VizEM Application Note

Simulation of 2D Microwave Fields in a L-bent Waveguide Using Time-Domain Electromagnetics Wave Solver

This application note illustrates the transient development of microwave field in an air-filled waveguide with an L-bend geometric feature. The *Time-Domain Electromagnetic Wave Solver Module* of the *VizEM Electromagnetics Modeling Software Package* developed by Esgee Technologies Inc. is used for this problem.

The 2D planar waveguide geometry and the computational mesh used for the simulations of this problem are shown in Figure 1. The waveguide is 100 cm long in the horizontal direction (*x*-direction) and 55 cm in the vertical (*y*-direction). The waveguide channel width is 10 cm in along the horizontal length and 18 cm along the vertical direction. The geometry comprises a wave inlet to the right and perfect electric conducting side walls along the length of the waveguide. The waveguide is terminated with a perfect conductor. The computational mesh has approximately 6,900 cells and comprises a single sub-domain for the wave propagation. The maximum of the mesh size is determined by the frequency of the microwave. For this particular simulation, the drive frequency is 1.5 GHz with in a vacuum wavelength of about 20 cm. The mesh resolution is such that about 40 mesh cells (5 mm length) resolve a single wavelength. It is important to note that the problem geometry does not accommodate a perfect integer number of wave lengths. Hence a true standing wave pattern at the drive frequency of 1.5 GHz is not expected for this problem.

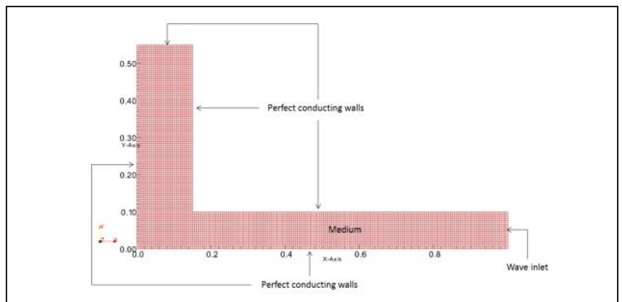

Figure 1: **Geometry and mesh for 2D waveguide with an L-bend.**

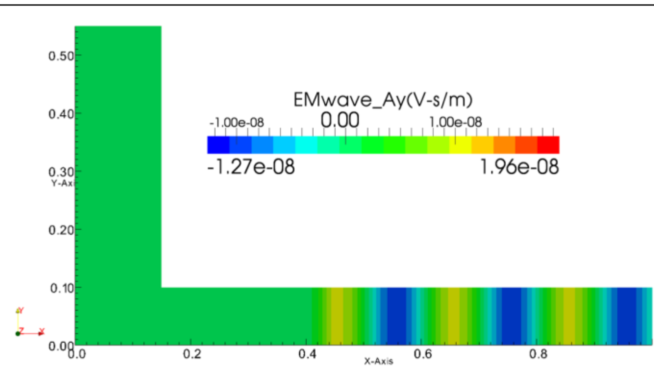

Figure 2: **Snapshot of the wave field at 0.6 ns after being launched at the waveguide inlet at the right.**

For the time-domain solver a time-step of 10^{-12} sec is used. This corresponds to an approximate CFL number of 0.3 for the time-step. The simulation is run to a final time of 84 ns.

A wave is launched from the right inlet boundary with a non-zero wave field component in the y-direction. The wave travels down the waveguide (in the *-x* direction) and negotiates the L-bend and further propagates up the waveguide in the *+y* direction. Finally the wave interacts with the perfect electric conductor termination and is reflected back down the waveguide to form a standing wave in the waveguide. As mentioned above the geometry is such that a stationary (steady) standing wave can never be achieved in this geometry. Figure 2 shows a snapshot of the wave at 0.6 ns after the wave is launched at the inlet (the initial conditions being a wave-free domain). The wavelength is observed to be about 20 cm and is exactly the vacuum wavelength for the 1.5 GHz excitation. At a perfect electric conducting wall the tangential component of the wave field is zero while the normal component is non-zero. This feature is clearly seen in the wave at this time.

