UNIVERSITY OF OULU

FACULTY OF INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING - ITEE

521225S RF COMPONENTS AND MEASUREMENTS

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DESIGN EXERCISE #1

AWR DESIGN ENVIRONMENT

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Introduction

RF and microwave circuits are essential components of modern communication systems, and designing them requires precise modeling and simulation. By utilizing simulation tools, we can efficiently and effectively simulate the behavior of these circuits, and tune their performance to meet specific requirements.

In this exercise, The AWR Design Environment (AWRDE) is introduced and explored. Basic operation such as loading touchstone files, creating plots, optimization, and tunning will be explored and how they are performed using AWRDE.

1. Example 1-1: Chapter 3 - MWO: Importing Data Files

In this example, the different instructions in [1, Chapter 3] are followed.

The example shows how to load touchstone files (s-parameters files) as data files in AWR Design Environment (AWRDE). First, a two port block is used to to load the imported data file into the schematic, as shown in Figure 1, and then the simulation is run and its results (S21 and S11) are compared to the ones of the imported data file, as shown in Figures 2 and 3. The schematic result are valued over the configured frequency range (2 GHz to 10 GHz) whereas the results loaded from the data file directly are presented fro th whole frequency range supported by the data file.

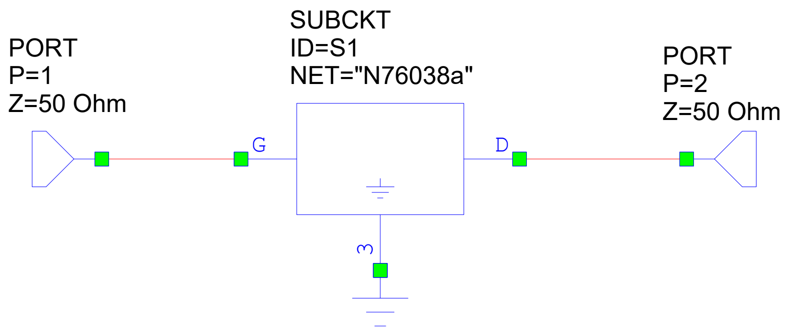


Figure 1: Example 1-1 schematic

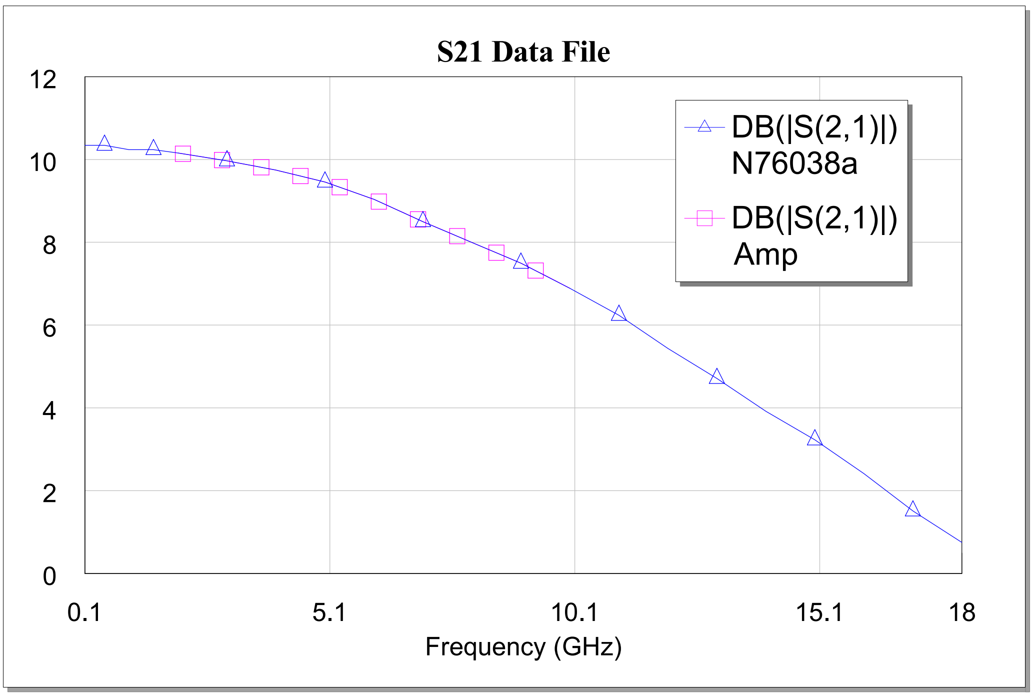


Figure 2: S21 with 50 Ω ports

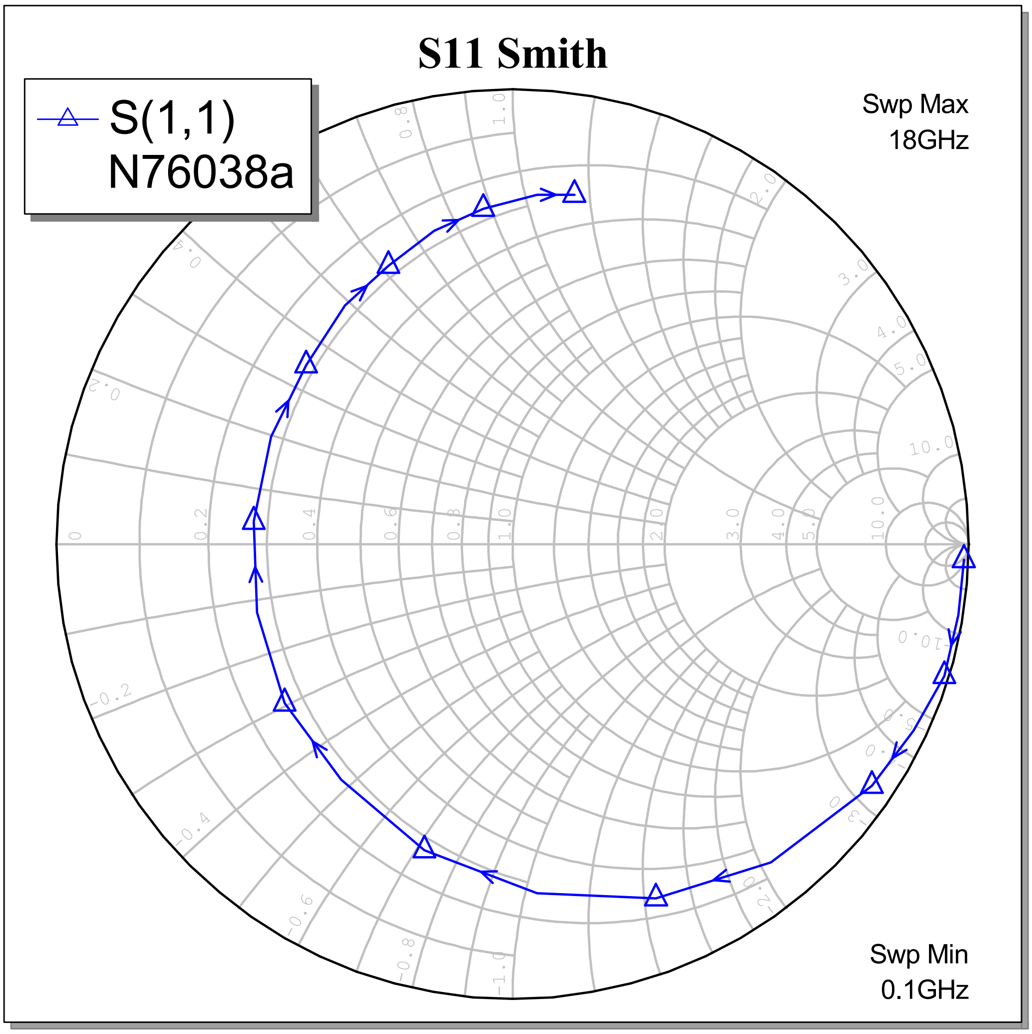


Figure 3: Data file S11 in smith chart

The example also explains how to edit port parameters and set their refrence impedance to 25Ω and compare the results,as shown in Figures 4 and 5. Changing the port impedances changes also the reflection coefficient simulated from the schematic whereas it doesn't affect the results loaded from the data file directly.

