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NN Design Hub: NN Librarie[S]

USER MANUAL
NN Librarie[S]

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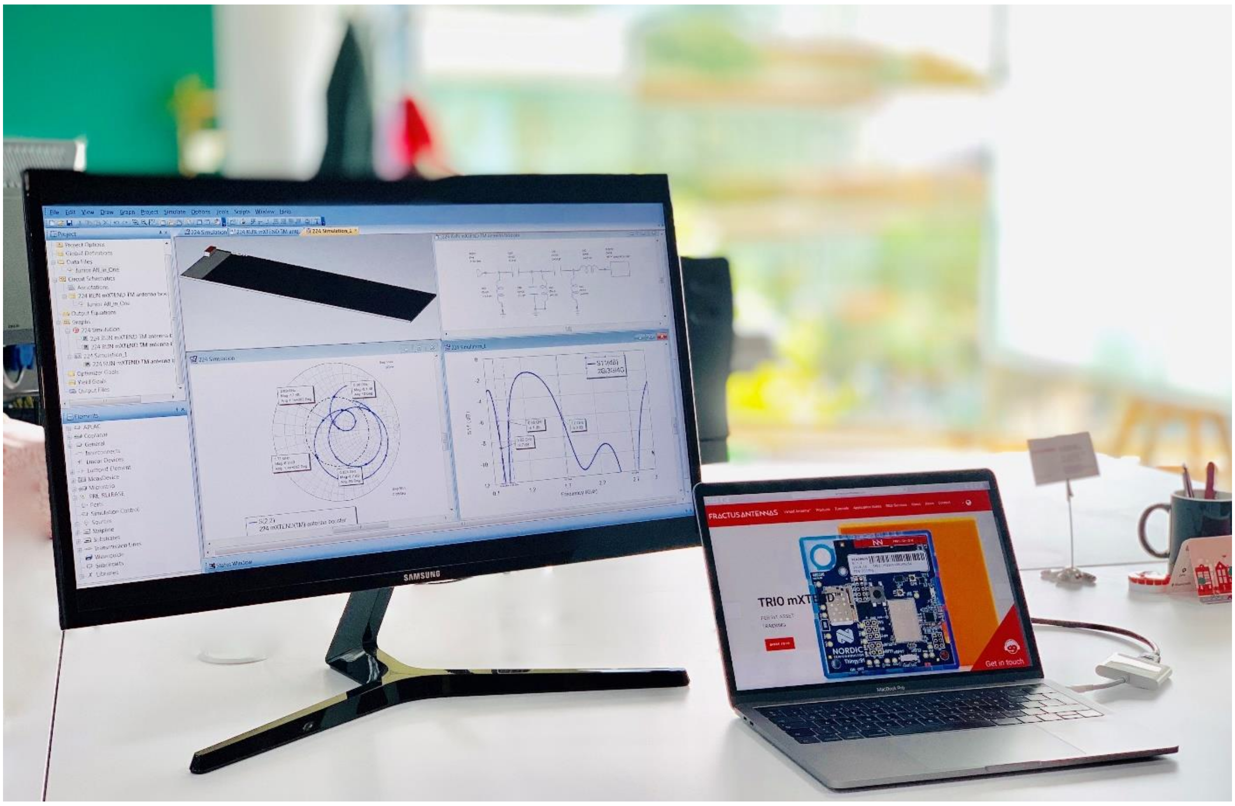


Here you are the NN Librarie[S], the new design tool by Ignion (NN) that helps you design the antenna for your wireless device using any standard RF CAD software. Just select your PCB size and the mXTEND™ antenna type, download the library file from our website and import it into your preferred design software.

Based on our 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. The NN Librarie[S] is composed of three sets of [S] parameters, one set for 1-port platforms, one set for 9-port platforms, and a set for 5-port platforms using the TRIO mXTEND™ in particular, containing one port, nine ports and five ports, respectively, for implementing a matching network for adapting your design. By choosing the file with the closer specs to your device you can implement your matching network easy and fast in just a few clicks.

INDEX OF CHAPTERS

1. WHAT IS A LIBRARY FILE?

1.1. LIBRARY FILE DEFINITION

The new tool, NN Librarie[S], provides a collection of [S]-parameter files for every specific mXTEND™ antenna component (i.e., a Virtual Antenna™ component) as mounted on a variety of wireless platforms with different form factors and printed circuit board (PCB) sizes. Each library file is associated to a different PCB size and a recommended clearance area, so you can make a choice of the most suitable one depending on the form factor of your wireless device. The NN Librarie[S] provides you a set of 1-port library files, a set of 9-port library files and a set of 5-port library files, containing the [S]-parameters for 1 port, 9 ports, and 5 ports, respectively, for matching your device. Upon uploading the corresponding library file into your circuit design software you can readily implement a matching network to match the device to its frequency or frequencies of operation and then complete the whole antenna integration work. So, embedding an antenna component into a new wireless device becomes as simple as including any other electronic part into a circuit design.

1.2. HOW TO GET A LIBRARY FILE

You can get an NN-library file by downloading the library file or files you need, or all of them, from the Ignion web. You can quickly and easily download them from the web by downloading the pack you need. If you do not use neither NI-AWR nor Optenni software as circuit design software your pack is the generic one. This pack is a .zip file that contains, apart from this User Manual, the collection of [S]-parameters files that compose the NN Librarie[S] and this User Manual. Once you have the library files at your disposal you can choose the one you need (see section 3) and import it into your circuit design software like any other .sp file. Then, you can readily implement a matching network to match the device to its frequency or frequencies of operation and then complete the whole antenna integration work.

1.3. LIBRARY FILE PLATFORM

You can find below, in *Figure 1*, an example of a basic platform you use in a file within the NN Librarie[S]. It includes a PCB ground plane layer mounted on an FR4 dielectric substrate of 1mm thickness and an mXTEND™ antenna component (e.g. a Virtual Antenna™ booster) located on a clearance area, that is, the area on the ground plane layer surrounding the antenna component where the ground plane conductor is removed. The mXTEND™ antenna component is in some platforms placed at a corner of the PCB in the clearance area, as shown in the left picture from *Figure 1a* or in *Figure 1b*, and in other platforms, the mXTEND™ component is placed at some distance from the corner (see the platform to the right in *Figure 1a*).

In general, the mXTEND™ antenna component is connected to a matching network by a feeding line, as indicated in *Figure 1a*. This feeding line features an L-shape for the platforms where the NN mXTEND™ component is not placed at the PCB corner (*Figure 1a)*. The feeding line features a 2mm width and for those where the feeding line features an L-shape the feeding line measures 5mm from the corner of the PCB to the mXTEND™ antenna component. For the case of a TRIO platform, where a TRIO mXTEND™ antenna component is used, two external-port solutions can also be implemented since this platform contains two feeding lines and two feeding areas where two matching networks can be implemented. The TRIO mXTEND™ antenna component is connected in these TRIO platforms to the matching networks by those feeding lines, as indicated in *Figure 1b*, those feeding lines featuring 1m width.

Figure 1 also shows the dimensions of the platform, being *AxC* the board dimensions and *wxh* the clearance area dimensions. The mXTEND™ antenna component is connected to one or, eventually two matching networks for two external-port solutions with the TRIO antenna component, by means of one or two feeding lines, as described before. Then, one or two feeding areas for allocating the matching network or networks are included at one or two connection points between the feeding line or lines and the ground plane edge.

The platforms available in the NN Librarie[S] that do not use the TRIO mXTEND™ antenna component give you the possibility of using either a full-layout implementation of the feeding area with several ports or a simplified feeding area with one single port. A full-layout provides more accuracy in the matching design because the different pads needed for allocating the matching network in a real design are already considered. One-single port platforms simplify the matching network design process. For more detail about the different feeding area layouts available in the NN Librarie[S] see section 4. Accordingly, our NN Librarie[S] provides you a set of 1-port library files and a set of 9-port library files in case of full-layout feeding areas, for platforms not using the TRIO mXTEND™ antenna component.

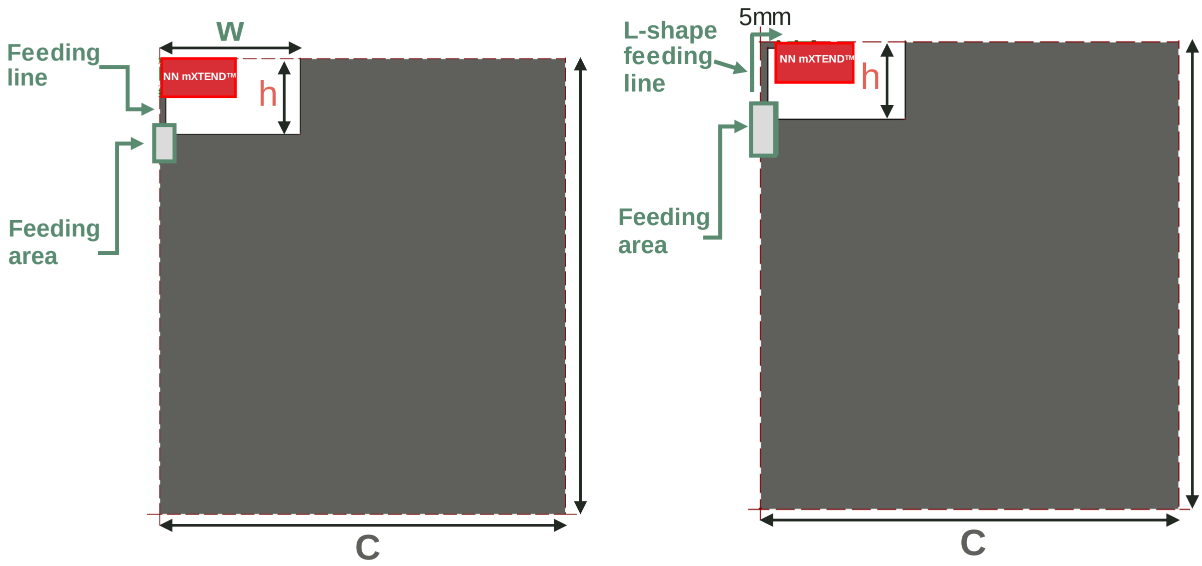


Figure 1a – Example of an NN platform used for creating a library file.

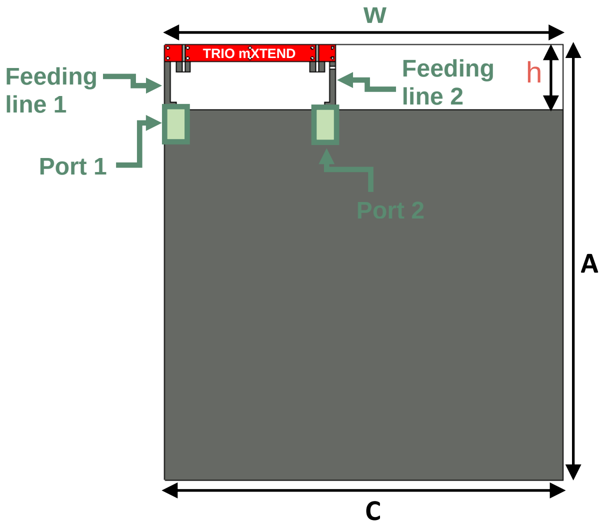


Figure 1b – Example of a TRIO platform used for creating a TRIO library file.

A library file provides the [S] parameters related to a platform as the one described before. These [S] parameters are obtained using an electromagnetic CAD software, all the simulations performed in the frequency range from 650MHz to 6GHz. This is possible because the range of mXTEND™ antenna components are non-resonant, so they can be matched and used in any of the frequency bands within that range, even in multiple ones within such a frequency range.

1.4. LIBRARY FILE NAMING

Let´s see now how each library file is named. For an easy and convenient identification, every file is individually named using the following general rule: ***NN_mXTEND™ Antenna Component_BAxC_Cwxh.s*p,*** where the ***** relates to the number of ports used in the feeding area of the platform related to the library file. Our NN Librarie[S] provides you a set of 1-port library files, a set of 9-port library files in case of full-layout feeding areas, and a particular set of 5-port library files for TRIO platforms.

Each name helps identifying the file content as the different parts of the name correspond to a specific information related to the simulated platform. This information is provided in the following *Table 1*. It is worth noticing that the extension ***.s*p*** indicates that the [S] params are calculated at * number of ports defined as it is shown in the section 4 of this manual.

<table>
<tr><th colspan="5">Library File Name</th></tr>
<tr><th>NN</th><th>mXTEND™ Antenna Component</th><th>BAxC</th><th>Cwxh</th><th>.s*p</th></tr>
<tr><td rowspan="2">Ignion Logo</td><td rowspan="2">Antenna component name</td><td>B: Board</td><td>C: Clearance</td><td rowspan="2">File extension</td></tr>
<tr><td>AxC: board dimensions</td><td>wxh: clearance dimensions</td></tr>
</table>

Table 1 – Library file name by parts.

For instance, if we have the following data on the file:

Library File Name				
NN	mXTEND^{TM} Antenna Component	BAxC	Cwxh	.s*p
Ignion Logo	CUBE	B: Board	C: Clearance	File extension
		AxC: 120X60	wxh: 60X11	

Table 1.1. – Example of a library file name by parts.

Then, the file name will be: ***NN_CUBE_B120x60_C60x11.s*p***

> ***Example of File Name***
>
> ***NN_CUBE_B120x60_C60x11.s*p contains the [S] params corresponding to an NN platform using a CUBE mXTEND^{TM} integrated in a board of dimensions 120mm x 60mm featuring a clearance of 60mm x 11mm for allocating the CUBE mXTEND^{TM} component.***

1.5. LIBRARY FILE CONTENT

Each library file contains the information described below and structured as follows.

