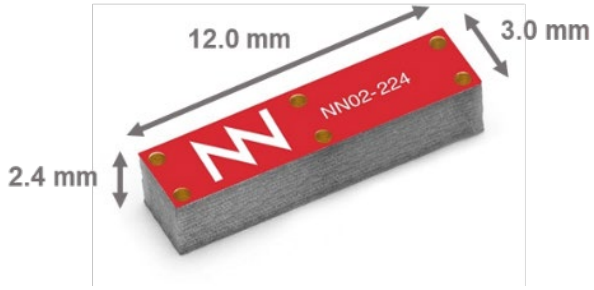
Group the desired **ISM bands**, including Bluetooth (863 – 928MHz and 2400 – 2500MHz), in one chip antenna component and join the new IoT concept in the **easiest**, **fastest**, **cheapest** possible way.

TABLE OF CONTENTS

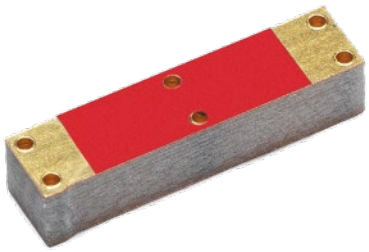
1. PRODUCT DESCRIPTION NN02-224

The RUN mXTEND™ antenna booster has been specifically designed for providing multiband performance in wireless devices, enabling worldwide coverage by allowing operation in the mobile/IoT communication standards. This application note shows how RUN mXTEND™ can be used to provide coverage in the ISM868/915 and 2.4GHz frequency bands to combine wireless services such as ISM868/915, LoRa, LoRaWAN, Sigfox, Simphony, ZigBee, and Bluetooth/WIFI for IoT applications. A single antenna is used for both frequency regions saving PCB size and cost.

TOP



BOTTOM



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

APPLICATIONS

- IoT devices
- Modules
- Routers
- Handsets and smartphones
- Tablets
- Digital cameras
- Smartwatches and wearables

BENEFITS

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

The RUN 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, general purpose, and off-the-shelf components.

2. ELECTRICAL PERFORMANCE

2.1. EVALUATION BOARD FOR ISM868-915 AND BLUETOOTH

Considering using a single antenna for your new ISM/Bluetooth device? The following solution explains how the RUN mXTEND™ antenna booster provides operation in the frequency regions ISM868/915 (863 MHz to 915 MHz) and Bluetooth (2400 MHz to 2500 MHz), through a single input/output port.

Measure	mm
A	131
B	120
C	60
D	8.0
E	5.0
F	11.0

Tolerance: ±0.2 mm

D: Distance between the RUN mXTEND™ antenna booster and the ground plane.

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

Clearance Area: 60 mm x 11 mm (CxF)

Figure 1 – EB_NN02-224-ISM-BT. Evaluation Board providing operation from 863 MHz to 928 MHz and from 2400 MHz to 2500MHz.

