Brainstorm: Broadband Antenna Design

Brainstorm: What are some key considerations when selecting a high frequency circuit board material?

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Determine the dielectric constant needed and the dielectric loss desired. There are many factors around these properties that are rarely captured in a data sheet or software property table, yet are very important in the selection of high frequency materials. Let’s first look at dielectric constant, as important as the value of the material dielectric constant itself, the variation of this property needs to be taken into account. The variation can be in the nature of the material itself (frequency, temperature, moisture) or can be a product of manufacturing processes (within panel, panel to panel and lot to lot). In order to have a consistent product once it transfers from product development to mass production, dielectric constant repeatability must be understood.

The second property to consider is the material’s loss tangent (dielectric loss). Designers are often tasked to keep a certain loss budget under consideration. Conductor and dielectric losses need to be separated in order to reach a better estimate of needed loss tangent. Keep in mind that conductor loss will be impacted by dielectric constant and laminate thickness, which dictate line width, as well as copper surface roughness effects. Selecting the combination of dielectric constant and loss tangent can be somewhat of an iterative process before narrowing it down to a few material types. One should not make a selection only by comparing data sheet properties. The reason is that the value reported depends on the test method and frequency used. Some tests derive loss tangent through measurement of total circuit loss while others look at perturbation of wave guides after a dielectric is inserted. Designers should not only make decisions based on data sheet values but should also consult with the material suppliers to better understand all key considerations in selecting a high frequency material.

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Since I work exclusively in the antenna field, my concerns may be different than, for instance, an RF power amp designer.

Obviously, my first concerns when evaluating a new P.C. Board material would be the dielectric constant and the loss of the materials. The dielectric constant effects the resonate lengths of antenna elements, so it is the primary concern. If I need to design an antenna to fit into a small enclosure, I would probably choose a high dielectric constant material. Typically the microwave materials I use have a dielectric constant of 2.2 to 4. The loss of the high frequency materials I use is approximately 0.002. This gives my antennas reasonably high efficiency.

The next concerns when evaluating the board material are mechanical. How ridged is the board material? How stable is the material over the temperature range I'm designing for? How easy is it to fabricate? Can my partner P.C.B. fabrication houses process it?

The stability is a large concern. If the material's characteristics vary greatly over the desired temperature range the performance of my antenna may also vary. In some cases knowing the amount the material will change over temperature, the design can be made broadband enough to still meet specifications. This becomes much harder as the antenna designs become more complex. Multi-element designs with on-board phasing circuits require very tight material tolerances to guarantee performance.

Manufacturability of the board by the P.C.B. fabricators is a major concern for me. More exotic materials, while offering major performance benefits, may be too costly to manufacture for the commercial market.

While it seems straight forward, there are many things that the designer must consider when choosing new materials.

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