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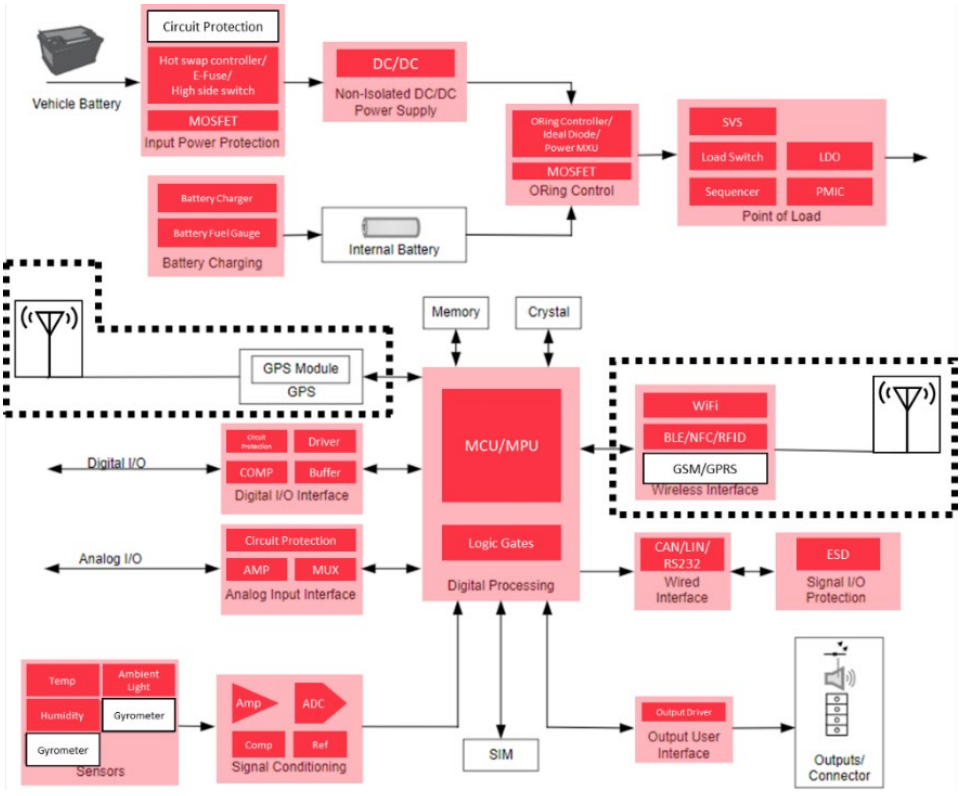
Multiband, tracking mini-antenna in Nordic's Thingy91

APPLICATION NOTE
TRIO mXTEND™ (NN03-310)

ASSET TRACKING – Asset Tracker

Some of the most important challenges that manufacturers face when designing and prototyping an asset tracker, are performance, battery life, accuracy and so on.
Any asset tracking device's data transmission has to be completely reliable, therefore, the antenna is a critical component in such device.
First, chip antenna technology has been proven to deliver top GNSS (GPS, GLONASS, GALILEO, BeiDou…) performance in a variety of tracking devices and fleet management applications. Usually, a ceramic patch antenna is the option of choice for its traditional connection with satellite systems applications in terms of a good reception if the receiver is reasonably stable with respect to the GNSS satellite constellation and if the application has no relevant space and cost constrains. Nowadays, the range of different types of tracking devices is very large, and all of them have different sizes and requirements. These have to consider one important fact: they are located everywhere and not always stable and facing to the satellite reception. As modern smartphones proved that an omnidirectional, linearly polarized antenna can deliver an optimal GNSS performance for the vast majority of applications, such antenna to integrate into your tracking device will ensure the best GNSS signal regardless of the satellite location and/or the distance from the data receiver. At this point, with the endless diversity of new devices requiring versatile GNSS connection, Virtual Antenna® components, being omnidirectional antennas, become the perfect choice where also, size, weight, portability, and cost are a priority.
Second, Virtual Antenna® technology allows for a single antenna to use multiple RF protocols with a single antenna component, letting your tracking device to broadcast a location via GPS while using Bluetooth or Cellular to receive or transmit data with an external device for configuration or managing purposes apart from location. This antenna versatility can be determining when deciding which is the best fit for your device, as you might have multiple solutions within only just one antenna component.
Furthermore, thanks to the use of the PCB for radiating, Virtual Antenna® technology allows for de-tuning to be easily solved by minor adjustments of the matching network, to adapt with the device's environment, such as close proximity to biological tissue, metal casings, concrete and so on. Also, the optimal use of the PCB to radiate the RF signal, ensures a top performance as the full size of the device is used as part of the antenna system. This will have an impact on how accurate and reliable a tracking device is.



