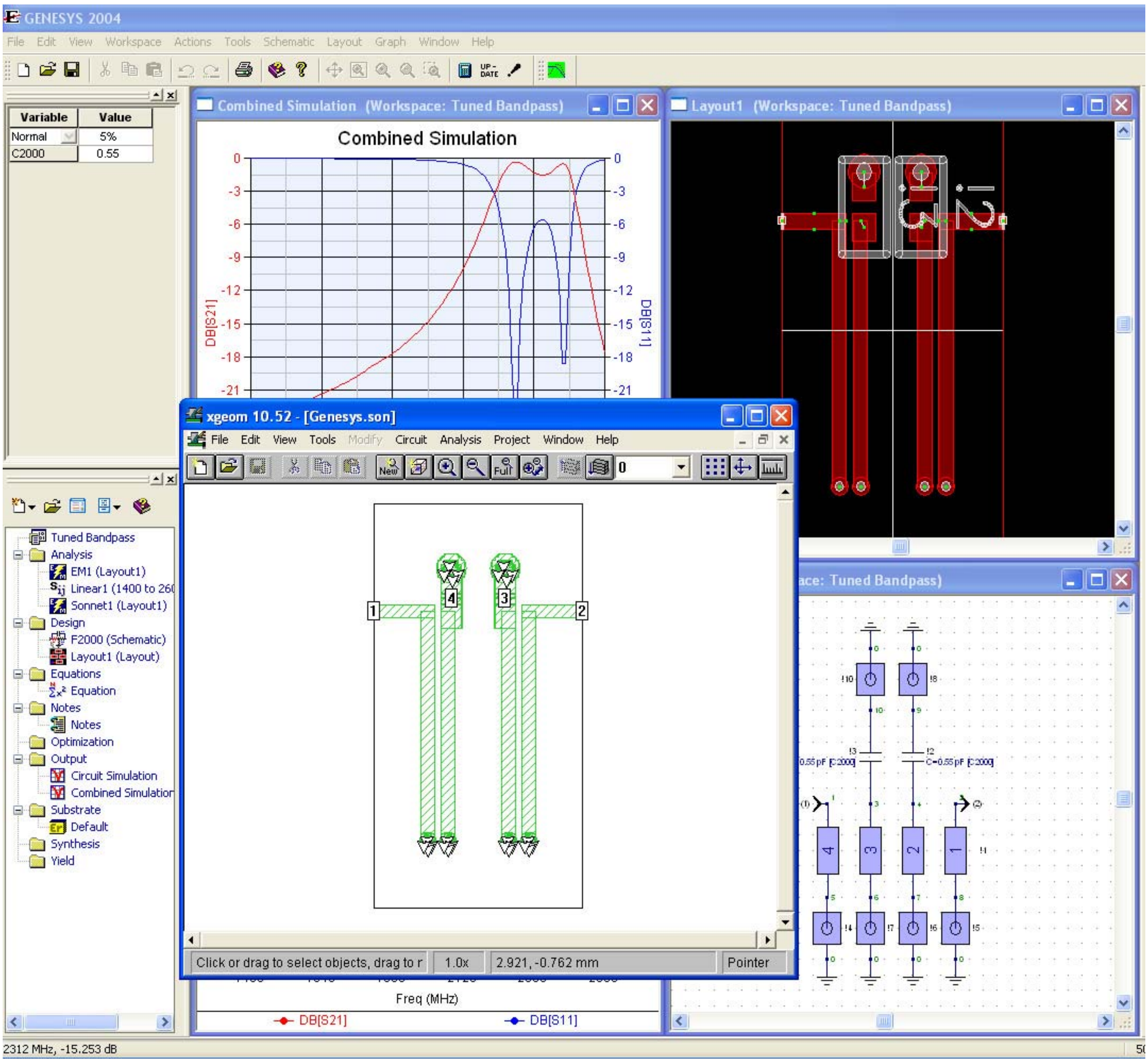
Using Sonnet® Interface in Eagleware-Elanix GENESYS™

