cover story

Open Architecture Solves
Large 3D Puzzles

Version 2.0 of CST's Design Studio modeling environment allows the seamless interaction of any number of solvers and simulation tools, as well as models and test data.

higher speeds and increasingly complex designs are blurring traditional boundaries between system modeling approaches. Complex computations are often best-solved by breaking them into a series of related, smaller problems. That is the approach used in Version 2.0 of the CST Design Studio (CST DS) from CST (Wellesley,

MA), an open design environment that allows a variety of electronic-design-automation (EDA) tools to be applied to different parts of circuit and system models. With the open environment, a design engineer is free to choose the most-appropriate solvers available, regardless of the simulation method or supplier.

The open environment also makes it possible to take advantage of available expertise, enabling integration of solutions from measurements, empirical approaches, analytic or semi-analytic methods, or solutions from numeric solvers of any kind. The CST DS supports the seamless integration of these different techniques within a single unifying framework.

The framework enables the creation of reusable parts with its fully parameterized, user-extendable and user-definable library of elements and blocks. When a numerical simulation is performed, it is stored for future refer-

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ence in a data base. If the required solution for a particular parameter set is not available when a simulation is performed, a new simulation will be launched. Any number of solvers can be made available for a simulation, with the fastest and most appropriate solver used for all of the constituent parts of a system. The fully parameterized parts offer an easy route to optimization and parameter studies.

CST DS makes full use of a Visual Basic for Applications (VBA)-compatible macro language. An integrated VBA interface builder (including a VBA editor and macro debugger) enables effective customization of the software. CST DS features a native graphical user interface (GUI) based on Microsoft Windows 95/98/NT/2000. In particular, the component-object-model (COM) interface enables seamless integration of a variety of software tools, including Matlab and Microsoft Excel, or even specialized proprietary tools. CST DS can be used as an object-linking-and-embedding (OLE) client, as well as an OLE server (allowing CST DS to steer or be steered by other OLE-compatible programs).

Analysis Approach

The analysis approach of CST DS is simple. The software allows an electromagnetic (EM)-based system to be broken down into smaller components known as blocks, each described by its own (generalized) scattering (S) matrix. The S-matrix data can originate from a variety of sources, including generalized S-matrices from CST Microwave Studio (CST MWS) which is tightly integrated with CST DS, solutions from other simulators, such as the EM suite of programs from Sonnet Software (Liverpool, NY), or files from other programs, such as Touchstone.

CST DS can also take into account higher-order modes or mode coupling, even for evanescent modes in waveguide systems. The partitioning of complex three-dimensional (3D) structures, even those with strong field coupling such as filters, is now feasible with CST DS, since all the required modes are coupled and the achievable accuracy is high.

In breaking large structures down into smaller parts, the memory requirements and simulation time (for the smaller portions) for most of the numerical field solvers are reduced considerably. This approach can be particularly advantageous for solvers based on the finite-element method (FEM) or the method of moments (MOM) where memory-hungry solvers can be kept in check—even for large overall systems. The memory usage of the Finite Integration Technique (FIT) solver used in CST MWS is more modest and scales linearly with the number of elements used for the
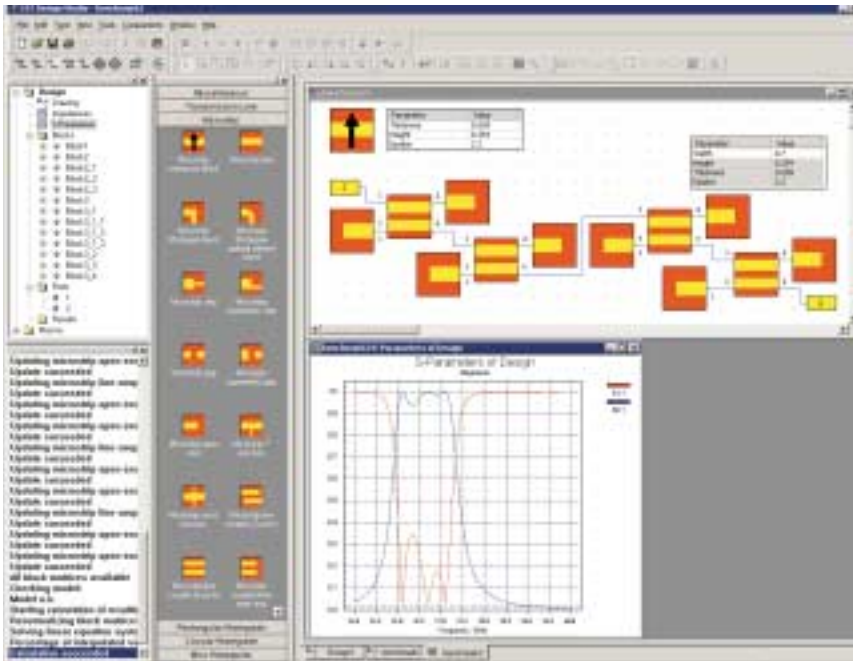
1. Using the reference-block capability of CST DS, the key parameters of a microstrip filter can be set globally, with the highlighted parameter (the width of a single stripline) controlled individually.

