FRACTUS ANTENNAS

NORDIC SEMICONDUCTOR

Embedded antennas for IoT

Adapting the Nordic Thingy:91 antenna to your cellular IoT design

Nordic Partner Webinar

with Fractus Antennas

October 2019

Duration: approx 45 mins

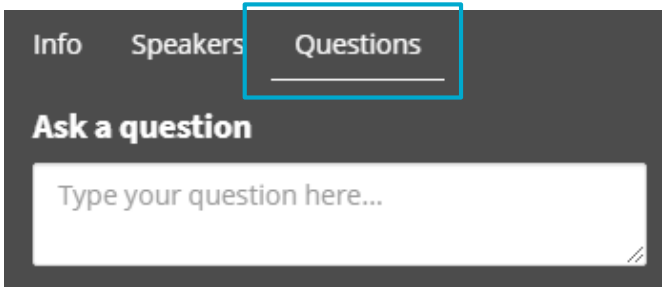
Today's host

Dr. Jaume Anguera

- Chief Scientist and Co-Founder at Fractus Antennas
- Inventor of Virtual Antenna™ Technology, 2008
- Author more than 130 granted patents and author of more than 220 papers (IEEE, EE, …)
- 20 years of experience in antenna design for the wireless industry
- Named to the European Inventor Award, 2014
- Technology Pioneer, World Economic Forum, 2005
- Associate Professor at Universitat Ramon LLull (Antenna Engineering)

Practicalities

- Duration: 45 mins
- Questions are encouraged!
- Please type your question in the Questions tab on the right sidebar
- All questions are anonymous
- We will answer questions towards the end
- All questions will be answered in a written Q&A shared a few days after the webinar
- Please use DevZone if you have further questions



{ DevZone

Content

- Brief on Nordic Thingy:91
- Fractus Antennas present the TRIO mXTEND™ embedded antenna and how you can adapt it for your cellular IoT designs
- Q&A

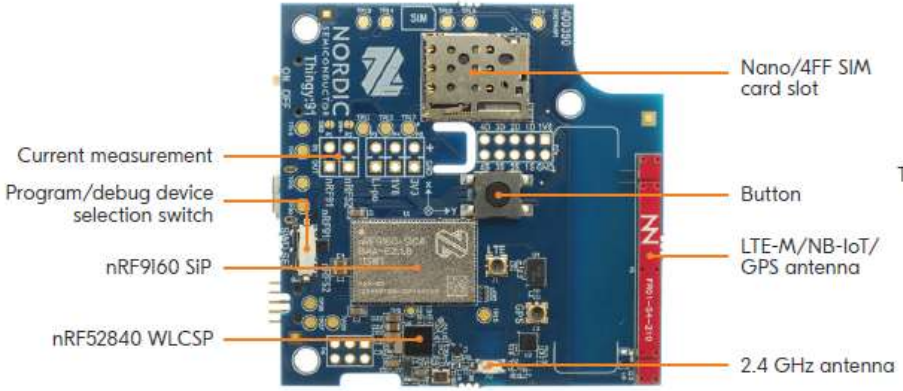
4

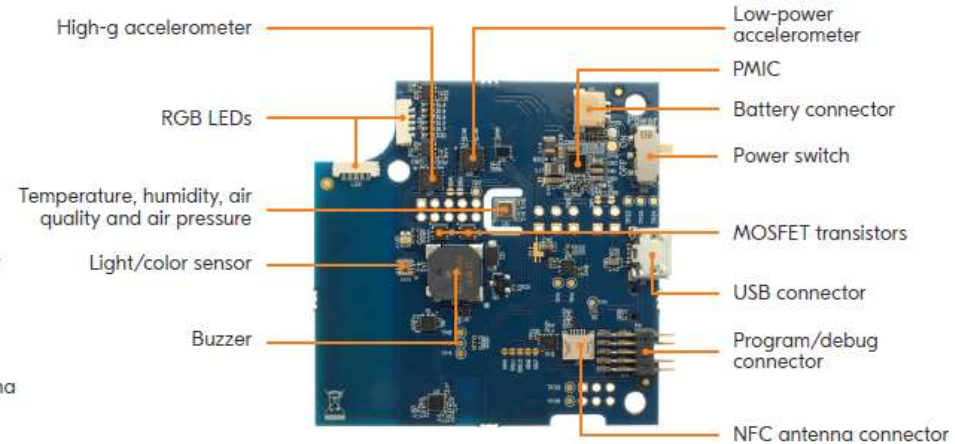
What is Nordic Thingy:91?

- An ‘out-of-the-box’ rapid prototyping kit for cIoT
- Supports LTE-M/NB-IoT and GPS
- Ships with a eSIM
- Supports Bluetooth Low Energy
- Lots of other sensors etc.
- Comes with a sophisticated application ready to go
- Dev tools and SDK

5

Nordic Thingy:91 hardware





NORDIC SEMICONDUCTOR

FRACTUS ANTENNAS

Embedded Antennas for IoT

Adapting the Nordic Thingy:91 Antenna to your cellular IoT Design

Dr. Jaume Anguera,

Chief Scientist

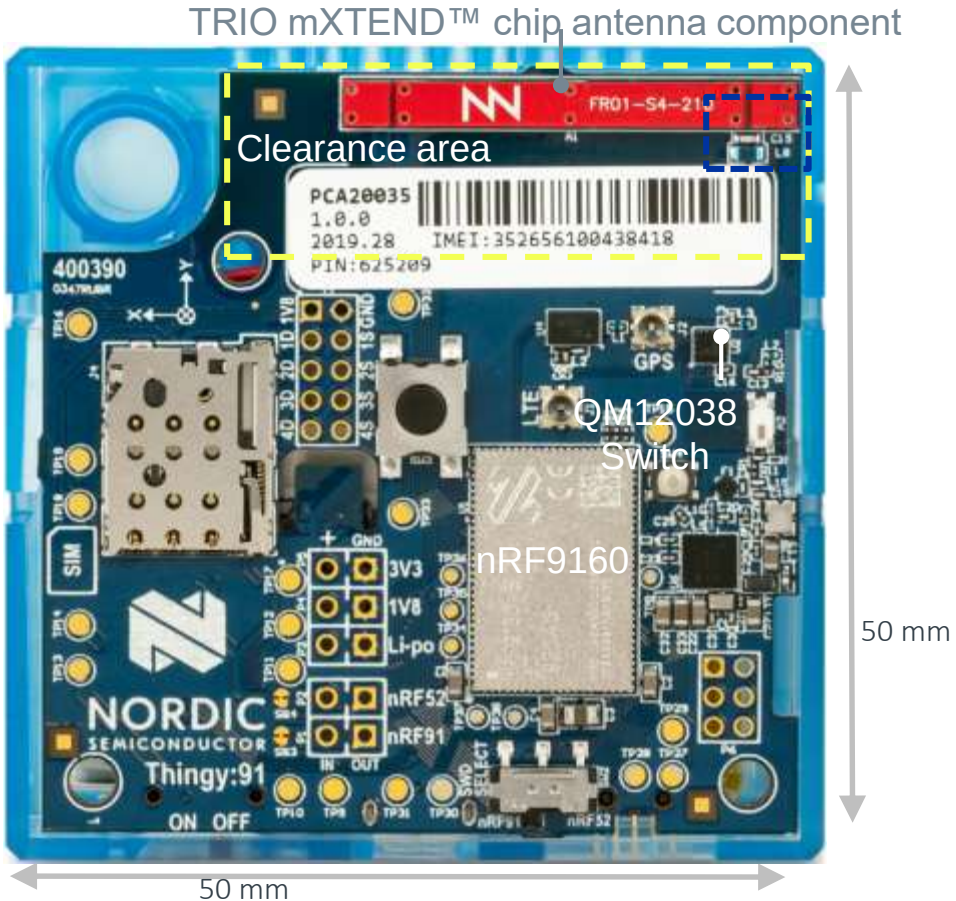
*FRACTUS ANTE**NN**AS*

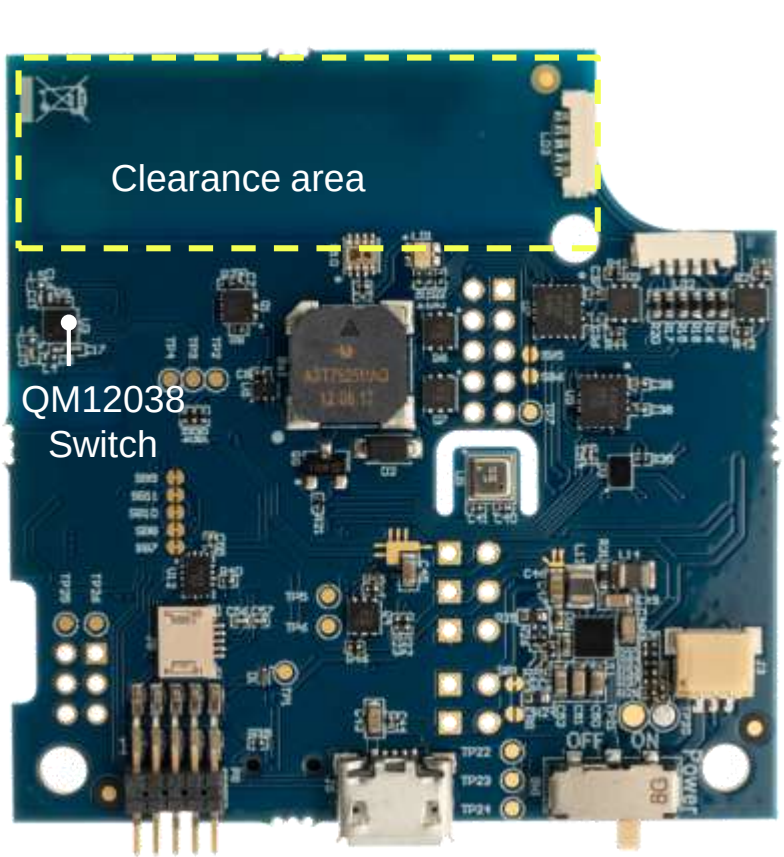
October 2019

Index

- About Virtual Antenna™
- Antenna Architecture for Nordic Thingy:91 based on nRF9160
- Adapting Nordic Thingy:91 design to your c-IoT Device
- Other form-factors
- Conclusions

Radio Frequency Architecture in the Nordic Thingy:91

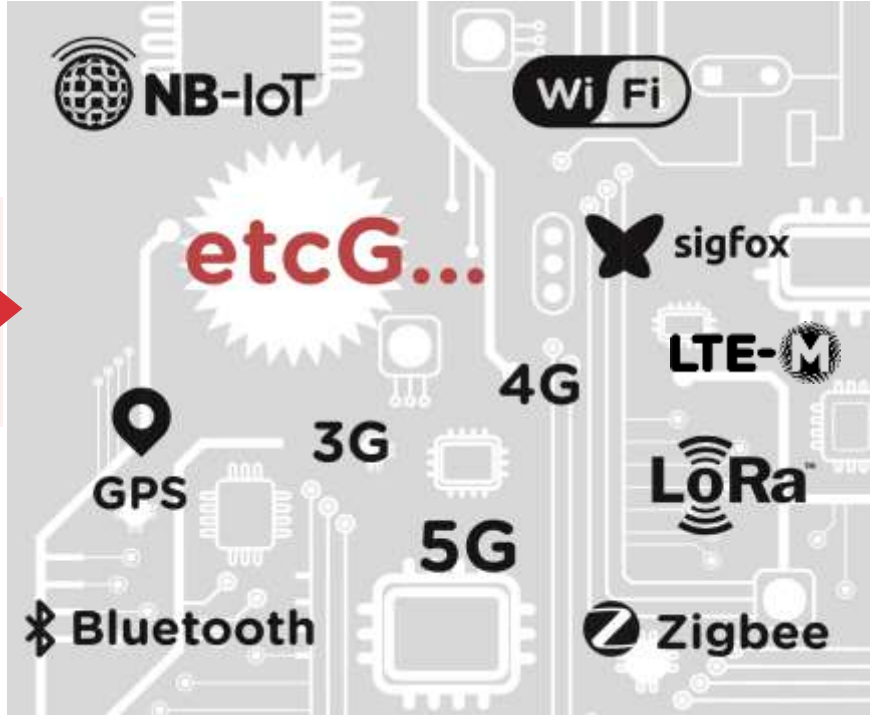





Virtual Antenna™
One antenna.
Any band.
Any device.
FR01-S4-210
Faster, Cheaper, Easier.
FRACTUS ANTENNAS

About **Virtual Antenna**™

One antenna
Any band
Any device



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

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.

