Circularly Polarized Microstrip Patch Antenna Using PBG Structures

K. P. Vinay, B. Ramesh, Lalbabu. P, Y.E. Vasanth Kumar, M. Meena Kumari

Abstract: In this work a microstrip dual feed antenna with PBG structure was proposed to improve the efficiency and bandwidth of the designed antenna. The prototype antenna was fabricated on Rogers RT 5880 substrate of thickness 0.76mm with Єr=2.2 and operating frequency 4.83GHz. The circular polarization is obtained by using dual feeding technique. The designed antenna is simulated with CST MW studio and the simulation results shows that the return loss, VSWR and Impedance bandwidth are in good correlation with the measured results. The designed prototype antenna can be used for receiving frequency for INSAT/Super- Extended C- band applications i.e., 4.83GHz.

Index Terms: Bandwidth, Photonic Band Gap (PBG), Rogers RT 5880 and VSWR.

I. INTRODUCTION

Recently microstrip patch antennas are the most sophisticated antenna based on its applications, with some merits such as easy to fabricate, low weight and cost and operation in the large frequency range [1]. Microstrip antennas are having, the biggest drawbacks in terms of narrow bandwidth, lower efficiency and relatively large. The important theme in microstrip antennas design is to enhance the inherent narrow bandwidth of microstrip antennas and to miniaturize the size of the patch antenna. The narrow bandwidth can be increased by increasing substrate thickness, but this will lead to a larger surface wave that will degrade antenna pattern and efficiency [2].

Non-contact exciting methods such as the proximity/aperture coupled can be used to enhance the impedance bandwidth, which is difficult to fabricate and also makes the antenna bulky. To override the problem of bulky nature, the basic antenna miniaturization techniques will be divided into lumped element loading, material loading, Shorting pins and antenna with Photonic Band Gap (PBG) structures [3]-[5].

The PBG structures are having, regular arrangements of metallic or dielectric material that shows band gap behavior that are susceptible to the permittivity, the height of the substrate, and the most importantly the PBG geometry [6]. The vital properties of PBG are the ability to reducing substrate absorption, surface waves, guide and control the Spread of electromagnetic waves and thus enhance the antenna performance by reducing the cross-polarization, back radiation and mutual coupling [7]-[8].

In this work a microstrip patch antenna with drilled holes in the substrate PBG structure is proposed. The proposed antenna is simulated with CST MW studio and simulation results are compared with the fabricated antenna which shows good correlation between them.

II. ANTENNA DESIGN

The structural geometry of the proposed microstrip patch antenna (MPA) established by drilling vacuum holes into the substrate material is depicted in the Fig-1. The PBG structure is obtained by drilling regular cylindrical holes in the substrate material Rogers RT 5880 having dielectric constant (ϵ_r) =2.2 with dimension 39mm×35mm×0.76mm is depicted in the Fig.1. The radius of the cylindrical hole is 1mm and the gap between the two cylindrical holes centre is 4mm, and the length and width of the rectangular patch is 19mm×16mm. The PBG structure is defined as a periodic structure and it is given by corresponding wave number at a stop band frequency (K) i.e.,

$$K = \frac{\pi}{d}$$

where d is period or cell spacing. If PBG is realized with regularly spaced holes, ripples for the elimination of harmonic based on cell spacing (d) and filling factor(r/d) which is determined as the ratio of the radius of cylindrical hole and the gap between the cells in order to get optimum work in the rejection band must be in the range of 0.24 to 0.3. The design of the microstrip patch is based on the transmission line model and its length and width are calculated using the expression shown below

$$L = L_{eff} - 2\Delta L \qquad (1)$$

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}} \qquad (2)$$

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)} \qquad (3)$$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}} \qquad (4)$$

$$W = \frac{c}{f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad (5)$$

The geometrical structure of the designed MPA with and without PBG structure is depicted in the Fig-2.

Revised Manuscript Received on April 07, 2019.
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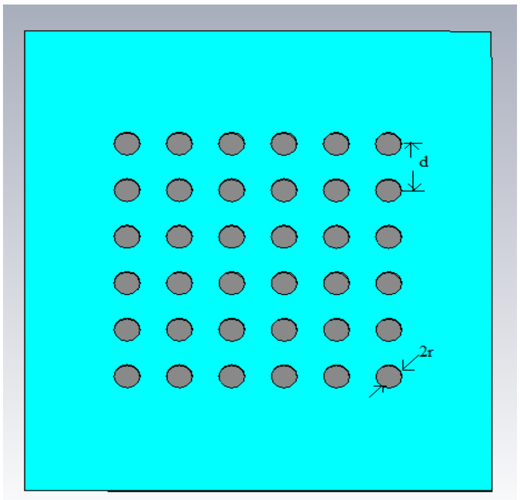

Fig.1 The 2D- geometry of the PBG structure.

