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SIMULATION & ANALYSIS

Efficient Simulation Using High-Frequency Printed Circuit Materials

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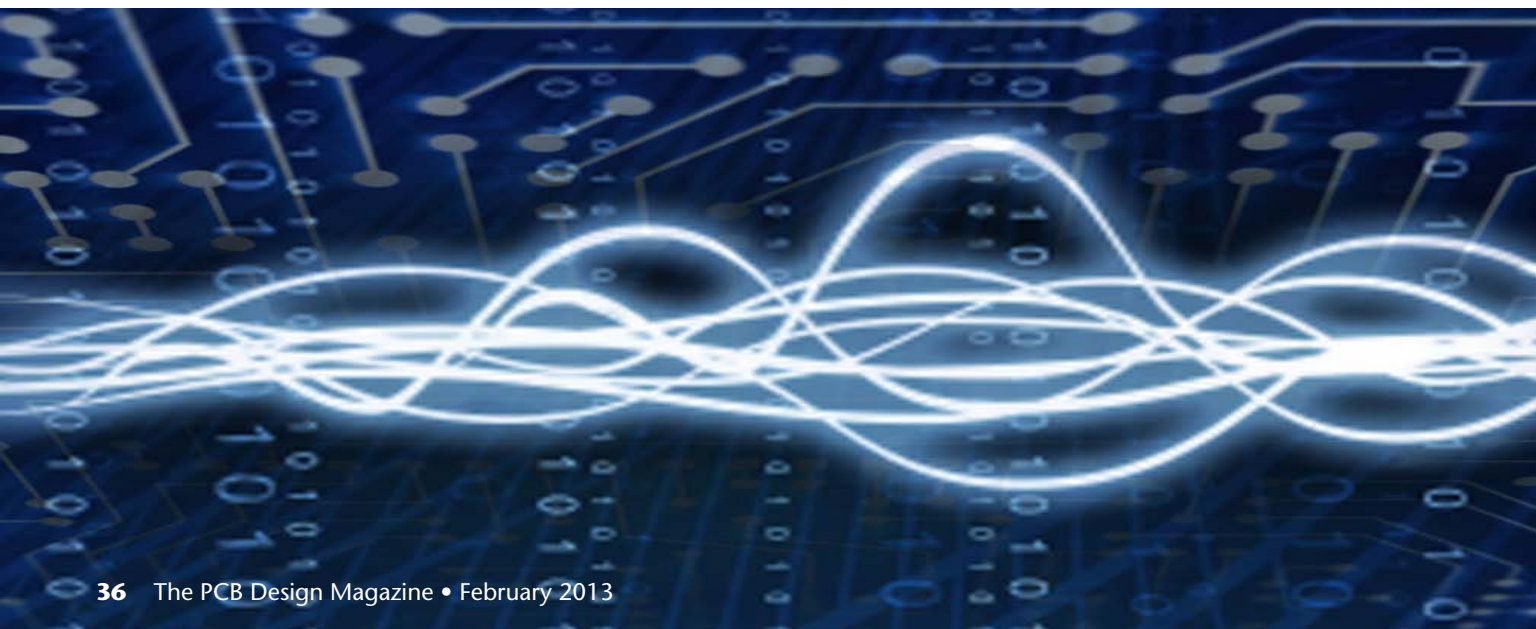
SUMMARY: ***Many different types of circuit simulation software are available, and each one is tailored to meet a different need. Dielectric constant and dissipation factor are two of the more important substrate properties to consider during simulation. The Dk value is provided on material datasheets, but Dk value can vary substantially depending on the test method.***

The general type of simulation software most often used for high-frequency laminates is impedance modeling or electromagnetic modeling tools. These software tools all require that circuit geometry be input, such as the conductor thickness, width, substrate thickness, and other details. The substrate properties which are generally most important are the dielectric constant (Dk or ε_r) and dissipation factor.

The Dk value is provided on material datasheets; however, anyone who is less savvy with material issues may be unaware that the Dk value can be very different depending on the test method. If the test method is not the same configuration as the circuit the designer is concerned with, the Dk value may be less accurate. A simple example: A common test method used for high-frequency circuit materials is the clamped stripline resonator at 10 GHz. If the designer is using this material and concerned with a microstrip transmission line circuit operating at 2 GHz, the Dk data from the stripline resonator may not be as accurate as needed.

