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Design of an Asymmetric branch-line coupler Using Implicit Space Mapping

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Abstract*:* The design of microwave coupler is widely studied in the literature and gets adequate design for all frequency bands imposed. In this article, we present the application of the new technique recently developed and which was initiated by Bandler, the Implicit Space Mapping (ISM) to overcome the heavy and time-consuming task that follows the design of microwave components using a theoretical study. The application of ISM algorithm contributed to the optimization of asymmetric branch-line coupler whose theoretical development is very complex. The different phases of the simulation are also presented to demonstrate the robustness and effectiveness of this technique. The appropriate simulation software is Agilent ADS.

Key words : Branch-line Coupler, Optimization, Coarse Model, Surrogate Model, Implicit Space Mapping.

INTRODUCTION

The microstrip directional couplers have been widely used in microwave systems in mobile satellite communications, in radar systems and antennas. They are the basis of the quality and performance of all circuits due to their characteristics to be adapted to four ports. They can provide a variety of functions, such as power divider, matching between the inputs and outputs of the balanced amplifiers ensuring isolation and introducing the phase in a number of applications [1].

The four-port couplers are used with active or passive components, additional matching circuits are necessary to obtain the desired output performance. If they can be terminated in arbitrary impedances, no matching circuit is required and the total size of microwave integrated circuit can be reduced. For this purpose the first asymmetric couplers four ports were suggested by Ahn et al [2]-[5]. Compared to symmetric couplers, they have a very complex theory, their designs are very strict and their optimizations are very tedious. Due to the evolution of computer-aided design methods, optimization has become a widely used technique for the microwave circuits design. Also is it possible with the theory largely developed in the literature to design a suitable design for any application, in accordance with imposed specifications. However the most complicated and time-consuming phase is the optimization phase. Several optimization algorithms have been successfully applied to the synthesis of passive components, but their disadvantage is the time allocated to the simulation becoming very exhaustive, which has encouraged the scientific community to focus its research to adapt optimization algorithms which consume less in terms of computing time. In this paper, we present the application of one of the latest developments of optimization algorithms in microwave planar topology, called Implicit Space Mapping (ISM) [6]-[8], it is a non- linear optimization, this technique was introduced by Bandler [9]-[10]. This algorithm through its non-linear optimization achieves the objectives in minimum time. Similarly, we propose structures branch-line couplers but with different terminations, which further complicates the theory couplers developed in the literature, then this structure is optimized by the ISM technique, we present the basic concept of this technique and we describe the details of its implementation for the structure optimization using the Agilent ADS software [11].

ISM CONCEPT

ISM theory has been extensively developed in the literature [6]-[10], in this paper, the concept allows to implement the use of this technique is presented; the basic simulation tool is ADS and ADS Momentum software. The distinguishing feature that leads to the success of SM is that it allows at a complex electromagnetic model called "Fine Model" an effective optimization using an adaptation with a model based on the circuits theory called "Coarse model" with a rapid iteratively optimization. The original SM algorithm is proposed in 1994. In this algorithm a linear mapping is assumed between the space of "Coarse" and "Fine" parameters model. The least squares solution of the linear equation is used to associate the correspondence points between the two spaces [12]. The Implicit SM (ISM) algorithm is based on the idea of assigned parameters, in this method; a set of auxiliary parameters is extracted to fit the coarse model at the Fine model, while the coarse model is calibrated by the parameters and re-optimized to predict the best Fine model. ISM is a simple and effective approach SM, it integrates its mapping in the coarse model, and it automatically adjusts it in the extraction parameter process [13]-[16].

U is defined as a minimax objective function with upper and lower specifications. Figures 1 and 2 illustrate the general concept of spatial mapping technique for direct implantation of electromagnetic solvers.

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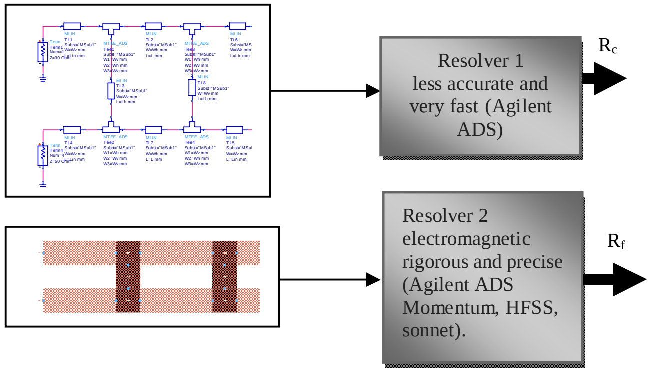

