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# **NN Design Hub: NN Librarie[S] for Cadence-AWR Microwave Office**

USER MANUAL  
NN Librarie[S]

## NN Design Hub: NN Librarie[S] for Cadence-AWR Microwave Office



Here you are the NN Librarie[S], the new design tool by Ignion (NN) that helps you design the antenna for your wireless device. Just select your PCB size and the mXTEND™ antenna type, download the library file from our website and import it into the Cadence-AWR Microwave Office software, or take it and use it directly from the Cadence-AWR Microwave Office, which also includes the NN Librarie[S].

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.

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# 1. WHAT IS A LIBRARY FILE?

## 1.1. LIBRARY FILE DEFINITION

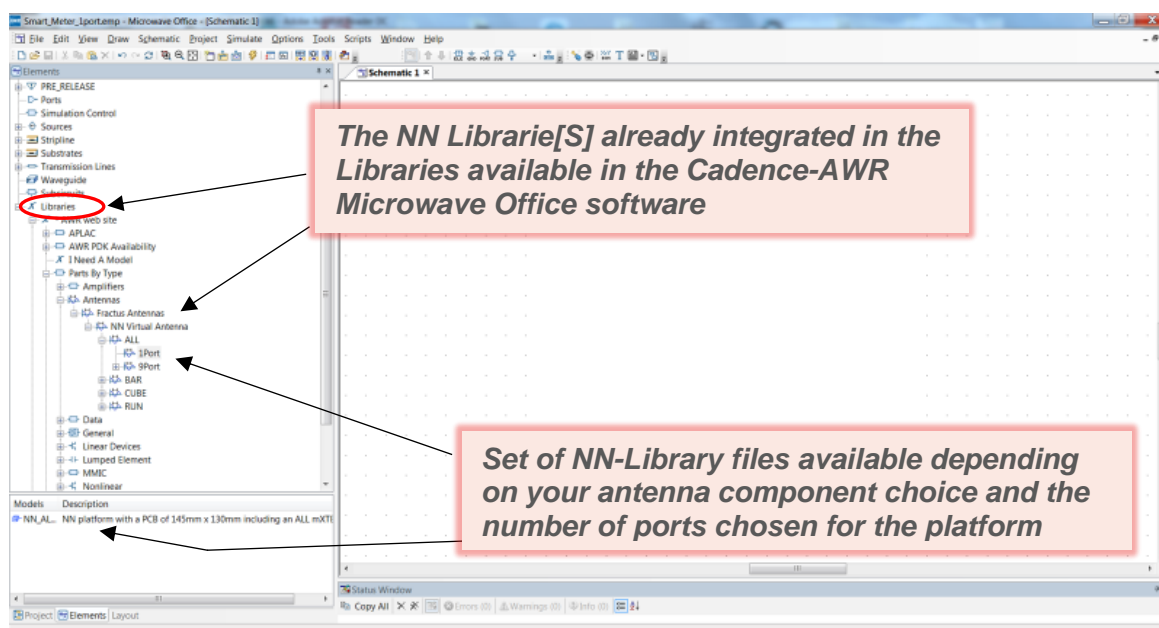
The new tool, NN Librarie[S], provides a collection of [S]-parameter files for every specific mXTEND™ antenna component (i.e., a Virtual Antenna™ component) as mounted on a variety of wireless platforms with different form factors and printed circuit board (PCB) sizes. Each library file is associated 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 using (if already available in your Cadence-AWR Microwave Office version) or uploading the corresponding library file into the Cadence-AWR Microwave Office 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 USE A LIBRARY FILE IN Cadence-AWR MICROWAVE OFFICE

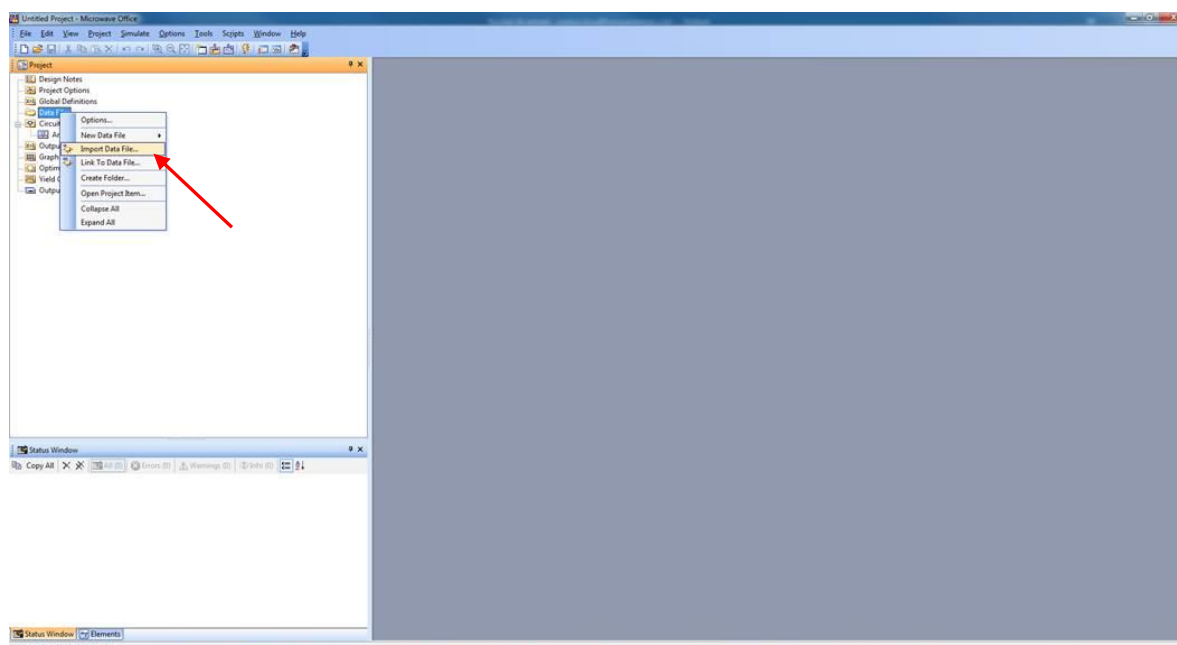
You have two possible ways of using an NN-library file in the Cadence-AWR Microwave Office software:

- directly from the NN Librarie[S] available in the Cadence-AWR Microwave Office (check availability in function of the version)
- downloading the library file or files you need from the Ignion [web](#) included in the .zip pack available for Cadence-AWR Microwave Office

If the NN Librarie[S] is available in your Cadence-AWR Microwave Office version, you should find the library files already integrated in the Libraries components at the Elements tab of the Cadence-AWR Microwave Office software (as shown in the image below). So far, only the 1-port and the 9-port library files are available directly in the Cadence-AWR Microwave Office.



If the Cadence-AWR Microwave Office version you use does not already integrate the NN Librarie[S], you can quickly and easily download the library files you need, or all of them, from the [web](#), by downloading the pack for the use of the NN Librarie[S] with the Cadence-AWR Microwave Office software. This pack is a .zip file that contains 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 import them into the Cadence-AWR Microwave Office software like any other .sp file, as shown in the image below.



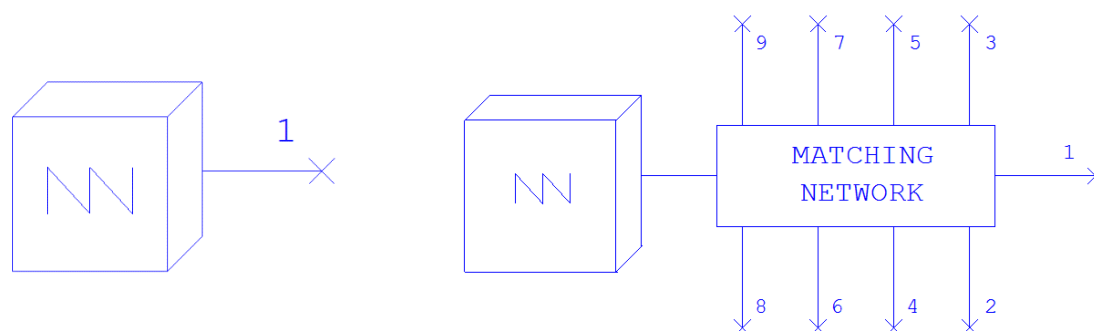
Once chosen the NN-library file you need (see section 3) and imported in the Cadence-AWR Microwave Office, you can readily implement a matching network to match the device to its frequency or frequencies of operation and then complete the whole antenna integration work. In Section 5.1.1.2 you can find the steps to follow for implementing your matching network with the Network Synthesis Wizard of Cadence-AWR Microwave Office software. You can also

implement a matching network by yourself once you have dragged the library file into a Microwave Office Schematic.

## 1.3. Cadence-AWR MICROWAVE OFFICE LIBRARY FILE REPRESENTATION

### 1.3.1. LIBRARY FILES SYMBOLS IN Cadence-AWR MICROWAVE OFFICE

Two of the three sets of library files composing the NN Librarie[S] are represented in the Cadence-AWR Microwave Office software by two different symbols, particularly designed for Cadence-AWR Microwave Office. Those symbols are provided in *Figure 1*. The one to the left represents a library file contained in the set of 1-port library files. The symbol to the right represents a library file contained in the set of 9-port library files. As you can see the 1-port file symbol contains 1 port and the 9-port file symbol contains 9 ports for allocating the components of the matching network that you design to adapt the device. In the following section, it is explained how to import these symbols into the Cadence-AWR Microwave Office software installation in an easy way.



**Figure 1** – Symbols designed for representing an NN-library file of 1 port (left) and an NN-library file of 9 ports (right) in the Cadence-AWR Microwave Office.

### 1.3.2. HOW TO IMPORT THE SYMBOLS

The steps for adding the NN Librarie[S] symbols, particularly designed for use in Cadence-AWR Microwave Office are:

- Open the Cadence-AWR Microwave Office software
- Go to “Help”
- Click on “Show Files/Directories” -> a list of files and directories is opened
- Double-click on folder “Appdatauser” -> the corresponding folder is opened
- If a "Symbols" folder does not exist in the "Appdatauser" folder, just create it! If it already exists, you do not need to create it
- Finally, double-click on “Symbols” folder and add/copy here the .syf files you've received in the NN Librarie[S] pack.



Once added the Cadence-AWR Microwave Office symbols to your Cadence-AWR Microwave Office installation, your library files will be represented by the symbols shown in the previous section.

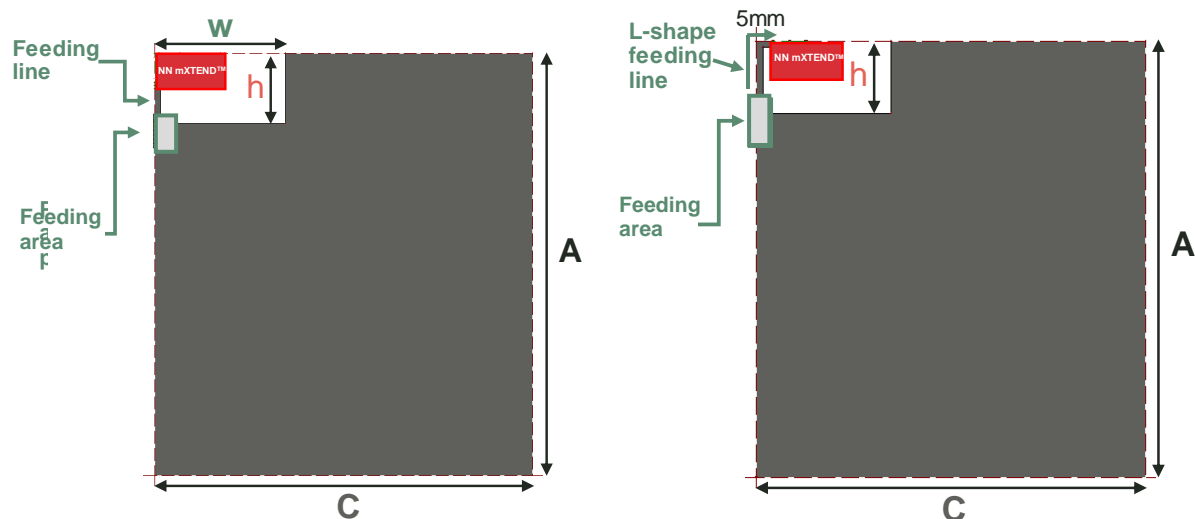
## 1.4. LIBRARY FILE PLATFORM

You can find below, in *Figure 2*, an example of a basic platform you use in any 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<sup>™</sup> antenna component (e.g. a Virtual Antenna<sup>™</sup> 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<sup>™</sup> 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 2a* or in *Figure 2b*, and in other platforms, the mXTEND<sup>™</sup> component is placed at some distance from the corner (see the platform to the right in *Figure 2a*).

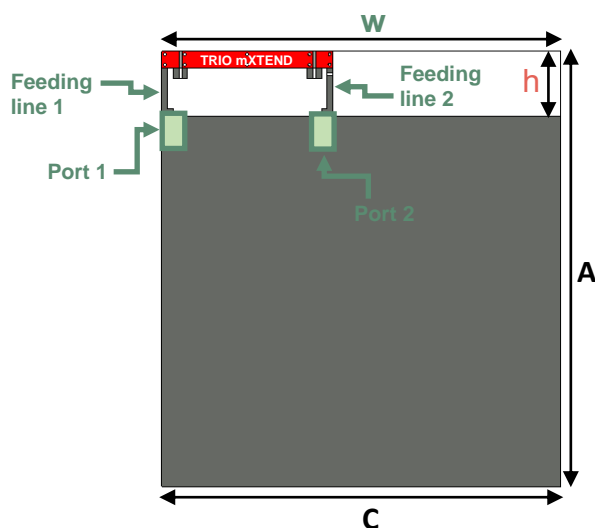
In general, the mXTEND<sup>™</sup> antenna component is connected to a matching network by a feeding line, as indicated in *Figure 2a*. This feeding line features an L-shape for the platforms where the NN mXTEND<sup>™</sup> component is not placed at the PCB corner (*Figure 2a*). The feeding line features 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<sup>™</sup> antenna component. For the case of a TRIO platform, where a TRIO mXTEND<sup>™</sup> 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<sup>™</sup> antenna component is connected in these TRIO platforms to the matching networks by those feeding lines, as indicated in *Figure 2b*, those feeding lines featuring 1mm width.