2.2. VSWR AND TOTAL EFFICIENCY

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

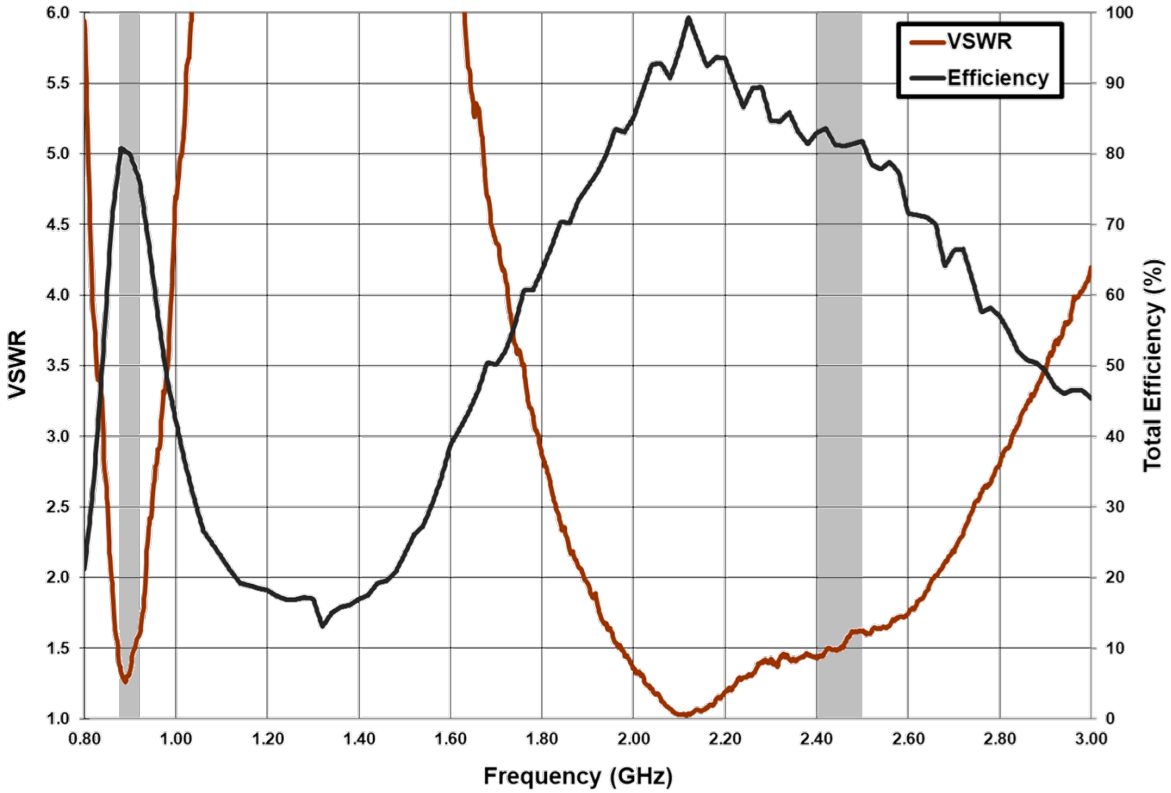
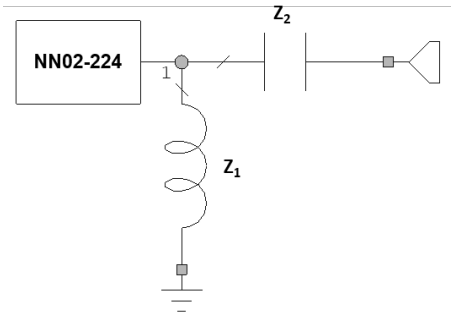


Figure 2 – VSWR and Total Efficiency for the 863 – 928 MHz and 2400 – 2500MHz from the evaluation board (Figure 1).

2.3. MATCHING NETWORK

The matching network and value components for these devices and PCB sizes are provided below. While the RUN mXTEND™ antenna booster remains the same in all the platforms the matching network topology and value of its components is adapted to every different PCB size for an optimum performance. The specs of a Ignion standard product are measured in a reference evaluation board, to isolate the antenna performance from other system elements. However, when incorporating into real designs, nearby components such as LCD's, batteries, covers and connectors may affect the antenna performance. For this reason, placing pads compatible with 0402 and 0603 SMD components for a matching network as close as possible to the feeding point is highly recommended. The matching network should be implemented in the ground plane area rather than the clearance area, this will provide a degree of freedom for tuning the RUN mXTEND™ antenna booster once the design is finished, taking into account all elements of the system (batteries, displays, covers, etc.). To ensure optimal results, the use of high Q and tight tolerance components is highly recommended (Murata components).

863 – 928 MHz and 2400 – 2500 MHz



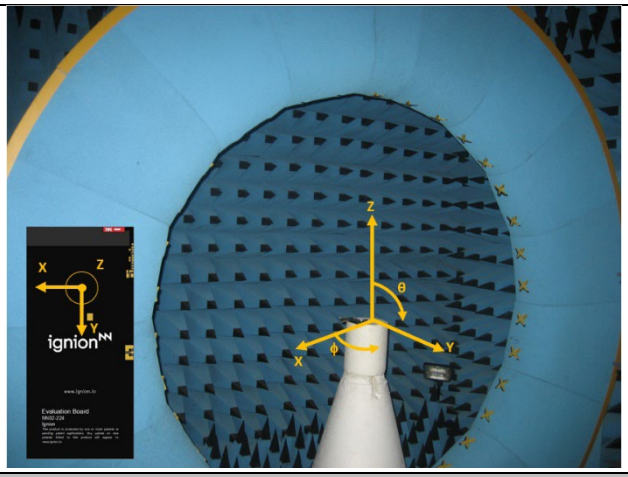
Z	Value	Part Number
Z_1	18 nH	LQW18AN18NG80
Z_2	0.6 pF	GJM1555C1HR60WB01

