PARTNER WEBINAR

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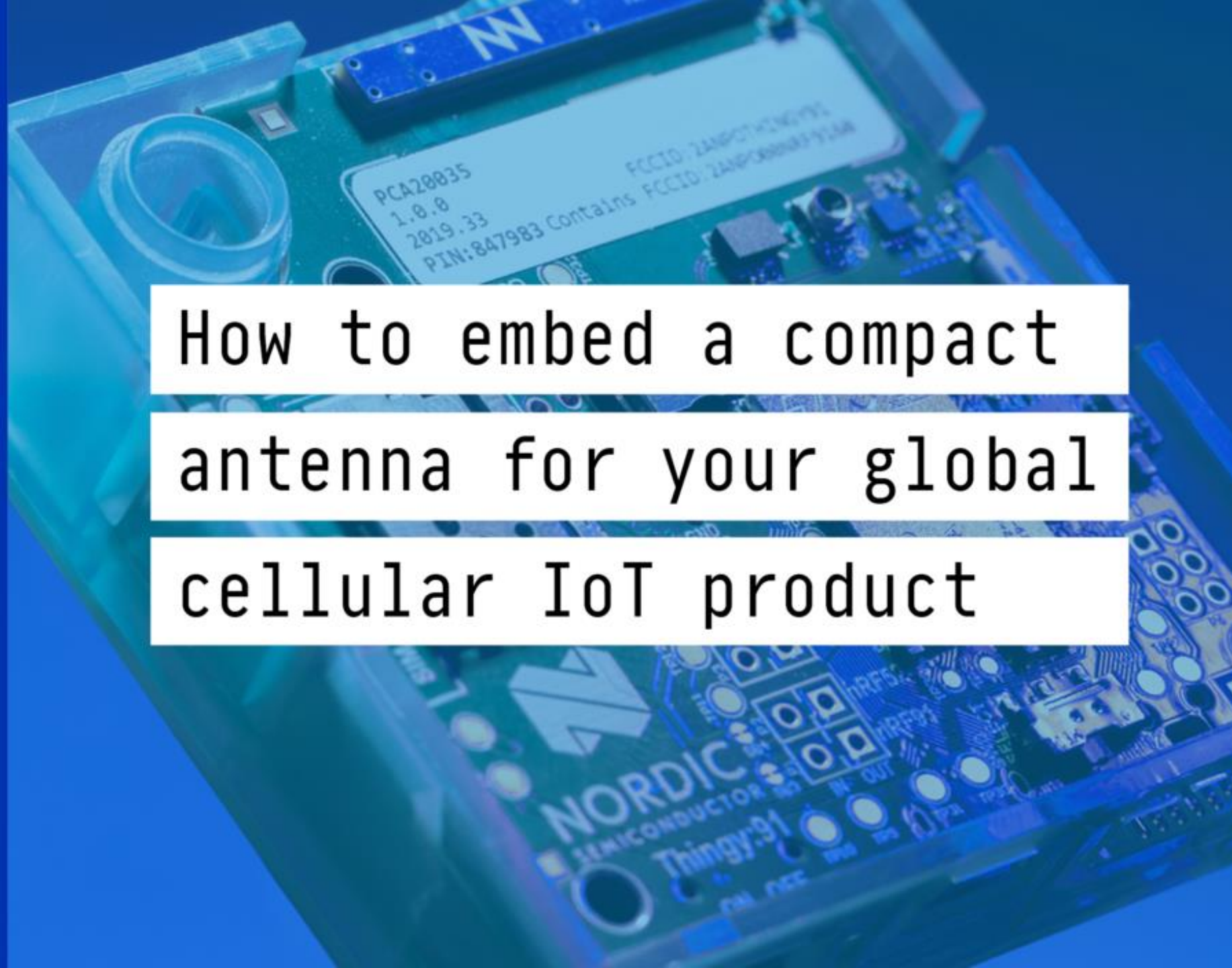
NORDICTECH WEBINARS



How to embed a compact antenna for your global cellular IoT product

Today's hosts

Petter Myhre

Head of Product Marketing

NORDIC SEMICONDUCTOR

Dr. Jaume Anguera

Co-Founder and CTO

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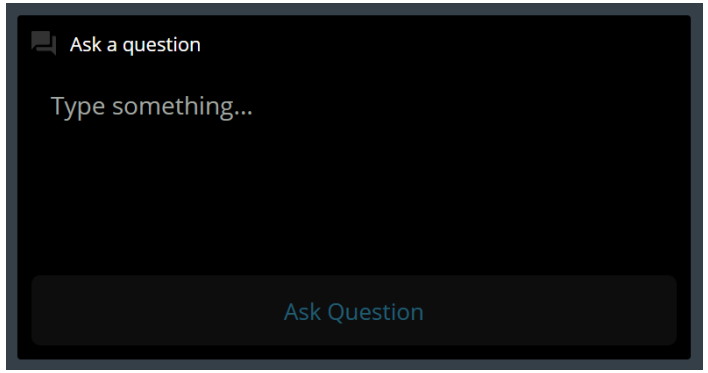
Practicalities

- Duration: ~60 mins
- Questions are encouraged!
- Please type questions in the top of the right sidebar
  - All questions are anonymous
  - Try to keep them relevant to the topic
- We will answer questions towards the end
- The chat is not anonymous, and should **not** be used for questions
- If you have more questions:
  - Go to DevZone for Nordic related questions
  - For questions to Ignion use support@ignion.io
- A recording of the webinar will be available together with the presentation at webinars.nordicsemi.com



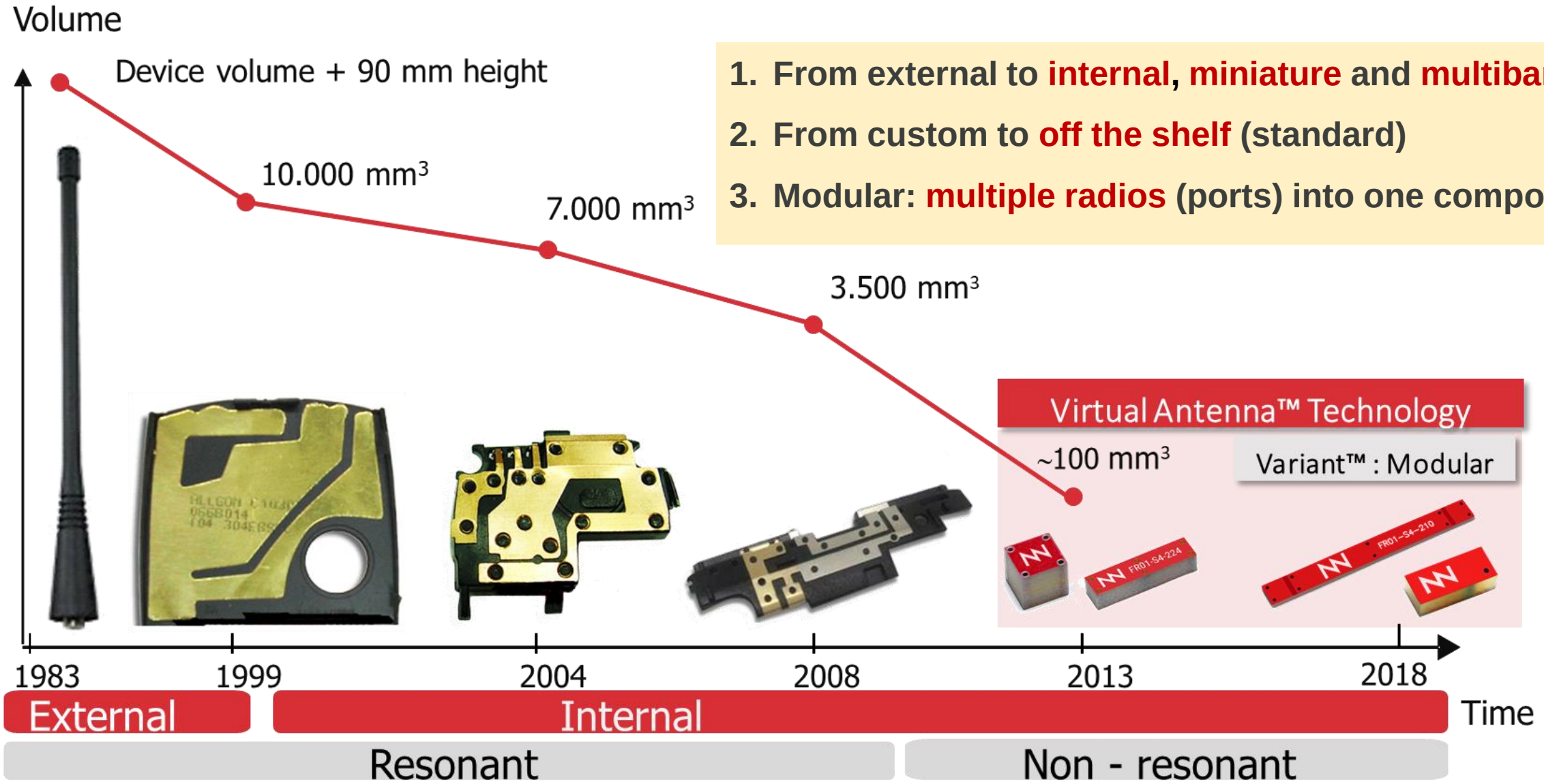
{ DevZone

Table of Contents

The first step…

…wins the battle

Antenna Evolution

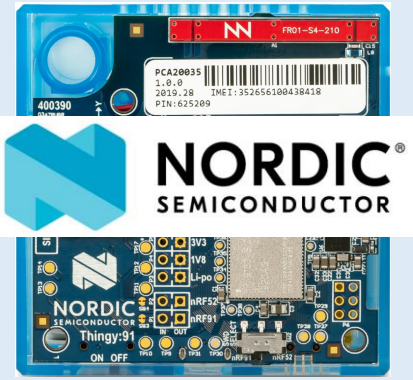


1. From external to **internal**, **miniature** and **multiband**
2. From custom to **off the shelf** (standard)
3. Modular: **multiple radios** (ports) into one component

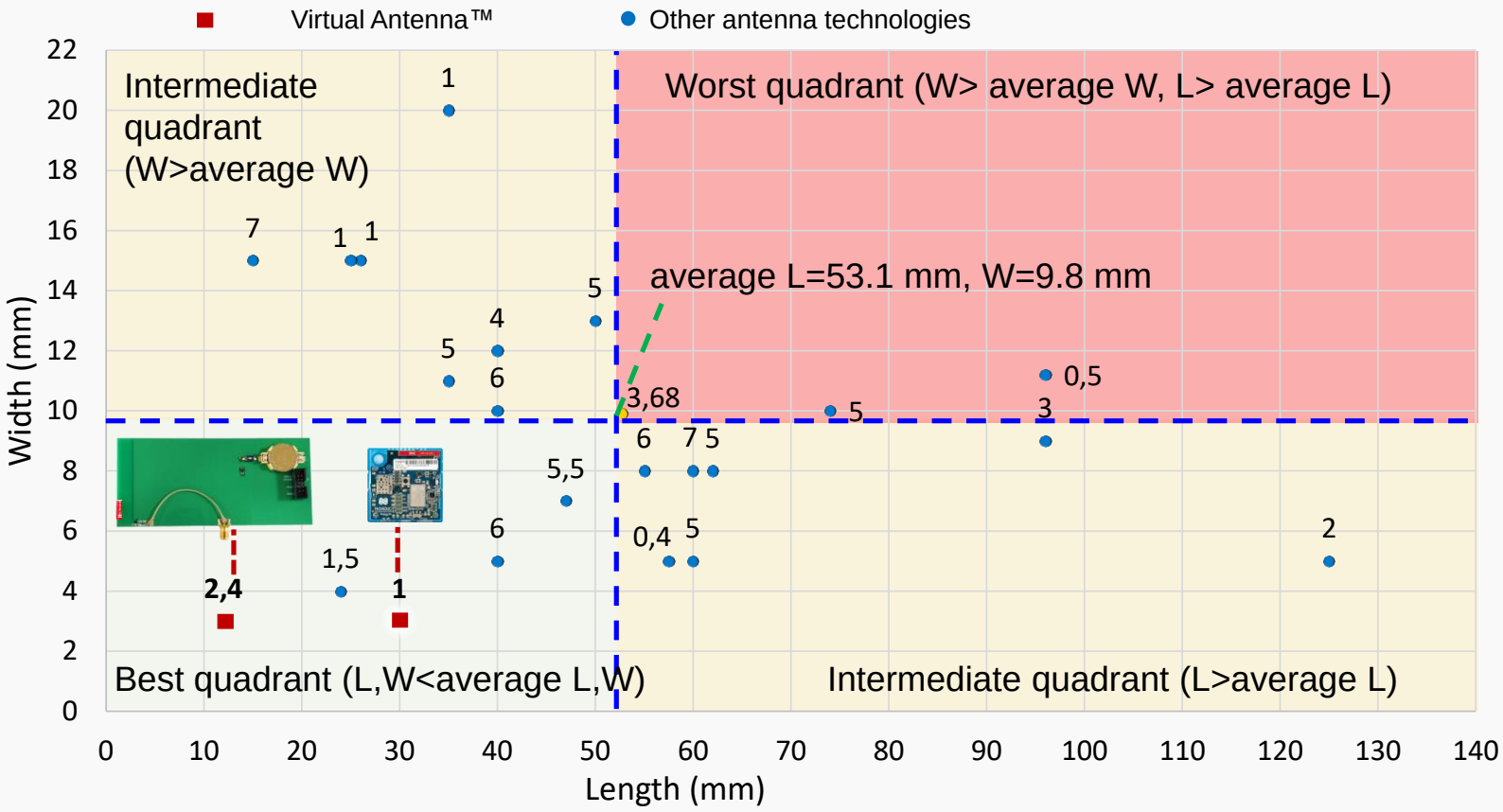
Virtual Antenna™ in the market

Already introduced in the market the following products and applications:

fleet management, smart tracking, smart metering, headsets, smart home, smart cities, alarms, IoT/Mobile modules, medical devices, IoT sensors



- Thingy:91 by **Nordic Semiconductor**
- **TRIO mXTEND™** by **NN**
- Global **Cellular IoT** with **embedded antenna**
- **Mobile + GPS** in a single antenna component



Virtual Antenna™ features

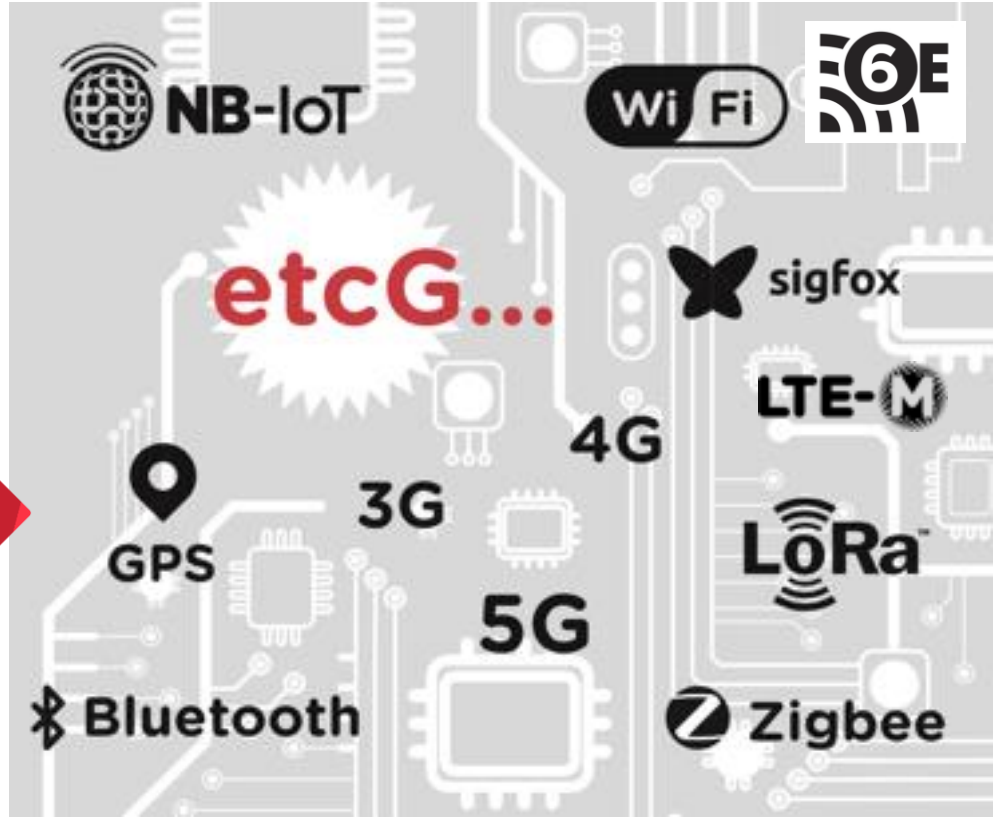
Use the **same antenna** in **every device**, **regardless of the form factor**. Change platform by just changing the matching network.

One antenna

Any band

Any device

Frequency is selected by the CUSTOMER, not by the antenna component



Use the **same antenna** for every **frequency band**, even for **multiple** of them all together (multiband design). Change protocol and frequency by **just changing the matching network**.

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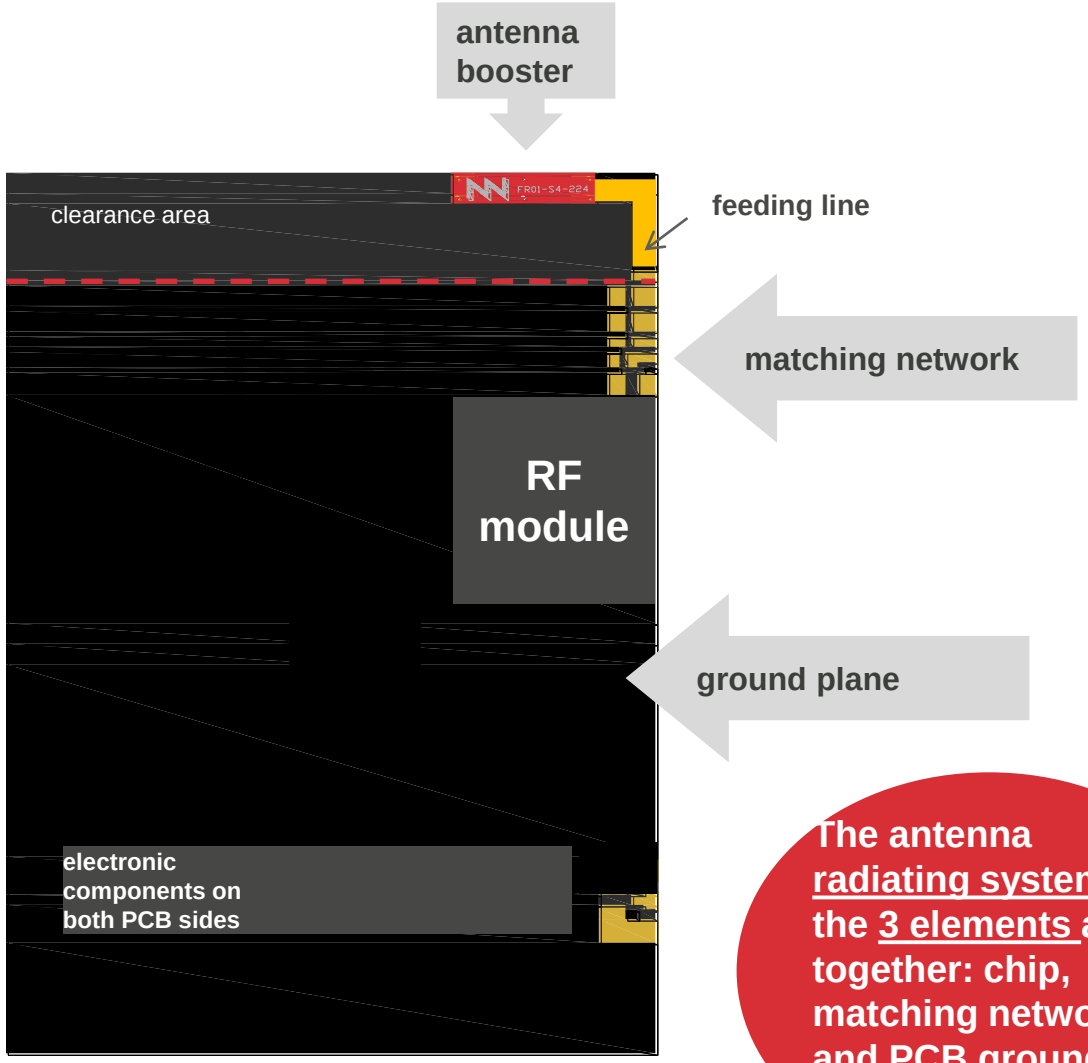
Table of Contents

