Parametric interconnect modeling using the IBM EIP tools

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Abstract

Mathematical models for electrical interconnect networks are a key enabling factor for rapid and reliable design of next-generation electronic systems. In this note we show how to construct accurate macromodels with some free parameters related to the interconnect geometry, suitable for fast and automated optimization of electronic systems. The proposed approach combines the electromagnetic solvers of the IBM EIP Suite with a state-of-the-art algorithm for parametric models construction.

Structure description

Moving parts are very common in many electronic equipments, like notebooks, digital cameras, cellphones. The interconnect we consider is inspired to the flexible cables typically found in these devices to connect the main body with the moving part [1]. The cross section is depicted in Fig.1, and shows two signal lines in the middle of a uniform dielectric. Two reference conductors are present on the right and left side of the signal lines. The separation between adjacent lines is 100 um, while the distance from the upper and lower ground planes is 50 um. The metal layers are 17.5 um thick and the total line length is 5 cm.

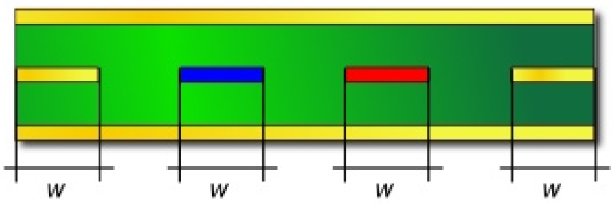

Figure 1: Cross section of the flexible cable

Our aim is to create a compact macromodel for this structure parameterized by the conductors width *w*, which is variable in the range 70 -- 130 um. The delivered macromodel will therefore be suitable for very efficient analysis and optimization of the effect of *w* on the performance of a flexible cable.

Methodology

The proposed methodology consists of two main steps: the computation of the scattering parameters of the line for various parameter values, and the construction of the final parametric model.

The first task is accomplished with the CZ2D planar solver from the IBM EIP tools suite [4], computing the S parameters of the line from 1 kHz up to 10 GHz. for width values from 70 um up to 130 um at steps of 5 um. In order to generate all responses in an automatic fashion, we take advantage of the Advanced Model Creator program (AMOC) included in the suite that provides a unique framework for modeling and simulation with scripting facilities, very useful to perform a sequence of simulations with variable parameters.
Then, we apply the parametric modeling algorithm proposed in [2,3] in order to generate a model for the line parameterized by the width *w*. Among the available responses, we use those for *w* = 70, 85, 100, 115, 130 um for the parametric model construction. The other data serve instead as reference values to assess the final model accuracy for intermediate values of *w*.

Results

We evaluate now the accuracy of the so obtained parametric model, that has order 28. The numerator coefficients are quadratic functions of the parameter *w*, while the denominator coefficients are linear in *w*. Figures 2 and 3 depict the real and imaginary part of the reflection coefficient as function of the conductors width w. In the figures, both the raw scattering data obtained from the EIP solver and the corresponding model response are depicted. A very good match can be observed for all values of width considered, showing the excellent accuracy reached by the computed model. The full behavior of the reflection coefficient with respect to frequency and width is instead shown in Fig.4.