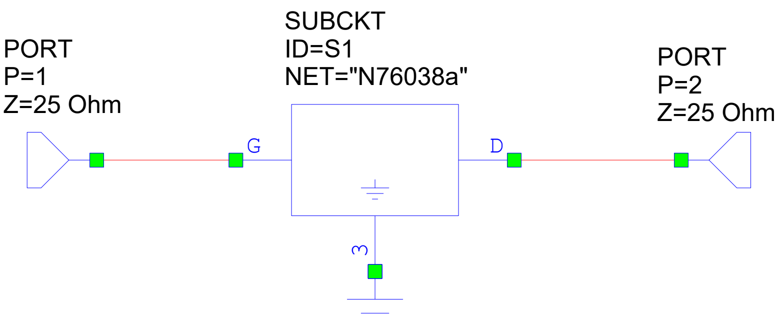


Figure 4: Example 1-1 schematic with 25 Ω ports

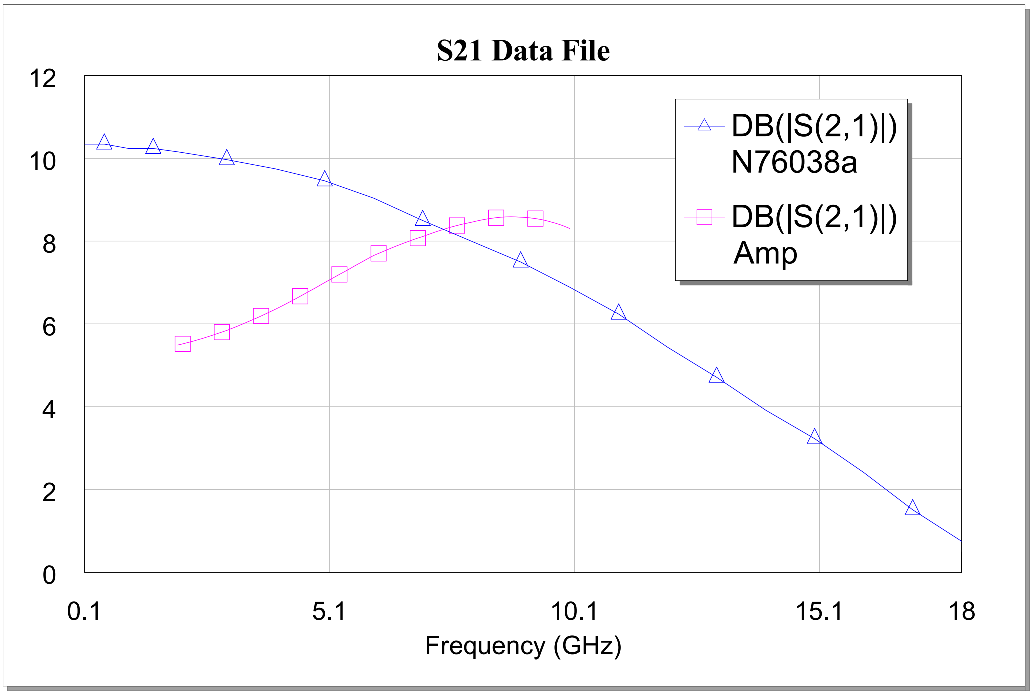


Figure 5: S21 with 25 Ω ports

Loading S-parameters files is a very helpful feature. It allows to compare different components and choose the one that best suits the application. It allows to simulate/model the operation supporting structures (matching networks, dividers, couplers ...) in combination with the actual components over the intended/interesting frequency range. It also enables de-embedding test fixtures effects in post-processing.

Ports in simulation are points of connection between different parts of a circuit or system. They allow signals to enter and exit the circuit or system, and enable the simulation tool to analyze the behavior of the circuit or system at those points. They represent the interface between a device or circuit and its surrounding environment thus its behavior in the context of the entire system, rather than in isolation, could be examined.

The smith chart shown in the [1, Chapter 3] and shown in Figure 3 represents the reflection coefficient (S11) loaded from the imported file. This confection is a transformation of the input impedance of the block characterized by the imported file.

2. Task 1-1: Simulation of the SMA connector from measurement data

In this task, the data from an SMA connector, Figure 6, measurement is imported and examined. Figure 7 show the magnitude and phase responses of the connector when it is opened. In this case, the connector represents a full reflection with a phase that is changing linearly with the frequency.