Sonnet Application Note: SAN-205A

JULY 2005



SONNET®
ELECTROMAGNETICS
SPECIALISTS

Description of Sonnet® Suites Professional™

Sonnet Suites Professional is an industry leading full-wave 3D Planar Electromagnetic (EM) field simulation software based on the Method of Moment (MoM) technique which accounts for all coupling and radiation effects from DC to THz. It also takes full advantage of mathematically robust and reliable FFT formulation which avoids time consuming, error prone numerical integration. Both MoM and FFT combined gives Sonnet an added assurance that it will give outstanding accuracy every time on problems that have traditionally been difficult to solve. Problems with high dielectric constant, thin dielectric layers and/or small dimensions with respect to the wavelength are handled especially well with Sonnet. Sonnet continues to be an indispensable tool for designers involved in RF/Microwave circuits such as distributed filters, transitions, Low Temperature Co-fired Ceramics, multi-layer RF packages, coplanar waveguides, and antennas. In addition, Sonnet has proven successful in mm-wave designs as well as in EMC and EMI analysis.

Sonnet Professional Key Benefits

- Accurately model passive components (inductors, capacitors, resistors) to determine values like RLC and Q factor
- Accurately model multi layer interconnects and via structures
- Generate a technology accurate electrical model for arbitrary layout shapes
- Quantify parasitic coupling between components, interconnects and vias
- Include substrate induced effects like substrate loss and eddy currents
- Visualize the current flow in components, interconnects and vias

Sonnet Professional Key Features

- FFT based Method of Moments analysis for ultimate reliability and accuracy
- Easy to learn, easy and efficient to use
- Only one high precision analysis engine – no need to switch between solvers
- Patented Conformal Meshing strategy for very efficient high accuracy meshing of curved structures
- Finite thickness modelling (including advanced N-sheet model)
- Dielectric bricks for truncated dielectric materials (e.g. MIM capacitor)
- Adaptive Band Synthesis for fast and reliable frequency sweeps with a minimum number of EM samples - more efficient than traditional approaches
- Easy to use data display for analysis results, including R, L, C, Q evaluation
- Equation capability for pre-defined or customized calculation on simulated data
- All configuration and technology setup is menu / dialog based– no need to edit configuration text files
- Remote simulation capability
- Compatible with the LSF cluster and load balancing system
- Seamless integration with Cadence® Virtuoso® , Agilent EEsof EDA's ADS, AWR® Microwave Office® and Analog Office™ and Eagleware-Elanix GENESYS™ design environments
- Sonnet Software Inc. is a Cadence Connections partner

