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Miniaturization Of Multiban Patch Antenna Using Stack Configuration

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Abstract- A novel technique for miniaturization of microstrip patch antenna is proposed for Portable and multifunctional Communication systems. Our proposed design consists of double fractal patch, PI-Shaped slot on fractal patch with first iteration and combination of L-Shape and U-Shape slots on the Ground plane. . In this way we get smaller size antenna which is smaller than the conventional antenna. The most interesting feature of our proposed design is that we are getting multiband response in the frequency range of 1-8GHZ having Directivity in the range of 3.76dBi-6.52dBi , good gain and good impedance bandwidth for desired bands. As we have used the double fractal patch with double substrate in which 1st substrate is FR4 and 2nd substrate is AIR .Co-axial cable is used as a feeding method. We have design the PI-shape on both fractal patch. We also employed shorting pin between fractal patch and ground plane. By the combination of all these proposed technique size of antenna is reduced 79.12%s and it produces multiband response while the impedance bandwidth and gain are satisfactory for each band .We can adjust different bands by changing position of shorting pin. This type of smaller size antenna has applications in mobile phone forDCS/DPS, ISM band, C-band, L-band , S-band and also in Radar application.

Keywords: Miniaturization, Double fractal patch antenna, Impedance bandwidth, Microstrip patch antenna.

I. Introduction

During the passage of time the value of multifunctional communication system is widely introduced practically as well as experimentally. It is important that PCS should be smaller in size and operate for many application. Many techniques have been proposed for reducing the size of antenna. But the main problem with the smaller size of an antenna is its lower gain. Some of the techniques are discussed below. Artificial magnetic conductor is used for miniaturization of an antenna and it reduces an antenna size but results in lower gain[1]. Complementary split ring resonators are used for miniaturization but size reduction is only 10% [2]. Size reduction of 21% is presented by using Koch fractal shape but after few iterations gain starts to decrease [3]. In short circuited technique, patch is shorted to the ground plane and this technique reduces size upto great extent but gain also decrease [4]. .Another main problem of the smaller size antenna is its narrow impedance bandwidth and lower gain[5]. In multiband response of the microstrip patch antenna is reported but gain is very smaller for most of bands[6]. Miniaturization of microstrip patch antenna with multiband performance is presented but impedance bandwidth is very narrow for all the desired bands [7]. Meta materials are used as ground plane to reduce antenna size[8]. With the high permittivity substrates size of antenna can be reduced upto great extent but this technique reduces radiation efficiency of antenna and impedance bandwidth of antenna also reduce [9]. Magnetic substrates can be used for this purpose but pure magnetic substrates are unlikely to obtain [10]. Therefore in the present study we used technique for miniaturization of double patch antenna with a good gain and satisfactory impedance bandwidth for each band. We used combination of U-Shaped and L-Shaped slots on the ground plane and PI-Shaped slot on the fractal patch. We also employed shorting pin between fractal patch and ground plane. By the combination of all these proposed techniques size of antenna reduced upto 79.12% and it produced multiband response in the frequency range of 1-8GHz and impedance bandwidth and gain are satisfactory for each band. We can adjust different bands by changing position of shorting pin.

II. Antenna Configuration

CST (computer simulation technology) Microwave Studio is used for antenna design and simulation. Fig 1(a) shows front view in which we have patch with the length of 16.95mm and width of 22.47mm.On the patch we have designed fractal shape by cutting four slots of equal length and width (length 5mm and width of 2mm).Then we made PI-Shaped slot on the patch which has horizontal & vertical length of 4mm and width of 1mm.Similar slots on four sides of patch (fractal shaped patch) reduced size of antenna as well as it enabled for multiband response. The PI-Shape slot increase current distribution path and it provides capacitive effect which counteract inductance of the Probe so bandwidth improvement is obtained due to the PI-Shape slot. Fig 1(b) shows back view of antenna on which we have ground plane .The length of ground plane is 28.95mm while its width is 34.47mm.On ground plane we have U-Shape and L-Shape slots which contribute in size reduction of antenna upto great extent. The horizontal length of U-shape is 8mm and width is 2mm. The vertical length of U-shape is 6mm and width is 2mm .The horizontal length of L-shape is 8mm and width is 2mm while the vertical length of L-shape is 6mm and width is 2mm. Fig1(c) shows bottom view of our proposed design which highlights Patch, Ground, Substrate, probe feeding and shorting pin. The patch and Ground are of Copper while FR4 is used as substrate which has dielectric constant of 4.3 and its thickness is kept 2mm while the second substrate which we have used is AIR which has a dielectric constant of 1.00and its thickness is kept 2mm. The antenna is fed by the Co-axial probe in which inner conductor is touched to patch through hole in the substrate while outer conductor is in contact with ground plane. We have shorting pin between patch and ground which capacitively coupled to the resonant circuit and it increase permittivity of substrate due to which it further reduce size. Fig 2 describes current distribution on patch of antenna., from fig it is clear that current density is more near edges of PI-Shaped slot than the remaining patch and current distribution path is increased due to the slot so electrical length has been increased due to which resonant frequencies are shifted downward and current is following multiple paths due to which it is showing multiband response.

