FR4 Grounded Multiband Micro strip Patch Antenna with Slot and Notch for L, S, and C Band Applications

[1]Rakesh Kumar Bajpai,[2]Rajeev Paulus,[3]Nitin Pandey,[4]Mohd. Aneesh,[5]Ashish Singh

[1,2]Dept. Electronics and Communication
Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad, 211007 India,
[3] Dept. Electronics and Communication,
Feroze Gandhi Institute of Engineering & Technology, Raibareli
[4] Dept. Electronics and Communication
VBS Purvanchal University Jaunpur
[5] Dept. Electronics and Communication
NMAMIT, NITTE, Udupi –India.

Abstract : In this paper a simulated study of slot and notch loaded rectangular patch antenna is presented. This proposed antenna shows the tripple frequency band operation which is depends on the inserted slot and notch on the rectangular patch. It is found the proposed antenna resonates at tripple distinct resonance mode at 2.5GHz, 4.2GHz, and 5GHz for lower and upper resonance frequencies respectively. The designed antenna shows tripple frequency response nature with frequency ratio 1.68 and 1.190. The various characteristics of slot and notch loaded rectangular patch antenna gain (5.7dBi, 5dBi, 6.4 dBi), directivity (5.7dBi, 3.4dBi, 3.9dBi), efficiency (90%, 40%, 90%) and radiation pattern lobes are found in good agreement.

IndexTerms **- Microstrip patch antenna, Multiband, FR4, L, S and C band.**

I. INTRODUCTION

Microstrip patch antennas becomes more popular among the researchers since last two decades due their attractive features such as low profile, light weight, compatibility with various monolithic microwave integrated circuits. Some of these fabulous features of these patch antennas in the field of wireless communication [1] encourage the researchers over the world wide. These antennas have been successfully utilized in many communication systems [2-3] such as satellite communication, cellular communication systems, wireless personal area, wireless local area network and synthetic aperture radar etc. These patch antennas are can be designed by various techniques, in which some popular techniques are based on aperture coupling [4], proximity coupling [5],loading of slots [7-8], loading of notches [9], parasitic elements [10], L-strip feed [11], microstrip line feed [12]. One of the most important techniques is inserting the slots and notches and by which diversion of current takes place over the patch to achieve dual band and multiband frequency response for wireless communication frequency range.

The various contributions of researchers and scientist on slot and notch loaded microstrip patch antennas are reported such as Analysis of slot-loaded rectangular microstrip patch antenna [13], Dualband printed antenna for CDMA/PCS handsets [14], open slot antenna for WLAN/WiMAX operation [15], U-Slot microstrip patch antenna [16]. All the above reported papers are based on the slot and notch loaded rectangular microstrip patch antenna for single or dual band operation.

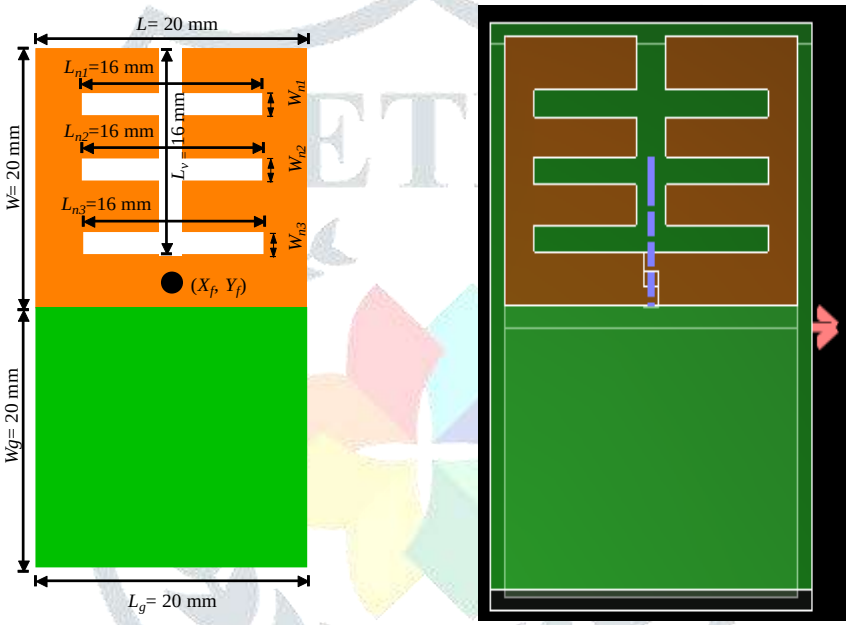
In this view, the main objective of this paper is to present a simulated design of slot and notch loaded rectangular patch antenna for multiband operation with sufficient amount of gain, directivity, axial ratio, reflection coefficient and good amount of radiation pattern lobes. The proposed antenna is investigated for tripple frequency band operation, so that a single antenna can be utilized for more than one frequency band. The proposed antenna structure is simulated in Zeeland IE3D simulation software.

