Virtual Antenna™ provides mobile and GPS connection in the Thingy:91 cellular IoT module

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1. INTRODUCTION

Society is used to connect people with phones, but now is time to connect things with things thanks to IoT (Internet of Things). IoT fosters new smart devices and applications as never seen before. Smart sensors, efficient waste control, industry 4.0, medical monitorization, smart agriculture, and asset tracking are few examples of the huge potential number of applications IoT will offer to our society. To connect things with things, a relevant player is needed which transmits and receives data to and from each thing: the antenna.

Wireless design engineers involved in making IoT devices, need to integrate the antenna in their devices beside other radiofrequency components such as modules, amplifiers, and filters. Therefore, an antenna should be small enough to fit it in the small space of an IoT device. At the same time, since the frequency spectrum for IoT devices is diverse, the antenna should be multiband.

From the production point of view, wireless design engineers work fast in launching new IoT devices into the market and therefore, no component can be a bottle neck. This stringent requirement makes the Virtual Antenna™ technology attractive to satisfy these demands of having a small, multiband and suitable for mass production antenna component [1]-[13].

Virtual Antenna™ technology enables worldwide wireless connection to one of the latest IoT smart tracking modules: Thingy:91. This multi-sensor cellular IoT prototyping platform is built in a ready to use 50 mm x 50 mm package, and this miniature tracking sensor incorporates, thanks to Virtual Antenna™ both cellular and GPS in the same antenna component [14]. Thingy:91 is also a very easy to use IoT cellular prototyping platform, it is thought to help wireless engineers with their next IoT smart tracking/sensor design without the need to build the whole hardware from the beginning. Position can be found with the GPS feature and the global range of LTE bands provided by the TRIO mXTEND™, while at the same time control all the environment and movement data: temperature, humidity, air quality, air pressure or even light data.

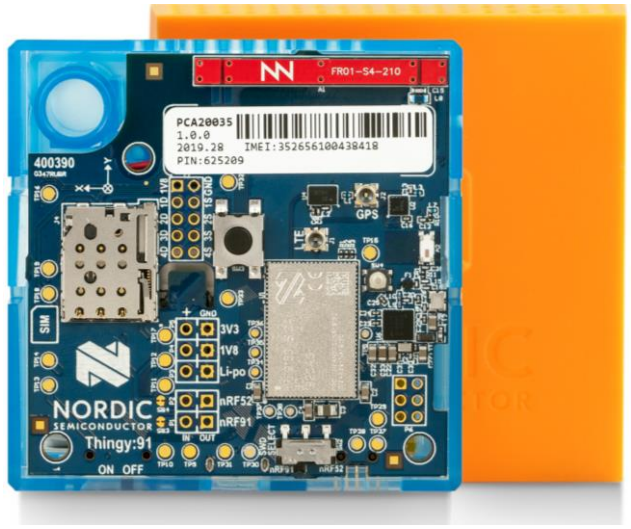


Figure 1 – TRIO mXTEND™ chip antenna component, member of the Virtual Antenna™ family, (component in red) embedded in Thingy:91 by Nordic Semiconductor which is a multi-sensor prototyping kit ideal for kick starting cellular IoT projects

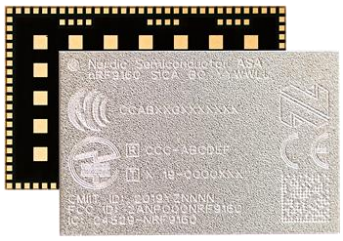
2. TRIO mXTEND™ ANTENNA COMPONENT & nRF91 PRODUCTS

Two main components of the Thingy:91 cellular IoT device are the TRIO mXTEND™ chip antenna and the nRF9160 module (Figure 2).

The TRIO mXTEND™ chip antenna component is in charge of effectively transmit and receive LTE signals and receive GPS signals. The TRIO mXTEND™ chip antenna component has been specifically designed for providing the major level of flexibility to operate any required frequency band inside any wireless device (Figure 2). TRIO mXTEND™ chip antenna component is capable of operating the main mobile communication standards, enabling worldwide coverage, such as LTE (698-960MHz, 1710-2690MHz and 3400-3800MHz), the main short range wireless bands such as Bluetooth and Wi-Fi (2400- 2500MHz and 4900-5875MHz), as well as the Global Navigation Satellite Systems such as GPS, GLONASS, and BeiDou (1561 MHz, 1575 MHz and 1598-1606 MHz) through the same antenna component.