About **Virtual Antenna**™

Virtual Antenna™: the latest generation of miniature, multiband, multipurpose chip antenna components for sub 6 GHz **cellular/IoT**

A game changing technology

Off-the-shelf
Ready to be delivered 'as is' with no need for customization.

Up to 10 times smaller
A booster can be 5³mm³ providing the same connectivity.

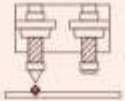
Versatility
A phone can be designed with several architectures yet still using the same component.

Scalability
The 'heart' of the design can be reused across multiple device models.

Modular
Modules or standard building blocks can be reused in the design of multiple devices.

Multiband
A single antenna provides connectivity in 3G, 4G and 5G bands.

Full performance
The same performance in a much smaller, off-the-shelf and versatile component.



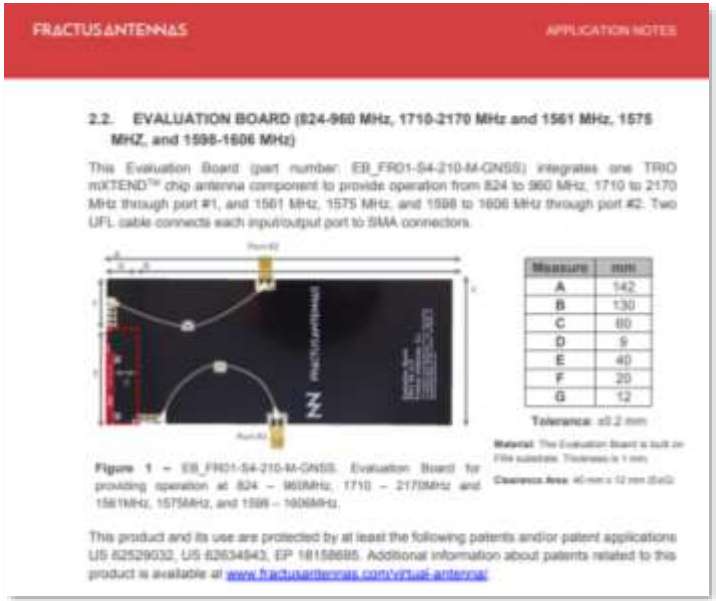
Pick & place
No manual assembly is needed, only a conventional SMT machine.

NN Products – Virtual Antenna™ boosters

Mobile + GNSS

IoT Smart Tracking

Mobile and GNSS in a single antenna package. Making your tracking device simpler.



FRACTUS ANTENNAS APPLICATION NOTES

2.2. EVALUATION BOARD (824-960 MHz, 1710-2170 MHz and 1561 MHz, 1575 MHZ, and 1598-1606 MHz)

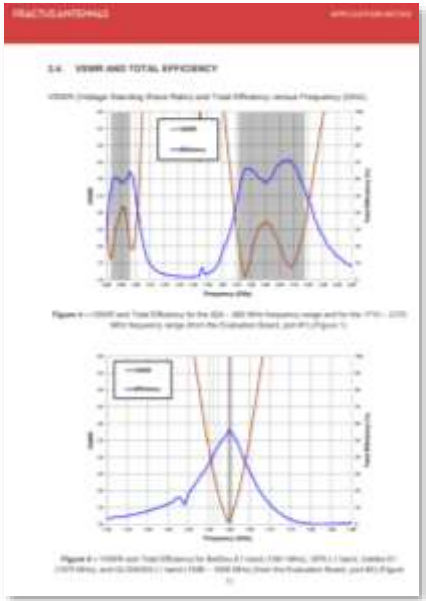
This Evaluation Board (part number: EB_FR01-S4-210-M-GNSS) integrates one TRIO mXTEND™ chip antenna component to provide operation from 824 to 960 MHz, 1710 to 2170 MHz through port #1, and 1561 MHz, 1575 MHz, and 1598 to 1606 MHz through port #2. Two UFL cable connects each input/output port to SMA connectors.

Measure	mm
A	142
B	130
C	80
D	9
E	40
F	20
G	12

Tolerance: ±0.2 mm

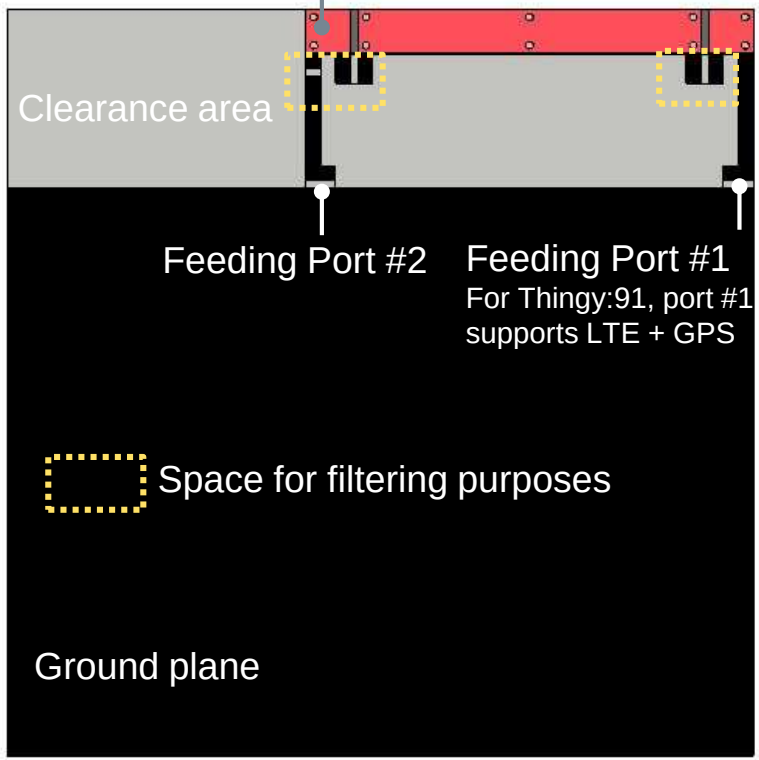
Figure 1 – EB_FR01-S4-210-M-GNSS Evaluation Board for providing operation at 824 – 960MHz, 1710 – 2170MHz and 1561MHz, 1575MHz, and 1598 – 1606MHz.

This product and its use are protected by at least the following patents and/or patent applications US 62529032, US 62634943, EP 18158695. Additional information about patents related to this product is available at www.fractusantennas.com/virtual-antenna/



Virtual Antenna™ in the Nordic Thingy:91

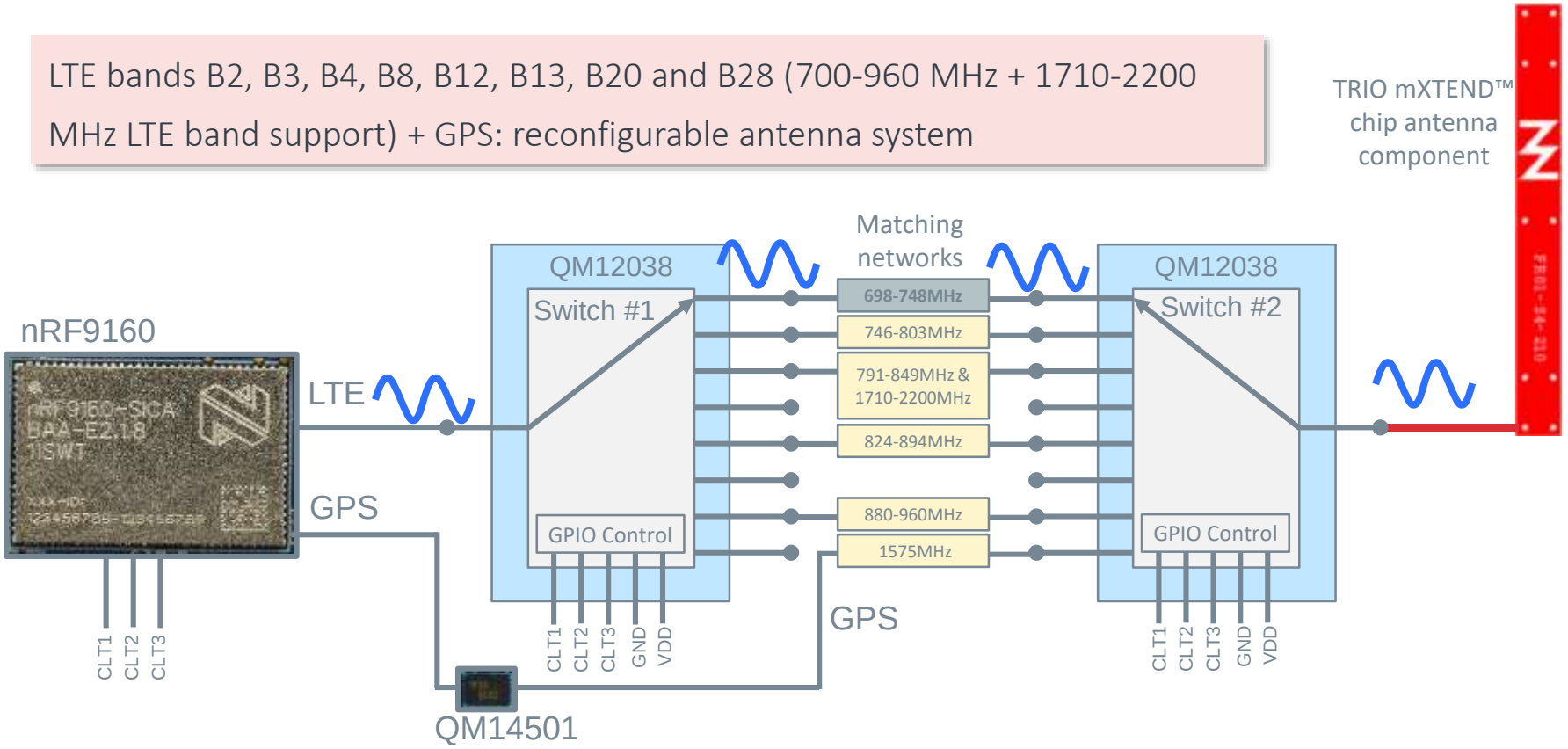
TRIO mXTEND™ chip antenna component: 30 mm x 3 mm x **1 mm** (h)