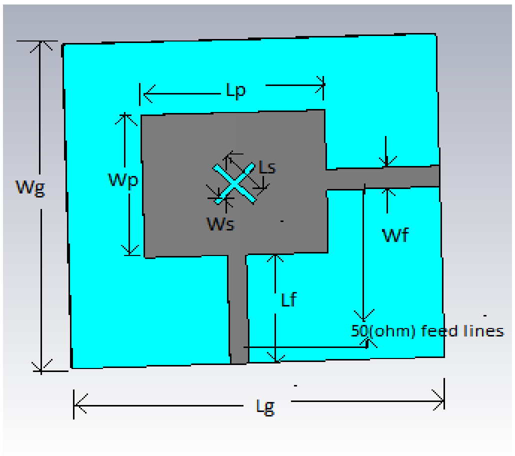

Fig.2(a)

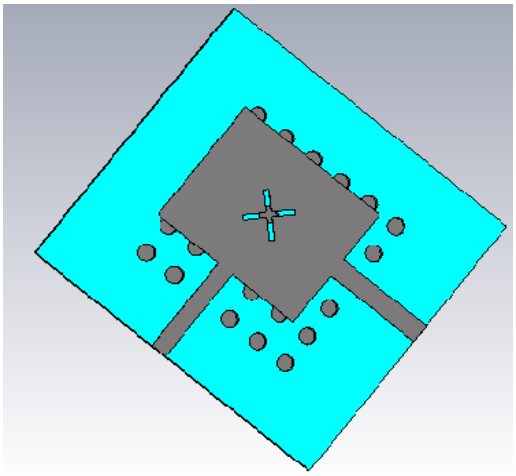

Fig.2(b)

Fig.2 The 2D-geometrical structure of the designed antenna (a) Without PBG structure (b) With PBG structure

Table-1 Dimensions of the designed MPA.

MPA-Design Variables	Values (mm)	MPA-Design Variables	Values (mm)
Lp	19	W_s	0.58
Wp	16	Lg	39
L_f	12	Wg	35
W_f	2	d	4
L_s	5.8	r	1

III. OUTCOMES AND ANALYSIS

The designed antenna is simulated with CST MW studio. The simulation results of return loss S_{11} without and with PBG structures are depicted in the Fig.3 and Fig.4.

From Fig.3(a), it can be easily observed that the MPA without PBG structure is having a lower return loss of -16.9dB at frequency 5.5GHz with a bandwidth of 410MHz and from the Fig.3(b), it is observed that the MPA with drilling vacuum holes PBG geometrical structure gives better S_{11} than the conventional patch antenna. The S_{11} of the MPA with PBG structure is -17.47dB at frequency 5.5GHz with a bandwidth of 460MHz. The bandwidth of the MPA with drilling vacuum holes in the dielectric material is larger than the MPA without PBG structure.

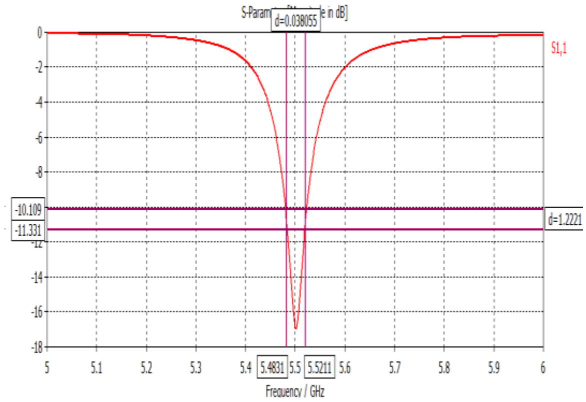

Fig.3(a)

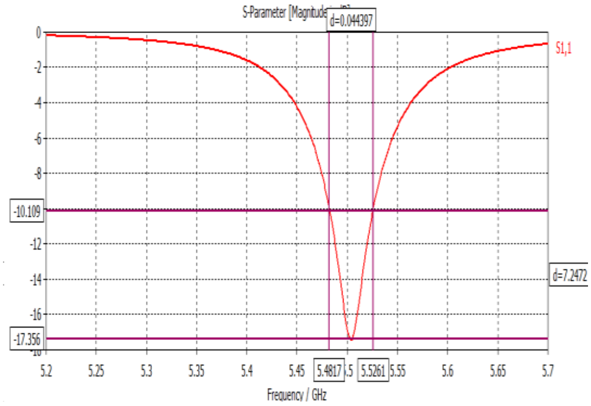

Fig.3(b)

Fig.3 The S_{11} of the designed MPA (a) Without PBG geometrical structure (b) With PBG geometrical structure

The directivity of the MPA without PBG structure is 8dBi and for the MPA with PBG geometrical structure is 8.2dBi which is depicted in the Fig.4 and Fig.5.