*Figure 2* also shows the dimensions of the platform, being  $A \times C$  the board dimensions and  $w \times h$  the clearance area dimensions. The mXTEND<sup>™</sup> 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<sup>™</sup> 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<sup>™</sup> antenna component.



**Figure 2a** – Example of an NN platform used for creating a library file.



**Figure 2b** – 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.

## 1.5. 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.

Library File Name				
NN	mXTEND™ Antenna Component	BAxC	Cwxh	.s*p
Ignion Logo	Antenna component name	B: Board	C: Clearance	File extension
		AxC: board dimensions	wxh: clearance dimensions	

**Table 1** – Library file name by parts.

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

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

**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™ integrated in a board of dimensions 120mm x 60mm featuring a clearance of 60mm x 11mm for allocating the CUBE mXTEND™ component.*

## 1.6. 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.*

### 1.6.1. HEADER INFORMATION

- The name of the library file.
- The name, reference and size of the mXTEND™ 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™ 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

## 1.6.2. PARAMETERS

### 1.6.2.1. 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 the 9 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  $Z=50\Omega$  (only resistance component).

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

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

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

**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.

### 1.6.2.2. 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.



```
6.500000000000000e-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
0.322334	155.985	0.699714	2.10175			

**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<sup>™</sup> ANTENNA COMPONENTS

The range of products by Ignion are named mXTEND<sup>™</sup>. Please, find below the whole range of available NN's Virtual Antenna<sup>™</sup> 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<sup>™</sup> antenna component used to create the library file names, as explained in section 1.5.



### **ALL** mXTEND<sup>™</sup>

Part number: FR01-S4-220  
Bands: 698 – 2690 MHz  
24.0 mm x 12.0 mm x 2.0 mm



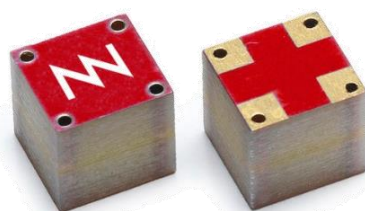
### **RUN** mXTEND<sup>™</sup>

Part number: FR01-S4-224  
Bands: 698 – 3800 MHz  
12.0 mm x 3.0 mm x 2.4 mm



### **BAR** mXTEND<sup>™</sup>

Part number: FR01-S4-232  
Bands: 698 – 2690 MHz  
10.0 mm x 3.2 mm x 3.2 mm



### **CUBE** mXTEND<sup>™</sup>

Part number: FR01-S4-250  
Bands: 698 – 2690 MHz  
5.0 mm x 5.0 mm x 5.0 mm



### **TRIO** mXTEND<sup>™</sup>

Part Number: FR01-S4-210  
Bands: 698 – 2690 MHz  
30.0 mm x 3.0 mm x 1.0 mm

**Figure 3** – NN mXTEND<sup>™</sup> 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 designed with the Cadence-AWR Microwave Office 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 <sup>2</sup>	Clearance Size wxh mm <sup>2</sup>	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

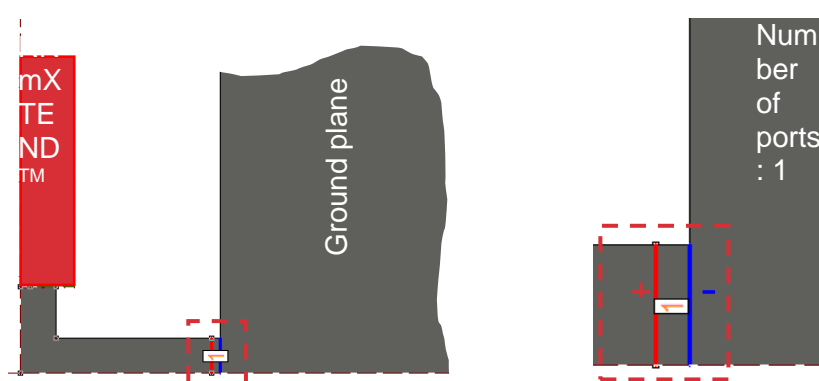
				NN_CUBE_B120x60_C60x11.s9p
	CUBE	105x45	45x11	NN_CUBE_B105x45_C45x11.s1p NN_CUBE_B105x45_C45x11.s9p
	CUBE	70x40	40x11	NN_CUBE_B70x40_C40x11.s1p NN_CUBE_B70x40_C40x11.s9p
IoT	RUN	90x90	90x11	NN_RUN_B90x90_C90x11.s1p NN_RUN_B90x90_C90x11.s9p
	RUN	90x70	70x11	NN_RUN_B90x70_C70x11.s1p NN_RUN_B90x70_C70x11.s9p
	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

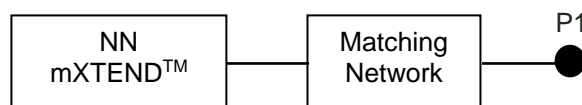
### 4.1. ONE-PORT LIBRARY FILES

The ports configuration used for implementing the feeding area of a platform related to a 1-port library file is shown below (*Figure 4*). 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<sup>™</sup> antenna component and the platform ground plane.