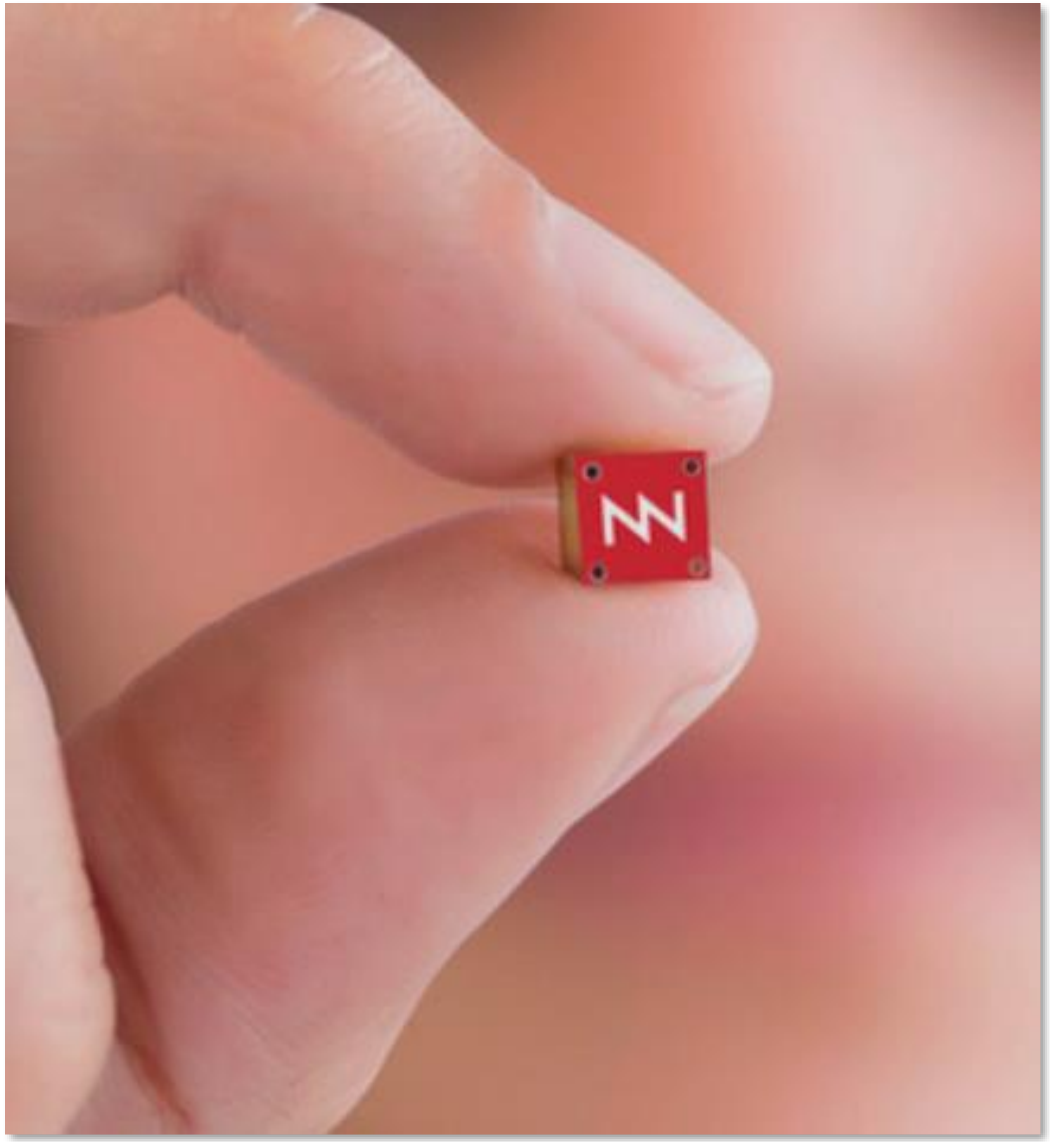
2. Virtual Antenna™ architecture

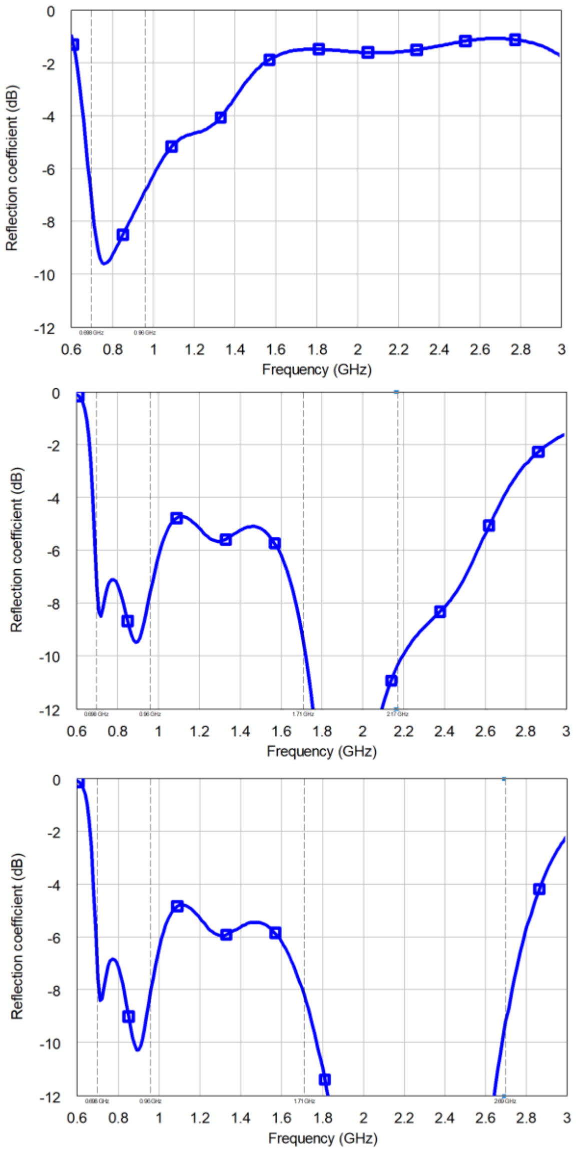


The antenna radiating system is the 3 elements all together: chip, matching network and PCB ground plane

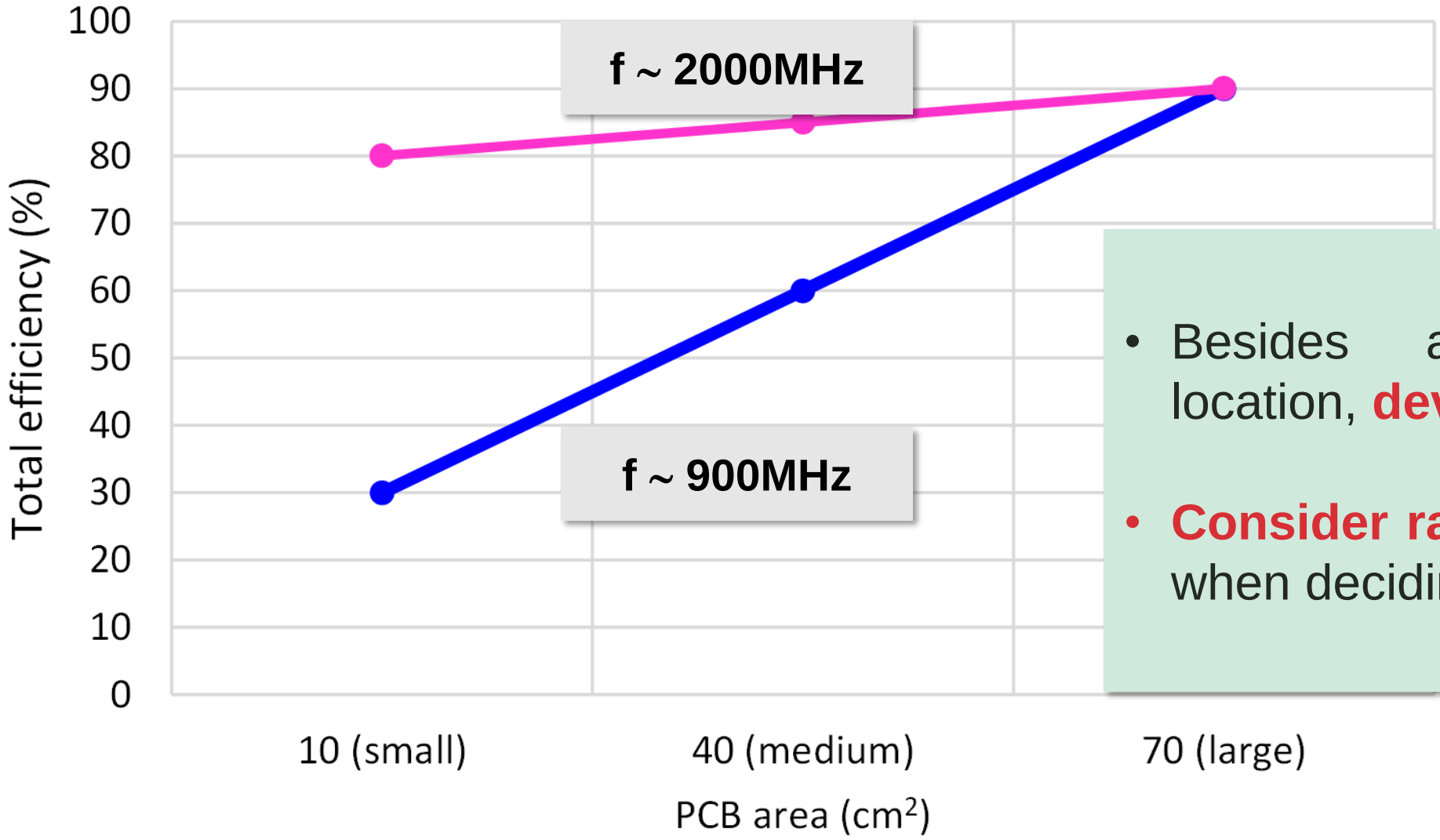
- **Virtual Antenna™ technology** is a new generation of chip antennas called **antenna boosters**.
- The system includes: an **antenna booster**, a **matching network** and a **ground plane**.
- Antenna booster **design** and **placement optimize radiation** from IoT system **ground plane**.
- Antenna booster design and placement enables packaging the antenna component in a **tiny** and **off-the-shelf chip** (**x10** times smaller).

Virtual Antenna™: select frequency operation





Besides antenna first, your IoT device size matters



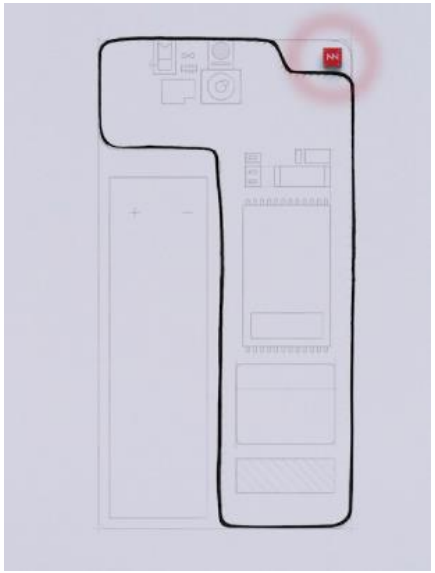
- Besides antenna booster location, **device size matters**
- **Consider radio performance** when deciding the device size

Note: Indicative measure values on a bare PCB

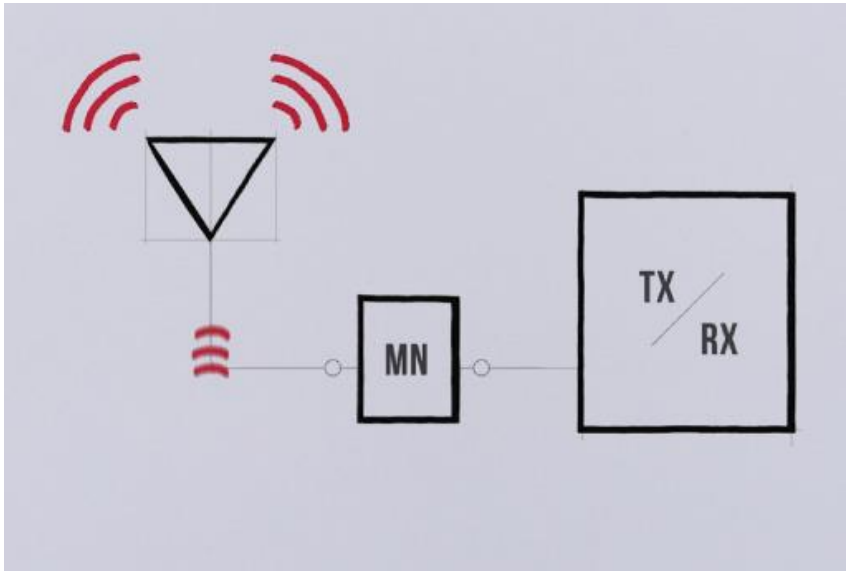
Table of Contents

3. Embed Virtual Antenna™ in 1,2,3

- Step #1. **Select** the best antenna booster and **place** it on the IoT device
- Step #2. **Design** the **matching network**
- Step #3. **Measure** the device



https://ignion.io/design-center/tutorials-webinars/



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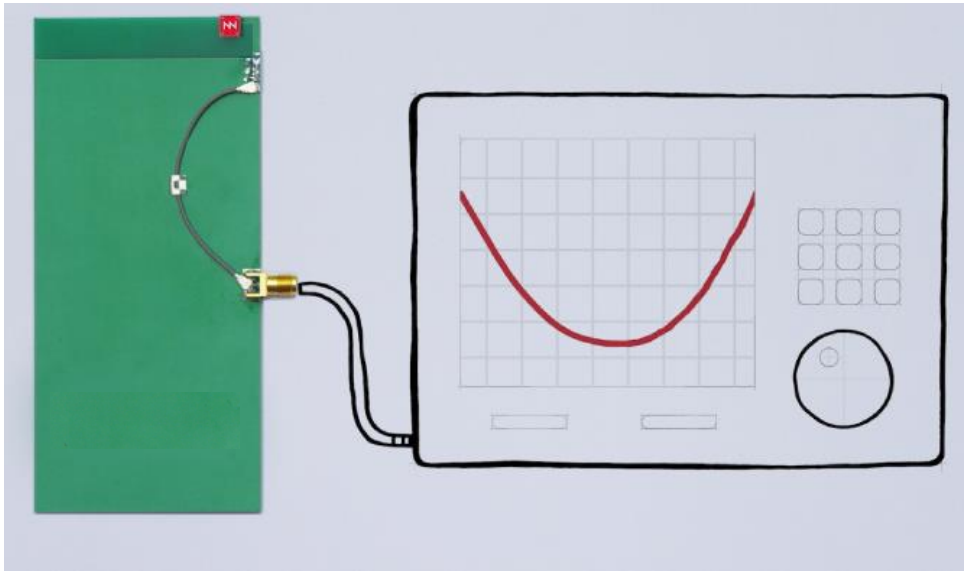
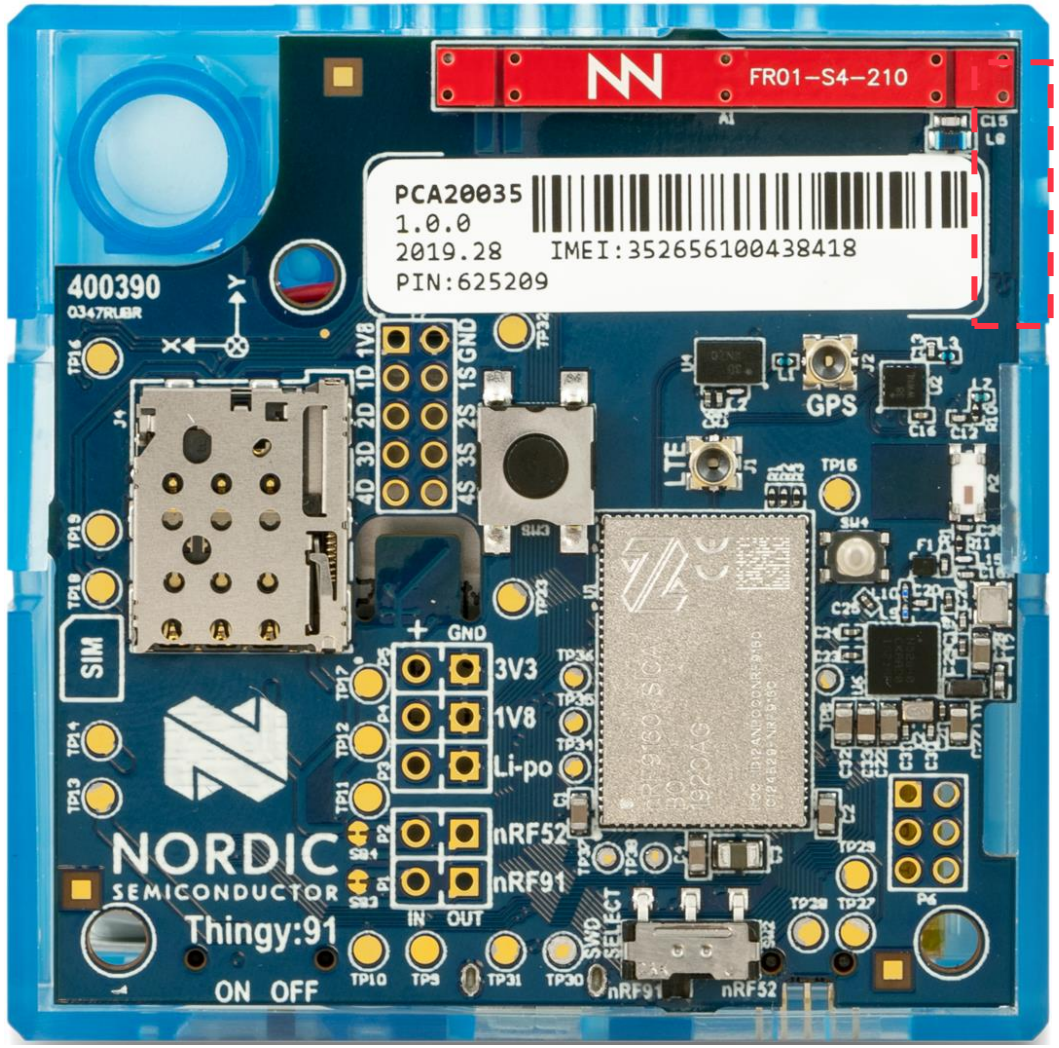
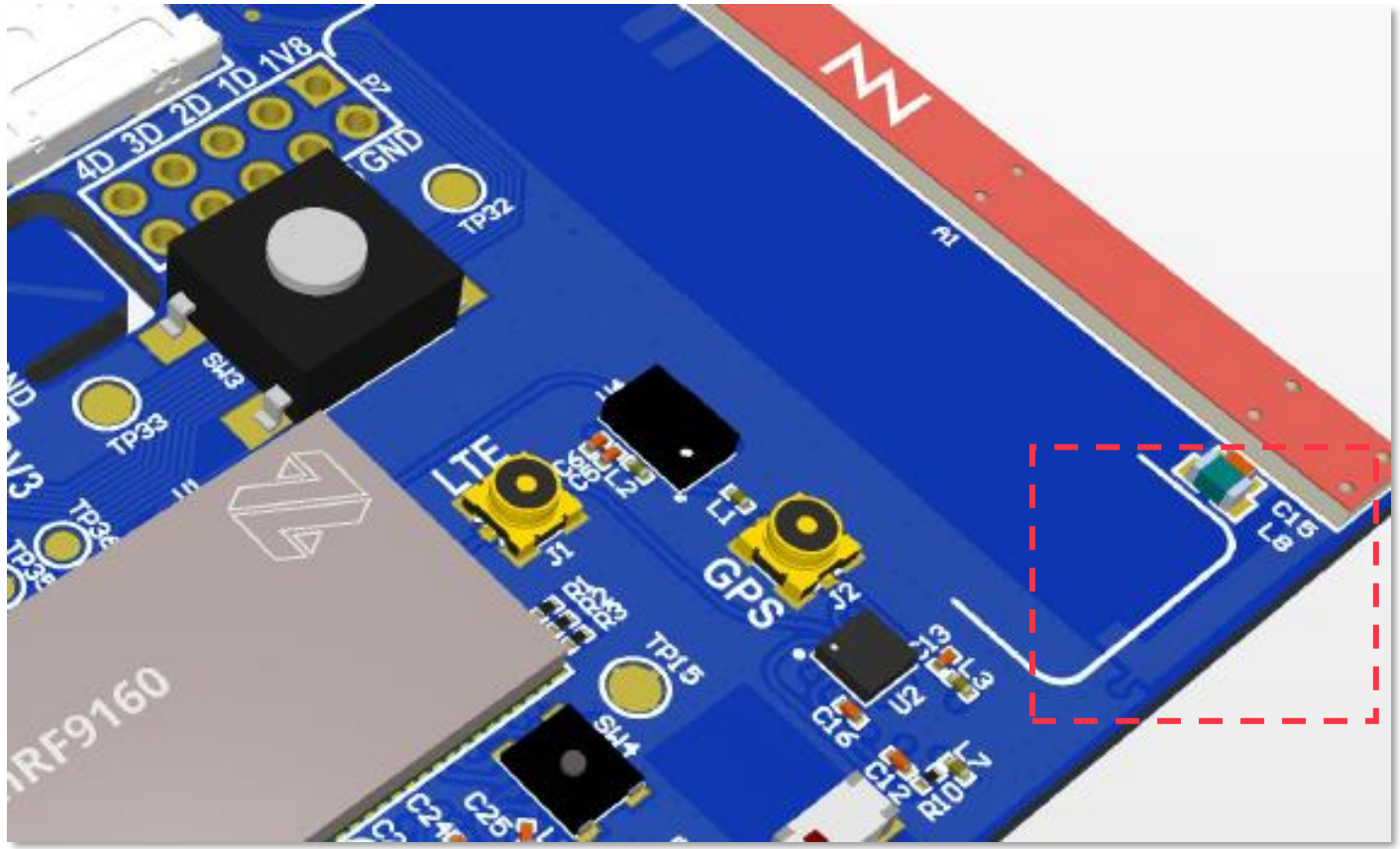


