Model-Based Dielectric Measurement Techniques
Using Custom Open-Ended Coaxial Probes

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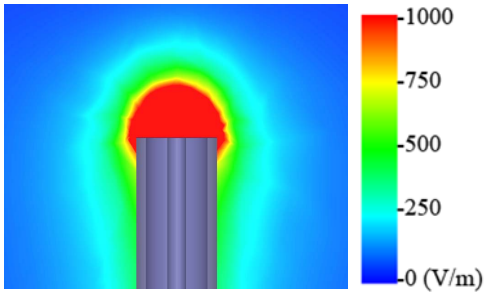

Figure 1a: Probe HFSS Model

Figure 1b. Probe and Portable VNA

A model-based dielectric measurement technique using custom open-ended coaxial probes has been developed for *in situ* measurements of vegetation, as well as for *in vivo* measurement of biological tissue dielectric constant. The impracticality of repeated device calibration, especially in time-limited field campaigns or in the operating room in the case of biological tissue, along with the high cost of commercial probes, has motivated the development of this model-based technique for accurate characterization of dielectric constant without the need for traditional three-standard probe calibration methods. Instead, this dielectric characterization technique relies on the use of precise finite element modeling of a specific probe geometry in order to generate a pre-computed lookup table linking the S-parameter measurement (using a VNA) to the corresponding complex dielectric constant for the material under test (spanning the expected range in the table below).

ε_r: 1 – 80	σ: 0 – 10 (S/m)	*f:* 0.3 – 6 GHz

A set of custom dielectric probes were fabricated with identical geometry by machining semi-rigid coaxial cables (0.086" OD) to a uniform length. Each probe was experimentally characterized by measuring the complex S_{11} parameter with the open end in air. A full-wave model of this cable geometry was then created in Ansoft HFSS (Figure 1a), and the model parameters were determined by iterative refinement to achieve the best fit for the S_{11} measurement in air across the frequencies of interest .Using this model, the lookup table of complex S_{11} data was then generated for the values of permittivity (ε_r), conductivity (σ), and frequency shown in the table above.

The presentation will discuss practical issues with *in situ* dielectric measurements using a portable VNA (Figure 1b). Furthermore, permittivity measurements obtained using the model-based technique as well as commercial software will be presented to illuminate practical advantages of probe modeling. The S_{11}-ε_r lookup method will be outlined with emphasis on open-ended air S_{11} measurements used to correct any probe and cable induced errors and calibration drifts.