Figure 3 – Matching Network implemented in the evaluation board (Figure 1) and Values of the components for each PCB dimensions

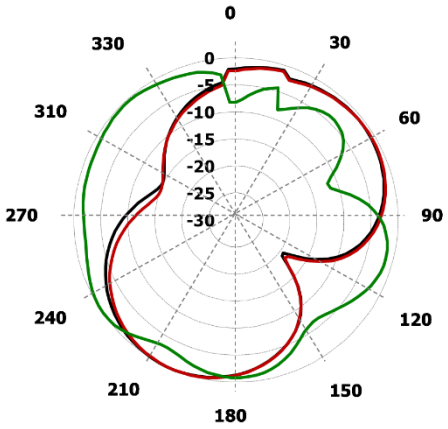
If you need assistance to design your matching network, please contact support@ignion.io, or try our free-of-charge[1] Antenna Intelligence Cloud design service, which will get you a chip antenna design including a custom matching network for your device in 24h[1]. Other information related to Ingion's 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/

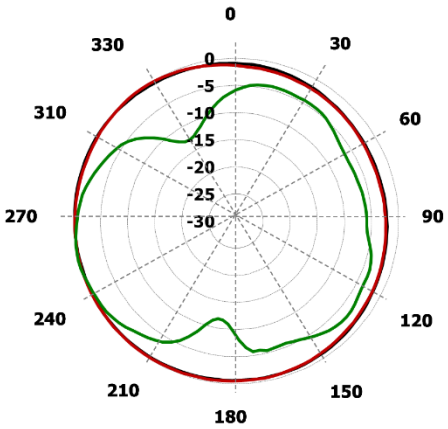
2.4. RADIATION PATTERNS ISM868/915 and BLUETOOTH, GAIN AND EFFICIENCY



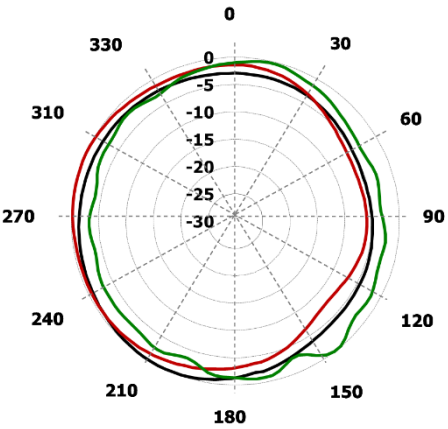
Measurement System Set-Up Evaluation Board in Plane XY