https://ignion.io/design-center/tutorials-webinars/

Step #1: Place your antenna booster

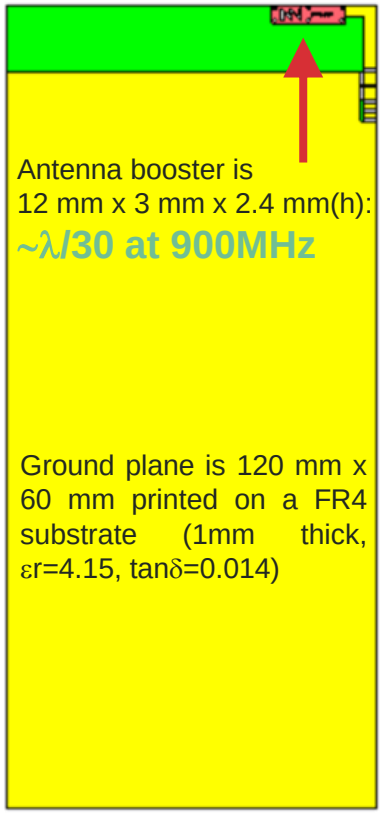


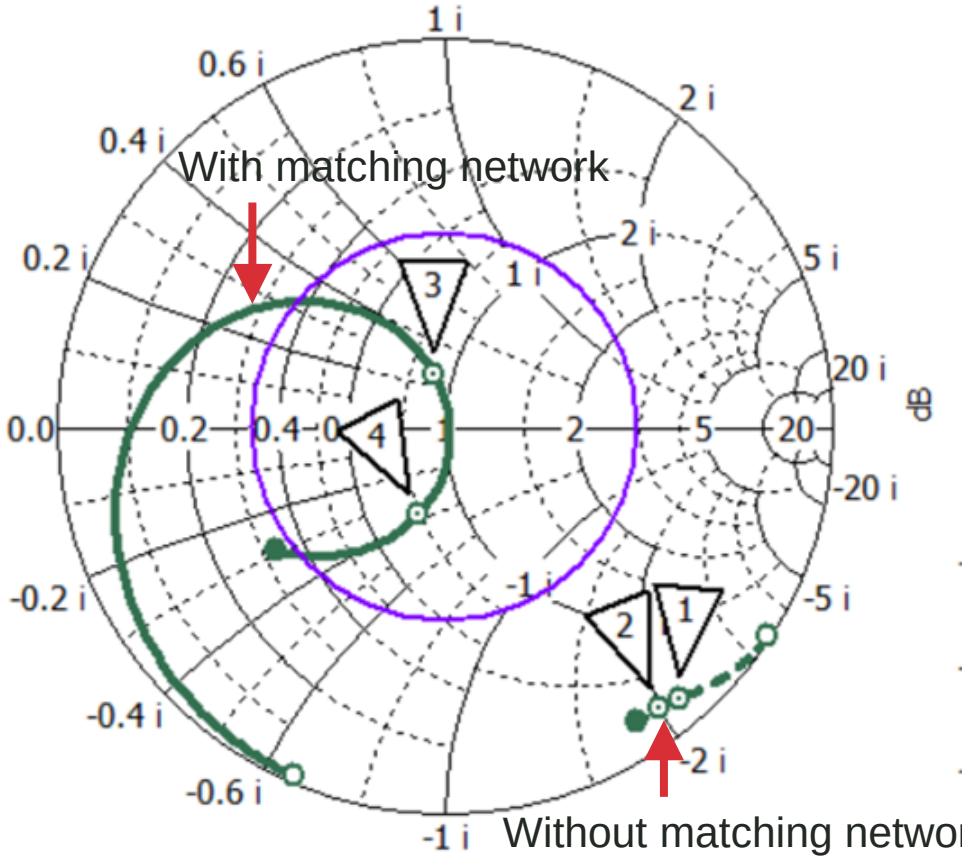


As a rule of thumb, placing the antenna booster at the **corner** provides **better bandwidth and efficiency**

Step #2: Design the matching network

- The antenna booster has a non-resonant impedance which can be easily matched with a matching network





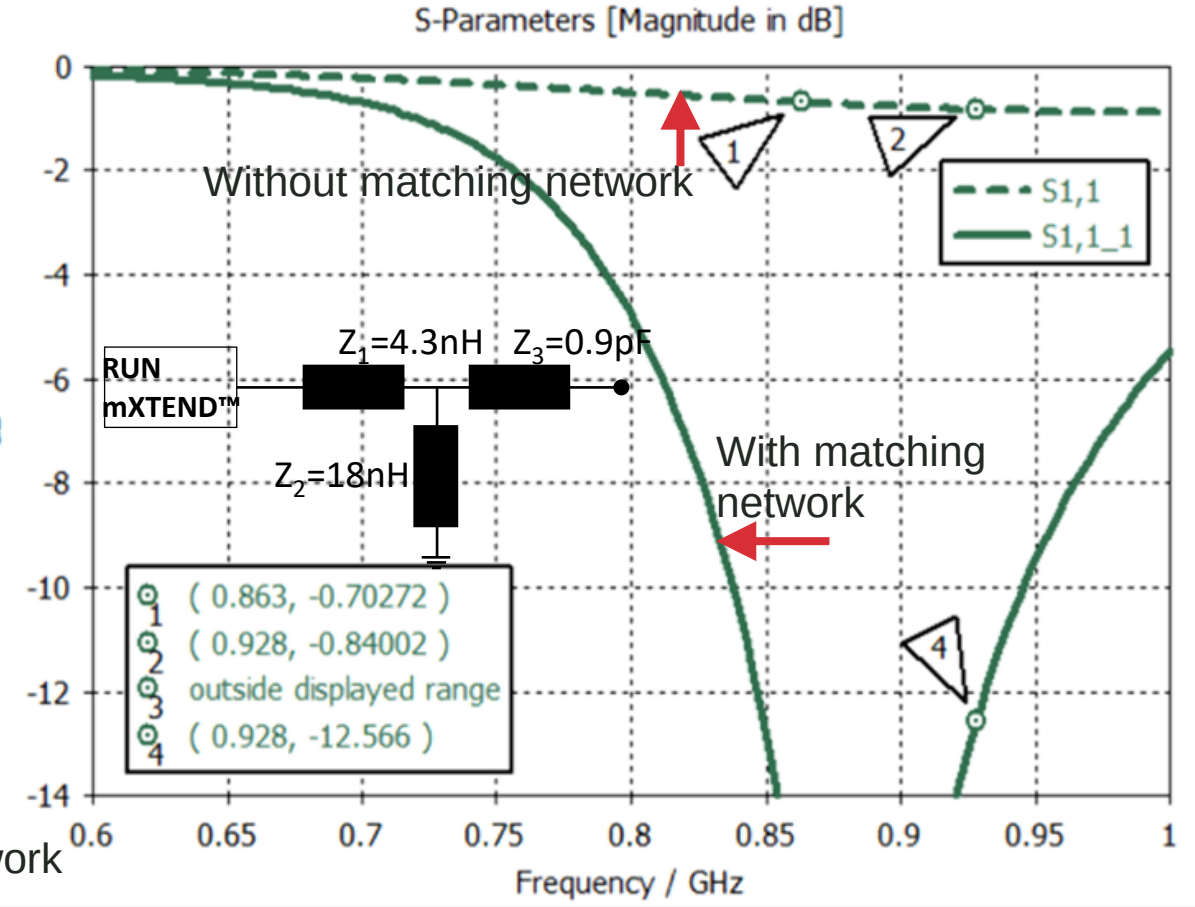


Table of Contents

4. Ignion Products – Virtual Antenna™

FR01-S4-230
CUBE mXTEND™ | Mobile | IoT Antenna
Bands: 698 - 2690 MHz
Dimensions: 5.0 mm x 5.0 mm x 5.0 mm

FR01-S4-224
RUN mXTEND™ | Mobile | IoT Antenna
Bands: 698 - 3800 MHz
Dimensions: 12.0 mm x 3.0 mm x 2.4 mm

FR01-S4-232
BAR mXTEND™ | Mobile | IoT Antenna
Bands: 698 - 2690 MHz
Dimensions: 10.0 mm x 3.2 mm x 3.2 mm

FR01-S4-210
TRIO mXTEND™ | Mobile | IoT Antenna
Bands: 698 - 2690 MHz
Dimensions: 30.0 mm x 3.0 mm x 1.0 mm

FR01-S4-220
ALL mXTEND™ | Mobile | IoT Antenna
Bands: 698 - 2690 MHz
Dimensions: 24.0 mm x 12.0 mm x 2.0 mm

NN03-320
DUO mXTEND™ | Mobile | IoT Antenna
Bands: 1561 - 5000 MHz
Dimensions: 7.0 mm x 3.0 mm x 2.0 mm

NN02-201
ONE mXTEND™ | 5G | Cellular IoT | Wi-Fi 6E
Operating range: 800 - 10600 MHz
Best for: 824 - 7125 MHz
Dimensions: 7.0 mm x 3.0 mm x 1.0 mm

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APPLICATION NOTE
RUN mXTEND™ (NN02-224)

RUN mXTEND™ –The antenna for IoT: NB-IoT, LoRa, Zigbee or Sigfox

- **Product:** RUN mXTEND™ NN02-224
- **Dimensions:** 12.0 mm x 3.0 mm x 2.4 mm
- **Frequency regions:** 698-960 MHz, 1710-2690 MHz and 3400-3800 MHz

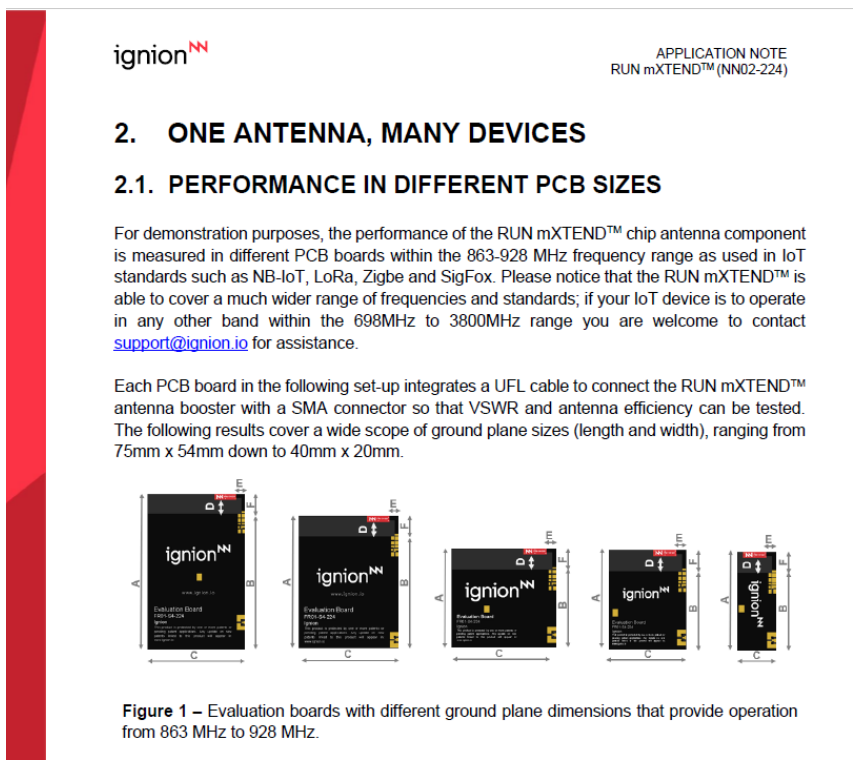
Do you need an antenna for **NB-IoT**? Use the RUN mXTEND™. Do you need an antenna for **LoRa**? Use the RUN mXTEND™. Do you need an antenna for **Sigfox**? Use the RUN mXTEND™. Doubts about the selection of a **licensed** or **unlicensed IoT standard**? The RUN mXTEND™ will be the choice anyway.

Forget antenna size, antenna shape, antenna placement, even antenna frequency! Choosing the right antenna for your IoT applications will never be a challenge any more, the antenna leaves the role of critical component and assumes one where the antenna becomes an **off-the-shelf** chip component able to be **tuned as needed**.

Our team has developed the RUN mXTEND™ chip antenna component that enables worldwide full performance and connectivity in all the frequency bands of operation for the Internet of Things. The RUN mXTEND™ antenna booster, and its versatility, is one of the best options to **go wireless** having any type of IoT platform because **one antenna covers the IoT frequency bands.** Using the mXTEND™ family you will be part of a new technology that will save you cost, **design time** and **risk.**

Find in this IoT application note how the same chip antenna component will operate at the frequency band you need in the **smallest package** ever.

Last Update: January 2021 2



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APPLICATION NOTE
RUN mXTEND™ (NN02-224)

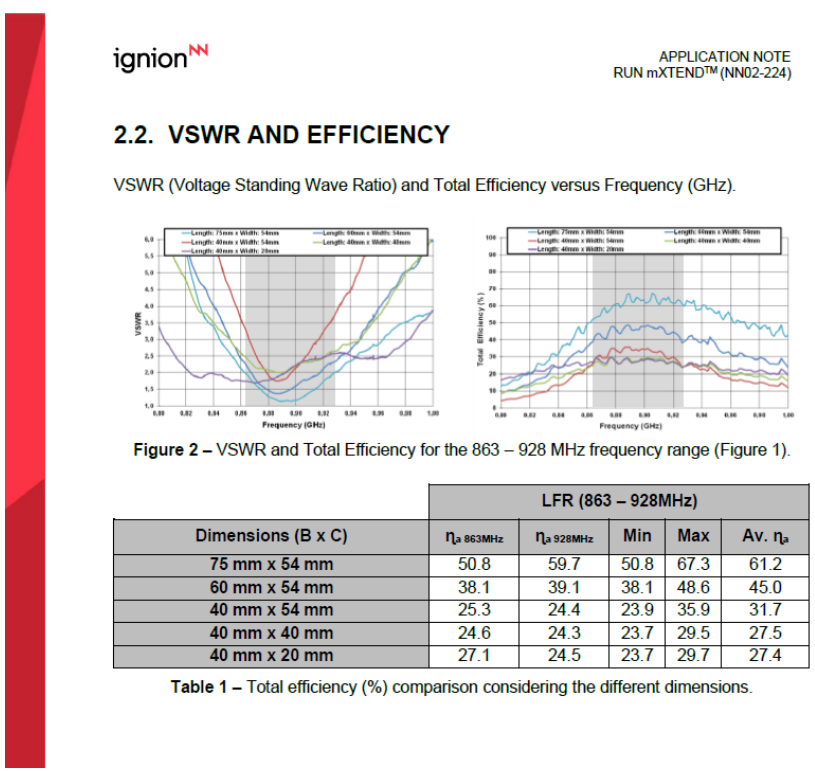
2. ONE ANTENNA, MANY DEVICES

2.1. PERFORMANCE IN DIFFERENT PCB SIZES

For demonstration purposes, the performance of the RUN mXTEND™ chip antenna component is measured in different PCB boards within the 863-928 MHz frequency range as used in IoT standards such as NB-IoT, LoRa, Zigbe and SigFox. Please notice that the RUN mXTEND™ is able to cover a much wider range of frequencies and standards; if your IoT device is to operate in any other band within the 698MHz to 3800MHz range you are welcome to contact support@ignion.io for assistance.

Each PCB board in the following set-up integrates a UFL cable to connect the RUN mXTEND™ antenna booster with a SMA connector so that VSWR and antenna efficiency can be tested. The following results cover a wide scope of ground plane sizes (length and width), ranging from 75mm x 54mm down to 40mm x 20mm.

Figure 1 – Evaluation boards with different ground plane dimensions that provide operation from 863 MHz to 928 MHz.



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APPLICATION NOTE
RUN mXTEND™ (NN02-224)

2.2. VSWR AND EFFICIENCY

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

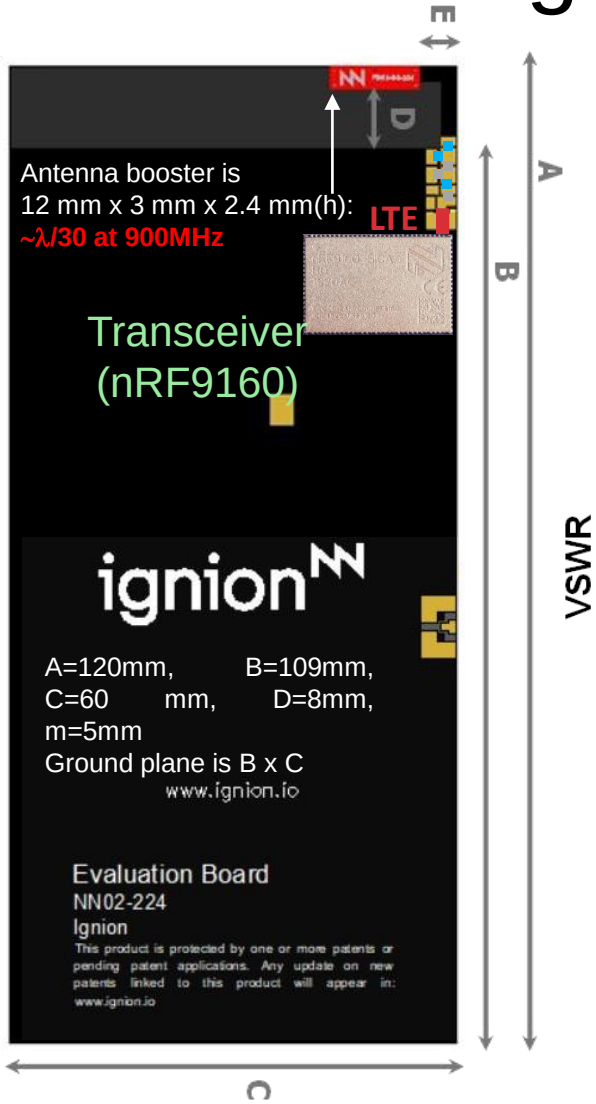
Figure 2 – VSWR and Total Efficiency for the 863 – 928 MHz frequency range (Figure 1).

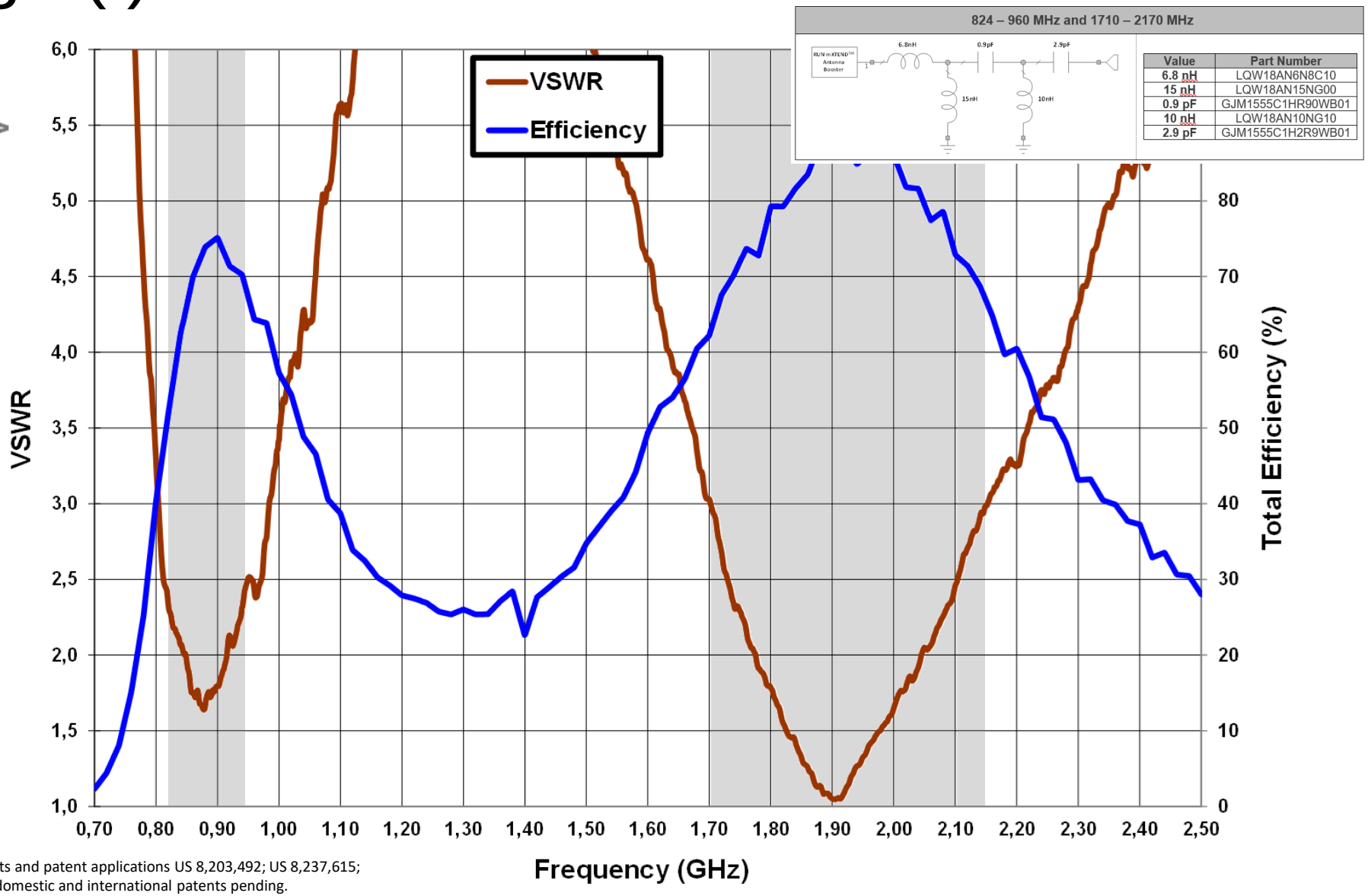
Dimensions (B x C)	LFR (863 – 928MHz)				
	$\eta_{a\ 863MHz}$	$\eta_{a\ 928MHz}$	Min	Max	Av. η_a
75 mm x 54 mm	50.8	59.7	50.8	67.3	61.2
60 mm x 54 mm	38.1	39.1	38.1	48.6	45.0
40 mm x 54 mm	25.3	24.4	23.9	35.9	31.7
40 mm x 40 mm	24.6	24.3	23.7	29.5	27.5
40 mm x 20 mm	27.1	24.5	23.7	29.7	27.4

Table 1 – Total efficiency (%) comparison considering the different dimensions.