TRIO mXTEND™ features 3 ports, so designers can flexibly use it to fit it in about any wireless architecture including up to three independent radios (e.g. cellular/GNSS/Bluetooth).

Dimensions: 30.0 mm x 3.0 mm x 1.0 mm
(a)



Dimensions: 10 mm x 16 mm x 1.0 mm LGA
(b)

Figure 2 a) The TRIO mXTEND™ chip antenna component by Fractus Antennas; b) nRF91 module by Nordic Semiconductor

The nRF9160 is a low power cellular IoT System-in-Package with integrated LTE-M, NB-IoT and GPS, supporting LTE bands from 700 MHz to 2.2 GHz through a single typical 50 Ω antenna pin. It features an output power up to 23 dBm and an RX sensitivity of -108 dBm at LTE-M and -114dBm at NB-IoT (HD-FDD mode).

It includes a1.8 V MIPI RFFE (RF front-end) digital control interface and MAGPIO control interface for external RF applications and an LTE modem RF control with external interface.

nRF9160 provides a dedicated 1.8 V digital interfaces for controlling external RF applications, such as antenna tuner devices:

MIPI RFFE interface pins: VIO, SCLK, SDATA. MAGPIO interface pins are: MAGPIO0, MAGPIO1, MAGPIO2.

The LTE modem drives these outputs timing accurately according to LTE protocol timing to set the correct antenna tuner settings per used frequency. User needs to inform the LTE modem through the modem API about the RF application e.g. antenna tuner device configuration, so that LTE modem knows how to drive it.

3. TRIO mXTEND™ & nRF91 LOW POWER CELLULAR IoT SYSTEM-IN-PACKAGE: MOBILE & GPS APPLICATION

3.1. LAYOUT RECOMMENDATIONS

On its starter configuration, Thingy:91 has been optimized for a small platform following these general guidelines and recommendations (Figure 3):

- Minimum recommended PCB size: 50 mm x 50 mm.
- Keep one continuous 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 LTE matching networks as close as possible to the feeding point (see next section for details about the matching network). For GPS, include pads compatible with 0402 SMD components.

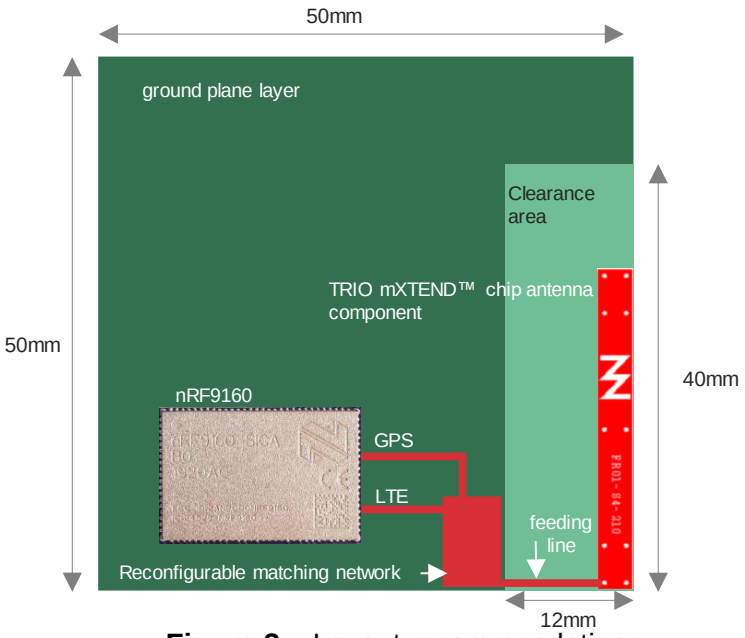


Figure 3 – Layout recommendations

3.2. ELECTRICAL SCHEME TO CONNECT TRIO mXTEND™ CHIP ANTENNA COMPONENT AND nRF91 CELLULAR IoT SYSTEM-IN-PACKAGE

A reconfigurable matching scheme combining the TRIO mXTEND™ chip antenna component, the nRF91 cellular IoT System-in-Package and the QM12038 from Qorvo enables operation at LTE bands (698MHz up to 2200MHz) in combination with GPS 1575MHz (Figure 4).