II. ANTENNA GEOMETRY AND DIMENSIONS

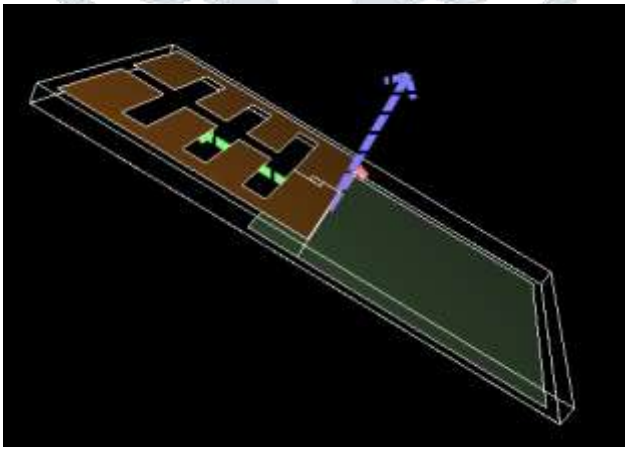
Figure 1 shows the structure of proposed antenna design. The slot and notch loaded rectangular patch antenna with ground plane for L, S and C band application shown in Figure 1. The rectangular patch has a dimension of 20x20 mm whereas the ground plane dimensions are taken order of 20x20 mm. in proposed 20x20 mm patch, 3 parallel slots of dimensions 16x2 mm are inserted in the patch, whereas a single 16x2 mm dimensions vertical notch is inserted in the proposed rectangular patch. A feed point is connected at coordinate $X_f = 0$, $Y_f = 2$ for the excitation of the proposed antenna. The proposed slot and notch loaded rectangular MSA is designed in IE3D simulation media. Figure 1(b) shows the front view of the simulated design of slot and notch loaded rectangular microstrip patch antenna in IE3D simulation software [17]. Figure 1(c) shows the side view of simulated slot and notch loaded rectangular MSA in IE3D simulation media. Firstly the proposed antenna is designed on foam substrate with relative permittivity (ε_r =1.07). Afterwards it was designed with higher relative permittivity material bakellite (ε_r =3.2). Thereafter for final design FR4 (ε_r =4.4) substrate is finally selected in IE3D simulation software and the final design of slot and notch loaded rectangular microstrip patch antenna is simulated. The various geometry parameters are given in Table 1. Where L_{n1}xW_{n1}, L_{n2}xW_{n2}, L_{n3}xW_{n3} are the dimensions of parallel slots over the proposed antenna design. The dimension of vertical notch is denoted with L_vxW_v and dimensions are opted in millimeter (mm).