Links to the related documentation associated to each product available by clicking the product images in the top

Multiband Design (I): RUN mXTEND™ antenna booster

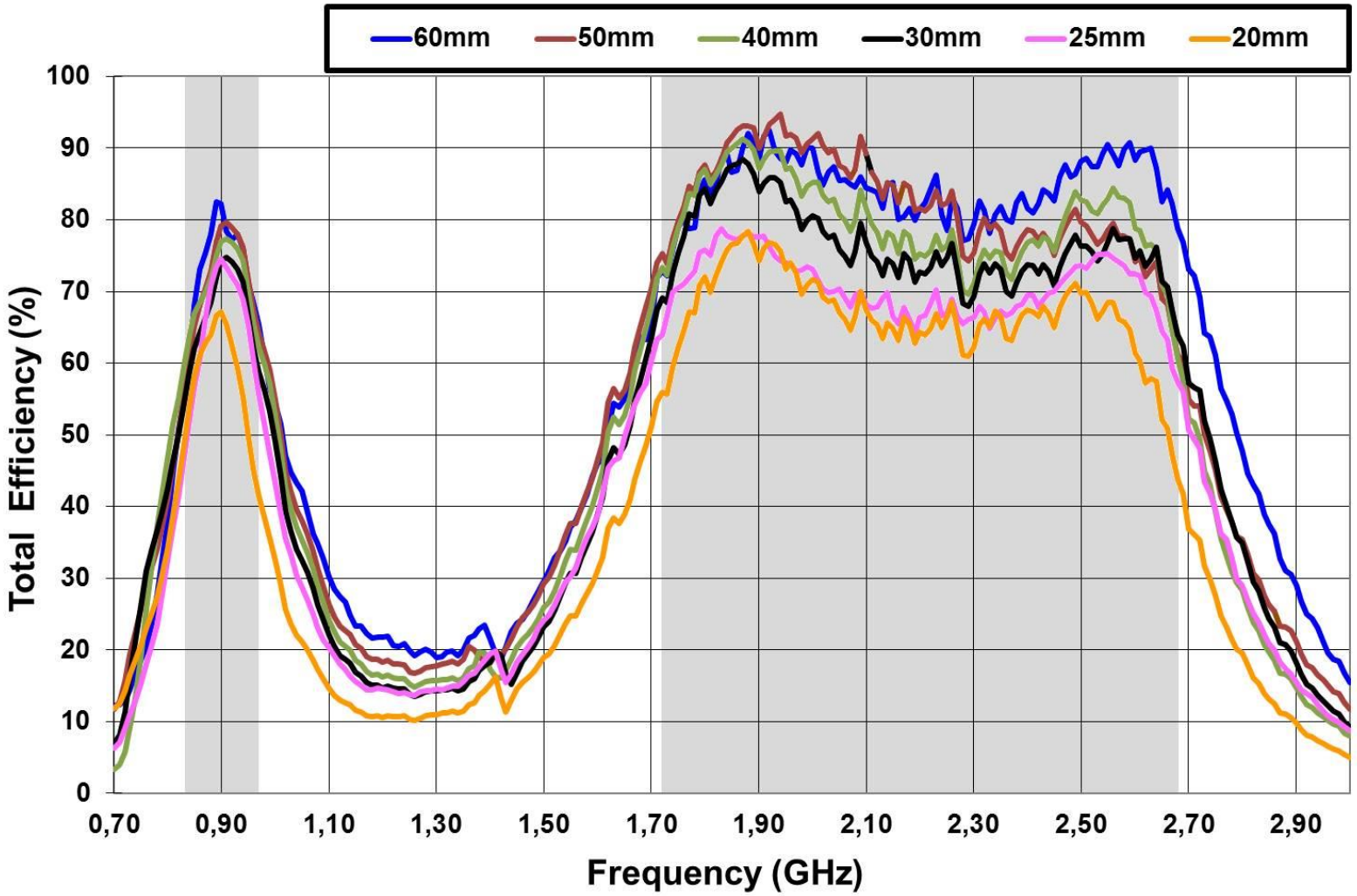




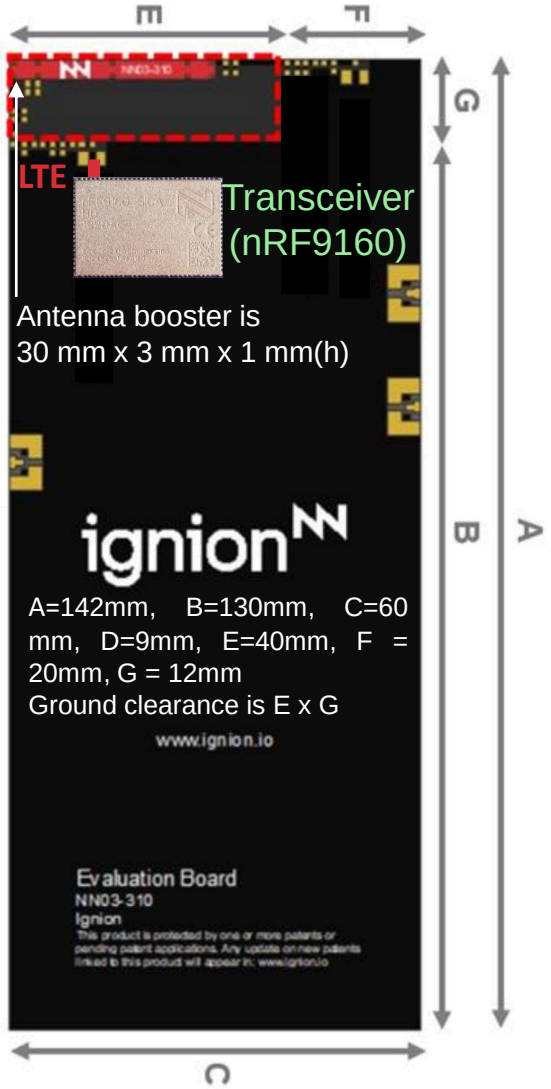
824 – 960 MHz and 1710 – 2170 MHz

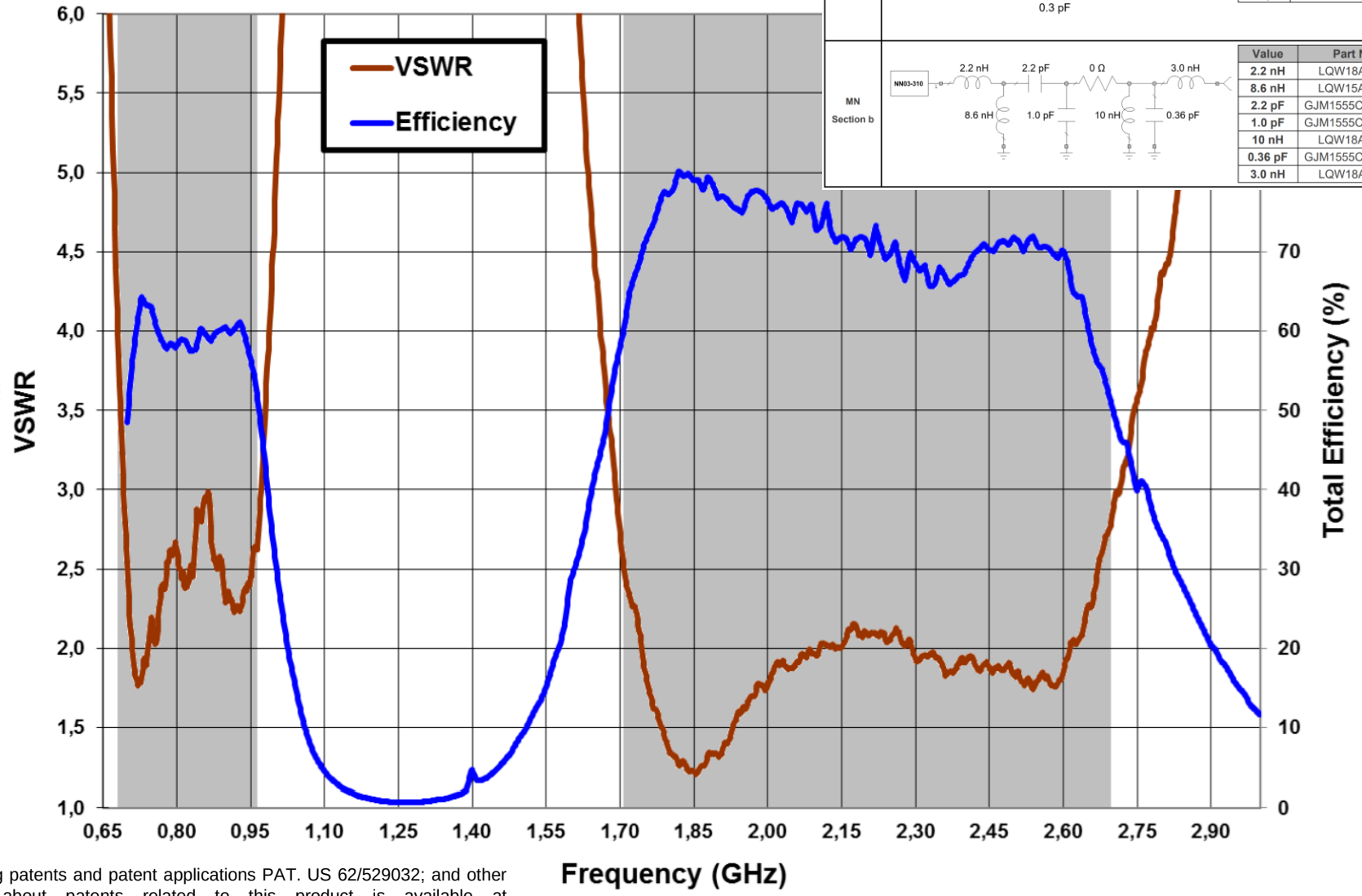
Value	Part Number
6.8 nH	LQW18AN6N8C10
15 nH	LQW18AN15NG00
0.9 pF	GJM1555C1HR90WB01
10 nH	LQW18AN10NG10
2.9 pF	GJM1555C1H2R9WB01

Multiband Design (II): RUN mXTEND™ antenna booster



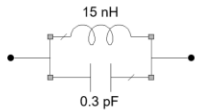
Multiband Design (III): TRIO mXTEND™





698 MHz – 960 MHz and 1710 MHz – 2690 MHz

MN Section a

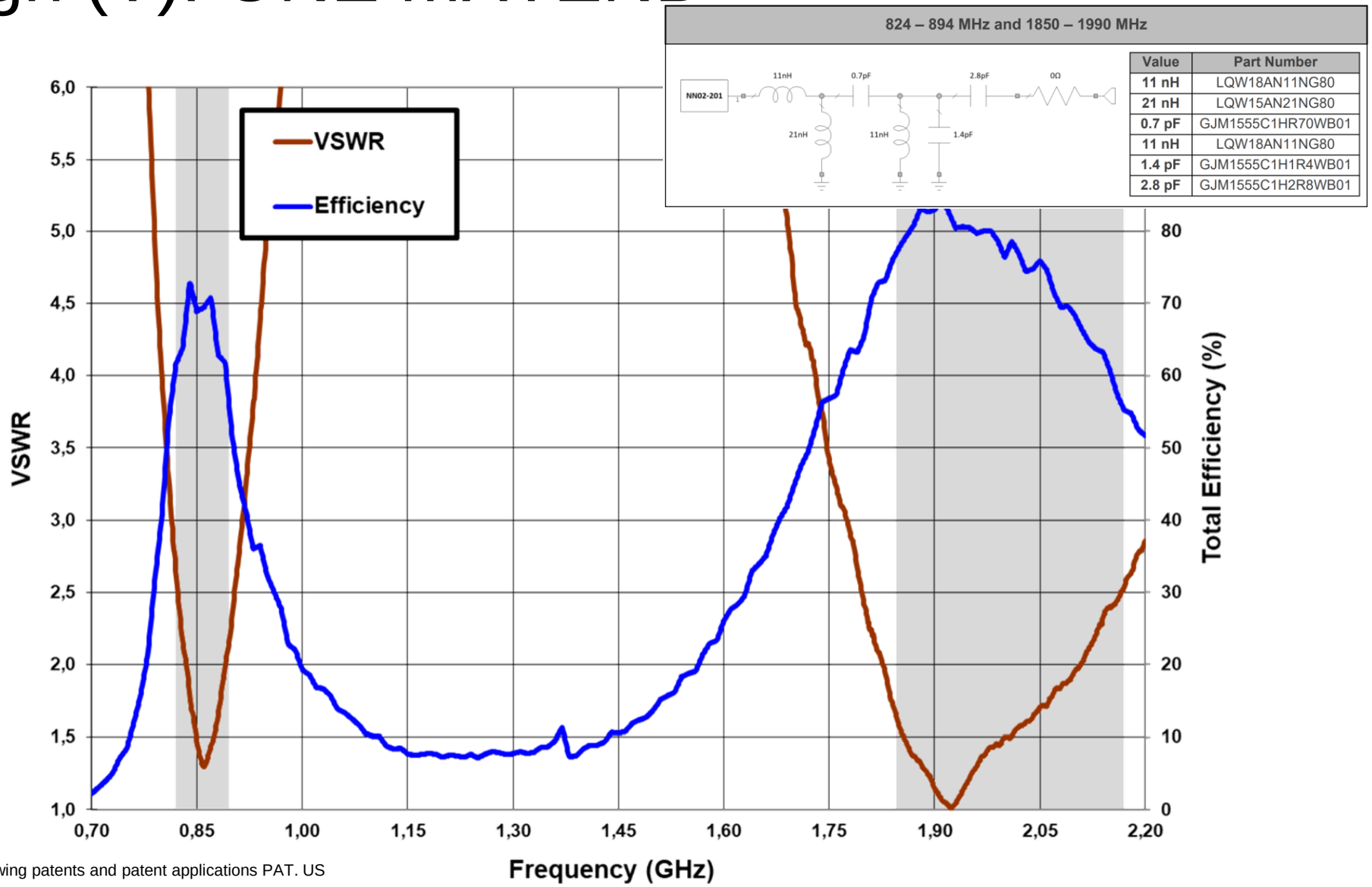


Value	Part Number
15 nH	LQW18AN15NG80
0.3 pF	GJM1555C1HR30WB01

MN Section b

Value	Part Number
2.2 nH	LQW18AN2N2C80
8.6 nH	LQW15AN8N6G80
2.2 pF	GJM1555C1H2R2WB01
1.0 pF	GJM1555C1H1R0WB01
10 nH	LQW18AN10NG80
0.36 pF	GJM1555C1HR36WB01
3.0 nH	LQW18AN3N0C80

Multiband Design (V): ONE mXTEND™

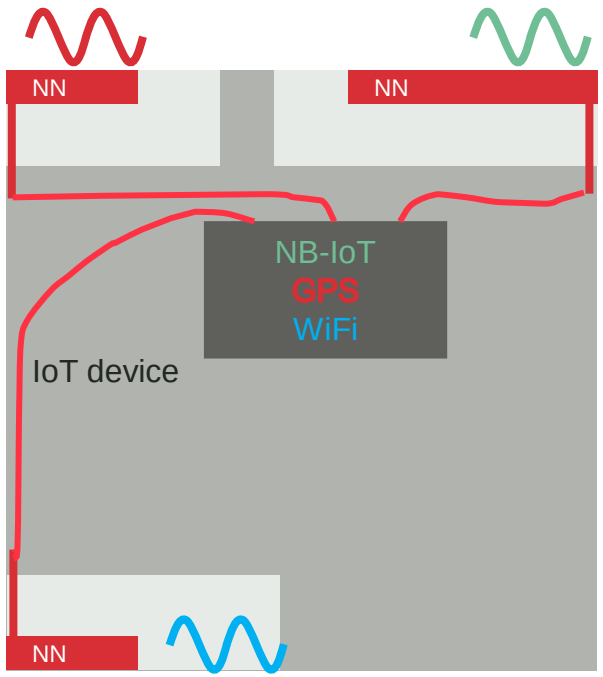


This product and its use are protected by at least one or more of the following patents and patent applications PAT. US 62/529032; and other domestic and international patents pending.

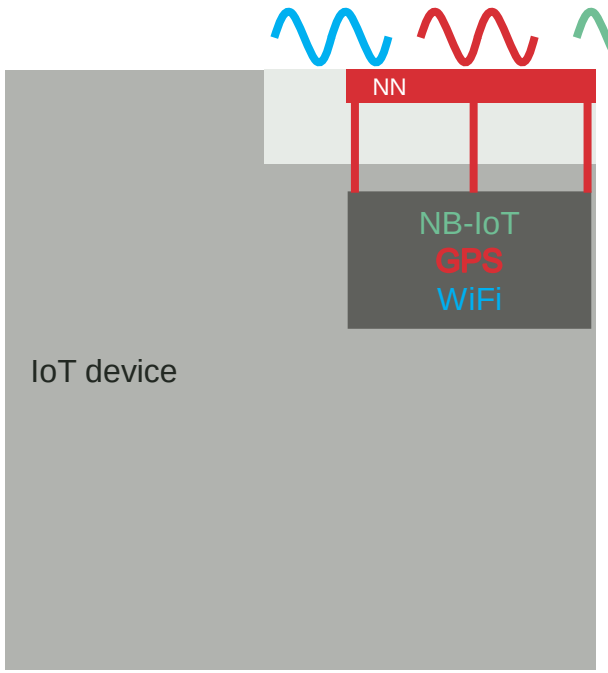
https://ignion.io/files/AN_NN02-201-2G_3G.pdf

TRIO mXTEND™: Multi-Radio

- Customer pains:
  - **Customized antenna** for any band, any device
  - **As many antennas as communication systems**: one antenna for NB-IoT/LTE-M+ one antenna for GNSS + one antenna for BLE/WiFi
- **Antenna solution** in the market: **TRIO mXTEND™ chip antenna!**