> ***Example of Library File Content: Header Information, Parameters Information***
>
> ***An example is provided below, it corresponds to the file NN_CUBE_B120x60_C60x11.s*p file introduced before.***
>
> ***It is worth noticing that a line beginning with the ! character corresponds to a comment line that it is normally not interpreted by a matching-circuits design software that reads this type of files.***

1.5.1. HEADER INFORMATION

- The name of the library file.
- The name, reference and size of the mXTEND^{TM} antenna component used in the NN platform to which corresponds the library file.
- A link to the NN´s website providing more information about the mXTEND^{TM} antenna specified in the previous point.
- Board dimensions.
- Clearance area dimensions.

- Feeding line shape and dimensions: a first dimension, from the ground plane edge to the board corner, and second dimension only for L-shape lines, from the board corner to the mXTEND™ antenna component.
- Possible applications for which the platform related to the library file can be used.
- Frequency range at which the [S] params included in this library file are calculated.
- The number of ports defined in the platform and for which the [S] parameters are calculated.
- A paragraph related to the NN´s patents and/or patents applications that protect this platform and the mXTEND™ antenna component as an NN product and their use.
- A paragraph related to our NN Wireless FastTrack service in case the user needs more assistance for designing his device.
- Some additional information preceded by the word "*Touchstone*" about the platform ports. These lines are sometimes interpreted by some of the matching-circuit softwares able to import and use the library file.

```
! IGNION VIRTUAL ANTENNA LIBRARY
!
! NN_CUBE_B120x60_C60x11
! CUBE mXTEND: FR01-S4-250 5.0 mm x 5.0 mm x 5.0 mm
! https://www.ignion.io/chip-antenna/
! Board: 120 mm x 60 mm
! Clearance Area: 60 mm x 11 mm
! Feeding line: L-shape; 11mm x 2mm and 5mm x 2mm
! Applications: Smartphone, Fleet management, IoT
! Frequency range 0.65GHz to 6GHz, step 10MHz
! Number of ports 1
!
! This product is protected by at least the following patent PAT. US 8,203,492 and other domestic
! and international patents pending. Any update on new patents linked to this product will appear in
! www.ignion.io/virtual-antenna/, all rights reserved. Copyright, Ignion 2019.
!
! Need more help? Your platform is much different than these examples in the manual? Use our
!NN Wireless Fast Track service (https://www.ignion.io/fast-track-project/), for free,
!and get a personalized antenna design in just 24 hours.
!
!
! Touchstone port 1 = "Series Port"
!
```

Example: Header information of a single-port library file, concretely the NN_CUBE_B120x60_C60x11.s1p

```
! IGNION VIRTUAL ANTENNA LIBRARY
!
! NN_CUBE_B120x60_C60x11
! Cube mXTEND™: FR01-S4-250 5.0 mm x 5.0 mm x 5.0 mm
! https://www.ignion.io/chip-antenna/
! Board: 120 mm x 60 mm
! Clearance Area: 60 mm x 11 mm
! Feeding line: L-shape; 11mm x 2mm and 5mm x 2mm
! Applications: Smartphone, Fleet management, IoT
! Frequency range 0.65GHz to 6GHz, step 10MHz
! Number of ports 9
!
! This product is protected by at least the following patent PAT. US 8,203,492 and other domestic and
! international patents pending. Any update on new patents linked to this product will appear in
! www.ignion.io/virtual-antenna/, all rights reserved. Copyright, Ignion 2018.
!
! Need more help? Your platform is much different than these examples in the manual? Use our
!NN Wireless Fast Track service (https://www.ignion.io/fast-track-project/), for free,
!and get a personalized antenna design in just 24 hours.
!
!
! Touchstone port 1 = "Series Port"
! Touchstone port 2 = "Shunt Port"
! Touchstone port 3 = "Series Port"
! Touchstone port 4 = "Shunt Port"
! Touchstone port 5 = "Series Port"
! Touchstone port 6 = "Shunt Port"
! Touchstone port 7 = "Series Port"
! Touchstone port 8 = "Shunt Port"
! Touchstone port 9 = "Series Port"
!
```

Example: Header information of a 9-port library file, concretely the NN_CUBE_B120x60_C60x11.s9p

```
! IGNION VIRTUAL ANTENNA LIBRARY
!
! NN_TRIO_B50x50_C50x12
! TRIO mXTEND: FR01-S4-210 30.0mm x 3.0mm x 1.0mm
! https://www.ignion.io/trio-mxtend-mobile-iot-antenna/
! Board: 50mm x 50mm
! Clearance Area: 50mm x 12mm
! Feeding line: straight line; 9mm x 1mm
! Applications: Smartphone, Fleet management, IoT
! Frequency range 0.65GHz to 6GHz, step ~5MHz
! Number of ports 5
!
! 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.
! Additional information about patents related to this product is available at
! www.ignion.io/virtual-antenna/, all rights reserved. Copyright, Ignion 2019.
!
! Need more help? Your platform is much different than these examples in the manual? Use our
!NN Wireless Fast Track service (https://www.ignion.io/fast-track-project/), for free,
!and get a personalized antenna design in just 24 hours.
!
!
! Touchstone port 1 = CST MWS port 1 ("Series Feeding Port 1")
! Touchstone port 2 = CST MWS port 2 ("Series in-Trio Port 1")
! Touchstone port 3 = CST MWS port 3 ("Series in-Trio Port 2")
! Touchstone port 4 = CST MWS port 4 ("Series Port in Feeding line of Port 2")
! Touchstone port 5 = CST MWS port 5 ("Series Feeding Port 2")
!
```

Example: Header information of a five-port library file related to a TRIO platform, concretely the NN_TRIO_B50x50_C50x12.s5p

1.5.2. PARAMETERS

1.5.2.1. Parameters general information

Following the header, the lines concern the representation of the [S] parameters. They are calculated by an EM CAD software at the port or ports defined in the platform related to the library file for each frequency included in the simulation. This is because each platform in the NN Librarie[S] enables implementing a matching network, as shown in section 4.

For each frequency, provided in GHz, the [S] params related to the ports defined in the corresponding platform are shown at the beginning of each line of [S] params for 1-port library files, and at the beginning of each paragraph of [S] params for 9-port or for 5-port library files. Each [S] parameter is represented by its magnitude and angle, as indicated by the “M” and the “A” found in the following examples, included in 1-port library files, in 9-port library files and in 5-port library files, respectively. The “R 50” text from the examples provided below indicates that the [S] params are calculated regarding an impedance Z=50Ω (only resistance component).

```
! IE3D S-Parameters Output Version 2.0
# GHZ S MA R 50
! Nport = 1
!
```

Example: Parameters general information of a 1-port library file.

```
! IE3D S-Parameters Output Version 2.0
# GHZ S MA R 50
! Nport = 9
!
```

Example: Parameters general information of a 9-port library file.

```
! CST MICROWAVE STUDIO 2019
# GHz S MA R 50
! Nport = 5
!
```

Example: Parameters general information of a 5-port library file.

1.5.2.2. Frequency, magnitude and angle

The last information provided is the **frequency**, the **magnitude** and the **angle** representing each [S] parameter related to the port of the structure for 1-port library files and to each of the 9 ports or 5 ports of the structure for 9-port and 5-port library files.

For the case of 1-port library files, a line of [S] params includes 1 [S] parameter related to the structure port calculated for the corresponding frequency, indicated at the beginning of the line. Then, in 1-port library files, there is as many number of lines of [S] parameters as number of computed frequencies.

```
6.5000000000e-001  9.9154595539e-001 -1.6113757198e+001
```

Example: Line of text with frequency, magnitude and angle for the [S] parameter related to a 1-port library file.

For the case of 9-port library files, each line of [S] params includes 9 [S] parameters related to each port calculated for the corresponding frequency, indicated at the beginning of each paragraph, as already mentioned. In total, 9x9 [S] params are calculated and provided for each frequency at each [S] paragraph.

```
6.50000000000000e-001 2.50068754269855e-001 1.52214978070981e+002 7.61850929784291e-001
        -5.44468308925773e+000    4.66963165069729e-001    1.72162180454406e+002
        2.93191507483463e-001    -8.10754730165073e+000    1.74510844131583e-001
        1.71986476312820e+002    1.18437307738526e-001    -9.52593599010154e+000
        5.66572190450041e-002    1.75180486768357e+002    6.19975571595999e-002    -
        1.23266198912485e+001 9.50771242509153e-003 -6.68968406286267e+001
```

Example: Line of text with frequency, magnitude and angle for the first 9 [S] parameters related to a 9-port library file.

For the case of 5-port library files, each line of [S] params includes 5 [S] parameters related to each port calculated for the corresponding frequency, indicated at the beginning of each paragraph, as already mentioned. In total, 5x5 [S] params are calculated and provided for each frequency at each [S] paragraph.

```
0.65        0.652598    1.10534     0.35822     155.981     0.379595    -42.8277
0.384279    -42.5167    0.38489     -43.2667
            0.358651    155.768     0.666692    -1.90763    0.37055     -43.7576
0.376328    -43.7316    0.377616    -44.6395
            0.380072    -42.9923    0.370987    -43.8452    0.703282    0.298179
0.327307    151.367     0.334947    147.749
            0.384515    -42.6033    0.376717    -43.8108    0.327299    151.367
0.704766    5.05031     0.322334    155.985
            0.384972    -43.2997    0.377981    -44.7119    0.334939    147.749
```

Example: Paragraph with frequency, magnitude and angle for the first 5x5 [S] parameters related to a 5-port library file.

As shown with the two last examples and as explained before, for each frequency a paragraph composed of 9 lines of 9 [S] parameters, so 9x9, i.e. 81 [S] parameters, or a paragraph composed of 5 lines of 5 [S] parameters, so 5x5, i.e. 25 [S] parameters are found in a 9-port or a 5-port library file, respectively, for each frequency.

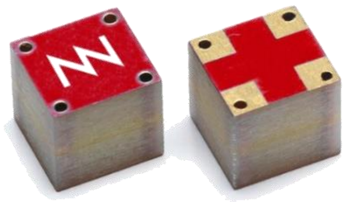
2. AVAILABLE mXTEND™ ANTENNA COMPONENTS

The range of products by Ignion are named mXTEND™. Please, find below the whole range of available NN´s Virtual Antenna™ components, used in the wireless platforms included in our NN Librarie[S]. You can also find below their part number and dimensions together with the possible bands covered in solutions already implemented with those pieces. Notice that the acronym standing out in bold and capital letters is the name of the mXTEND™ antenna component used to create the library file names, as explained in section 1.4.

FR01-S4-220
ALL mXTEND™
Bands: 698 – 2690 MHz
24.0 mm x 12.0 mm x 2.0 mm

FR01-S4-224
RUN mXTEND™
Bands: 698 – 3800 MHz
12.0 mm x 3.0 mm x 2.4 mm

FR01-S4-232
BAR mXTEND™
Bands: 698 – 2690 MHz
10.0 mm x 3.2 mm x 3.2 mm



FR01-S4-250
CUBE mXTEND™
Bands: 698 – 2690 MHz
5.0 mm x 5.0 mm x 5.0 mm

FR01-S4-210
TRIO mXTEND™
Bands: 698 – 2690 MHz
30.0 mm x 3.0 mm x 1.0 mm

Figure 2 – NN mXTEND™ antenna components available in the NN Librarie[S].

3. CHOOSE THE RIGHT LIBRARY FILE FOR YOUR APPLICATION

The table below provides the different platforms available for direct download. Each platform not using the TRIO mXTEND™ antenna component has two library file names assigned that you can find on the right-side column. The .s1p or the .s9p file extensions indicate the number of ports used in the feeding area of the platform related to the file. For the case of TRIO platforms, the .s5p file extension indicates the number of ports implemented in the platform, as shown in section 4.3, for designing a TRIO solution. The dimensions of the board together with those of the clearance area available in the board for allocating the NN mXTEND™ antenna component are included in the third and fourth columns. Once decided the library platform that fits your device requirements you can choose to work with 1 or 9 ports for designing your matching network for the case of non-TRIO solutions. The use of just one port simplifies the matching network design process. Using 9 ports provides more accuracy on the matching results, but it may require a more advanced knowledge on how to implement a matching network. So, depending on your expertise you can choose a 1-port file or a 9-port file. For example, if this is one of your first matching networks you can firstly use the 1-port file you need for your platform, and later readjust the matching network obtained with the 1-port approach with a 9-port configuration for more accuracy. If you feel comfortable designing matching networks with a more than one port approach you may prefer to implement your matching network directly using the 9-port file.

Choose the right file: Size, Space and Clearance

A quick look to the table allows you to choose a library file depending on your platform requirements, especially in terms of size and the available space for allocating the mXTEND™ antenna component, that is the clearance area.