With this architecture, designers have the freedom to individually optimize their matching networks into their devices and eventually upgrade their designs to include other LTE bands not considered in this case, thanks to the multiband nature of the Virtual Antenna™ technology. (Figure 5).

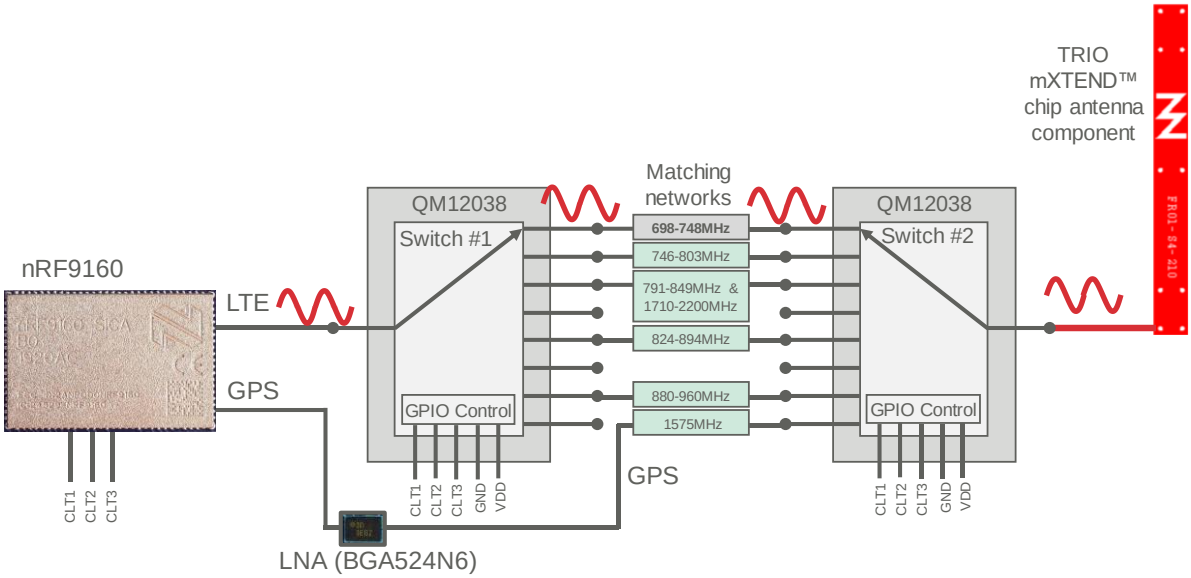


Figure 4 – Scheme for connecting TRIO mXTEND™ chip antenna component and nRF9160

To see more tips on how to design your IoT device with Thingy:91 and Virtual Antenna™, click on the next video.

Thingy:91 Webinar

The cellular frequency band of operation is automatically controlled by the nRF9160 through a GPIO interface. Such interface controls the Qorvo SP8T switches with three control lines (CLT1-3). In this application note, six matching networks designed with the Cadence-AWR Microwave Office software are used to match different bands of LTE as well as GPS. For each band, a simple L-type matching network using SMD components is designed (Figure 5) – (Table 1).