Block Diagram: Asset Tracking – Asset Tracker

In the Block Diagram above, we see an example of an Asset Tracker Application. Some of the main components within a device like this, are:

Microcontroller unit (MCU):
An MCU or MPU is an intelligent semiconductor and the main component in any device. It is what allows for the whole system to function, by translating the data programmed in it to commands that all the other components will understand an execute to deliver results. It is essentially the brains of the module.
Choosing the best performing antenna will allow for a faster data transmission, which will lead the MPU to perform at its full capacity.

Battery system:
Whether if it's a rechargeable battery or a regular one, it's the main power unit for any Asset Tracker. All this system, engineered to manage the power transmission, is essential for the proper function of the device. For a sensor tag, the battery will be the factor that defines the life of the device (until recharging or changing the battery).
Chip antenna technology ensures a lower consumption than other types of antennas, such as an external one, bringing the overall device consumption to its lowest, which translates into longer battery life. Also, if the device doesn't have the right antenna, the transceiver will have to consume more power, reducing the battery life.

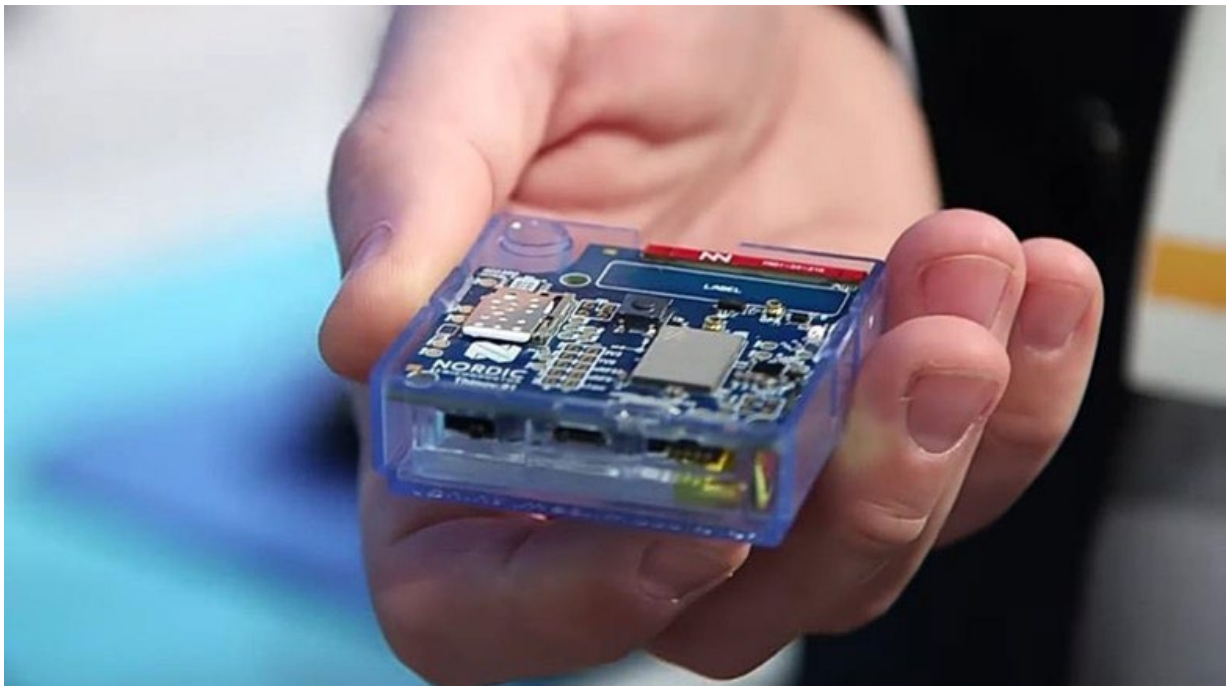
Antenna/s (wireless interface and GPS):
Any tracking device needs to have a reliable transmission of data to both satellites and gateways or other devices in other to do its function properly. That is why the antenna is one of the most important components within any tracking device. For an optimal antenna efficiency (and clearance area), the component's placement is crucial, therefore, its implementation within the device's design has to be in an early stage.
Furthermore, when tracking assets globally or through different types of networks and frequency bands, Virtual Antenna® technology will enable for a single antenna to be used, making the overall tracking device smaller, slimmer, and simpler.

