MICROSTRIP CIRCULATOR BANDWIDTH INVESTIGATION

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This paper presents an investigation of bandwidth performance of a microstrip circulator with the potential of integration with active circuits in a T/R module. The Y-junction architecture (*H. Bosma, "On stripline Y circulator at UHF,", IEEE Trans. MTT, Jan. 1964*) is modified to a microstrip multi-layer design with commercial ferrite materials operating below the ferromagnetic resonance (FMR). The geometry of the device shown in the figure contains the main microstrip dielectric substrate, a ferrite puck, and a second dielectric fill layer under the ferrite material. A modified mathematical approach of the classical equations is developed to correct for the device resonance, and used to obtain the initial circulator design. The structure is then simulated using a finite-element full-wave simulator (Ansys HFSS). A study is performed relative to various parameters, such as substrate thickness and permittivity, ferrite material properties, ferrite layer thickness and cylinder radius, external DC magnetic bias field strength and profile, dielectric fill layer thickness and permittivity, and microstrip matching circuit. The goal of the parametric study is to maximize bandwidth while keeping low insertion loss, high return loss and high isolation, and to provide design guidelines for circulators with this geometry. Several circulators implemented with a commercial material (Trans-Tech TT-105) around 3.8GHz are designed and characterized to experimentally validate the design procedure. Other shapes for the ferromagnetic material are also investigated, as well as scaling to higher frequencies. Finally, an approach to integration of this type of circulator in gallium nitride (GaN) integrated circuits (MMICs) is also presented.

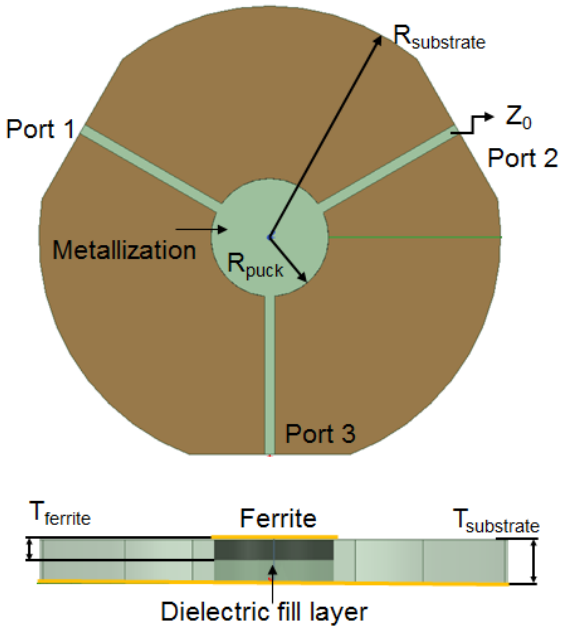

Figure. Top view and cross-section of the circulator architecture. The top view shows the microstrip metallization. The cross-section shows the ferrite cylinder with dielectric fill layer underneath.