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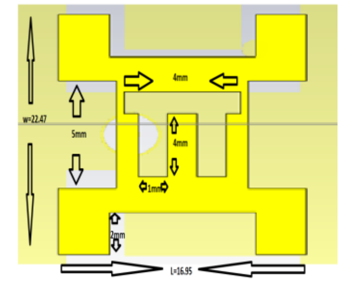
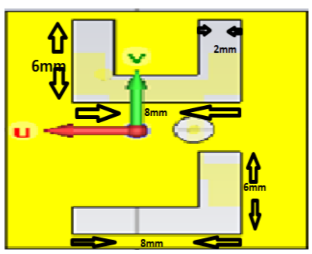
This means that for an antenna with the same resonance frequency, the overall surface of antenna is decreased to a great extent.



(a)



(b)

(c)

Fig 1 (a) *Front view (b) back view (c) Bottom view*

III. Results and Discussion

We monitored different parameters like Gain, Return Loss, Impedance bandwidth and radiation pattern for various frequencies of interest, all the parameters have shown satisfactory performance.

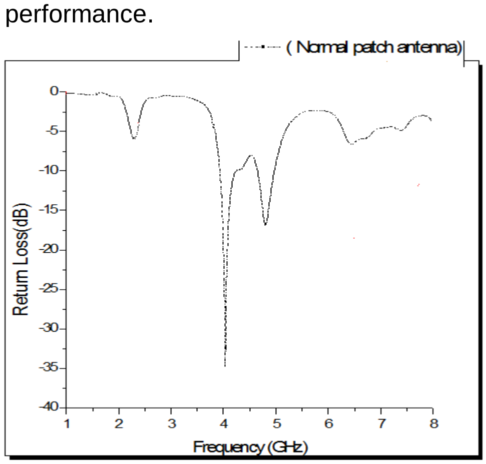


Fig 2 *Return Loss of conventional antenna.*

In fig 3The antenna is designed for 4.1GHz and the miniaturized antenna is operating on a fundamental frequency of 1.97GHz. Which is clear from the graph. The resonant frequencies are shifted downward due to the slots because of increase in inductance and capacitance. The size of convention antenna with the fundamental resonant frequency of 1.97GHz would require dimensions of 48.50×37.62=1824.57mm2. While in my proposed design it is obtained by dimensions of just22.47×16.95 =380.86mm2 so it means that our proposed design has reduced size upto 79.12%,which is more significant than all the previously published techniques**.**

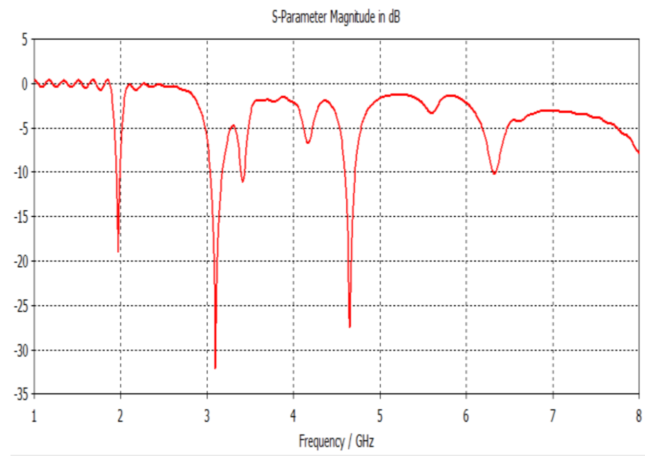


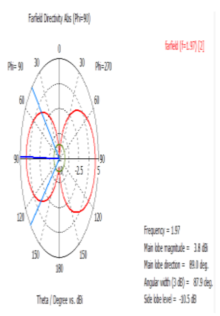
Fig 3 *Return Loss of miniaturized antenna.*