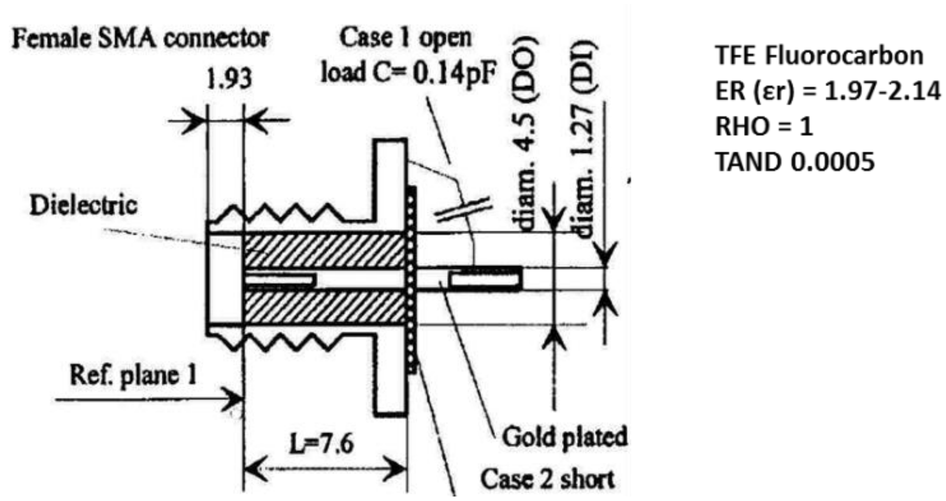
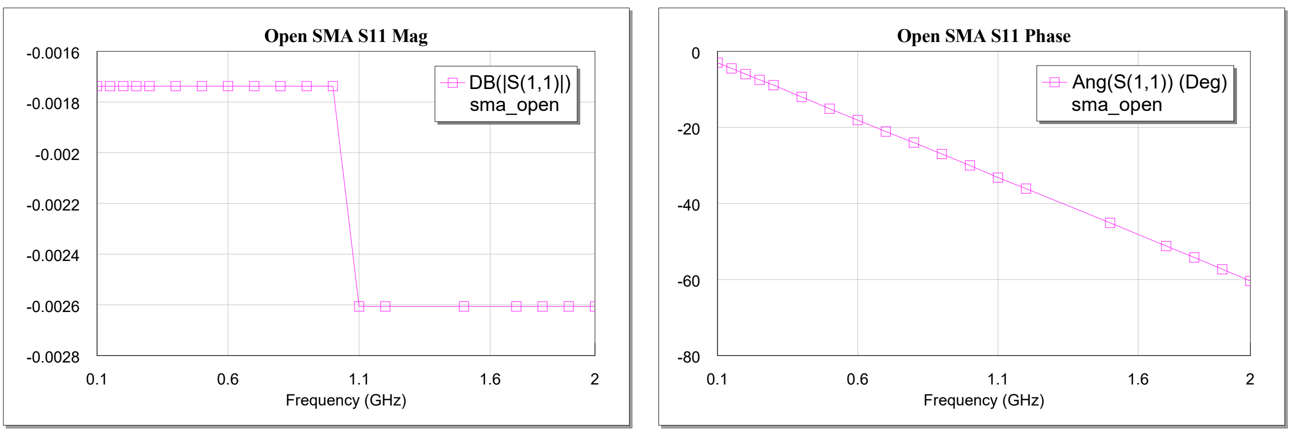


Figure 6: SAM connector structure

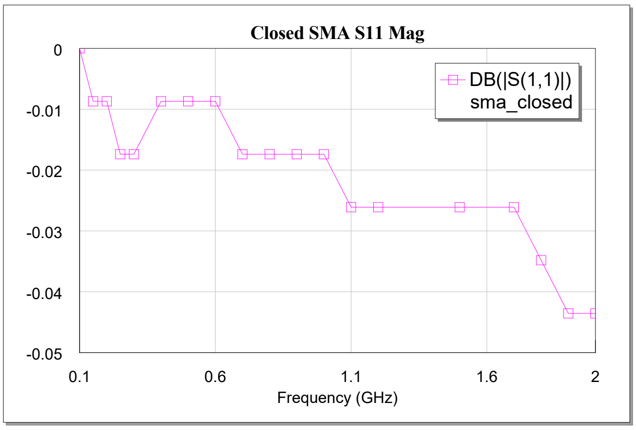


(a) Magnitude

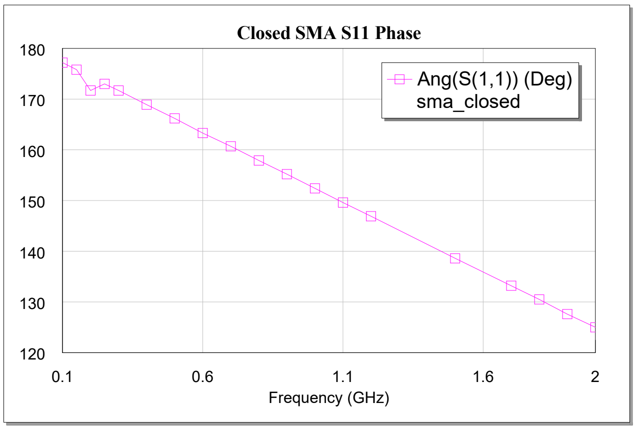
(b) S11 phase of open SMA

Figure 7: Phase

Similarly, Figure 8 shows the magnitude and phase responses of the connector when it is closed. In this case too, the connector represents a full reflection (with an insignificant reduction in S11 magnitude compared to the open case) and a phase that is changing linearly with the frequency.



(a) Magnitude



(b) Phase

Figure 8: S11 response of closed SMA

3. Task 1-2: Define equivalent circuit for resistor connected to SMA-connector

In this task, the data from the measurements of a 50 Ω surface mount chip resistor that is soldered to an SMA connector, Figure 9, is examined. The data is examined in terms of the input impedance Z11 as shown in Figure 10. Over the examined frequency range, the combination of the resistor and the SMA connector represents almost a 50Ω resistor with negligible imaginary part.

