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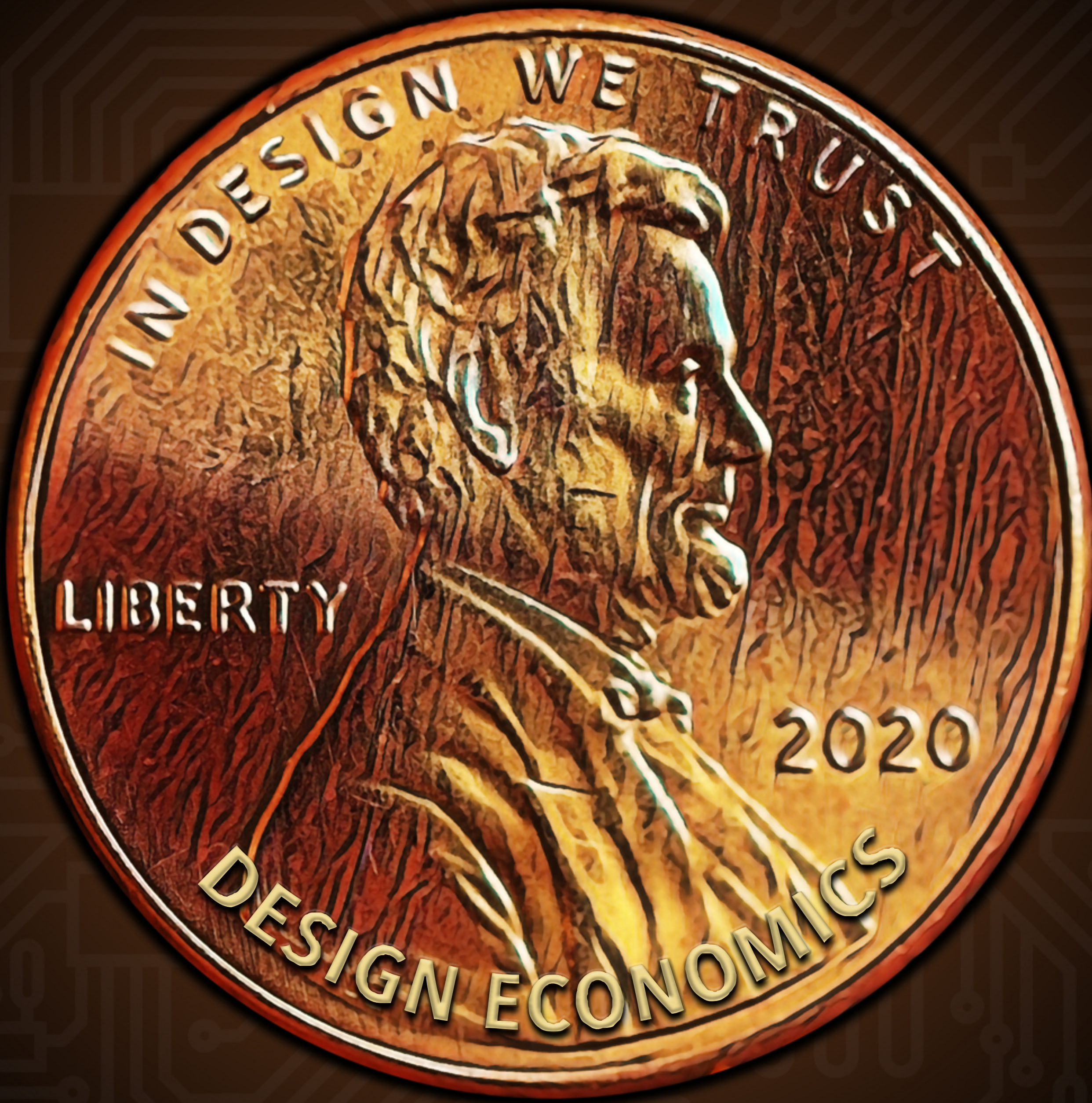

Understanding Dk Data Key to Cost-aware Design

Lightning Speed Laminates

Feature Column by John Coonrod, ROGERS CORPORATION

In the development stages of a circuit for a new PCB application, there are usually several iterations to the circuit, including testing, redesigning, building new circuits, etc. These many changes can be costly, and it is not uncommon for a project to have 4–8 changes before it can be released to the market. One item that can substantially reduce the number of changes and the associated costs is the use of a good circuit simulation software.