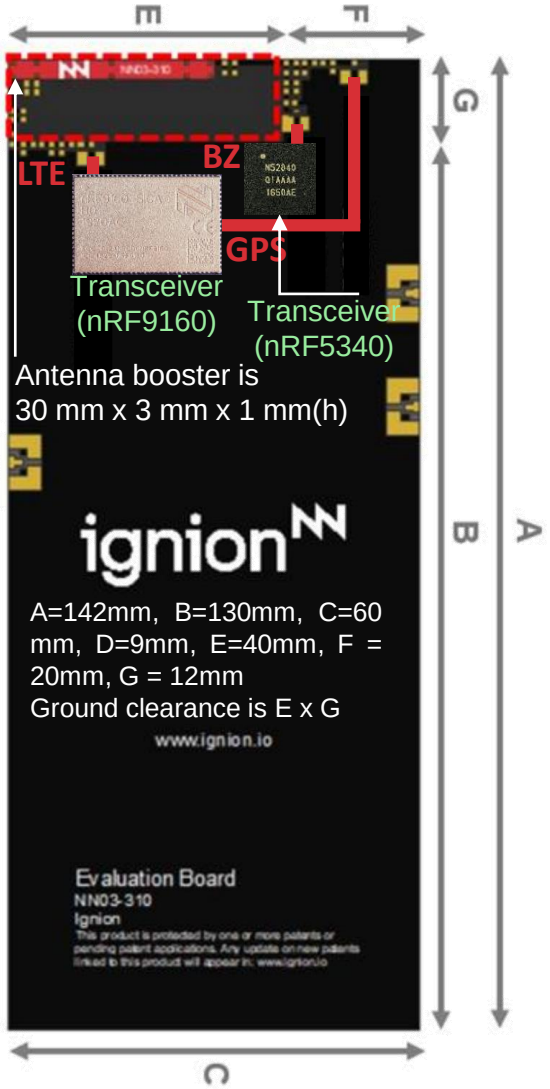


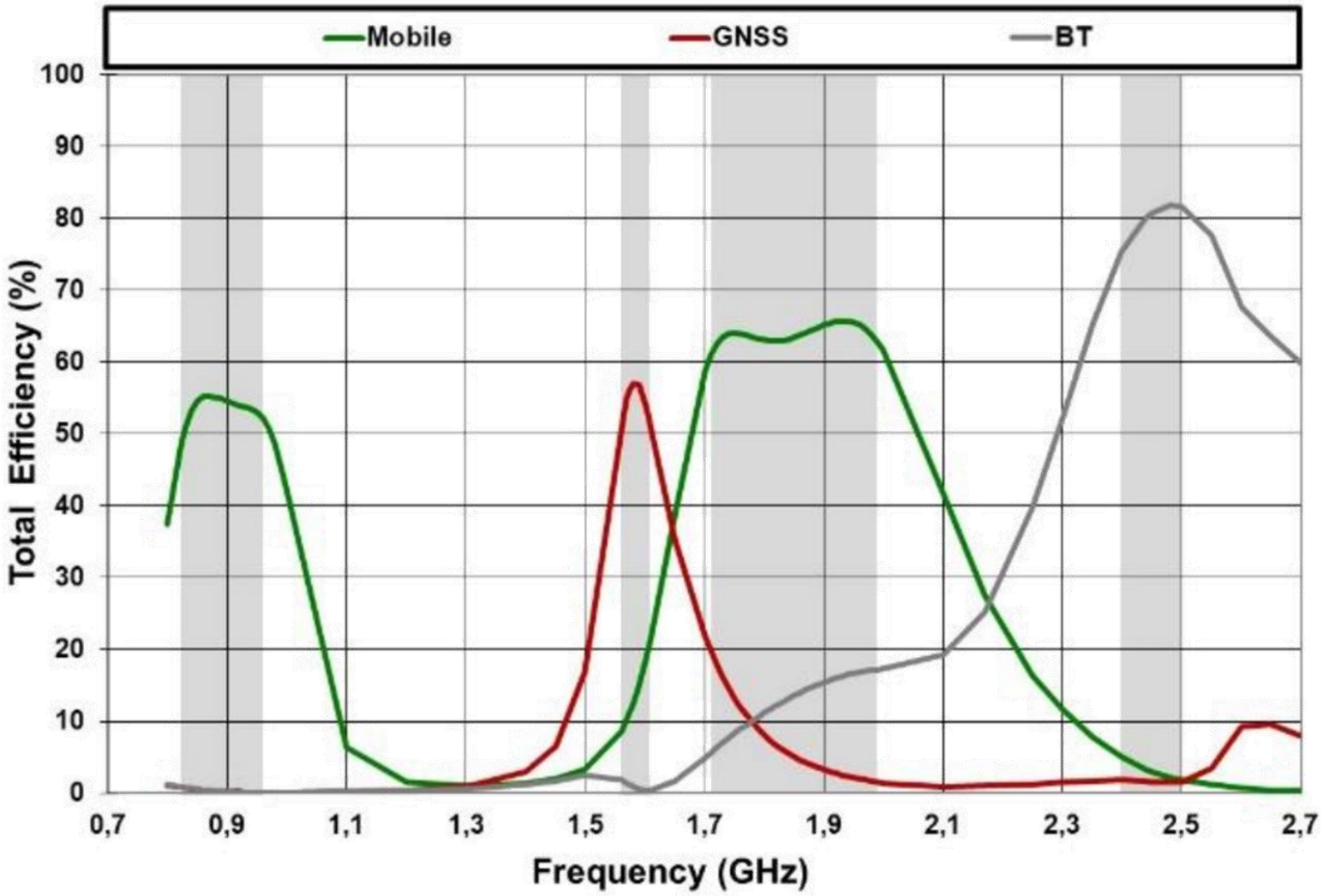
Current technology:
- 3 antennas: **not cost effective**
- Large area on the device: **difficult** to **integrate** other **components**
- **Slow to design**
- **Bulky** solution: **stopper** for Open Hardware Platform **designers**



Virtual Antenna™:
- 1 antenna: **cost effective**
- Small area on the device: **easy** to **integrate** other **components**
- **Fast** to **design: reduced time** to **market**
- **Compact** solution: make **design easy** for Open Hardware Platform designers

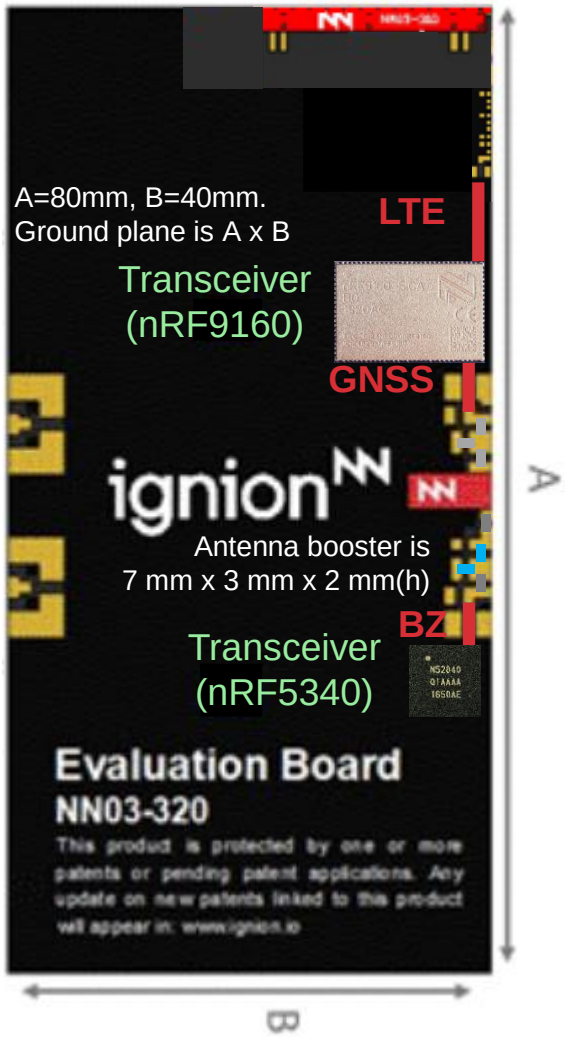
Multi-Radio (I): Cellular IoT, GNSS, and BT/Thread/Zigbee





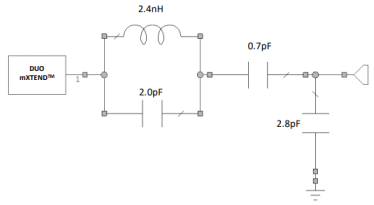
https://ignion.io/files/AN_NN03-310_Mobile_GNSS_BZ.pdf

Multi-Radio (II): DUO mXTEND™ - GNSS & BT/Thread/Zigbee



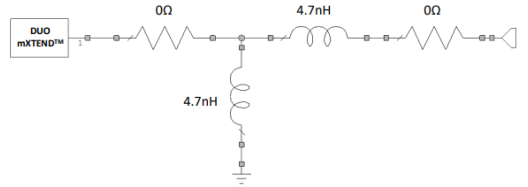
1561 MHz – 1606 MHz and 2400 MHz – 2500 MHz

MN GNSS

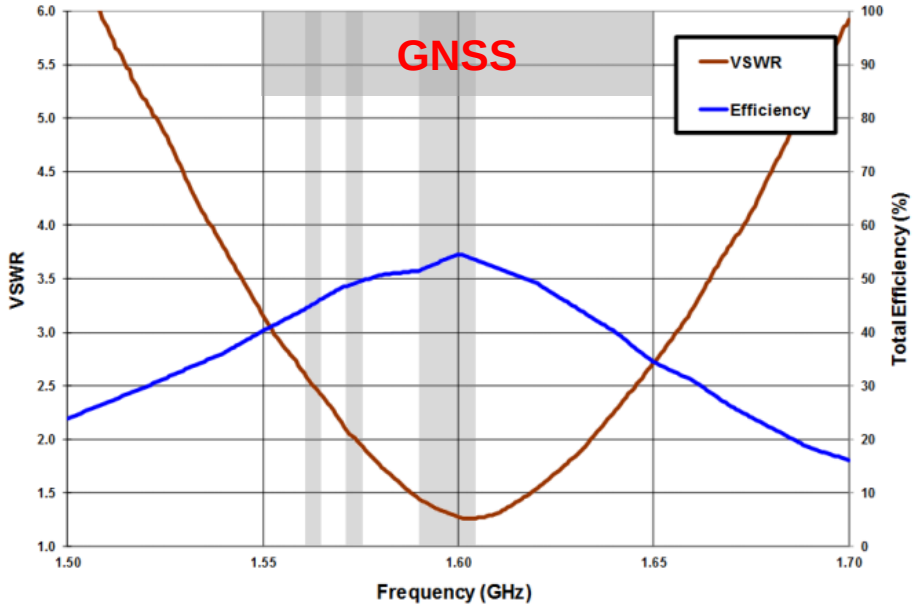


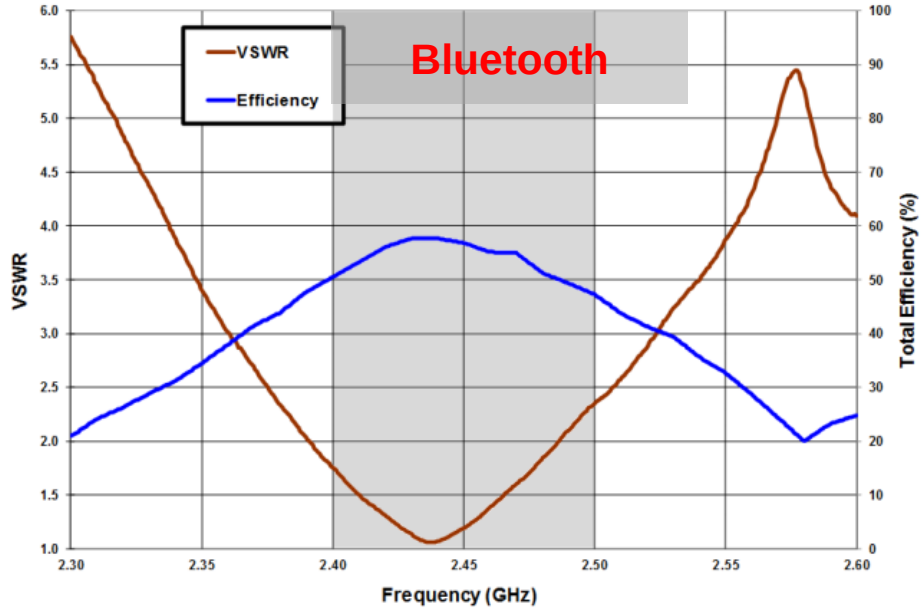
Value	Part Number
2.4 nH	LQW15AN2N4C00
2.0 pF	GJM1555C1H2R0WB01
0.7 pF	GJM1555C1HR70WB01
2.8 pF	GJM1555C1H2R8WB01

MN BT

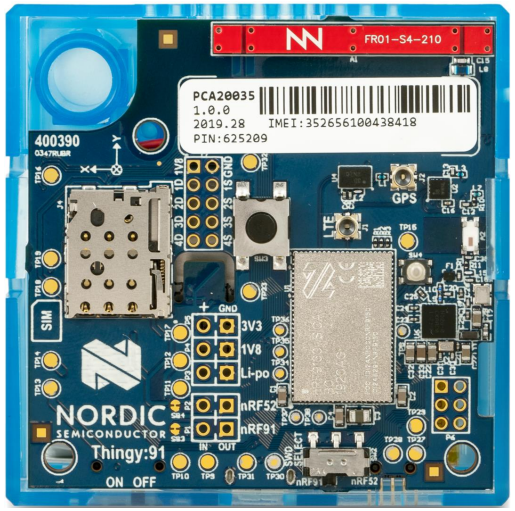


Value	Part Number
0 Ω	-
4.7 nH	LQW15AN4N7G80
4.7 nH	LQW15AN4N7G80
0 Ω	-





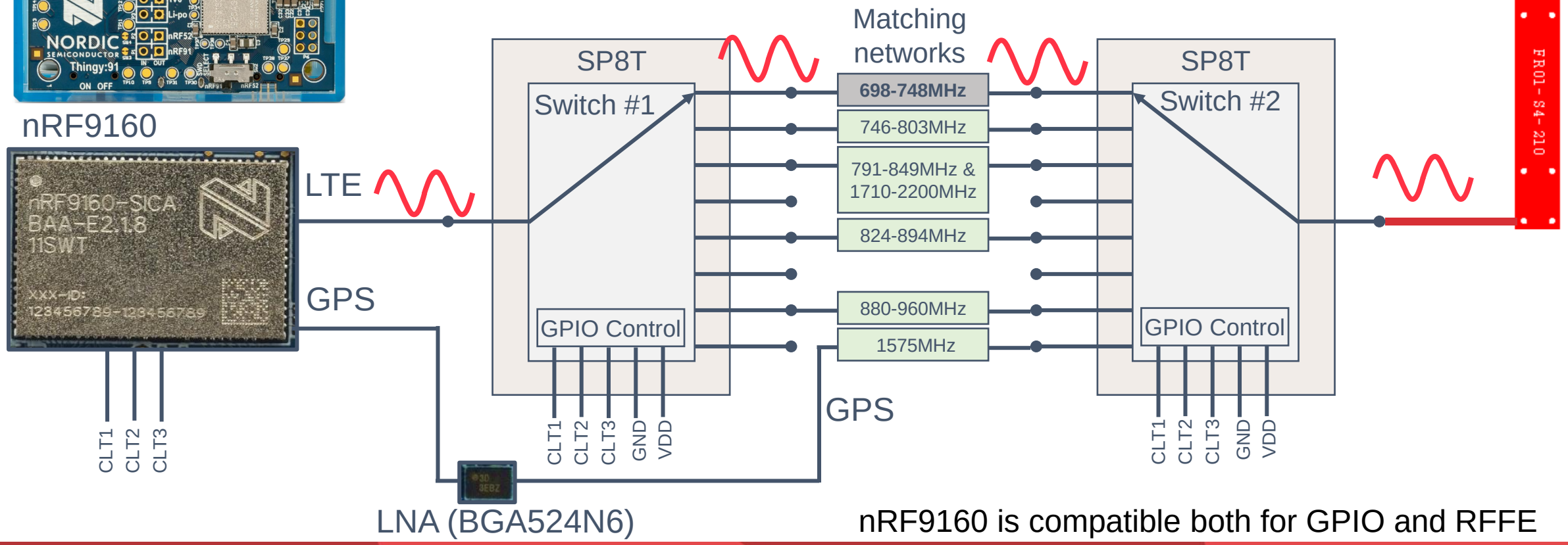
Global IoT Platform with a Tunable Network



nRF9160

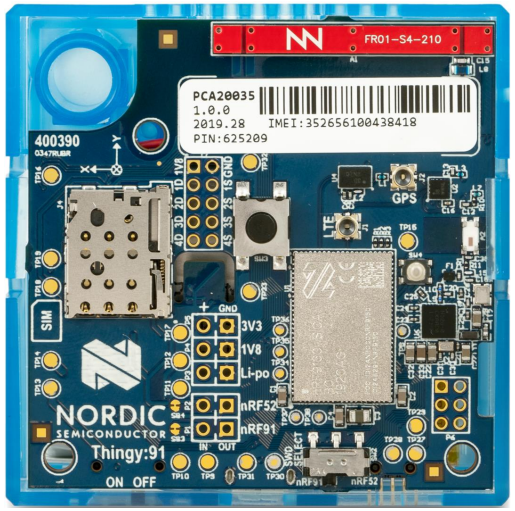
LTE bands B2, B3, B4, B8, B12, B13, B20 and B28 (700-960 MHz + 1710-2200 MHz LTE band support) + GPS: reconfigurable antenna system

TRIO mXTEND™ chip antenna component



nRF9160 is compatible both for GPIO and RFFE

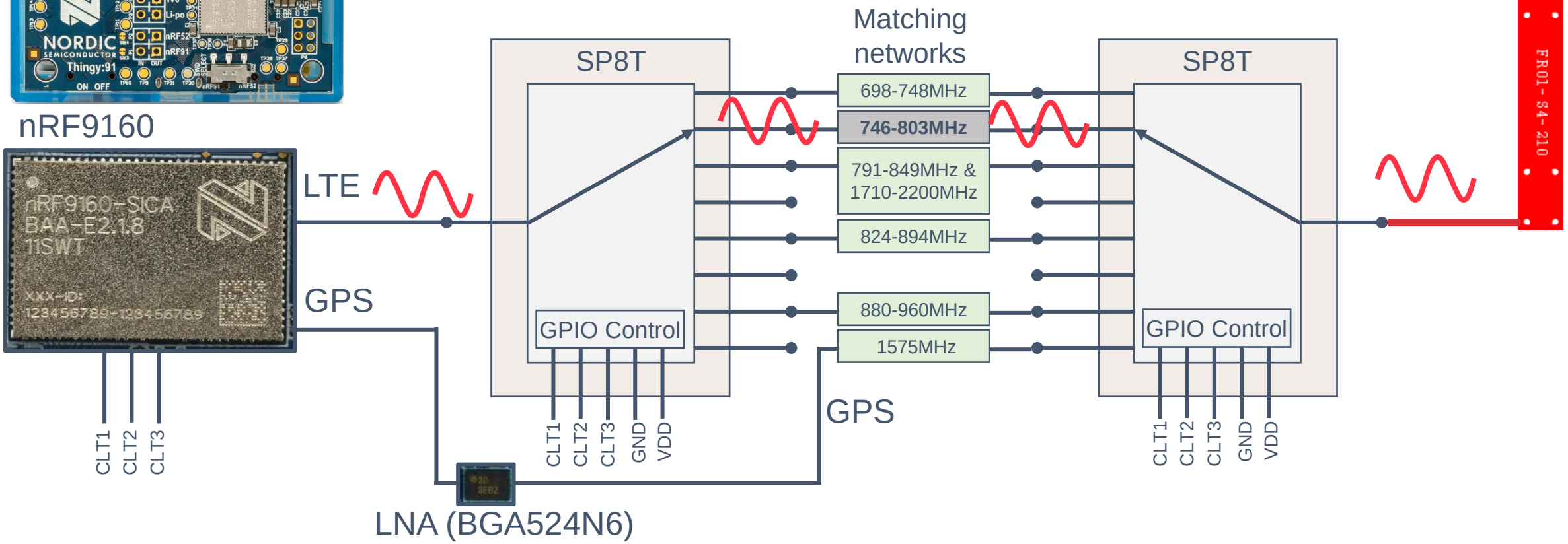
Global IoT Platform with a Tunable Network



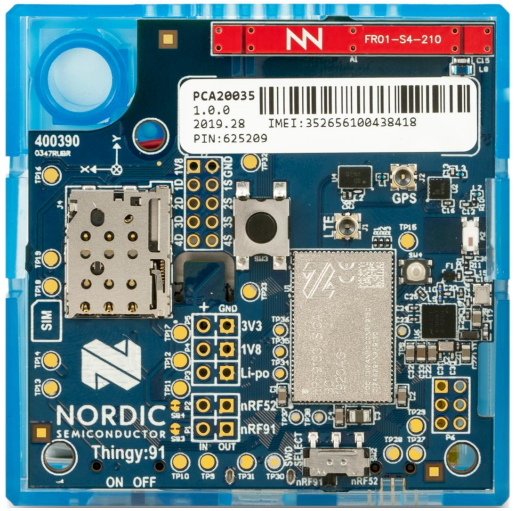
nRF9160

LTE bands B2, B3, B4, B8, B12, B13, B20 and B28 (700-960 MHz + 1710-2200 MHz LTE band support) + GPS: reconfigurable antenna system