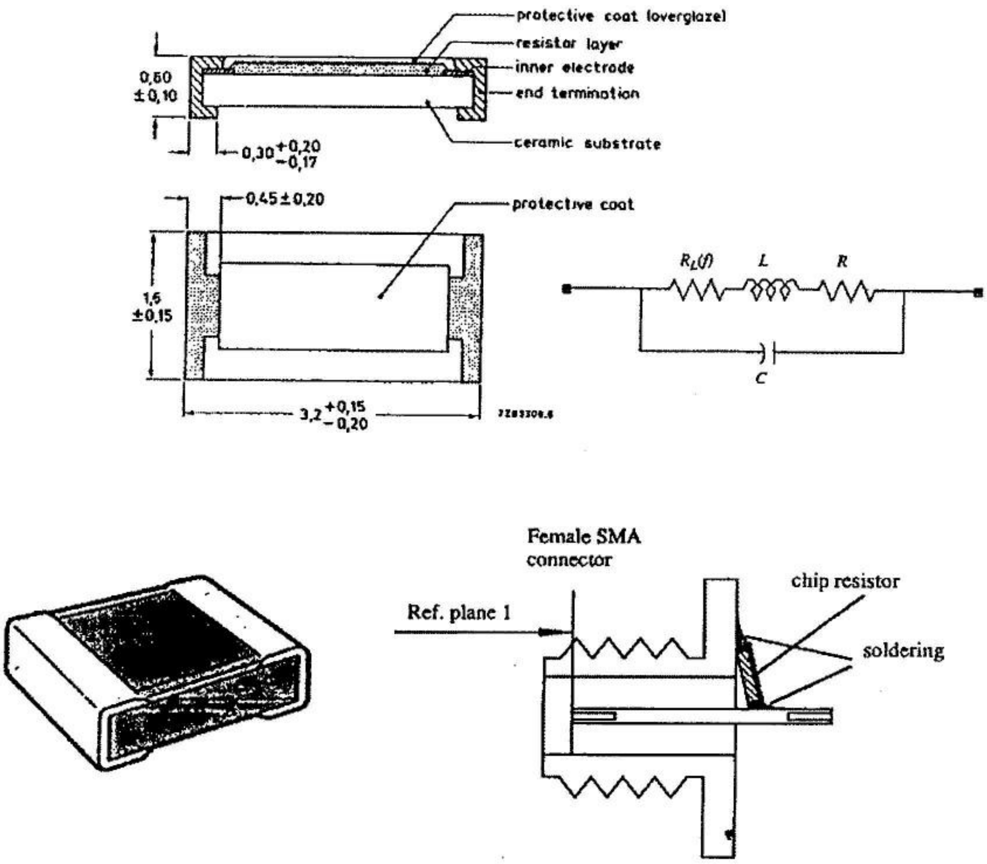
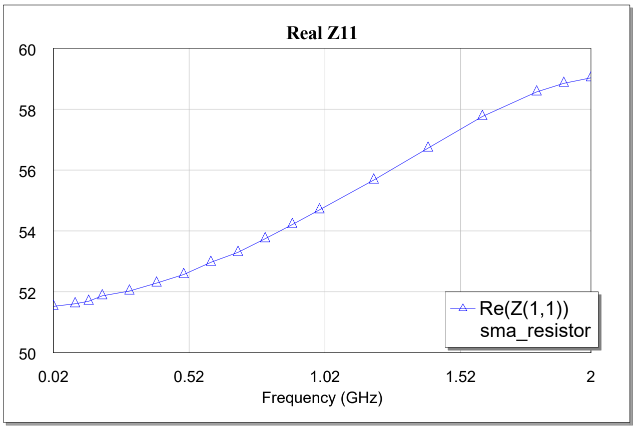
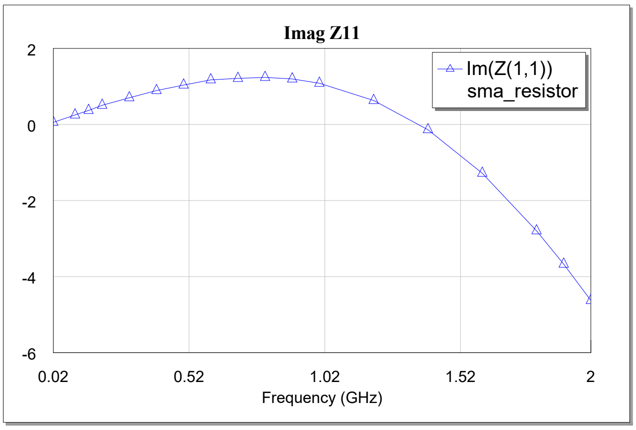