**Figure 4** – 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 5*. Any matching network topology can be designed within this port configuration.



**Figure 5** – Generic matching network allocated in the port defined in an NN platform with a feeding area composed of just 1 port.

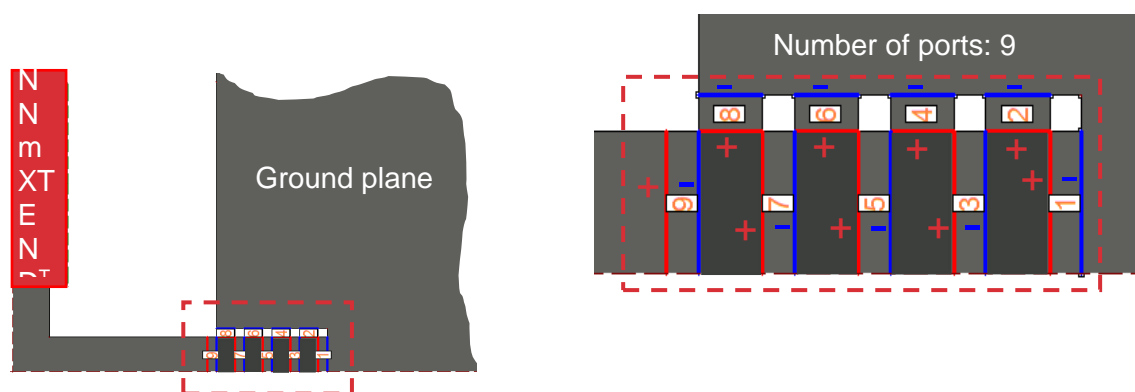
## 4.2. NINE-PORT LIBRARY FILES

The pads and ports configuration related to a platform of this library is shown as below (*Figure 6*). 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  $1 \times 2 \text{ mm}^2$  and they are spaced apart by a gap of  $0.5 \text{ mm}$ . 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 6*.

Particularly, port 9 is defined between a pad and a feeding line that is connected in its end to the mXTEND<sup>TM</sup> 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.

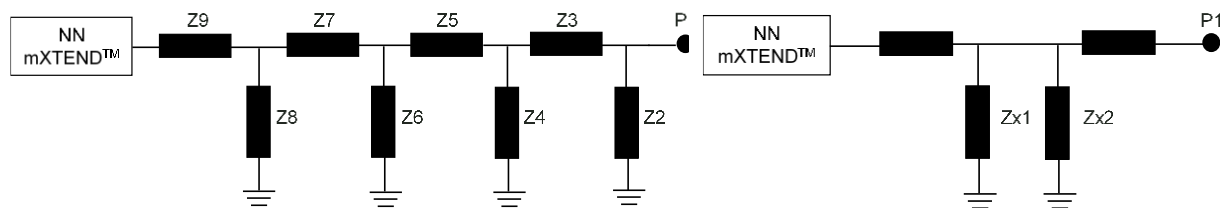
In section 5 of this document you can find some examples where you can check that if the matching network designed requires components in all or most of the ports, port 1 will be the feeding port. If the matching network implemented does not require components in all the ports, the feeding port can be 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 6** – NN platform pads and ports defined.

The matching network topology (*Figure 7*) 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  $Z_1$  at port 1 before closing the port with a feeding port. It is also worth noticing that two components arranged in a

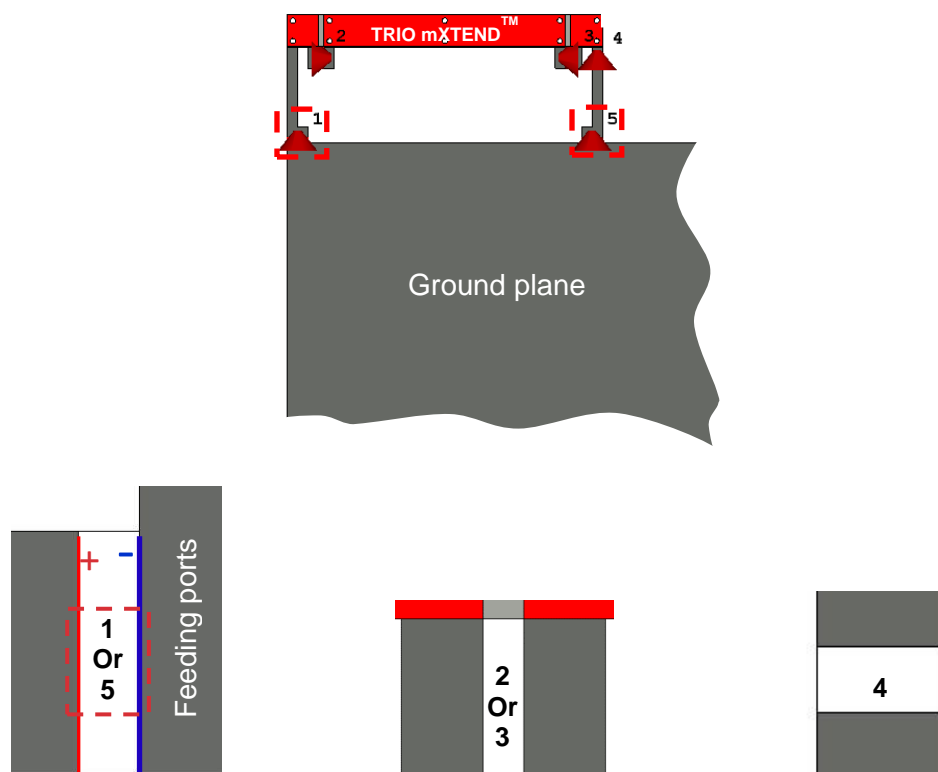
shunt configuration can also be used in a same port X, this configuration is shown in the right topology example from *Figure 7*.



**Figure 7** – 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 8). 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<sup>™</sup> 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 8.



**Figure 8 – TRIO platform ports configuration**

## **5. HOW TO USE A LIBRARY FILE IN Cadence-AWR MICROWAVE OFFICE: 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<sup>2</sup> board with a clearance of 45 x 25 mm<sup>2</sup>.

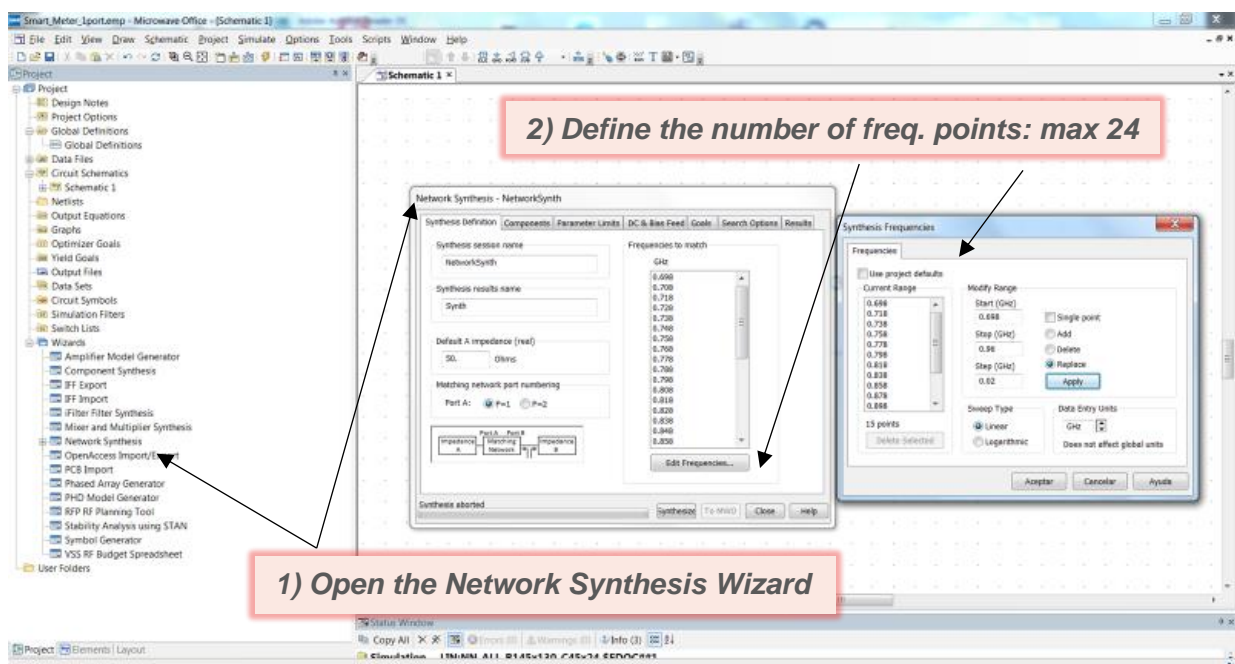
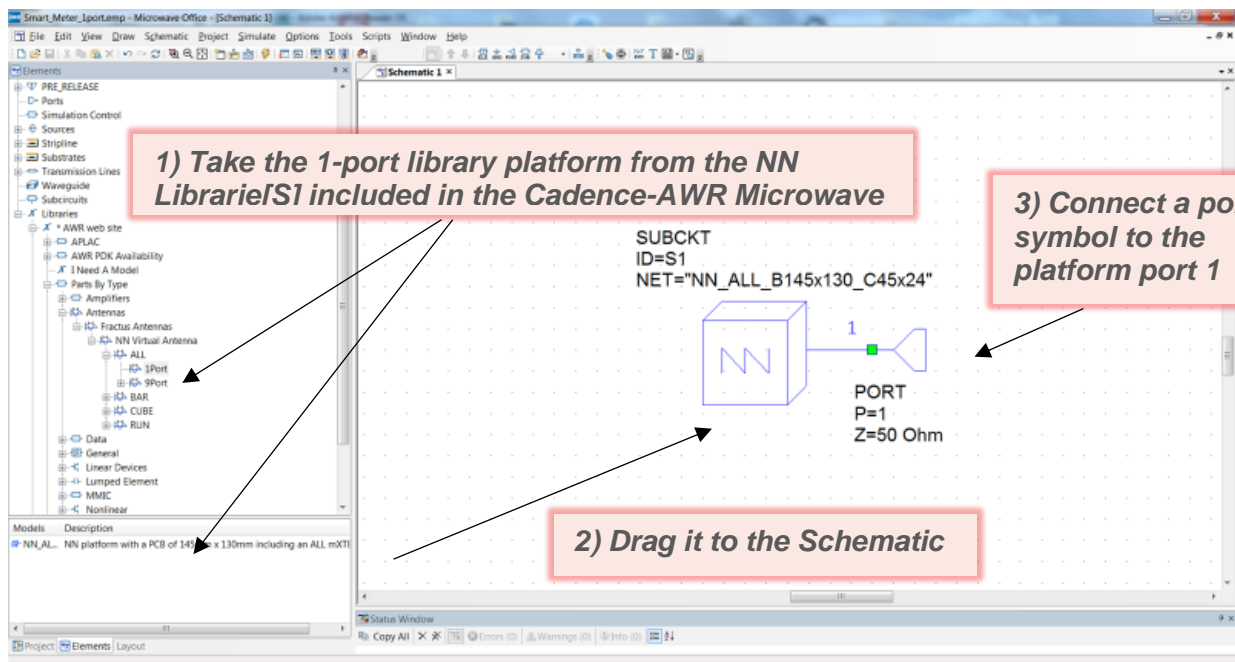
The information above is the only data you need to choose the most suitable library file. Use Table 2 to see available files and you must choose the one closer in specs to your specific project.

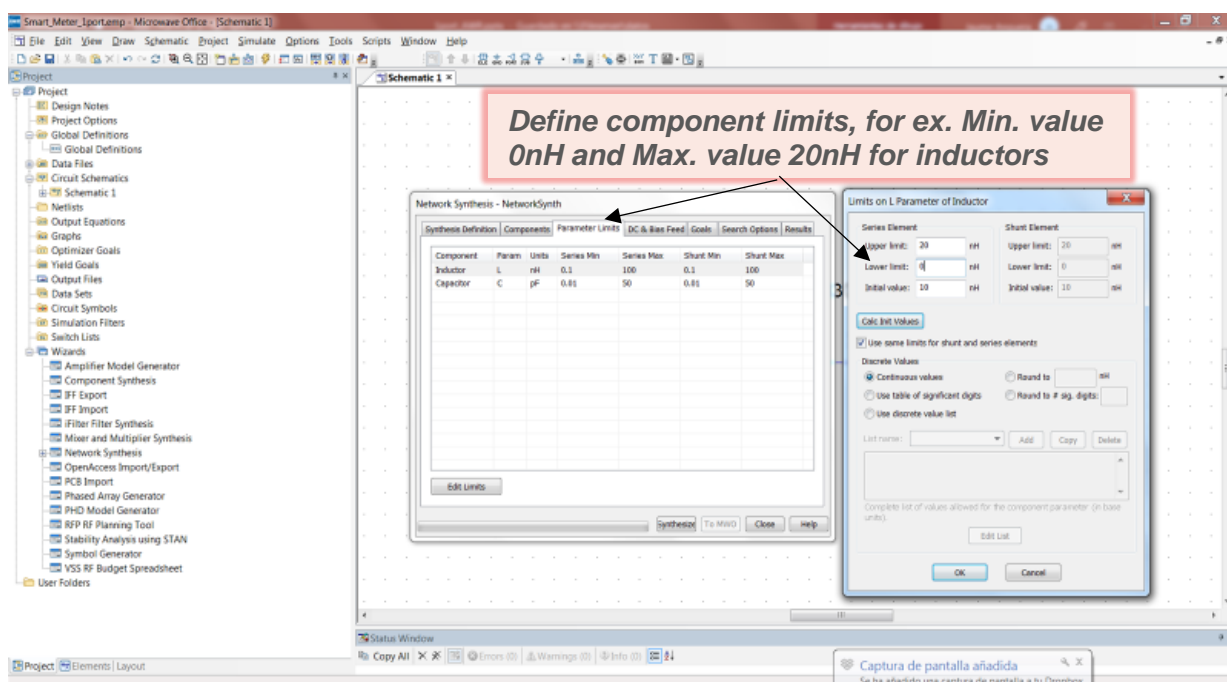
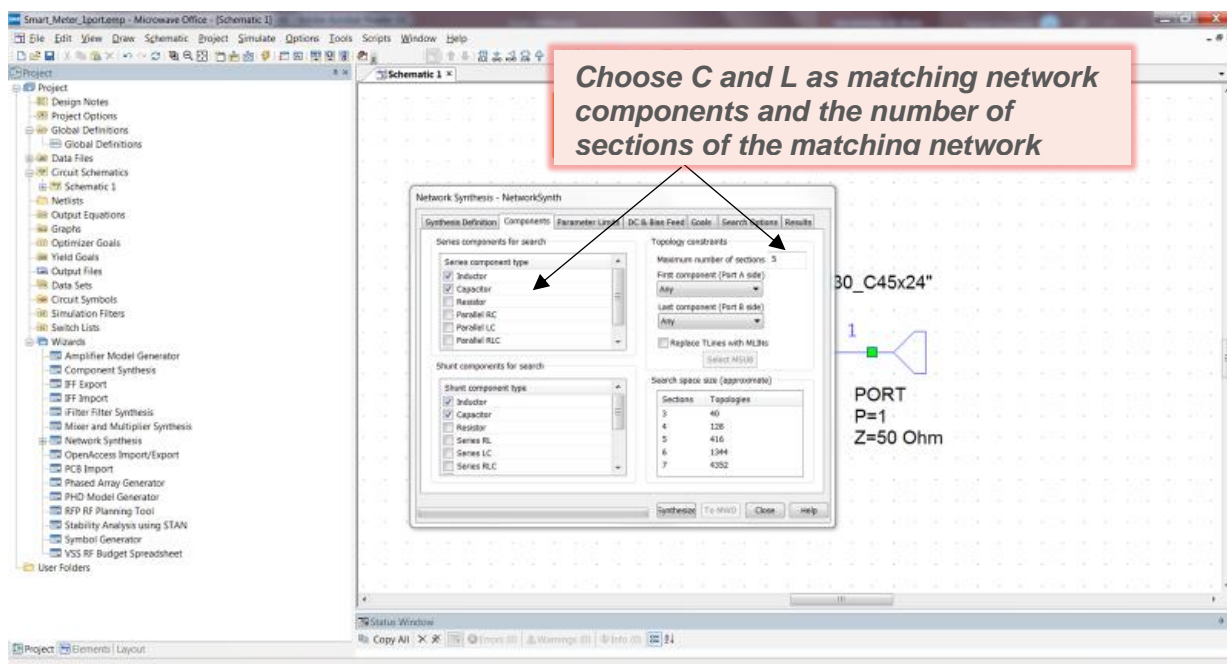
In this case the 1-port library file will be NN\_ALL\_B145x130\_C45x24.s1p. The antenna is an ALL mXTEND™ (see section 2 of this manual) placed at the corner of the PCB. You can find how to get the library file you need at section 1.2.

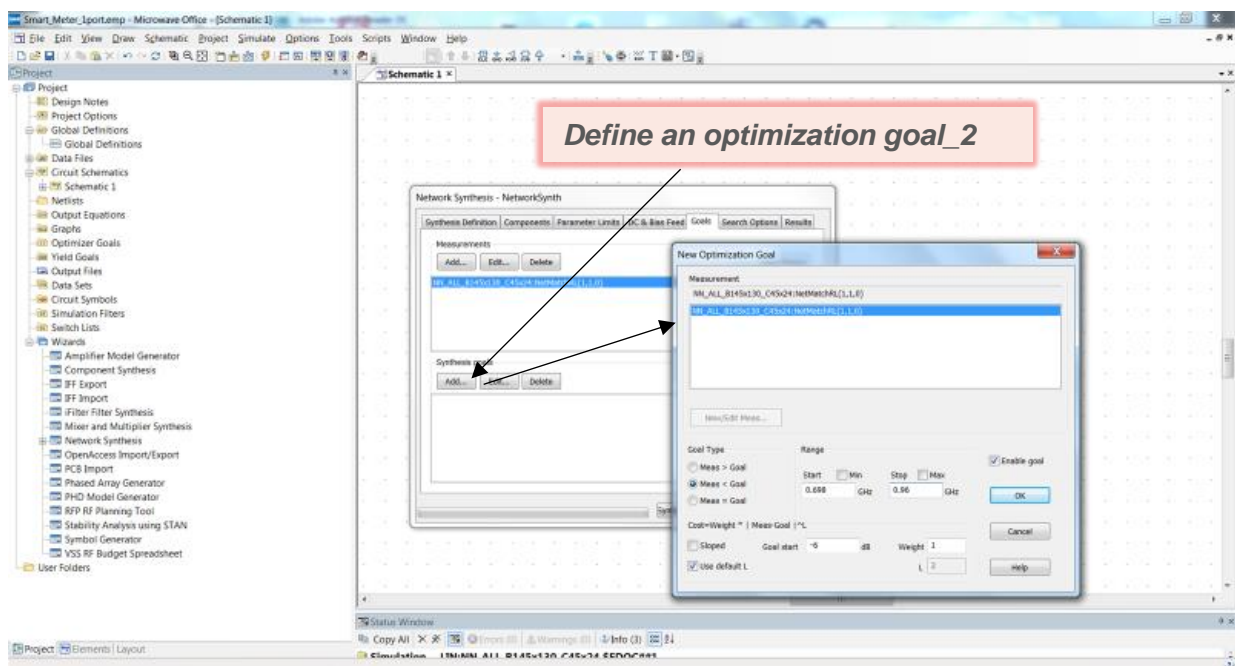
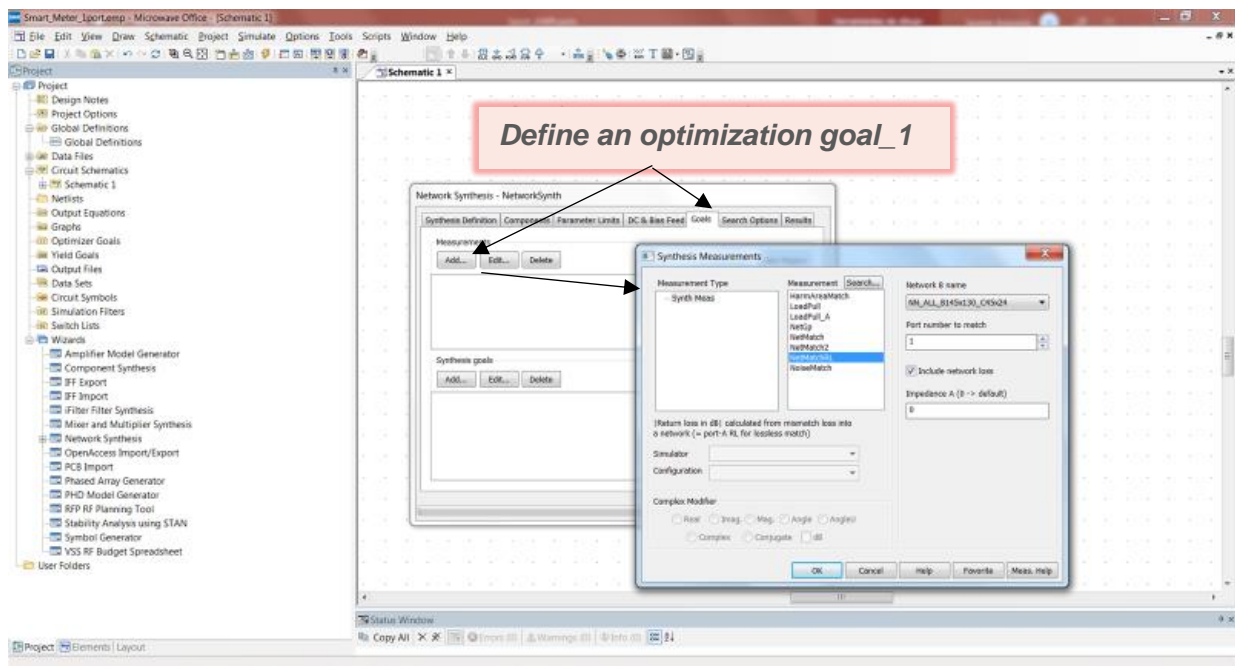
##### **5.1.1.2. STEP 2: MATCHING NETWORK IMPLEMENTATION**

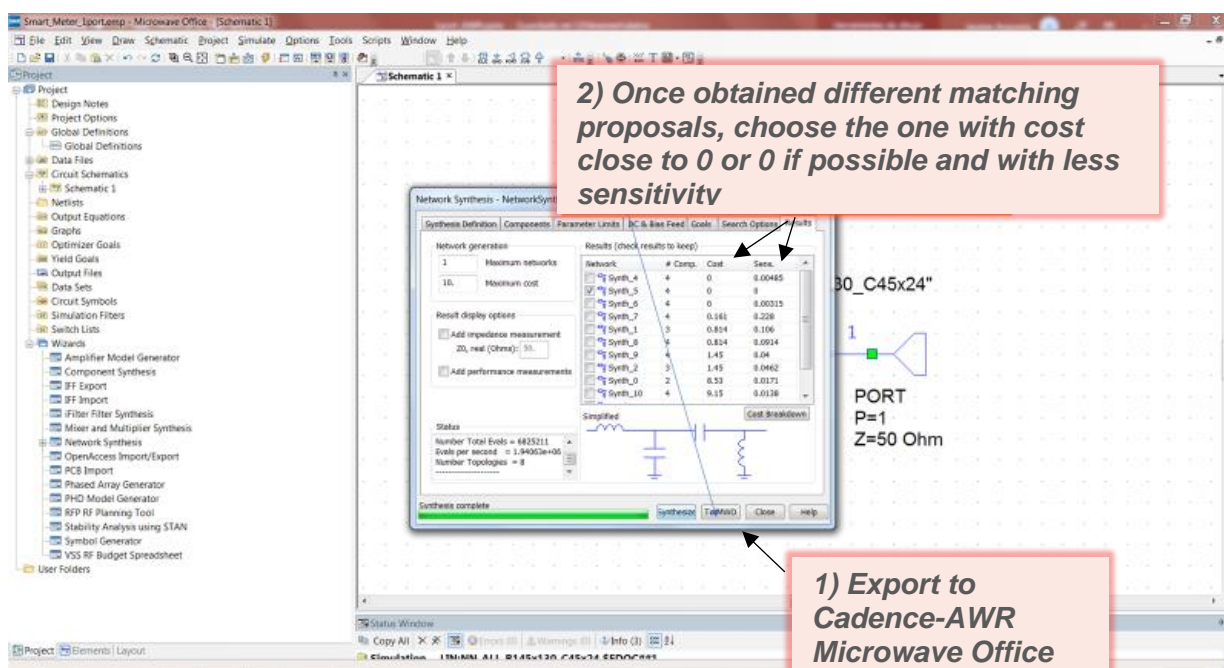
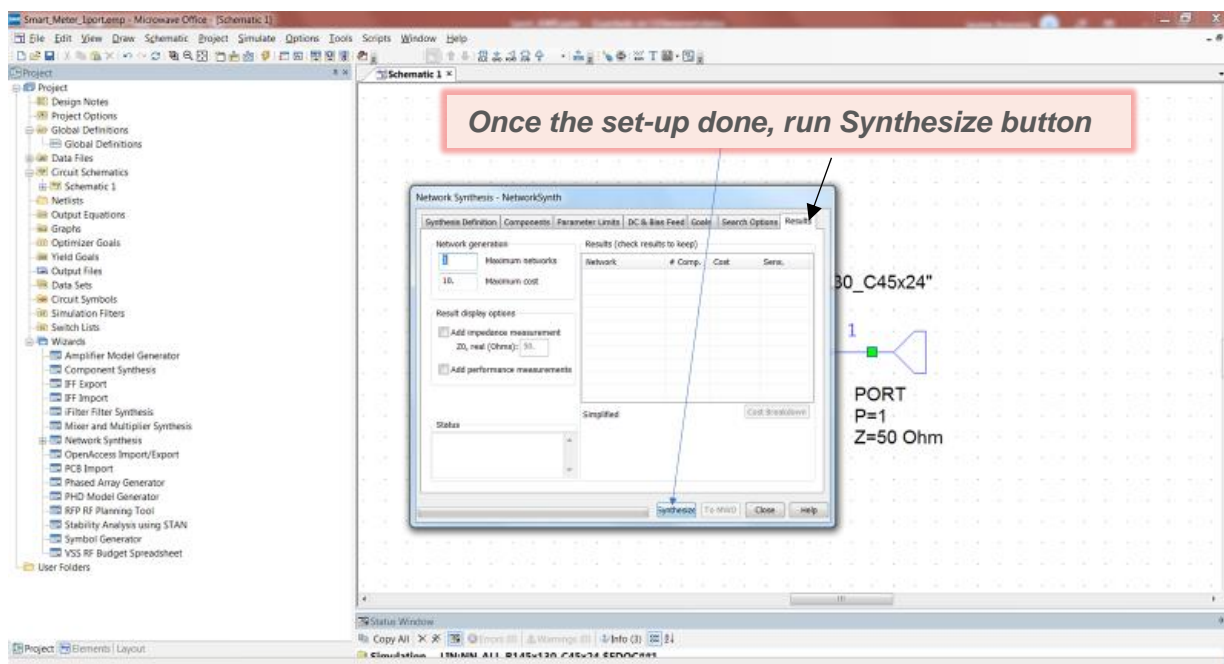
The Network Synthesis Wizard of the Cadence-AWR Microwave Office software can be used for implementing a suitable matching network for the platform previously chosen. Below, you'll find the steps to follow.

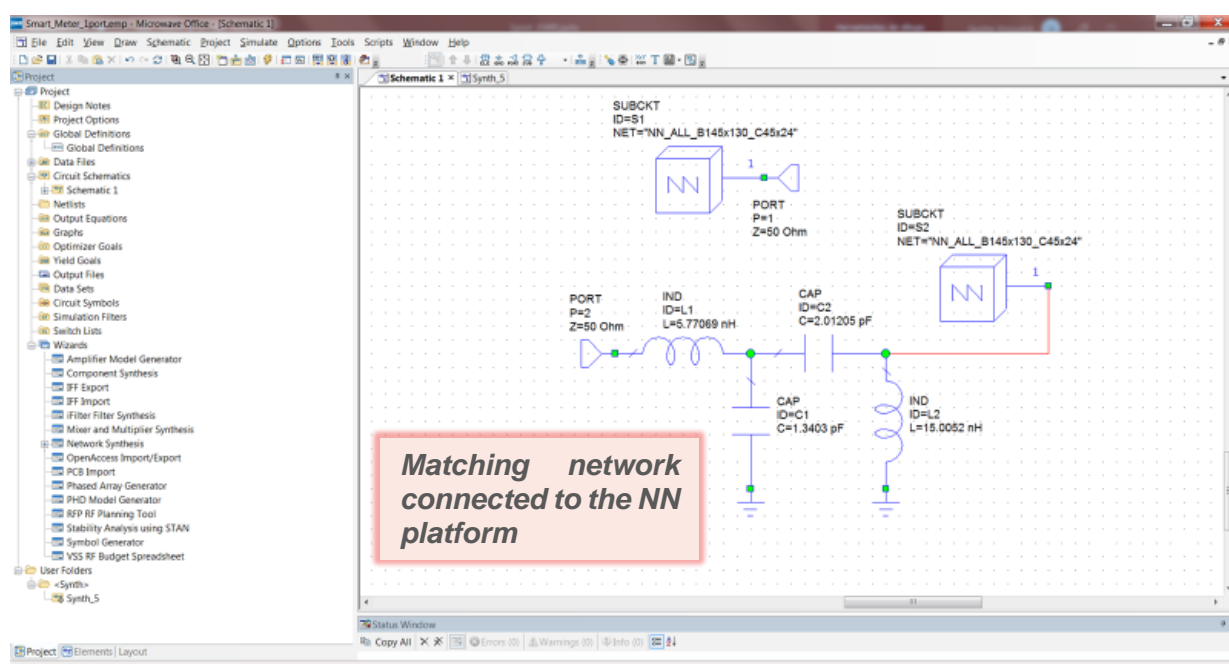
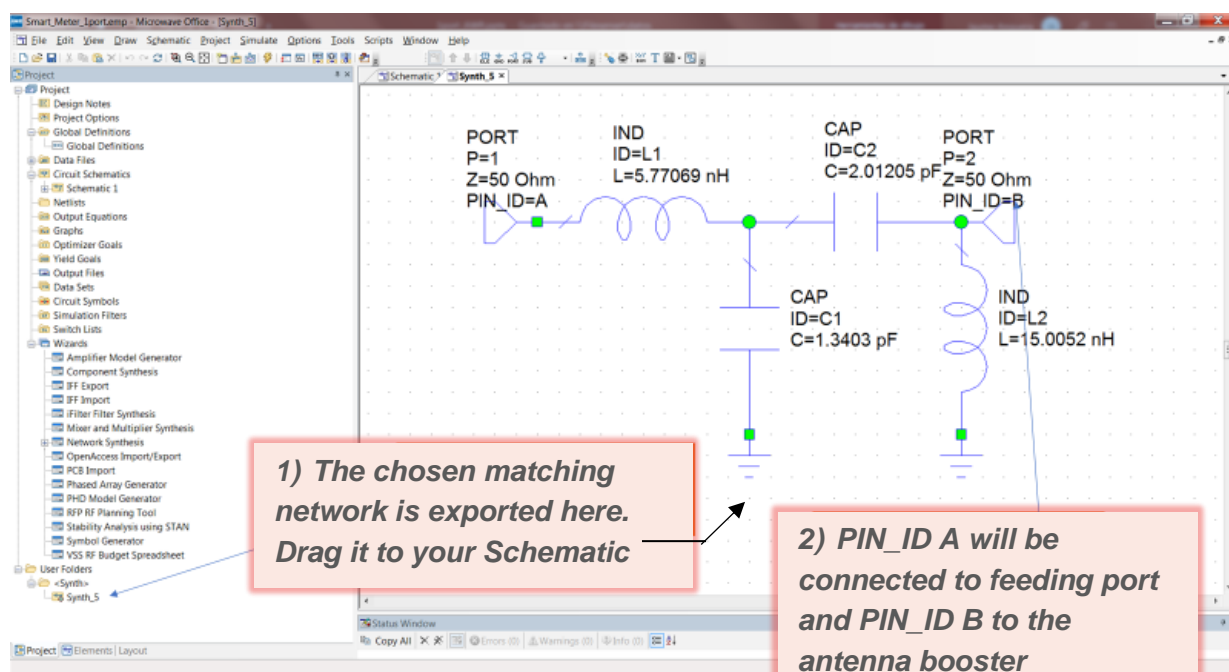




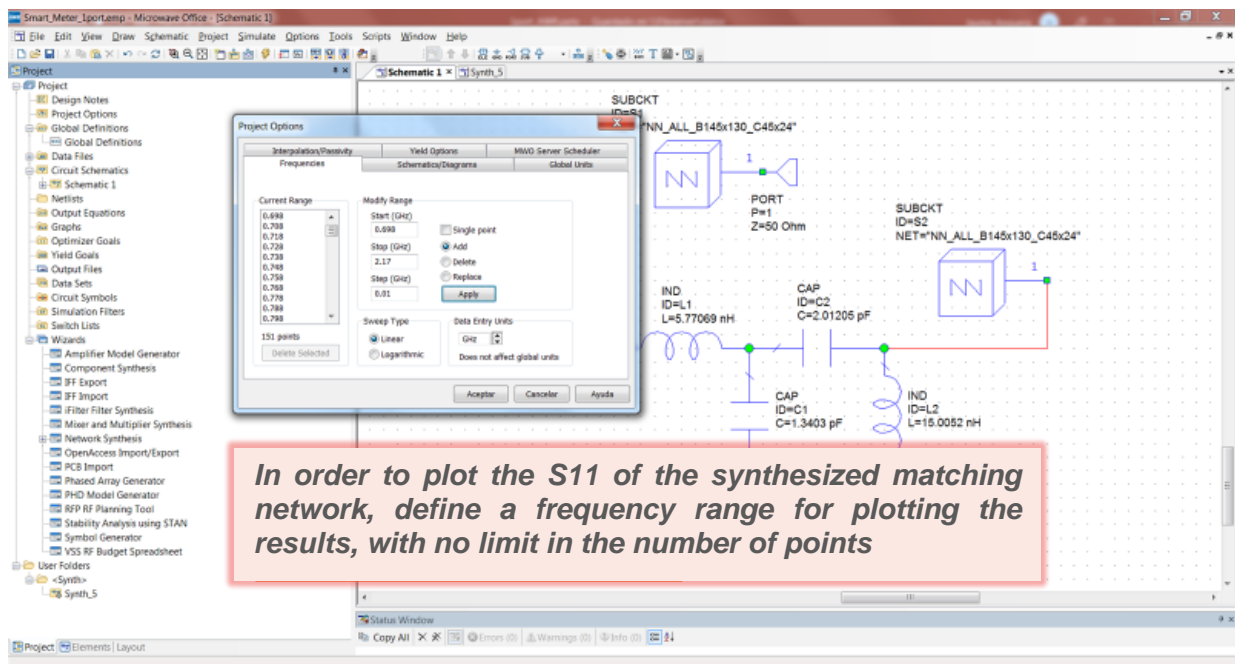






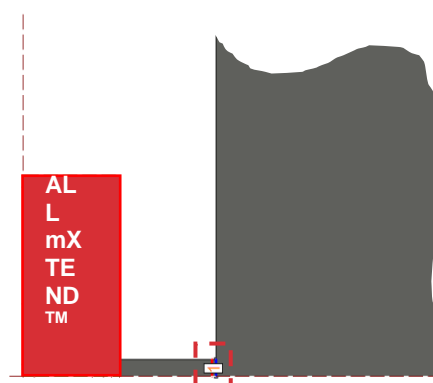






It is worth noticing that the values obtained for the matching network components with the Network Synthesis Wizard presented above are optimized values that need to be adjusted to real values. After designing the matching network, you can plot the reflection coefficient obtained.

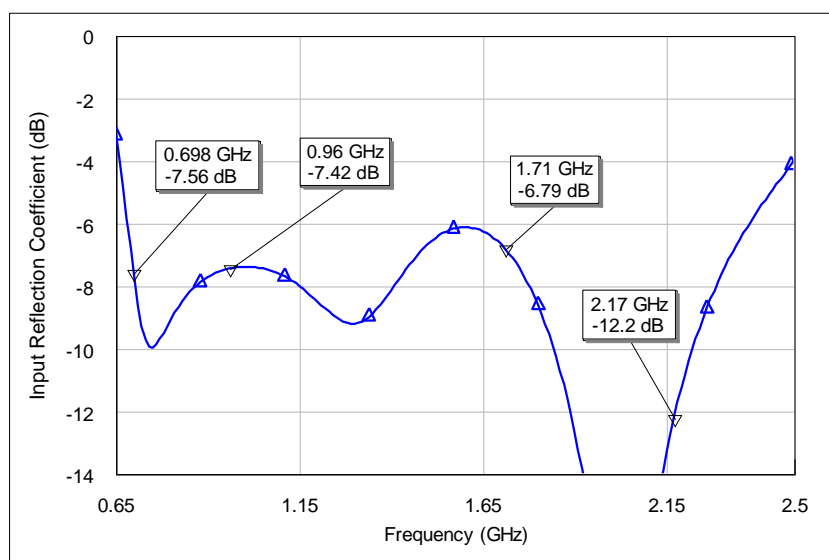
