Popsicle shaped Microstrip Patch Antenna design for Space Research applications

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Abstract — *In this paper, a popsicle shaped gigahertz (GHz) microstrip patch antenna with a reduced ground has been proposed. The Flame Retardant (FR-4) material having a dielectric constant (ε_r) of 4.4 has been employed as substrate in proposed antenna design having thickness of 1.44 mm. The copper material has been employed as patch and ground due to its low resistivity and high mechanical strength having thickness of 0.10 mm. The reduction in the dimensions of ground has been made to improve the various antenna return loss and bandwidth. The proposed antenna design is resonant at frequency of 5.434 GHz having corresponding return loss of -43.75 dB. The impedance bandwidth of the proposed antenna design is 211.9 MHz (5.325 GHz to 5.537 GHz). The performance of proposed antenna has been analysed in terms of gain (dB), directivity (dBi), return loss (dB), impedance bandwidth (MHz), VSWR (Voltage Standing Wave Ratio), impedance (ohms) and Half Power beam width (θ). It has been observed that the proposed popsicle shaped gigahertz antenna has a directivity and gain of 4.845 dBi and 4.84 dB, respectively at the corresponding resonant frequency. The CST Microwave Studio 2016 has been used for designing and simulating of proposed antenna design. The proposed antenna can be used for the Space Research applications.*

Keywords — CST Microwave Studio, dB, dBi, directivity, patch antenna, return loss, gigahertz.

I. INTRODUCTION

The microstrip patch antenna also named as patch antenna, is usually fabricated on a dielectric substrate which acts as an intermediate between a ground plane at the bottom side of substrate and a radiating patch on the top of substrate [1]. The patch of the antenna can be designed in many shapes like rectangular, circular, triangular, elliptical, ring, square and any more but mostly, rectangular shape is used because of the simplicity associated with the design. The selection of dielectric substrate material is the most important parameter while designing an antenna. The size of an antenna is primarily dependent on the dielectric constant of a substrate. The size of antenna is inversely proportional to dielectric constant *i.e.* higher is the dielectric constant, lower is the size of antenna [2]. There are various varieties of substrates available with different values of dielectric constant but in this antenna design, Fire Retardant (FR4) material with dielectric constant of 4.4 has been used. The feeding in microstrip antenna can be defined as the means to transfer the power from the feedline to the patch, which itself acts as a radiator. The microstrip feed line has been used in microstrip patch antenna designs because it is relatively simple to fabricate [3]. The microstrip patch antenna has been significantly used for wireless applications because of low cost, small antenna size, better efficiency, light weight, ease of mobility, ease of installation, and is relatively in expensive to manufacture on printed circuit board (PCB). However, a part from its advantages, there are some drawbacks of microstrip patch antenna. It handles less power and has limited bandwidth [4]. The bandwidth of microstrip patch antenna can be improved by either using a slotted patch [5][6] or by using reduced ground plane [7][8]. The parameters of proposed antenna are improved by the use of reduced ground.

II. ANTENNA GEOMETRY

In the proposed gigahertz antenna design, the substrate of thickness 1.44 mm has been employed. The material used for substrate is Flame retardant (FR-4) material due to its light weight and having a value of dielectric constant of 4.4. The copper material is used for both patch and ground due to low resistivity of value $1.68\times10^{-8}\Omega$m. The thickness of various component has been shown in Fig. 1. In proposed antenna design, popsicle shaped patch is used with various dimensions shown in Fig. 2. The back view of the proposed antenna design is shown in Fig. 3 with dimensions of reduced ground.

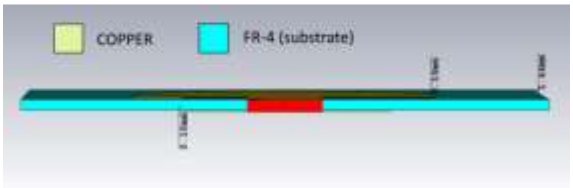

Fig. 1 Side view of the proposed antenna.

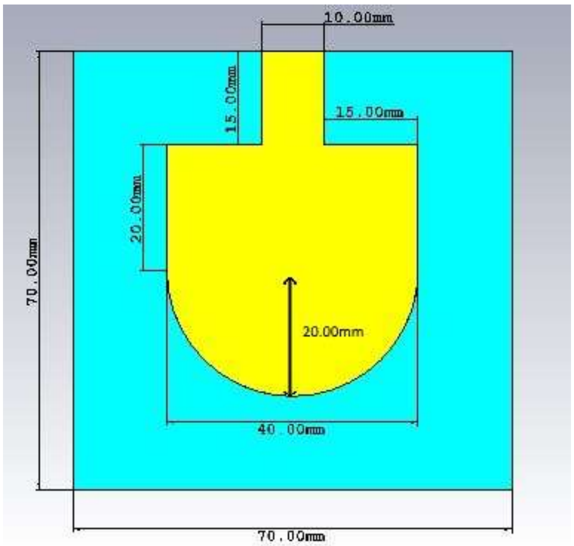

Fig. 2 Top view of the proposed antenna.