Application	NN mXTEND™ Antenna Component	Board Size AxC mm^2	Clearance Size wxh mm^2	Library File Name
Smart meter	RUN	145x130	45x24	NN_RUN_B145x130_C45x24.s1p NN_RUN_B145x130_C45x24.s9p
	ALL	145x130	45x24	NN_ALL_B145x130_C45x24.s1p NN_ALL_B145x130_C45x24.s9p
Smartphone	RUN	130x60	20x11	NN_RUN_B130x60_C20x11.s1p NN_RUN_B130x60_C20x11.s9p
Fleet Management Module	RUN	120x60	60x11	NN_RUN_B120x60_C60x11.s1p NN_RUN_B120x60_C60x11.s9p
	RUN	105x45	45x11	NN_RUN_B105x45_C45x11.s1p NN_RUN_B105x45_C45x11.s9p
	RUN	70x40	40x11	NN_RUN_B70x40_C40x11.s1p NN_RUN_B70x40_C40x11.s9p
	CUBE	120x60	60x11	NN_CUBE_B120x60_C60x11.s1p NN_CUBE_B120x60_C60x11.s9p

	CUBE	105x45	45x11	NN_CUBE_B105x45_C45x11.s1p NN_CUBE_B105x45_C45x11.s9p
	CUBE	70x40	40x11	NN_CUBE_B70x40_C40x11.s1p NN_CUBE_B70x40_C40x11.s9p
IoT	RUN	90x90	90x11	NN_RUN_B90x90_C90x11.s1p NN_RUN_B90x90_C90x11.s9p
	RUN	90x70	70x11	NN_RUN_B90x70_C70x11.s1p NN_RUN_B90x70_C70x11.s9p
	RUN	85x55	55x11	NN_RUN_B85x55_C55x11.s1p NN_RUN_B85x55_C55x11.s9p
	RUN	70x55	55x11	NN_RUN_B70x55_C55x11.s1p NN_RUN_B70x55_C55x11.s9p
	RUN	50x55	55x11	NN_RUN_B50x55_C55x11.s1p NN_RUN_B50x55_C55x11.s9p
	RUN	50x40	40x11	NN_RUN_B50x40_C40x11.s1p NN_RUN_B50x40_C40x11.s9p
	RUN	50x20	20x11	NN_RUN_B50x20_C20x11.s1p NN_RUN_B50x20_C20x11.s9p
	CUBE	90x90	90x11	NN_CUBE_B90x90_C90x11.s1p NN_CUBE_B90x90_C90x11.s9p
	CUBE	90x70	70x11	NN_CUBE_B90x70_C70x11.s1p NN_CUBE_B90x70_C70x11.s9p
	CUBE	85x55	55x11	NN_CUBE_B85x55_C55x11.s1p NN_CUBE_B85x55_C55x11.s9p
	CUBE	70x55	55x11	NN_CUBE_B70x55_C55x11.s1p NN_CUBE_B70x55_C55x11.s9p
	CUBE	50x55	55x11	NN_CUBE_B50x55_C55x11.s1p NN_CUBE_B50x55_C55x11.s9p
	CUBE	50x40	40x11	NN_CUBE_B50x40_C40x11.s1p NN_CUBE_B50x40_C40x11.s9p
	CUBE	50x20	20x11	NN_CUBE_B50x20_C20x11.s1p NN_CUBE_B50x20_C20x11.s9p
Wearable	RUN	30x30	14x5	NN_RUN_B30x30_C14x5.s1p NN_RUN_B30x30_C14x5.s9p
Routers/Repeaters	RUN	140x120	120x11	NN_RUN_B140x120_C120x11.s1p NN_RUN_B140x120_C120x11.s9p
	BAR	140x120	120x11	NN_BAR_B140x120_C120x11.s1p NN_BAR_B140x120_C120x11.s9p
Smart meter	TRIO	110x80	80x12	NN_TRIO_B110x80_C80x12.s5p
Fleet management	TRIO	110x50	50x12	NN_TRIO_B110x50_C50x12.s5p
Fleet management	TRIO	80x70	70x12	NN_TRIO_B80x70_C70x12.s5p
IoT	TRIO	80x30	30x12	NN_TRIO_B80x30_C30x12.s5p
IoT	TRIO	50x50	50x12	NN_TRIO_B50x50_C50x12.s5p
IoT	TRIO	50x35	35x12	NN_TRIO_B50x35_C35x12.s5p

Table 2 – Platforms available in the NN Librarie[S].

4. PLATFORM PADS AND PORTS

4.1. ONE-PORT LIBRARY FILES

The ports configuration used for implementing the feeding area of a platform related to a 1-port library file is shown below (*Figure 3*). One single port is defined for allocating the matching network that you will design for matching your device. The port is defined in a gap between a feeding line that is connected in its end to the mXTEND™ antenna component and the platform ground plane.

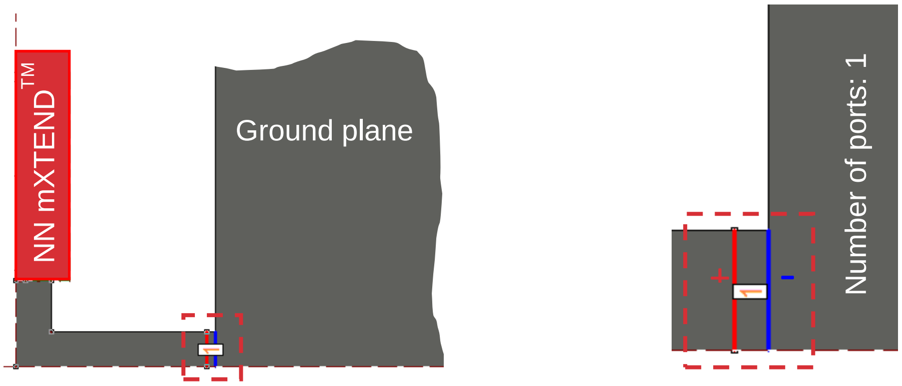


Figure 3 – NN platform port configuration defined for 1-port library files.

It is worth noticing that for the platforms included in the set of 1-port library files, the port defined corresponds to a feeding port where the matching network can also be implemented, as it is represented below in *Figure 4*. Any matching network topology can be designed within this port configuration.

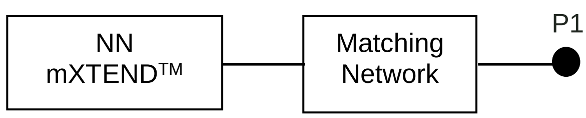


Figure 4 – Generic matching network allocated in the port defined in an NN platform with a feeding area composed of just 1 port.

4.2. NINE-PORT LIBRARY FILES

The pads and ports configuration related to a platform of this library is shown as below (*Figure 5*). Instead of defining one single port to allocate the matching network, different pads, more concretely 4 pads (colored in a darker grey), are included in the feeding area of the platform in order to use a realistic model that takes into account the pads effect in the input impedance of the structure.

The pads are 1x2 mm^2 and they are spaced apart by a gap of 0.5mm. In such a pads configuration, 9 corresponding ports are defined, some of them allocated in the gaps between the pads and other ports between a pad and the ground plane of the structure, as it is represented below in *Figure 5*.

Particularly, port 9 is defined between a pad and a feeding line that is connected in its end to the mXTEND™ antenna. Ports 9, 7, 5, 3 and 1 are series ports and ports 8, 6, 4 and 2 are shunt ports connecting a pad to the platform ground plane. It is worth noticing that in the context of this document and for the platforms included in our library, a port does not necessary correspond to a feeding port.

In section 5 of this document you can find some examples where you can check that if the matching network designed requires components in all or most of the ports, port 1 will be the feeding port. If the matching network implemented does not require components in all the ports, the feeding port can be located at another port different from port 1, to avoid the transmission line effect resulting from connecting the remaining series pads with short-circuits or resistance components with resistance value equal to 0 until port 1. For the case of just a few ports needed for allocating the matching network it is suggested to use a port different from port 1 as feeding port.

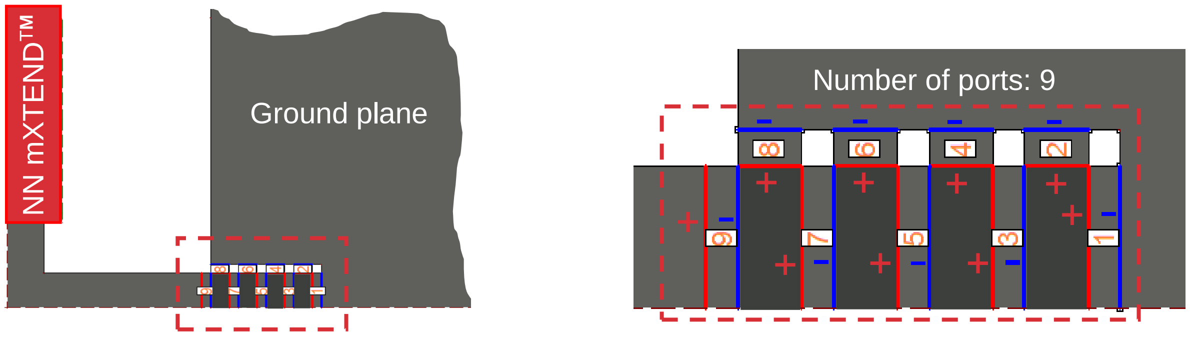


Figure 5 – NN platform pads and ports defined.

The matching network topology (*Figure 6*) represents a generic topology of a matching network whose components are allocated at the ports defined in the platform, so that $Z_{2..9}$ corresponds to a component allocated in the '2..9' port. In this topology no component has been included at port 1, according to a real case of a matching network mounted on a real platform, where the feeding cable, connector or alike is going to fully occupy the port, without leaving place for allocating a component. But it is possible to add in simulations a component Z1 at port 1 before closing the port with a feeding port. It is also worth noticing that two components arranged in a shunt configuration can also be used in a same port X, this configuration is shown in the right topology example from *Figure 6*.

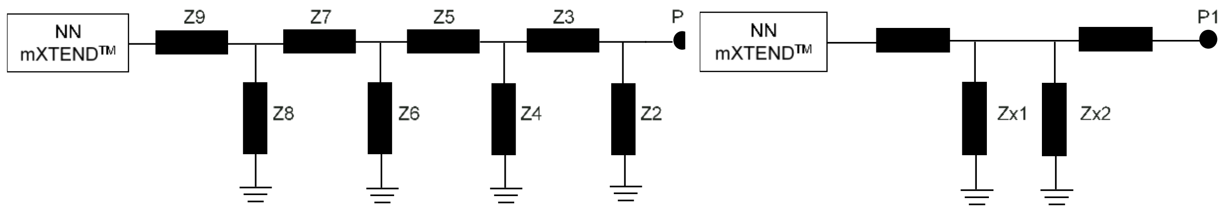


Figure 6 – Left: generic matching network topology allocated in the ports defined in an NN platform from the library. $Z_{2..9}$ corresponds to a component placed at the '2..9' port. Right: topology example representing a shunt configuration of components allocated in the same 'x' port.

4.3. TRIO LIBRARY FILES

The ports configuration used for implementing a TRIO solution is shown below (Figure 7). Two single ports are defined in two feeding areas for allocating the matching networks that you will design for matching your device. These ports are defined in a 0.5mm gap between a feeding line that is connected in its end to the mXTEND™ antenna component and the platform ground plane. Three other ports are also defined, for allocating additional matching circuits, if necessary, typically filter circuits used in TRIO solutions. Those ports are also defined in gaps of 0.5mm implemented between two pads as shown in Figure 7.

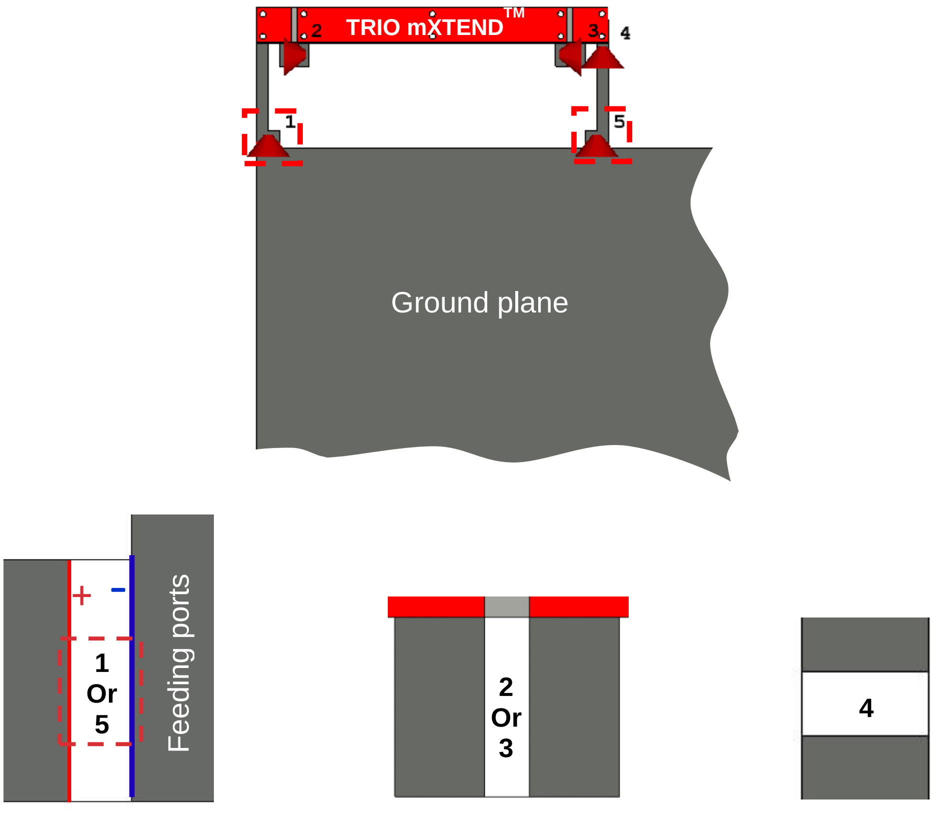


Figure 7 – TRIO platform ports configuration.