Figure 9: Structure, equivalent circuit and measurement set-up of the chip resistor



(a) Real part

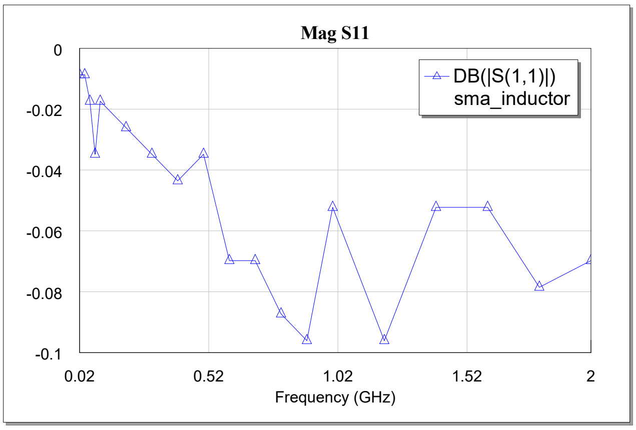


(b) Imaginary part

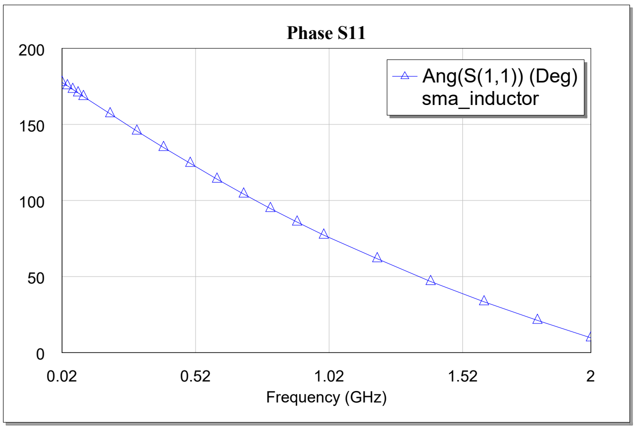
Figure 10: Input impedance Z11 of SMA + resistor

4. Task 1-3: Define equivalent circuit for inductor connected to SMA-connector

Similar to the previous task, an inductor soldered to an SMA connector is characterized and the results in different formats. Figure 11 shows the magnitude and phase of the input reflection coefficient S11, whereas Figures 12 shows the real and imaginary parts of the input impedance.

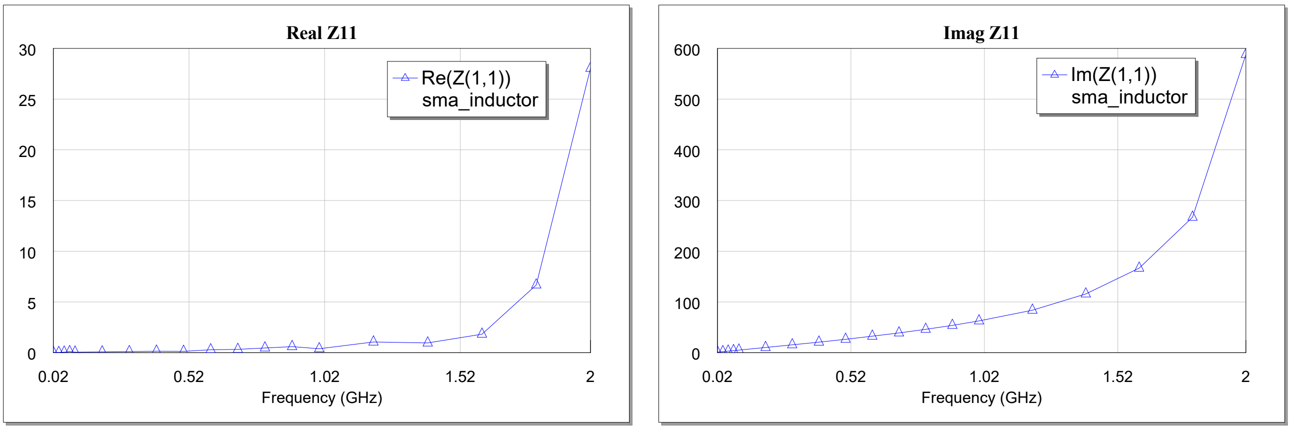


(a) Magnitude



(b) Phase

Figure 11: S11 response of SMA + Inductor



(a) Real part **(b)** Imaginary part

Figure 12: Input impedance Z11 of SMA + Inductor

5. Example 1-2: Chapter 4-MWO: Using the Linear simulator

In this example, the different instructions in [1, Chapter 4] are followed.