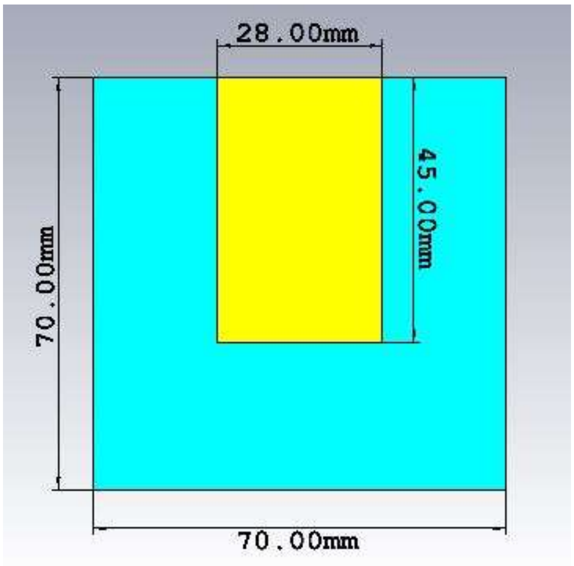

Fig. 3 Bottom view of the proposed antenna.

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III. Results

The performance of the proposed gigahertz microstrip patch antenna with reduced ground has been analysed in terms of impedance (Ω), return loss (dB), VSWR (Voltage Standing Wave Ratio), gain (dB), directivity (dBi), impedance bandwidth (MHz) and Half Power beam width. For the observation of these parameters, the CST microwave studio 2016 has been used. The proposed popsicle shaped antenna design has minimum return loss of -43.75 dB corresponding to the resonant frequency at 5.434 GHz has been shown in Fig. 4. The impedance bandwidth of 211.9 MHz (5.325 GHz to 5.537 GHz) is covered by the proposed antenna design as shown in Fig. 5 by markers named as 1 and 2. The Smith Chart has been used for obtaining value of impedance of proposed antenna design which is 50.01Ω shown in Fig. 6. The proposed popsicle shaped gigahertz antenna design has directivity of 4.845 dBi and gain of 4.84 dB as shown in Fig. 7 and Fig 8, respectively. In Fig. 9, the VSWR plot of proposed antenna design is shown which indicates that the value of VSWR lies below the minimum acceptable value of 2. The half power beamwidth of the proposed antenna design has been shown in polar plot having a value of 41.2 degrees in Fig. 10.

IV. Conclusions

In this research paper, a popsicle shaped gigahertz microstrip patch antenna with reduced ground has been simulated and designed using CST Microwave Studio 2016. The proposed antenna is resonant at a frequency of 5.434 GHz with corresponding return loss of -43.75 dB. The designed antenna has the directivity and gain of 4.845 dBi and 4.84 dB at the corresponding resonant frequency. The proposed antenna design has impedance of 50.01 Ω with an operating frequency range of 211.9 MHz (5.325 GHz to 5.537 GHz) which can be employed in the Space Research applications.

