



Agilent EEsof EDA

Overview on Microwave Coupled Line Filters Based on ADS

This document is owned by Agilent Technologies, but is no longer kept current and may contain obsolete or inaccurate references. We regret any inconvenience this may cause. For the latest information on Agilent's line of EEsof electronic design automation (EDA) products and services, please go to:

www.agilent.com/find/eesof

New Design Methodology for Microwave Coupled Line Filters Based on Agilent Advanced Design System.

Laurent Vantrepol, Pascal Boivin, Thales Communications, France
Bruno Bazire, Thales Communications / IRCOM , France
Vincent Poisson, Agilent Technologies, France

Abstract

This paper presents a new design methodology for microwave coupled lined filters. This new approach is based on Agilent Advanced Design System (ADS) EDA (Electronic Design Automation) software which combines circuit simulation and electromagnetic simulation under a single platform. . This paper describes how the EM simulator is used to automatically build parametrized models and how the designers can use these models to reduce the design and optimisation cycles.

1. Introduction

Today, wireless communications require larger bandwidth both in military and civil applications. This requirement leads to the use of higher frequency bands to 40 GHz and above.

In the current transceivers, microwave filters are key elements and their design shows how critical they are and how it is important to optimize their performance. To design these filters, it is necessary to have accurate passive models based on electromagnetic simulation. We will call them 'EM Models'.

We describe a method to create microstrip models to enable accurate optimization of coupled line filters at 40 GHz, where analytical models are reaching their limits.

The EDA software should integrate in a single environment a powerful linear simulator, an optimizer and an electromagnetic simulator. The design environment should be easily configurable to support this new methodology. For these reasons, we have chosen Advanced Design System (ADS), the RF & Microwave design software from Agilent Technologies, which integrates all the layout and simulator features to support this methodology (Fig. 1).

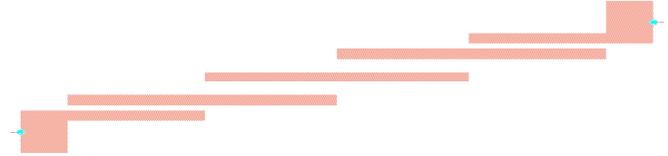


Figure 1: Coupled-line filter example (ADS Layout)

2. Objectives

The main objective is to dramatically reduce the development cycle of microwave coupled line filters.

The use of analytical models in simulation and optimization phases enables the designer to save an enormous amount of time compared to electromagnetic simulation and optimization. But these models reach their validity limit around 40 GHz. Moreover they are limited to a predefined set of topologies.

On the other hand at these frequencies and above, Momentum simulation (the 2.5-D electromagnetic simulator integrated in ADS) gives excellent results versus measurements.

We want to combine the advantages of both approaches: simulation and optimization speed, with accuracy and arbitrary topologies of electromagnetic simulations. To achieve this, we chose to develop a methodology to automatically create electromagnetic-based models.

We can create models for many basic components (Transmission line, Coupled lines, CROSS, TEE, STEP etc...) based on EM simulation. These new models can be used in circuit simulation just like the analytical models. Simulation, Tuning, and Parameter Sweeps are possible without compromising accuracy.

3. Model Creation

The basic idea is to model the filter using a set of elementary models based on [S] parameter blocks coming from EM simulations. (Fig. 1).

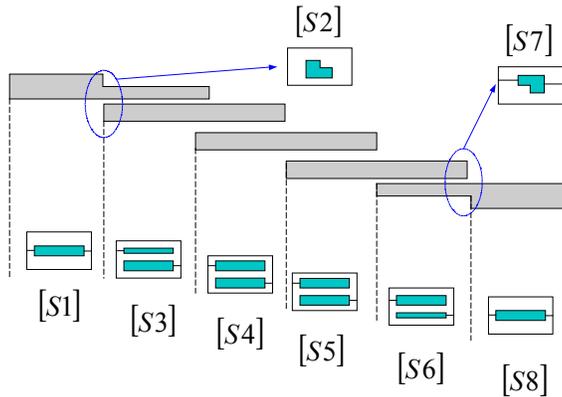


Figure 2: Set of elementary models for the coupled line filter

Each element is simulated over a range of minimum and maximum parameter values set by the designer. This is called the parameter-space of that element. Then the designer can use these models with circuit simulators and optimizers to efficiently design the filter and set the optimum values.