5. HOW TO USE A LIBRARY FILE: EXAMPLES

5.1. ONE-PORT LIBRARY FILES

5.1.1. IoT – SMART METER

5.1.1.1. STEP 1: LIBRARY FILE SELECTION

Let´s say you have a new project and you need to design a new smart meter application within a frequency range from 698 MHz to 960 MHz and/or from 1.71 GHz to 2.17 GHz. You also know the platform used is featuring a 142 x 129 mm^2 board with a clearance of 45 x 25 mm^2.

The information above is the only data you need to choose the most suitable library file. Use Table 2 to see available files and you must choose the one closer in specs to your specific project.

In this case the 1-port library file will be NN_ALL_B145x130_C45x24.s1p. The antenna is an ALL mXTEND™ (see section 2 of this manual) placed at the corner of the PCB. You can find how to get the library file you need at section 1.2.

5.1.1.2. STEP 2: MATCHING NETWORK IMPLEMENTATION

Now you can implement for the platform previously chosen, a suitable matching network with your preferred circuit design software. *Figure 8* provides a zoom of the feeding area (red dashed square) and the corner of the PCB where the antenna component is placed, showing how the antenna component is connected to the feeding area. The feeding area is in this case composed of just 1-port, as seen in *Figure 8*, and it is connected to the antenna component by means of a straight feeding line of 2mm width.

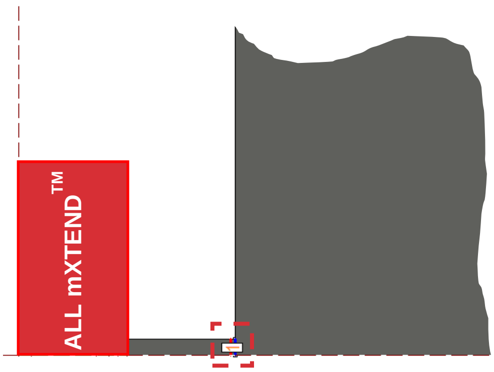
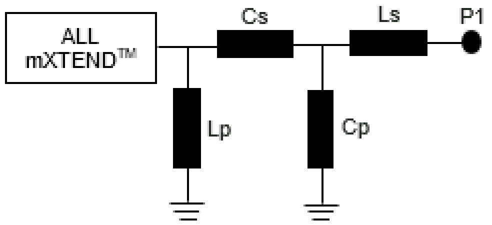


Figure 8 – Zoom of the antenna component and the feeding area of the NN platform used in the example here provided for modeling an IoT/smart meter device.

The matching network designed for matching this platform is allocated in the feeding area port of the platform as shown below in *Figure 9*. The value and part numbers of the real components used for implementing it are specified in the table next to the network topology. The bottom image in *Figure 9* represents how the matching network and a feeding port are allocated in the port defined in the feeding area of the NN platform.



	Value	Part Number
Lp	15nH	LQW18AN15NG80
Cs	2.0pF	GJM1555C1H2R0WB01
Cp	1.3pF	GJM1555C1H1R3WB01
Ls	5.7nH	LQW15AN5N7B80

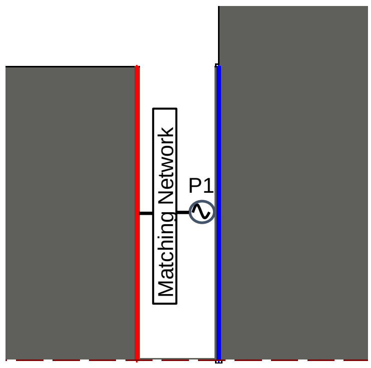


Figure 9 – Matching network designed along with the values and the part numbers of the real components used for implementing it. Below, an image of the single-port feeding area of the NN platform used in this example, allocating a matching network and a feeding port, is provided.

Here you are a schematic of the [S] params representing the 1-port library file used for this example, the NN_ALL_B145x130_C45x24.s1p file, and how the matching network circuit provided above for this example is connected to the [S] params schematic of one port representing the library file.

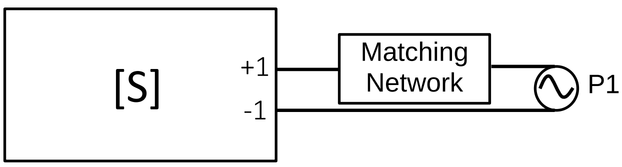


Figure 10 – An [S]-parameters representation corresponding to the 1-port library file used for this example, connected to a matching network representing the matching network designed for the example and provided in *Figure 9*.

After designing the matching network in your circuit design software, you can plot the reflection coefficient obtained.

5.1.1.3. STEP 3: RESULTS

The input matching obtained with the matching network designed above is shown in the following *Figure 11*. It shows the input reflection coefficient for this smart metering example. The design is matched below -7dB in the frequency bands of interest, ranging from 698MHz to 960MHz and from 1.71GHz to 2.17GHz.

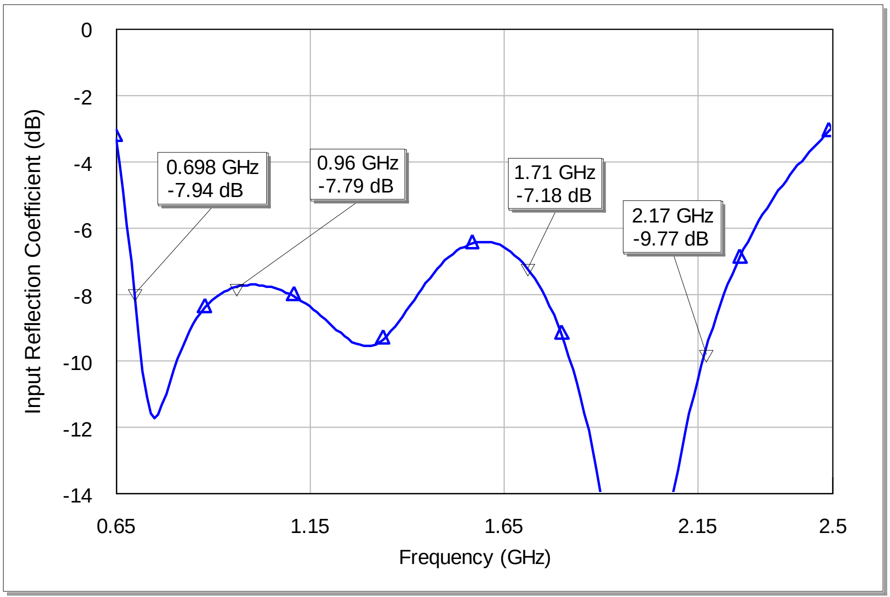


Figure 11 – Input reflection coefficient related to the IoT/smart meter example here provided.

5.1.2. MOBILE – FLEET MANAGEMENT MODULE

5.1.2.1. STEP 1: LIBRARY FILE SELECTION

Imagine you need to design the antenna for a new fleet management application module and you need connectivity within a frequency range going from 824 MHz to 960 MHz and/or from 1.71 GHz to 2.17 GHz. The module features a 125 x 60 mm^2 board with a clearance of 61 x 13 mm^2.

The information above is the only data you need to choose the most suitable library file. Use Table 2 to see available files and you must choose the one closer in specs to your specific project.

The corresponding library file providing the [S] params related to this 1-port platform is the NN_RUN_B120x60_C60x11.s1p. The RUN mXTEND^{TM} antenna booster (see section 2 of this manual) is then chosen and it is placed at 5 mm from the corner of the PCB. The RUN mXTEND^{TM} is connected to the feeding area, where the matching network is allocated, by an L-shape feeding line of 2mm width as it is seen in picture from *Figure 12*. You can find how to get the library file you need at section 1.2.

5.1.2.2. STEP 2: MATCHING NETWORK IMPLEMENTATION

Once you have chosen the platform for the smart meter example you can implement a matching network with your preferred circuit design software. *Figure 12* provides a zoom of the feeding area (red dashed square) and the corner of the PCB where the antenna component is placed, showing how the antenna component is connected to the feeding area. The feeding area is in this case composed of just 1-port, as seen in *Figure 12*, and it is connected to the antenna component by means of an L-shape feeding line of 2mm width.

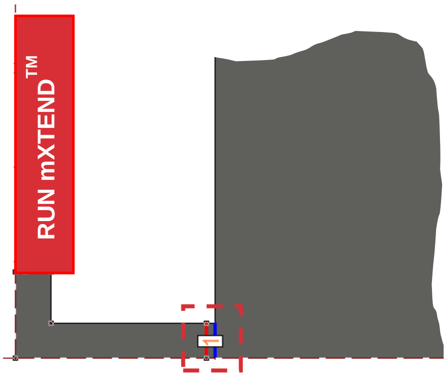
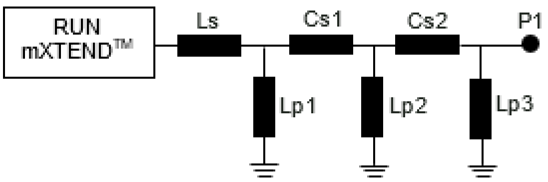


Figure 12 – Zoom of the antenna component and the feeding area of the NN platform used in the fleet management example here provided.

The matching network designed for matching this platform is allocated in the feeding area port of the platform, as shown below in *Figure 13*. The value and part numbers of the real components used for implementing it are specified in the table next to the network topology. The bottom image in *Figure 13* represents how the matching network and a feeding port are allocated in the port defined in the feeding area of the NN platform.



	Value	Part Number
Ls	6.7nH	LQW15AN6N7G80
Lp1	14nH	LQW15AN14NG80
Cs1	1.1pF	GJM1555C1H1R1WB01
Lp2	5.5nH	LQW15AN5N5B80
Cs2	2.7pF	GJM1555C1H2R7WB01
Lp3	6.7nH	LQW15AN6N7G80

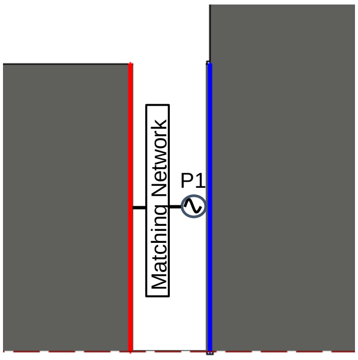


Figure 13 – Matching network designed along with the values and the part numbers of the real components used for implementing it. Below, an image of the single-port feeding area of the NN platform used in this example, allocating a matching network and a feeding port, is provided.

Here you are a schematic of the [S] params representing the 1-port NN library file used for this example, the NN_RUN_B120x60_C60x11.s1p file, and how the matching network circuit provided above for this example is connected to the [S] params schematic of one port representing the library file.

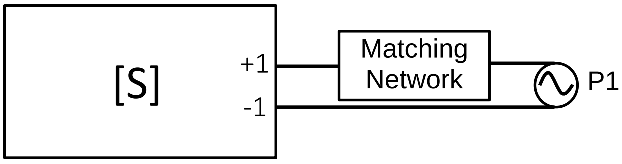


Figure 14 – An [S]-parameters representation corresponding to the 1-port library file used for this example, connected to a matching network representing the matching network designed for the example and provided in *Figure 13*.

After designing the matching network in your circuit design software, you can plot the reflection coefficient obtained.

5.1.2.3. STEP 3: RESULTS

The matching performance resulting from using the matching network (*Figure 13*) proposed in the previous section 5.1.2.2. is shown in the following *Figure 15*. It shows the input reflection coefficient for this fleet management example. The design is matched below -6dB in the frequency bands of interest, ranging from 824MHz to 960MHz and from 1.71GHz to 2.17GHz.

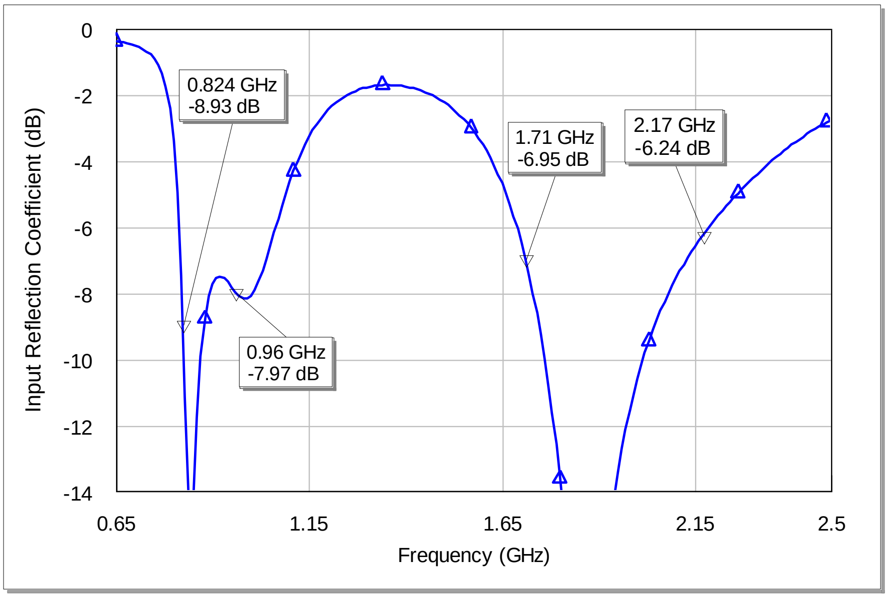


Figure 15 – Input reflection coefficient related to the fleet management example here provided.

