Journal of Magnetism and Magnetic Materials xxx (xxxx) xxx

Contents lists available at ScienceDirect

Journal of Magnetism and Magnetic Materials

journal homepage: www.elsevier.com/locate/jmmm

Two split rings resonator-based perfect metamaterial absorbers with the incident and polarization angle independent for sensing applications

Mst Ishrat Jahan [a,1], Mohammad Ullah [b,c,1], Hamzah Ahmad [a], Rasidi Roslan [b,c], Izan Izwan Misnon [b,c,*], Rajan Jose [b,c]

[a] Faculty of Electrical and Electronics Engineering, Universiti Malaysia Pahang Al-Sultan Abdullah 26600 Pekan, Malaysia
[b] Centre for Advanced Intelligent Materials, Universiti Malaysia Pahang Al-Sultan Abdullah 26300 Gambang, Malaysia
[c] Faculty of Industrial Sciences and Technology, Universiti Malaysia Pahang Al-Sultan Abdullah 26300 Gambang, Malaysia

ARTICLE INFO

Keywords:
Tri-band
Absorbance
Perfect metamaterial absorber
Pressure sensor
Moisture sensor
Density sensor

ABSTRACT

The perfect metamaterial absorber (PMA) optimized for high-performance absorbers to find the multiple sensing application. The structural composition of the PMA consists of two split ring resonators with six split gaps configured in an exhibit symmetry of rotation. The fundamental component of the design has three distinct layers: (1) the top and bottom layers, composed of a metallic substance with copper dielectric substrate with a thickness of 0.035 mm that exhibits lossy metal; (2) the middle layer, made of a lossy dielectric material referred to as Rogers RT5870 dielectric substrate with a thickness of 1.575 mm. The findings reveal that the absorber achieves a broad absorption spectrum, with simulated results from the CST Microwave Studio simulator indicating absorption peaks at 5.88, 9.20, and 15.88 GHz. whereas the strong absorbance is 99.91, 99.99, and 99.97 % with a good quality factor (Q) 29.40, 9.20, 13.23, respectively. The structural dimensions (7×7 mm^2) are designed to deliver remarkable performance. The tri-band PMA exhibits polarization independent at various angles, including 0, 45, 90, 135, and 180° for both transverse magnetic (TM) and transverse electric (TE) modes. It has excellent absorption capabilities across multiple angles of incidence from 0 to 80°, including the whole operational spectrum. A comparative investigation of the circuit indicates the enhanced performance of the PMA, demonstrating its potential for exceptional functionality inside the advanced design system (ADS) software. Furthermore, the structures under consideration, which were simulated using the High-Frequency Structure Simulator (HFSS), demonstrate a strong agreement with the highest level of absorption seen at each resonance peak in the CST simulation outcomes. This paper introduces an alternative protocol, expressed in terms of the TE and TM modes, for use with the restricted symmetric structure to find multiple sensing application. The proposed study highlights the exceptional properties of PMA provides several practical advantages, including its high absorption capacity, in multiple sensing application, insensitivity to incident and polarization angles, satellite technology, raw satellite feeds, and radars owing to these performance features.

1. Introduction

Metamaterial is a material that has unique construction and excellent achievement [1,2,3]. Metamaterial absorbers (MA) have recently become popular due to their exceptional absorbing properties, which include features like ultra-thin densities, compact dimensions, low-cost systems, and easily controlled characteristics [4]. Due to its unique electromagnetic properties, it has been employed for various applications [5]. Bakir et al. indicated that MA has an absorbance rate of 91.8 % at a frequency of 4.2 GHz [6]. On the other perspective, the ideal multimode absorber should possess characteristics such as polarization insensitivity, omnidirectionality, and an absorption coefficient that approaches unity [4]. Periodic array patterns often fabricate MA with exceptional absorption capabilities, including lossy materials [7]. Such structures can effectively confine and attenuate incoming electromagnetic (EM) waves [8]. The EM absorbers have been widely used in many civilian and military applications, including electromagnetic compatibility, shielding, and stealth technologies [9]. Metamaterials are often

* Corresponding author at: Centre for Advanced Intelligent Materials, Universiti Malaysia Pahang Al-Sultan Abdullah 26300 Gambang, Malaysia (I.I. Misnon).
E-mail address: iezwan@umpsa.edu.my (I.I. Misnon).
[1] Authors contributed equally to this work.

https://doi.org/10.1016/j.jmmm.2024.171904
Received 20 November 2023; Received in revised form 5 February 2024; Accepted 25 February 2024
0304-8853/