Fig 1: the necessary resolver at ISM technical

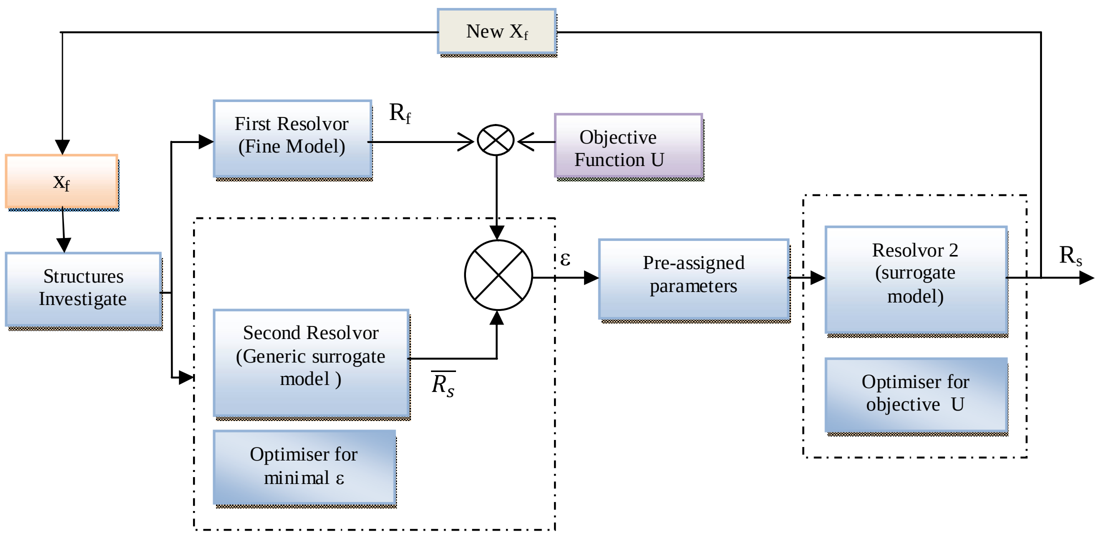

Fig 2: Graphical representation of the ISM concept

RESULTS

The structure of the branch-line coupler is shown in Figure 3, the specifications for the optimization are given as follows, and the termination impedances are different values such as 30Ω, 60Ω, 40Ω and 50Ω:

$$For\ 5GHz \leq f \leq 5.8GHz\ and\ 6.2GHz \leq f \leq 7.5GHz \begin{cases} -20dB \leq S_{11} \leq -10dB \\ -20dB \leq S_{14} \leq -10dB \end{cases}$$

$$For\ 5.8GHz \leq f \leq\ 6.2GHz \begin{cases} -40dB \leq S_{11} \leq -35dB \\ -35dB \leq S_{14} \leq -25dB \end{cases}$$

$$For\ 5GHz \leq f \leq 7.5GHz \begin{cases} -10dB \leq S_{12} \leq 0dB \\ -10dB \leq S_{13} \leq 0dB \end{cases}$$

The substrate used is FR4 with permittivity ε_r = 4.3, the height h=1.5mm, the loss angle tgα= 0.0004 and the metal is copper, its thickness is T = 35µm.

The vector to be optimized is $X = [W_h W_v\ L\ L_{in}]\ in\ \ mm.$

$X^{(0)} = [5\ 5\ 15\ 15]\ in\ mm$

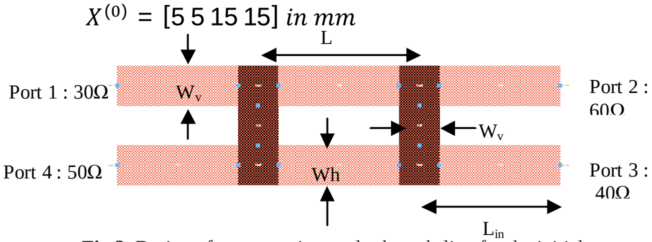

Fig 3: Design of asymmetric coupler branch-line for the initial vector

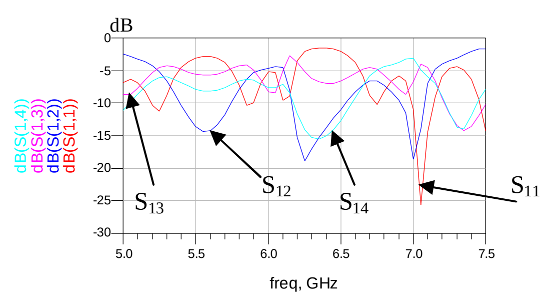

Fig 4: Different S_{ij} coupler parameters simulated with ADS Momentum for the initial value of the vector X