When to Use Sonnet Professional Analysis

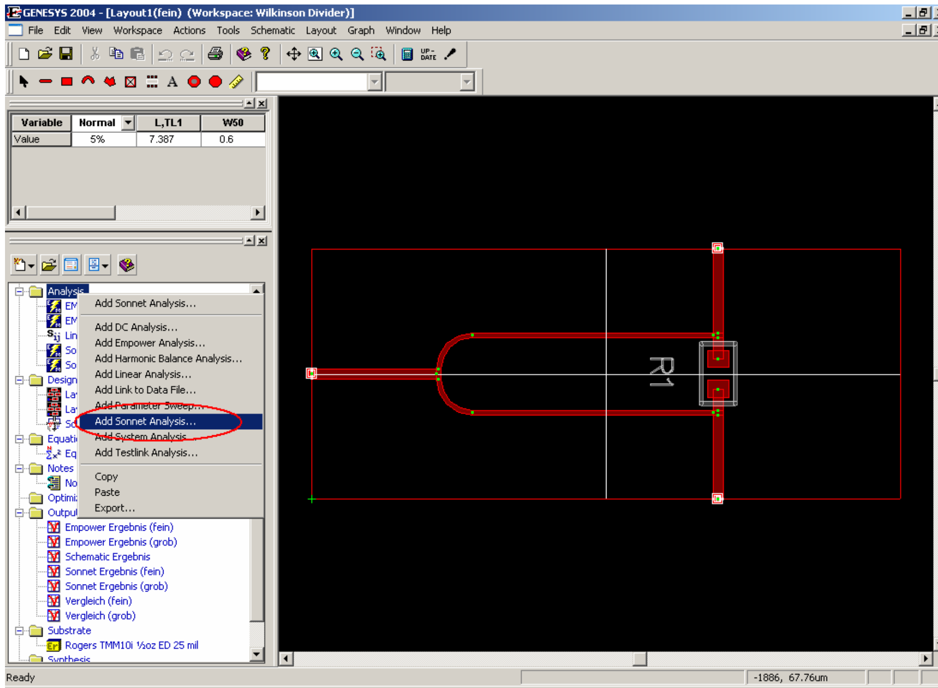
- When parasitic coupling is present.
  - Parasitic coupling is not always easy to predict without using electromagnetic analysis. Even elements which are "sufficiently" far apart can suffer from parasitic coupling: inductive or capacitive coupling, resonance effects due to grounding and surface waves that might propagate at the substrate boundary under certain conditions. Sonnet Professional analysis is based on the physical properties of your technology and will account for such physical effects.
- When accurate circuit models are not available or circuit model parameters are out of range.
  - Model based circuit simulators are based on models for a specific application, with limited parameter range. For example, only selected geometries, substrate types and substrate parameters are available. It is difficult to estimate the error induced by parameter extrapolation, so using models outside their designed parameter range is not suitable for critical applications.
  - Whenever a layout feature cannot be described by a circuit model, due to its geometry or technology, the physics based analysis with Sonnet Professional will provide the answer. An example for this could be a special inductor, capacitor or transformer which is not included in the design kit. Sonnet can be used to analyze those components "on the fly", or generate a full library of components models with trustworthy electrical results.

Introduction

Eagleware-Elanix GENESYS™ 2004 introduces an easy to use interface to the Sonnet® Suites Professional™ (Release 9.52 or later). You can now integrate Sonnet analyses directly within GENESYS Workspace to take full advantage of the advanced features and options of the Sonnet electromagnetic (EM) simulator.

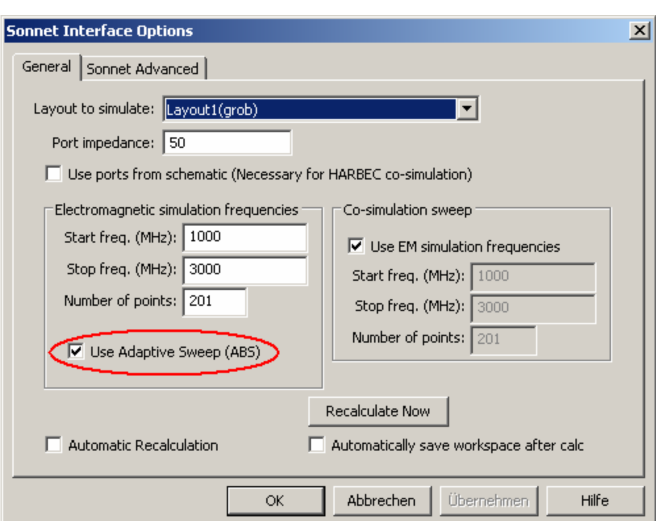
Getting Started:

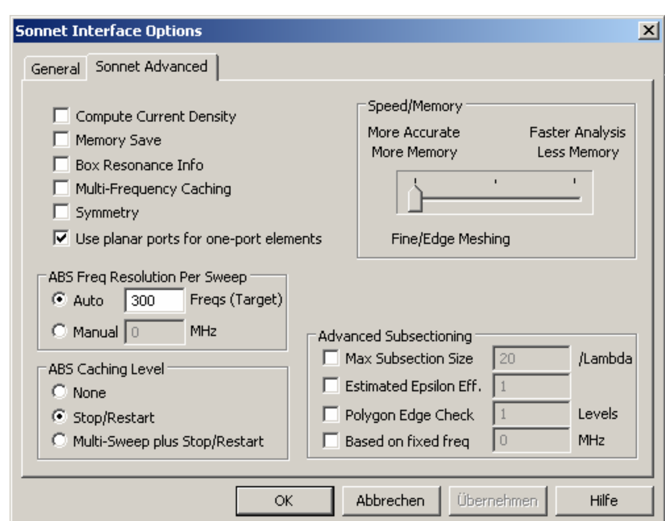
After the layout has been created, you can set up a Sonnet simulation in GENESYS by simply adding a Sonnet analysis in the GENESYS Workspace Window: Right click on *Analysis* ➔ *Add Sonnet Analysis*. This is the same procedure as if you were to add an Empower™ simulation.