3.1 Automatic Layout Generation

The basic elements can present several parameters.

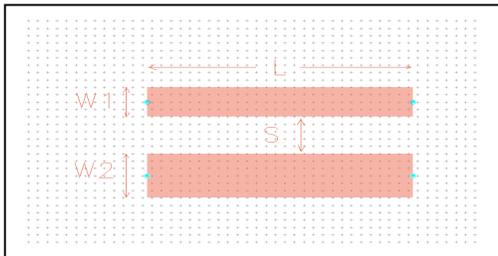


Figure 3: Example of coupled-lines parameters

For example, we can choose that $W1$ varies from $100\mu\text{m}$ to $300\mu\text{m}$ with a $50\mu\text{m}$ step (i.e. 5 values), $W2$ varies from $100\mu\text{m}$ to $300\mu\text{m}$ with a $50\mu\text{m}$ step (i.e. 5 values), S varies from $100\mu\text{m}$ to $500\mu\text{m}$ with a $50\mu\text{m}$ step (ie 9 values). These specifications lead to 225 layouts and EM simulations (Fig. 3).

The layout creation and EM simulation phase has been automatized thanks to the flexible environment in ADS. A specific interface called ‘Parametric Design’ allows the user to define all the needed parameters to create the models in a batch mode.

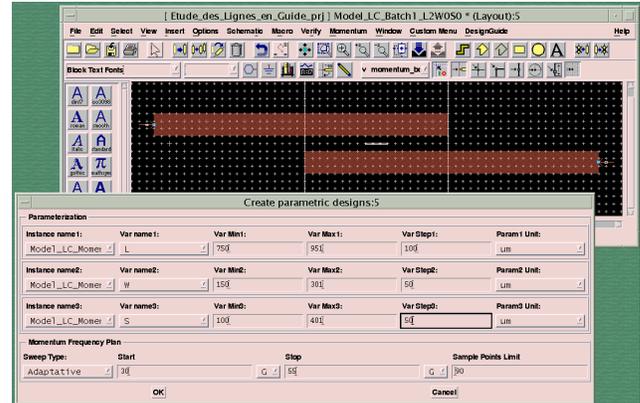


Figure 4: ‘Parametric Design’ User Interface

Once the layout is defined, the designer needs only to specify the geometry parameter ranges, the frequency range and run the model creation (Fig. 4).

3.2 Arbitrary parameterized geometry creation with the ‘graphical cell compiler’.

To be able to generate the EM models as described above in 3.1, it is necessary to have a parameterized geometry (i.e. layout macro). This is the case when we use the existing shapes of the ADS libraries (for example, the Microstrip library).

When we want to create arbitrary parameterized geometry, we use the Graphical Cell Compiler (GCC). This ADS feature allows the user to define variables, associate variables to any geometry dimension and automatically create a parameterized layout macro without writing any code.

3.3 Electromagnetic Simulations

As mentioned above, all of the electromagnetic simulations are run in batch mode. For each simulation, we get a dataset containing the [S] parameters.

3.4 ‘Data Access Component’ (DAC)

To access this datasets from the circuit page, we will use an ADS component called ‘Data Access Component’ (DAC).

By specifying the value of the parameters on the schematic page (W1, W2 and S in our coupled-line example), we can use the corresponding EM simulation result with the circuit simulator.

3.4.1 Compilation

To allow the [S] parameter interpolation and increase simulation speed, the ‘datasets’ are compiled in a unique file (format “S2PMDIF”) which is the kernel of our EM Model.

In our coupled-lined example, we access the [S] parameters through a DAC dedicated to two ports elements called S2PMDIF. This design is our model and allows [S] for parameter interpolation (Fig. 5).