θ = 90º Plane XY at 868 MHz, 915 MHz, and 2450 MHz



ϕ = 0º Plane XZ at 868 MHz, 915 MHz, and 2450 MHz



ϕ = 90º Plane YZ at 868 MHz, 915 MHz, and 2450 MHz

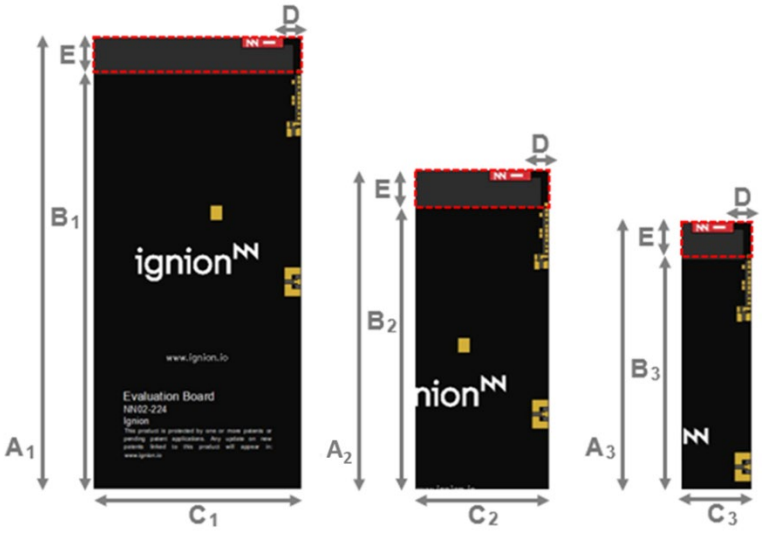
ISM868/915	**Gain**	**Peak Gain**	1.6 dBi
		Average Gain across the band	1.4 dBi
		Gain Range across the band (min, max)	1.0 **<–>** 1.6 dBi
	Efficiency	**Peak Efficiency**	80.7 %
		Average Efficiency across the band	77.9 %
		Efficiency Range across the band (min, max)	71.1 – 80.7 %
Bluetooth	**Gain**	**Peak Gain**	2.9 dBi
		Average Gain across the band	2.8 dBi
		Gain Range across the band (min, max)	2.8 **<–>** 2.9 dBi
	Efficiency	**Peak Efficiency**	83.8 %
		Average Efficiency across the band	82.1 %
		Efficiency Range across the band (min, max)	81.1 – 83.8 %

Table 1 – Antenna Gain and Total Efficiency from the evaluation board (Figure 1) within the ISM868/915 (863 – 928 MHz) and Bluetooth (2400 – 2500 MHz) band. Measures made in the STARLAB 18 anechoic chamber.

3. ISM863/915 AND BLUETOOTH SOLUTION WITH DIFFERENT PCB DIMENSIONS FOR SEVERAL DEVICES

3.1. DIFFERENT EVALUATION BOARDS FOR MULTIPLE SOLUTIONS

The following solution explains how the RUN mXTEND™ antenna booster provides operation in the frequency regions ISM868/915 (863 MHz to 915 MHz) and Bluetooth (2400 MHz to 2500 MHz), through a single input/output port. The design is shown in 3 different IoT boards sizes, all of them reusing exacting the same component but just a different matching network.



Measure	mm
$A_{1\text{-}2\text{-}3}$	131 - 93 - 76
$B_{1\text{-}2\text{-}3}$	120 - 82 - 65
$C_{1\text{-}2\text{-}3}$	60 - 38 - 20
D	5.0
E	11.0

Tolerance: ±0.2 mm

E: Distance between the edge of the PCB and the ground plane.

Clearance area: 11mm x $C_{1\text{-}2\text{-}3}$ mm (red dotted square)

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

Figure 4 – Evaluation Board with different size dimensions providing operation from 863 MHz to 928 MHz and from 2400 MHz to 2500 MHz.

3.2. VSWR AND TOTAL EFFICIENCY

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

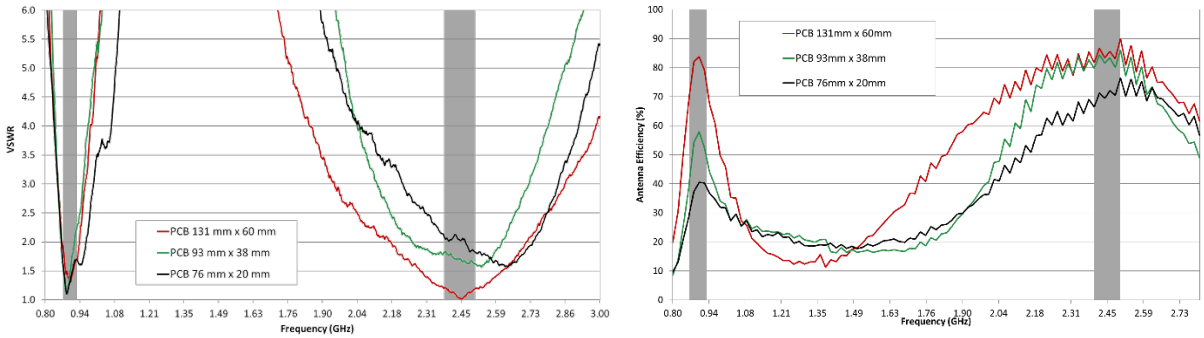


Figure 5 – VSWR and Total Efficiency for the 863 – 928 MHz and 2400 – 2500MHz from the evaluation board (Figure 4).

