Electrostatic analysis of a strip conductor

Description

Nowadays, microstrip lines, or striplines are widely in various electrical and electronic applications, especially in solid state microwave systems. A stripline has a very simple structure. It is commonly comprised of a thin narrow metal strip on the top of a dielectric substrate situated on a firm conducting plane.

In this validation example, we consider a strip transmission line embedded in a dielectric substrate. The relative permittivity of the dielectric substrate, ε_r = 12.85. The strip conductor is of infinitesimal thickness, with a width w = 5mm. A voltage of 1V is applied to the strip. The substrate is confined to a conducting shield from each side of the cross section. The shielding box is, in fact, grounded, and has a width a = 20mm, and a height b = 10mm, as shown in Figure 1. We wish to validate the results of EMS against the published data [1].
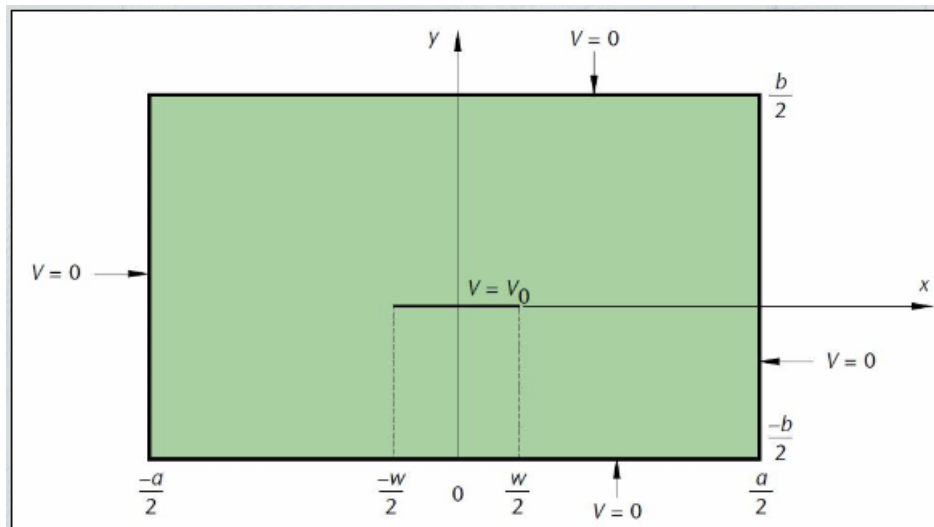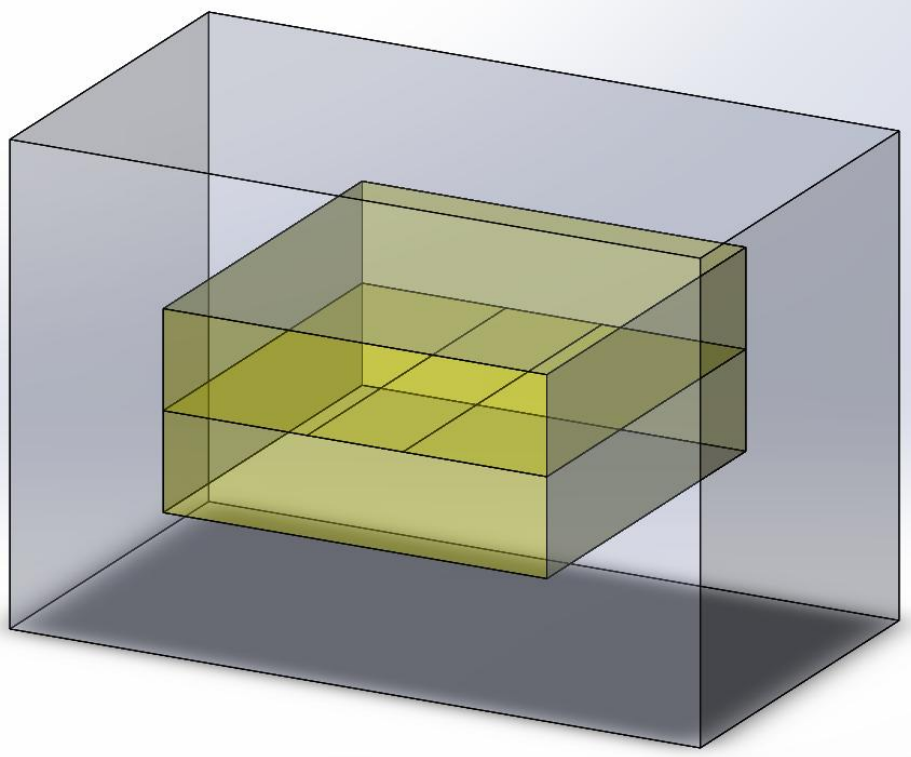

Figure 1: Cross section of a strip transmission line

Figure 2: Solid model of the stripline

The study

The Electrostatic module of EMS is used to compute the electric potential field in the stripline and the dielectric substrates. After creating the Electrostatic study, or the design scenario, in EMS, three important steps shall always be followed. That is, apply the proper material for all solid bodies, apply the necessary boundary conditions, or the so called Loads/Restraints in EMS, and mesh the entire model.