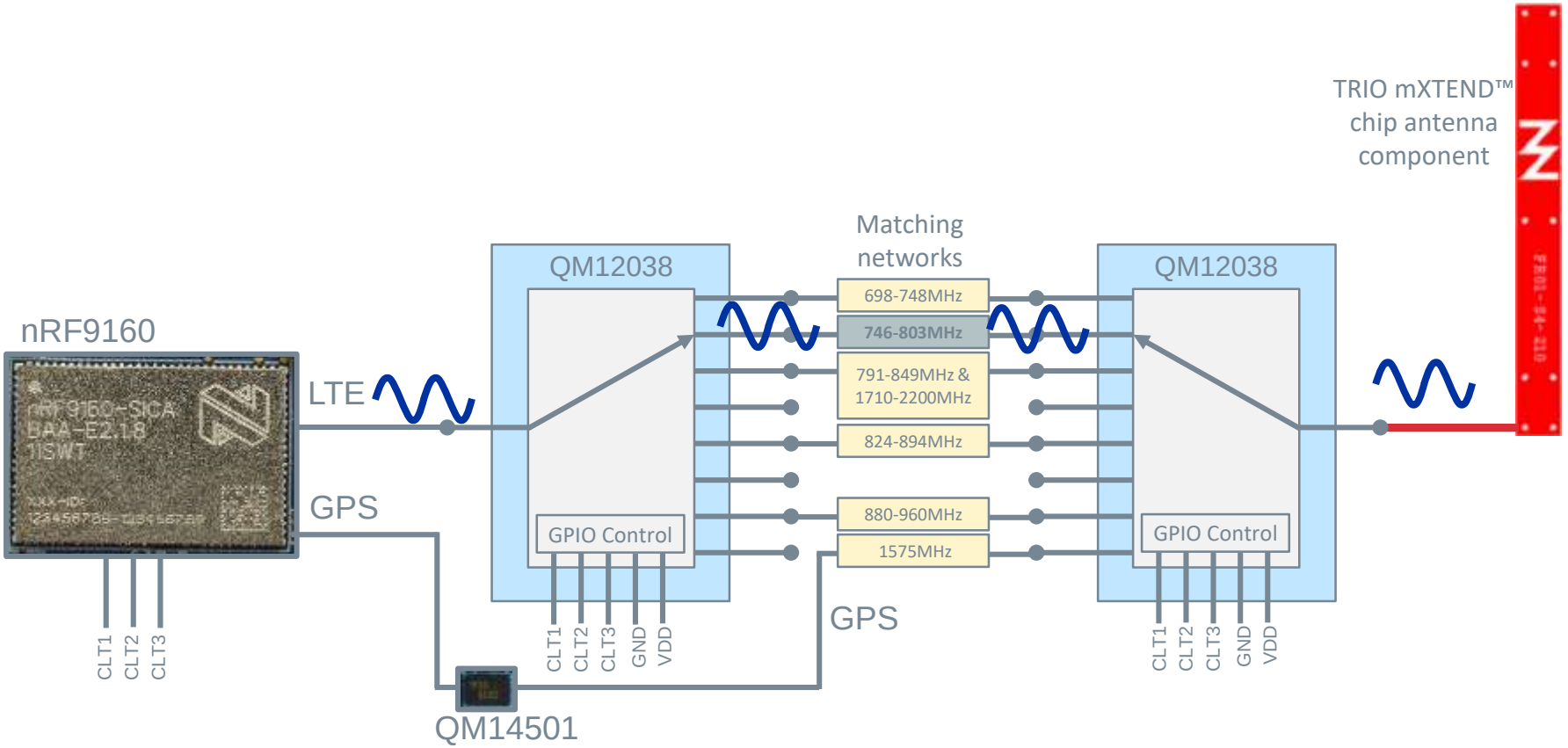
https://www.fractusantennas.com/files/AN_FR01-S4-210_Thingy91.pdf

Antenna Architecture for Nordic Thingy:91 Platforms

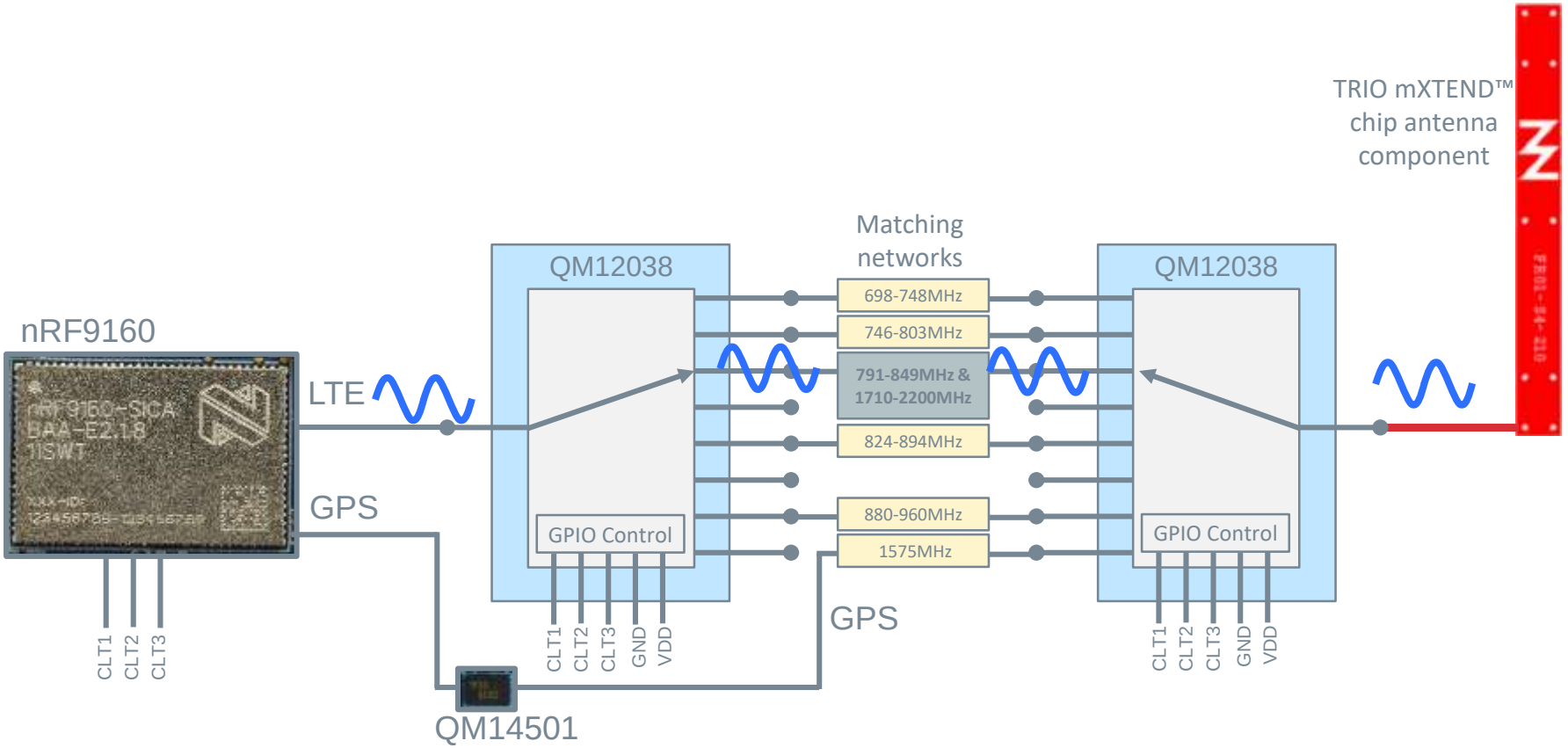
LTE bands B2, B3, B4, B8, B12, B13, B20 and B28 (700-960 MHz + 1710-2200 MHz LTE band support) + GPS: reconfigurable antenna system



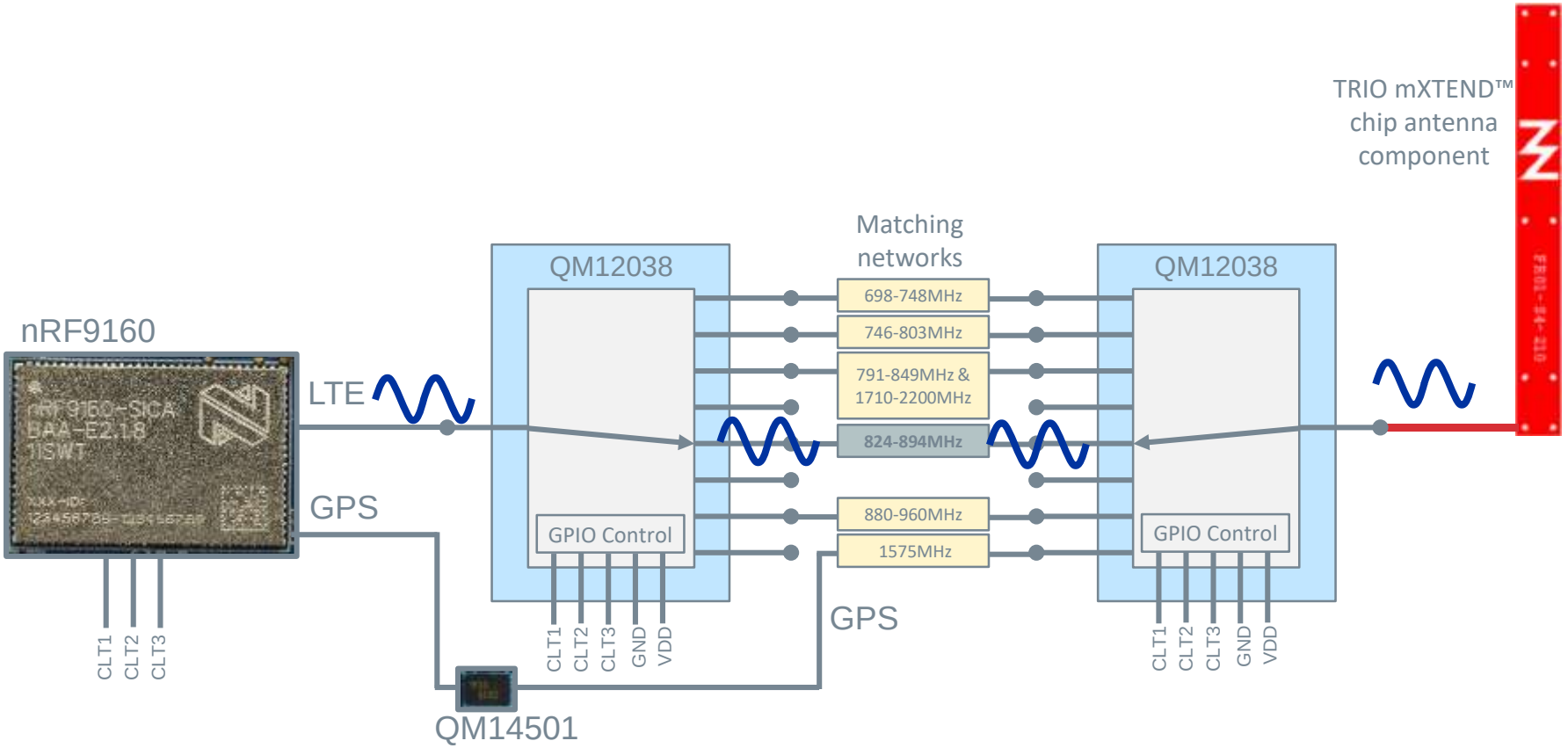
Antenna Architecture for Nordic Thingy:91 Platforms