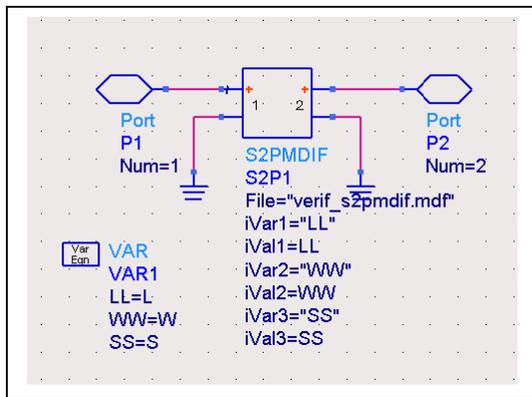


Figure 5: [S] parameters access through S2PMDIF

3.4.2 Symbol creation and parameter definition

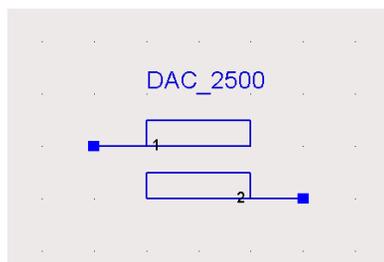


Figure 6 : Symbol example.

We associate a symbol, which will represent the EM model in the top-level schematic (Fig. 6), and define parameters corresponding to the geometry parameters (Fig 7).

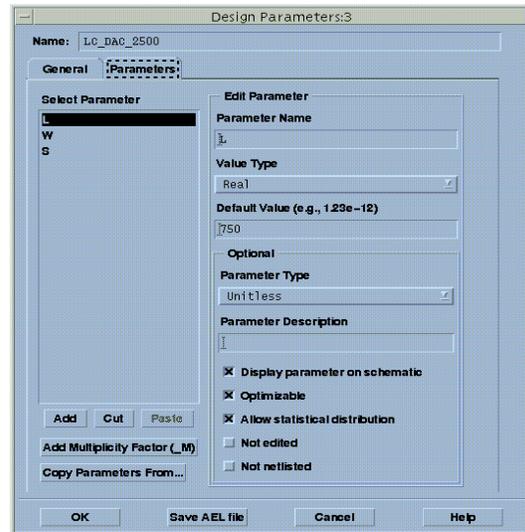


Figure 7 : Parameters definition

4. Example: 41.8 GHz Microstrip Coupled - Line Filter.

We describe here how to use the models created in section 3, and we compare the results with full EM simulation.



Figure 8 : Filter Topology

- Substrate Permittivity : $\epsilon_r=3.38$
- Substrate Height : 8 mils

4.1 Circuit Simulation based on the new E.M models

The filter (symmetrical) is based on 13 models:

- 2 access lines at the input and at the output (Fig. 9).
- 5 identical transmission lines
- 6 coupled lines with different gaps: S1=152 μ m, S2=254 μ m et S3=279 μ m.



Figure 9: Access Lines

The [S] parameter simulation is setup in the ADS schematic (Fig. 10).

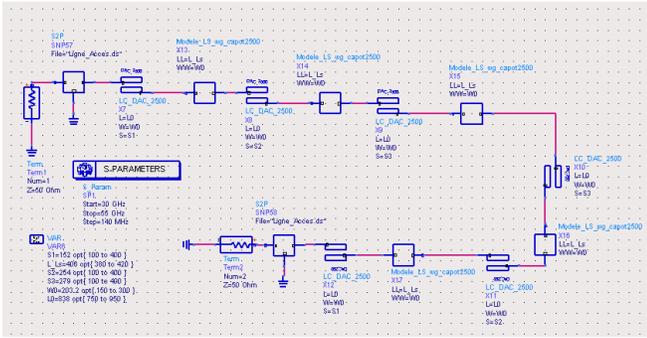


Figure 10: Use of E.M based models in the ADS schematic.

4.2 Comparison with a full electromagnetic simulation

The whole filter has been simulated with Momentum in a 100 mils by 100 mils waveguide; it takes 30 minutes per frequency point to solve this filter on a Pentium III platform (Fig. 11).

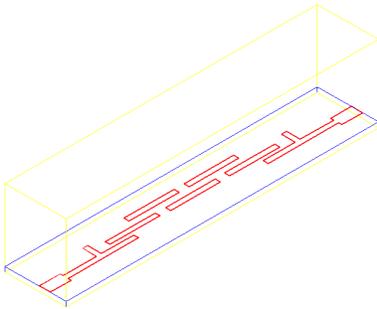


Figure 11: The filter simulated with Momentum

We obtain very similar results with EM based models compared to the Momentum simulation (Fig. 12). The small differences come from the [S] parameter interpolation and from coupling between elementary components. But with EM models, it takes only 30 seconds to simulate the filter over the complete frequency range on the same Pentium III platform.

