Speeding Up 3D EM Simulation

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CST DESIGN STUDIO&#153 is a new electromagnetic simulation tool for an efficient design of complex and highly resonant structures. By splitting the complex system into smaller components, each described by its S-matrix, the complete system's behavior can be quickly analyzed. While a complete 3D simulation of the whole system sometimes requires a long analysis time, this new technique provides the same accuracy as a 3D simulation but in a fraction of the time. What makes CST DESIGN STUDIO&#153 of particular interest, is its ability to consider higher order mode coupling between the subcomponents, so that the structure can be divided in smaller parts without any loss of accuracy.
The accurate analysis and design of passive high frequency filter circuits is a demanding task since both, geometry and material properties become more and more complex. Conventional circuit simulators using analytic library elements as well as specialized internal EM simulators are fast, but, if details such as consideration of skin effect losses or complex curvatures of materials are of importance, the accuracy of their results will quickly be compromised.
The CST MICROWAVE STUDIO&#153 electromagnetic simulation package overcomes these limitations by its ability to solve Maxwell's equations for arbitrary geometries, including sophisticated material models. Of course, compared to standard circuit simulations, the wide application range and accuracy of such simulators have to be paid for with longer analysis times. However, in combination with CST DESIGN STUDIO&#153 this disadvantage is counteracted.

Application Example

The diplexer structure, discussed in this article, consists of two bandpass filters (Figure 1). In order to predict the complete electromagnetic behavior including skin effect losses and curvatures, the highly developed features of a 3D simulation tool are required. Furthermore a very fine discretisation around the metal foils is indispensable, especially to accurately predict the passband's edge frequencies. Therefore, more than a hundred thousand single mesh elements, considerably varying in size (high aspect ratio) are required in order to model the device accurately. Although the geometry looks quite simple, the electromagnetic complexity of this highly resonant system and the described mesh requirements qualify it as an ideal benchmark candidate for the comparison of simulation engines.

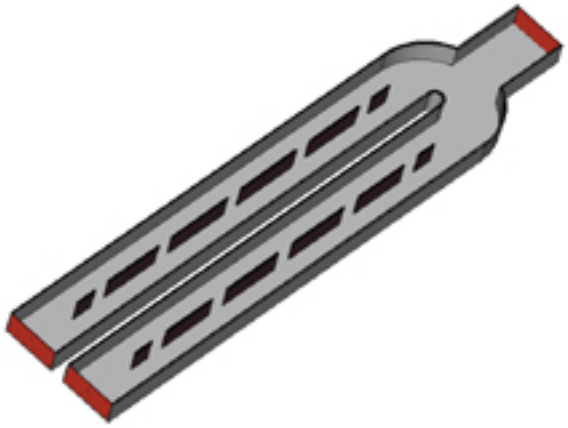

Figure 1: Geometry of the high frequency bandpass structure. In CST MICROWAVE STUDIO&#153 both the metal foils and the waveguide cover can be analyzed as a finite conductor under the influence of skin effect losses.

Various simulation methods behave significantly different with respect to the numerical effort, especially when attacking larger numbers of mesh elements. Implicit algorithms (e.g. all methods, calculating a problem in the frequency domain) behave in a strongly non-linear way (in computer resources) with increasing problem sizes, whereas explicit algorithms such as the FDTD and FIT method can handle large problems within a reasonable memory size.

Here, the simulation of the complete diplexer using CST MICROWAVE STUDIO&#153 is shown (Figure 2), a simulator based on the Finite Integration (FI) method. The advantage of CST MICROWAVE STUDIO&#153 compared to conventional time domain codes is the precise geometrical representation even of curved shapes, achieved by the Perfect Boundary Approximation&#153(tm) (PBA). This method avoids staircase approximation of curved structures, without giving up any advantages of the explicit time integration algorithm. Despite the outstanding speed and memory efficiency of CST MICROWAVE STUDIO&#153, compared to other 3D EM Simulators on the market, the complete 3D simulation of the 2-arm diplexer takes a few hours on a standard desktop PC, so that advanced design strategies, including parameter sweeping and optimization runs, are not practical.