After adding a Sonnet Analysis, you can setup the analysis parameters. Under the "General" section of the properties dialog box, the analysis frequencies can be entered. It is highly recommended to use the Adaptive Sweep (ABS) option. The Sonnet ABS (Adaptive Band Synthesis) option intelligently interpolates the EM simulation results and significantly reduces the simulation time. The other options in this section are similar to Empower analyses.

Under the "Sonnet Advanced" Section, additional Sonnet specific options may be modified. A list of these options and their descriptions are provided at the end of this document. It is highly advised that you review these descriptions before changing these advanced options. In most situations, it is not necessary to change these settings.

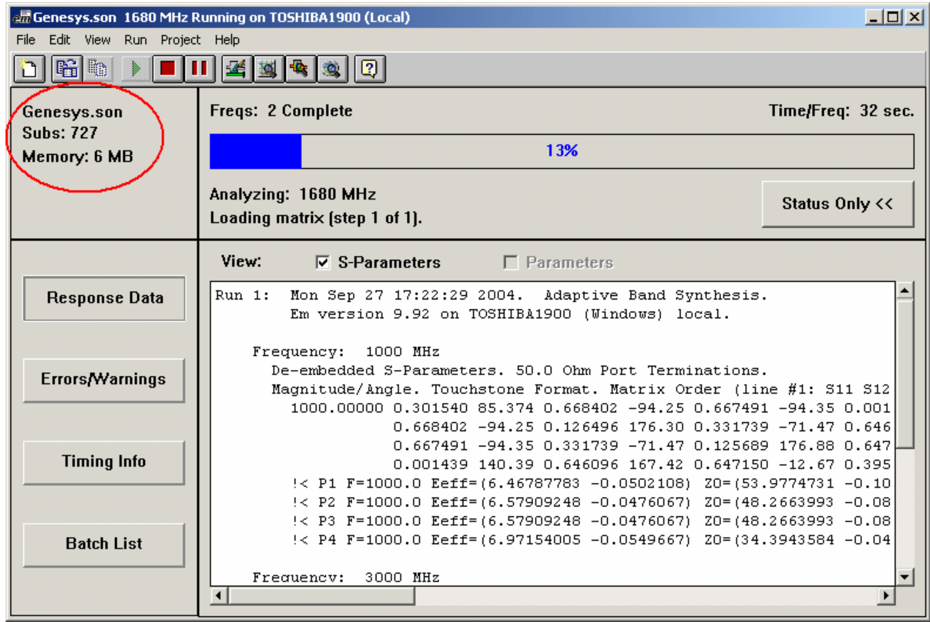




Performing the Analysis:

Once a Sonnet Analysis has been added to the GENESYS workspace the simulation is started by simply updating the workspace. GENESYS automatically invokes the Sonnet analysis and Sonnet Simulation Status window appears. Please, note that the default project name of “Genesys.son” is *always* used. In the status window, you can identify how much memory is used by the Sonnet simulation, track the progress of the analysis, and you may invoke all available Sonnet programs.

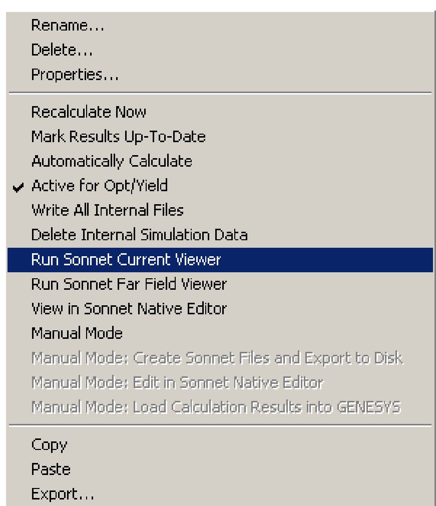
After the simulation has finished, switch or return to your GENESYS application window. You will find that all simulation results have been transferred from Sonnet to your workspace.



