CAD OF SELF-BIASED FERRITE CIRCULATORS

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Self-biased (SB) ferrites are an attractive solution to achieve full integration of RF front-ends in, e.g. a GaN-on-SiC MMICs process. Nano-composite magnetic materials have the advantage of operating at X-band and below, unlike self-biased hexaferrites (*Y. Zhang, et al., "Synthesis and Properties of FeCo-Based Anisotropic Magnetic Nanocomposites", 62nd Conf. Magnetism and Magnetic Materials, 2017).* The design and fabrication of this type of materials is still in progress, and the maturation of such technology will require the understanding of the best computer aided design (CAD) practices for simulating non-reciprocal devices. This study investigates the different CAD approaches for modeling microstrip circulators implemented with self-biased ferrites. The device magnetic cavity can be considered as a ferrite superimposed with a field from a permanent magnet. Under this assumption, magnetostatic co-simulations are used to calculate as an equivalent external bias field for the microwave full-wave simulation. On the other hand, the de-magnetization of the material inside the circulator ferrite cavity results in a non-uniform distribution of the magnetic bias field (MBF) and hence unsaturation in some regions. This can be modeled by dividing the ferrite cavity into smaller regions with a uniform MBF with a different amplitude applied to each volume *(M. Pinto et al, "Design Oriented Modeling of Microstrip Ferrite Circulators," EuMW 2018)*. A comparison between the two techniques is performed and validated by measurements of a fabricated device. In order to understand measurement variations among different SB ferrite samples, a parametric analysis of the material parameters is performed, as well as dimensional tolerance limits for monolithic microwave MMIC circulators.

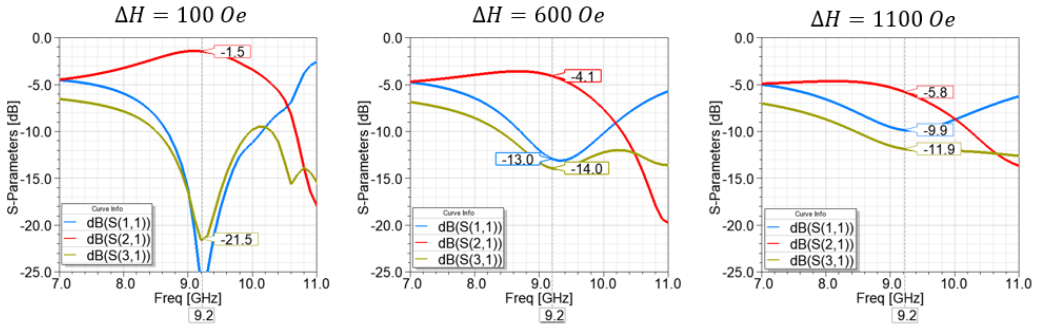

Figure. Simulated performance of self-biased circulator return loss, isolation and insertion loss for a range of ferromagnetic resonance linewidth values, considering a constant magnetization saturation Ms = 0.45 T and keeping the ratio of remnant to saturated magnetization constant (Mr/Ms=0.72).