Figure 9 provides a zoom showing the antenna component and the feeding area (red dashed square) of the NN platform used for this smart meter example, and showing how the antenna component, which is placed at the PCB corner, is connected to the feeding area. The feeding area is in this case composed of just 1-port, as seen in Figure 9, and it is connected to the antenna component by means of a straight feeding line of 2mm width. The matching network designed is connected to the port of the platform as shown in the last previous steps provided for composing the matching network.



**Figure 9**– 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.

### 5.1.1.3. STEP 3: RESULTS

The matching obtained with the matching network designed above is shown in the following *Figure 10*. It shows the input reflection coefficient for this smart metering example. The design is matched below -6dB in the frequency bands of interest, ranging from 698MHz to 960MHz and from 1.71GHz to 2.17GHz.



**Figure 10** – 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

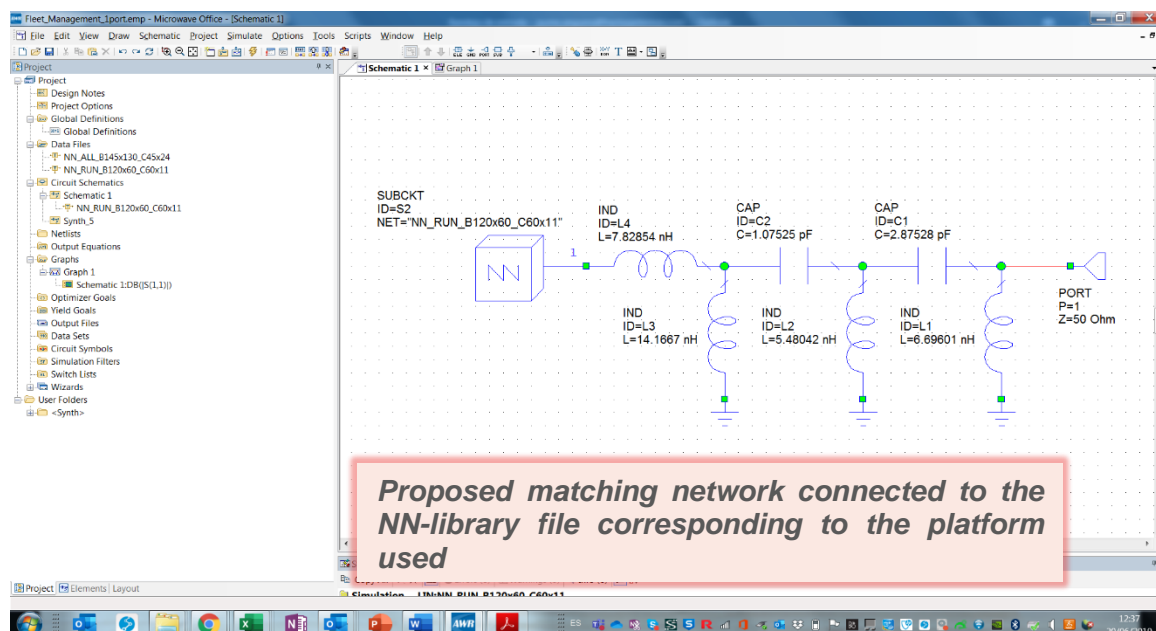
Imagine you need to design the antenna for a new fleet management application module and you need connectivity within a frequency range going from 824 MHz to 960 MHz and/or from 1.71 GHz to 2.17 GHz. The module features a 125 x 60 mm<sup>2</sup> board with a clearance of 61 x 13 mm<sup>2</sup>.

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™ 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™ 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 11*. You can find how to get the library file you need at section 1.2.

### 5.1.2.2. STEP 2: MATCHING NETWORK IMPLEMENTATION

The Network Synthesis Wizard of Cadence-AWR Microwave Office proposes the following matching network for matching the NN platform previously chosen for modeling your device. For more detail on how to design a matching network with the Network Synthesis Wizard you can have a look at the steps provided in the previous example (see Section 5.1.1.2) for creating the matching network. The following image shows the matching network connected to the NN 1-port library platform chosen from the NN Librarie[S] included and available in the Cadence-AWR Microwave Office software.



**Figure 11** – Matching network proposed by the Network Synthesis Wizard for matching the fleet management example here provided.

Figure 12 provides a zoom showing the antenna component and the feeding area of the NN platform used for this fleet management example, and showing how the antenna component, which is placed at 5mm from the corner, 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. The matching network designed is connected to the port '1' of the platform as shown in Figure 11.

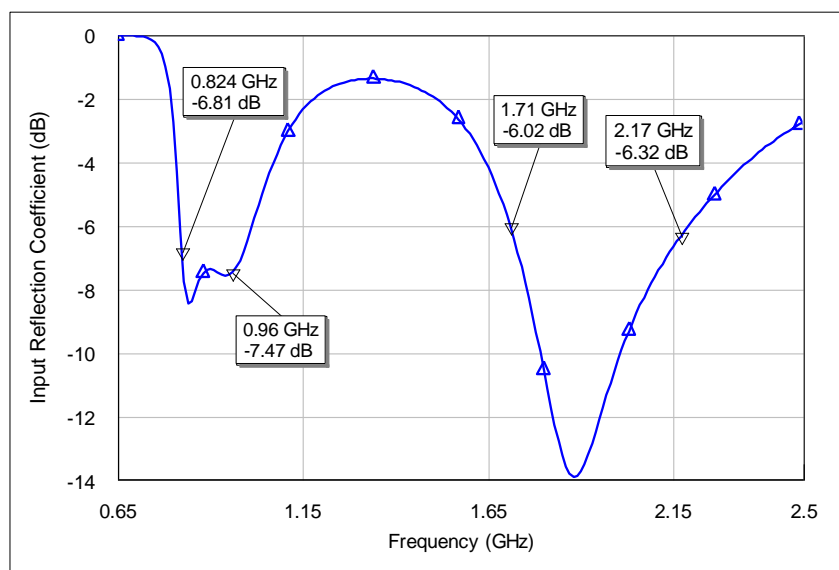




**Figure 12** – Zoom of the antenna component and the feeding area of the NN platform used in the fleet management example here provided.

### 5.1.2.3. STEP 3: RESULTS

The matching performance resulting from using the matching network (*Figure 11*) proposed in the previous section 5.1.2.2. is shown in the following *Figure 13*. 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 13** – 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

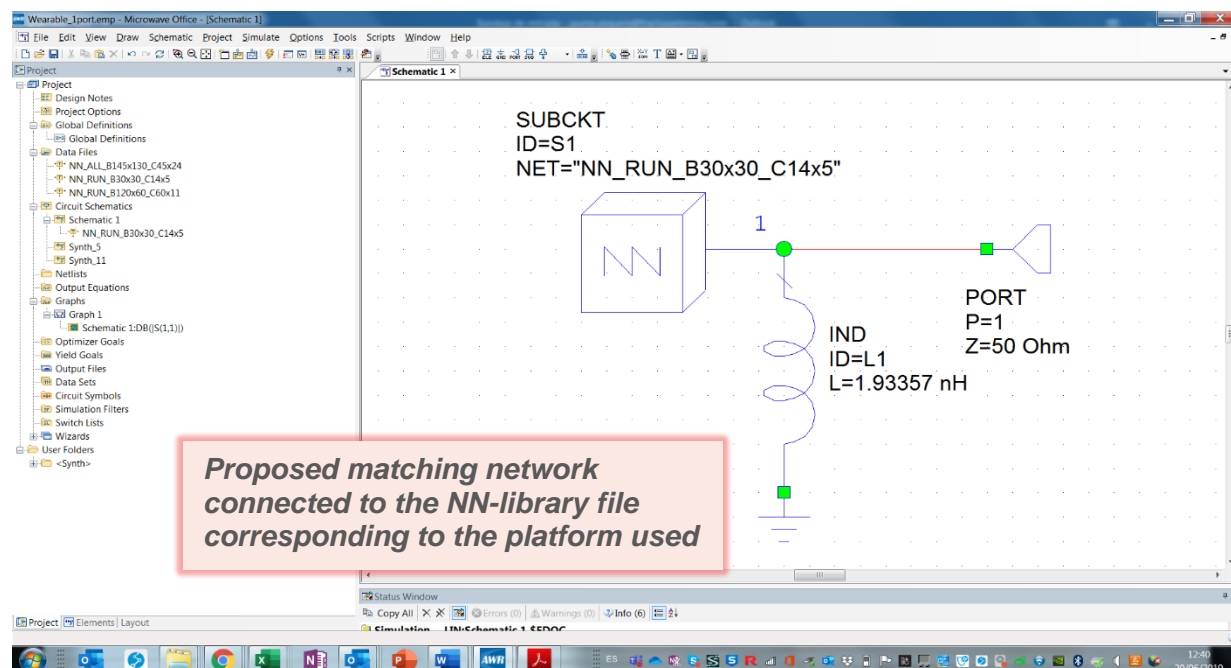
If you need to cover ISM bands operating within the 2.4 GHz to 2.5 GHz range, here you are the example. This might be the case for instance of a wearable device establishing a short-range wireless link with a computer or mobile device. In this example, the platform used features a 32 x 32 mm<sup>2</sup>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

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.

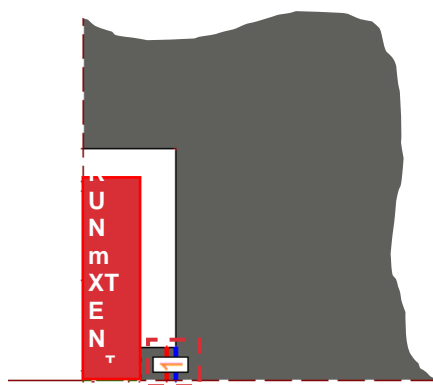