Table 1. Parameters for proposed antenna design

Parameter	Value
Dielectric Constant of FR4 (ε_r)	4.4
Length of patch (L)	20 mm
Width of Patch (W)	20 mm
Length of ground patch (L_g)	20 mm
Width of ground patch (W_g)	20 mm
Feed point coordinate (x,y)	(0, 2)
Length of parallel notches (L_{n1}, L_{n2}, L_{n3})	16 mm
Width of parallel notches (W_{n1}, W_{n2}, W_{n3})	2 mm
Length of vertical notches (L_v)	16 mm
Width of parallel notches (W_v)	2 mm
Height (h)	1.52 mm



(a) **(b)**



(c)

Figure 1. (a) Proposed antenna design (b) Simulated antenna design (c) Side view of simulated antenna design

III. RESULTS AND DISCUSSION

This section of the manuscript shows the simulated results of the proposed antenna. Figure 2 shows the variation in reflection coefficient for several dielectric materials. From the observation of these results it is observed that multiband characteristics are achieved with increasing the value of dielectric constant of substrate. Initially foam is used as substrate for simulation of antenna design and we found dual resonating frequency at 4.7 GHz and 5.6 GHz with a small dip bellow -10dB. Further Bakelite (ε_r =3.2) used as a substrate for simulation of antenna design and found a long dip of resonating frequency bellow -10dB whereas a single band is achieved at 4.2 GHz. Afterward again improving the value of dielectric constant and opted FR4 (ε_r 4.4) substrate

for antenna design and found a better response than the comparison of previously opted substrate. With selecting FR4 (ε_r 4.4) a better response is achieved and simulated antenna design gives tripple frequency band responses at 2.5GHz, 4.2GHz, and 5GHz respectively. From here it is observed that with increasing the value of dielectric substrate a multiband response are achieved over a single patch antenna. Figure 3 shows the comparative plot for gain and directivity with the variation in frequency. This figure depicted that maximum 5.7 dBi at 2.5 GHz, 5dBi at 4.2 GHz and 6.4 dBi at 5.2 GHz. The obtained second parameter is directivity and achieved 5.7dBi, 3.4 dBi, 3.9 dBi at 2.5 GHz, 4.2GHz and 5 GHz respectively.

