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Welcome to SIMULATION CITY

Using Simulation to Assist With PCB Design

Lightning Speed Laminates

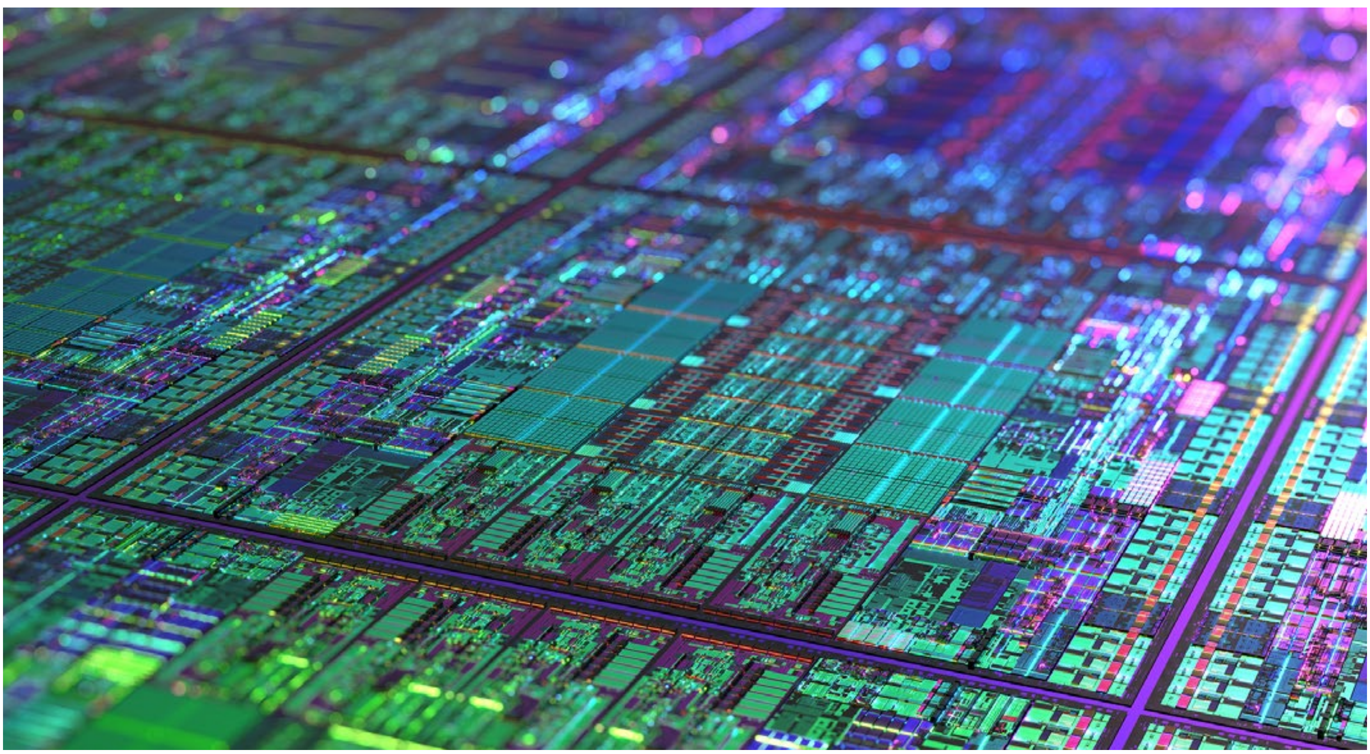
Feature Column by John Coonrod, ROGERS CORPORATION

There are many different types of simulation software on the market, which can be very helpful for the PCB designer. Each tool has its own set of capabilities and limits. Understanding the basic attributes can help the designer choose the appropriate software for their design task. In general, the tool which most designers use for more complex structures, found in RF and high-speed digital (HSD) applications, is the field solver. However, there are several different types of field solvers.

Knowing the basic differences between simulation tools can be important for many reasons. In some cases, one type of field solving software will yield more accurate results than another type due to how the software performs the field solving and how the modeled structure is meshed. Additionally, the closed form equation software is usually much faster for generating results as compared to field solving software, but closed form equations are typically less accurate, and they have more limits for the type of structure to be modeled.

Software Options

There are several closed form equations programs which are used for some RF and HSD design considerations. One of these programs is available for free download from the Rogers Technology Support Hub.[1]. MWI-2019 uses many different closed form equations based



on menu driven user-defined structures. The structures are simple transmission line circuits with configurations most used. The microstrip transmission line is a very common RF structure that is modeled using MWI-2019 and has proven to have accurate results, as compared to measured circuit performance. The software will solve for impedance, insertion loss, effective dielectric constant, wavelength, propagation delay, phase angle, and more.