5.1.3. ISM – WEARABLES

5.1.3.1. STEP 1: LIBRARY FILE SELECTION

If you need to cover ISM bands operating within the 2.4 GHz to 2.5 GHz range, here you are the example. This might be the case for instance of a wearable device establishing a short-range wireless link with a computer or mobile device. In this example, the platform used features a 32 x 32 mm^2 board with a clearance of 14 x 4 mm^2.

The information above is the only data you need to choose the most suitable library file. Use Table 2 to see available files and you must choose the one closer in specs to your specific project.

In this case the library file you need to choose is NN_RUN_B30x30_C14x5.s1p, the closest to your real situation. You can find how to get the library file you need at section 1.2.

5.1.3.2. STEP 2: MATCHING NETWORK IMPLEMENTATION

Once you have chosen the suitable platform for the wearables example you can implement a matching network with your preferred circuit design software. *Figure 16* provides a zoom of the feeding area (red dashed square) and the corner of the PCB where the antenna component is placed, showing how the antenna component is connected to the feeding area. The feeding area is in this case composed of just 1-port, as seen in *Figure 16*, and it is connected to the antenna component by means of a straight feeding line of 2mm width.

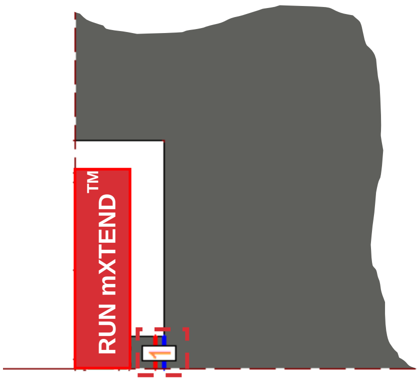
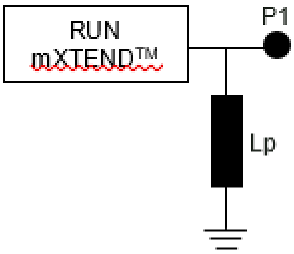


Figure 16 – Zoom of the antenna component and the feeding area of the NN platform used in the wearables example here provided.

The matching network designed for matching this platform is allocated in the feeding area port of the platform, as shown below in *Figure 17*. The value and part numbers of the real components used for implementing it are specified in the table next to the network topology. The bottom image in *Figure 17* represents how the matching network and a feeding port are allocated in the port defined in the feeding area of the NN platform.



	Value	Part Number
Lp	2.4nH	LQW15AN2N4G80

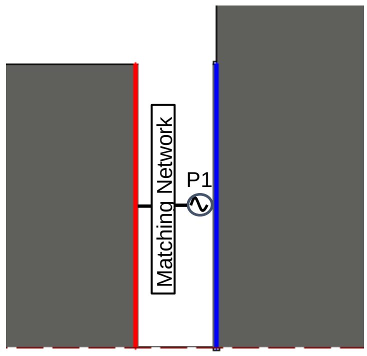


Figure 17 – Matching network designed along with the values and the part numbers of the real components used for implementing it. Below, an image of the single-port feeding area of the NN platform used in this example, allocating a matching network and a feeding port, is provided.

Here you are a schematic of the [S] params representing the 1-port NN library file used for this example, the NN_RUN_B30x30_C14x5.s1p file, and how the matching network circuit provided above for this example is connected to the [S] params schematic of one port representing the library file.

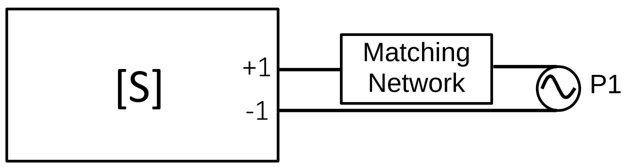


Figure 18 – An [S]-parameters representation corresponding to the 1-port library file used for this example, connected to a matching network representing the matching network designed for the example and provided in *Figure 17*.

After designing the matching network in your circuit design software, you can plot the reflection coefficient obtained.

5.1.3.3. STEP 3: RESULTS

The matching performance resulting from using the matching network proposed in the previous chapter 5.1.3.2. is shown in the following *Figure 19*. It shows the input reflection coefficient for this wearables example. The design is matched below -9dB in the frequency bands of interest, ranging from 2.4 GHz to 2.5 GHz.

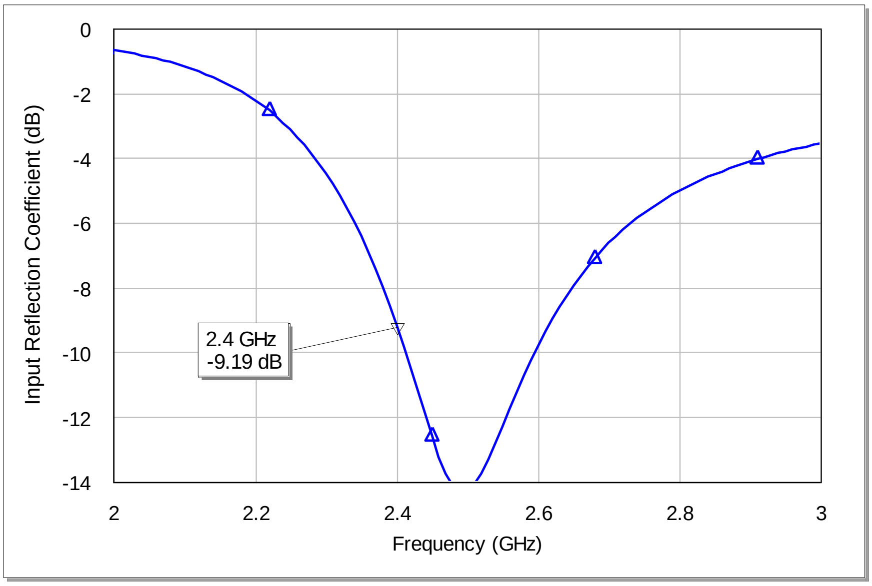


Figure 19 – Input reflection coefficient related to the wearables example here provided.

5.2. NINE-PORT LIBRARY FILES

5.2.1. IoT - SMART METER

5.2.1.1. STEP 1: LIBRARY FILE SELECTION

Let´s say you have a new project and you need to design a new smart meter application within a frequency range from 698 MHz to 960 MHz and/or from 1.71 GHz to 2.17 GHz. You also know the platform used is featuring a 142 x 129 mm^2 board with a clearance of 45 x 25 mm^2.

The information above is the only data you need to choose the most suitable library file. Use Table 2 to see available files and you must choose the one closer in specs to your specific project.

In this case the library file will be NN_ALL_B145x130_C45x24.s9p. The antenna is an ALL mXTEND™ (see section 2 of this manual) placed at the corner of the PCB. You can find how to get the library file you need at section 1.2.

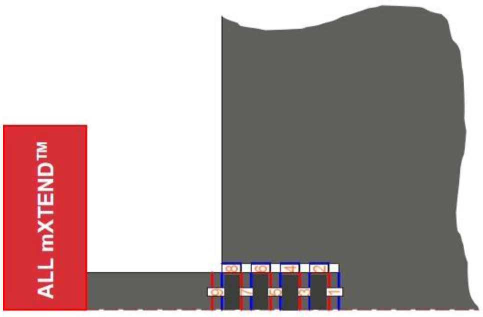
5.2.1.2. STEP 2: MATCHING NETWORK IMPLEMENTATION

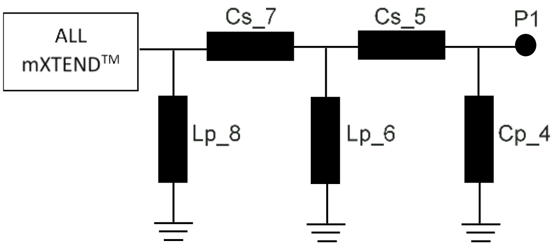
Figure 20 shows a picture of a piece of the platform used for this case, showing the pads area and ports defined in the structures included in this library file.

Below the platform you can find the matching network designed and used for matching this platform. The value and part numbers of the real components used for implementing it are specified in the table next to the topology.

As seen in *Figure 20*, the matching network designed is formed by five components: a shunt inductance, a series capacitance, another shunt inductance followed by another series capacitance, the matching network finishes with a shunt capacitance.

In this case the port used as feeding port is port 1. The bottom image in *Figure 20* represents how all the components are allocated in the nine ports defined in the platform when its [S] parameters library file is connected to the components of the five-components matching network described before. The ports not containing a component, either a short-circuit or a circuit component, as for example an inductor or a capacitor, allocate an open-circuit, which is represented by an empty port in the bottom image.





	Value	Part Number
Lp_8	12nH	LQW18AN12NG80
Cs_7	1.4pF	GJM1555C1H1R4WB01
Lp_6	10nH	LQW18AN10NG80
Cs_5	2.6pF	GJM1555C1H2R6WB01
Cp_4	1.4pF	GJM1555C1H1R4WB01

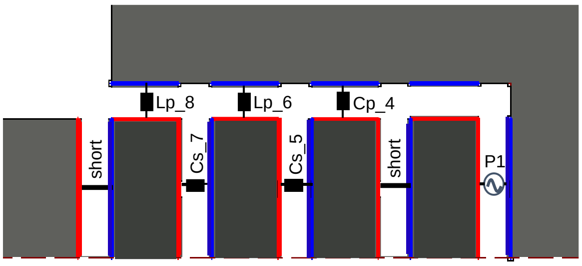


Figure 20 – Matching network designed together with its components position in the NN platform area assigned for allocating the matching network, regarding the ports defined on it.

Here you are a schematic of the [S] params representing the library file of this specific example, NN_ALL__B145x130_C45x24.s9p.

This schematic is a generic representation of how to implement the matching network circuit provided for this example with a software of matching circuits design. Each software will have its particularities on how to implement those [S] block to components connections, as well as on how to implement a short and an open-circuit.

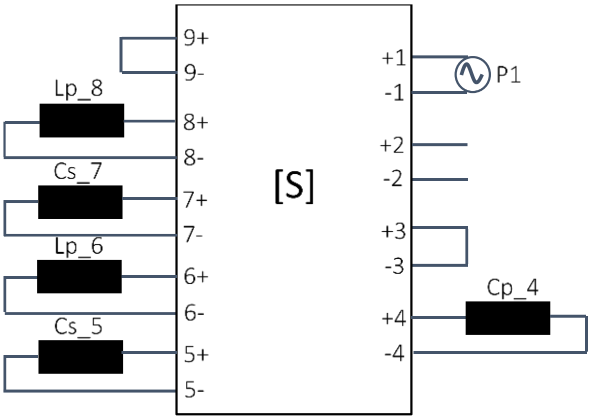


Figure 21 – [S] parameters block corresponding to the library file used, connected to the components of the matching network designed for this example.

5.2.1.3. STEP 3: RESULTS

The result of the above matching network (*Figure 20*) is shown in the following *Figure 22*. It shows the input reflection coefficient for this smart metering example. The design is matched below -7dB in the frequency bands of interest, ranging from 698MHz to 960MHz and from 1.71GHz to 2.17GHz.

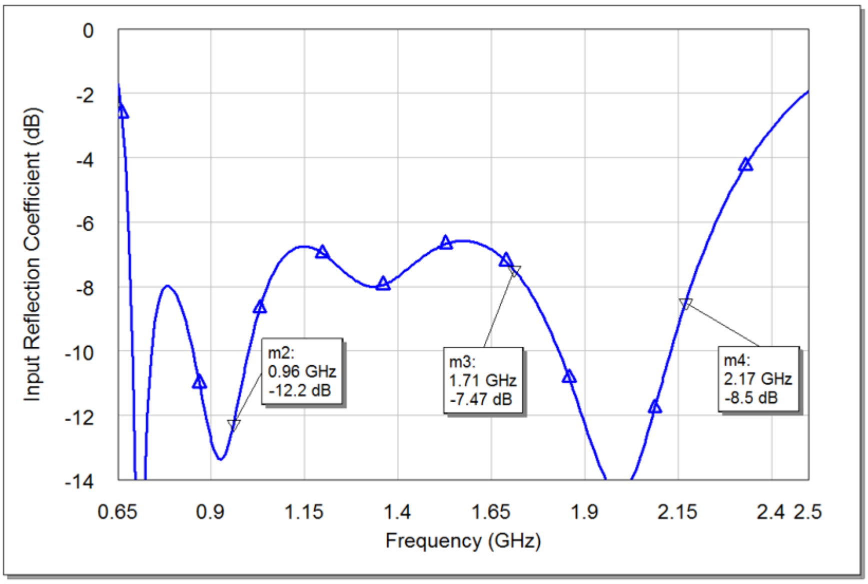


Figure 22 – Input reflection coefficient related to the IoT/smart meter example here provided.

5.2.2. MOBILE – FLEET MANAGEMENT MODULE

5.2.2.1. STEP 1: LIBRARY FILE SELECTION

Imagine you need to design the antenna for a new fleet management application module and you need connectivity within a frequency range going from 824 MHz to 960 MHz and/or from 1.71 GHz to 2.17 GHz. The module features a 125 x 60 mm^2 board with a clearance of 61 x 13 mm^2.

The information above is the only data you need to choose the most suitable library file. Use Table 2 to see available files and you must choose the one closer in specs to your specific project.

The corresponding library file providing the [S] params related to this platform is the NN_RUN_B120x60_C60x11.s9p. The RUN mXTEND^{TM} antenna booster is the chosen one and it is placed at 5 mm from the corner of the PCB. The RUN mXTEND^{TM} is connected to the pads area, where the matching network is allocated, by an L-shape feeding line of 2mm width as it is seen in the top picture from *Figure 23*. You can find how to get the library file you need at section 1.2.

