Study of Microwave Photon-Magnon Coupling Using COMSOL Multiphysics®

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Abstract

Split Ring Resonator (SRR) has lately garnered appreciation in the scientific community for their abilities to constitute such materials which unlike their counterparts, made up of magnetic elements, show high magnetic energy density over a very confined space and consume less power. They are made up of nonmagnetic materials and are lightweight options against bulkier ferrite in the high-frequency range (GHz). We are studying the microwave photon- magnon coupling by investigating the resonance of SRR loaded with BLIG ((LuBi)_{3}Fe_{5}O_{12}), a ferrite film. The observations are based on experiments as well as simulation results obtained by using RF Module of COMSOL®.

The SRR is configured in this paper as a single, 10mm x 10mm square-shaped copper ring, placed on a Roger 4003 substrate. The microwave resonance in SRR is being excited through a 1.6 mm copper feed-microstripline running close to it. The whole structure is then encapsulated in an air box. The air box is surrounded by PML boundary condition to mimic the free space. The input and output of feedline are defined by the lumped port boundary condition. The metallic parts are defined by Perfect Electric Conductor boundary condition. Along with providing the said boundary conditions, COMSOL^{TM} gives liberty to the user to localize meshing density in critical areas and, thus, in optimizing the accuracy, computation time and memory requirements. The magnetic resonance is achieved by placing the ferrite film on top of the feed and SRR ring in presence of DC magnetic field.

The first stage of our exercise aimed to run the experiments and simulations in absence of BLIG film so that in the later stage the microwave phenomenon can be separated from the combined response of both magnetic and microwave effects. In the process, the dependency of the performance of single ring SRR on attributes like permittivity of the substrate, length of the ring, length of air gap, the shape of the ring, etc., was also investigated.

In the second stage, magnetic resonance is induced by including a 7.9 um thick BLIG film. Currently work is going on to simulate the BLIG loaded SRR to study the microwave photon and magnon coupling in future. The software accepts anisotropic values for parameters and thus, the permeability tensor for the in-plane magnetized film will be introduced in the design.

The S-parameters were used throughout to mark the performance of the device and were

recorded by sweeping the frequency from 1 - 10 GHz. The results obtained for the unloaded (without ferrite film) SRR, through simulations were found in accordance with the experimental values for first three peaks and can be seen in figure 1 attached to the abstract.

Figures used in the abstract

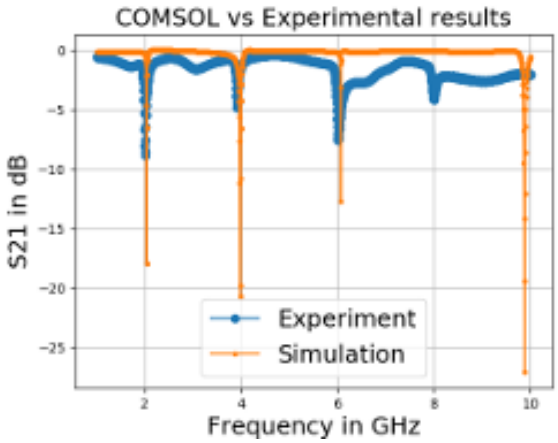

Figure 1: S21 (in dB) parameter obtained through simulation and experiment