TRIO mXTEND™ chip antenna component



Global IoT Platform with a Tunable Network



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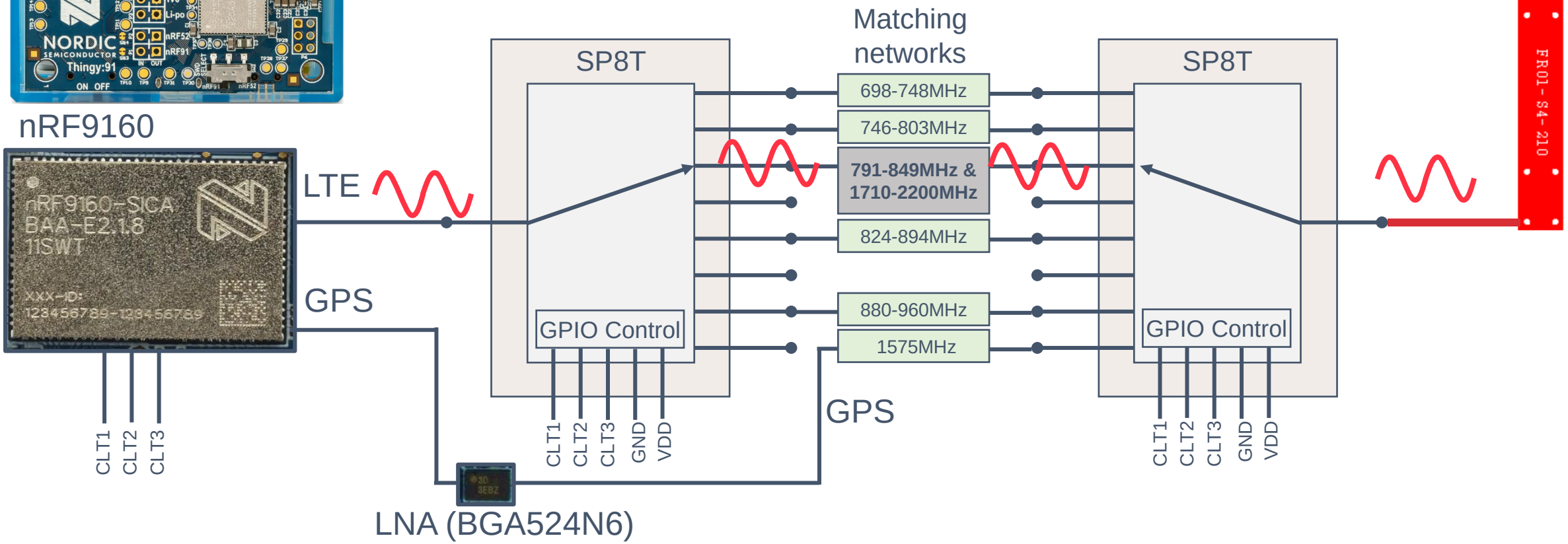
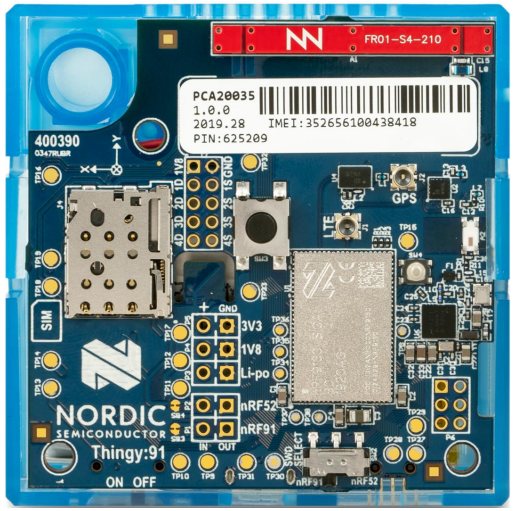
TRIO mXTEND™ chip antenna component



Global IoT Platform with a Tunable Network



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LTE bands B2, B3, B4, B8, B12, B13, B20 and B28 (700-960 MHz + 1710-2200 MHz LTE band support) + GPS: reconfigurable antenna system

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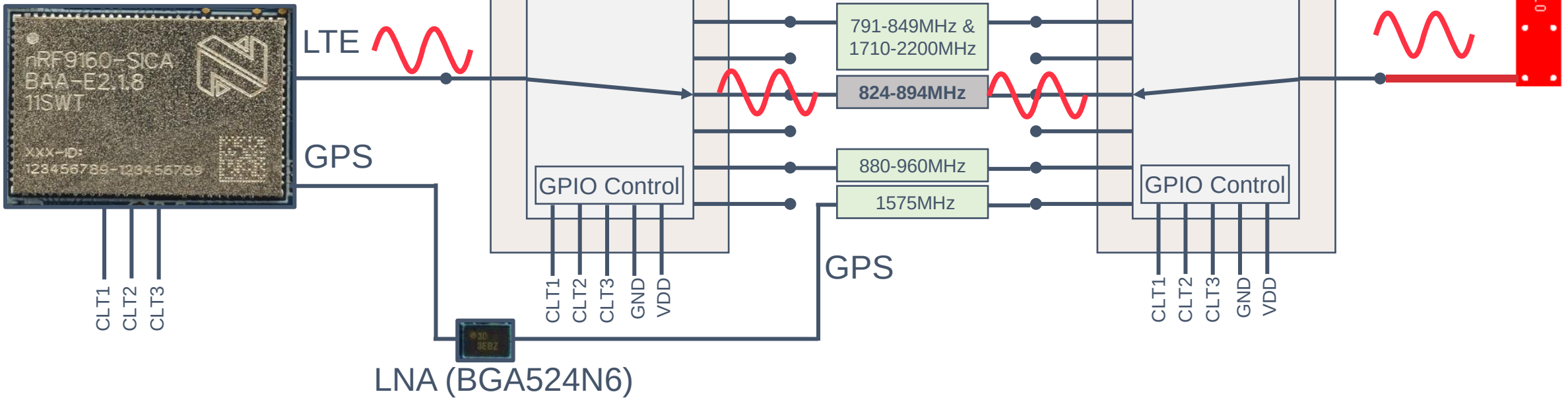
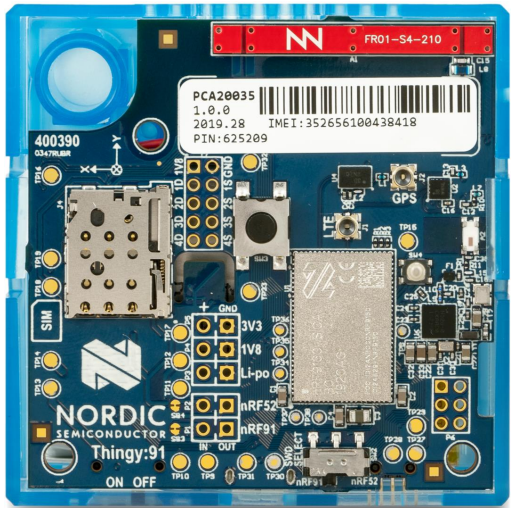


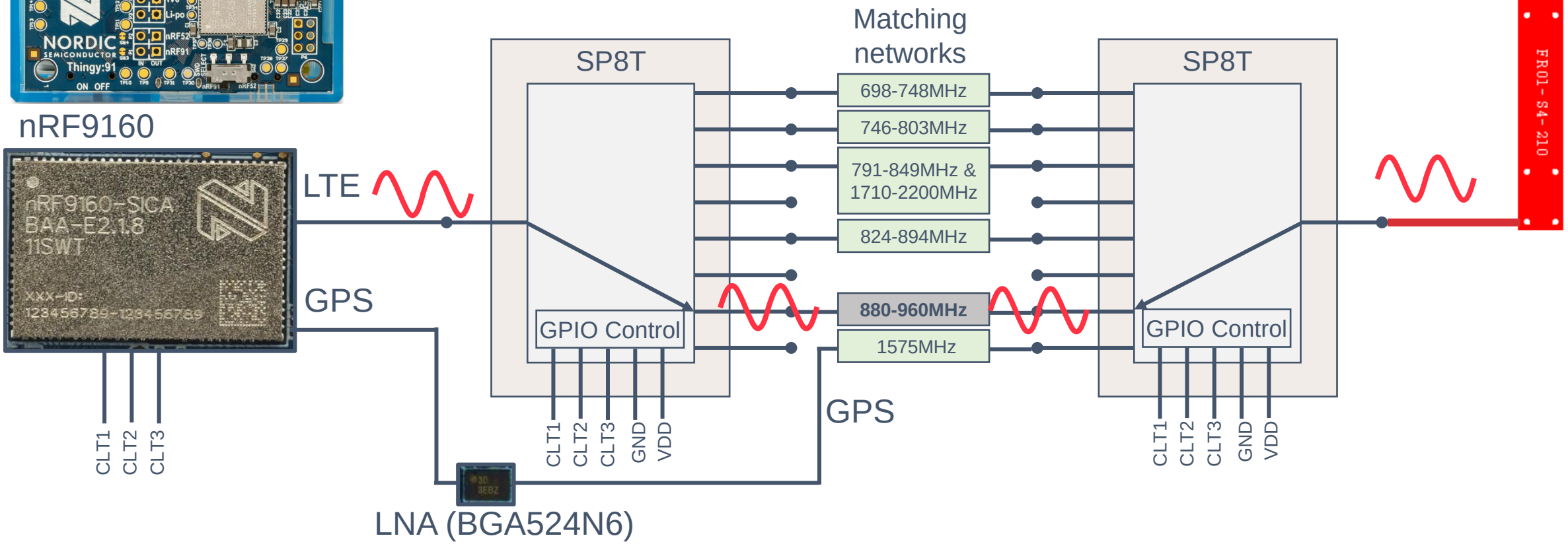
Global IoT Platform with a Tunable Network



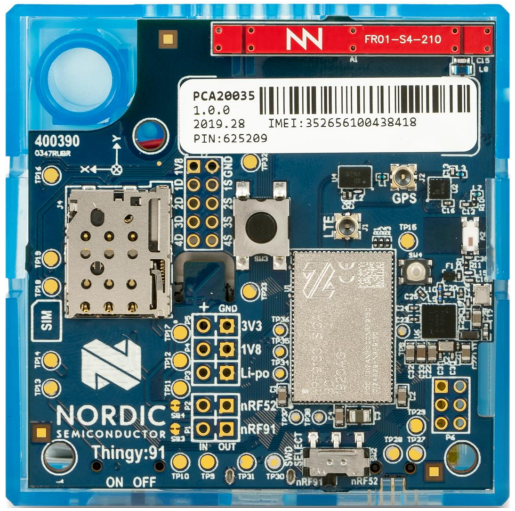
nRF9160

LTE bands B2, B3, B4, B8, B12, B13, B20 and B28 (700-960 MHz + 1710-2200 MHz LTE band support) + GPS: reconfigurable antenna system

TRIO mXTEND™ chip antenna component



Global IoT Platform with a Tunable Network



nRF9160

LTE bands B2, B3, B4, B8, B12, B13, B20 and B28 (700-960 MHz + 1710-2200 MHz LTE band support) + GPS: reconfigurable antenna system

TRIO mXTEND™ chip antenna component

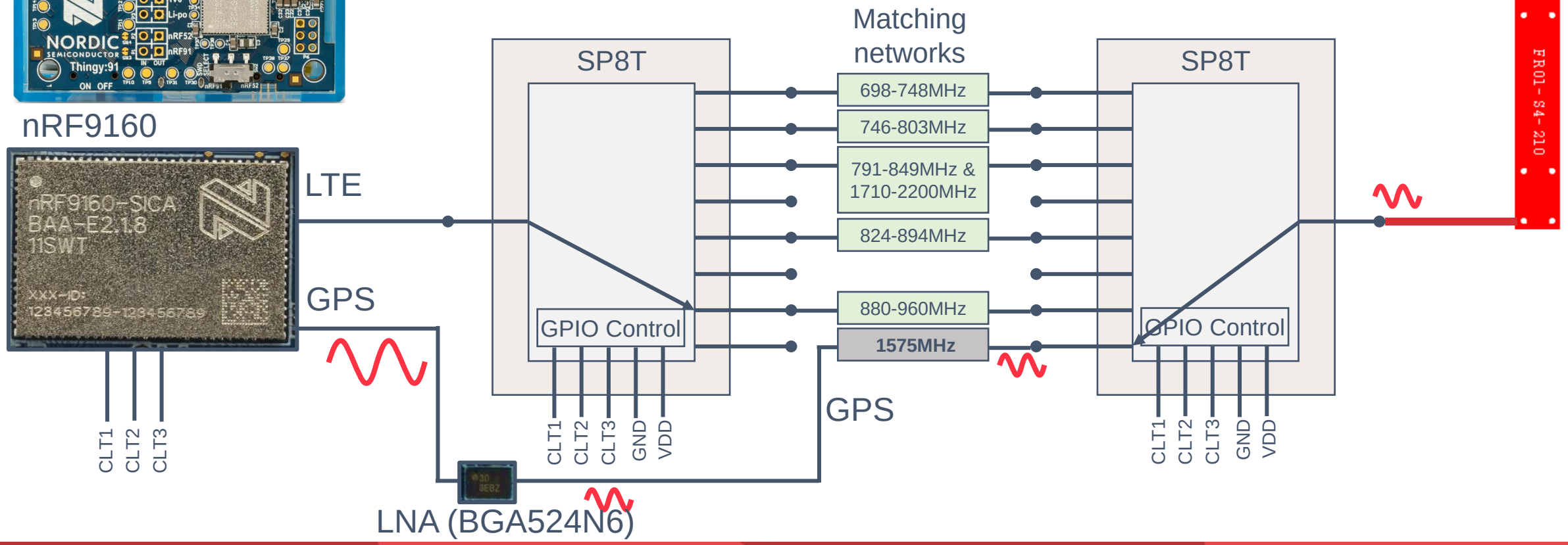
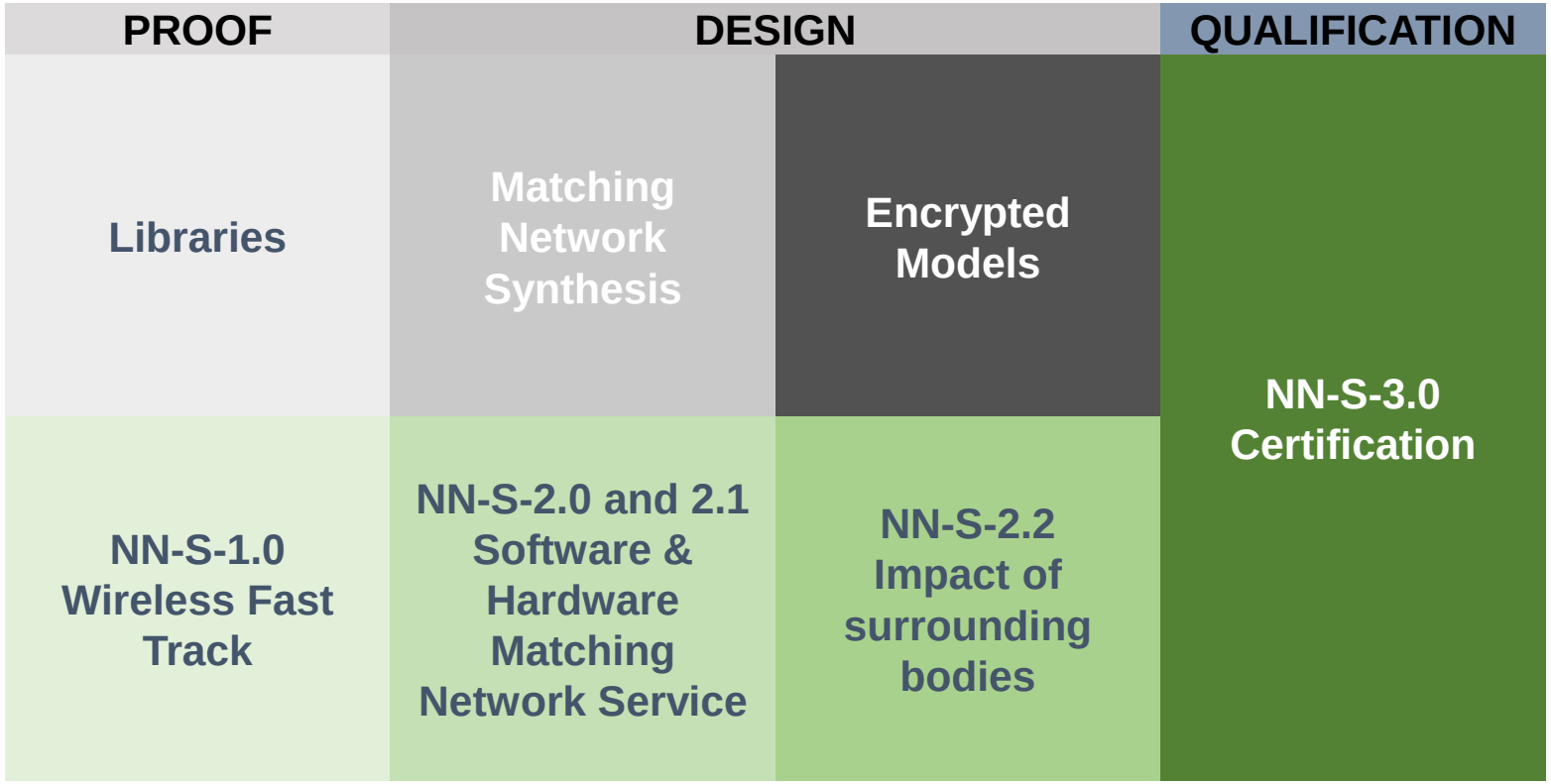


Table of Contents

5. EDA Tools: from conception to mass production

- Libraries: Proof of concept phase
- Matching network synthesis: Design phase
- Encrypted Virtual Antenna™ products: Design phase

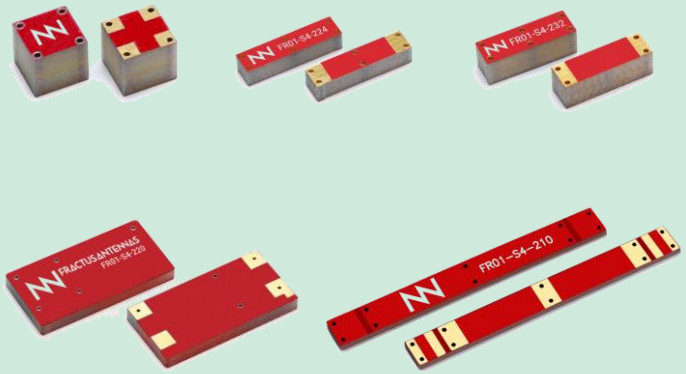


5.1 Virtual Antenna™ libraries available at Microwave Office by Cadence-AWR

- [S] parameters are available at Cadence AWR Software for several platforms and with different antenna boosters. A quick-guide is also included with several examples
- Basic steps:

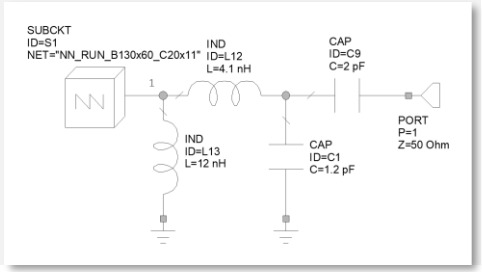
#1: **Choose** the suitable **platform** and the **frequency bands of operation**

#2: **Select** the **antenna booster** that best suits your device



#3: **Design** the **matching network** with Cadence AWR Software

1. Define the frequency bands of operation
2. Specify the target SWR/S_{11}
3. Let the Network Synthesis work for us, and…**"Get your matching network in the blink of an eye"**