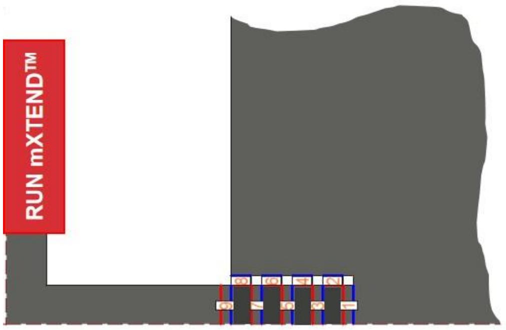
5.2.2.2. STEP 2: MATCHING NETWORK IMPLEMENTATION

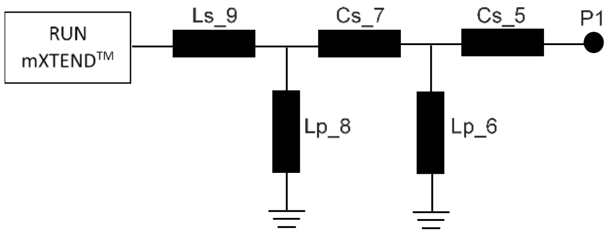
See in *Figure 23* the piece of the platform described before and used for this case, showing the pads area and ports defined in the structures included in this library file.

Below the platform you can find the matching network designed and used along with the value and part numbers of the real components used for the design implementation.

As seen in *Figure 23*, the matching network designed is composed of five components, a series inductance firstly, followed by a shunt inductance, a series capacitance, another second shunt inductance followed by another series capacitance. For this case the port used as feeding port is port 1 but port 3 or port 4 could also have been chosen.

The last image in *Figure 23* represents the location of the nine ports defined in the platform when its [S] parameters library file is connected to the components of the five-components matching network described before. The ports not containing a component, either a short-circuit or a circuit component, as for example an inductor or a capacitor, allocate an open-circuit, which is represented by an empty port in the bottom image.





	Value	Part Number
Ls_9	7.1nH	LQW15AN7N1G80
Lp_8	15nH	LQW18AN15NG80
Cs_7	0.9pF	GJM1555C1HR90WB01
Lp_6	9.2nH	LQW15AN9NG80
Cs_5	2.3pF	GJM1555C1H2R3WB01

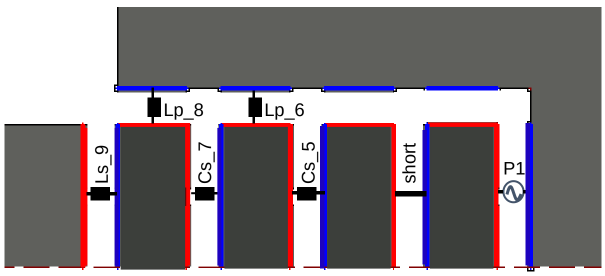


Figure 23 – Matching network designed, and its components position in the NN platform area assigned for allocating the matching network, regarding the ports defined on it.

Find below a schematic of the [S] params representing the library file of this specific example, NN_RUN_B120x60_C60x11.s9p.

This schematic is a generic representation of how to implement the matching network circuit provided for this example with a software of matching circuits design. Each software will have its particularities on how to implement those [S] block to components connections, as well as on how to implement a short and an open-circuit.

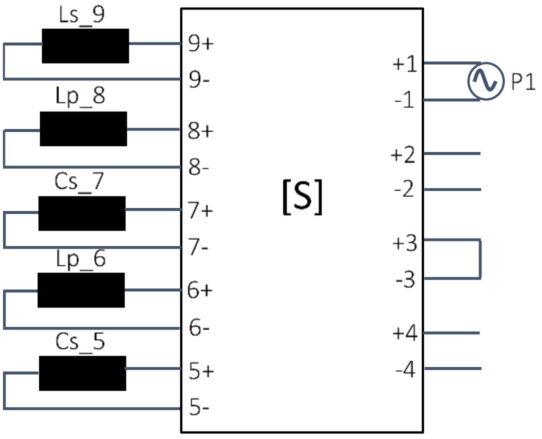


Figure 24 – [S] parameters block corresponding to the library file used, connected to the components of the matching network designed for this example.

5.2.2.3. STEP 3: RESULTS

The input matching obtained for the above matching network, provided in *Figure 23,* is shown in the next *Figure 25*. You can find the input reflection coefficient obtained after using such matching network. The design is matched below -6dB in the frequency bands of interest, going from 824MHz to 960MHz and from 1.71GHz to 2.17GHz for the target applications of this example.

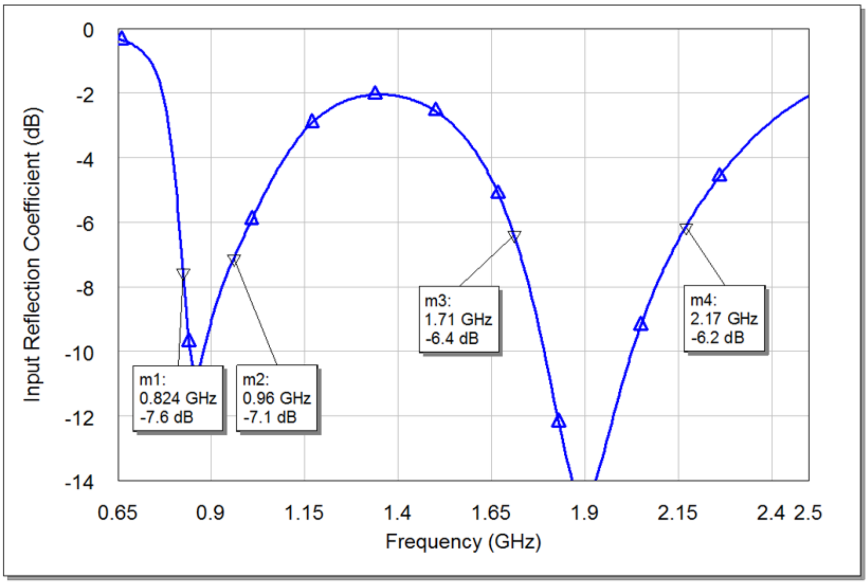


Figure 25 – Input reflection coefficient related to the Mobile/Fleet management example here provided.

5.2.3. ISM – WEARABLES

5.2.3.1. STEP 1: LIBRARY FILE SELECTION

If you need to cover ISM bands operating within the 2.4 GHz to 2.5 GHz range, here you are the example. This might be the case for instance of a wearable device establishing a short-range wireless link with a computer or mobile device. In this example, the platform used features a 32 x 32 mm^2 board with a clearance of 14 x 4 mm^2.

The information above is the only data you need to choose the most suitable library file. Use Table 2 to see available files and you must choose the one closer in specs to your specific project.

In this case the library file you need to choose is NN_RUN_B30x30_C14x5.s9p, the closest to your real situation. You can find how to get the library file you need at section 1.2.

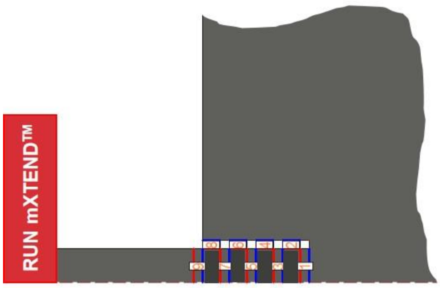
5.2.3.2. STEP 2: MATCHING NETWORK IMPLEMENTATION

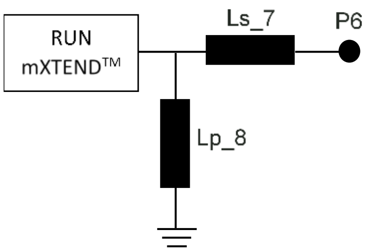
Figure 26 shows a picture of a piece of the platform used for this case, showing the pads area and ports defined in the structures included in this library file.

Just below the platform you can find the matching network, also the value and part numbers of the real components used for implementing, are below the topology.

As seen in *Figure 26*, the matching network designed formed by two components, a shunt inductance followed by a series inductance. For this case, the port used as feeding port is port 6 instead of port 1 to avoid the transmission line effect produced by the path between port 3 to port 1.

The last image in *Figure 26* represents how the components are allocated in the nine ports of the platform. The ports not containing a component, either a short-circuit or a circuit component such an inductor or a capacitor, allocate an open-circuit and are represented by an empty port in the picture to the bottom. If port 1 was chosen as feeding port, ports 5 and 3 would be short-circuited and then the corresponding path from port 7 to port 1 would have an impact on the input impedance evaluated at the feeding port 1. Allocating the components of the matching network designed as shown in the bottom picture avoids this effect. However, it does not mean that choosing port 1 as feeding port could not also be a possible implementation.





	Value	Part Number
Lp_8	2.3nH	LQW15AN2N3C10
Ls_7	3.3nH	LQW15AN3N3D10

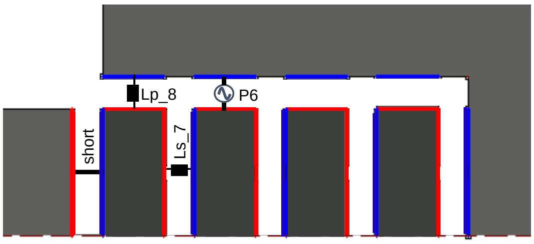


Figure 26 – Matching network designed, and its components position in the NN platform area assigned for allocating the matching network, regarding the ports defined on it.

You can find now a schematic of the [S] params representing the library file for NN_RUN_B30x30_C14x5.s9p.

This schematic is a generic representation of how to implement the matching network circuit provided for this example with a software of matching circuits design. Each software will have its particularities on how to implement those [S] block to components connections, as well as on how to implement a short and an open-circuit.

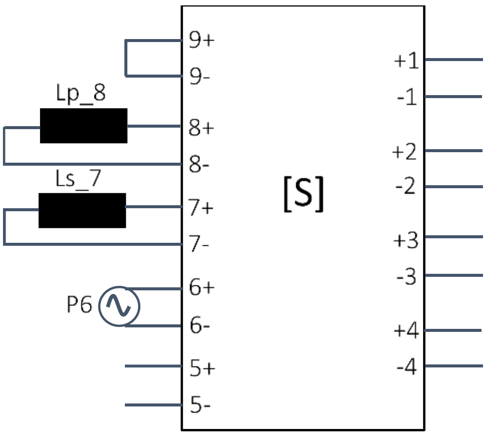


Figure 27 – [S] parameters block corresponding to the library file used, connected to the components of the matching network designed for this example.

5.2.3.3. STEP 3: RESULTS

In the following graph (*Figure 28*) you can find the input reflection coefficient obtained. The design is matched below -7dB in the frequency range going from 2.4 GHz to 2.5 GHz.

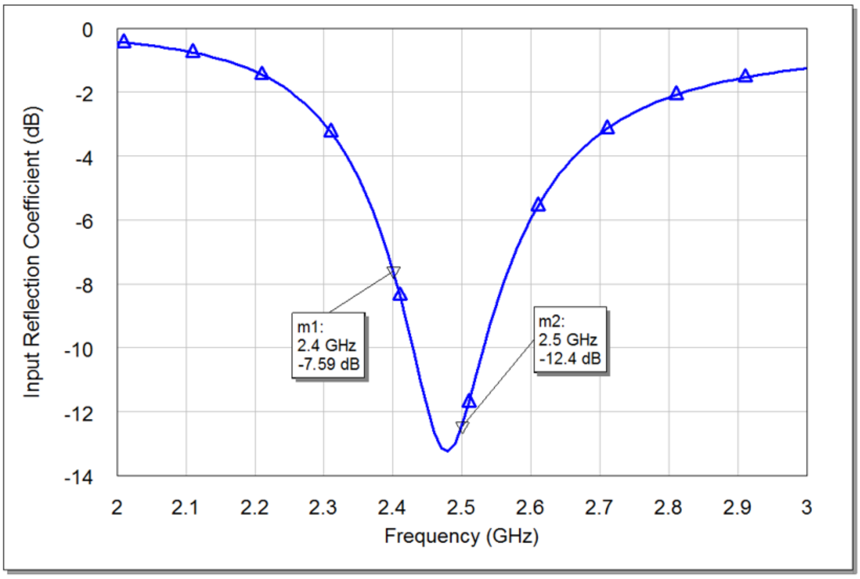


Figure 28 – Input reflection coefficient related to the ISM/wearables example here provided.

5.3. TRIO LIBRARY FILES

5.3.1. MOBILE – SMART METER

5.3.1.1. STEP 1: LIBRARY FILE SELECTION

Let´s say you have a new project and you need to design a new smart meter application module within a frequency range from 824 MHz to 960 MHz and/or from 1.71 GHz to 2.17 GHz. You also know the platform used is featuring a 114 x 52 mm^2 board with a clearance of 52 x 13 mm^2.

The information above is the only data you need to choose the most suitable library file. Use Table 2 to see available files and you must choose the one closer in specs to your specific project.

In this case the library file will be NN_TRIO_B110x50_C50x12.s5p. The antenna is a TRIO mXTEND™ (see section 2 of this manual) placed at the corner of the PCB. You can find how to get the library file you need at section 1.2.

5.3.1.2. STEP 2: MATCHING NETWORK IMPLEMENTATION

Now you can implement for the platform previously chosen, a suitable matching network with your preferred circuit design software. *Figure 29* provides a zoom of the corner of the PCB where the antenna component is placed, showing the feeding areas (red dashed squares) and how the antenna component is connected to them. The feeding areas are in this case composed of just 1-port, as seen in *Figure 29*, and they are connected to the antenna component by means of a straight feeding line of 1mm width. As seen in the same picture, three other ports are included for having the possibility of allocating circuit components at those points for configuring the design.