From graph in fig 3 it is also clear that our proposed miniaturized antenna is showing multiband response with satisfactory impedance bandwidth(for the return loss value less than(–10dB) and sufficient gain like 1.97GHz with impedance bandwidth of 64.74MHz and gain of 2.41dB for L-band, 3.11GHz with impedance bandwidth of 137.5MHz and having gain of 4.36dB applicable for /DCS /DPS &S- bands. 3.42GHz with impedance bandwidth of 40.46MHz and gain of 2.98 dB for S- bands. 4.65GHz with impedance bandwidth of 129.48MHz having gain 4.51 dB for C-band and 6.31GHz with impedance bandwidth of 809MHz and having gain of 2.96dB for C-band and Radar applications. These discussed results are summarized in table.1

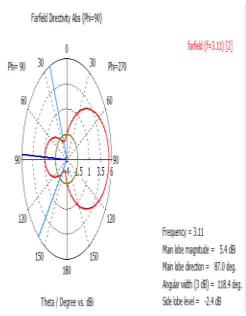
TABLE 1 *.SIMULATION RESULTS OF MINIATURIZED ANTENNA*

Resonance frequency(GHz)	1.97	3.11	3.42	4.65	6.31
Gain (d B)	2.41	4.36	2.98	4.51	2.96
Impedance bandwidth(MHz)	64.74	137.5	40.46	129.48	809.48
Return Loss(d B)	-19	-32.4	-11.3	-27.1	-10.15

Radiation Patterns as shown in fig 3 are monitored for frequencies of 1.97GHz ,3.11GHz, 3.42GHz, 4.65GHz, 6.31GHz. Direction of major lobes are consistent for these frequencies.

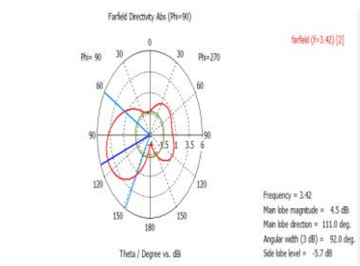


(a)

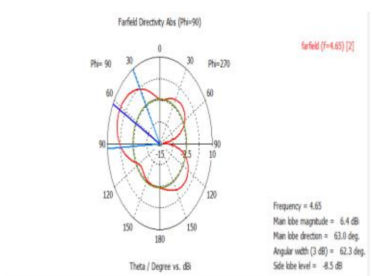


(b)

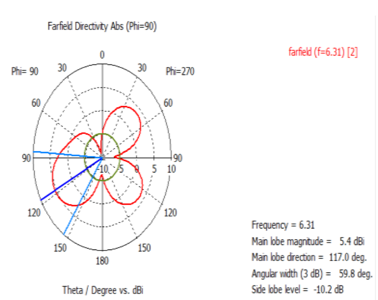
Fig 2 *Ration Pattern of the proposed miniaturized antenna for (a) at f=1.97 GHz (b) at f=3.11GHz*



(a)



(b)



(c)

Figure 3 *Radiation Pattern of the proposed antenna for (a) at f=3.42GHz (b) at f=4.65GHz (c) 6.31GHz.*

IV. Conclusion

A novel design for miniaturization of Microstrip patch antenna is proposed. Antenna with size reduction of 79.12% is obtained using combination of U-Shaped and L-Shaped slots on the ground plane and PI-Shaped slot on the double fractal patch of antenna with shorting pin between patch and ground. As a result antenna produced multiband response with a high gain and sufficient impedance bandwidth for each band. We can adjust the different band by changing the position of shorting pins. This antenna is very suitable for many applications like in Mobile phone for DPS/DCS ,ISM band , C –band , L-band , S-band and also in Radar application.

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