Numerical Study of Copper Surface Roughness Effects for Stripline Structures

Xichen Guo, Ji Chen, and David R. Jackson
Department of ECE, University of Houston, Houston, TX 77204-4005

Stripline transmission line is often used for high-speed signal propagation on the backplane traces that are designed for use in 10+ Gbps networks. The center conductor of the stripline is often deliberately roughened in order to provide extra adhesion to the substrate. This makes the calculation of signal attenuation along the stripline important at these high frequencies. One significant numerical challenge is the fact that the size of the surface roughness is on a very different size scale from the stripline dimensions, making an accurate modeling of the entire structure prohibitive.

A practical method to evaluate the roughness effects, including the signal attenuation and the affect on the phase constant of the propagating signal, is proposed and investigated here. In the proposed method the surface roughness profile is modeled as periodic repetition of hemispheroidal bumps ("teeth") that exist on the conductor surface of the stripline conductor.

An equivalent surface impedance is extracted from the propagation wavenumber of a surface wave (a perturbed parallel-plate mode) that exists when modeling a small length of parallel-plate waveguide that has a much smaller cross sectional dimension than the actual stripline structure. The quasi-TEM parallel-plate waveguide has a periodic roughened metal surface on the top, and a perfectly conducting wall on the bottom. Perfect magnetic conducting walls are used for the side walls of the parallel-plate structure.

A waveport in HFSS (modeling an infinite exciting waveguide) is used to excite the parallel-plate structure that has surface roughness. HFSS is then used to determine the wavenumber of the surface wave.

An equivalent surface impedance (which accounts for the periodic roughness) is then used in a simple analytical model (an ideal parallel-plate waveguide with a top surface impedance wall) to determine the required value of the equivalent surface impedance in the model that will give the same complex wavenumber as the quasi-TEM mode in the parallel-plate waveguide with roughness. This equivalent surface impedance is then used to determine the resistance per unit length and the internal inductance per unit length of the stripline, and from this the propagation wavenumber on the stripline can be determined.

This approach is validated using measurements, and it is shown to provide an estimation of the attenuation on the actual stripline structure to within 0.2 Np/m for roughness tooth height up to 8 microns.