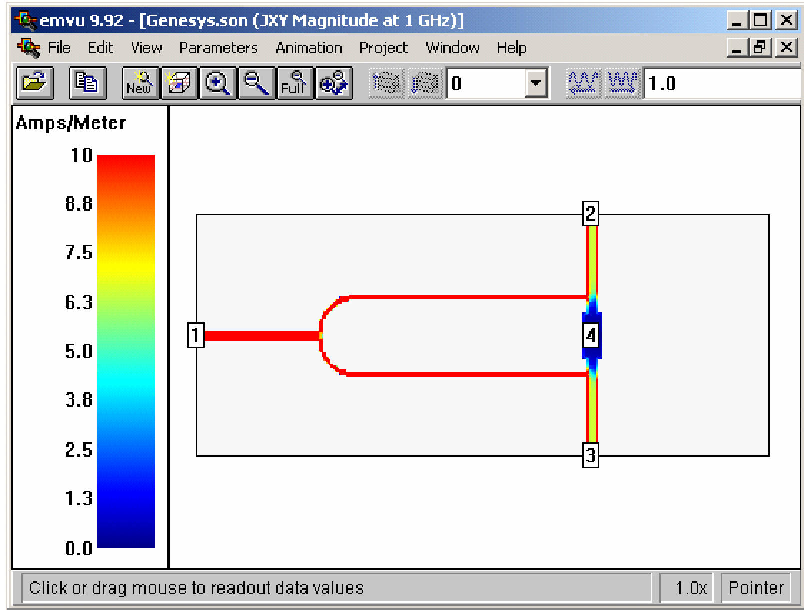
Viewing the Results:

At this point, you can continue to work on your circuit design within GENESYS. However, there are several important Sonnet features that can be invoked within the GENESYS workspace environment.

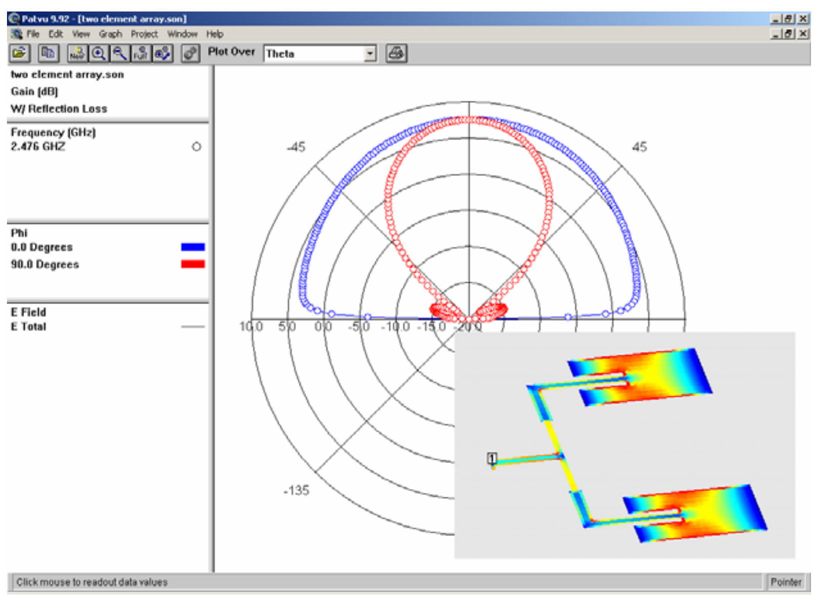
When you *right-click on a Sonnet Analysis entry* in the workspace window, several Sonnet specific sub-entries are accessible in the pop-up menu:



• **Run Sonnet Current Viewer:** You can run the Sonnet Current Density viewer with this command if you have selected the “Compute Current Density Options” before the circuit was analyzed.



• **Run Sonnet Far Field Viewer:** When you have analyzed a planar antenna with Sonnet, the antenna far field pattern can be observed with the Sonnet Far Field Viewer. Please, note that the current density has to be calculated for that purpose.