The results in Figure 4 show that the initial solution does not meet the specifications imposed above. The use band [5.8-6.2] GHz, the reflection coefficient S_{11} is around -2.5dB, the direct coupling S_{12} is attenuated at -15dB and isolation S_{14} is about -6.5dB, and except S_{13} coupling that meets the requirements of the specifications and has a value of -5.1dB. For the first ISM optimization technique, the results presented in Figure 5 occur tracking objectives during optimization.

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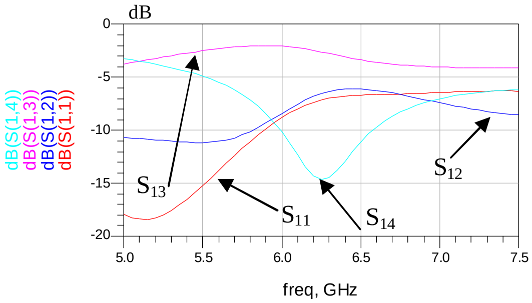

Fig 5: Various S_{ij} coupler parameters simulated with ADS Momentum for the optimized value of the vector X in the 1st iteration.

The optimized vector *X* at the first iteration is given by:

$$X^{(1)} = [0.86\ \ 1.49\ \ 6.07\ \ 6.24]\ in\ mm$$

At the sixth iteration, the optimized vector responds well the specifications:

$$X^{(6)} = [0.94\ \ 0.45\ \ 15.18\ \ 19.5]\ in\ mm$$

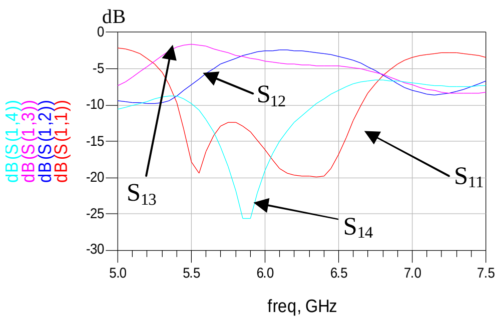

Fig 6: Different parameters S_{ij} coupler simulated with ADS Momentum for the value of the vector *X* optimized at the sixth iteration

In Figure 6, the reflection coefficient S_{11} is less than -10 dB in the use band, the S_{14} represents isolation is very satisfactory and reaches -30db, the coupling parameters S_{12} and S_{13} are -3dB, the designed coupler distribute power on both channels in an equitable way. Figure 7 shows the phases of the branches 2 and 3, the phase difference is 90 degrees. Figures 8 and 9 present respectively the design of asymmetric coupler with optimized ADS Momentum and coupler photo fabricated with the technical characteristics of the substrate and the optimized dimensions vector.

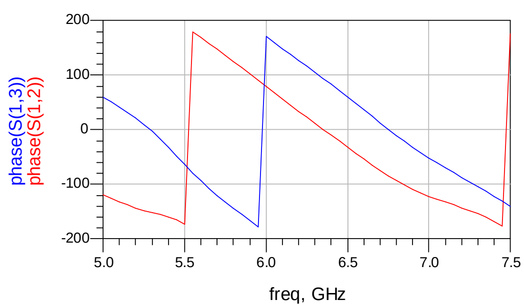

Fig 7: Phases of channels : direct 2 and coupled 3

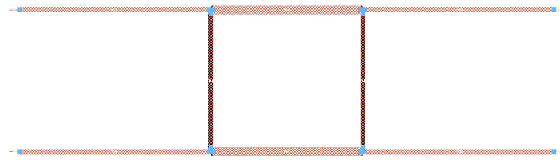

Fig 8: Final design of the asymmetric branch-line coupler for the optimized vector X

Fig 9: Photo of the asymmetric coupler fabricated with optimized dimensions

CONCLUSION

The concept of implicit space mapping for design optimization was presented. ISM is intended to simplify the design process. This technique was successfully applied to model a branch-line coupler and optimizing its design parameters, with substitution the 'Fine' model time-consuming calculation by the 'Surrogate' model, which should be quick and valid in a wide range of parameters. ISM algorithm improves the efficiency of the optimization with a much reduced computation time. The conception of an asymmetric coupler showed the robustness of the ISM method.