A wide variety of PCB sizes

Ground plane

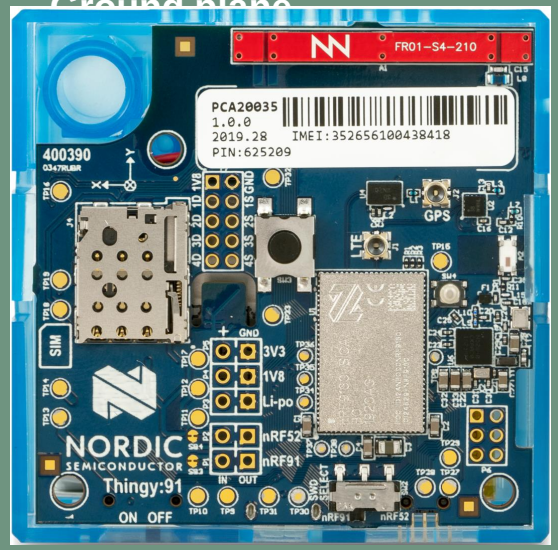
Ground plane

Ground plane

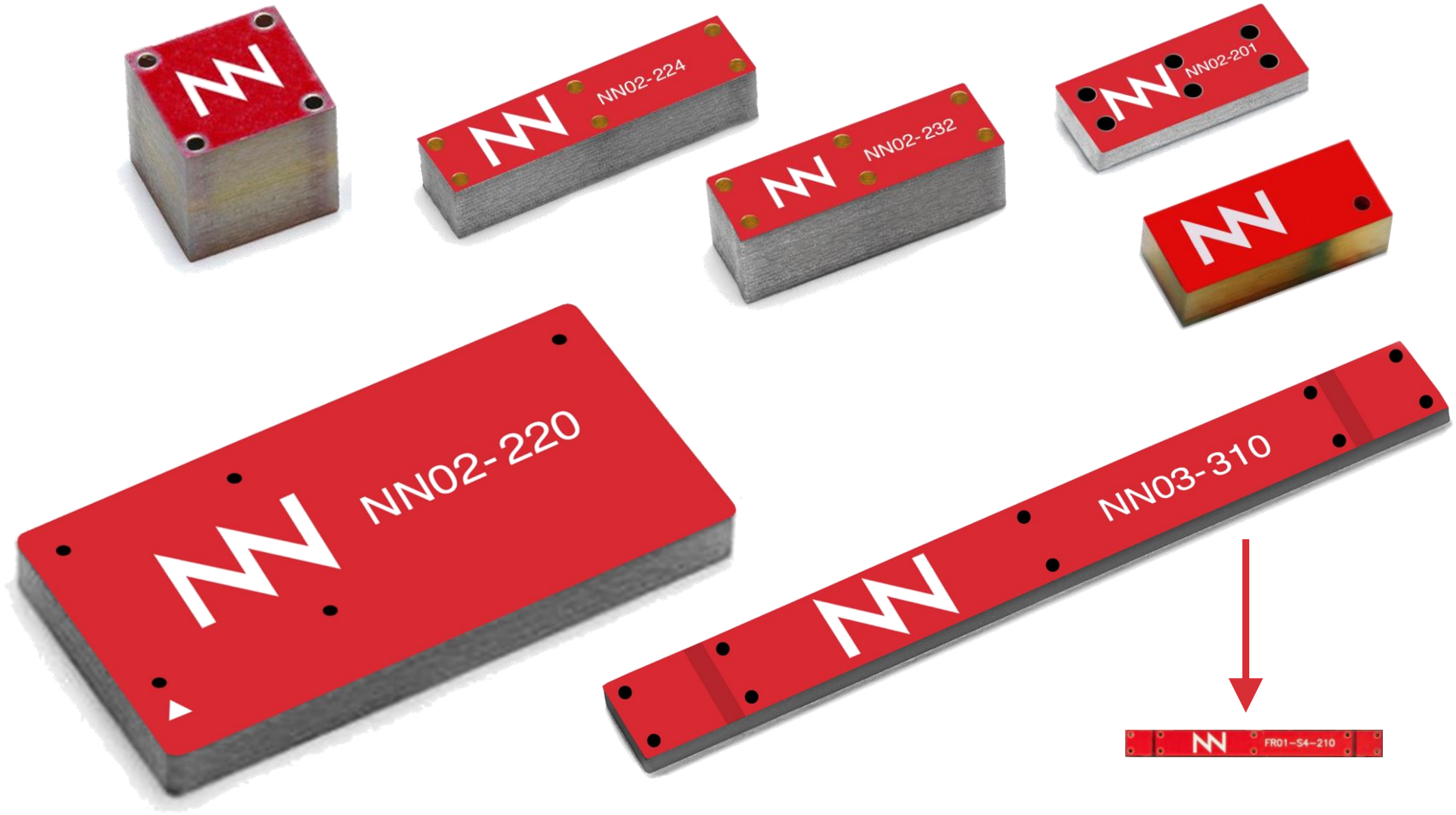
Ground plane

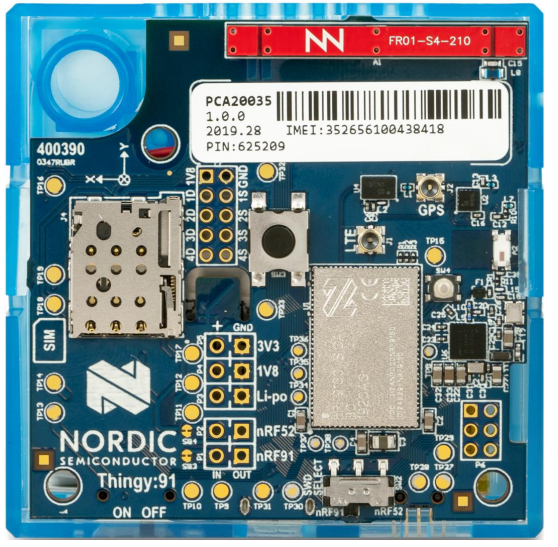
Ground plane

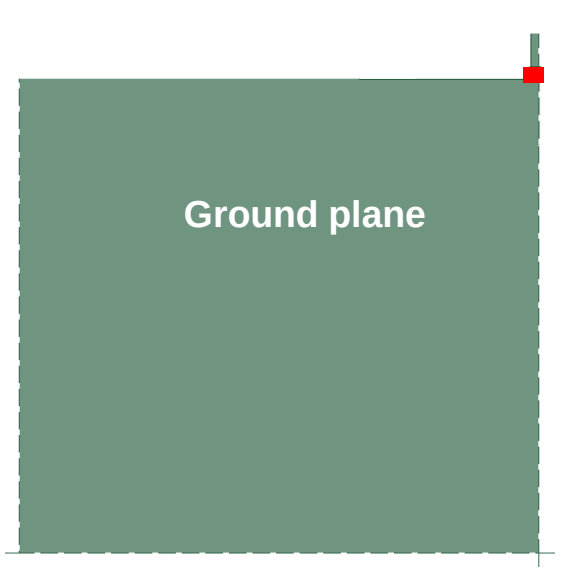
Ground plane



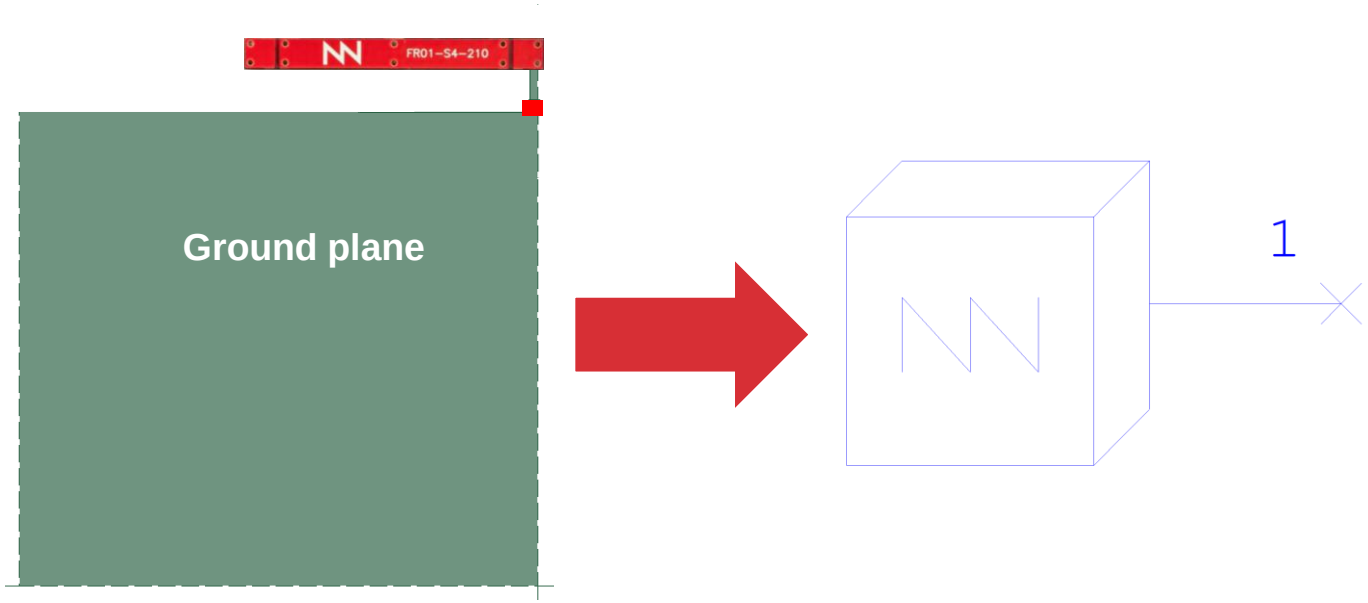
A wide variety of antenna boosters







S_{11}-data from 0.6GHz to 10.6GHz ready to use



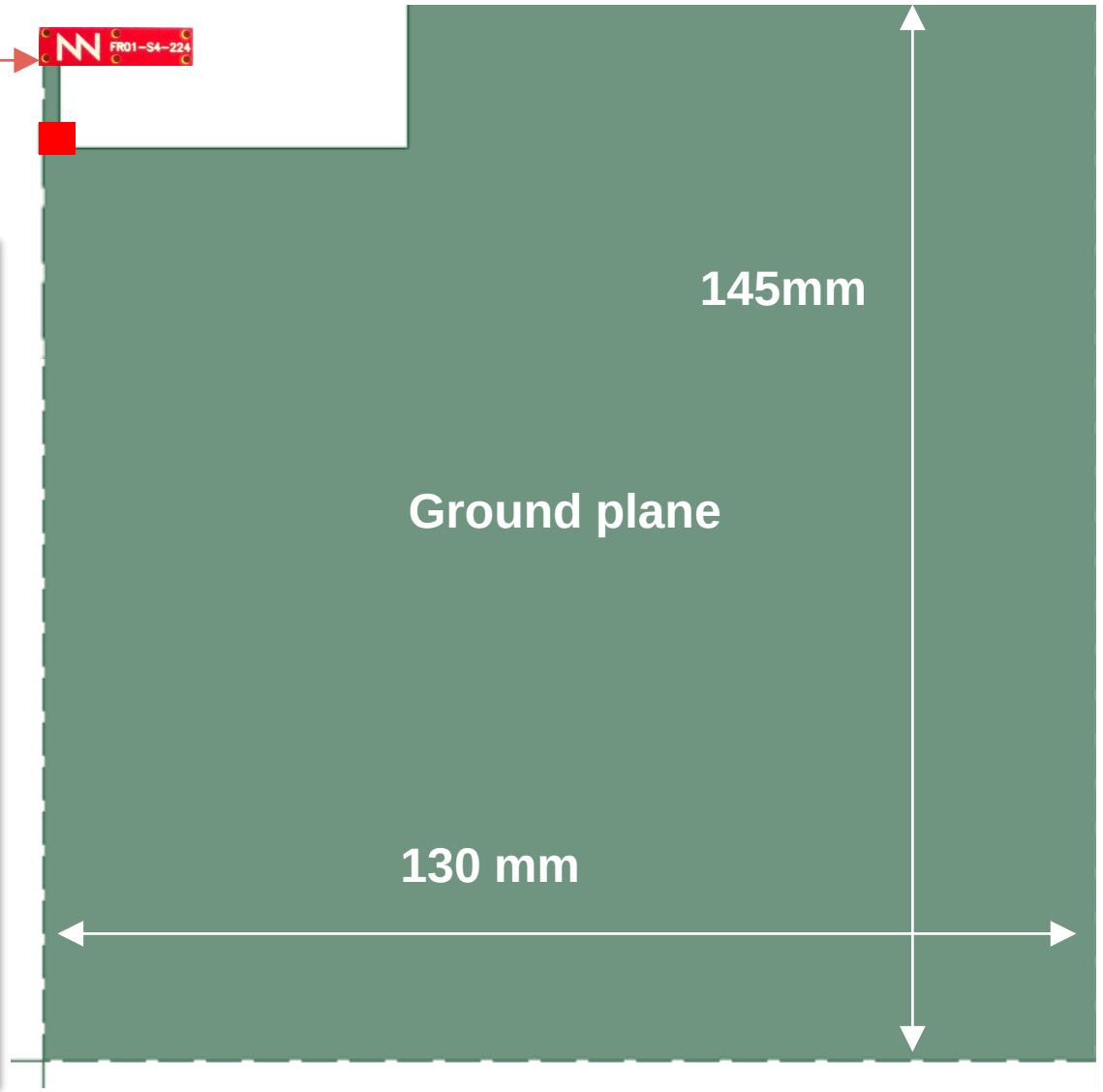

```
# GHZ S MA R 50
! Nport = 1

 6.5000000000e-001  9.0419430558e-001 -3.5979721205e+001
 6.6000000000e-001  8.9512095340e-001 -3.6966724097e+001
 6.7000000000e-001  8.8547223888e-001 -3.7962244764e+001
 6.8000000000e-001  8.7525648565e-001 -3.8964573114e+001
 6.9000000000e-001  8.6448771221e-001 -3.9972120415e+001
 7.0000000000e-001  8.5318506998e-001 -4.0983507730e+001
 7.1000000000e-001  8.4137193667e-001 -4.1997657549e+001
 7.2000000000e-001  8.2907467522e-001 -4.3013883899e+001
 7.3000000000e-001  8.1632109280e-001 -4.4031975607e+001
 7.4000000000e-001  8.0313865893e-001 -4.5052267088e+001
.....
```

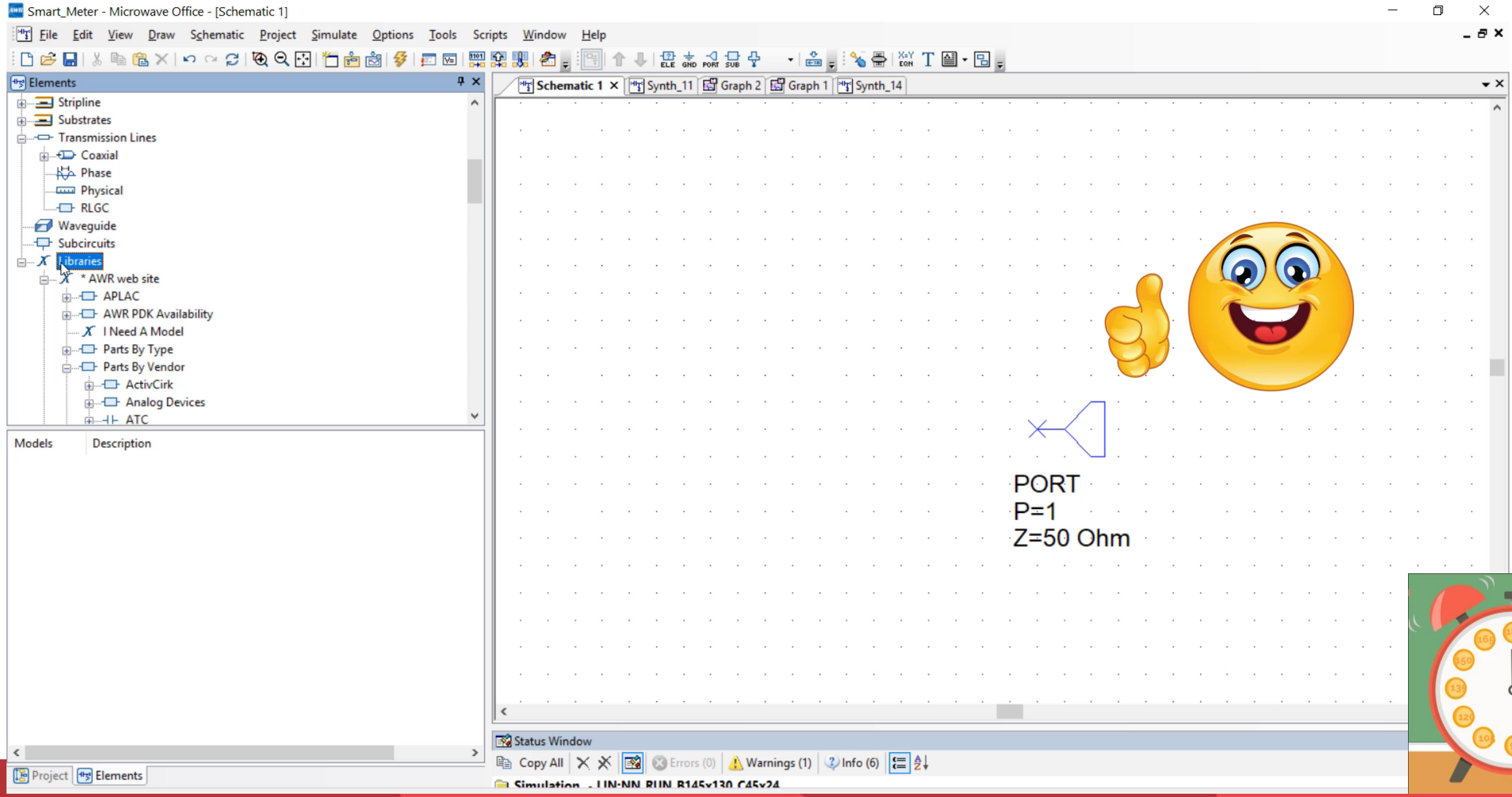
IoT design with Virtual Antenna™ Library

Antenna booster:
12 mm x 3 mm x 2.4 mm (h)
~ λ/35 @ 698MHz

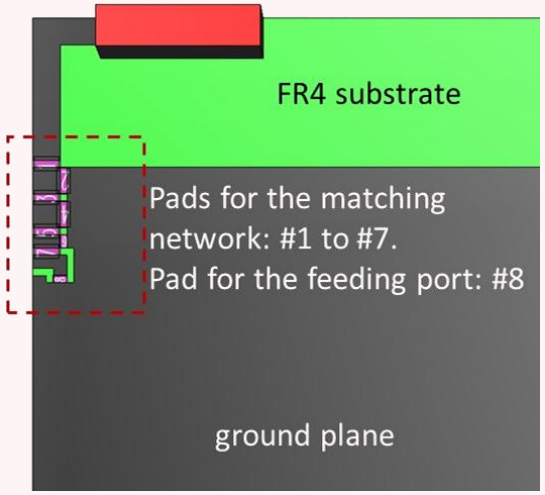
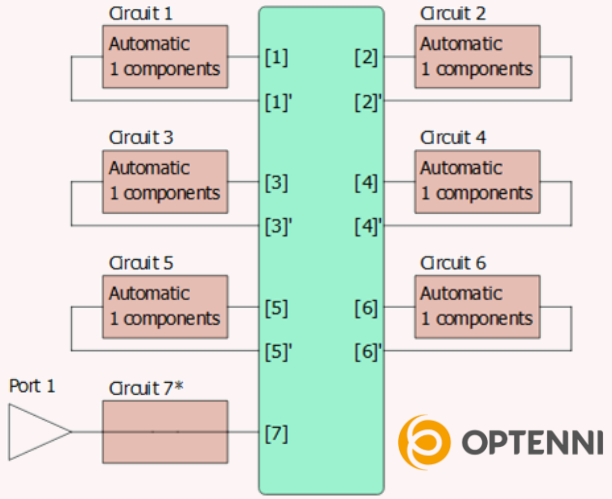
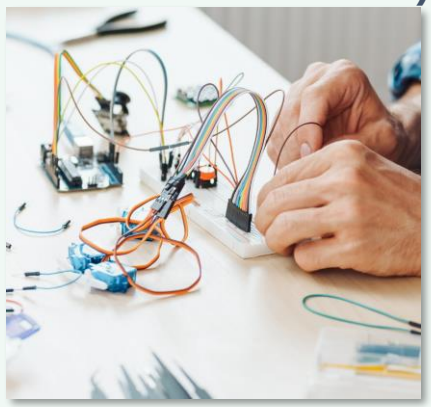
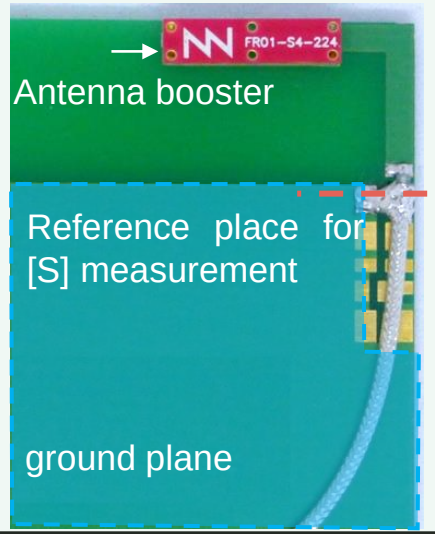
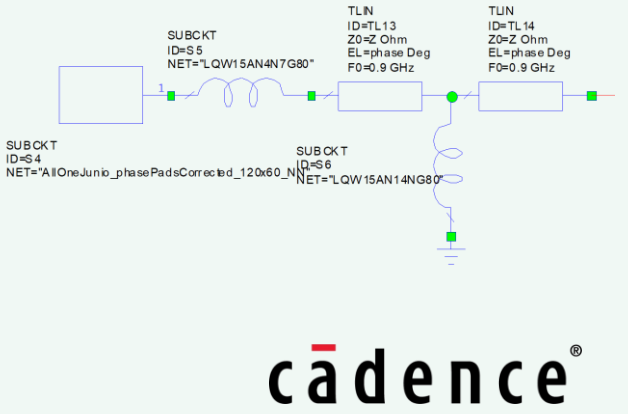
1. **Select your device (PCB size):**
   145 mm x 130 mm PCB
2. **Select the suitable antenna booster and position on the PCB:**
   12 mm x 3 mm x 2.4mm
3. **Define the frequency bands of operation:**
   LTE 698MHz-960MHz and 1710MHz-2690MHz
4. **Specify the target SWR/S_{11}:**
   S_{11}<-6dB at both frequency regions
5. **Let the Network Synthesis work for us, and…**