	LFR (863 – 928 MHz)					HFR (2400 – 2500 MHz)				
A	**$\eta_{a\ 863MHz}$**	**$\eta_{a\ 928MHz}$**	**Min**	**Max**	**Av. η_a**	**$\eta_{a\ 2400MHz}$**	**$\eta_{a\ 2500MHz}$**	**Min**	**Max**	**Av. η_a**
131mm x 60mm	70.5	74.5	70.5	83.7	79.9	81.8	89.8	81.8	89.8	84.9
93mm x 38mm	40.9	49.1	40.9	57.8	52.8	79.9	85.9	79.9	85.9	82.5
76mm x 20mm	29.9	38.8	29.9	36.8	40.4	66.6	76.3	66.6	76.3	70.9

Table 2 – Antenna efficiency (%) comparison considering the different PCB dimensions.

3.3. MATCHING NETWORK

The matching network and value components for these devices and PCB sizes are provided below. While the RUN mXTEND™ antenna booster remains the same in all the platforms the matching network topology and value of its components is adapted to every different PCB size for an optimum performance. The specs of a Ignion standard product are measured in a reference evaluation board, to isolate the antenna performance from other system elements. However, when incorporating into real designs, nearby components such as LCD's, batteries, covers and connectors may affect the antenna performance. For this reason, placing pads compatible with 0402 and 0603 SMD components for a matching network as close as possible to the feeding point is highly recommended. The matching network should be implemented in the ground plane area rather than the clearance area, this will provide a degree of freedom for tuning the RUN mXTEND™ antenna booster once the design is finished, taking into account all elements of the system (batteries, displays, covers, etc.). To ensure optimal results, the use of high Q and tight tolerance components is highly recommended (Murata components).

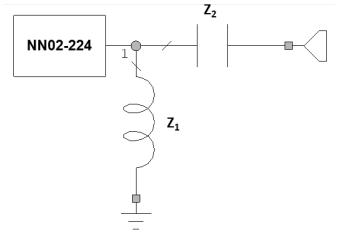
863 – 928 MHz and 2400 – 2500 MHz			
	**PCB dimensions (mm x mm)**	**Z1 [Value (Part Number)]**	**Z2 [Value (Part Number)]**
	131 x 60	19 nH (LQW18AN19NG80)	0.6 pF (GJM1555C1HR60WB01)
	93 x 38	19 nH (LQW18AN19NG80)	0.6 pF (GJM1555C1HR60WB01)
	76 x 20	18 nH (LQW18AN18NG80)	0.7 pF (GJM1555C1HR70WB01)

Figure 6 – Matching Network implemented in the evaluation board (Figure 4) and values of the components for each PCB dimensions.

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, which will get you a chip antenna design including a custom matching network for your device in 24h[2]. Other information related to Ingion's range of R&D services is available at: https://www.ignion.io/rdservices/

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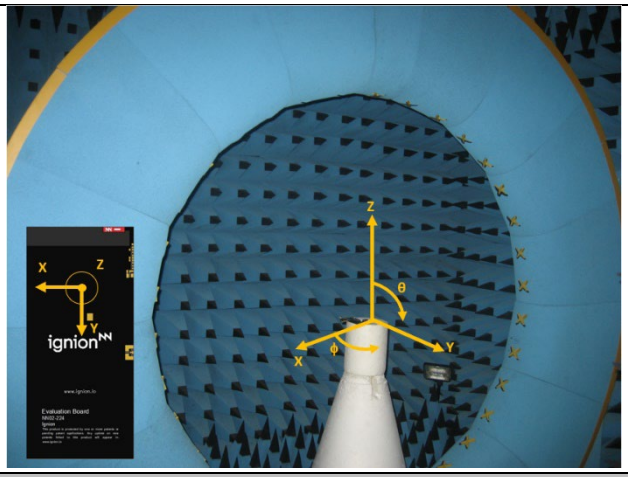
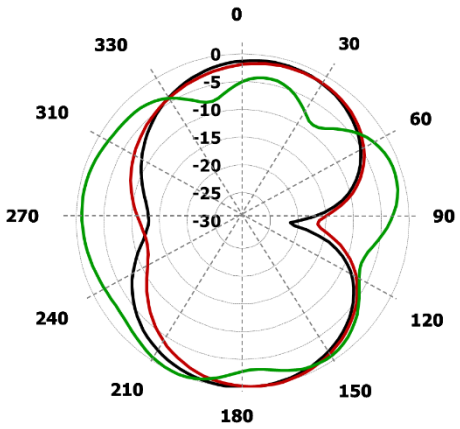
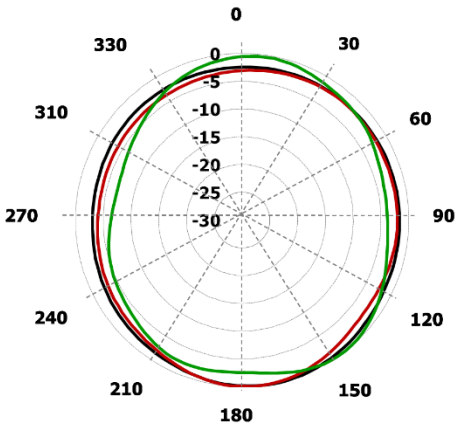
3.4. RADIATION PATTERNS ISM868/915 and Bluetooth, GAIN AND EFFICIENCY for a 131mm x 60mm PCB size



