EM Simulation of a Low-Pass Filter Based on a Microstrip Defected Ground Structure

José E. Rayas-Sánchez[1], Jorge Aguilar-Torrentera[1], Zabdiel Brito-Brito[1], Juan C. Cervantes-González[2], Carlos A. López[2]

[1]Universidad Jesuita de Guadalajara, Tlaquepaque, Jalisco, Mexico
[2]Intel Guadalajara Design Center, Tlaquepaque, Jalisco, Mexico

Abstract

We perform electromagnetic simulations of a low-pass filter consisting of an open stub and unit sections implemented as defected ground structures (DGS). The DGS belong to a class of electromagnetic bandgap structures in which a defect on the backside ground plane creates bandpass and stopband characteristics over certain frequency intervals [1].Figure 1 shows the geometrical structure of the low-pass filter considered herein. Such a structure was proposed in [2] as a filter with wide and deep stopband characteristics and low insertion losses. A distinct feature of the defected ground structure is the ability to increase the effective inductance and capacitance of the microstrip transmission line without varying the microstrip width, W. This avoids parasitics that arise in conventional microwave filters, which diminish the effective rejection band at higher frequencies. The filter design parameters are the gap distance of the aperture, g, the lattice area defined by a and b, and the width and length of the cross-junction open stub, Wc and Pc, respectively (Figure 1). Each DGS unit section consists of two rectangular etches of area a×b connected through a narrow etched aperture of area W×g. Etches are on the backside metallic ground plane with thickness t, equal to that of the metal trace. The microstrip line sections that connect input/output ports were designed as 50-ohm-lines. Using COMSOL, different filter implementations were carried out with the aim at evaluating the computational costs that represent the usage of different simulator features. These implementations consider lumped and numerical ports, metallic conductors implemented as infinitesimally thin perfect electric conductors and in the form of hollow lines defined with impedance boundary conditions, low and high mesh resolutions; among other features. We found that a COMSOL implementation that has low computational cost becomes a fairly good approximation of the COMSOL implementation based on accurate items, which we named as fine model. The fine model responses (Figure 2) present an excellent agreement with respect to measured data reported in [2] (Figure 3). The filter presents deep attenuation characteristics in the stopband up to frequencies exceeding 10GHz. The attenuation characteristic is deteriorated as the magnitude of the transmission scattering parameter increases with frequency, which is a consequence of the large radiation losses that take place at the DGS units, which are also evaluated by simulation. We choose a bounding box based on two air layers surrounding the filter structure to handle effectively the radiation. Given the resonances found with an electrically enclosed box, we used scattering boundaries on top and bottom covers instead of using perfect electric conductor. This selection matches with the field absorbing conditions at which measurements were performed [2]. To reduce

interactions with the enclosing box, a parametric analysis was carried out to determine the box size at which filter responses become very insensitive to the boundaries. Computational costs, simulation times, and COMSOL settings such as enclosing box, port types, etc. , for the low-pass filter implementations, are provided.

Reference

1. Y. Qian, V. Radisic, and T. Itoh, “Simulation and experiment of photonic bandgap structures for microstrip circuits”, in Asia Pacific Microwave Conference (Proc. APMC’97), Hong Kong, China, Dec. 1997, pp. 585-588.
2. D. Ahn, J. Park, C. Kim, J. Kim, Y. Qian, and T. Itoh, “A design of the low-pass filter using the novel microstrip defected ground structure,” IEEE Trans. Microwave Theory Tech., vol. 49, pp. 86-4537, Jan. 2001.

Figures used in the abstract

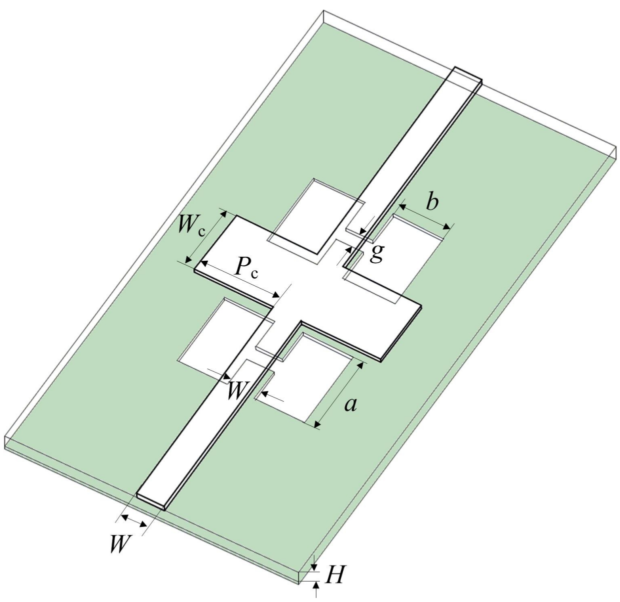

Figure 1: Low-pass filter with two-DGS unit sections using cross-junction opened stub.

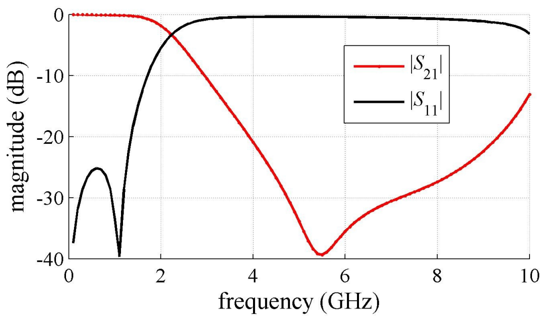

Figure 2: COMSOL results of the fine model implementation, confirming good insertion-loss and wide attenuation characteristics, in excellent agreement with measured data in Figure 3.

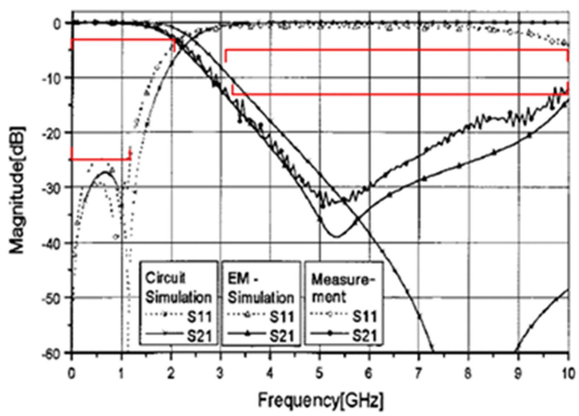

Figure 3: Simulated and measured results of the fabricated DGS low-pass filter (from [2]).