Metamaterial Microwave Absorber (MMA)) for Electromagnetic Interference (EMI)) Shielding in X-band

Rakesh Mishra

Defence Institute of Advanced Technology Department of Applied Physics

Ravi Gupta

Defence Institute of Advanced Technology

Suwarna Datar (✉ suwarna.datar@gmail.com)

Defence Institute of Advanced Technology Department of Applied Physics <https://orcid.org/0000-0002-9513-0064>

Research Article

Keywords: Metamaterial, Rotational symmetry, Microwave Absorber, EMI shielding

Posted Date: March 24th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-335762/v1>

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
[Read Full License](#)

Abstract

The present paper is aimed at investigating application of planar Metamaterial (MM) structures for effective EMI Shielding and Stealth applications in X-Band. Various MM structures using FR4 substrate and Copper conductors were conceived and designed followed by simulations carried out using CST MWS Suite software. As a first step, the designs were aimed at achieving extremely high absorption for normal incidence, polarisation independence and maintaining high absorption in wide angle performance while keeping the requirement of light weight, flexibility and environmental ruggedness in mind for deployability on platforms to achieve effective stealth against Radars and for other EMI shielding applications. Circularly symmetric, single layer Metamaterial Microwave Absorber (MMA) design over thin FR4 substrate in spokes and wheel structural arrangement provided these desired features. The thin FR4 substrate of 0.6 mm provides the light weight and flexibility while absorbing the EM waves. Rotational symmetry of the spoke and cut-wheel design gives it polarisation independence and 4 ring planar array concept with rings scaled to different sizes in the same plane in the unit cell provided the increase in bandwidth. Reduction in received signal level of the echo is depicted by the S-Parameter at the input port. Getting values of this S-Parameter less than -60dB at resonant frequency for MMAs is highly encouraging and is not reported much in literature. Enhancement of nearly 3-8 times in operating bandwidth was achieved by changing size of rings in each quadrant in the co-planar array having four resonant rings in each unit cell.

Full Text

This preprint is available for [download as a PDF](#).

Figures

Figure 1

Orthographic front view of the proposed MMA with spoke and wheel structure

Figure 2

Perspective schematic view of proposed MMA

Figure 3

Perspective view of Zmax Port used for excitation. The Zmin port was not used because it is redundant due to metallic back plane.

Figure 4

The orthographic front view of the unit Cell of 4-Ring Array type Spoke and Cut-Wheel MMA having each ring structure scaled in size using a scaling factor in X-Y plane.

Figure 5

The perspective view of the front side of unit Cell of 4-Ring Array type MMA.

Figure 6

Reflection Parameter S_{Zmax} of -67.11 dB at normal incidence depicts 100% absorbance of scattered energy at the metasurface at resonant frequency.

Figure 7

Orientation of polarisation angle ϕ (f) and incidence angle θ (q). Angle ϕ varies along the blue circle and angle θ varies along the green circle.

Figure 8

S_{Zmax} vs frequency for varying polarisation angles ϕ while keeping $\theta = 00$.

Figure 9

S_Zmax vs frequency for varying incidence angles q while keeping f=00

Figure 10

S_Zmax vs frequency when both polarisation and incidence angle vary (keeping q =f).

Figure 11

Results of simulation on 4-Ring Planar Array of Spoke and Cut Wheel MMA Absorption vs Frequency

Figure 12

Results of simulation on 4-Ring Planar Array of Spoke and Cut Wheel MMA S1.1 Parameter vs Frequency.

Figure 13

Photograph of 20 x 20 array of fabricated MMA measuring 240 mm x 240 mm and expanded view on the right side.

Figure 14

Results of testing of Single Ring Spoke and Cut wheel MMA structure

Figure 15

Measurements carried out on the fabricated MMA using microscope.

Figure 16

Simulations carried out using measurements of the parameters of fabricated MMA while changing the electrical permittivity (Epsilon) of the FR-4 substrate.