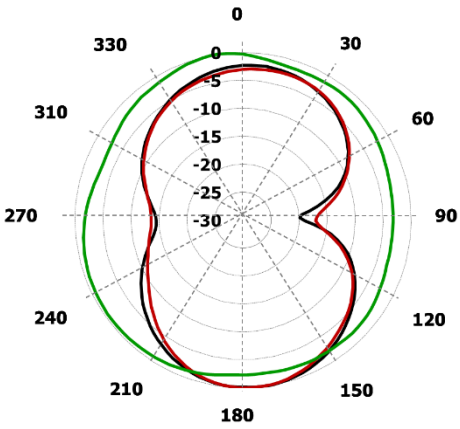
Measurement System Set-Up
Evaluation Board in Plane XY



θ = 90º Plane XY at 868 MHz, 915 MHz, and 2450 MHz



ϕ = 0º Plane XZ at 868 MHz, 915 MHz, and 2450 MHz

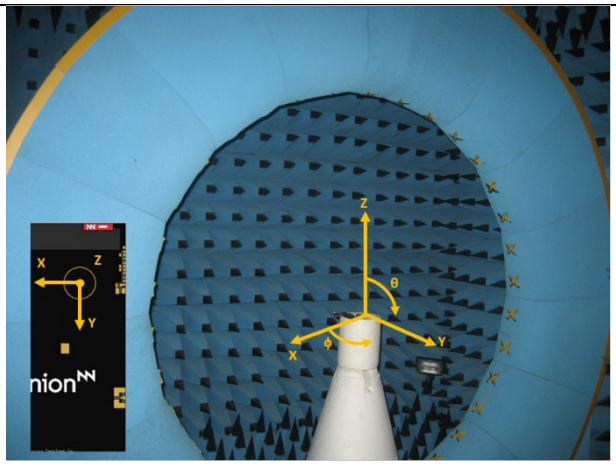


ϕ = 90º Plane YZ at 868 MHz, 915 MHz, and 2450 MHz

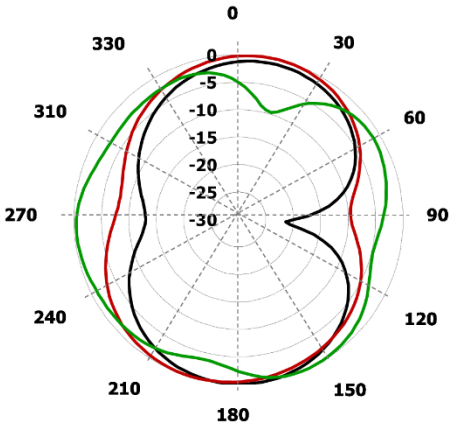
ISM868/915	**Gain**	**Peak Gain**	3.3 dBi
		Average Gain across the band	3.0 dBi
		Gain Range across the band (min, max)	2.2 **<–>** 3.3 dBi
	Efficiency	**Peak Efficiency**	83.7 %
		Average Efficiency across the band	79.9 %
		Efficiency Range across the band (min, max)	70.5 – 83.7 %
Bluetooth	**Gain**	**Peak Gain**	2.7 dBi
		Average Gain across the band	2.3 dBi
		Gain Range across the band (min, max)	2.0 **<–>** 2.7 dBi
	Efficiency	**Peak Efficiency**	89.8 %
		Average Efficiency across the band	84.9 %
		Efficiency Range across the band (min, max)	81.8 – 89.8 %