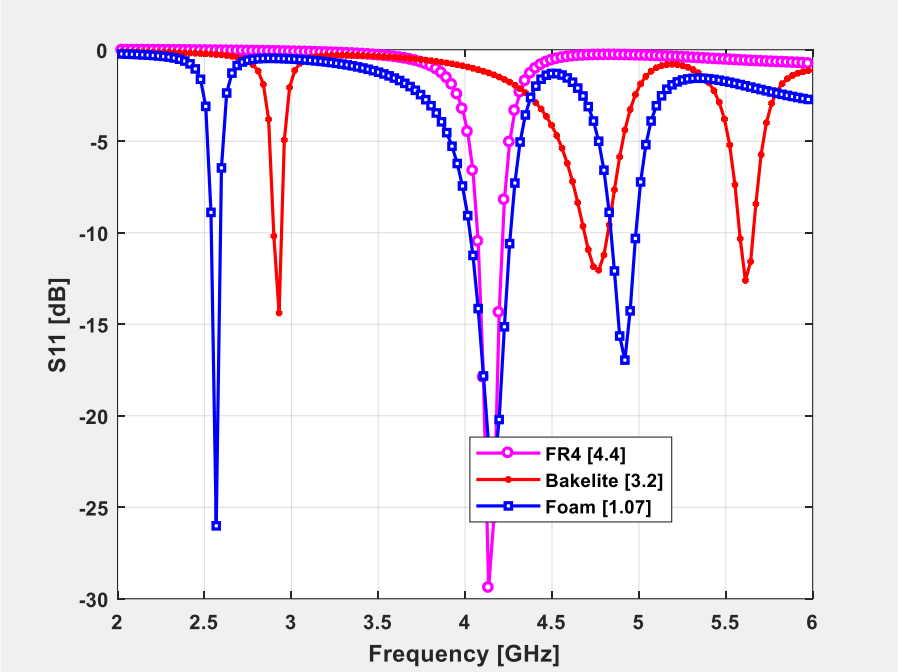


Figure 2. Reflection coefficient variation for several dielectric materials

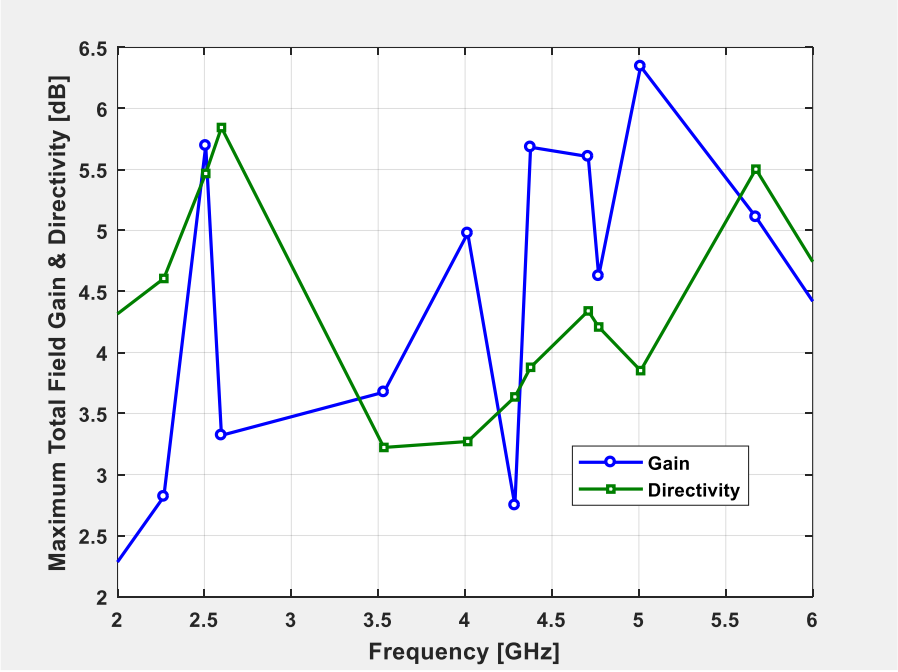


Figure 3. Comparative plot of gain and directivity with frequency

The simulated gains of the proposed antenna at various frequencies are shown in figure 3. The comparative plot for efficiency with the variation in frequency is shown in figure 4. The achieved efficiency is 90%, 40% and 90% at 2.5 GHz, 4.2GHz and 5GHz respectively. The comparative plot of axial ratio with frequency is plotted in figure 5. The achieved axial ratios are 0.3, 1.9, and 2 for frequencies 2.5 GHz, 4.2GHz and 5 GHz frequency respectively.

The 3D radiation pattern of proposed antenna design is shown in figure 6(a) and 6(b). Figure 6(a) shows the top view for radiation pattern of simulated antenna design whereas figure 6(b) shows the back 3D view for proposed simulated antenna design. From both of these two figures it is clearly found that sufficient amount of radiated field is successfully achieved.