In summary, when designing an Asset Tracking Device, you should consider, at an early stage, the best performance and size antenna needed for your device. This will ensure its optimal clearance area as well as placement within the PCB, along with the avoidance of any potential future connectivity, efficiency, de-tuning and/or interferences issues. By choosing Virtual Antenna® technology as your antenna solution, thanks to its high RF efficiency and adaptability, you will ensure best performance in your Asset Tracking device.

Moreover, Virtual Antenna® components, by being off-the-shelf, tunable, and versatile antennas, will allow for faster development times, predictability of design from minute one and a fast and flexible adaptation to different tracking forms.
In this application note, we will review the performance and different metrics of the Thingy91, Nordic's ready-to-use reference design IoT module.

MOBILE+GPS IN A SMALL IoT MODULE: WORLDWIDE SMART TRACKING, ONLY ONE ANTENNA

- **Frequency regions:** 698-960 MHz, 1710-2200 MHz and 1575 MHz



Thingy:91 - Your new smart tracking device ready to use, embedding TRIO mXTEND™ antenna component & nRF91 cellular IoT System-in-Package

The latest wireless technology to connect any **IoT smart tracking** device **worldwide** is built and ready to use in a **50 mm x 50 mm package**.

At Ignion (**NN**) and Nordic Semiconductor, we are eager to show you Thingy:91, a **miniature** IoT module tracking and sensor that incorporates **both cellular** and **GNSS** in the **same antenna** component while providing worldwide connectivity from 700 MHz up to 2200 MHz.

Thingy:91 is also a very **easy to use IoT cellular prototyping platform**, it is thought to help you with your next IoT smart tracking/sensor design without the need to build the whole hardware from the beginning. Find any position 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.

Build your ideal IoT product today, it´s almost done: **Thingy:91**.

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1. TRIO mXTEND™ ANTENNA COMPONENT & nRF91 PRODUCTS

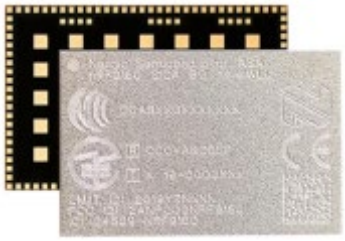
TRIO mXTEND™ NN03-310

Dimensions: 30.0 mm x 3.0 mm x 1.0 mm

The **TRIO mXTEND™ chip antenna component** (NN03-310) has been specifically designed for providing the major level of flexibility to operate any required frequency band inside any wireless device. TRIO mXTEND™ chip antenna component is capable of operating the main mobile communication standards, enabling worldwide coverage, such as GSM850, GSM900, GSM1800/DCS, GSM1900/PCS, UMTS, LTE700, LTE800, LTE850, LTE900, LTE1700, LTE1800, LTE1900, LTE2000, LTE2100, LTE2300, LTE2500, LTE2600, LTE3500, LTE3600 and LTE3700 (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).

nRF91



Dimensions: 10 mm x 16 mm x 1.0 mm LGA

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 a 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 particular RF application e.g. antenna tuner device configuration, so that LTE modem knows how to drive it.

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

2.1. LAYOUT RECOMMENDATIONS

On its starter configuration, Thingy:91 has been optimized for a small platform following these general guidelines and recommendations (Figure 1):

