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Design and Optimization of Microstreap Patch Antenna for Ultra High Frequency(UHF) Band

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Abstract : Microstrip patch antenna is versatile and vast field of antenna theory. A particular aspect of work done in this field is presented. In addition a different antenna configuration that improves electrical performance and sustainability is described. We analyzed microstrip antenna in IE3D by finite moment of method. In this paper a rectangular microstrip patch antenna with a ground plane is proposed. The antenna is resonant at 1 GHz frequency. The FR-4 substrate with Dielectric constant 4.3 and loss tangent 0.019 is used for proposed design at resonant frequency of 1GHz. Radiation characteristics, gain and return loss of the proposed antenna is simulated using Zeland IE3D simulation software.

General Terms :- Rectangular microstrip patch antenna, Ground plane
Keywords :- Microstrip patch antenna, gain, directivity, IE3D Simulator, Dielectric substrate, return loss.

I. INTRODUCTION

Microstrip patch antenna consists of a dielectric substrate which has a radiating patch on one side of the dielectric which has a ground plane on the other side. Microstrip patch antenna radiates because of the fringing fields along the edges of the patch. Microstrip patch antennas have several well-known advantages such as light weight, low volume, low profile planar configurations and ease of fabrication and can be easily integrated. However, intricate feeding mechanisms to meet the suitable phase delays make the antenna system complicated and also cause signal loss.

In this paper we have analyzed Rectangular geometry and tried to find out at which feed point better directivity and efficiency can be obtained. For our detected feed points we have checked out all the remaining parameters such as dB and phase of S parameter, VSWR, Smith chart, radiation pattern, band width, total radiated power and average radiated power. The structure is showing good results in terms of gain and directivity. Its return losses are also of acceptable level.

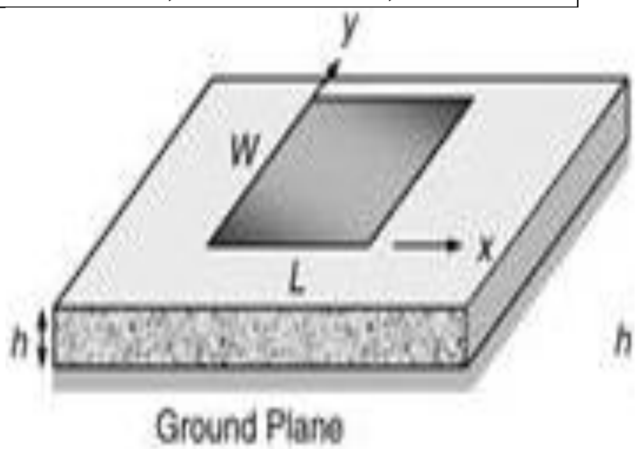

Fig.1. Rectangular micro strip patch antenna

II. EFFECTIVE PARAMETER

The principal purpose of antenna is to shield the antenna and associated equipment from environment. This improves the availability since the antenna is not affected by wind, rain or ice. Typical applications include antennas for radar, telemetry, tracking, cellular communications, surveillance, and radio astronomy.

A dielectric or ferrite coating on the surface of antenna can alter the electromagnetic characteristic, provide electrical insulation and protect the antenna from environment. Some ferrite and dielectric ceramic coating can allow certain antenna design to reduce in size or height while providing acceptable radiation characteristic.

The geometry and configuration of praised antenna is
shown in Figure 1.The antenna consists of a slot on the ground plane and via holes connecting the rectangular patch and the microstrip feed-line. All

of these are mounted on a square substrate of a thickness of 1.5 mm and a relative permittivity of 4.3 with length and width of 71.07568 mm and 92.144 mm respectively.

The effective parameters which define the required geometries effective length and breadth of rectangular patch.

Theoretical analysis and calculation of a single microstrip patch is calculated with following equations.

The first step is to find the width of rectangular patch.