2. This microstrip patch antenna includes a patch-antenna array and associated feed network. It can be broken into smaller parts to simplify simulation.

discretization of a 3D geometrical model. However, there is still a large advantage to concentrating an optimization on only a small part of a structure rather than resimulating the whole system for each new optimization parameter.
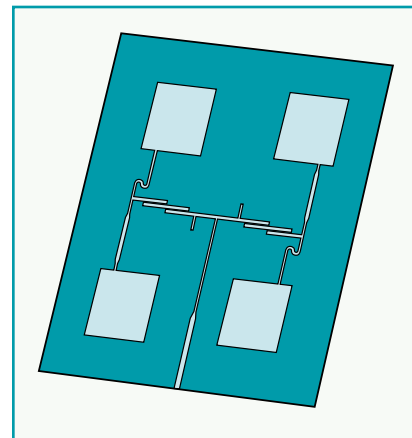
Parameter Sweep

Version 2.0 of CST DS features improvements in all aspects of the code. The software now features a quasi-Newton-type optimizer, which enables a faster approach to an optimum solution over the conventional steepest-descent approach. Integration of the "parameter sweep" technique is also greatly improved compared to Version 1.0, making parameter studies of an arbitrary number of variables much more straightforward.

"Blocks" are the fundamental elements used in CST DS to design a system. The range of these blocks has been significantly extended in Version 2.0 by the inclusion of predefined library elements. A block can be a parameterized model of a structure that will be solved numerically in 3D, or it can be a third-

party solution from another simulator. A block can also be based on measurements from a vector-network analyzer (3D) or tables of S-parameter data.

The library of available elements is greatly augmented by access to CST MWS blocks. The results for all previously used parameter sets are stored in a data base so that only new parameter sets require new numerical simulations. This "solver-on-demand" approach and re-use of existing data cuts down central-processing-unit (CPU) requirements considerably.

One of the new elements is the De-embedding Block. Using it, a user is allowed to ignore arbitrary circuit parts, in particular the influence of connectors
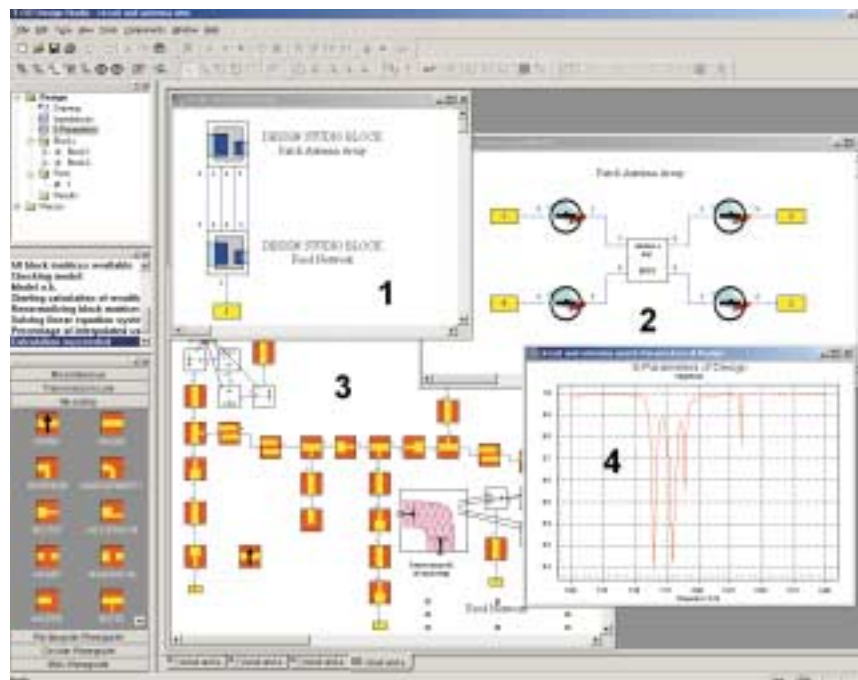
3. This screen shot shows the CST DS representation of the patch antenna of Fig. 2 as two Design Studio blocks and an external feed (window No. 1).