- 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

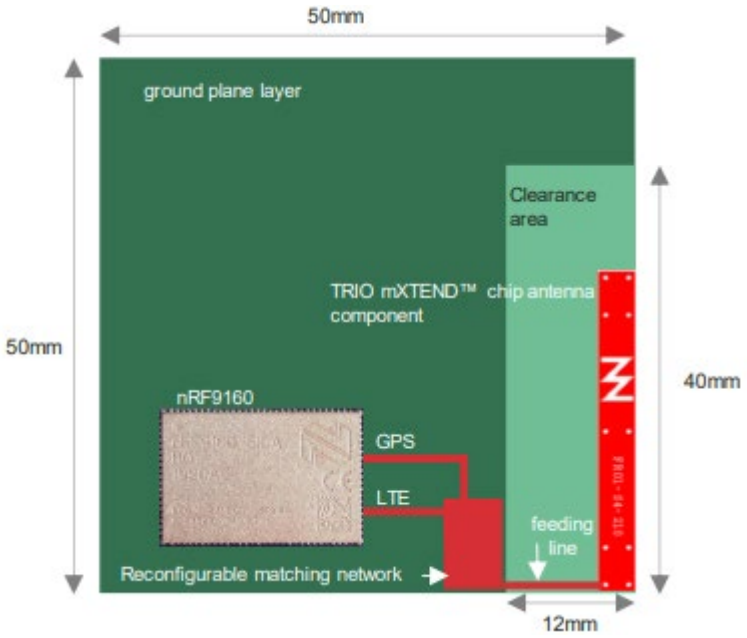


Figure 1 – Layout recommendations

If you are designing a **different device size**, **the Ignion Team can assist you** in optimizing the antenna design in your platform in less than **24 hours**. If you need assistance to design your matching network beyond this application note, please contact support@ignion.io, or try our free-of-charge[1] **NN Wireless Fast-Track** design service, you will get your chip antenna design including a custom matching network for your device in 24h[1]. Other related to NN's range of R&D services is available at: https://www.ignion.io/rdservices/

[1] See terms and conditions for a free NN Wireless Fast-Track service in 24h at: https://www.ignion.io/fast-track-project/

2.2. 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 a switch (QM12038 from Qorvo or one alternative part from Infineon BGS18GA14) enables operation at LTE bands (698MHz up to 2200MHz) in combination with GPS 1575MHz (Figure 2).
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 (Figure 3).

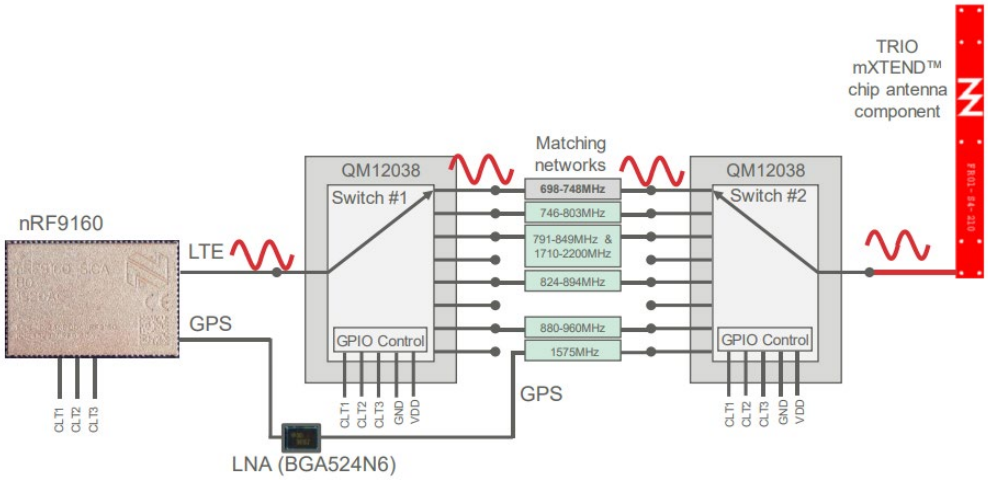


Figure 2 – Scheme for connecting TRIO mXTEND™ chip antenna component and nRF9160. The Infineon BGS18GA14 switch could be one alternative to the QM12038 from Qorvo shown in the image above.

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 NI-AWR software are used to match different bands of LTE as well as GPS. For each band, a simple L-type matching network using 0201 SMD components is employed (Figure 3) – (Table 1).

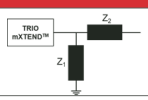
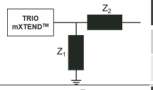
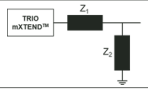
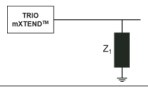
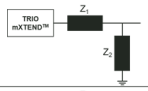
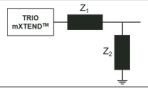
STATE	Frequency band	Matching Network		
RF5	698-748MHz & 1710-2200MHz		Component	Value	Part Number
			Z1 (L6)	5.1nH	LQW03AW5N1J00
			Z2 (C10)	5.5pF	GJM0332C1H5R5WB01
RF7	746-803MHz & 1710-2200MHz		Component	Value	Part Number
			Z1 (L7)	4.7nH	LQW03AW4N7J00
			Z2 (R10)	0Ω	-
RF8	791-849MHz & 1710-2200MHz		Component	Value	Part Number
			Z1 (C11)	9.2pF	GJM0332C1E9R2WB01
			Z2 (L5)	6.2nH	LQW03AW6N2J00
RF3	824-894MHz & 1710-2200MHz		Component	Value	Part Number
			Z1 (C12)	1.5pF	GJM0334C1E1R5WB01
RF1	880-960MHz & 1710-2200MHz		Component	Value	Part Number
			Z1 (C9)	2.5pF	GJM0335C1E2R5WB01
			Z2 (L4)	Open circuit	-
RF4	GPS (1575MHz)		Component	Value	Part Number
			Z1 (L3)	2.2nH	LQW15AN2N2C10
			Z2 (C13)	2.5pF	GJM1555C1H2R5WB01
RF2&6	available for other bands	empty			

