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## Optimization Approach of Simulating Transmission Line Components/Systems Using Centralized Commercially Licensed CST Studio Suite®

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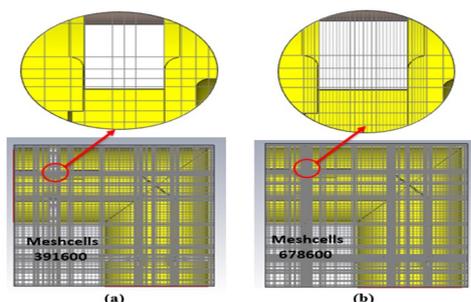
The Radiofrequency (RF)/Microwave passive transmission line components are used to carry the high-frequency EM waves in a guided manner from the source to the load. The design of the transmission lines used for this purpose largely depends on the amplitude and the frequency of the propagating EM wave. The characteristic impedance of the transmission lines depends on the impedance of the source and the load or vice versa which is also a function of the dimensional parameters of the transmission line. For example, the characteristic impedance of a lossless coaxial transmission line with air or vacuum as the dielectric medium is a logarithmic function of outer conductor diameter by inner conductor diameter [1]. It is always recommended to simulate the performance of a transmission line component at the operating power level. **CST (version 2019) Microwave Studio® (MWS) available on ANTYA** is one of the modules in the commercial software package CST STUDIO SUITE® [2] and is widely used for the modeling and simulation of high frequency electromagnetic (EM) components/systems. The frontend modeling tool available with CST is quite handy and provides options to build complex geometries with quite an ease. The various parameters affecting the simulation are discussed below:

### I. Meshing Scheme

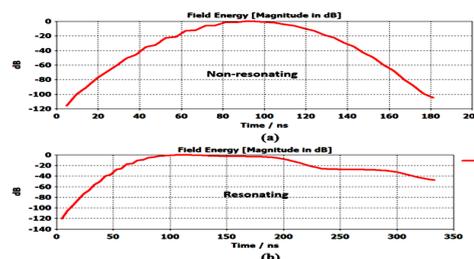
The MWS module takes inputs in terms of the geometrical features (interacting with EM field) of the Radiofrequency (RF)/Microwave component and therefore the approximation in the definition reflects in terms of inaccuracies or deviation from desired output. Once the component is modeled, the whole model is discretized in several mesh cells and the Maxwell equations are solved in each cell to get the overall response of the component. The meshing tool in MWS employs both hexahedral and tetrahedral meshing techniques which can be deployed based on a few input settings like frequency range, mesh cells per unit wavelength, etc. The global mesh setting provides an adapted meshing of the model which may or may not cover all the details of geometrical features like slots, holes, curvatures, the gap between conductors or insulators. It is recommended that the meshing of these local features should be refined through the local mesh setting. A typical example of such a meshing scheme is shown in figure 1.

### II. Type of RF/microwave component

Typically, the excitation pulse amplitude decays rapidly in a non-resonating structure to reach the defined accuracy level but a resonating structure stores the EM energy for several calculation cycles till a defined accuracy level is reached. A typical example of field energy decay in a non-resonating and resonating



**Figure 1: Inner conductor joint of a coaxial line (a) meshed with global mesh settings (b) refined through local meshing.**



**Figure 2: Field energy decay in (a) non-resonating (b) resonating structure**

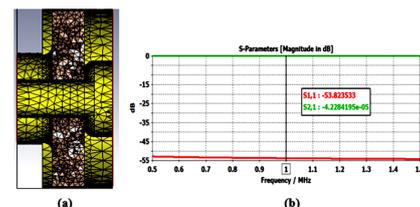
structure to achieve an accuracy level of -40dB is shown in figure 2. It is always recommended to switch the solver to the frequency domain if the required accuracy level is not achieved even after several calculation cycles or the solver terminates before the accuracy level is reached.