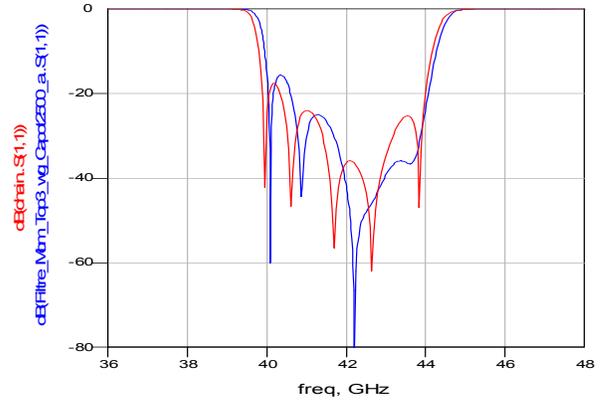
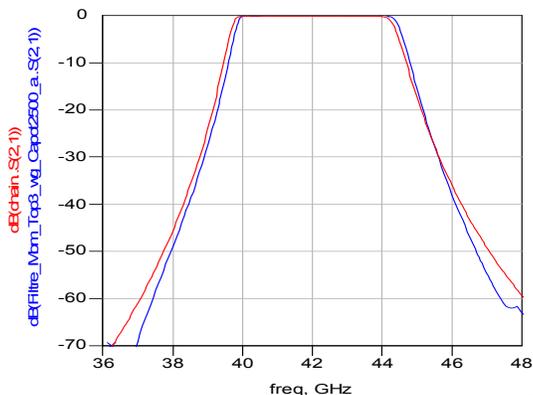


Figure 12: Comparison between EM model simulation (Red), and Momentum simulation (Blue).

5. Conclusion

Comparison for several microwave filter topologies shows a very good agreement with measurements. This new EM model methodology has tremendous advantages for the designer:

- 1) This methodology allows the designer to optimize passive structures and gain a considerable amount of time in the design phase compared to a pure electromagnetic approach. We have typically reduced our development time by a factor of 5.
- 2) This methodology provides a level of accuracy that is an order of magnitude better than any analytical models available in any commercial microwave design software.
- 3) This methodology could be applied to other technologies (Stripline, Coplanar, LTCC, and Board...) and is not limited to pre-defined geometries.

References

- [1] *Thales Communications*, Amelioration de modèles pour simulations et optimisation de filtres hyperfréquences gravés à lignes couplées, Bruno Bazire, Septembre 2001.
- [2] *Agilent Technologies*, ADS 2001 User Guide

For more information about Agilent EEsof EDA, visit:

www.agilent.com/find/eesof



Agilent Email Updates

www.agilent.com/find/emailupdates
Get the latest information on the products and applications you select.



Agilent Direct

www.agilent.com/find/agilentdirect
Quickly choose and use your test equipment solutions with confidence.

www.agilent.com

For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

www.agilent.com/find/contactus

Americas

Canada	(877) 894-4414
Latin America	305 269 7500
United States	(800) 829-4444

Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Thailand	1 800 226 008

Europe & Middle East

Austria	0820 87 44 11
Belgium	32 (0) 2 404 93 40
Denmark	45 70 13 15 15
Finland	358 (0) 10 855 2100
France	0825 010 700*
	*0.125 €/minute
Germany	01805 24 6333**
	**0.14 €/minute
Ireland	1890 924 204
Israel	972-3-9288-504/544
Italy	39 02 92 60 8484
Netherlands	31 (0) 20 547 2111
Spain	34 (91) 631 3300
Sweden	0200-88 22 55
Switzerland	0800 80 53 53
United Kingdom	44 (0) 118 9276201

Other European Countries:

www.agilent.com/find/contactus

Revised: March 27, 2008

Product specifications and descriptions in this document subject to change without notice.

© Agilent Technologies, Inc. 2008

Printed in USA, February 01, 2002
5989-8992EN



Agilent Technologies