REFERENCES

[1] T serng, H. Q., and S. R. Nelson,"5-18 GHz, 3dB Hybrid couplers," Electrics Lett., vol. 17, 1981, pp. 258-259.

[2] H.-R. Ahn, I.-S. Chang, and S.-W. Yun, Miniaturized 3-dB Ring Hybrid Terminated by Arbitrary Impedances, *IEEE Trans. Microwave Theory Tech.*, Vol. 42, pp. 2216–2221, December 1994.

[3] H.-R. Ahn, I. Wolff, and I.-S. Chang, Arbitrary Termination Impedances, Arbitrary Power Division and Small-Sized Ring Hybrids, *IEEE MTT-S Dig.*, pp. 285–288, June 1997.

[4] H.-R. Ahn, I. Wolff, and I.-S. Chang, Arbitrary Termination Impedances, Arbitrary Power Division and Small-Sized Ring Hybrids, *IEEE Trans. Microwave Theory Tech.*, Vol. 44, pp. 2241–2247, December 1997.

[5] H.-R. Ahn and I. Wolff, Asymmetric Four-Port and Branch-Line Hybrids, *IEEE Trans. Microwave Theory Tech.*, Vol. 48, pp. 1585–1588, September 2000.

[6] J.W. Bandler, Q.S. Cheng, N.K. Nikolova and M.A. Ismail, "Implicit space mapping optimization exploiting preassigned parameters", *IEEE Trans Microwave Theory Techniques*, Vol. 52, pp. 378–385, 2004.

[7] S. Koziel, J.W. Bandler, and K. Madsen, A spacemapping framework for engineering optimization Theory and implementation, IEEE Trans Microwave Theory Tech 54, pp. 3721–3730. 2006.

[8] Fuqun Zhong, Bo Zhang, Yong Fan, Minghua Zhao and Guan Gui, "Application of Implicit Space Mapping in the Design of Hammerhead Filter in Millimeter-Wave Band", Research Journal of Applied Sciences, Engineering and Technology, pp. 670-674, March 15, 2012.

[9] S. Koziel* and L. Leifsson, "Low cost parameter extraction and surro-gate optimization for space mapping design design using EM-Based coarse models", Progress In Electromagnetics Research B, Vol. 31, pp.117-137, 2011.

[10] Bandler, J. W., Q. S. Cheng, S. A. Dakroury, A. S. Mohamed, M. H. Bakr, K. Madsen, and J. Sondergaard, "Space mapping: The state of the art," *IEEE Trans. Microwave Theory Tech.*, Vol. 52, No. 1, pp.337-361, Jan. 2004.

[11] Agilent ADS, Version 2008, Agilent Technologies, 1400 Fountaingrove Parkway, Santa Rosa, CA 95403-1799, 2008.

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[12] J.W. Bandler, R.M. Biernacki, S.H. Chen, P.A. Grobelny and R.H. Hemmers, "Space mapping technique for electromagnetic optimization", *IEEE Trans. Microwave Theory Techniques*, Vol. 42, pp. 2536–2544, 1994.
[13] Q.S. Cheng and J.W. Bandler, "An implicit space mapping technique for component modeling", Proc 36th European Microwave Conf, Manchester, UK, pp. 458–461, 2006.
[14] Qingsha S. Cheng,John W. Bandler,and Slawomir Koziel, "A Simple ADS Schematic for Space Mapping", 2009 IEEE MTT-S International Microwave Workshop Series on Signal Integrity and High-Speed Interc. (IMWS2009-R9), pp.35-38 , Guadalajara, Mexico, Feb. 19-20, 2009.
[15] Tavakoli S, Zeinadini M, Mohanna Sh. Modelling and design of microwave devices using space mapping techniques. Canadien Journal on Electrical and Electronics Engineering Vol.1, N° 5, pp 116-120, September 2010.
[16] Bri S., Saadi A., HABIBI M. « Microwave Filters Design Optimisation by Implicit Space Mapping Technique » , Inter. Journ. Of Emmer. And Tren. in Engineering and Development (rs publication), pp 367-379, Issue 2 vol. 7, November 2012.