and transitions. This new feature also makes the inverse behavior of a Block available. So, using an appropriate De-embedding Block, which may be either analytical or simulated, arbitrary inner ports of a microwave structure may be accessed and the electromagnetic behavior of the attached components and their interaction may be studied.

More complex, hierarchical structures can be created through the use of "Design Studio blocks." A Design Studio block can contain fundamental blocks, as well as further Design Studio blocks. These complex structures can be created within CST DS or loaded from a file. All the details of a complex system can be contained within these Design Studio blocks.

Reference Blocks

"Reference blocks" are used within CST DS to represent the common properties of a larger number of blocks. As an example, **Fig. 1** shows a microstrip filter where the reference-block metallization and substrate thickness, as well as the substrate permittivity is set with values for the whole structure. The properties of each block can be displayed using labels (such as the Parameter label) used in Fig. 1. In this example, the width of a single stripline is highlighted as the only parameter that can be adjusted individually. All of the other parameters are set globally within the reference block.

The GUI in Version 2.0 has also been markedly improved. The GUI features a Microsoft Outlook-like control bar (the center left portion of Fig. 1) which enables rapid construction of a complex structure out of predefined blocks using "drag-and-drop" techniques. The control bar is extendable by user-defined library elements, which can be illustrated with the built-in bitmap editor.

Tight integration with CST MWS enables the synthesis of systems incorporating planar and 3D structures. For example, **Fig. 2** shows a microstrip patch antenna including the antenna array and associated feed network. The complete system behavior is of interest, as

well as the behavior of the feed network and the resulting radiation characteristics of the antenna array. A straightforward approach to this problem using a 3D EM field solver requires a very fine grid resolution everywhere to accurately simulate the radiation

from the patch antennas, as well as the edge-coupled filters.

Figure 3 shows the CST DS representation of the four patch antennas and the feed network. At the uppermost level (window No. 1 in Fig. 3) this system is represented by only two Design Studio

blocks and an external feed. Double-clicking on the upper Design Studio block opens the model that lies beneath, in this case the patch-antenna array (window No. 2 in Fig. 3). The main element in this patch-array subsystem is a fully parameterized CST MWS block containing the patch antennas without the feed network. This Design Studio block provides the S-parameter of the complete antenna array, including coupling between the single antennas. The far-field behavior of the complete array is available through CST MWS.

To derive the S-matrices of the patch array without taking into account the feed-network, additional power sources must be included in the CST MWS model. Since these artificial elements should not influence the simulation results, they are subtracted in CST DS from the CST MWS S-matrix through the use of the de-embedding blocks (marked in Fig. 3 by the large minus signs that surround the CST MWS block). The use of the de-embedding-block functionality of CST DS makes the creation of arbitrary inner ports in a 3D model possible.

In this example, the de-embedding blocks are realized by a user-defined parameterized library element. Changing any of the parameters will trigger a new simulation run if the results are not already accessible through the data base. The results for this subsystem (as well as those of every single block) are available within the software and so the optimization of subsystems is straightforward.

The second Design Studio block (window No. 3 in Fig. 3) contains the planar feed circuit. It is mostly built with analytic blocks from the CST DS element library. Sonnet EM models provide the system description of the meander lines. The CST DS model is fully parameterized, taking advantage of a reference block to set the common parameters for the planar circuit. The feed circuit was optimized to the design frequency range.

Finally, the broadband system response of the whole circuit is derived (Window No. 4 in Fig. 3). The overall system can now be optimized. The signal phase and amplitude on the antenna

ports can be fed into CST MWS to derive the array far-field characteristics for the particular configuration.

Version 2.0 of CST DS brings numerous improvements to all aspects of the program. Version 2.0 is currently available for a variety of operating systems, including Windows 95/98/NT/2000. **CST of America, Inc., 8 Grove St., Suite 203, Wellesley, MA 02482; (781) 416-2782, FAX: (781) 416-4001, e-mail: info@cst-america.com, Internet: www.cst-america.com.**