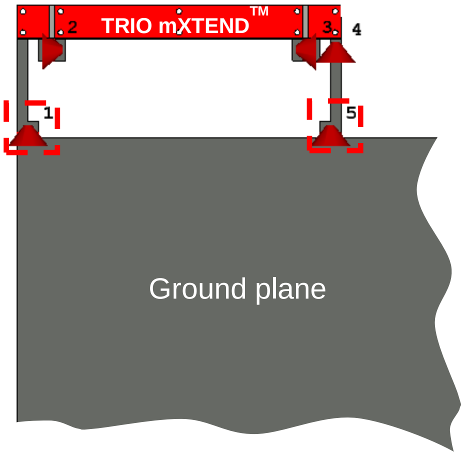
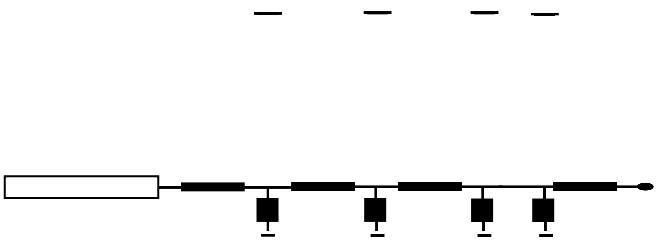


Figure 29 – Zoom of the antenna component showing the ports implemented in the TRIO platform used in the example here provided for modeling a mobile/smart meter device.

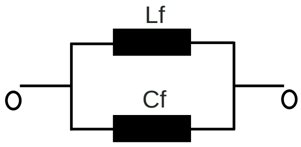
The matching networks designed for matching this example are provided in *Figure 30.* The 7 components matching network is allocated in the feeding area port 1 of the platform as shown below in *Figure 30*. The matching circuit composed of 2 components is allocated at the port 2. The value and part numbers of the real components used for implementing them are specified in the tables next to the network topologies. The bottom image in *Figure 30* represents how these matching circuits and a feeding port P1 are allocated in the port 1 and the port 2 defined in the TRIO platform.

Port 1:



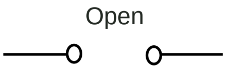
	Value	Part Number
Ls1	0nH	--
Lp1	6.4nH	LQW15AN6N4G80
Cs1	3.0pF	GJM1555C1H3R0WB01
Cp1	1.7pF	GJM1555C1H1R7WB01
Lp2	5.2nH	LQW15AN5N2G80
Cp2	0.7pF	GJM1555C1HR70WB01
Ls2	1.6nH	LQW15AN1N6C80

Port 2:

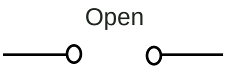


	Value	Part Number
Lf	11nH	LQW18AN11NG80
Cf	0.9pF	GJM1555C1HR90WB01

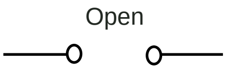
Port 3:



Port 4:



Port 5:



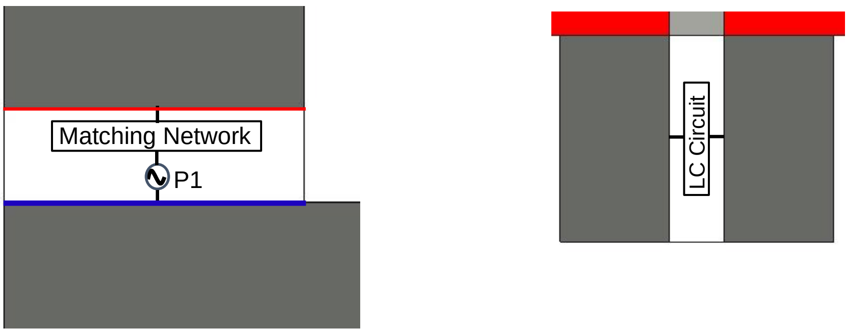


Figure 30 – Matching network designed along with the values and the part numbers of the real components used for implementing it. Below to the left: an image of the single port feeding area 1 of the TRIO platform used in this example, allocating a matching network and a feeding port P1. Below to the right: an image of the port 2 allocating its corresponding matching network.

Here you are a schematic of the [S] params representing the 5-port library file used for this example, the NN_TRIO_B110x50_C50x12.s5p file, and how the matching network circuits provided above for this example are connected to the [S] params schematic representing the library file.

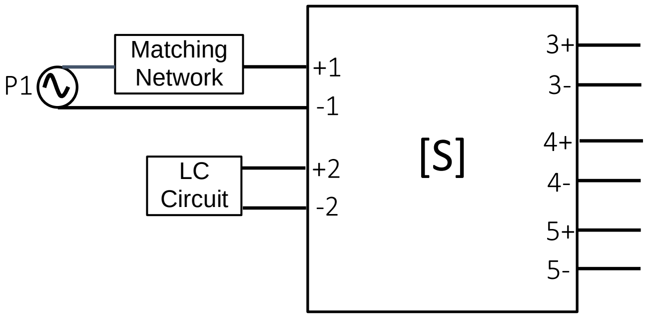


Figure 31 – An [S]-parameters representation corresponding to the 5-port library file used for this example, connected to generic matching networks representing the matching networks designed for the example and provided in *Figure 30*.

After designing the matching networks in your circuit design software, you can plot the reflection coefficient obtained.

5.3.1.3. STEP 3: RESULTS

The input matching obtained with the matching network designed above is shown in the following *Figure 7*. It shows the input reflection coefficient for this mobile/smart meter example. The design is matched below -6.5dB in the frequency bands of interest, ranging from 824MHz to 960MHz and from 1.71GHz to 2.17GHz.

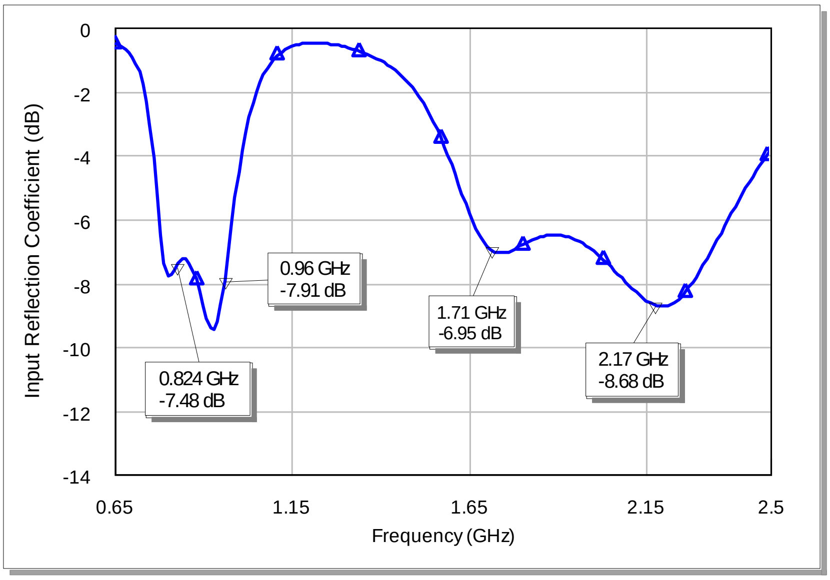


Figure 32 – Input reflection coefficient related to the mobile/smart meter example here provided.

5.3.2. MOBILE & GNSS – FLEET MANAGEMENT

5.3.2.1. STEP 1: LIBRARY FILE SELECTION

Imagine you need to design the antenna for a new fleet management application module and you need connectivity within a frequency range going from 824 MHz to 960 MHz and/or from 1.71 GHz to 2.17 GHz (mobile frequencies), and from 1.561GHz to 1.606GHz (GNSS frequencies). The module features a 115 x 50 mm^2 board with a clearance of 50 x 13 mm^2.

The information above is the only data you need to choose the most suitable library file. Use Table 2 to see available files and you must choose the one closer in specs to your specific project.

The corresponding library file providing the [S] params related to this platform is the NN_TRIO_B110x50_C50x12.s5p. The TRIO mXTEND™ antenna component (see section **¡Error! No se encuentra el origen de la referencia.** of this manual) is then chosen and it is placed at the corner of the PCB. The TRIO mXTEND™ is connected to the feeding areas, where the matching networks are allocated, by straight feeding lines of 1mm width as it is seen in picture from *Figure 33*. You can find how to get the library file you need at section 1.2.

5.3.2.2. STEP 2: MATCHING NETWORK IMPLEMENTATION

Once you have chosen the platform for the fleet management example you can implement a matching network with your preferred circuit design software. *Figure 33* provides a zoom of the feeding areas (red dashed squares) and the corner of the PCB where the antenna component is placed, showing how the antenna component is connected to the feeding areas. The feeding areas are in this case composed of just 1-port, as seen in *Figure 33*, and they are connected to the antenna component by means of straight feeding lines of 1mm width.

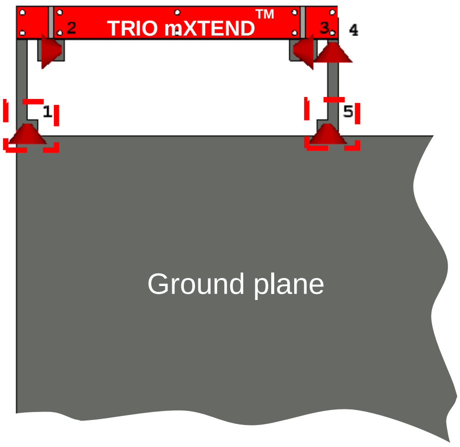
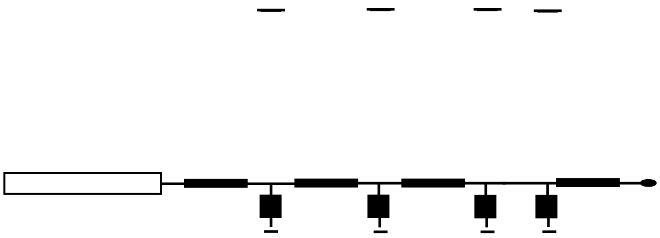


Figure 33 – Zoom of the antenna component showing the ports and the feeding areas of the TRIO platform used in the fleet management example here provided.

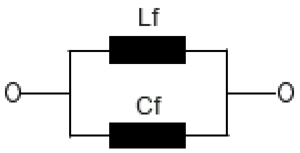
The matching networks designed for matching this example are provided in *Figure 34*, and they are allocated in the feeding area ports 1 and 5 of the platform, and which correspond to the feeding ports P1 and P2 respectively, as shown below in *Figure 34*. Two more matching circuits are necessary for adapting this two-port solution. Their topologies are also provided in *Figure 34*. The value and part numbers of the real components used for implementing them are specified in the table next to the network topology. The bottom image in *Figure 34* represents how these matching circuits and a feeding ports are allocated in the ports defined in the TRIO platform.

Port 1:



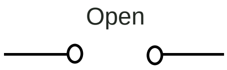
	Value	Part Number
Ls1	3.0nH	LQW15AN3N0G80
Lp1	5.4nH	LQW15AN5N4G80
Cs1	3.1pF	GJM1555C1H3R1WB01
Cp1	1.8pF	GJM1555C1H1R8WB01
Lp2	4.1nH	LQW15AN4N1G80
Cp2	1.3pF	GJM1555C1H1R3WB01
Ls2	0nH	--

Port 2:

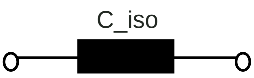


	Value	Part Number
Lf	4.5nH	LQW15AN4N5G80
Cf	1.7pF	GJM1555C1H1R7WB01

Port 3:

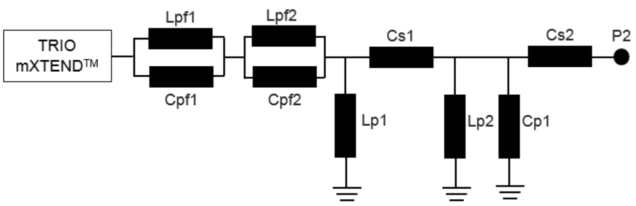


Port 4:



	Value	Part Number
C_iso	0.1pF	GJM1555C1HR10WB01

Port 5:



	Value	Part Number
Lpf1	0nH	--
Cpf1	--	--
Lpf2	2.5nH	LQW15AN2N5G80
Cpf2	1.9pF	GJM1555C1H1R9WB01
Lp1	13nH	LQW18AN13NG80
Cs1	0.3pF	GJM1555C1HR30WB01
Lp2	4.0nH	LQW15AN4N0G80
Cp1	2.0pF	GJM1555C1H2R0WB01
Cs2	1.4pF	GJM1555C1H1R4WB01

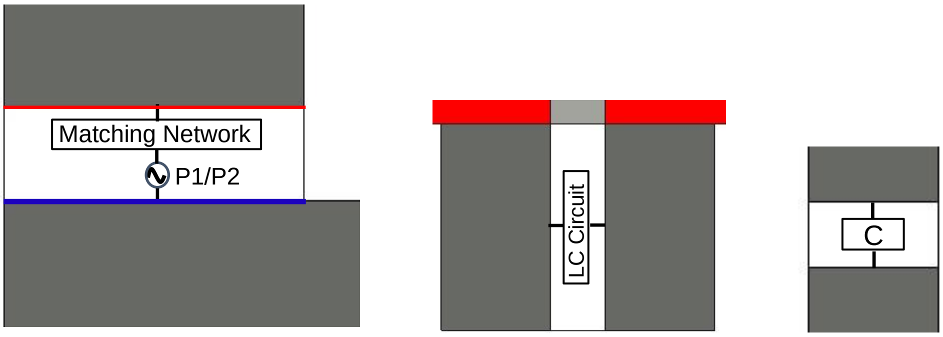


Figure 34 – Matching network designed along with the values and the part numbers of the real components used for implementing it. Below to the left: an image of the single port feeding areas 1 (P1) or 5 (P2) of the TRIO platform used in this example, allocating a matching network and a feeding port. Below in the center: an image of the port 2 allocating the LC circuit provided above. Below to the right: an image of the port 4 allocating a component, more concretely a capacitor.