### III. Size of the model in comparison to wavelength

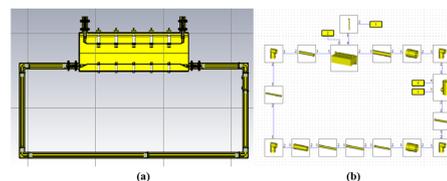
The time taken to simulate a model becomes unusually long when the size of the model is very small or very large compared to the wavelength. A typical example of the former condition is a 6-1/8 inch to 3-1/8 inch coaxial line reducer of length ~ 80mm simulated for frequency band of 500 kHz to 1.5 MHz (wavelength: 200m to 600m). The time taken for simulation of the reducer with time domain solver was more than 12 hours as compared with the frequency domain solver which took 6 iterations or less than an hour. The meshed model and corresponding S-parametric response is shown in figure 3. For a model having size >> wavelength the mesh density is too high which leads to long simulation time. The best way to reduce simulation time is optimize the mesh density, use HPC resources and split the model in small units which are combined in a co-simulation module.

### IV. Complexity of the model

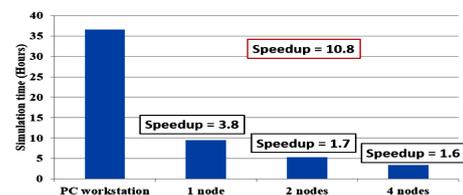
Sometimes the models to be simulated



**Figure 3: The 6-1/8inch to 3-1/8inch reducer (a) meshed model (b) S-parametric response.**



**Figure 4: Traveling wave resonator (a) full model (b) split in small units.**



**Figure 5: The simulation speeds up by HPC**

are too large compared to wavelength and at the same time too complex that the number of mesh cells required to accommodate all the geometrical features extends up to few cores and above. For example, figure 4 (a) shows a model of a traveling wave resonator (TWR) having physical length 12 times the guide wavelength. Due to narrow bandwidth response the model doesn't achieve the defined accuracy level of -40dB in time domain solver. One option is switching to frequency domain solver. Another option is to split the model in several units as shown in figure 4 (b). Each unit was simulated independently and were combined in a co-simulation module to find the overall response of the TWR [3]. This practice reduces the calculation load several times and reduces the time taken for simulation.

### V. Compute Resources

Time taken for simulating any model is largely dependent on the type of resource used. For example, a multi-element impedance matching circuit is simulated on both a PC workstation and HPC cluster with 2 acceleration licenses. While the simulation speeds up by 3.8 X on a single node, it can be sped up to 10.8 X when using full capability with 4 nodes of HPC as shown in figure 5.

### References:

1. Pozar D M 2012 *Microwave Engineering fourth edition* (John Wiley & Sons, Inc), chapter 2 p 56.
2. CST STUDIO SUITE <https://www.3ds.com/products-services/simulia/products/cst-studio-suite>
3. Akhil Jha et.al. "Performance optimization of test facility for coaxial transmission line components based on traveling wave resonator", Rev. Sci. Instrum. 91, 074702 (2020).

**"The simulation time for the large and complex models can be significantly reduced using the HPC resources for the centralized commercial-ly licensed CST Studio Suite®"**

## Environment Modules-II: Creating the Custom User Modules For User Specific Applications

In the last issue, we have described the usefulness of "module" utility and how it can be used in ANTYA for availing the applications installed at the shared location. However, there are some applications which the user prefers to install in the home directory only. In this issue, we focus on how to create custom modulefiles for the applications installed in user home directories and thus avoiding the need to export the paths manually. This will also be useful in case of multiple versions of the same applications are installed and required by the user. Next issue will be on ease of use of modules and sharing custom modulefiles with other HPC Users

### 1. Creating Custom Modulefiles in user specific directories

The easiest way to create custom modulefiles for your applications is to copy one of the included module files and customize it to your needs. For example, you can copy any modulefile located at /home/cm/shared/modulefiles/ and then change the setenv and prepend-path lines to be specific to your application location. Here is an example of how visit-3.1.2 installed in user home area (/home/username/visit) can be used as a custom modulefile is given below:

#### ◆ First create the directory for your private modulefiles

```
$ mkdir -p $HOME/privatemodules/modulefiles
cd $HOME/privatemodules/modulefiles
mkdir visit
```

#### ◆ Copying an existing modulefile for visit from the shared location to your private modulefiles directory, inside the visit directory

```
$ export TMP_MOD_PREFIX=/home/cm/shared/modulefiles
cp $TMP_MOD_PREFIX/visit/3.1.2 visit/.
```

#### ◆ Modifying the custom module file as below:

```
##Module1.0
proc ModulesHelp { } {
    global version modroot
    puts stderr "sets the Environment for visit 3.1.2 in my
home directory"
}
module-whatis "Sets the environment for using visit-3.1.2"
# for Tcl script use only
set version 3.1.2
set app visit
set topdir /home/username/visit

prepend-path PATH $topdir/bin
prepend-path PATH $topdir/3.1.2/linux-x86_64/bin
prepend-path LD_LIBRARY_PATH $topdir/3.1.2/linux-x86_64/lib
```

### 2. Adding the Custom Modulefiles

The easiest way to create custom modulefiles for your applications is to copy one of the included module files and customize it to your needs.

```
$ module use $HOME/privatemodules/modulefiles
Now your modulefile inside the visit folder will be visible
and can be loaded
```

```
$ module load visit/
visit/2.13 visit/3.1.2
```

```
To make the custom module permanently available
$ echo "module use $HOME/privatemodules/modulefiles" >> $HOME/.bashrc
```

## Other Recent Work on HPC (Available in IPR Library)

Trapped particle instability in : II Inhomogeneous Vlasov plasmas	SANJEEV KUMAR PANDEY
Trapped particle instability in : I Homogeneous Vlasov plasmas	SANJEEV KUMAR PANDEY

## Acknowledgement

The HPC Team, Computer Division IPR, would like to thank all Contributors for current issue of GANANAM.

**On Demand Online Tutorial Session on HPC Environment for New Users Available**  
Please send your request to  
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## ANTYA UPDATES AND NEWS

### 1. New Software Installed

- ⇒ OpenFoam7.0 module
- ⇒ oneAPI Base Toolkit and oneAPI HPC Toolkit available using the below command:

```
source /home/application/oneapi/
setvars.sh
```

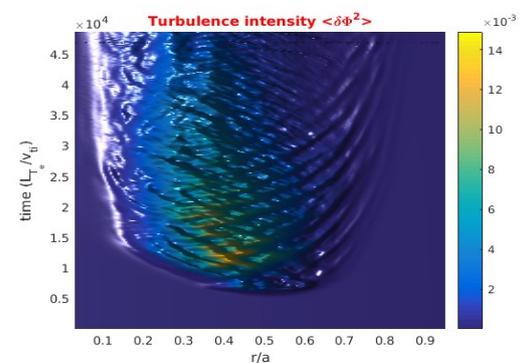
### 2. PBS Altair Access Portal

(<https://10.20.39.6:4443>) upgraded to latest version 2020.3 and following applications have been integrated:

- ◆ Visit
- ◆ Paraview
- ◆ Matlab
- ◆ Ansys
- ◆ VMD

All these applications can be used directly from this web portal.

## Spatial Temporal Behavior of Turbulent Intensity (HPC Picture of the Month)



Pic Credit: [Amit Singh](#)

The above figure is generated from the non-linear simulation on ANTYA for ADITYA-like tokamak's using GTS code for ion temperature gradient driven modes.

GTS code is used under a collaboration of PPPL-IPR, and provided by Dr. Rajaraman Ganesh.

**TIP OF THE MONTH**  
TO SUBMIT AN INTERACTIVE JOB WITH A JOB SCRIPT  

```
$ qstat -I jobscript.sh
```