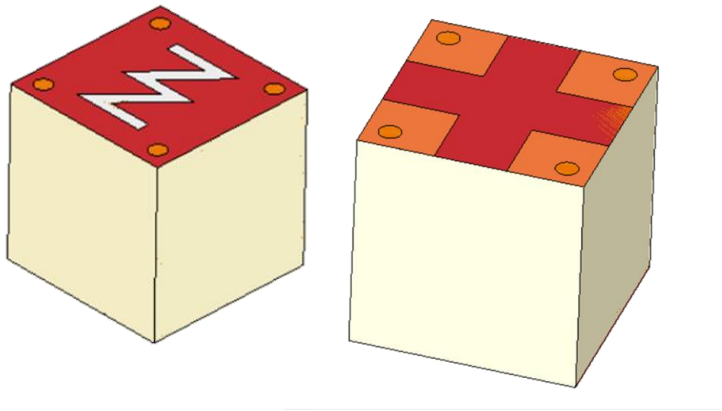
A multi-band smart-meter device



5.2 EDA for Matching Network Synthesis

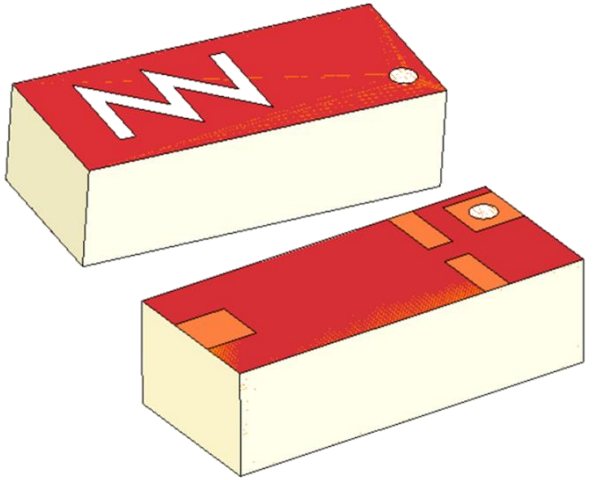
	Method		Description	Procedure
SIMULATION PHASE	**Full layout (simulation domain)** 			1) Full-wave simulation to obtain the [S] matrix 2) Import the [S] matrix to a network synthesis tool to obtain the matching network. 3) Specify targets 4) Network synthesis J. Anguera, A. Andújar, G. Mestre, J. Rahola, J. Juntunen, "Design of Multiband Antenna Systems for Wireless Devices Using Antenna Boosters", *IEEE Microwave Magazine*,, pp.102-114, Dec. 2019.
PROTOTYPING PHASE	**Single port (measurement domain)** 			1) Measurement of S_{11} of the antenna booster in the real device without any matching network 2) Import the [S] matrix to a network synthesis tool to obtain the matching network. Pads are modelled by short transmission lines 3) Specify targets 4) Network synthesis

5.3 Virtual Antenna™ products are available for CST STUDIO SUITE: Encrypted Models



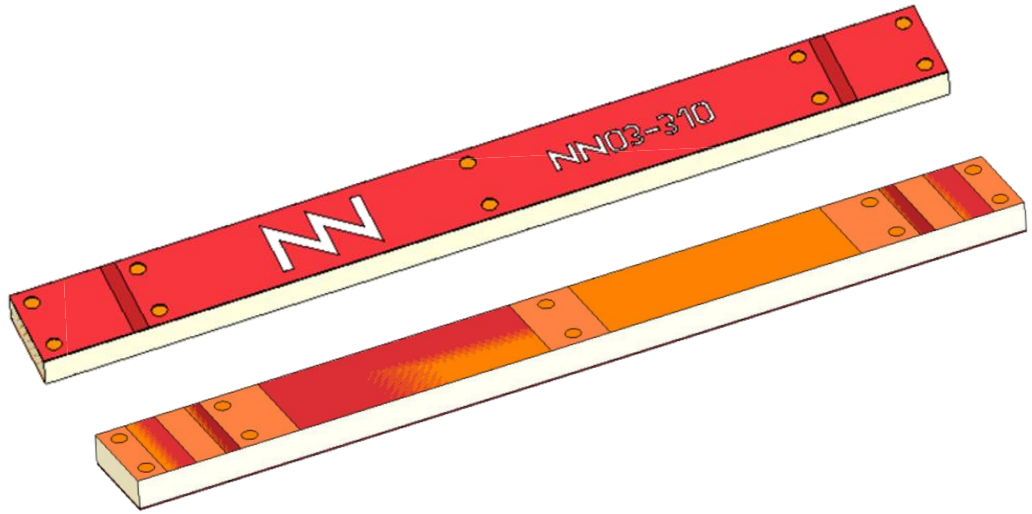
Virtual Antenna™ products are **available** for **wireless engineers** for **CST STUDIO SUITE** thanks to the encrypted tool

DASSAULT SYSTEMES
The 3DEXPERIENCE® Company



IoT Devices with TRIO mXTEND™ Antenna Booster

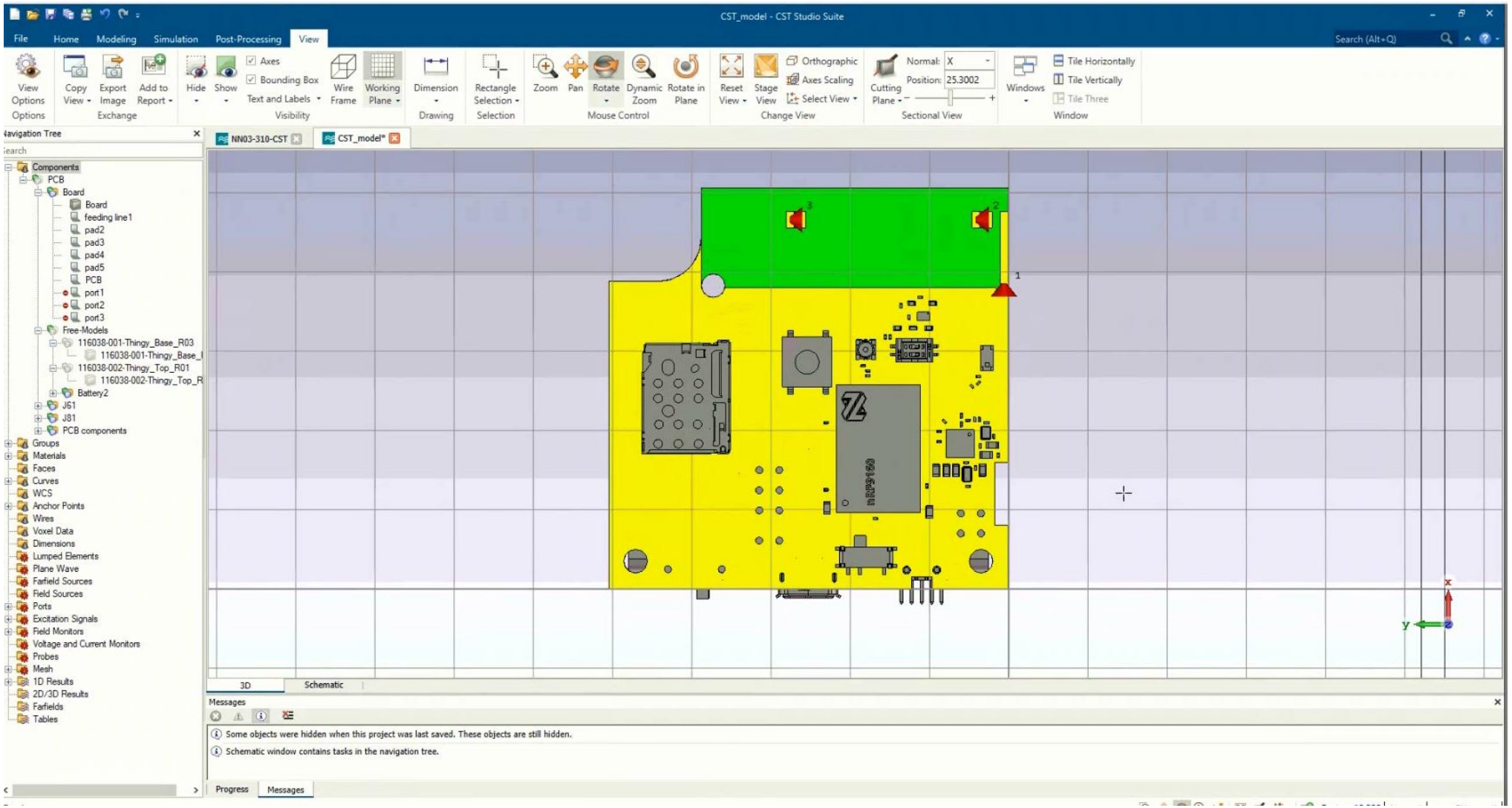
- Example: Cellular Tracking Open IoT Platform LTE + GPS



TRIO mXTEND™ antenna booster
Operating range: 0.698GHz - 8GHz
Best for: 0.698GHz – 8GHz
Dimensions: 30.0 mm x 3.0 mm x 1.0 mm
A dual-port antenna

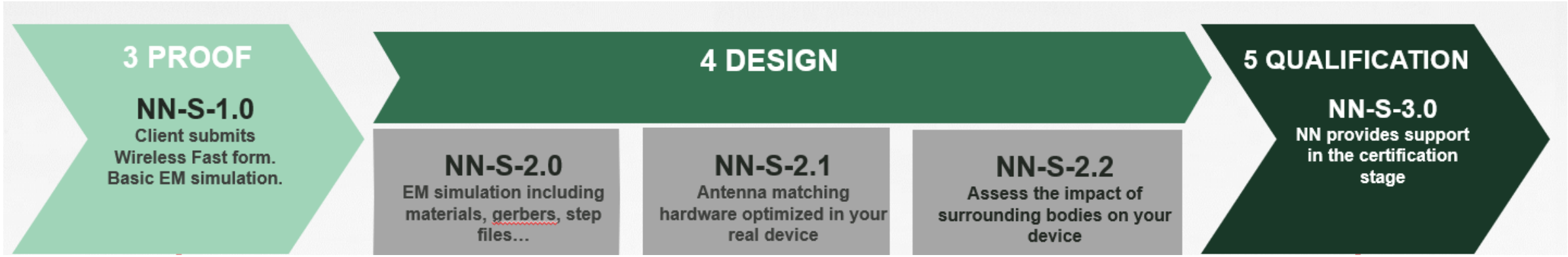
Encrypted TRIO mXTEND™ antenna booster
Same physical properties as the real product

TRIO mXTEND™ antenna booster: LTE and GNSS



5.4 Supporting services to accelerate your time-to-market

NN Services: A predictable antenna integration journey



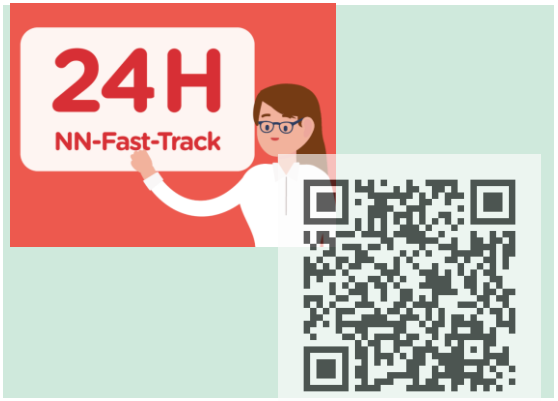
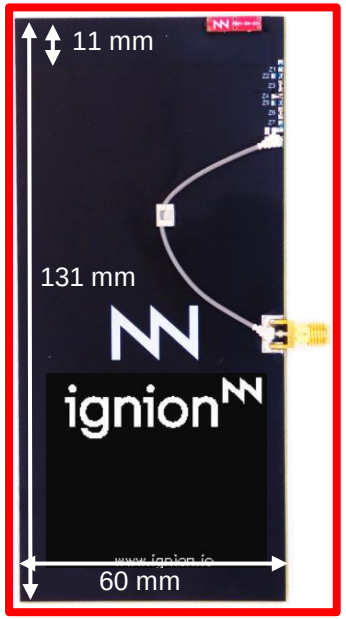
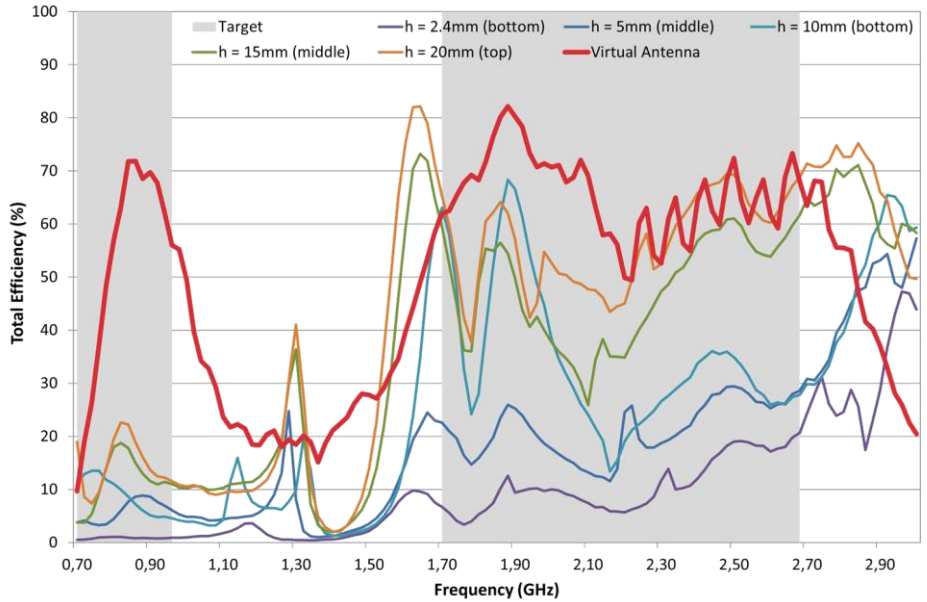
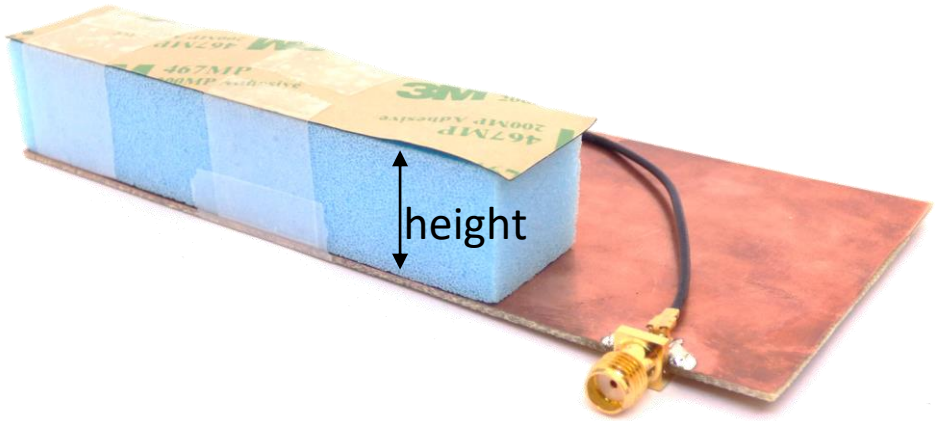


Table of Contents

Virtual Antenna™ vs FPC Antennas

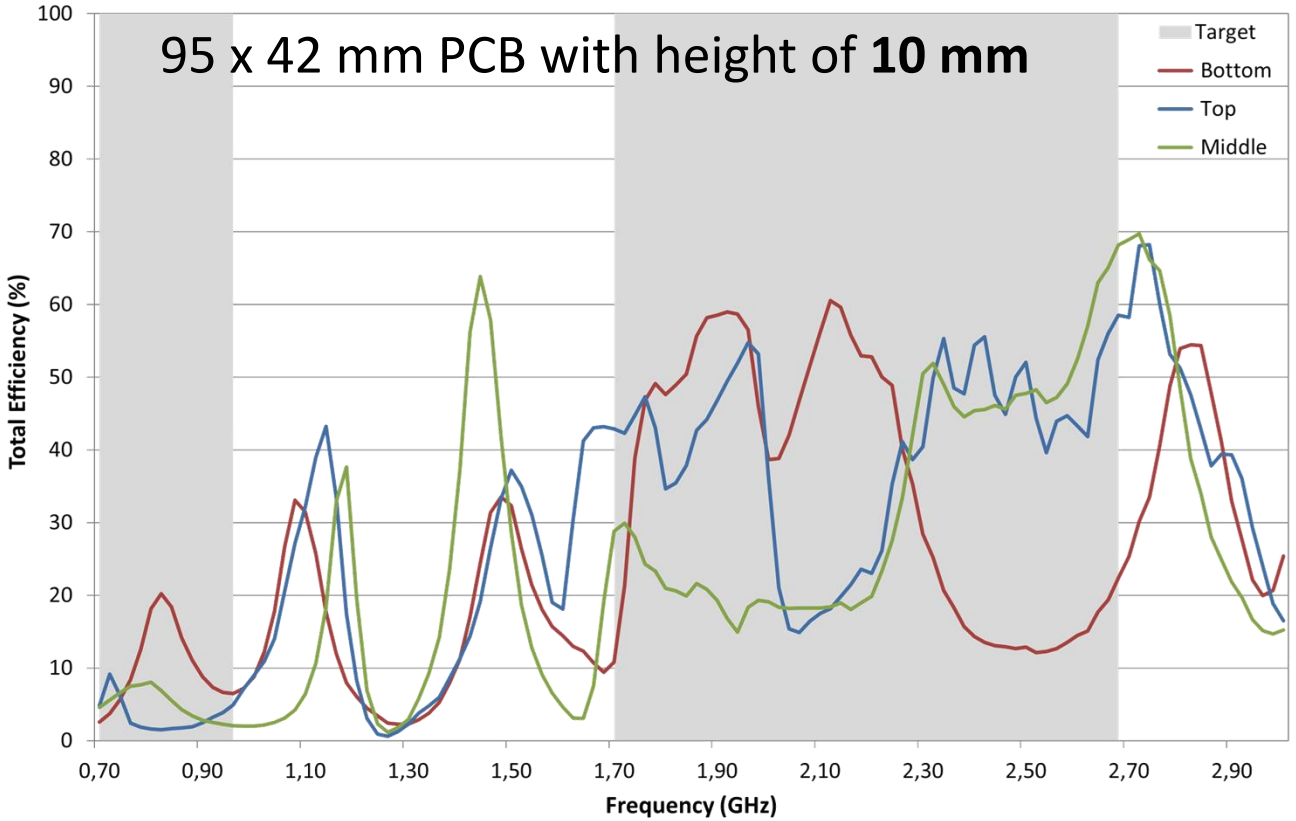


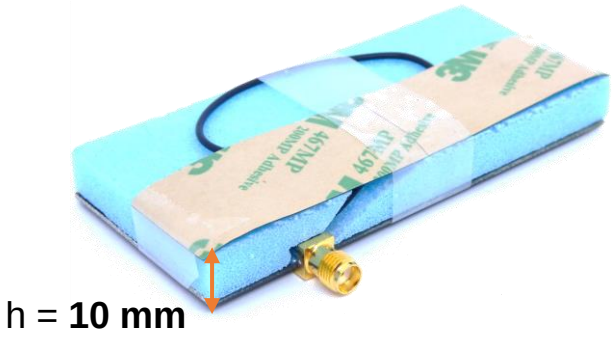




Antenna Efficiency (%)		698 MHz	960 MHz	Average	1710 MHz	2690 MHz	Average
Sticker	Height = **2.4mm** (bottom-right)	0.5	0.9	**0.8**	6.7	20.6	**10.9**
	Height = **5mm** (bottom-left)	3.8	6.1	**5.7**	22.5	28.6	**21.3**
	Height = **10mm** (bottom-left)	11.0	4.5	**9.0**	63.0	27.7	**34.5**
	Height = **15mm** (bottom-left)	3.8	11.0	**11.7**	59.4	61.7	**47.5**
	Height = **20mm** (bottom-left)	18.9	11.5	**14.8**	65.1	68.8	**56.4**
Virtual Antenna™		9.6	56.0	**52.0**	61.9	67.9	**65.7**

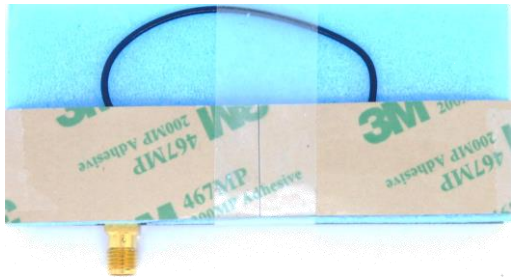
FPC antennas: Unpredictable Performance



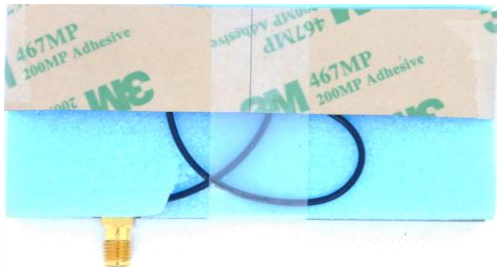


MIDDLE

BOTTOM



TOP



Antenna Efficiency (%)	698 MHz	960 MHz	Average	1710 MHz	2690 MHz	Average
TOP	4.8	4.9	**3.0**	42.8	58.5	**40.2**
MIDDLE	4.5	2.0	**5.0**	28.7	68.1	**33.5**
BOTTOM	2.5	6.4	**10.3**	10.8	22.3	**35.2**

7. Take Away

- **First steps** when designing your IoT device are the most important to get the best out of your device… consider **Virtual Antenna™ first** together with **device size:**
    1. Select your **PCB size**
    2. Select the **antenna booster** and its **location**
    3. Design the **matching network**
    4. Place the **Nordic Semiconductor transceiver close** to the **matching network** (<5mm)
- Virtual Antenna™: **any band, any device** thanks to a matching network
- Virtual Antenna™: **10 times smaller antenna chip**, **off-the-shelf** and **pick&place**
- You can **embed Virtual Antenna™** with **EDA tools** or following our **supporting services**
- **Virtual Antenna™** and **Nordic Semiconductor** transceiver enables **IoT multi-band** and **multi-radio** embedded solutions for **NB-IoT, LTE-M, GPS, Bluetooth Low Energy, Thread, Zigbee** for **any IoT device**

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