Figure 3 – Matching networks for LTE and GPS used in the electric scheme shown in Figure 2

Technical features	698 – 748 MHz	746-803 MHz	791-849 MHz	824-894 MHz	880-960 MHz	1575 MHz	1710-2220 MHz
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	-40 to + 125 ºC						
Impedance	50 Ω						

Table 1 – Technical features measured in a fully-populated device including casing – Thingy:91 (Figure 4)

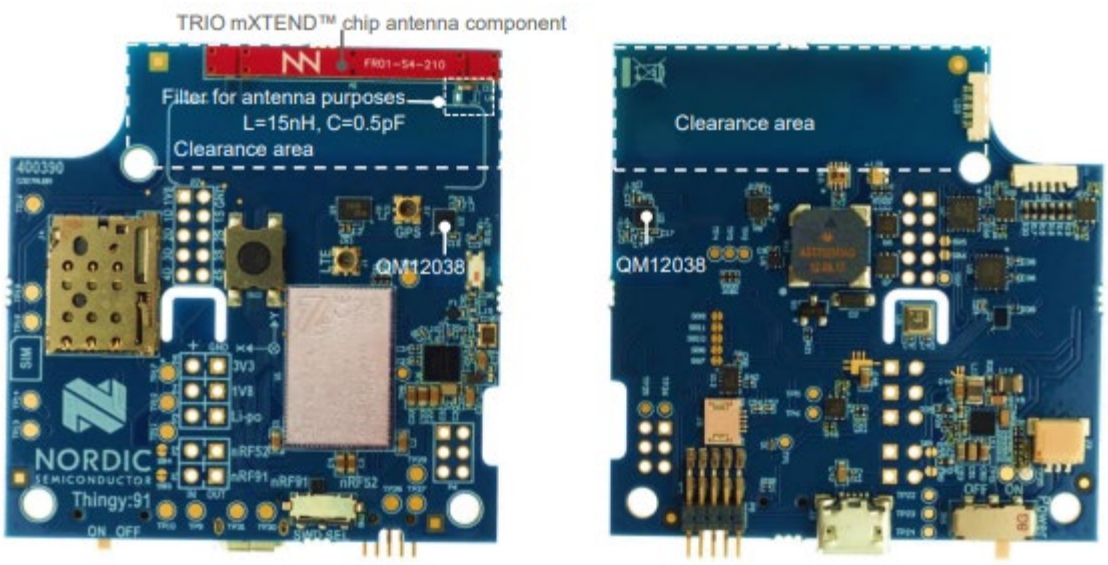


Figure 4 – Details of the clearance area, antenna, nRF9160 and switches location on a PCB

3. THINGY:91

A device example of the architecture explained in this application note 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 free.

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.

APPLICATIONS

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

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.

It has the TRIO mXTEND™ chip antenna component for LTE-M, NB-IoT and GPS connected to the nRF9160, supporting a global range of LTE bands.

4. PRODUCT CHANGE NOTIFICATION

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PCN Number: NN19100013

Notification Date: October 07th, 2019

Part Number identification:

Part Number changes, it will be applied in all the document of the company (User Manual, Data Sheet, …)

Previous Part Number	New Part Number
FR01-S4-210	NN03-310

Reason for change:

	Specs (electrical/mechanical)		Manufacturing location
	User Manual/Data Sheet		Quality/Reliability
	Material/Composition		Logistics
	Processing/Manufacturing	X	Other: Part Number

Change description

1.- Part Number: From FR01-S4-210 FRACTUS to NN03-310 Ignion in the User Manual

OLD

NEW

Comments:

1.- Electrical and Mechanical specs remain the same

2.- Footprint in the PCB to solder the chip antenna remains the same

Identification method

1.- The part number on the antenna is different

User Manual	X	Available from: January 2020
Samples	X	Available from: January 2020

Ignion Contact:

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Do you need more help with your antenna for your device?

Use our **Antenna Intelligence Cloud service** and get your ready-to-test antenna design specially thought for your platform **free of charge**[1] and in **24 hours**.

https://www.ignion.io/antenna-intelligence/

The TRIO mXTEND™ chip antenna component 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

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