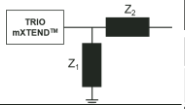
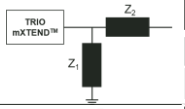
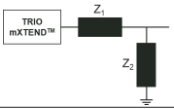
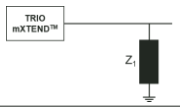
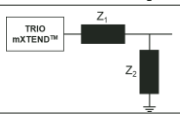
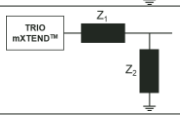
STATE	Frequency band	Matching Network			
RF5	698-748MHz & 1710-2200MHz		Component	Value	Part Number
			Z_1	5.1nH	LQW03AW5N1J00
			Z2 (C10)	5.5pF	GJM0332C1H5R5WB01
RF7	746-803MHz& 1710-2200MHz		Component	Value	Part Number
			Z_1	4.7nH	LQW03AW4N7J00
			Z_2	0Ω	-
RF8	791-849MHz& 1710-2200MHz		Component	Value	Part Number
			Z_1	9.2pF	GJM0332C1E9R2WB01
			Z_2	6.2nH	LQW03AW6N2J00
RF3	824-894MHz		Component	Value	Part Number
			Z_1	1.5pF	GJM0334C1E1R5WB01
RF1	880-960MHz		Component	Value	Part Number
			Z_1	2.5pF	GJM0335C1E2R5WB01
			Z_2	Open circuit	-
RF4	GPS (1575MHz)		Component	Value	Part Number
			Z_1	2.2nH	LQW15AN2N2C10
			Z_2	2.5pF	GJM1555C1H2R5WB01
RF2&6	available for other bands	empty			

Figure 5 – Matching networks for LTE and GPS used in the electric scheme shown in Figure 4

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%	12.6%	15.7%	18.5%	11.2%	39.8%	47.4%
VSWR	< 3:1						
Radiation Pattern	Omnidirectional						
Polarization	Linear						
Weight (approx.)	0.25 g.						
Temperature	-40º to + 125 ºC						
Impedance	50 Ω						

Table 1 – Technical features measured in a fully-populated device including casing – Thingy:91 (Figure 6)

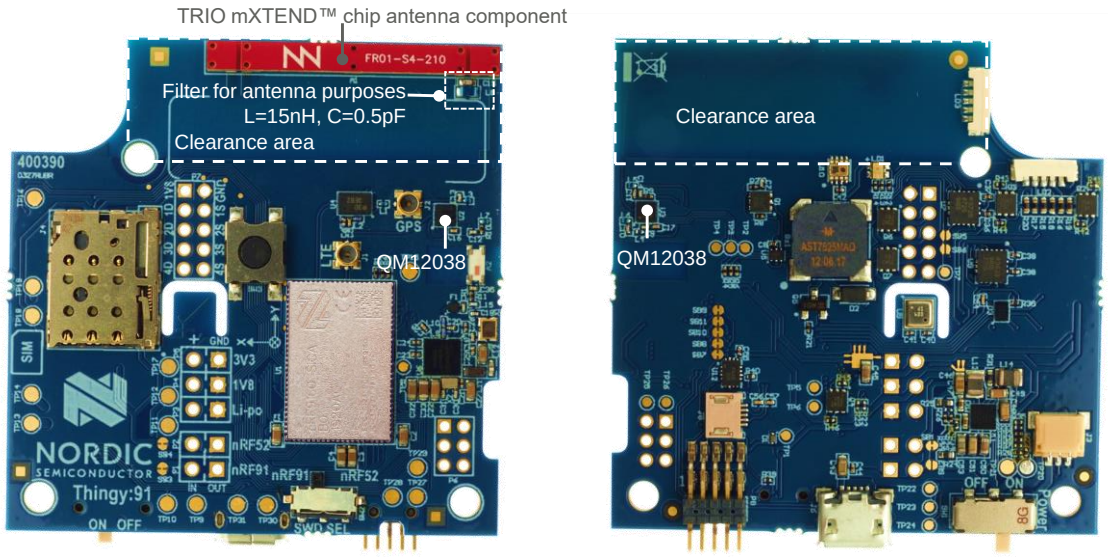


Figure 6 – Details of the clearance area, antenna, nRF9160 and switches location on a PCB

3.3. ADAPTING NORDIC THINGY:91 DESIGN TO YOUR CELLULAR IOT DEVICE

For IoT devices having a different form factor than the Nordic Thingy:91, a new RF tool called Libraries[S] is available [6]-[7]. Librarie[S], the new design tool by Fractus Antennas helps to design the antenna for a wireless device using any standard RF CAD software such as AWR Microsoft Office. Just select the PCB size and the mXTEND™ antenna type, download the library file from the website and import it into a preferred design software [6]. Based on Virtual Antenna™ technology, all files in the NN Librarie[S] form a group of [S] parameters for several wireless platforms, with different PCB/ground plane form factor and clearance area dimensions using different mXTEND™ antenna components, and in particular the TRIO mXTEND™ chip antenna component (Figure 7). By choosing the file with the closer size to the IoT device under development, the designer can implement a matching network easy and fast in just a few clicks.