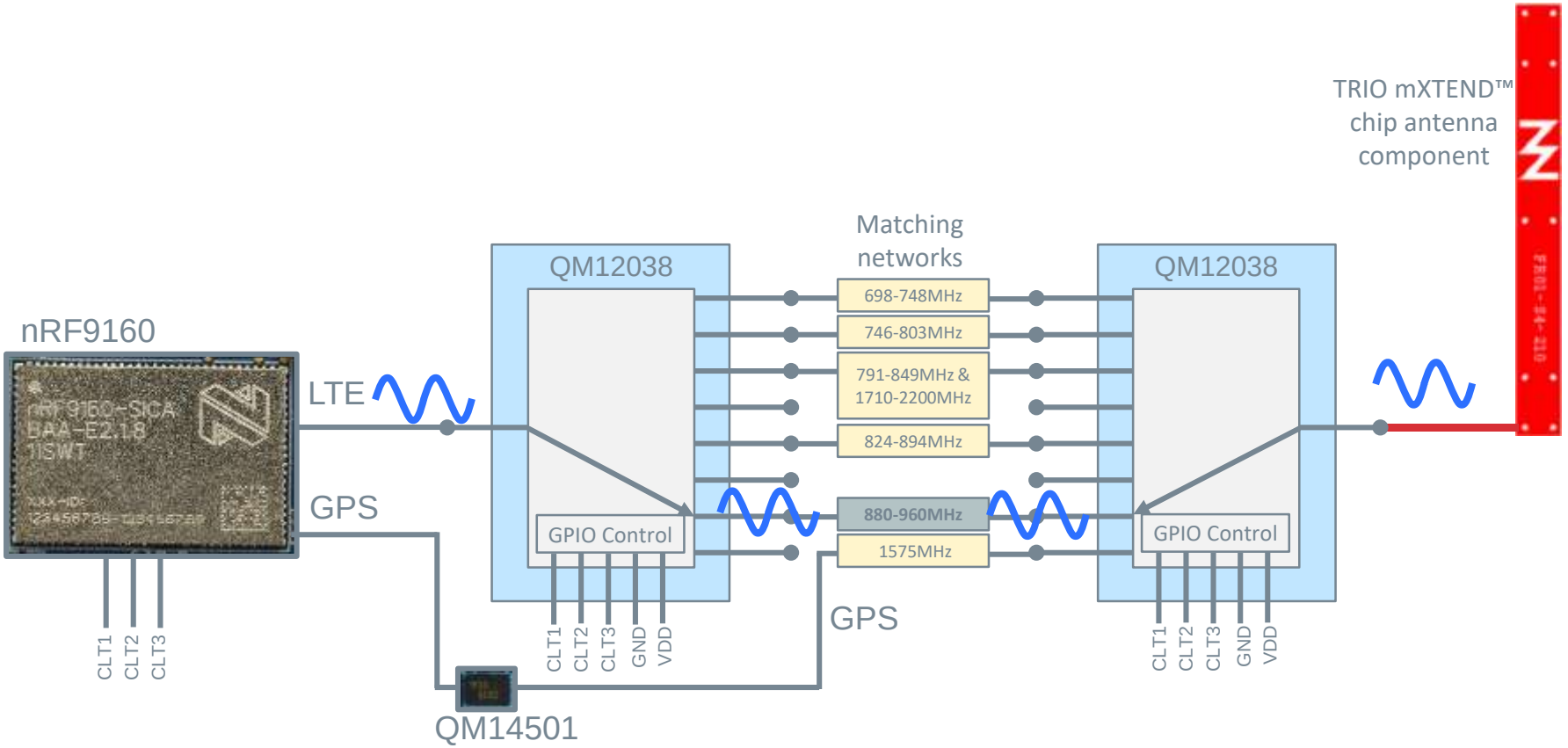
Antenna Architecture for Nordic Thingy:91 Platforms



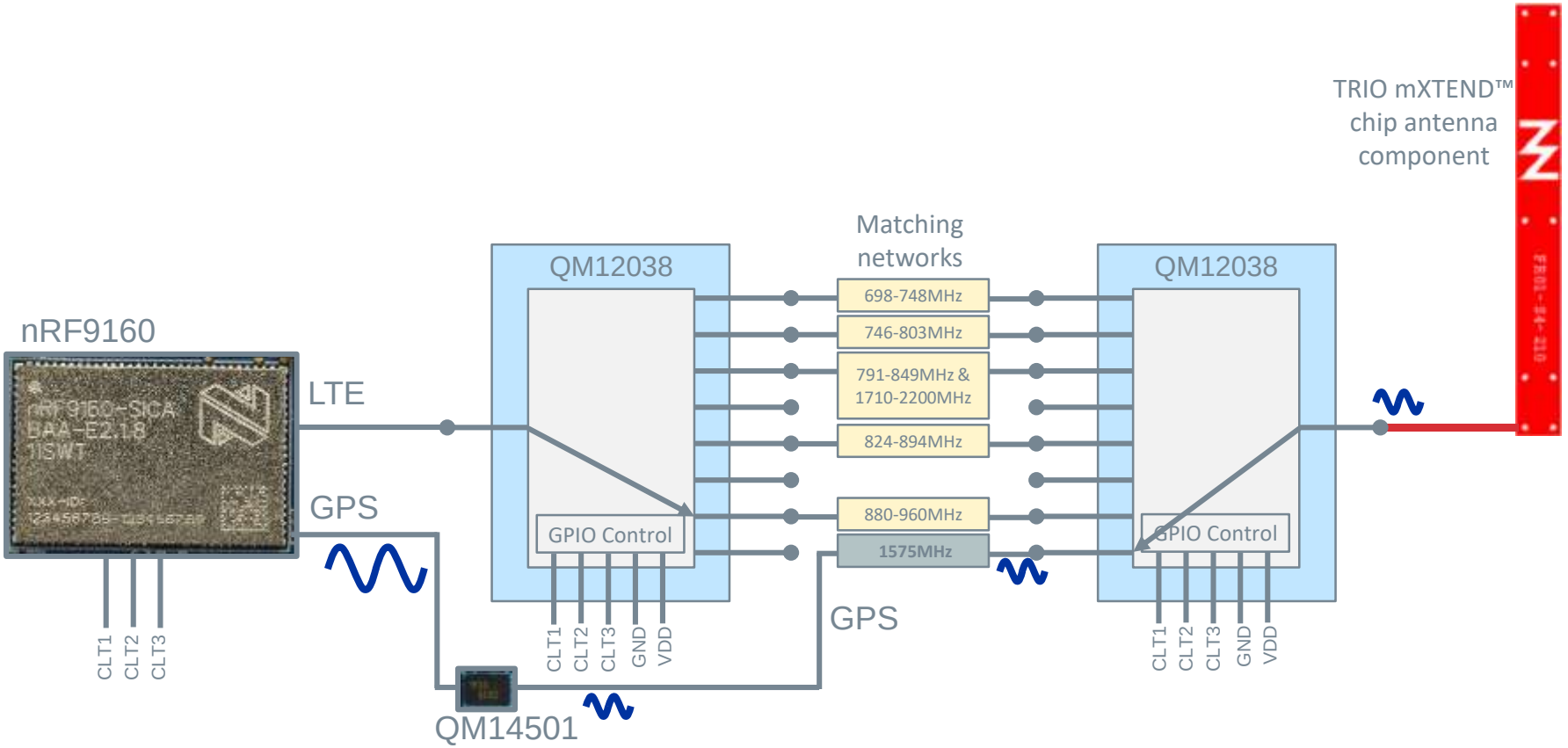
Antenna Architecture for Nordic Thingy:91 Platforms



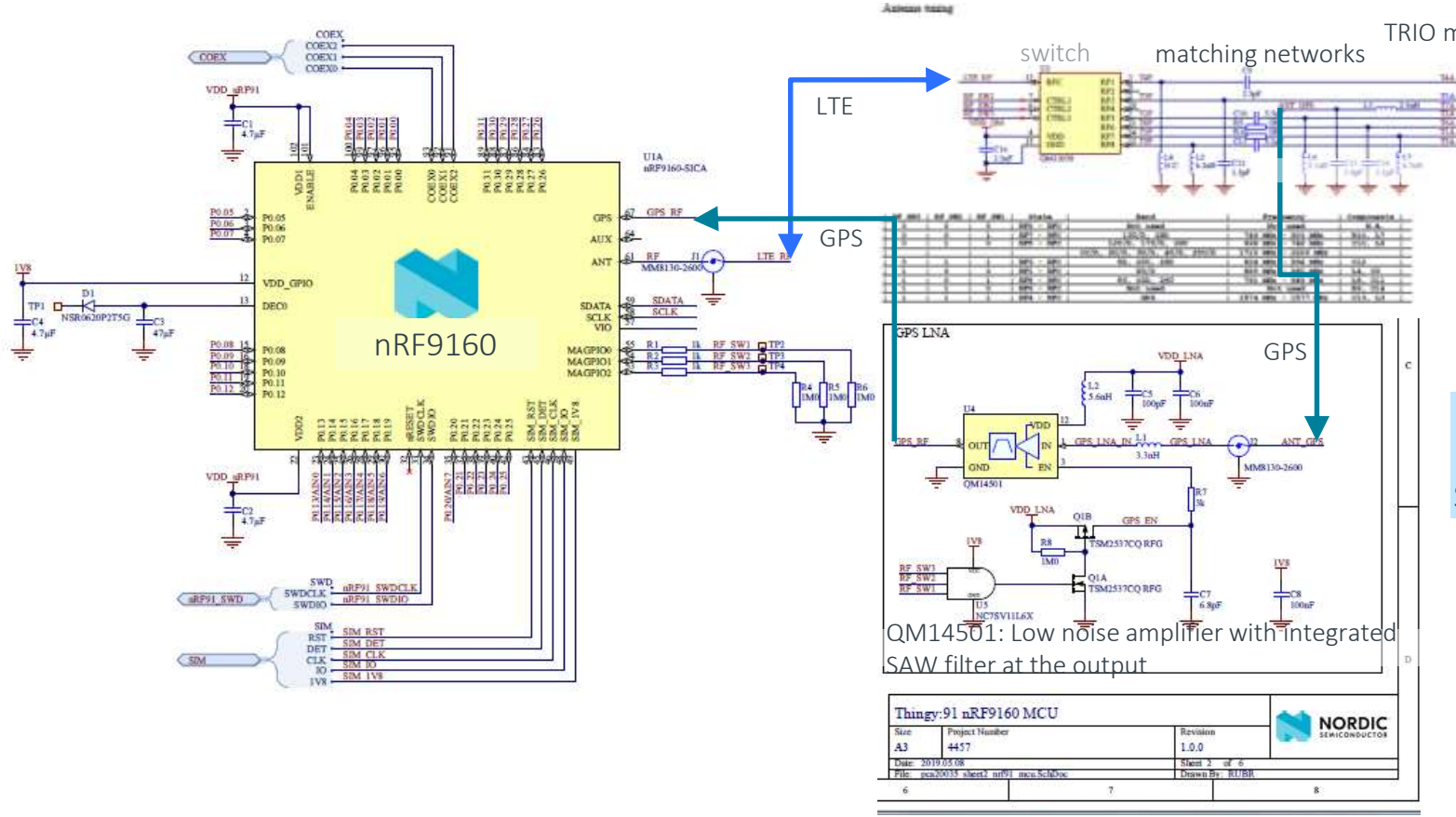
Antenna Architecture for Nordic Thingy:91 Platforms



Antenna Architecture for Nordic Thingy:91 Platforms

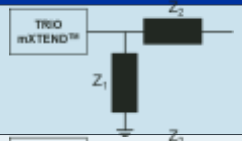
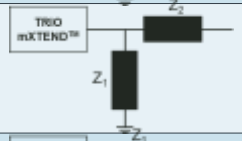
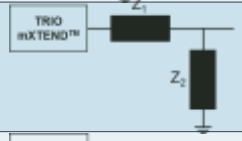
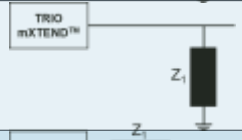
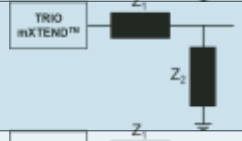
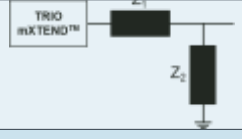