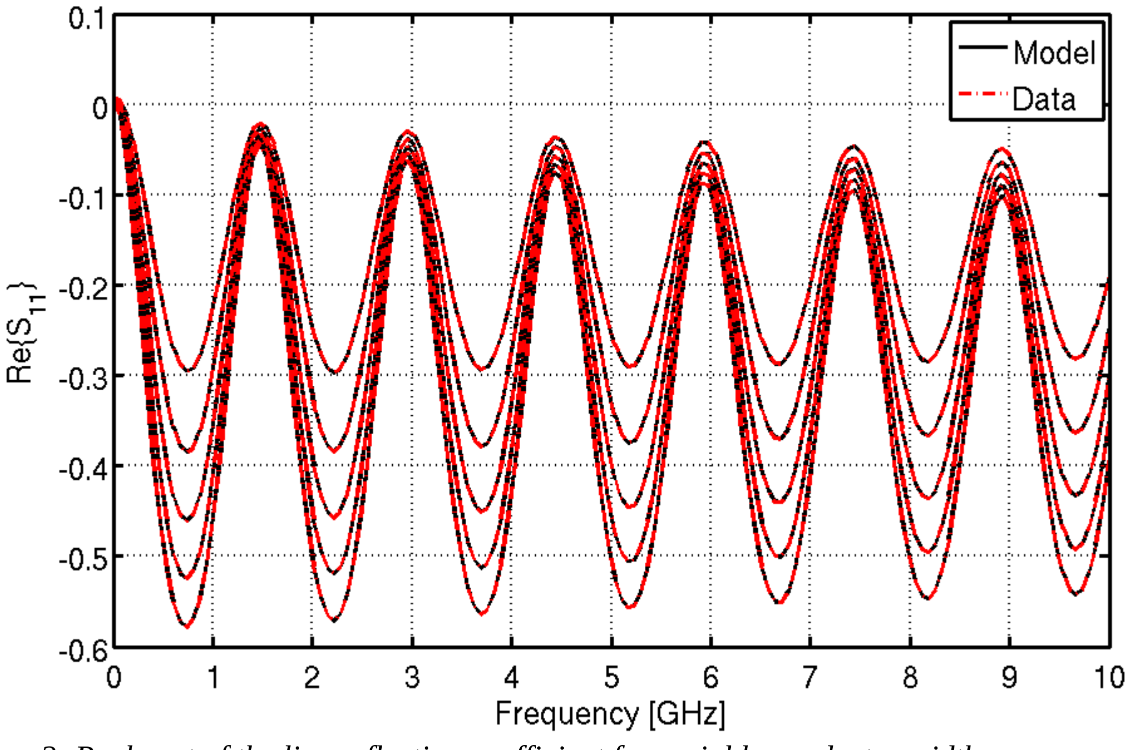

Figure 2: Real part of the line reflection coefficient for variable conductor width w.

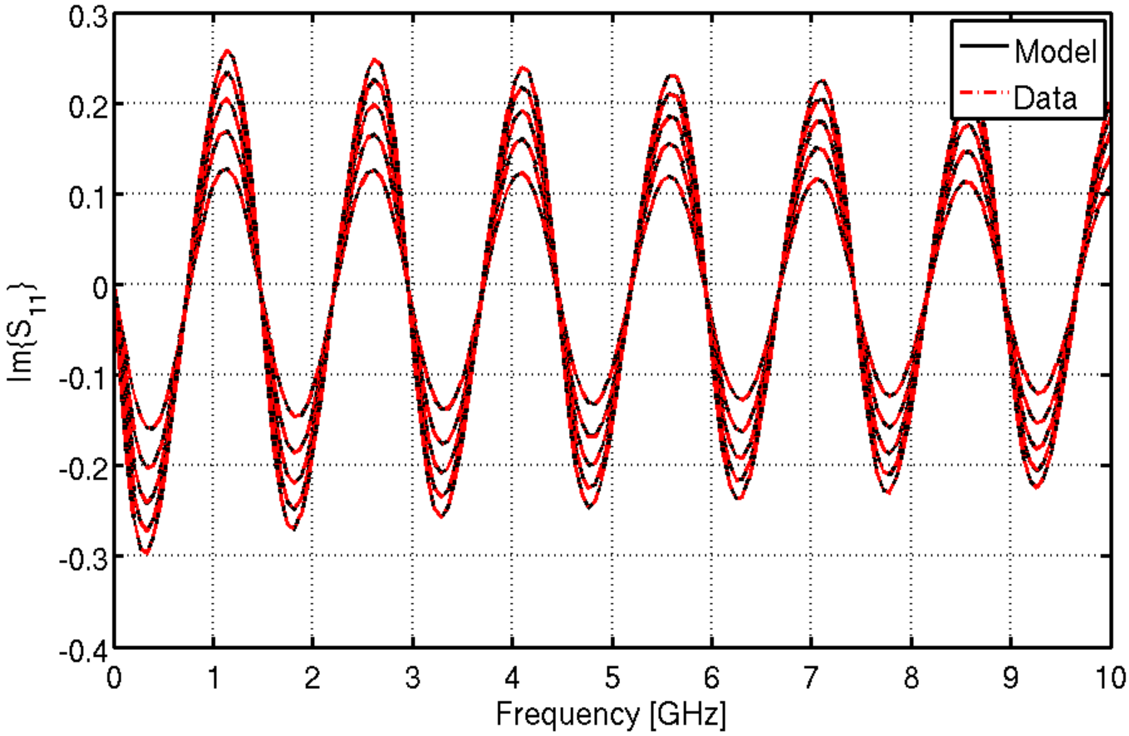

Figure 3: Imaginary part of the line reflection coefficient for several values of conductors width w.