### 5.1.3.2. STEP 2: MATCHING NETWORK IMPLEMENTATION

The Network Synthesis Wizard of the Cadence-AWR Microwave Office software proposes the following matching network for matching the NN platform previously chosen for modeling your device. For more detail on how to design a matching network with the Network Synthesis Wizard you can have a look at the steps provided in the smart meter example (see Section 5.1.1.2) for creating the matching network. The following image in *Figure 14* shows the matching network designed, connected to the NN 1-port library platform chosen before from the NN Librarie[S] included and available in the Cadence-AWR Microwave Office software.



**Figure 14** – Matching network proposed by the Network Synthesis Wizard for matching the wearables example here provided.

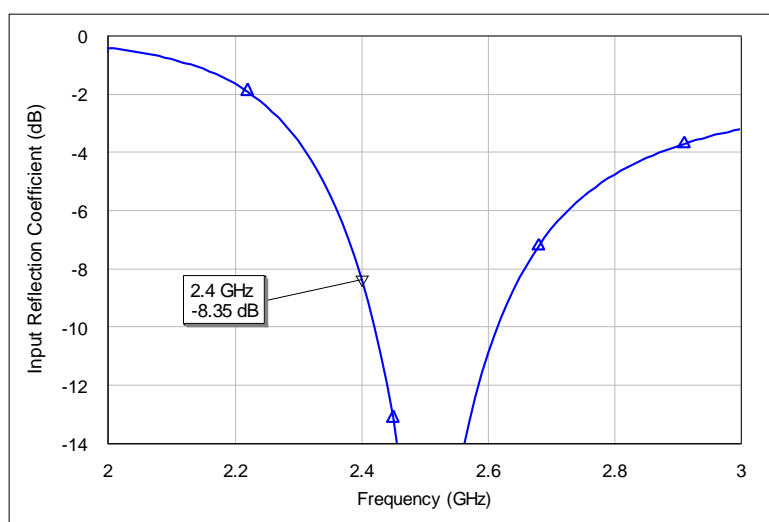
Figure 15 provides a zoom showing the antenna component and the feeding area (dashed red square) of the NN platform used for this wearable example, and showing how the antenna component, which is placed at the corner, is connected to the feeding area. The feeding area is in this case composed of just 1-port, as seen in Figure 15, and it is connected to the antenna component by means of a straight feeding line of 2mm width. The matching network designed is connected to the port '1' of the platform as shown in Figure 14.



**Figure 15** – Zoom of the antenna component and the feeding area of the NN platform used in the wearable example here provided.

### 5.1.3.3. STEP 3: RESULTS

The matching performance resulting from using the matching network proposed in the previous section 5.1.3.2 is shown in the following Figure 16. It shows the input reflection coefficient for this wearable example. The design is matched below -6dB in the frequency bands of interest, ranging from 2.4 GHz to 2.5 GHz.



**Figure 16** – Input reflection coefficient related to the wearable 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<sup>2</sup> board with a clearance of 45 x 25 mm<sup>2</sup>.

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.

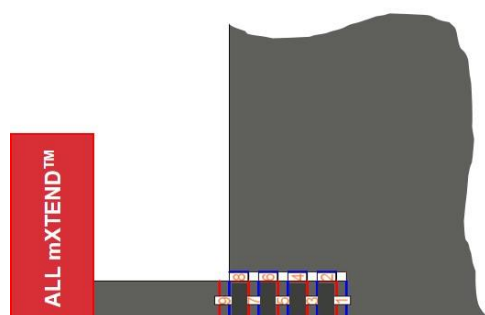
In this case the library file will be NN\_ALL\_B145x130\_C45x24.s9p. The antenna is an ALL mXTEND<sup>™</sup> (see section 2 of this manual) placed at the corner of the PCB. You can find how to get the library file you need at section 1.2.

#### 5.2.1.2. STEP 2: MATCHING NETWORK IMPLEMENTATION

Figure 17 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.

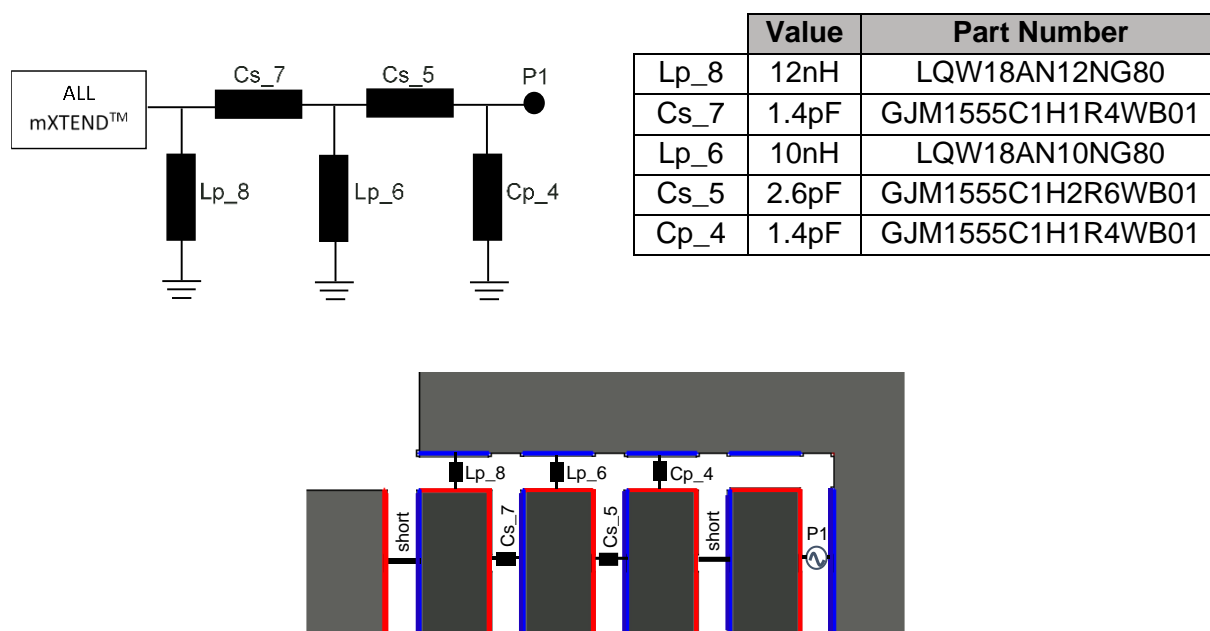
Below the platform you can find the matching network designed and used for matching this platform. The value and part numbers of the real components used for implementing it are specified in the table next to the topology.

As seen in Figure 17, 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.



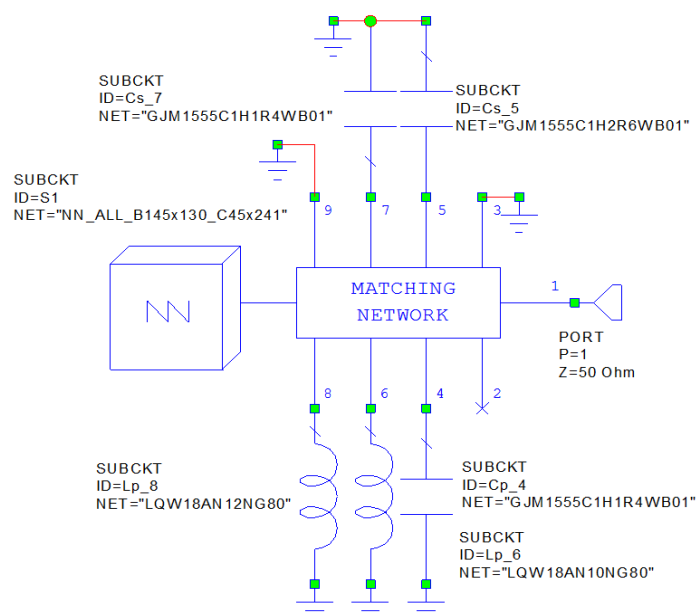
port in the bottom image.

In this case the port used as feeding port is port 1. The bottom image in Figure 17 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



**Figure 17** – 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.

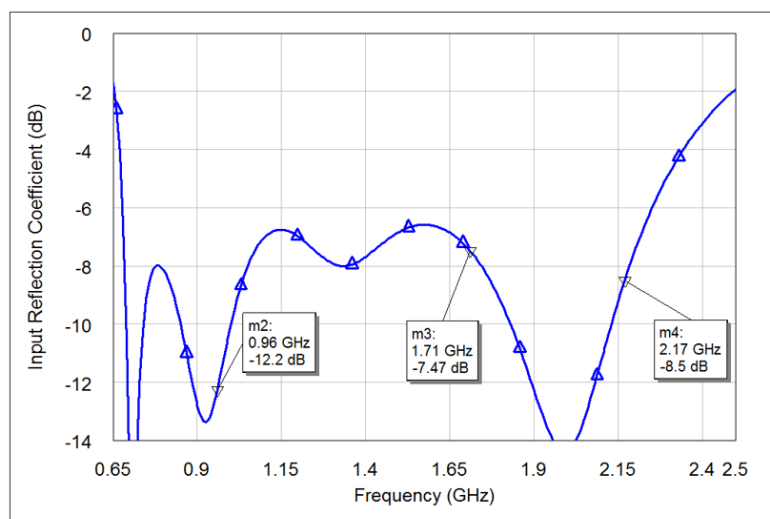
Here you are a schematic of the [S] params representing the library file of this specific example, NN\_ALL\_\_B145x130\_C45x24.s9p. This schematic is a representation of how to implement the matching network circuit provided for this example using the 9-port library file available in the Cadence-AWR Microwave Office.



**Figure 18** – [S] parameters representation corresponding to the 9-port library file used for this example, connected to the components of the matching network designed and provided in *Figure 17*.

### 5.2.1.3. STEP 3: RESULTS

The result of the above matching network (*Figure 17*) is shown in the following *Figure 19*. It shows the input reflection coefficient for this smart metering example. The design is matched below -6dB in the frequency bands of interest, ranging from 698MHz to 960MHz and from 1.71GHz to 2.17GHz.