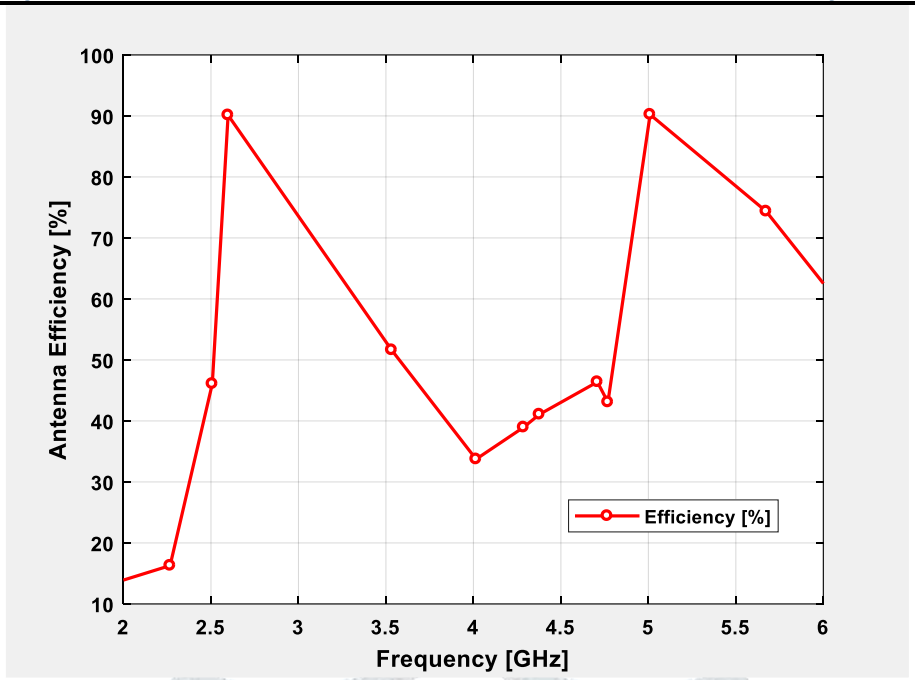


Figure 4. Comparative plot of efficiency with frequency

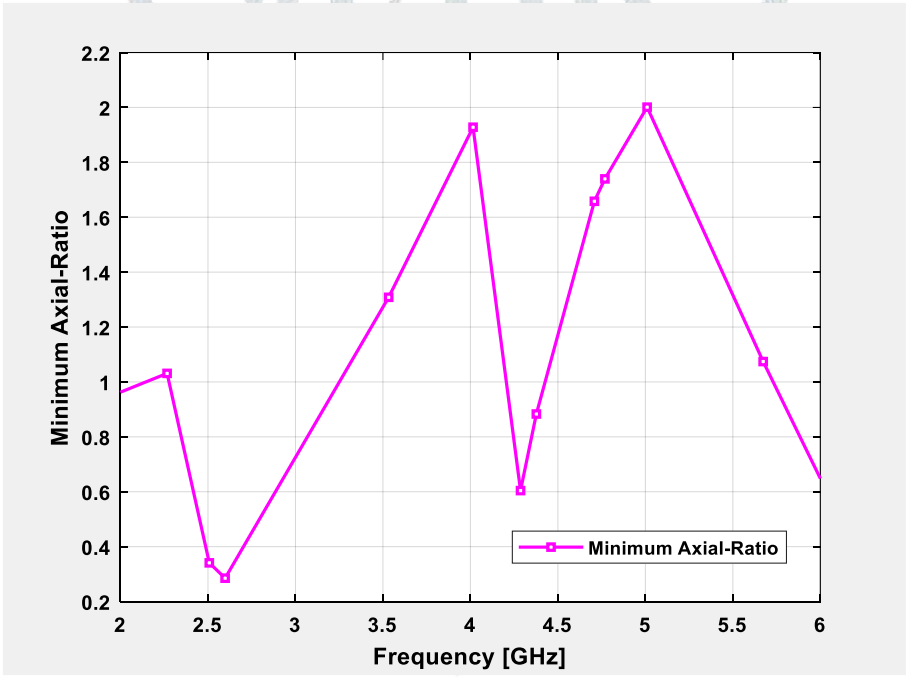
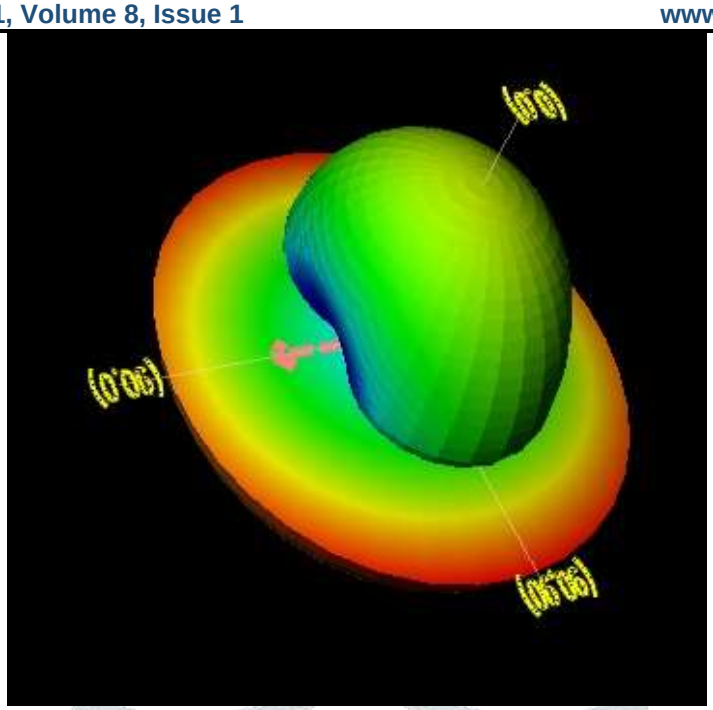
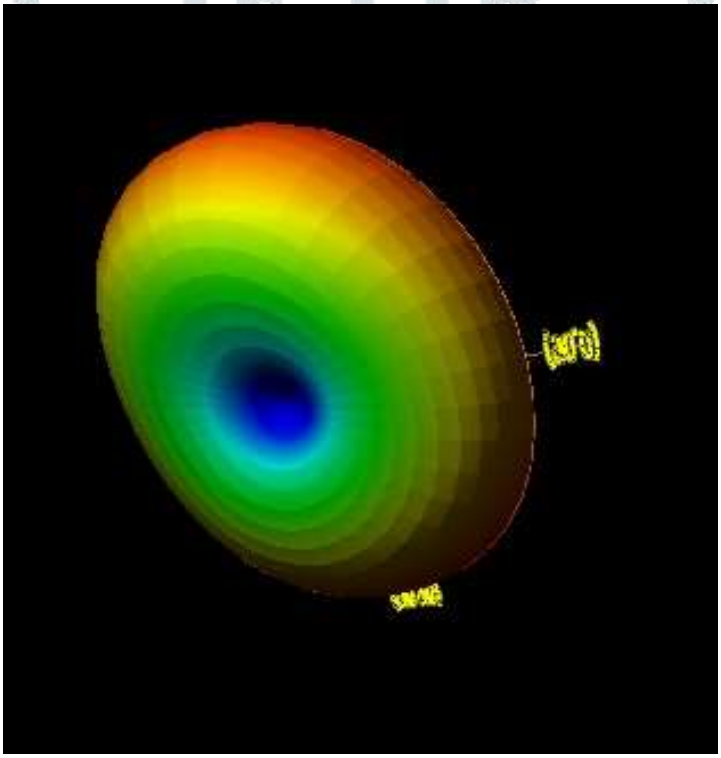


Figure 5. Comparative plot of minimum axial ratio with frequency



(a)



(b)

Figure 6. 3D radiation pattern (a) Top 3D view (b) Back 3D view

IV. CONCLUSION

From the above results it is inferred that the simulated design of slot and notch loaded rectangular microstrip patch antenna with ground plane gives tripple frequency band at 2.5 GHz, 4.2 GHz and 5 GHz respectively. The results are obtained in close agreement with the required frequencies which easily meets to the L, S and C band applications. The proposed antenna exhibits tripple frequency band operation at 2.5 GHz, 4.2 GHz and 5 GHz with sufficient bandwidth and moderate gain 5.7dBi, 2.5dBi and 5dBi respectively. The antenna provides good radiation pattern in front and back side lobe also. The axial ratio section successfully achieved approximately 1 at all radiating frequencies. This antenna can be utilized for L, S and C band applications. The simulated slot and notch loaded rectangular microstrip patch antenna can be find good applications in wireless personal communications.

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