The different test methods are designed for specific reasons. The clamped stripline test method is a very good test method for evaluating raw substrate properties at a specific frequency and in a relatively high-volume testing environment. The stripline structure has a layering configuration of ground-signal-ground and this test method uses a clamping fixture that can test raw substrate quickly. The test uses a thin circuit (signal layer) which features the copper resonator pattern. On both sides of this circuit, the raw substrate will be placed and then the outer metal plates (ground planes) will be clamped together. The Dk can be tested within a few minutes, and when a materials manufacturer requires testing several hundred substrate samples per day, this is a good test method to use.

Referring back to the example, where stripline and microstrip were compared, the mi-



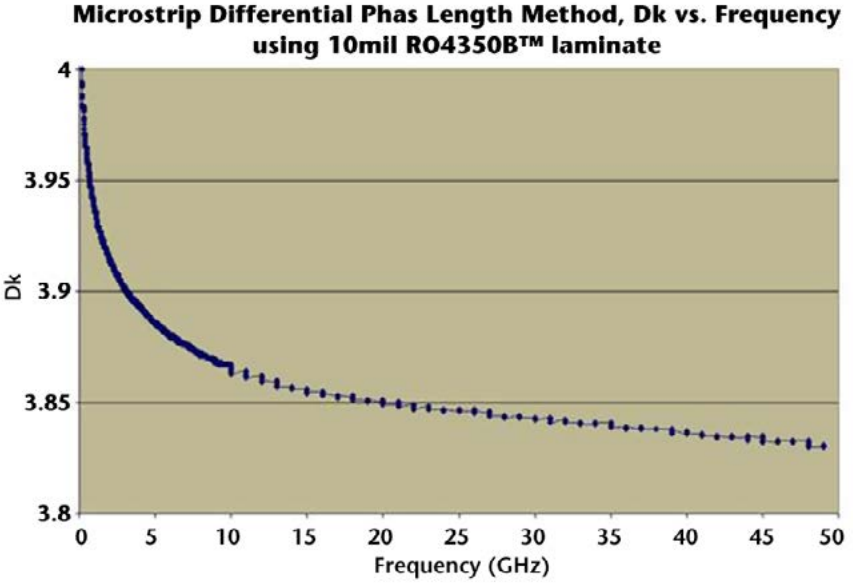


Figure 1: Graph showing Dk vs. frequency curve.

crostrip circuit is a two-copper-layer circuit with a layer configuration of signal-ground. This is obviously very different from the stripline structure, and one apparent difference is that the microstrip will have some electric fields in air while the stripline will fully contain all electric fields within the substrate. This difference by itself shows how data collected for a stripline structure may be different than for a microstrip circuit. Another possible issue is that the Dk of any circuit material is frequency dependent. The variance of the Dk as compared to frequency is called dispersion, and some circuit materials have more dispersion than others. Most high-frequency circuit materials have relatively low dispersion, which means the Dk doesn't vary much with frequency. The stripline resonator is testing the substrate at a specific frequency and in many applications the frequency of concern will be different than the test method frequency. Many other applications may be wideband where the Dk performance over a wide range of frequencies can be important to know.

Most circuit material suppliers understand the different test methods and the need for knowing the Dk at different frequencies and for different circuit structures. Rogers Corporation can provide design Dk data in order to assist in circuit design with high-frequency circuit materials. The majority of Dk testing is done on microstrip transmission line circuits. The test method used is the microstrip differential phase length method which uses circuits made on the same sheet of material, which are identical in every manner except length. There is a long circuit and a short circuit. The testing process nearly eliminates the effects of the connectors and signal launch, and generates data specific to the circuit and materials. The data yielded from this test is a Dk vs. frequency curve as shown in Figure 1.

A curve like this can be very helpful for circuit designers concerned with Dk at varying frequency ranges. This curve also shows something true of all circuit materials at lower microwave frequency (less than 8 GHz). The Dk vs. frequency response is non-linear. This area can have a different trend for dissimilar materials with different Dk, dissipation factor, thickness and sometimes copper type.

The high-frequency circuit material suppliers typically possess an abundance of information regarding their materials used in different circuit configurations as well as frequency. It is always recommended to get the material supplier involved with new applications in order to help minimize potential issues. **PCBDESIGN**

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