There are many very good software programs on the market that will allow a circuit designer to predict the electrical performance of a circuit. The predicted electrical performance simulation is done on a model of the circuit and is often related to impedance and insertion loss. There are many other circuit attributes that can be simulated, but there are usually some differences between the actual circuit performance and the predicted performance of the simulated model. Sometimes, these differences are small; other times, the differences are very significant.

Before the designer inputs the data into the simulation software, they need to make sure they know the details behind how the data was generated. Since all simulation models are not the same due to the unique desired performance of the circuit, the data being input may not be appropriate for a specific model. The inaccurate information could be caused by the input from the user, who is defining the model. Sometimes, it could be an oversight from the user, or it could be inaccuracies from the information which the user assumes to be accurate. One area of potential inaccuracy for these software programs is the dielectric constant (Dk) value for a circuit material. Although, even when the Dk value is accurate, the user may use it inappropriately due to a misunderstanding of how the Dk value was obtained and what it represents.

The Dk of any dielectric material is frequency-dependent. In other words, when testing the same piece of material and using the same test method, it should be expected to get slightly different Dk values when testing at different frequencies. There is a range of frequencies where the Dk changes more with a change in frequency, and that is typically from a few megahertz up to about 5 GHz to 10 GHz. After about 10 GHz, and out to about 250 GHz, the Dk frequency curve will have a slight negative slope for most low loss circuit materials. Considering this range of frequencies, and depending on the degree of polarity of the circuit material, the slight decrease in Dk with an increase of frequency is usually in the range of 2% or less. For more accurate circuit modeling, it is important to use material data that was produced at the same frequency as the circuit being modeled.

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Another issue, which is typically a little more problematic for Dk values used in circuit simulation, is anisotropy. Most circuit materials are anisotropic, which means the Dk is not the same on the three axes of the material. It is pretty common for most circuit materials to have a Z-axis (thickness axis) Dk, which is different from the x-y plane of the material. The X-axis and Y-axis are typically similar for Dk values, but the Z-axis is often quite different. Also, for the testing to determine the Dk of a material, there are common test methods that evaluate the Z-axis of the material only and other test methods that evaluate the X-Y plane only.

If a designer uses the Dk information in their model, which was produced by testing the X-Y plane (instead of the Z-axis), it may or may not be appropriate for their particular model. It is good for the designer to be aware of what type of test method was used to determine the Dk, as well as the frequency at which the Dk value was obtained.

In the case of most high-frequency circuit materials, which have a Dk around 4 or less, the anisotropy is typically not that significant. In most of these cases, the difference between the Z-axis and the X-Y plane Dk values is 3% or less. However, for non-filled, glass-reinforced circuit materials, these Dk differences can be much higher.

In the case of higher Dk materials, such as materials with Dk values in the range of 6 or higher, there can be much larger differences in the Dk values of the Z-axis when compared to the X-Y plane values. For these materials, it is not uncommon to see Dk differences due to anisotropy of 5–15%, depending on the material. There are some exceptions, where some high Dk materials are formulated to have minimal anisotropy; however, the designer should consider anisotropy when using materials with higher Dk values.

Lastly, the designer should use Dk values from a test method that is most similar to their circuit design and at the same frequency as their application. Since there are a limited number of test methods and a very diverse number of circuit applications, it can be difficult for the designer to find a good match between the test method and their model. Regardless, the designer should investigate and try to use a Dk value that was generated in a manner that is as close to their model as possible. Further, engage with the material supplier to see if they have other Dk information that may be more appropriate for their design. DESIGN007

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