Here you are a schematic of the [S] params representing the 5-port library file used for this example, the NN_TRIO_B110x50_C50x12.s5p file, and how the matching network circuits provided above for this example are connected to the [S] params schematic representing the library file.

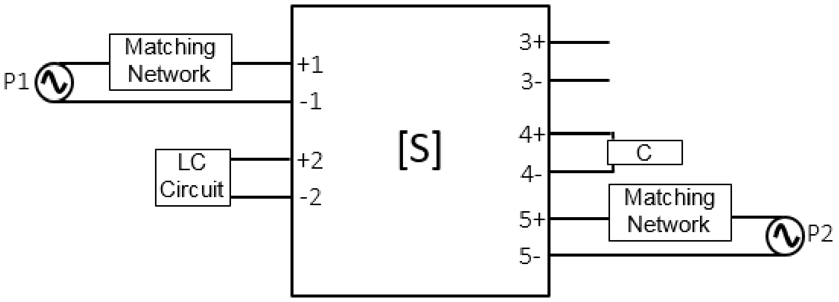


Figure 35 – An [S]-parameters representation corresponding to the 5-port library file used for this example, connected to generic matching networks representing the matching networks designed for the example and provided in *Figure 34*.

After designing the matching networks in your circuit design software, you can plot the reflection coefficient obtained.

5.3.2.3. STEP 3: RESULTS

The matching performance resulting from using the matching networks (*Figure 34*) proposed in the previous section 5.1.2.2. is shown in the following *Figure 36*. It shows the input reflection coefficient for this fleet management example. The design is matched below -6dB in the frequency bands of interest, ranging from 824MHz to 960MHz, from 1.71GHz to 2.17GHz and from 1.561GHz to 1.606GHz.

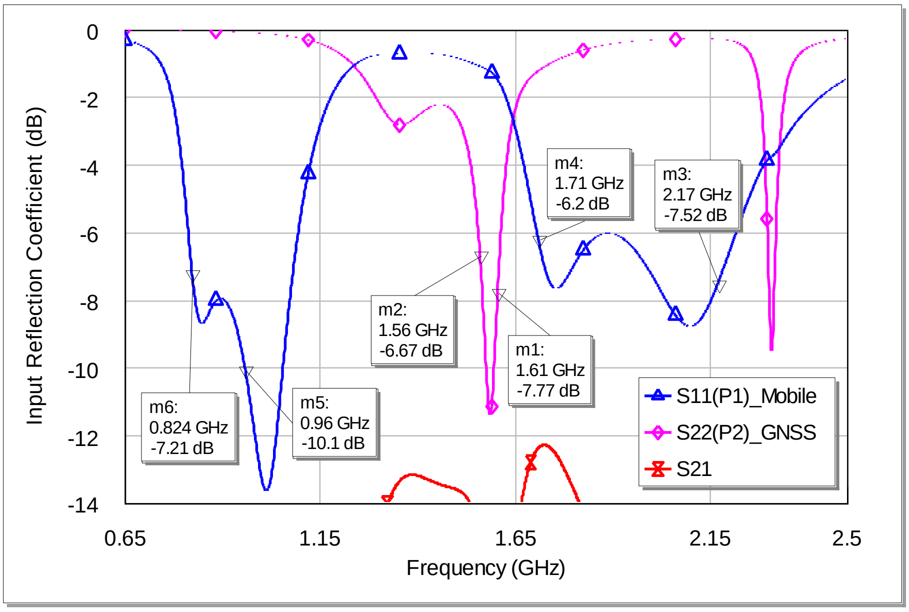


Figure 36 – Input reflection coefficient related to the fleet management example here provided.

5.3.3. MOBILE & GPS – IoT SMART TRACKING

5.3.3.1. STEP 1: LIBRARY FILE SELECTION

If you need to cover Mobile & GPS bands operating within the 698 MHz to 960 MHz range in combination with GPS, here you are the example. This might be the case for instance of an IoT smart tracking device. In this example, the platform used features a 52 x 50 mm^2 board with a clearance of 50 x 12 mm^2.

The information above is the only data you need to choose the most suitable library file. Use Table 2 to see available files and you must choose the one closer in specs to your specific project.

In this case the library file you need to choose is NN_TRIO_B50x50_C50x12.s5p, the closest to your real situation. You can find how to get the library file you need at section 1.2.

5.3.3.2. STEP 2: MATCHING NETWORK IMPLEMENTATION

Once you have chosen the suitable platform for this smart tracking example you can implement a matching network with your preferred circuit design software. *Figure 37* provides a zoom of the corner of the PCB showing the feeding areas (red dashed squares) and how the antenna component is connected to them. The feeding areas are composed of just 1-port, as seen in *Figure 37*, and they are connected to the antenna component by means of a straight feeding line of 1mm width.

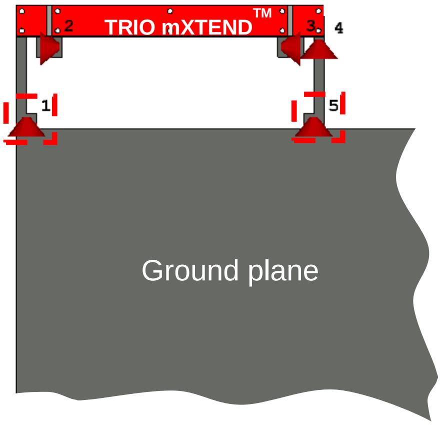
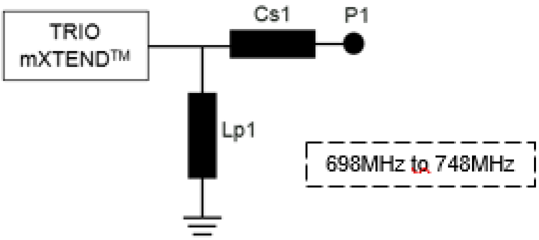


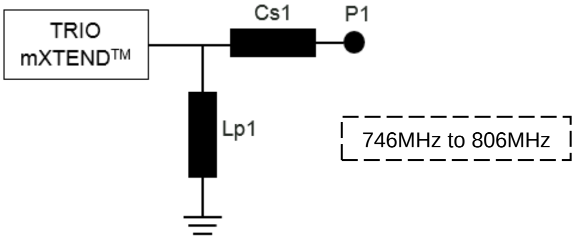
Figure 37 – Zoom of the antenna component showing the feeding areas of the TRIO platform used in the smart tracking example here provided.

The matching network designed for matching this platform is a reconfigurable matching controlled by switches. Different matching networks are implemented for covering sub-ranges in the frequency range going from 698 MHz to 960 MHz, those sub-ranges being 698MHz to 748MHz, 746MHz to 803MHz, 791MHz to 849MHz, 824MHz to 894MHz and 880MHz to 960MHz. Also GPS band is covered. *Figure 38* provides some of those matching networks indicating the frequency sub-range they cover. The value and part numbers of the real components used for implementing them are specified in the table next to the network topology.

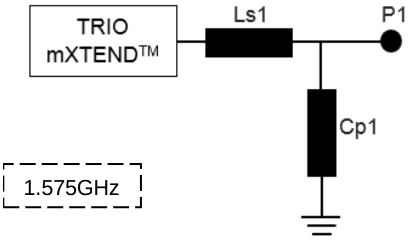
Port 1:



	Value	Part Number
Lp1	12nH	LQW18AN12NG80
Cs1	1.8pF	GJM1555C1H1R8WB01

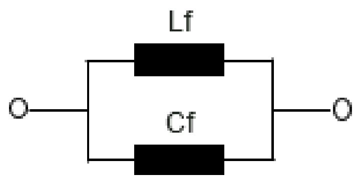


	Value	Part Number
Lp1	9.2nH	LQW15AN9N2G80
Cs1	2.3pF	GJM1555C1H2R3WB01



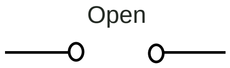
	Value	Part Number
Ls1	9.0nH	LQW15AN9N0G80
Cp1	2.9pF	GJM1555C1H2R9WB01

Port 2:

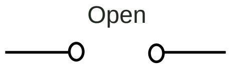


	Value	Part Number
Lf	15nH	LQW18AN15NG80
Cf	0.3pF	GJM1555C1HR30WB01

Port 3:



Port 4:



Port 5:

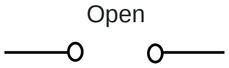


Figure 38 – Matching networks designed along with the values and the part numbers of the real components used for implementing them.

Here you are a schematic of the [S] params representing a TRIO library file used for this example, the NN_TRIO_B50x50_C50x12.s5p file, and how the matching network circuit, including switches, for this example is connected to the [S] params schematic representing the library file.

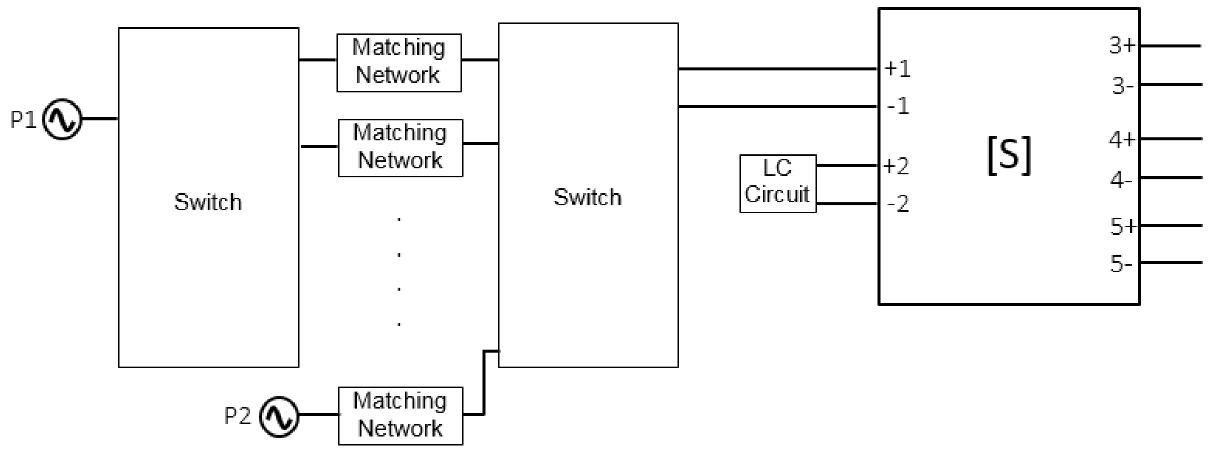


Figure 39 – An [S]-parameters representation corresponding to a TRIO library file used for this example, connected to the matching network circuit designed for the example.

After designing the matching network in your circuit design software, you can plot the reflection coefficient obtained. The insertion losses of the switches used have been taken into account for obtaining this result.

5.3.3.3. STEP 3: RESULTS

The matching performance resulting from using the matching networks proposed in the previous section 5.3.3.2. is shown in the following *Figure 40*. It shows the input reflection coefficients for this smart tracking example. The design is matched below -6dB in the frequency sub-bands of interest, sub-bands within the range going from 824 MHz to 960 MHz and the GPS band at 1.575 GHz frequency.

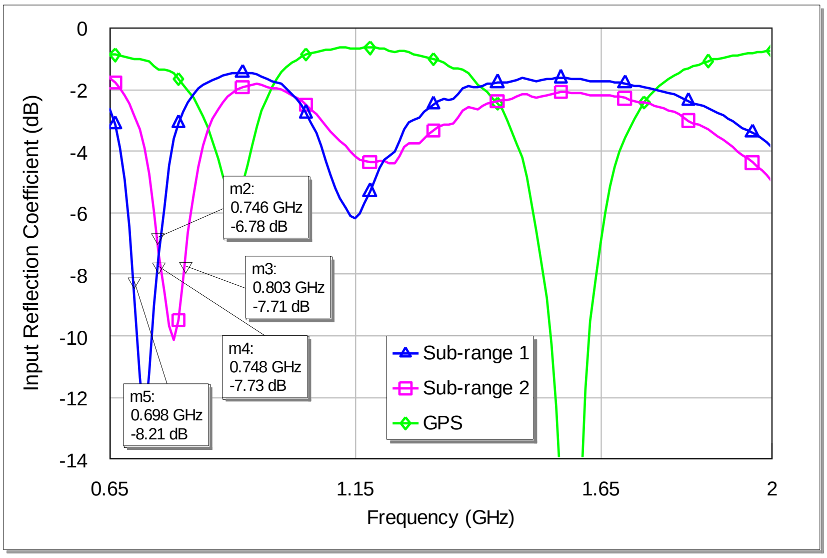


Figure 40 – Input reflection coefficients related to the smart tracking example here provided.

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Ignion is an ISO 9001:2015 certified company. All our antennas are lead-free and RoHS compliant.

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