Table 3 – Antenna Gain and Total Efficiency from the evaluation board 131mm x 60mm PCB dimensions (Figure 4) within the ISM868/915 (863 – 928 MHz) and Bluetooth (2400 – 2500 MHz) band. Measures made in the STARLAB 18 anechoic chamber.

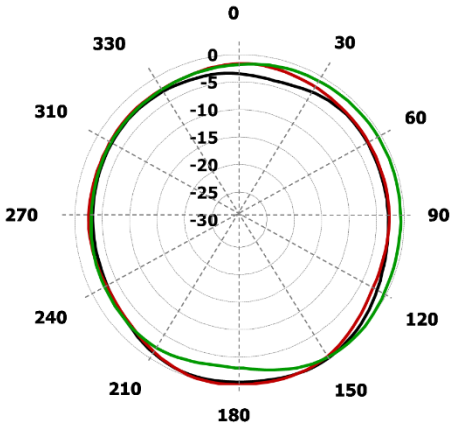
3.5. RADIATION PATTERNS ISM868/915 and Bluetooth, GAIN AND EFFICIENCY for a 93mm x 38mm PCB size



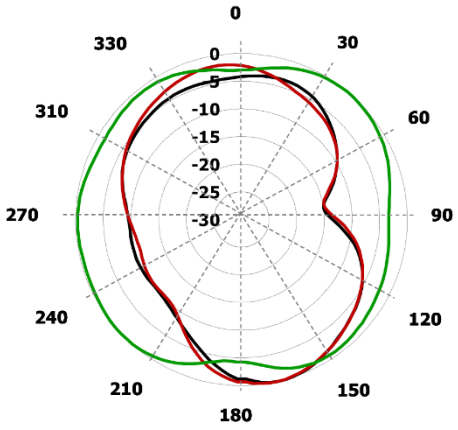
Measurement System Set-Up
Evaluation Board in Plane XY