Figure 3 shows the transient development of the wave field at various times after the wave is launched at the inlet. At 6.6 ns the wave has reflected off the termination boundary and formed a standing wave pattern within the wave guide. Note that the perfect conducting waveguide wall in the vertical section of the waveguide dictates that the *y*-component of the wave field is zero, which results in a wave pattern that looks different from the horizontal section of the waveguide.

As seen in Figure 3, the amplitude of the standing wave grows in time until about 13 ns following which the amplitude decreases to reach a minimum at about 60 ns. After 60 ns the amplitude of the standing wave starts increasing again and the pattern repeats itself. Essentially the transient snapshots in Figure 3 show the occurrence of a lower frequency modulation of the standing wave indicating that a stationary (steady) standing wave is not established in this geometry as mentioned earlier.

This problem demonstrates the importance of using a time-accurate (time-domain) simulation of the electromagnetic wave phenomena and ability to capture higher and lower harmonic transients that are not resolved by a frequency-domain solution.

The *VizEM* software package provides a very robust environment to solve such problems with quick turnaround. The *VizEM* software is available through the *Overviz* framework. This framework features an easy-to-use interface that provides utilities for problem set-up, problem solution, and post-processing of the solution. Once a mesh is available, the problem discussed in this

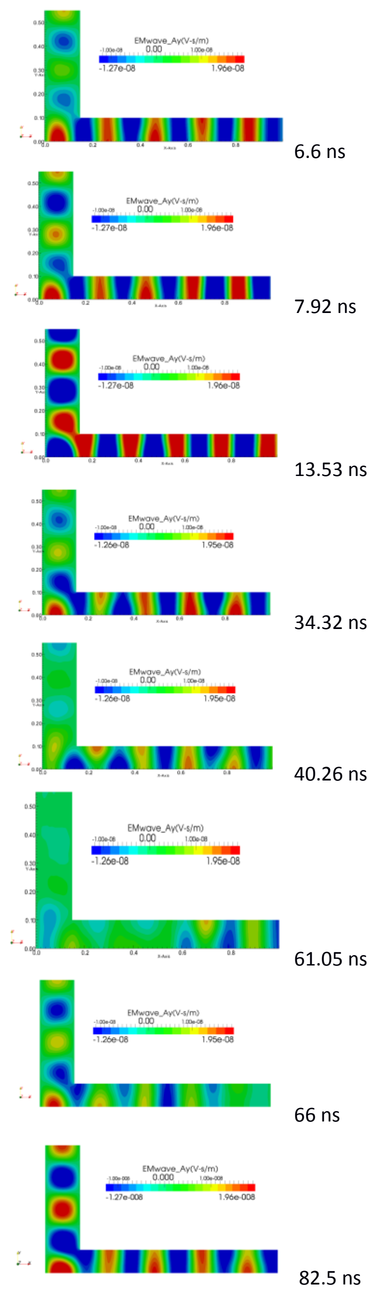

Figure 3: **Development of standing wave pattern and occurrence of a low frequency modulation of the standing wave in the waveguide.**

note can be set-up within a matter of a few minutes. The *Overviz* framework provides “intelligent” default options that the user can trust and use in the absence of additional information.

The different modules within the *VizEM* software package are used seamlessly within the other software packages offered by Esgee Technologies. For example the *Time-Domain Electromagnetic Wave Solver Module* used in the above problem can be called by the *VizGlow Plasma Modeling Software Package* to solved coupled electromagnetic wave—plasma problems, such as in high-frequency capacitively coupled plasma (CCP) reactors. Examples of such coupled problems are discussed in other Application Notes.

For further information on this application note or details about the *VizEM* and other software packages you may contact us at

Esgee Technologies Inc.
14, North Peak
Austin, Texas 78746, USA
info@esgeetech.com
www.esgeetech.com