Materials

In the Electrostatic analysis of EMS, the only required material property is the relative permittivity, which is shown in Table 1 for the dielectric substrate and the surrounding air.

Component/Body	Material Name	Relative Permittivity
Air box	Air	1.0
Substrate 4	TMM-13	12.85
Substrate 5	TMM-13	12.85

Table 1: Relative permittivity of the two dielectric substrates and the surrounding air

The application of materials is straight forward. Just right-click on the component icon and apply the material.

Loads/Restraints

Loads and restraints are necessary to define the electric and magnetic environment of the model. The results of analysis directly depend on the specified loads and restraints. Loads and restraints are applied to geometrical entities as features that are fully associative to geometry and automatically adjusted to geometrical changes.

In this study, the stripline has an electric potential of 1V, while the shielded conductor around the substrate is grounded.

Meshing

Meshing is a very crucial step in the design analysis. EMS estimates a global element size for the model taking into consideration its volume, surface area, and other geometric details. The size of the generated mesh (number of nodes and elements) depends on the geometry and dimensions of the model, element size, mesh tolerance, and mesh control. In the early stages of design analysis where approximate results may suffice, you can specify a larger element size for a faster solution. For a more accurate solution, a smaller element size may be required.

In this particular benchmark, the meshing is rather straightforward since the geometry does entail small regions and gaps. Thus, the global element size is set to 3 mm with a mesh tolerance of 0.15 mm. To

achieve a good accuracy without increasing the total number of mesh elements, it is recommended to apply a mesh control to the regions where a large field or variation is expected. A local mesh control of 1.2 mm is applied to the dielectric substrate. Figure 3 shows the resulting mesh.
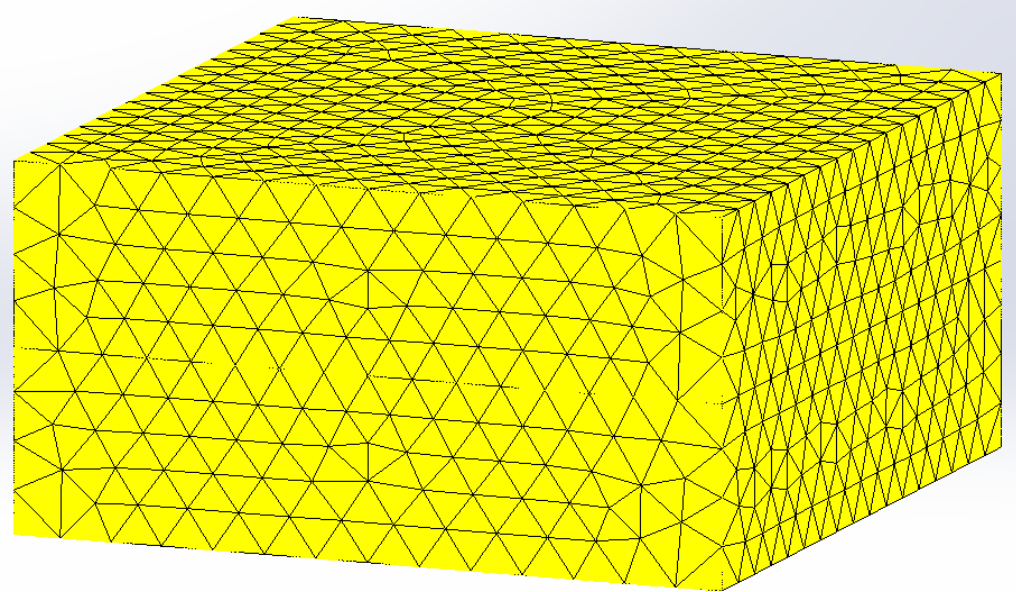

Figure 3: Mesh of the structure without the air region

Results

After a successful run, the Electrostatic module produces four result folders and a result table. The folders contain the electric field **E**, the displacement field **D**, the potential distribution **V**, and the force density, respectively. The results table contains the energy. Furthermore, all of the results can be visualized in various formats such as fringe, vector, contour, section, line, and, clipping plots. The results can easily be zoomed-in, exported, and dissected.