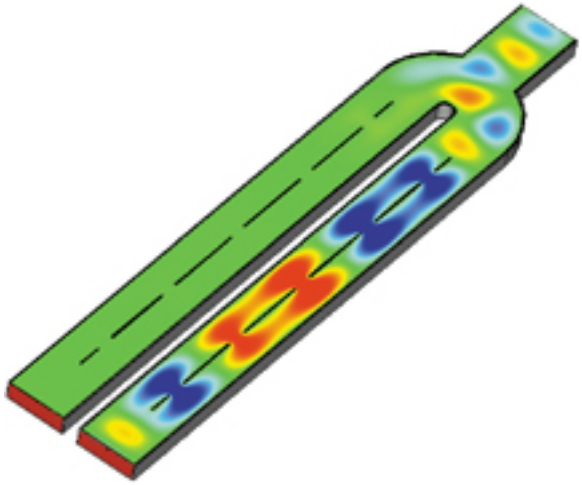

Figure 2: Strength of the electric field value at a frequency, perfectly passing through one arm and stopped in the other arm. The simulation is performed with CST MICROWAVE STUDIO

Technology

At this point the benefit of the new program CST DESIGN STUDIO becomes obvious:

its ability to speed up the described simulation without losing accuracy. CST DESIGN STUDIO reaches this goal by splitting up a complex system into smaller components, described by component S-matrices. Taking into account higher order modes in the S-matrix description, the structure can be dissected even at locations where the fundamental mode alone is not sufficient to describe the electromagnetic coupling accurately.

Particularly for resonant structures the gain in simulation time can be dramatic: the structure can be split up into non-resonant parts, which are then analyzed much faster than structures with multiple narrow spaced resonances. In addition, time domain simulators such as CST MICROWAVE STUDIO have the possibility of speeding up a simulation by increasing the simulation bandwidth, therefore using a shorter stimulation pulse.

CST DESIGN STUDIO is a package of high functionality which interfaces to different simulators or even measurement data, so that each component can be analyzed with the simulator best suited to the particular component. Furthermore, analytic models and/or libraries are available, which again speeds up the daily design work. The intuitive and easy to use interface is based on the latest software technology (Figure 3). This enables the user to build up clear schematic drawings of complex structures and circuits, keeping a clear overview by adding text and graphic elements.

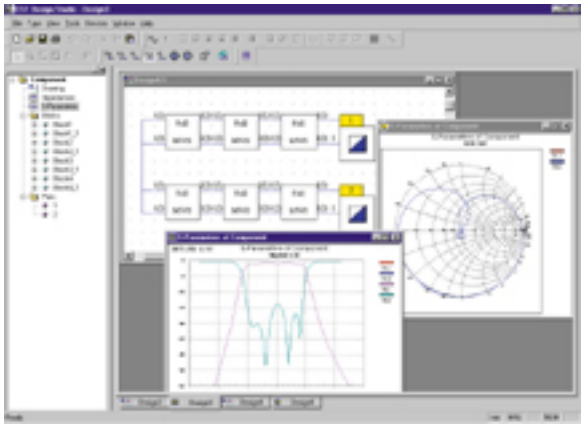

Figure 3: User Interface of CST DESIGN STUDIOtm>. The diplexer is split into smaller subcomponents. Taking into account higher order mode coupling between the components ensures highly accurate simulation results md> more than 10 times faster, compared to the conventional 3D simulations.

CST DESIGN STUDIO is a new tool for the fast design of passive high frequency devices. Even highly resonant structures can be split into non-resonant sub-components.

The new approach is capable of taking skin effect losses as well as arbitrary curved structures and boundaries into account. Since the simulation time is reduced significantly compared to conventional tools, CST DESIGN STUDIO now even allows full parameterization and optimization studies for complex systems, while maintaining all required accuracy.

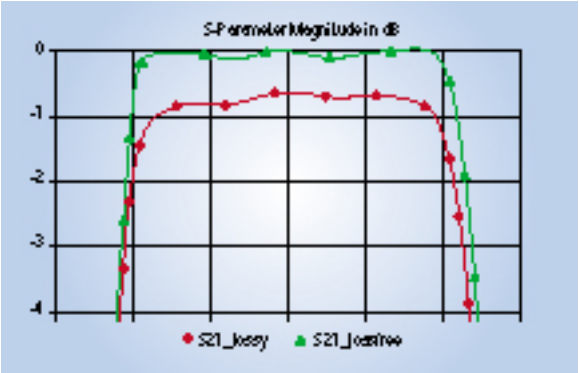

Figure 4: S21-parameter as a function of frequency. Due to its tight integration with CST MICROWAVE STUDIO, all advantages of this general purpose EM tool are maintained in CST DESIGN STUDIO. As shown, the pass band transmission is reduced by more than 0.5 dB when considering skin effect losses.

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