• **View in Sonnet Native Editor:** When you select this entry, you can view the circuit layout in the Sonnet project editor Xgeom™ to check the circuit and simulation parameters. Please, note that this view is only a preview. Any modifications of the layout performed within the Sonnet project editor will be automatically overwritten later if the layout in GENESYS is changed.

• **Manual Mode:** In this mode you can modify the layout within the Sonnet project editor so that you can use advanced Sonnet features like Conformal Mesh. Please, note that a manual mode analysis will not run automatically when you update the GENESYS workspace. If this entry is selected, three additional menu entries can be chosen:

– *Create Sonnet Files and Export to Disk*: Choose this entry if you want to overwrite the Sonnet project with the GENESYS layout. This may be necessary if the layout in GENESYS has been changed and you do not want to modify the layout manually in the Sonnet project editor. However, any previous manual modifications to the Sonnet project will be overwritten.
– *Edit in Sonnet Native Editor*: Select this entry to edit and analyze the layout in the Sonnet project editor Xgeom.
– *Load Calculation Results into GENESYS*: When a Sonnet analysis has finished, you have to load the results back into GENESYS using this menu entry.

Sonnet “Advanced” Interface Options:

GENESYS allows you to use Sonnet specific advanced options under the “Sonnet Advanced” dialog box. Below is a short description of these options. For a more detailed explanation or other options not available through the GENESYS interface please refer to the Sonnet User’s Guide.

• **Compute Current Density:** If this option is selected, the complete current density distribution of the circuit is analyzed and stored. The distribution can be viewed with the Sonnet current density viewer. Please note that the simulation time increases when this option is selected.

• **Memory Save:** The internal matrix storage will be done with single precision instead of double precision if this option is selected. If the simulation requires more memory than physical RAM is installed, this option could help to avoid swapping the memory to the disk. This option can introduce some inaccuracies for lower frequencies depending on the cell size. A warning message will be issued if any analyzed frequency is too low. If no warning is issued, you can safely use the memory save option.

• **Box Resonance Info:** When the box size is large with respect to the wavelength, box resonances can occur. If this option is selected, warning messages are output in the Sonnet analysis window.

• **Multi-Frequency Caching (MFC):** This option is obsolete for backward compatibility.   We recommend using ABS instead of MFC.

• **Symmetry:** This option adds an ideal magnetic wall to your circuit that runs horizontally from the left to the right and is vertically centered. The line of symmetry is displayed as a dashed line in the Sonnet project editor. All metallization below this line will be ignored in the analysis. You can use symmetry to significantly reduce the analysis time however, you must ensure that the circuit above the line of symmetry must be exactly the same as the circuit below.

• **Use planar ports for one-port elements:** This is an Eagleware-specific option. When lumped elements (e.g. SMD’s) are included in the layout, auxiliary ports are automatically added to the analyzed circuit. These auxiliary ports are connected to the footprints of the SMD’s. If the option is turned ON, the auxiliary ports are ungrounded internal ports located on the top metallization layer. If the option is turned OFF, via ports to the ground metallization are used instead. We recommend turning this option ON.

• **Speed/Memory:** This slider allows you to control the memory usage for an analysis by controlling the subsectioning of your circuit (please refer to the "Subsectioning" chapter in the Sonnet User's Guide for a complete discussion of subsectioning, Min, Max and edge meshing,). The high memory setting produces a more accurate answer and usually increases the analysis time. In contrast, low memory setting runs faster but does not yield as accurate an answer. There are presently three settings for this slider:

- *Fine/Edge Meshing (left):* Sonnet uses XMin, YMin and the edge meshing settings of each individual polygon. This is the default setting. It uses the most memory and returns the most accurate answer.
- *Coarse/Edge Meshing (center):* Sonnet checks the XMin (YMin) value of each individual polygon. If the value is less than 50, Sonnet uses 50. Otherwise, Sonnet uses the XMin (YMin) value of that polygon. Sonnet uses the edge meshing settings of each individual polygon.
- *Coarse/No Edge Meshing (right):* XMin and YMin are treated the same as cited for the option above, but Sonnet disables edge meshing for all polygons. This setting uses the least amount of memory and runs the fastest but at the cost of some accuracy.