The example shows how to use equations and tune and optimize a circuit's (Low-Pass-Filter) parameters to achieve the desired response and specifications in AWRDE.

The schematic and response of the LPF before optimization are shown in Figures 13 and 14, respectively.

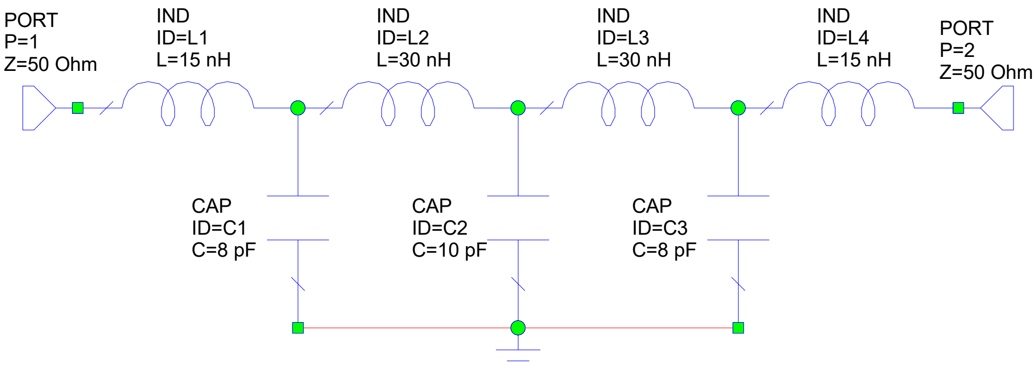


Figure 13: Example 1-2 schematic without optimization

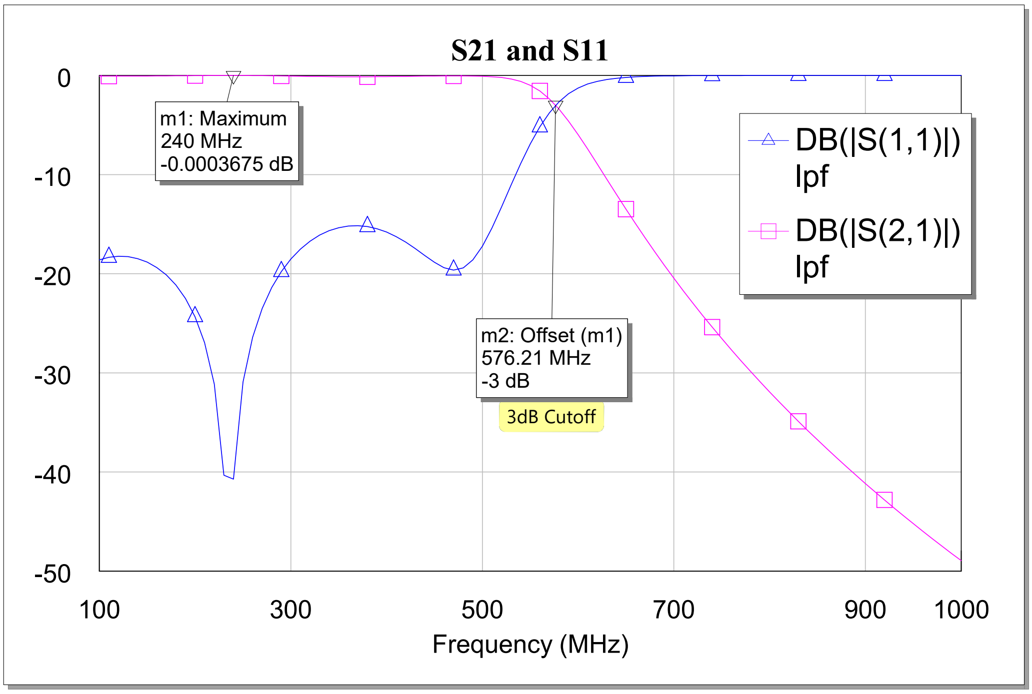


Figure 14: S21 and S11 without optimization

Similarly, the schematic and response after optimization are shown in Figures 15 and 16, respectively.