If you are designing a different device size, besides libraries, other tools for technical support are available, as the NN Wireless Fast Track Service for wireless engineers to design their IoT devices with an embedded Virtual Antenna™ fast and easy [15].

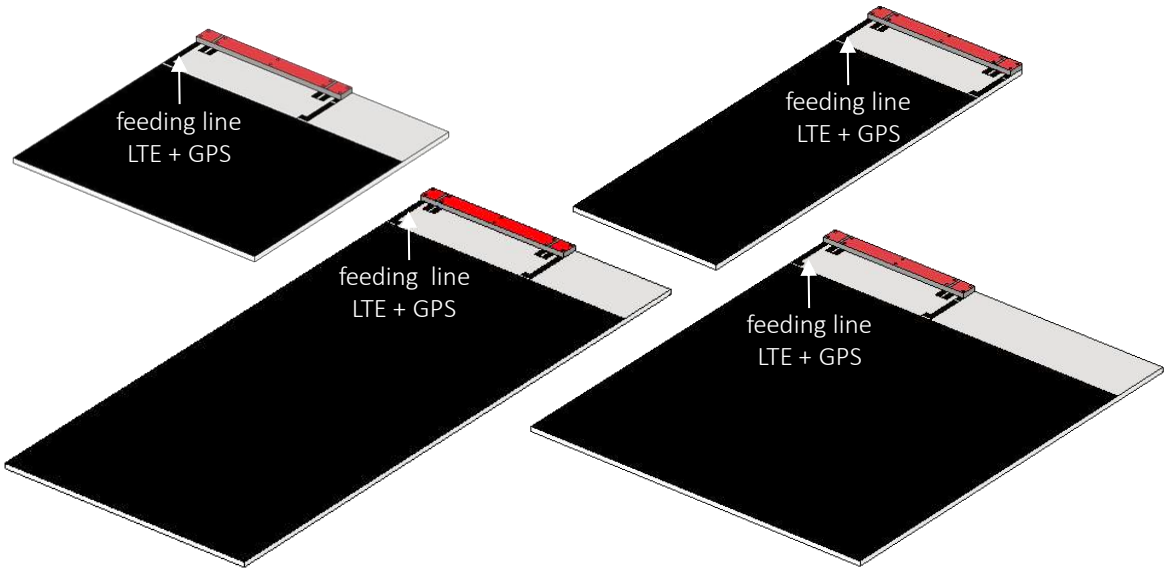


Figure 7 – Examples of different form factors with TRIO mXTEND™ chip antenna component available at Librarie[S]

4. THINGY:91

As mentioned, a device example of the architecture explained in this paper is the Open Hardware Platform Thingy:91. The Nordic Thingy:91 is a battery-operated prototyping platform for cellular IoT, certified for global operation. It integrates the nRF9160 SiP, supporting LTE-M, NB-IoT and GPS, and a nRF52840 board controller, supporting Bluetooth Low Energy and NFC. Source code for firmware, hardware layout, schematics are all available for open for wireless engineers designing IoT devices [16].

APPLICATIONS

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

It is the ideal platform for rapidly developing a prototype for any cellular IoT concept. It is especially suited for any flavor of asset tracking application. Find the position with the GPS integrated in the nRF9160 SiP, and the accelerometers to do motion analysis and sleep when nothing is happening.

An exhaustive set of sensors is included to gather data about the environment, and the movement of the Nordic Thingy:91. Temperature, humidity, air quality, air pressure, color and light data can easily be extracted for local or remote analysis.

For input, the Nordic Thingy:91 offers a user-programmable button. Visual output is achieved with user programmable RGB LEDs, while a buzzer can provide audible output.

5. CONCLUSIONS

Virtual Antenna™ is a disruptive technology featuring miniature, off the shelf and multiband antenna components that enables connectivity into ready to use platforms thanks to its reconfigurable nature, Virtual Antenna™ is ready in prototyping kits such as the Thingy:91 by Nordic Semiconductor - 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.

6. REFERENCES

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