Waveguide Calibration and Material Characterization under Common and Differential Excitation

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Approximately a decade ago, the typical network analyzer (NWA) found in laboratories was a two-port device for measuring the scattering parameters S_{11},S_{21} under forward excitation and S_{22},S_{12} under reverse excitation. The forward and reverse excitation was generally controlled via a switch since only a single source was employed. Modern NWA designs now include multiple ports and multiple sources, being strongly influenced by the demands of integrated circuit technology in which interconnects are arranged in differential-mode pairs to reduce electromagnetic interference. These multisource NWA's now allow simultaneous measurement of mixed-mode (i.e., common-differential-mode) scattering parameters in order to rapidly assess design performance. It was recently discussed (M. Havrilla, "Rectangular waveguide mode and bandwidth enhancement using common and differential excitation," URSI National Radio Science Meeting Abstracts, pg. 28, Boulder, Colorado, January 2017) how this multisource capability can be exploited to enhance bandwidth performance and offer mode control in rectangular waveguides. The goal of this paper is to discuss how to calibrate and subsequently extract material parameters from measured rectangular waveguide data under mixed-mode excitation.

Mixed-mode scattering parameters are reviewed first. A dual-probe rectangular waveguide feed/launcher design is presented, followed by a discussion on how this new feed enhances bandwidth and electromagnetic field control under common and differential excitation. The final step and primary goal is to discuss the critical aspects of how the device can be calibrated and how the measured common and differential-mode scattering parameters can be utilized to extract constitutive properties from material samples. Since common and differential measurements enhance measurement diversity, planned future work in the area of anisotropic and bianisotropic materials will also be discussed.

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