The microstrip structure in MWI-2019 software yields results based on the closed form equations defined from a well-known paper published by Hammerstad and Jensen[2]. The basic procedure in this paper will solve for effective Dk, impedance, and insertion loss. The insertion loss calculation is a summation of dielectric loss and conductor loss. For frequencies greater than a few GHz, the conductor loss results need to be augmented for the effects of the copper surface roughness and specifically the roughness at the substrate-copper interfaces of the microstrip circuit. There are many different routines which can be used to account for copper roughness and the routine that works best for the type of closed form equations used in MWI-2019 is the Hall-Huray[3] model. This model allows MWI-2019 to account for the additional losses associated with roughened copper across a very wide range of frequencies.

Another item to consider with microstrip, and especially when using closed form equations, is transmission line dispersion. Microstrip circuits are known to be dispersive and basically dispersion is due to the fields of the propagating waves using both air and dielectric. Air will have no dispersion and the dielectric material will have dispersion. The dispersion associated with the dielectric material is essentially stating that the dielectric constant will change, given a change in frequency. This does not happen with air, and due to these differences, the microstrip transmission line will have different wave behavior at different frequencies—aside from the expected wave property changes with frequency, such as high frequency waves having shorter wavelength as an example. There is an excellent dispersion routine for microstrip from a paper by Deibele and Beyer[4] but considering how the closed form equations work with MWI-2019 software, a procedure by Kirschning and Jansen[5] has proven to be more accurate.

As a quick and general summary for software using closed form equations, they are much faster for generating results as compared to field solving, and they can be relatively accurate, but the accuracy is sometimes dependent upon special considerations for items related to copper surface roughness and dispersion for some models. There are other potential issues to consider for closed form equation software, however, the more accurate field solving software has its own set of issues to be considered.

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A Field Solver Conversation

There are two types of field solvers: 2D and 3D field solvers. The 2D field solvers are best to use when the designer is considering a standalone circuit configuration on a parallel plate structure, such as a filter design on a PCB. However, if a designer would like to model the connector transition to the PCB which has the filter, then a 3D field solver would be best to use. The filter, itself on the PCB, is a parallel plate structure and 2D field solving will generate accurate results. However, the connector transition, from the connector(s) to the PCB, is a 3D problem to solve and a 3D field solver would be the right choice. For the experiments that I do, I understand the connector transition quite well (usually) from many years of experience; because of that I can use a 2D field solver to solve my design issues on the PCB that I'm evaluating.

The 2D field solvers nowadays are typically referred to as 2.5D or planar 3D and the true 3D field solvers are typically referred to as arbitrary 3D field solving. Again, these descriptions are admittedly simplified but a planar 3D field solver will solve Maxwell's equations using method of moments (MoM) and an arbitrary 3D field solver will also solve Maxwell's equations but the software may use finite element Analysis (FEA), using a mesh that is three-dimensional. The mesh is the analysis grid of the circuit to be modeled and is used to solve Maxwell's equations at discrete points, as well as how each of these points can interact with its neighboring point. These points make up the grid or mesh. An arbitrary 3D field solver will use a three-dimensional grid that will have the shape of a tetrahedron (four-sided) or maybe a hexahedron (six-sided) grid element. The arbitrary 3D solver will use these connected grid elements for everything in the circuit such as conductor layers, dielectric layers, air, etc. However, a planar 3D solver will use a planar grid (mesh) and it will be applied for the conductor layers only. The fields will still be solved in 3D for the planar 3D software, but solutions will be between the different conductor features, and so the dielectric material between these conductors will certainly have an influence. There are tricks that can be done with planar 3D field solving to get a circuit solution similar to arbitrary 3D software, such as for a circuit conductor; one can build up layers of conductors to form the overall circuit conductor which may be very thick and coupled to another thick conductor, as an example.

Conclusion

In summary (and how I typically use these programs), I will use the closed form equation software as an approximate tool and use the field solver for doing the detailed design work. I use the closed form calculators in the beginning of the design phase to go through the various tradeoffs when considering different high frequency circuit materials, thicknesses, conductor widths, RF structures, etc. Once I have the basic circuit defined from using the closed form equation software, the detailed work will be done using a field solver. However, when using MWI-2019 closed form equation software, and if I am just evaluating a simple microstrip transmission line circuit, I usually do not need a field solver because MWI-2019 is very accurate for that type of circuit and for many years I have received good correlation between the software and measured results. **DESIGN007**

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John Coonrod is technical marketing manager at Rogers Corporation. To read past columns or contact Coonrod, click here.