For this particular benchmark, the 3D plot of the electric potential field is compared against the reported results in [1]. In addition, the line plot feature of EMS is used to compare the electric potential at three points with coordinates in mm (10, 3.75), (11.558, 3.75) and (12.338, 1.25). As Figures 4-6 indicate, the results of EMS match those reported by the authors of [1].
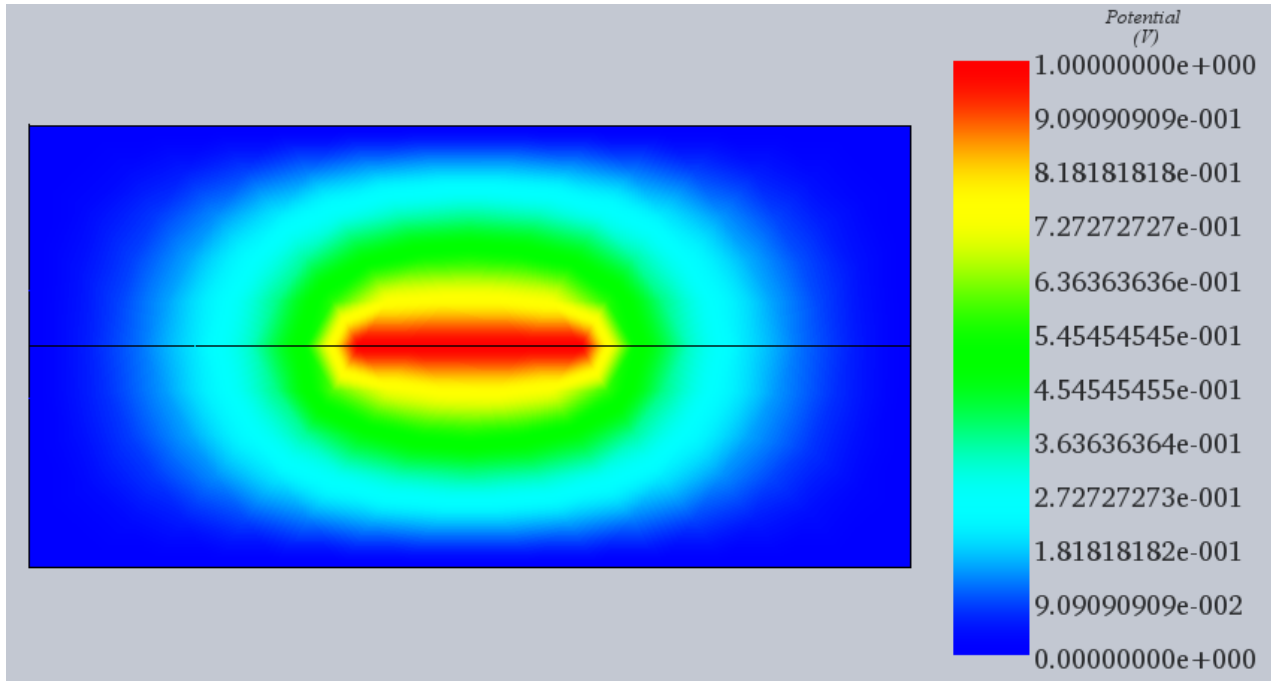
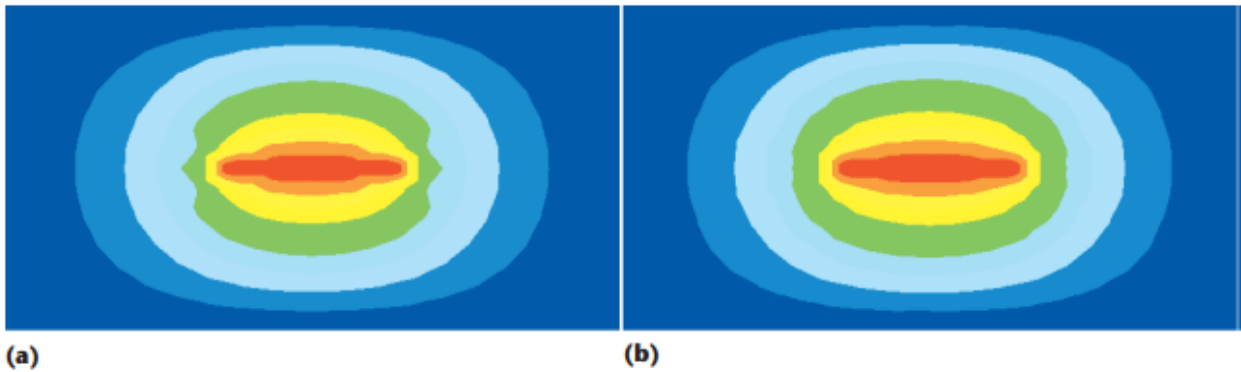Figure 4: Electric potential field obtained by EMS