Antenna Architecture for Nordic Thingy:91 Platforms



All schematics available at Nordic Semiconductor web

Matching Networks

STATE	Frequency band	Matching Network
RF5	698-748MHz & 1710-2200MHz	
RF7	746-803MHz	
RF8	791-849MHz	
RF3	824-894MHz	
RF1	880-960MHz	
RF4	GPS (1575MHz)	
RF2&6	available for other bands	empty

Component	Value	Part Number
Z1 (L6)	5.1nH	LQW03AW5N1J00
Z2 (C10)	5.5pF	GJM0332C1H5R5WB01

Component	Value	Part Number
Z1 (L7)	4.7nH	LQW03AW4N7J00
Z2 (R10)	0Ω	-

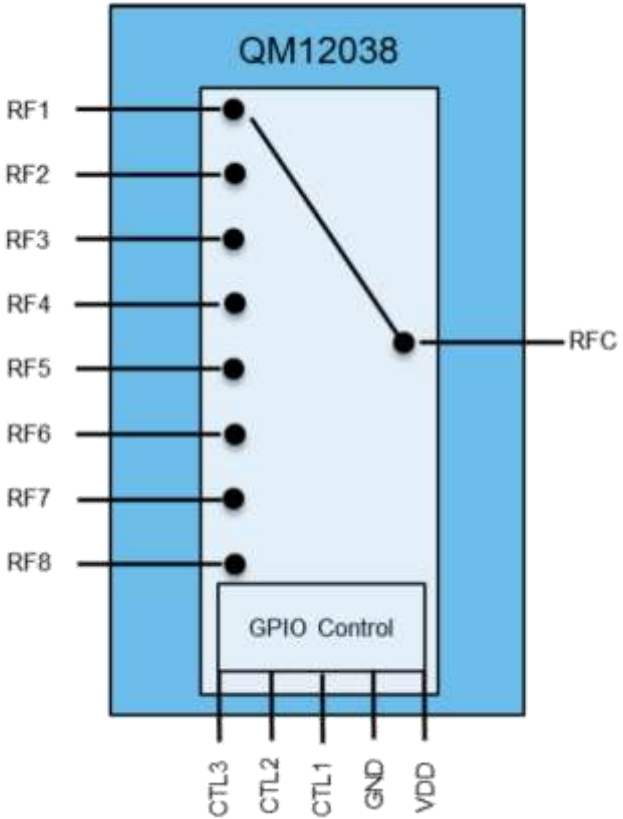
Component	Value	Part Number
Z1 (C11)	9.2pF	GJM0332C1E9R2WB01
Z2 (L5)	6.2nH	LQW03AW6N2J00

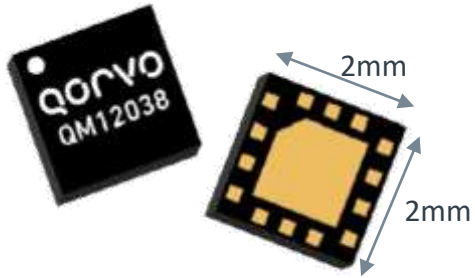
Component	Value	Part Number
Z1 (C12)	1.5pF	GJM0334C1E1R5WB01

Component	Value	Part Number
Z1 (C9)	2.5pF	GJM0335C1E2R5WB01
Z2 (L4)	Open circuit	-

Component	Value	Part Number
Z1 (L3)	2.9nH	LQW03AW2N9C00
Z2 (C13)	3.9pF	GJM0333C1E3R9WB01

About the Switch



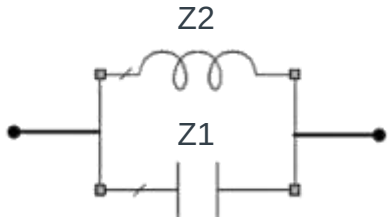


15 Pin 2 x 2 x 0.57 mm Module Package

Features:

- Excellent insertion loss and isolation performance
  - 0.5dB Typ IL, Band 5
  - 40dB Typ Isolation, Band 5
- Multi-Band operation 700MHz to 2700MHz
- GPIO compatible to 1.8V typ (1.3V min)
- Power handling +32dBm, 50Ω
- Compact 2mm x 2mm, Module package
- No DC blocking capacitors required (unless external DC is applied to the RF ports)

Considerations on the TRIO mXTEND™ chip antenna



Component	Value	Part Number
Z1 (C15)	0.3pF	GJM1555C1HR30WB01 (Q_{min}=570)
Z2 (L8)	15nH	LQW18AN15NG80 (Q_{min}=78)

- This is a filter used to optimize antena performance
- In order to optimize efficiency, the inductor is SMD 0603 and the capacitor SMD 0402
- Murata components are used. Other brands can be used as long as they keep the same quality factor (Q)

Adapting Nordic Thingy:91 design to your c-IoT Device

Video Tutorials

Easy. In only 3 simple steps you can obtain high antenna performance in the smallest space ever.

https://www.fractusantennas.com/tutorials/

STEP 1

Place the antenna component

Video #1

STEP 2

Design your matching network

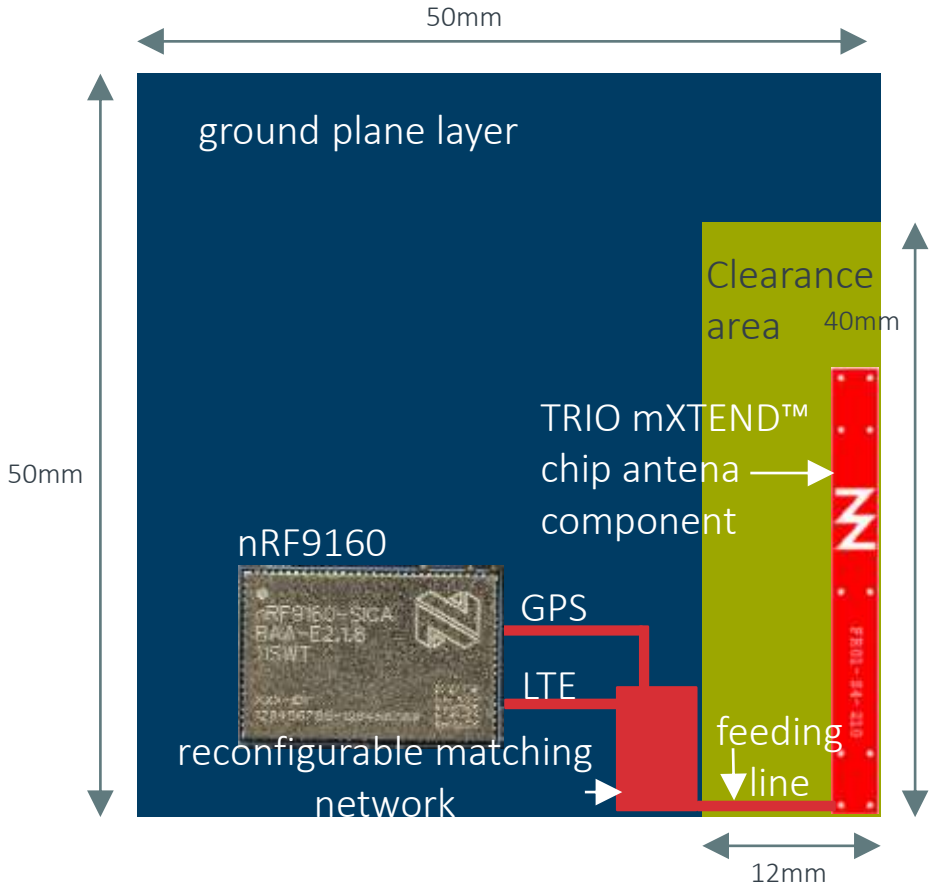
Video #2

STEP 3

Test your device

Video #3

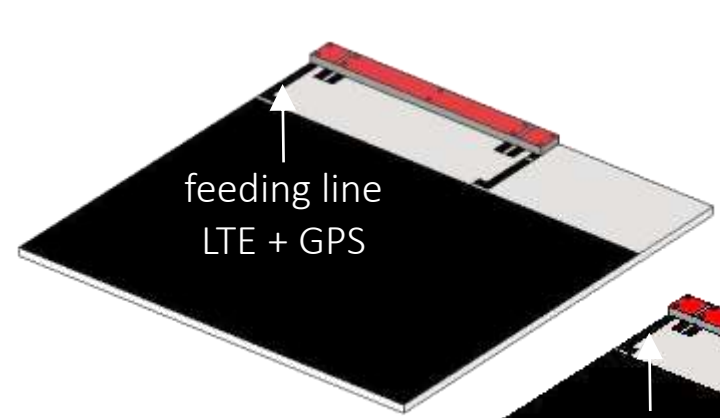
Design Guidelines (I)

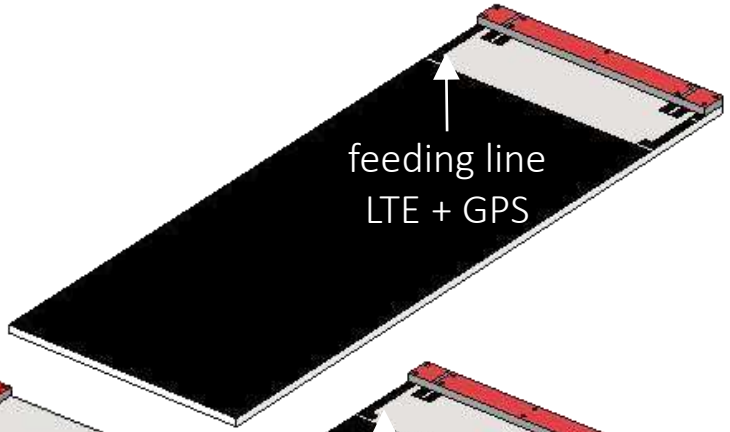


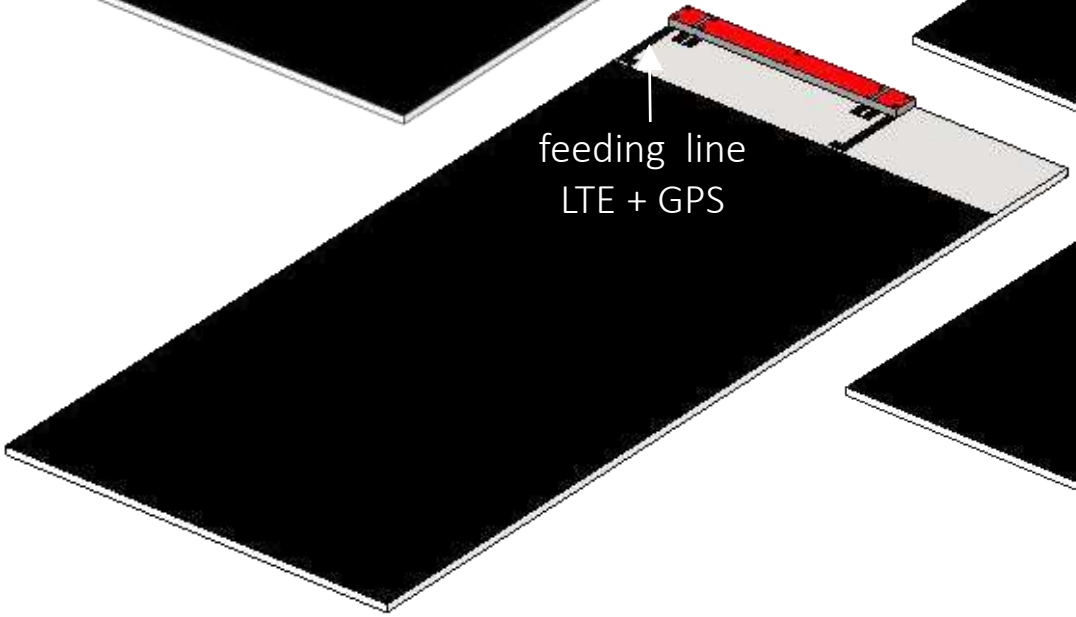
On its starter configuration, Thingy:91 has been optimized for a small platform following these general guidelines:

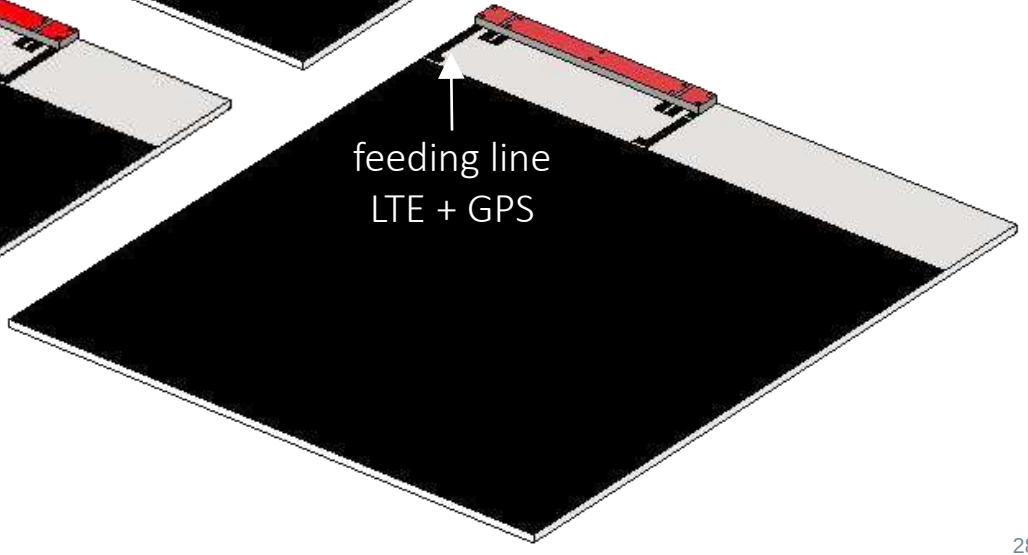
- Minimum **recommended PCB size: 50 mm x 50 mm**
- Keep one **continuous RF ground plane** layer
- **Place** the TRIO mXTEND™ **chip antenna** component close to a **corner of the PCB**
- Include a **feeding line** 1mm width as close to the **corner** as possible
- **Leave a ground clearance** (area free of any component or conductive traces) of at least 40 mm x 12 mm. This clearance area applies to all layers
- Include the **nRF9160** front end module from Nordic Semiconductor **close to the antenna matching network** layout
- Include **pads compatible with 0201 SMD** components for the matching networks as close as possible to the feeding point
- **Transmission lines** conneting the switch with matching networks and nRF9160 should have a characteristic impedance of **50 Ω**

Design Guidelines (II)





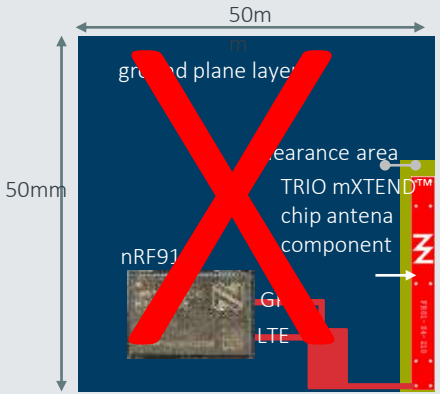




Design Guidelines (III): Do-not rules

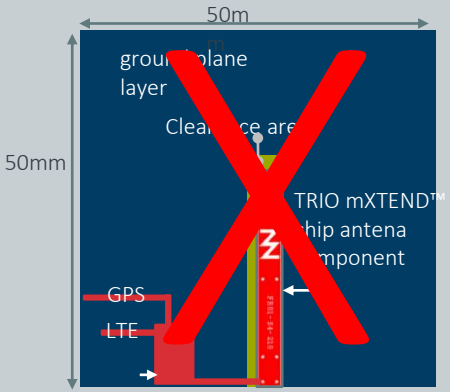
Clearance Area

- Avoid small clearance area
- Avoid traces on the clearance area



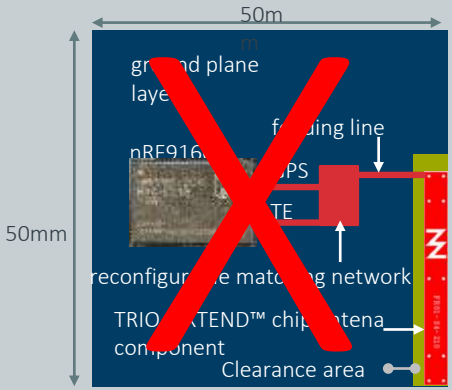
Antenna placement

- Avoid placing the antenna in the middle of the ground plane



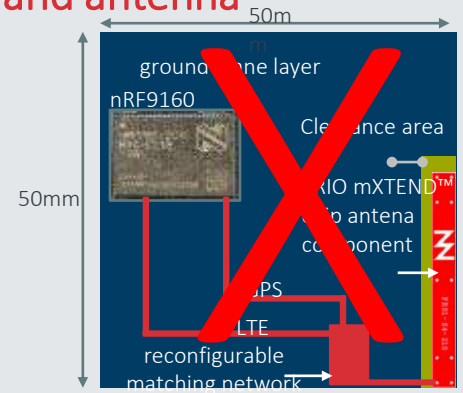
Antenna feeding

- Avoid the feeding at the center of the ground plane

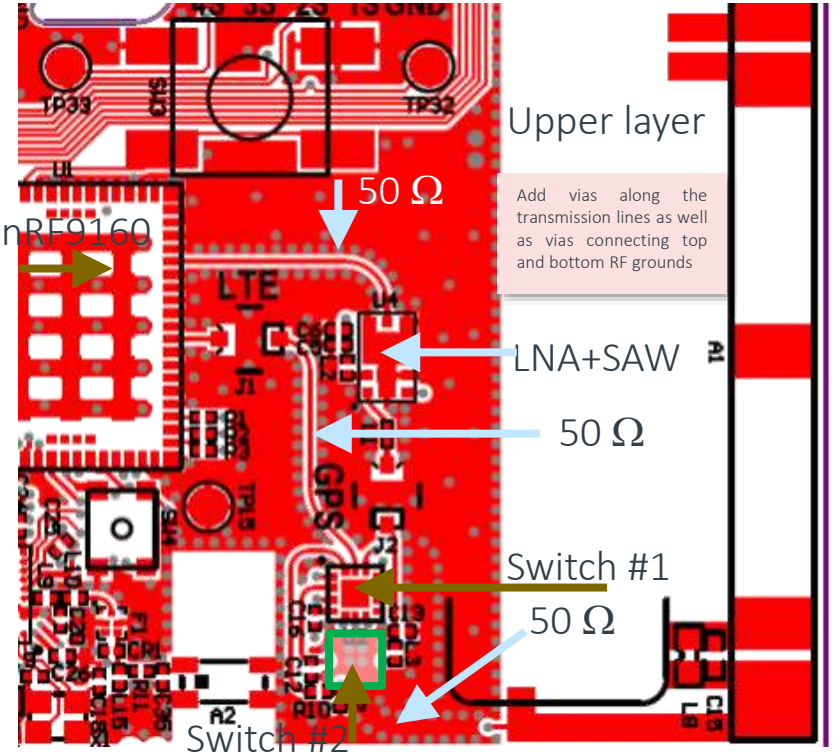


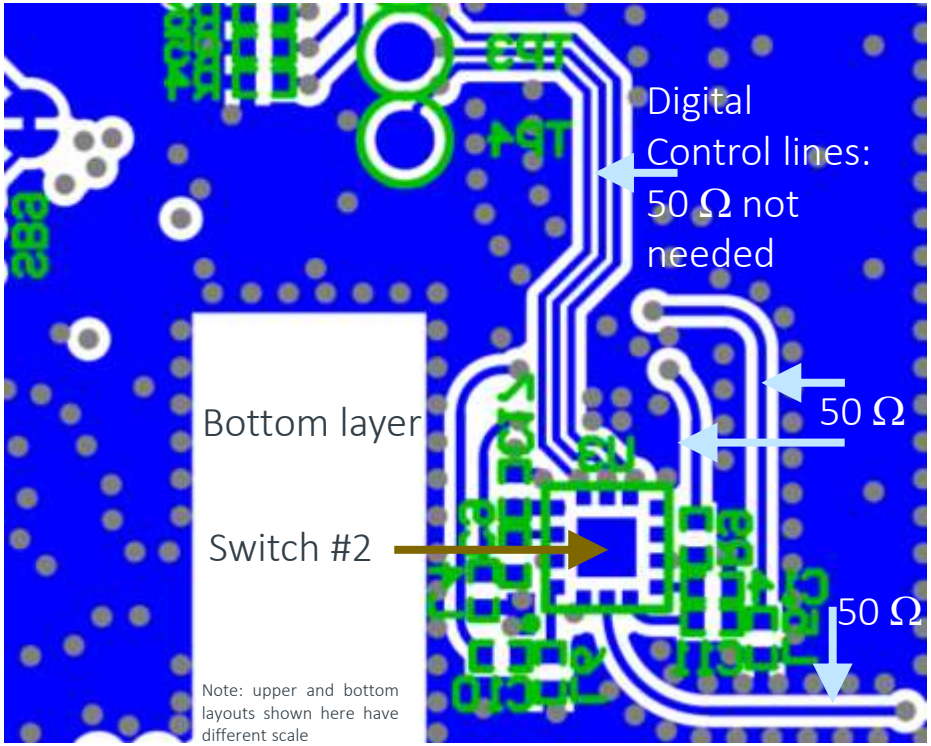
Distance RF module and antenna

- Avoid long distances between the TRIO mXTEND™ chip antenna and the nRF9160 module



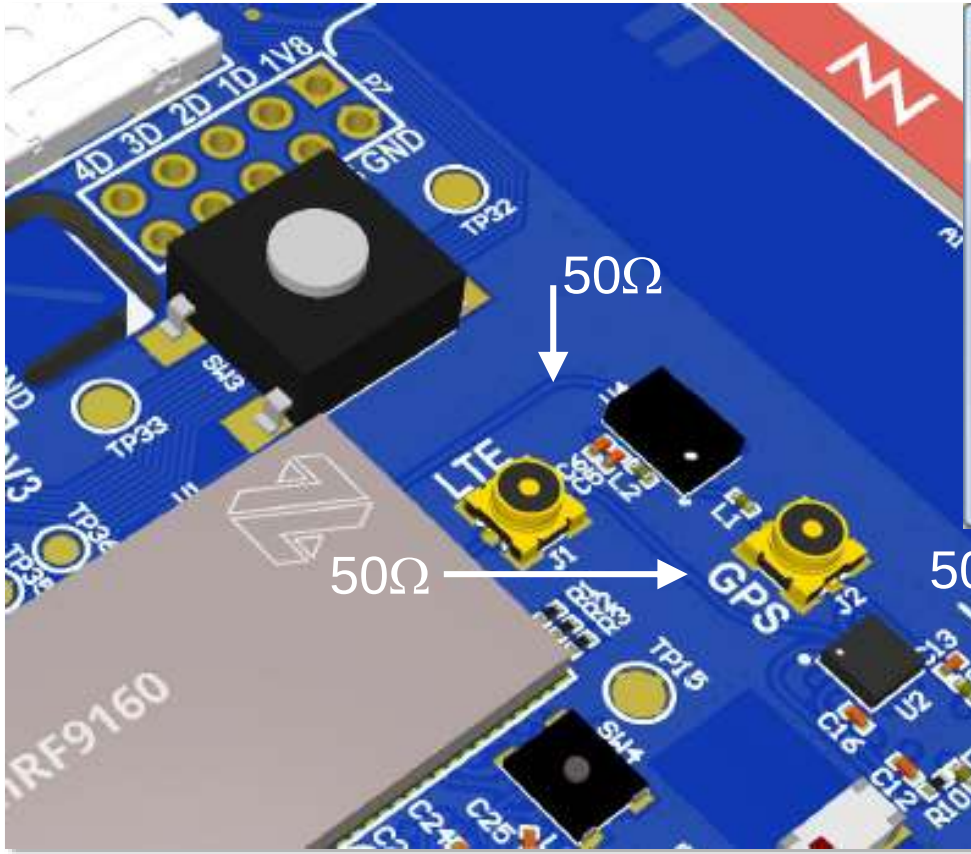
Design Guidelines (IV): 50 Ω transmission lines