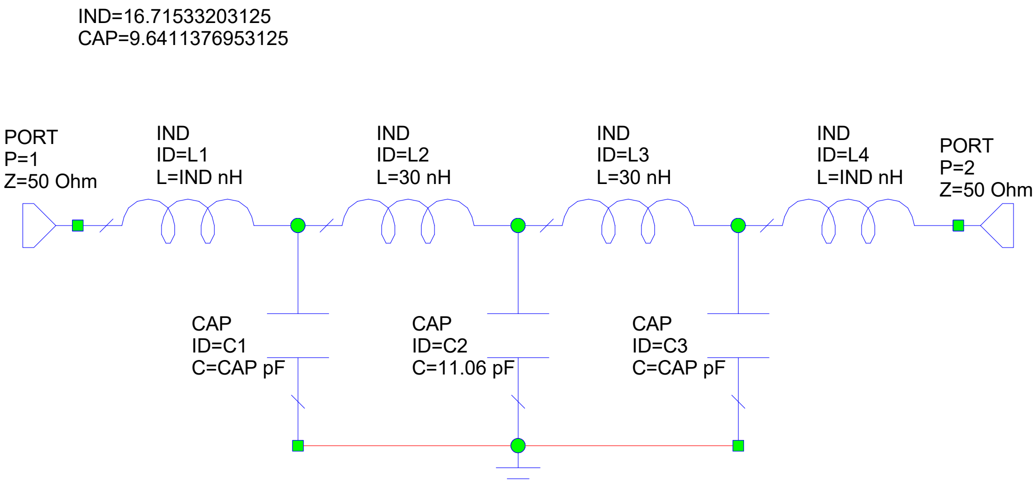


Figure 15: Example 1-2 schematic after optimization

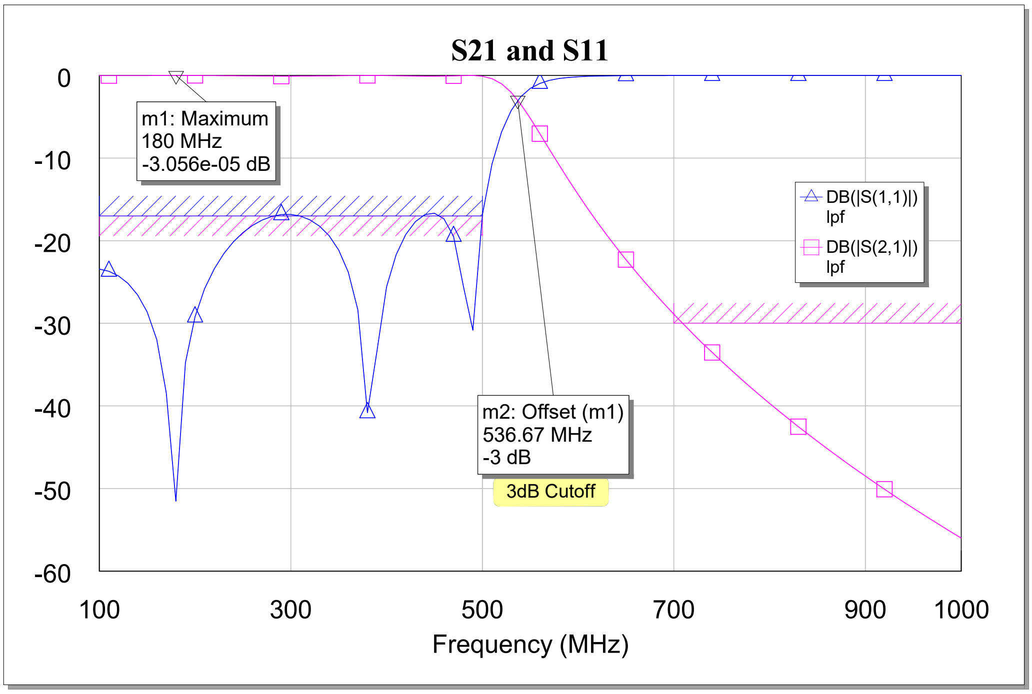


Figure 16: S21 and S11 after optimization

After optimization, the value of the capacitors C1 and C3 is 9.6411376953125 pF and the value of inductors L1 and L4 is 16.71533203125 nH.

The 50 Ω value has been used a convention and it has became a standard for port impedances between component and test equipment manufactures. It has been chosen as a compromise between the impedance corresponding to minimum loss (77 Ω), maximum power (30 Ω) [2].

Feedback

- The exercise took about one day. The simulations themselves didn't take much to finish but most of the time was consumed by the report.
- The exercise was easy as it incorporates only loading data files and creating plots.
- The questions were easy.
- This was my first time to use of AWRDE so it was interesting to see its analogy and how it compares to keysight ADS. I did learn how to import data s-parameters files, create plots, and navigate the interface of AWRDE.

References

[1] Cadence / National Instruments, *Microwave Office Getting Started Guide, v14.02*, 2019.

[2] Wikipedia contributors, *Nominal impedance — Wikipedia, the free encyclopedia*, https://en.wikipedia.org/w/index.php?title=Nominal_impedance&oldid=1092527573, [Online; accessed 5-April-2023], 2022.