• **ABS Freq Resolution per Sweep:** The resolution provides the minimum value of the gap between data points in an Adaptive Band Synthesis (ABS). This can be calculated automatically by the Sonnet solver or input by the user.

- *Auto*: The resolution of the frequency band used in an ABS analysis is determined by the analysis engine. This is the default setting. The automatic setting provides approximately 300 frequency points in the band.
- *Manual*: If you wish to set the resolution for an ABS analysis, select this radio button and enter the desired resolution in the adjacent text entry box.

There are several things to be aware of when using the manual setting for the ABS resolution. Coarse resolution does not speed things up. Once a rational polynomial is found to "fit" the solution, calculating the adaptive data uses very little processing time. A really coarse resolution could produce bad results by not allowing the ABS algorithm to analyze at the needed discrete frequencies. Fine resolution does not slow down the analysis unless the number of frequency points in the band is above approximately 1000 - 3000 points. A step size resulting in at least 50 points and less than 2000 points is recommended.

• **ABS Caching Level:** The ABS caching level determines if and how much of the ABS caching data is stored in your project:

– *None*: Select this option if you do not wish to store any ABS cache data in your project. If this option is selected and you stop an ABS analysis *before* completion, the only data available is the data calculated for the discrete data points. When you resubmit the ABS job, the cache data will need to be recalculated. Thus, the analysis must start all over again.

– *Stop/Restart*: Select this option to store the ABS cache data while an ABS analysis is running. This allows you to stop an ABS analysis and restart it at a later time without losing the data from the processing done before the stop. This option deletes the cache data when convergence is reached and the ABS analysis is completed. This is the default setting.

– *Multi-Sweep plus Stop/Restart*: Selecting this cache level saves the ABS cache data for every analysis performed on the project. This saves you processing time on any subsequent ABS analyses but be aware that the cache data will be calculated for any analysis of the project including non-ABS types of analysis, increasing the project size. This option should be used when you think you might want to re-analyze the project, using different ABS ranges or settings.

Please note, if you use this option, all your analyses should have the same subsectioning frequency. This ensures that any pre-existing ABS cache data can be used in the present analysis. If you use the Multi-Sweep option, we recommend using also the "Based on fixed freq" option as described below.

• **Advanced Subsectioning:** The advanced subsectioning options allow you to control the default subsectioning of your circuit by the analysis engine. *Important note: these options should only be changed by an experienced user*.

– *Max Subsection Size*: Sonnet uses a variable subsection size. Small subsections are used where needed, such as round corners, and larger subsections are used elsewhere. This reduces the size of the matrix which must be inverted. The size of the subsections are *always* equal to or greater than a single cell. It can *never* be smaller than a single cell. This field allows you to limit the maximum size of the subsection, generated by the analysis engine, in terms of subsections per wavelength. The default of 20, used when this option is not on, is fine for most work and means that the maximum size of a subsection is 18 degrees at the highest frequency of analysis. Increasing this number decreases the maximum subsection size until the limit of 1 subsection = 1 cell is reached.

– *Estimated Epsilon Eff.*: Sonnet has an algorithm that estimates the effective dielectric constant to determine the maximum subsection size. If this option is selected you may override the automatic algorithm and force Sonnet to use your dielectric constant. If this option is not on, "Auto" appears in the text entry box to indicate that Sonnet is using a default value.

– *Polygon Edge Check*: Sonnet considers one adjacent metal level in either direction from the present level when computing the subsectioning. This is an important consideration when thin dielectric layers are used. Polygon Edge Checking allows you to override the automatic algorithm and specify how many adjacent levels should be considered when calculating subsections. Please note that entering a value of zero causes Sonnet to only look at the present metal level.

– *Based on fixed freq*: Sonnet uses the entered frequency for all analyses of this project to determine the wavelength that is used in setting the maximum subsection size.

This application note is based on the original work of Dr.-Ing. Michael Reppel of
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