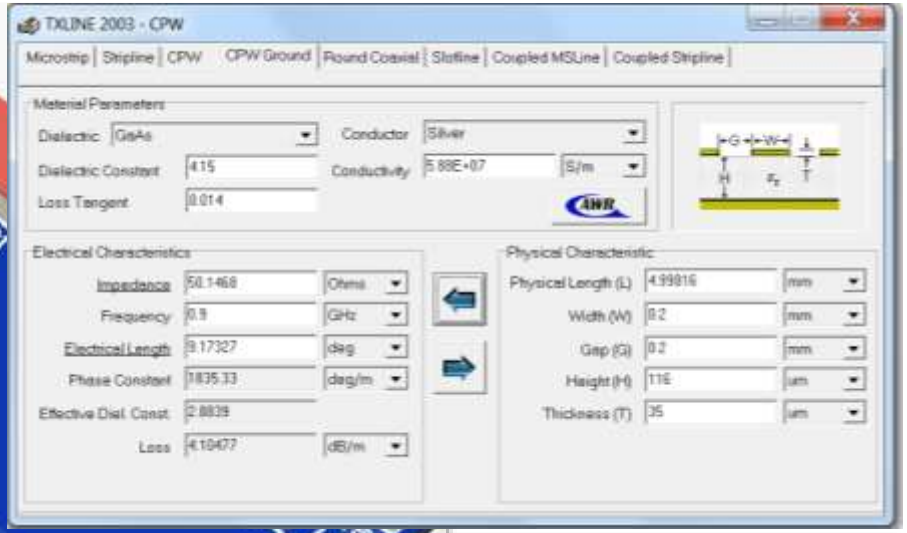




- Transmission lines connecting the antenna with switch #2, matching networks with the switches, and switch #1 with the nRF9160 module, must present a 50 Ω characteristic impedance

Design Guidelines (V): 50 Ω transmission lines



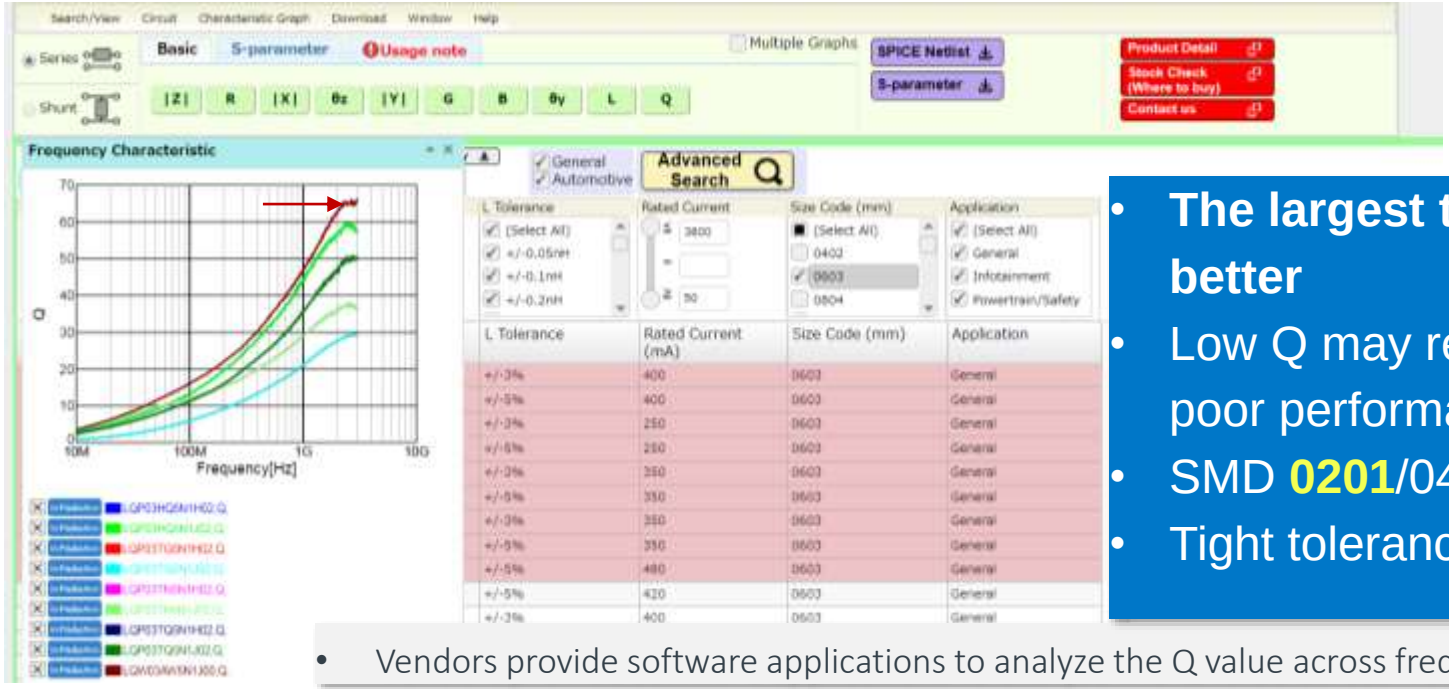


NI-AWR Software Txline calculator: A free and interactive calculator for the analysis and synthesis of transmission-line structures

Design Guidelines (VI): About Inductors and Capacitors

- Do I need to know something else besides L or C value?

  Yes, Q matters!!

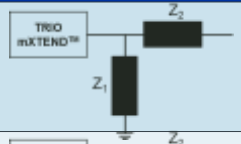
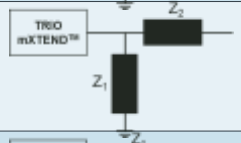
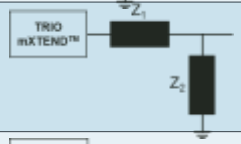
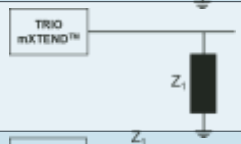
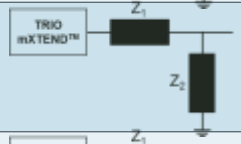
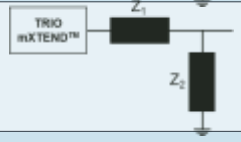


- **The largest the Q, the better**
- Low Q may result in poor performance
- SMD **0201**/0402/0603
- Tight tolerance (2%, 3%)

- Vendors provide software applications to analyze the Q value across frequency

http://ds.murata.co.jp/software/simsurfing/en-us/index.html

Design Guidelines (VII): Matching Networks

STATE	Frequency band	Matching Network
RF5	698-748MHz & 1710-2200MHz	
RF7	746-803MHz	
RF8	791-849MHz	
RF3	824-894MHz	
RF1	880-960MHz	
RF4	GPS (1575MHz)	
RF2&6	available for other bands	empty

Component	Value	Part Number	Q min
Z1 (L6)	5.1nH	LQW03AW5N1J00	40 at 698MHz
Z2 (C10)	5.5pF	GJM0332C1H5R5WB01	76 at 2200MHz

Component	Value	Part Number	
Z1 (L7)	4.7nH	LQW03AW4N7J00	40 at 746MHz
Z2 (R10)	0Ω	-	

Component	Value	Part Number	
Z1 (C11)	9.2pF	GJM0332C1E9R2WB01	166 at 849MHz
Z2 (L5)	6.2nH	LQW03AW6N2J00	40 at 791MHz

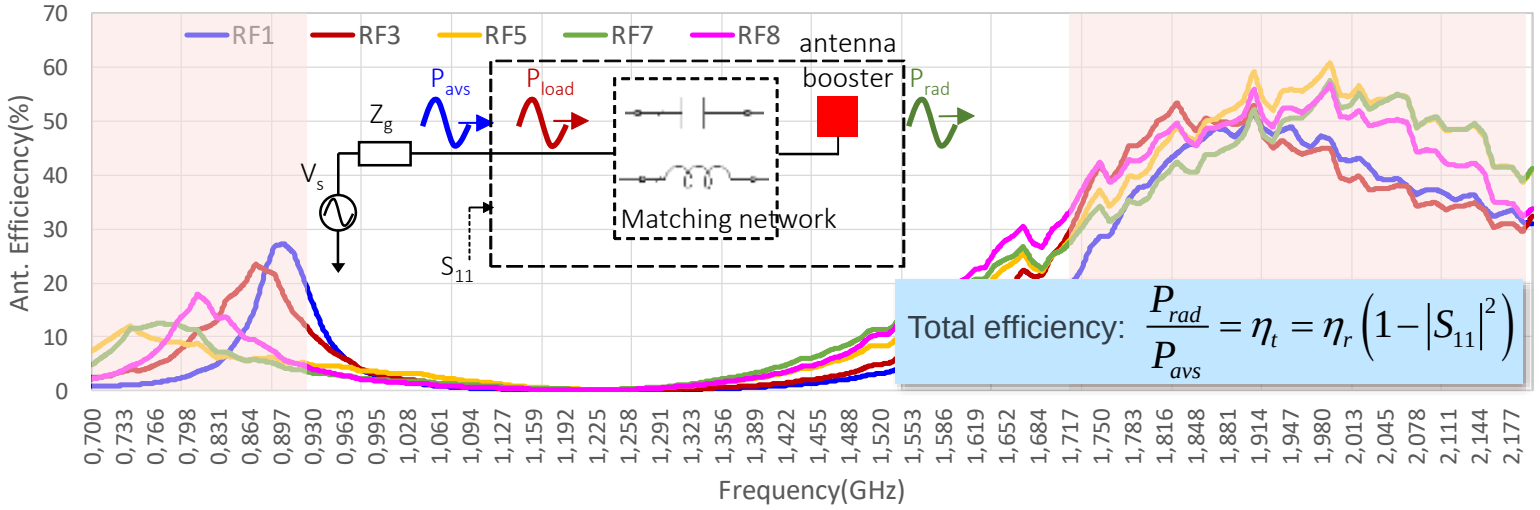
Component	Value	Part Number	
Z1 (C12)	1.5pF	GJM0334C1E1R5WB01	461 at 894MHz

Component	Value	Part Number	
Z1 (C9)	2.5pF	GJM0335C1E2R5WB01	402 at 960MHz
Z2 (L4)	Open circuit	-	