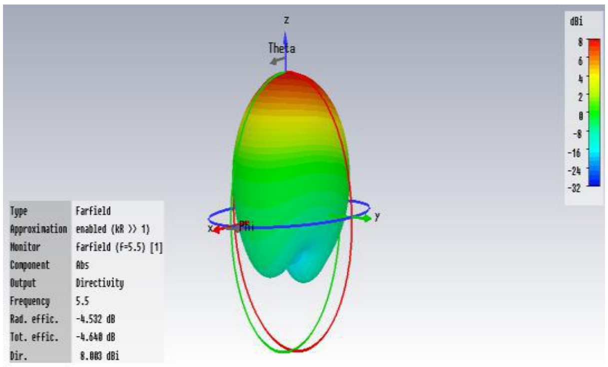

Fig.4 The 3D- radiation pattern of the MPA without PBG structure

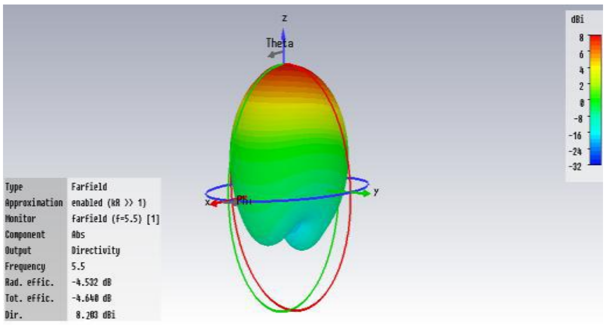

Fig.5 The 3D-radiation pattern of the MPA with PBG structure

The prototype antenna is fabricated and analyzed with Vector Network Analyzer and the S_{11} is measured. From the measured results, the return loss of -15.48dB at 4.83GHz with a bandwidth of 313MHz is obtained. The fabricated antenna with measurement setup and the S_{11} of the fabricated antenna is depicted in the Fig.7 and Fig.8. Table-2 depicts the comparison between measured and simulation results.

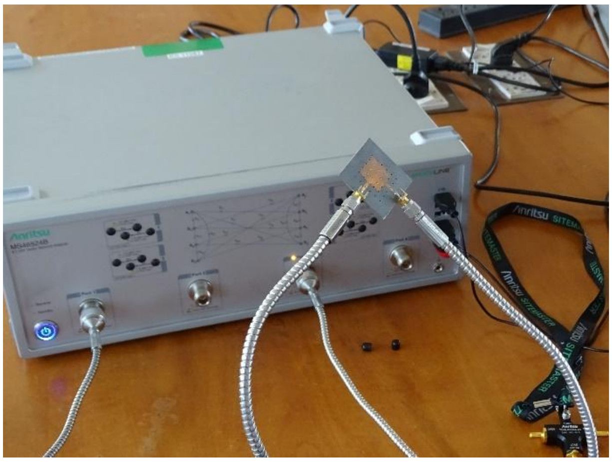

Fig.7 The fabricated antenna with the measurement setup

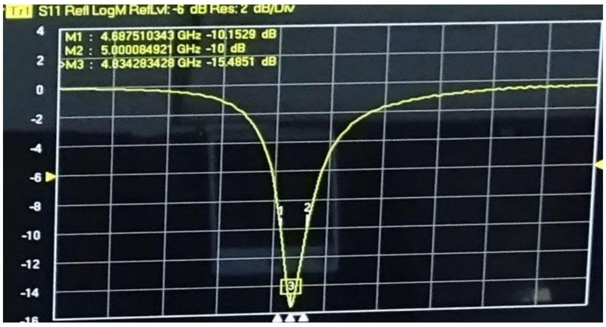

Fig.8 The S_{11} of the fabricated antenna

Table-2: Comparison between simulation results and measured results of the prototype antenna

Prototype Antenna with PBG	Operating Frequency (GHz)	S_{11} (in dB)	VSWR	Bandwidth (MHz)
Simulation results	5.5	-17.47	1.24	470
Measured results	4.83	-15.48	1.40	313

IV. CONCLUSION

In this work, an MPA with dual feed PBG structure has been simulated, fabricated and measured. It is observed that from the simulation results the MPA with PBG geometrical structure is having lower S_{11} when compared to the MPA without PBG structure. The measurement results show that the proposed antenna can be used for receiving frequency for INSAT/Super- Extended C- band applications. Both replicated and measured results depict the performance of the MPA with PBG structure reduces surface waves. The measured bandwidth is smaller than the simulated bandwidth due to frequency shifting.

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