θ = 90º Plane XY at 868 MHz, 915 MHz, and 2450 MHz



ϕ = 0º Plane XZ at 868 MHz, 915 MHz, and 2450 MHz

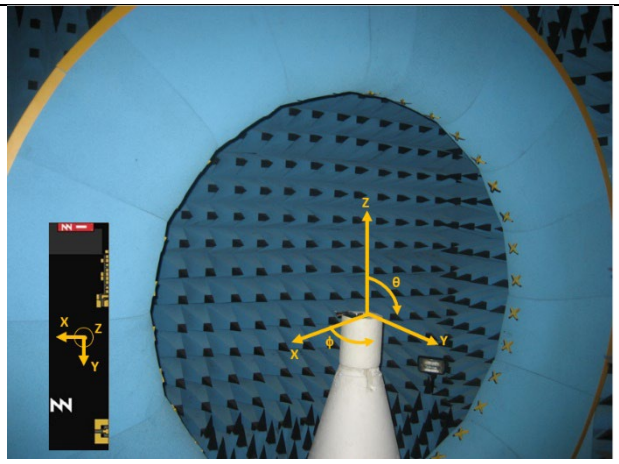


ϕ = 90º Plane YZ at 868 MHz, 915 MHz, and 2450 MHz

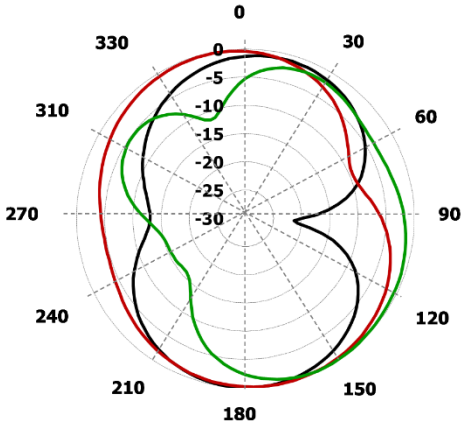
ISM868/915	**Gain**	**Peak Gain**	2.3 dBi
		Average Gain across the band	1.6 dBi
		Gain Range across the band (min, max)	0.2 **<–>** 2.3 dBi
	Efficiency	**Peak Efficiency**	57.8 %
		Average Efficiency across the band	52.8 %
		Efficiency Range across the band (min, max)	40.9 – 57.8 %
Bluetooth	**Gain**	**Peak Gain**	1.9 dBi
		Average Gain across the band	1.8 dBi
		Gain Range across the band (min, max)	1.7 **<–>** 1.9 dBi
	Efficiency	**Peak Efficiency**	85.9 %
		Average Efficiency across the band	82.5 %
		Efficiency Range across the band (min, max)	79.9 – 85.9 %

Table 4 – Antenna Gain and Total Efficiency from the evaluation board 93mm x 38mm PCB dimensions (Figure 4) within the ISM868/915 (863 – 928 MHz) and Bluetooth (2400 – 2500 MHz) band. Measures made in the STARLAB 18 anechoic chamber.

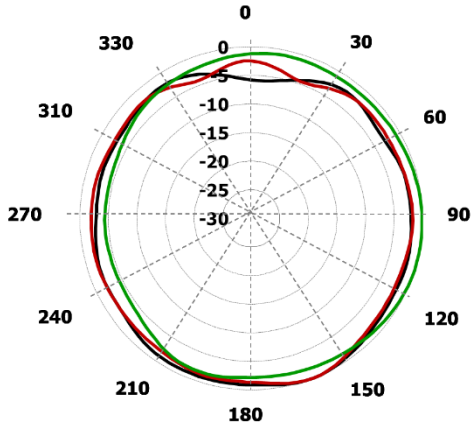
3.6. RADIATION PATTERNS ISM868/915 and Bluetooth, GAIN AND EFFICIENCY for a 76mm x 20mm PCB size



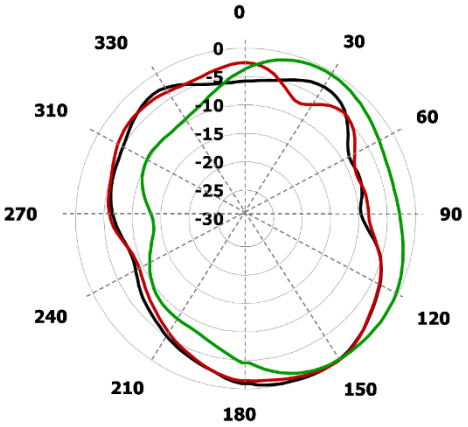
Measurement System Set-Up Evaluation Board in Plane XY



θ = 90º Plane XY at 868 MHz, 915 MHz, and 2450 MHz



ϕ = 0º Plane XZ at 868 MHz, 915 MHz, and 2450 MHz



ϕ = 90º Plane YZ at 868 MHz, 915 MHz, and 2450 MHz

ISM868/915	**Gain**	**Peak Gain**	0.4 dBi
		Average Gain across the band	-0.2 dBi
		Gain Range across the band (min, max)	-1.4 **<–>** 0.4 dBi
	Efficiency	**Peak Efficiency**	40.4 %
		Average Efficiency across the band	38.0 %
		Efficiency Range across the band (min, max)	29.9 – 40.4 %
Bluetooth	**Gain**	**Peak Gain**	3.4 dBi
		Average Gain across the band	2.9 dBi
		Gain Range across the band (min, max)	2.6 **<–>** 3.4 dBi
	Efficiency	**Peak Efficiency**	76.3 %
		Average Efficiency across the band	70.9 %
		Efficiency Range across the band (min, max)	66.6 – 76.3 %

Table 5 – Antenna Gain and Total Efficiency from the evaluation board 76mm x 20mm PCB dimensions (Figure 4) within the ISM868/915 (863 – 928 MHz) and Bluetooth (2400 – 2500 MHz) band. Measures made in the STARLAB 18 anechoic chamber.

The RUN mXTEND™ antenna booster 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

ignion

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Accelerated.

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