Component	Value	Part Number	
Z1 (L3)	2.9nH	LQW03AW2N9C00	60 at 1575MHz
Z2 (C13)	3.9pF	GJM0333C1E3R9WB01	206 at 1574MHz

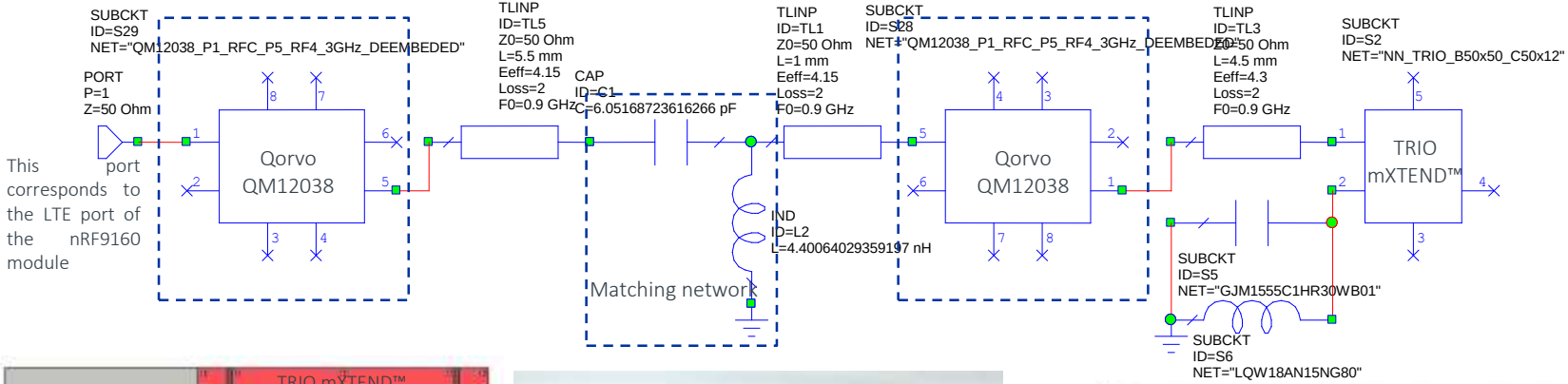
Technical Features of Nordic Thingy:91

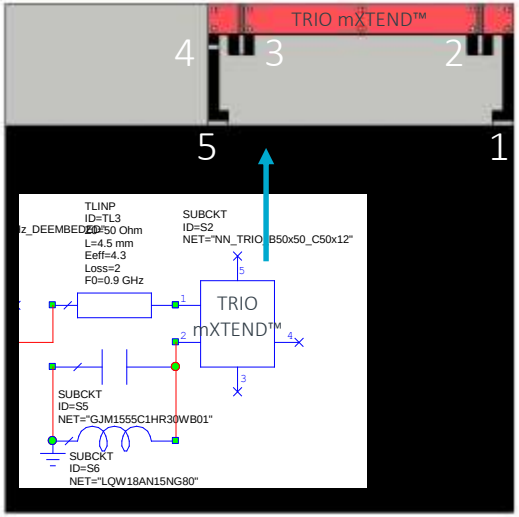
Technical features	698 – 748 MHz	746-803 MHz	791-849 MHz	824-894 MHz	880-960 MHz	1575 MHz	1710-2220MHz
Average Efficiency	10.0%	12.0%	14.8%	19.0%	20.2%	20.6%	49.9%
VSWR	< 3:1						
Radiation Pattern	Omnidirectional						
Polarization	Linear						
Weight (approx.)	0.25 g.						
Temperature	-40 to + 120 °C						
Impedance	50 Ω						

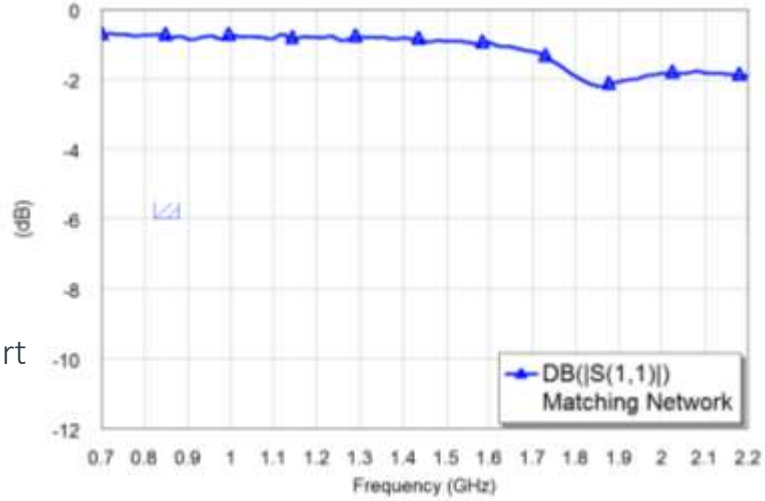


Designing your Matching Network (I)

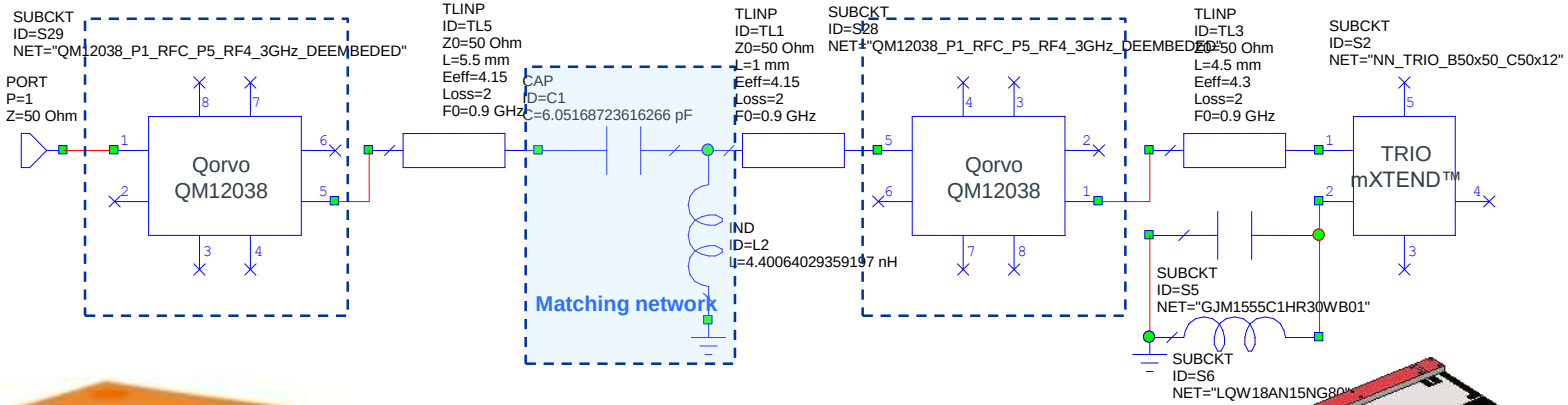
This port corresponds to the LTE port of the nRF9160 module

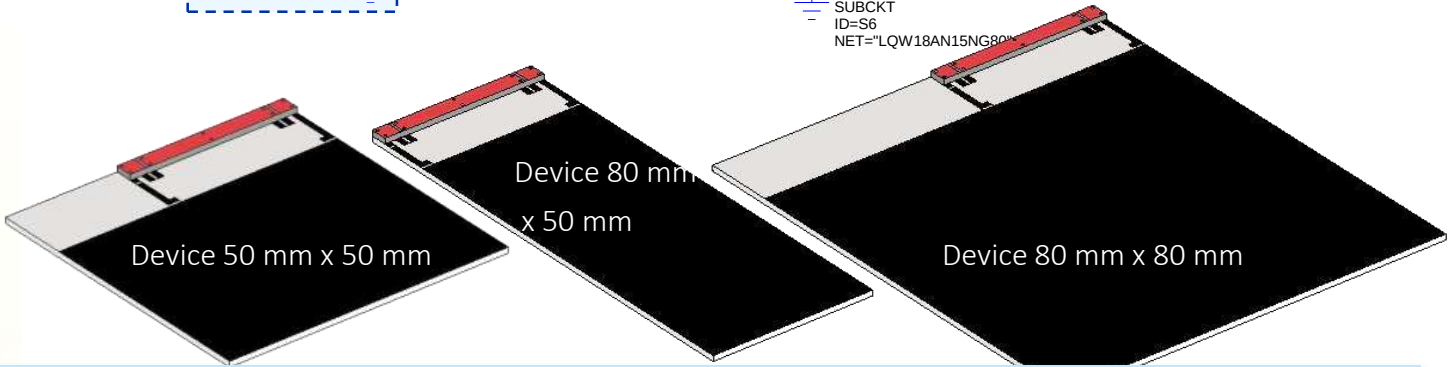






Designing your Matching Network (II)





- For devices housed in plastic/ruber cases, the value of L/C component of the matching networks may be need to be readjusted to compensate the frequency shift of the case
- A library of S-parameters are available at FRACTUS ANTENNAS for other platform sizes

NN Wireless Fast Track

Your Antenna Design, Free of Charge, In 24h

1. Fill out the form
2. Reply to email
3. Get free design in 24h

Off-the-shelf and tiny Virtual Antenna™ component specially selected for your application by the NN Engineering Team.

https://www.fractusantennas.com/fast-track-project/

Conclusions

- Virtual Antenna™ Technology: off-the-shelf antenna product, small, multi-band, and pick&place (SMD component)
- Thingy:91 by Nordic Semiconductor is a multi-sensor prototyping kit ideal for kick starting cellular IoT projects
- Thingy:91 with the TRIO mXTEND™ embedded antenna will help cellular IoT designers to develop new applications fast and easy

APPLICATIONS:

- Logistics and asset
- Tracking
- Smart city
- Smart agriculture
- Predictive maintenance & industrial
- Wearables & medical

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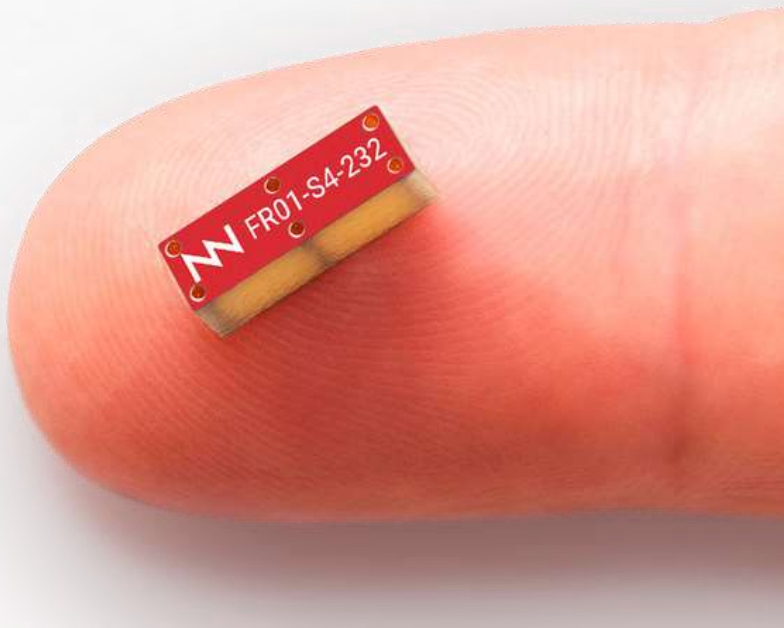

NORDIC SEMICONDUCTOR

FRACTUS ANTENNAS

Embedded Antennas for IoT

Adapting the Nordic Thingy:91 Antenna to your cellular IoT Design

Dr. Jaume Anguera,

Chief Scientist

*FRACTUS ANTE**NN**AS*

October 2019