**Figure 19** – 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<sup>2</sup> board with a clearance of 61 x 13 mm<sup>2</sup>.

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<sup>™</sup> antenna booster is the chosen one and it is placed at 5 mm from the corner of the PCB. The RUN mXTEND<sup>™</sup> 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 20*. You can find how to get the library file you need at section 1.2.

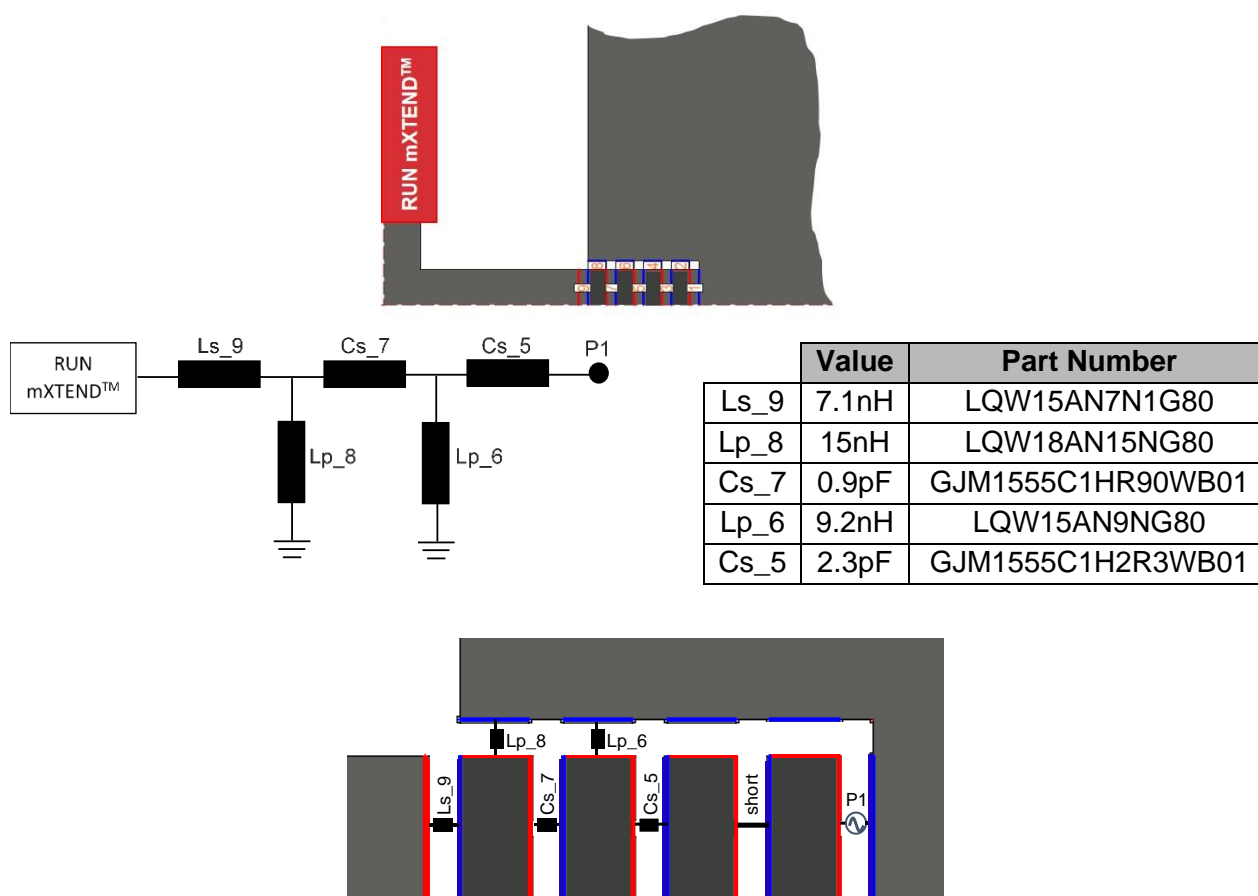
### 5.2.2.2. STEP 2: MATCHING NETWORK IMPLEMENTATION

See in *Figure 20* 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.

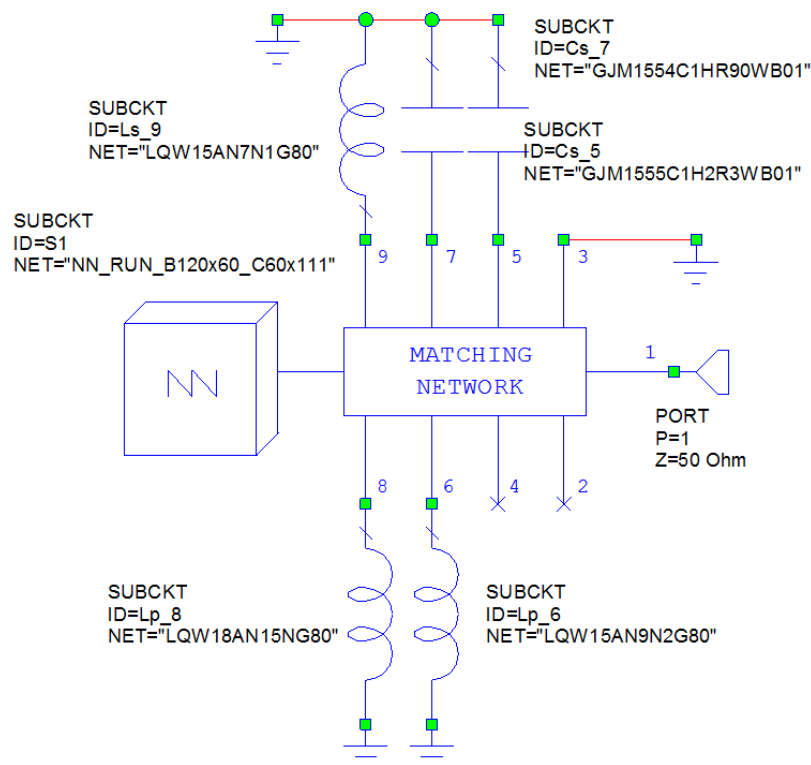
As seen in *Figure 20*, the matching network designed is composed of five components, a series inductance firstly, followed by a shunt inductance, a series capacitance, another second shunt inductance followed by another series capacitance. For this case the port used as feeding port is port 1 but port 3 or port 4 could also have been chosen.

The last image in *Figure 20* 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, allocate an open-circuit, which is represented by an empty port in the bottom image.



**Figure 20** – 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 representation of how to implement the matching network circuit provided for this example using the mentioned 9-port library file.

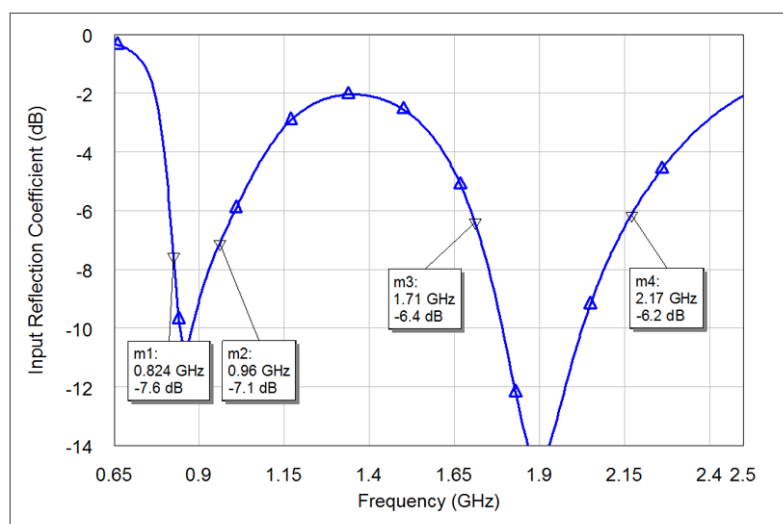


**Figure 21** – [S] parameters representation corresponding to the 9-port library file used for this example, connected to the components of the matching network designed and provided in *Figure 20*.

### 5.2.2.3. STEP 3: RESULTS

The input matching obtained for the above matching network is shown in the next *Figure 22*. 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 22** – 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<sup>2</sup> board with a clearance of 14 x 4 mm<sup>2</sup>.

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

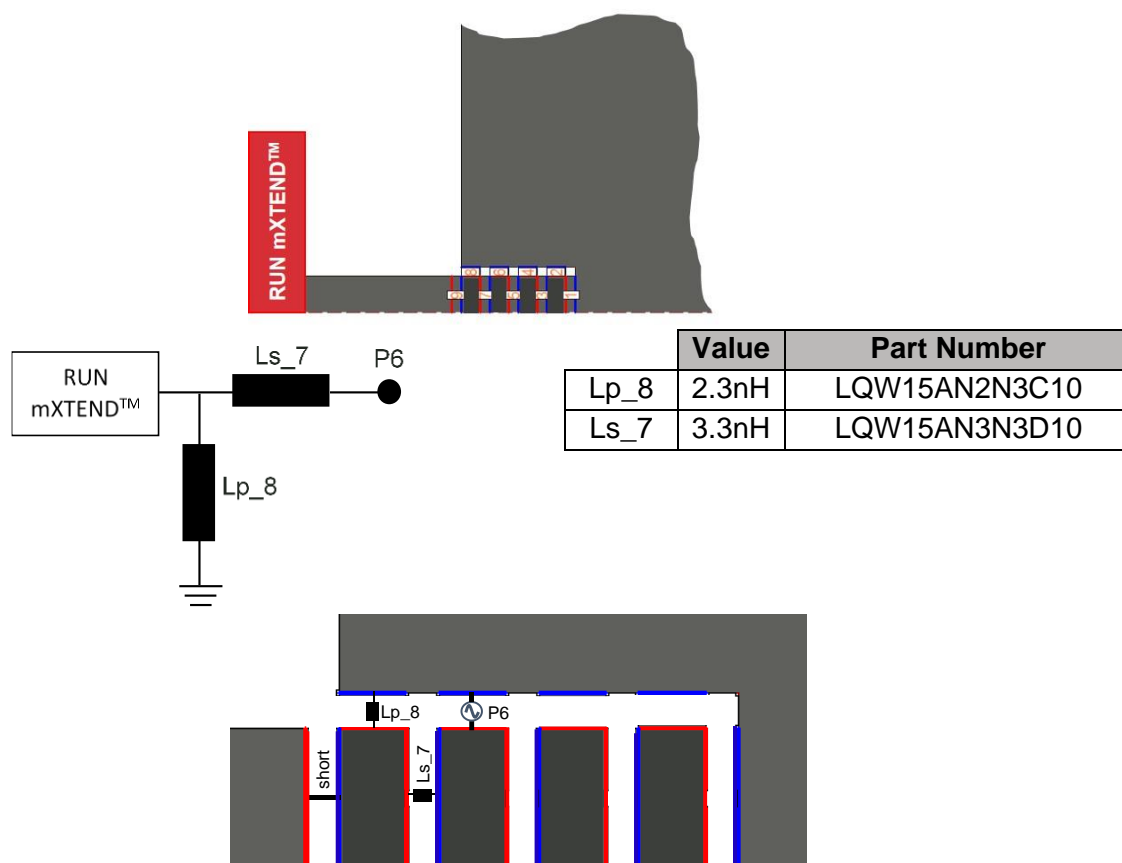
*Figure 23* shows a picture of a piece of the platform used for this case, showing the pads area and ports defined in the structures included in this library file.

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 23*, 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.

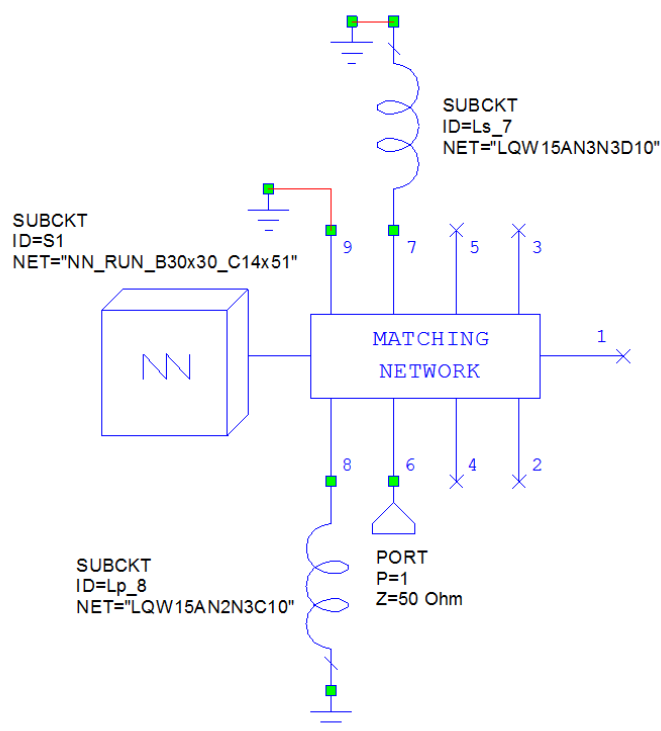
The last image in *Figure 23* represents how the components are allocated in the nine ports of the platform. The ports not containing a component, either a short-circuit or a circuit component

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.



**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.

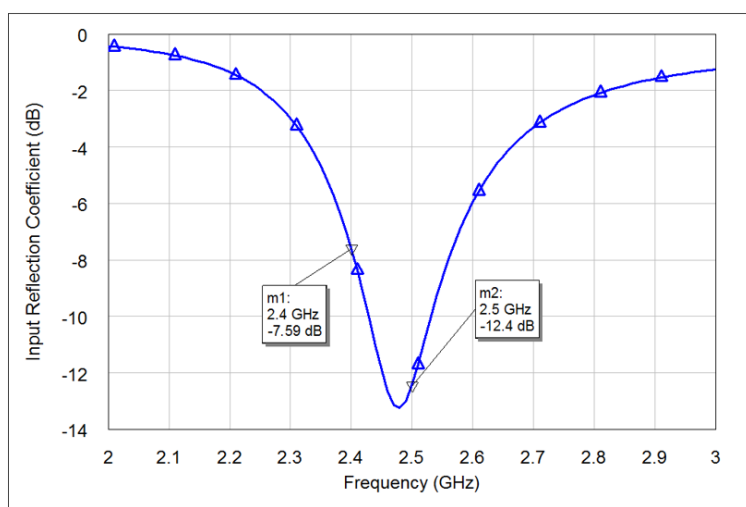
You can find now a schematic of the [S] params representing the library file for NN\_RUN\_B30x30\_C14x5.s9p. This schematic is a representation of how to implement the matching network circuit provided for this example using the mentioned 9-port library file.



**Figure 24** – [S] parameters representation corresponding to the 9-port library file used for this example, connected to the components of the matching network designed and provided in *Figure 23*.

### 5.2.3.3. STEP 3: RESULTS

In the following graph (*Figure 25*) you can find the input reflection coefficient obtained. The design is matched below -6dB, or even below -10dB, in the frequency range 2.4 GHz to 2.5 GHz.



**Figure 25** – 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

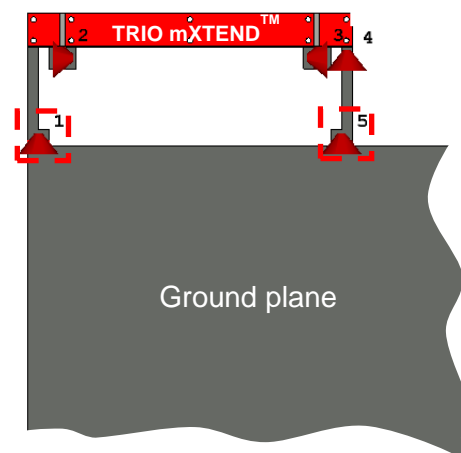
Let's say you have a new project and you need to design a new smart meter application module within a frequency range from 824 MHz to 960 MHz and/or from 1.71 GHz to 2.17 GHz. You also know the platform used is featuring a 114 x 52 mm<sup>2</sup> board with a clearance of 52 x 13 mm<sup>2</sup>.

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

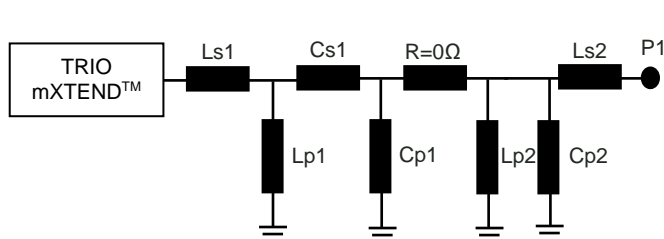