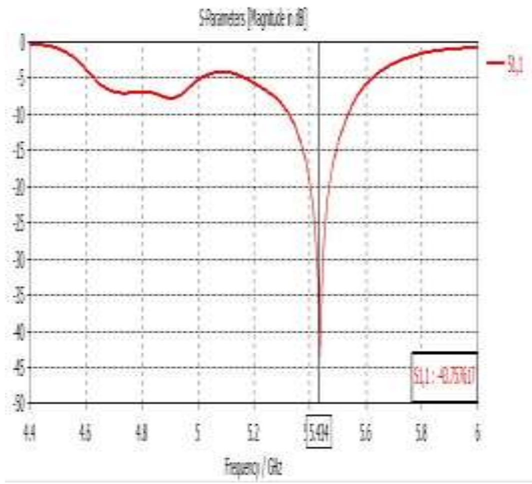

Fig. 4 Return loss plot of the proposed antenna

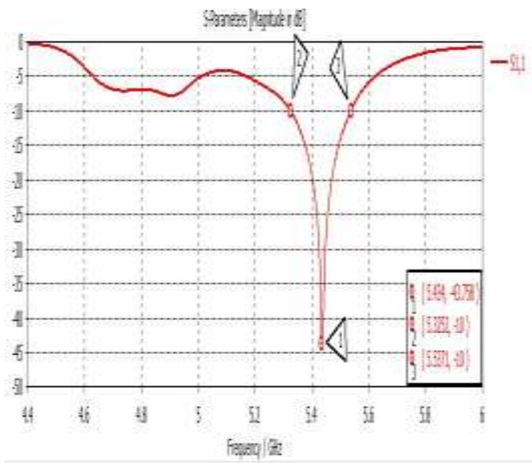

Fig. 5 Bandwidth plot of the proposed antenna

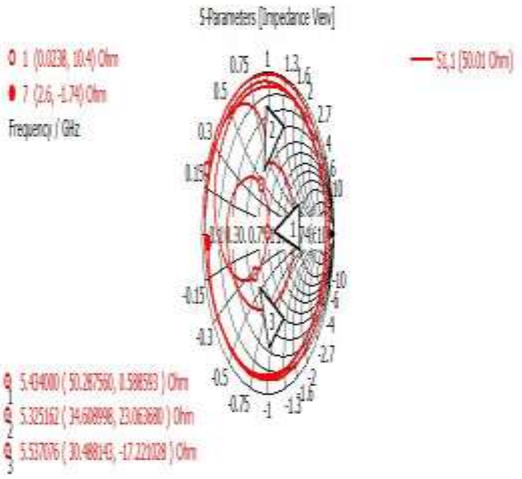

Fig. 6 Smith Chart of the proposed antenna

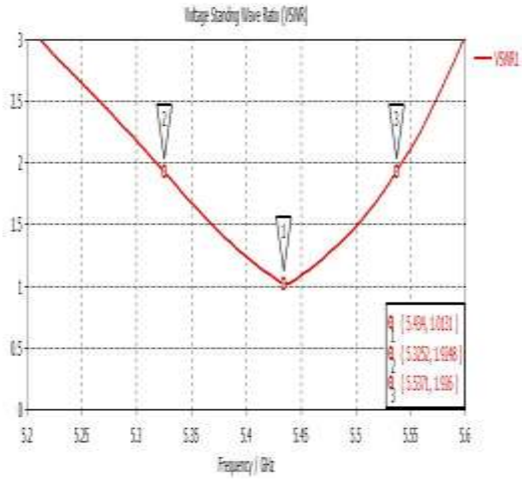

Fig. 9 VSWR of the proposed antenna

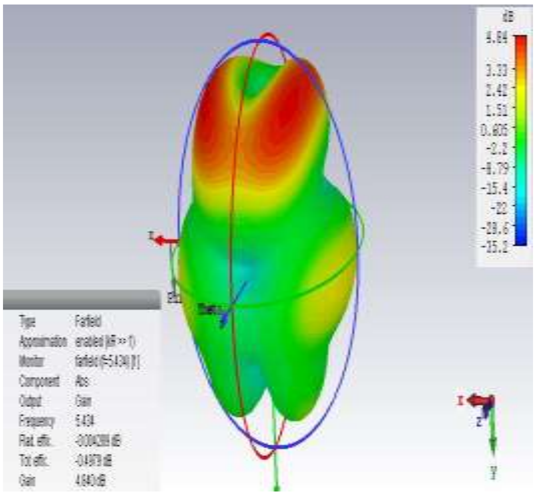

Fig. 7 Gain of the proposed antenna

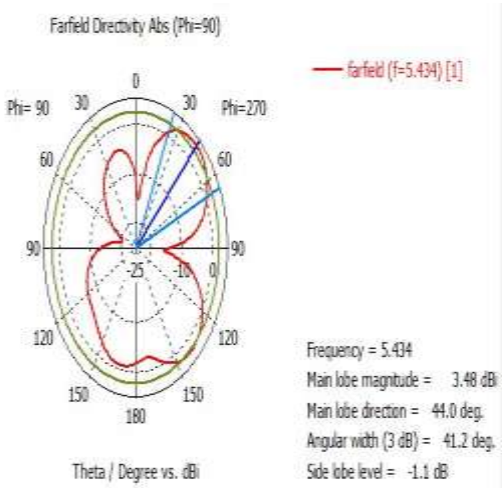

Fig. 10 Polar plot of the proposed antenna

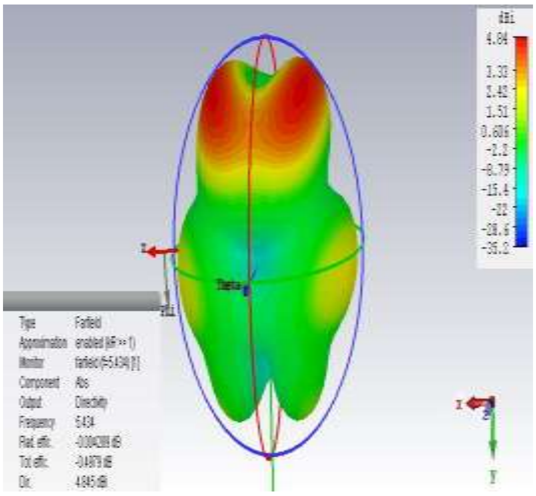

Fig. 8 Directivity of the proposed antenna

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