Figure 5: The results of the electric potential field using (a) the DBEM and (b) the FEM as reported in [1]
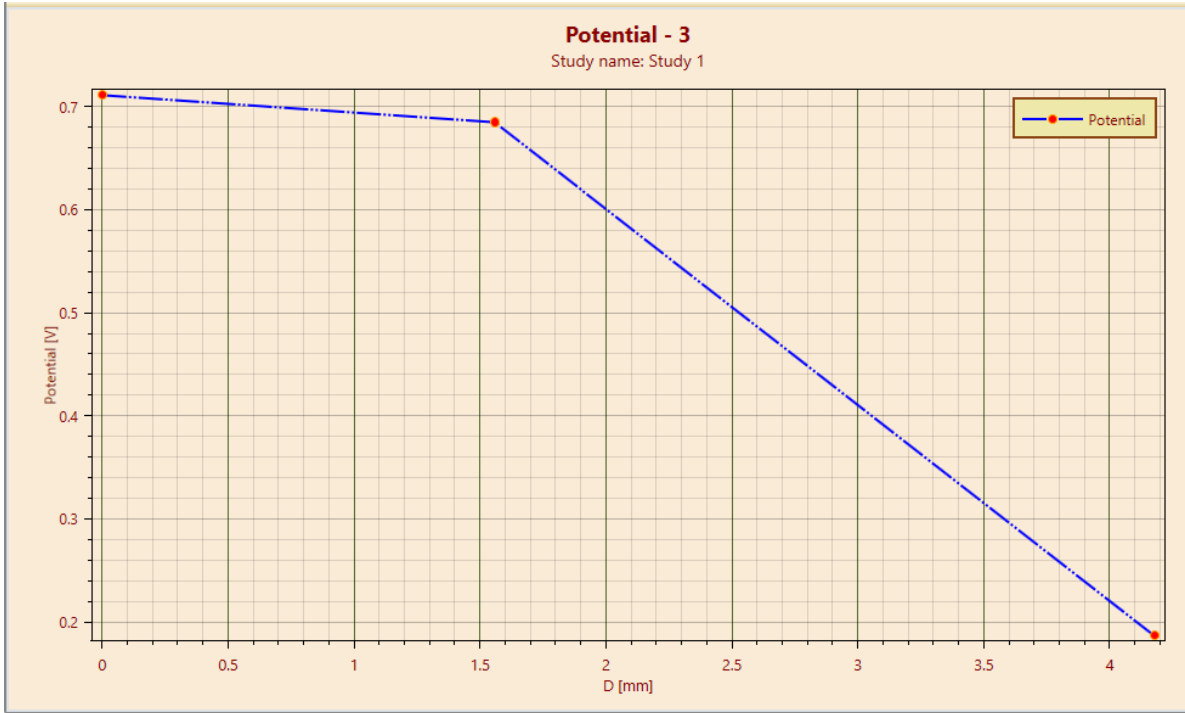
Figure 6 : Line plot of the electric potential between (10, 3.75), (11.558, 3.75) and (12.338,1.25)

obtained by EMS

Locations (x,y)	Results from the conventional BEM U,T kernels	Results from the direct BEM L,M kernels	Results from the DBEM U,T,L,M kernels	Results from the FEM	Difference between the DBEM and the FEM (%)
(10.000, 3.75)	N/A	N/A	$0.70048\ V_0$	$0.7104\ V_0$	−1.396
(11.558, 3.75)	N/A	N/A	$0.66288\ V_0$	$0.6742\ V_0$	−1.679
(12.338, 1.25)	N/A	N/A	$0.17862\ V_0$	$0.1863\ V_0$	−4.122
(−3.25, −5.62)	N/A	N/A	$0.39078\ V_0$	$0.4082\ V_0$	−4.268

Table 2 : The results of electric potential under diverse numerical methods reported in [1]

The results of the 3D electric potential plot and the magnitudes of the reference points, Point 1 (0.7112 V), Point 2 (0.6849 V) and Point 3 (0.1867 V) as a ratio versus the maximum potential V_0 = 1V on the stripline closely match the results obtained from [1].

Conclusion

This benchmark demonstrates the high accuracy achieved by the Electrostatic module of EMS compared to the published results. Hence, in addition of being fully integrated in SolidWorks and Inventor, EMS is also accurate and easy to use.

References

[1] Chyuan, S.W.; Liao, Y.S., Chen, J.T.; "An Efficient Method for Solving Electrostatic Problems," Computing in Science and Engineering, Vol. 5, No. 3, May-June 2003, pp. 52-58.