Now you can implement for the platform previously chosen, a suitable matching network with your preferred circuit design software. *Figure 26* provides a zoom of the corner of the PCB where the antenna component is placed, showing the feeding areas (red dashed squares) and how the antenna component is connected to them. The feeding areas are in this case composed of just 1-port, as seen in *Figure 26*, 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 26** – 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.

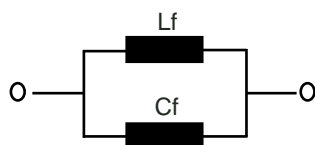
The matching networks designed for matching this example are provided in *Figure 27*. The 7 components matching network is allocated in the feeding area port 1 of the platform as shown below in *Figure 27*. The matching circuit composed of 2 components is allocated at the port 2. The value and part numbers of the real components used for implementing them are specified in the tables next to the network topologies. The bottom image in *Figure 27* 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:**



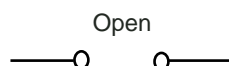
	Value	Part Number
Ls1	0nH	--
Lp1	6.4nH	LQW15AN6N4G80
Cs1	3.0pF	GJM1555C1H3R0WB01
Cp1	1.7pF	GJM1555C1H1R7WB01
Lp2	5.2nH	LQW15AN5N2G80
Cp2	0.7pF	GJM1555C1HR70WB01
Ls2	1.6nH	LQW15AN1N6C80

**Port 2:**

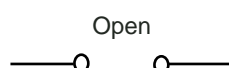


	Value	Part Number
Lf	11nH	LQW18AN11NG80
Cf	0.9pF	GJM1555C1HR90WB01

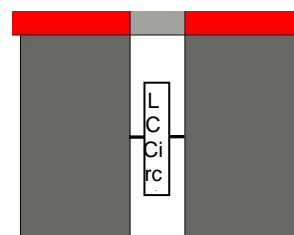
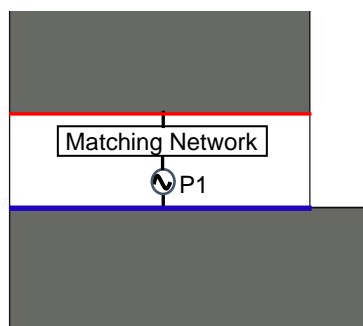
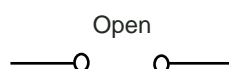
**Port 3:**



**Port 4:**



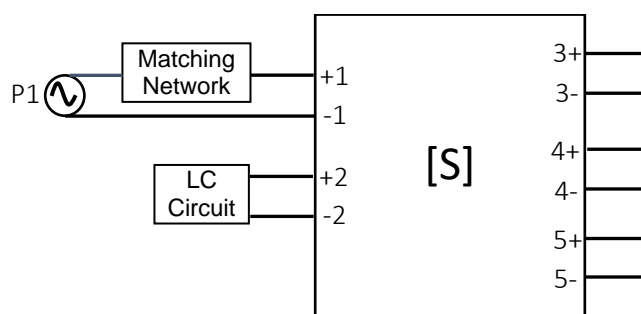
**Port 5:**



**Figure 27** – 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.

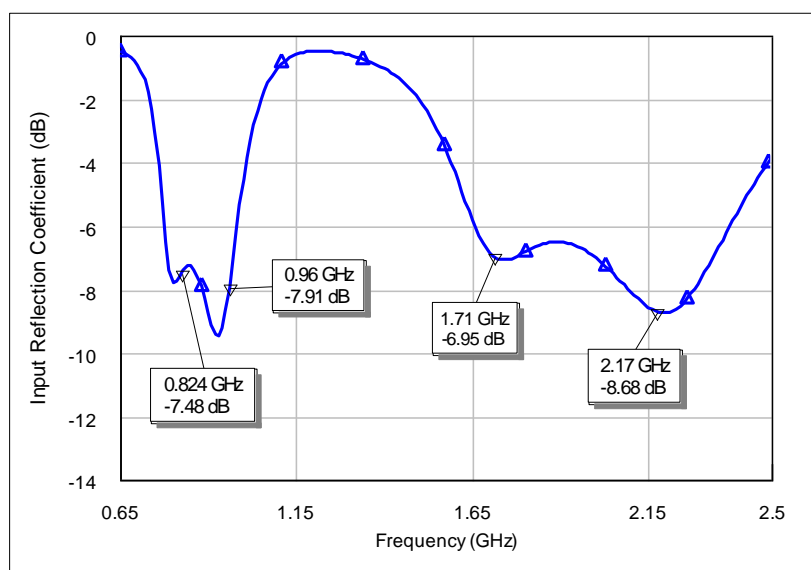


**Figure 28** – An [S]-parameters representation corresponding to the 5-port library file used for this example, connected to generic matching networks representing the matching networks designed for the example and provided in *Figure 27*.

After designing the matching networks with the Cadence-AWR Microwave Office, 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 29*. 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 29** – 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

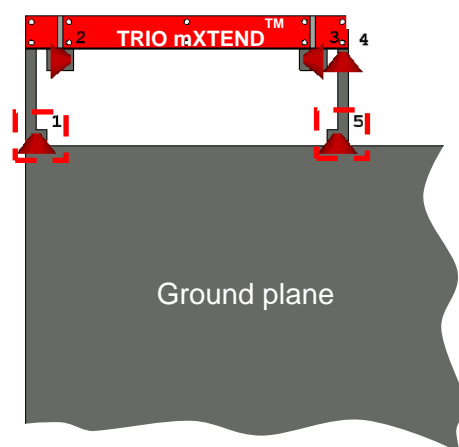
Imagine you need to design the antenna for a new fleet management application module and you need connectivity within a frequency range going from 824 MHz to 960 MHz and/or from 1.71 GHz to 2.17 GHz (mobile frequencies), and from 1.561GHz to 1.606GHz (GNSS frequencies). The module features a 115 x 50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

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 2 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 30* 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 30*, and they are connected to the antenna component by means of straight feeding lines of 1mm width.

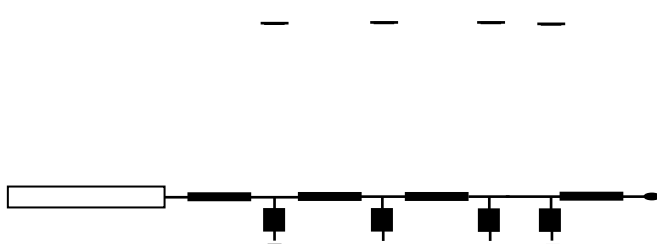


**Figure 30** – Zoom of the antenna component showing the ports and the feeding areas of the TRIO platform used in the fleet management example here provided.



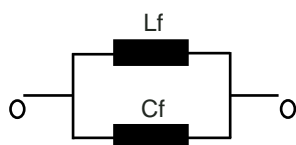
The matching networks designed for matching this example are provided in *Figure 31*, and they are allocated in the feeding area ports 1 and 5 of the platform, and which correspond to the feeding ports P1 and P2 respectively, as shown below in *Figure 31*. Two more matching circuits are necessary for adapting this two-port solution. Their topologies are also provided in *Figure 31*. 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 31* represents how these matching circuits and a feeding ports are allocated in the ports defined in the TRIO platform.

Port 1:



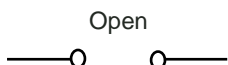
	Value	Part Number
Ls1	3.0nH	LQW15AN3N0G80
Lp1	5.4nH	LQW15AN5N4G80
Cs1	3.1pF	GJM1555C1H3R1WB01