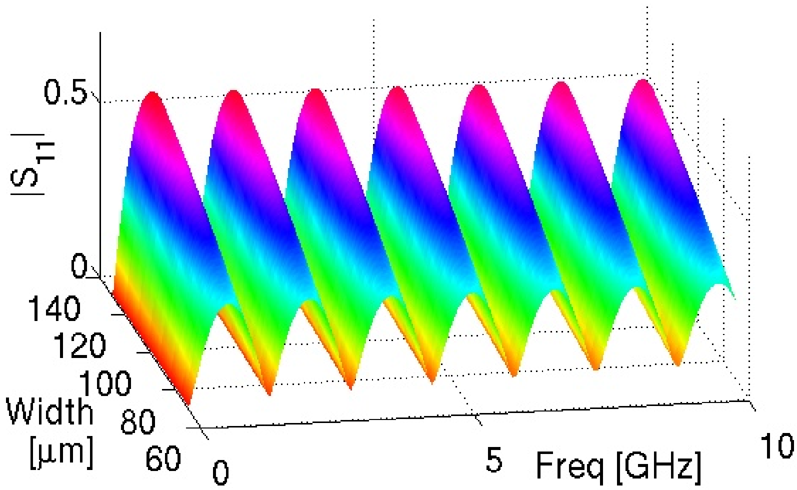

Figure 4: Magnitude of the line input coefficient with respect to frequency and conductors width.

Figure 5 refers instead to the line transmission coefficient magnitude. The excellent accuracy shown by the figures is futher confirmed by the fact that the maximum model to data error among all elements of the S matrix is below 1.4 x 10^{-3}, uniformly with respect to frequency and width.

Since the computed model can be easily cast to an equivalent circuit, it can be used in any simulation tool available on the market to represent very faithfully the flexible cable under consideration. The free parameter *w* is a key feature that enables, with respect to standard models without free parameters, the model reuse in different designs, as well as the fast evaluation and optimization of the interconnect performance with respect to its width.

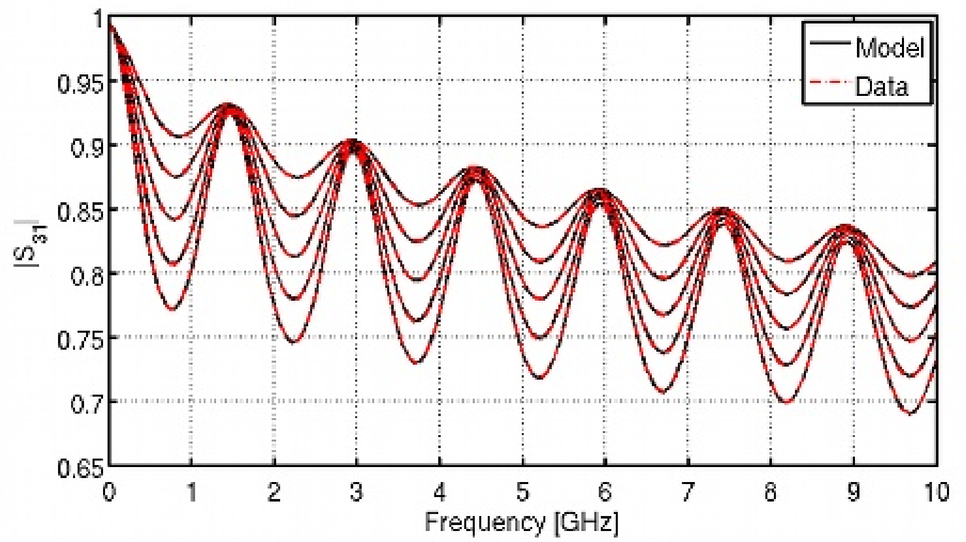

Figure 5: Magnitude of the line transmission coefficient.

Conclusion

In this note we have shown how the IBM EIP solvers and a recently proposed algorithm can be combined to produce very accurate parametric models for interconnect elements. In these models some key design parameters, like geometrical dimensions or material properties, are still accessible to the designer after model creation. This unique feature is of paramout importance in sensitivity, what-if analyses, and automated optimizations of electrical interconnects.

References

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[2] P. Triverio, M. Nakhla, S. Grivet-Talocia, "Parametric Macromodeling of Multiport Networks from Tabulated Data" , *IEEE 16th Topical Meeting on Electrical Performance of Electronic Packaging (EPEP 2007)*, Atlanta (GA), USA, pp. 51-54, October 29-31, 2007

[3] P. Triverio, S. Grivet-Talocia, M.S. Nakhla, "An Improved Fitting Algorithm for Parametric Macromodeling from Tabulated Data" , *Proc. Of 12th IEEE Workshop on Signal Propagation on Interconnects*, Avignon, France, May 12-15, 2008

[4] IBM Electromagnetic Field Solver Suite of Tools, available online at: *http://www.alphaworks.ibm.com/tech/eip*