Cp1	1.8pF	GJM1555C1H1R8WB01
Lp2	4.1nH	LQW15AN4N1G80
Cp2	1.3pF	GJM1555C1H1R3WB01
Ls2	0nH	--

Port 2:

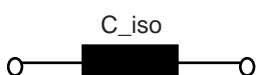


	Value	Part Number
Lf	4.5nH	LQW15AN4N5G80
Cf	1.7pF	GJM1555C1H1R7WB01

Port 3:

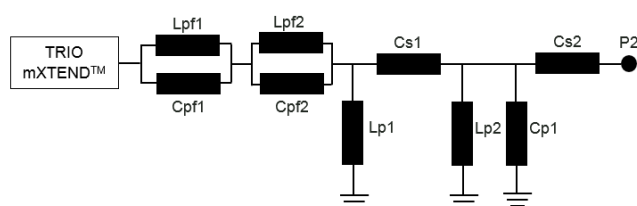


Port 4:

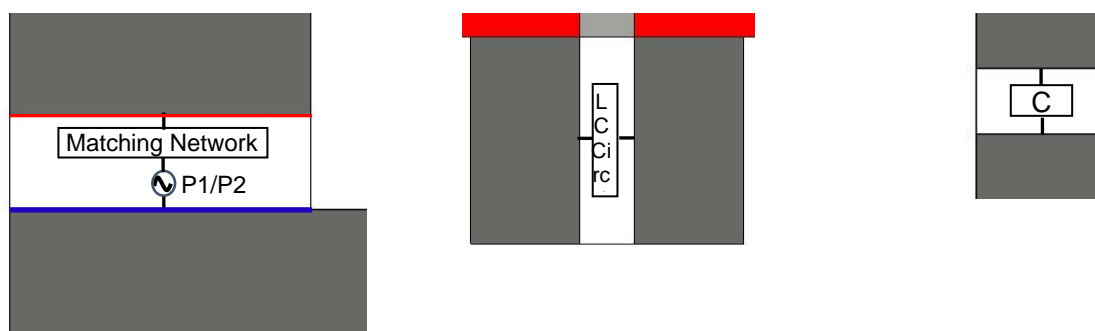


	Value	Part Number
C_iso	0.1pF	GJM1555C1HR10WB01

Port 5:

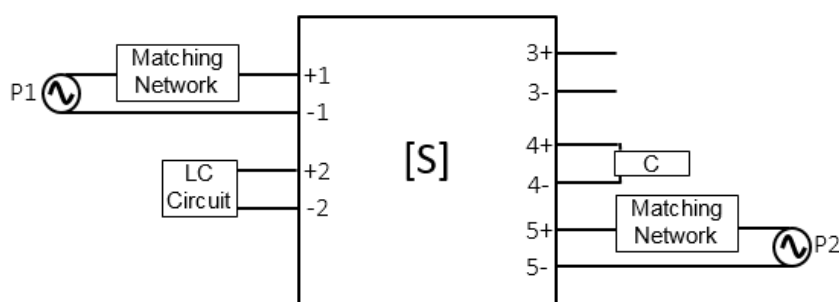


	Value	Part Number
Lpf1	0nH	--
Cpf1	--	--
Lpf2	2.5nH	LQW15AN2N5G80
Cpf2	1.9pF	GJM1555C1H1R9WB01
Lp1	13nH	LQW18AN13NG80
Cs1	0.3pF	GJM1555C1HR30WB01
Lp2	4.0nH	LQW15AN4N0G80
Cp1	2.0pF	GJM1555C1H2R0WB01
Cs2	1.4pF	GJM1555C1H1R4WB01



**Figure 31** – 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.

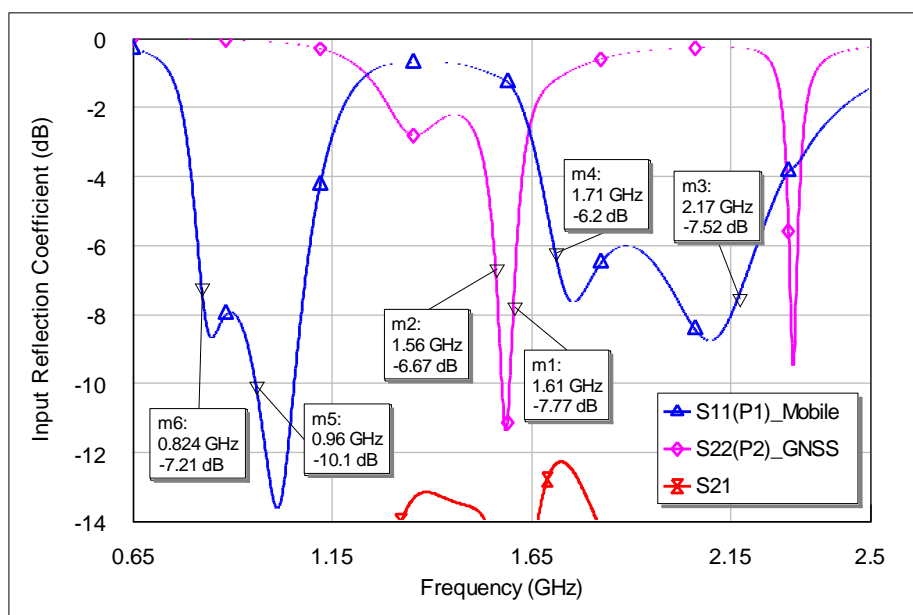


**Figure 32** – An [S]-parameters representation corresponding to the 5-port library file used for this example, connected to generic matching networks representing the matching networks designed for the example and provided in *Figure 31*.

After designing the matching networks with the Cadence-AWR Microwave Office, you can plot the reflection coefficient obtained.

### 5.3.2.3. STEP 3: RESULTS

The matching performance resulting from using the matching networks (*Figure 31*) proposed in the previous section 5.1.2.2. is shown in the following *Figure 33*. 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 33** – 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

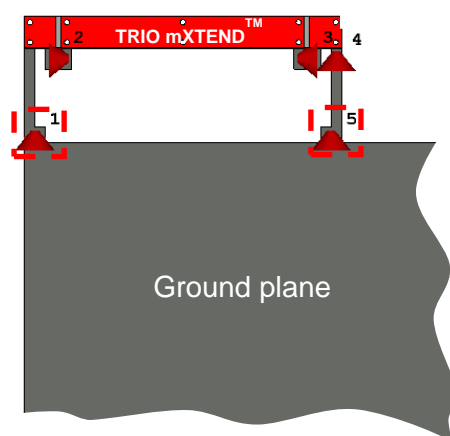
If you need to cover Mobile & GPS bands operating within the 698 MHz to 960 MHz range in combination with GPS, here you are the example. This might be the case for instance of an IoT smart tracking device. In this example, the platform used features a 52 x 50 mm<sup>2</sup> board with a clearance of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

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

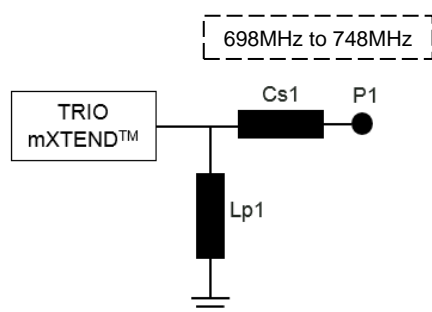
Once you have chosen the suitable platform for this smart tracking example you can implement a matching network with your preferred circuit design software. *Figure 34* provides a zoom of the corner of the PCB showing the feeding areas (red dashed squares) and how the antenna component is connected to them. The feeding areas are composed of just 1-port, as seen in *Figure 34*, and they are connected to the antenna component by means of a straight feeding line of 1mm width.



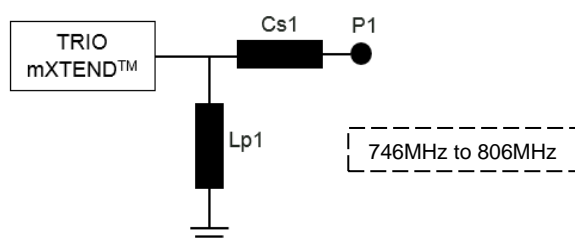
**Figure 34** – Zoom of the antenna component showing the feeding areas of the TRIO platform used in the smart tracking example here provided.

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 35* 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.

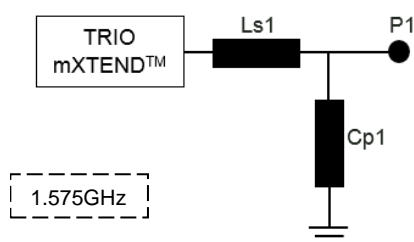
Port 1:



	Value	Part Number
Lp1	12nH	LQW18AN12NG80
Cs1	1.8pF	GJM1555C1H1R8WB01

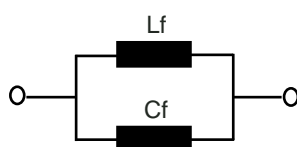


	Value	Part Number
Lp1	9.2nH	LQW15AN9N2G80
Cs1	2.3pF	GJM1555C1H2R3WB01



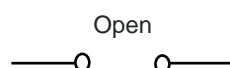
	Value	Part Number
Ls1	9.0nH	LQW15AN9N0G80
Cp1	2.9pF	GJM1555C1H2R9WB01

Port 2:

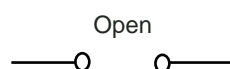


	Value	Part Number
Lf	15nH	LQW18AN15NG80
Cf	0.3pF	GJM1555C1HR30WB01

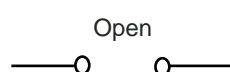
Port 3:



Port 4:

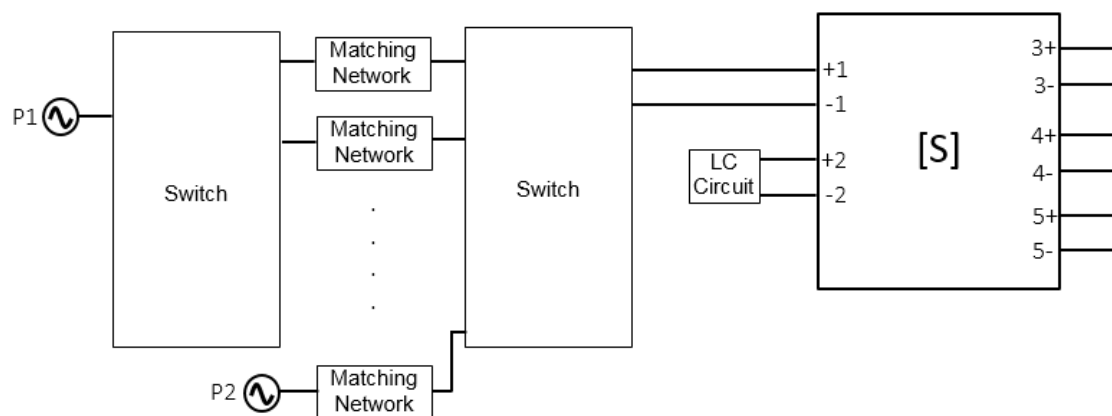


Port 5:



**Figure 35** – 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.

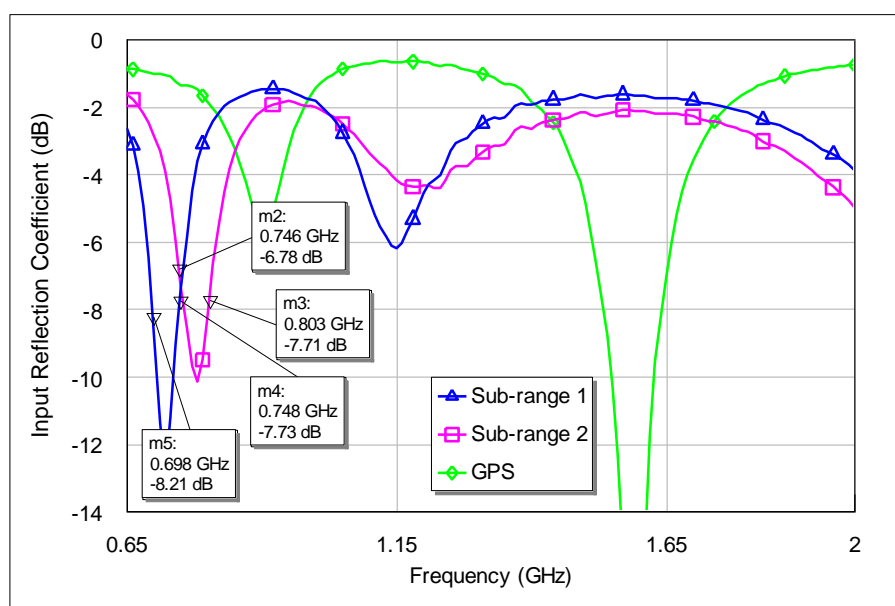


**Figure 36** – An [S]-parameters representation corresponding to a TRIO library file used for this example, connected to the matching network circuit designed for the example.

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 37*. 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 37** – Input reflection coefficients related to the smart tracking example here provided.

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