Width of rectangular patch is given by:

$$W = \frac{C}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}}$$

Where C is speed of light=3*10^11 mm,
fo is resonant frequency=1Ghz
& εr is Dielectric constant of the substrate=4.3

Effective dielectric constant is given by:

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{\frac{1}{2}}$$

Change in length is given by:

$$\triangle L = \frac{0.412h\left(\epsilon_{reff} + 0.3\right)\left(\frac{W}{h} + 0.264\right)}{\left(\epsilon_{reff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)}$$

Where, h is the height of the substrate. εeff, effective dielectric constant

Effective length is given by:

$$L_{eff} = \frac{c}{2f_0\sqrt{\epsilon_{reff}}}$$

Where, εeff is the effective dielectric constant of the substrate. To measure for the fringing effects, the actual length of the patch also includes the correction factor due to fringing effect

Actual length is given by:

$$L = L_{eff} - 2\triangle L$$

Taking FR-4 substrate with Dielectric constant εr 4.3 and loss tangent 0.019 is used for proposed design at resonant frequency (fo) of 1 GHz. the above parameters comes out to be W = 92.144 mm, εr eff = 4.4539, ΔL = 0.6941 mm, Leff = 71.07568 mm, L = 69.6874 mm.

Ground patch of the geometry is design with the following equations:

Length of ground patch, Lg = 6h+Leff
Width of ground patch, Wg = 6h+W

Lg = 80.07568 mm
Wg= 101.144 mm

Table 1. Antenna Design parameters:

Antenna parameters	Dimensions
Resonant frequency fo	1 GHz
Dielectric constant εr	4.3
Height of Substrate (h)	1.5 mm
Width (W)	92.144 mm
Length (L)	71.07568 mm
Effective dielectric substrate εr eff	4.4539
Width of ground patch Wg	101.144 mm
Length of ground patch Lg	80.7568 mm

III.PROPOSED ANTENNA DESIGN

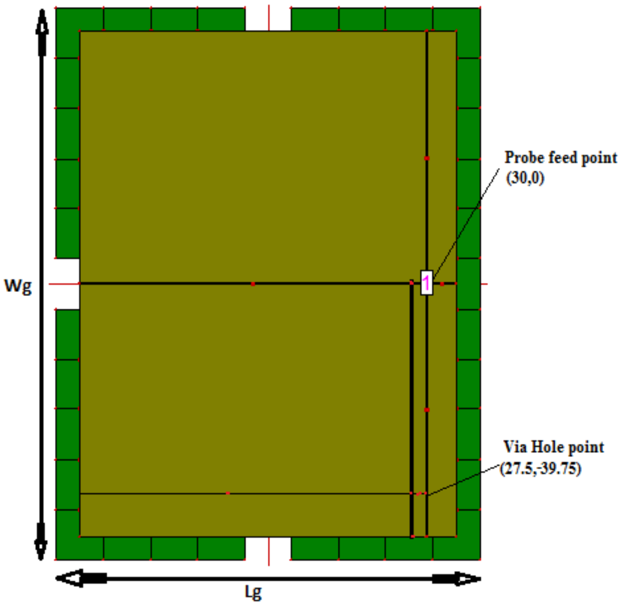

Fig.2. Geometry of proposed single patch array Antenna

IV .SIMULATED MICROSTRIP RECTANGULAR PATCH ANTENNA DESIGN AND RESULTS

The proposed geometry of microstrip antenna designed with IE3D and simulation is performed . At the resonant frequency of 1GHz the design is simulated in the frequency range of 0 to 0.6GHz. The radiation pattern is bidirectional. The simulated results, return losses versus frequency for geometry shown in fig.4.We are getting better return loss at four different frequency are -25.88dB at .1224 GHz , -25.83dB at .2204 GHz,-20.56dB at .4653 GHz and -18.55dB at .551GHz and The frequency bands for these with return losses(below -10dB) of the proposed antenna are:

a) 0.01GHz to 0.159 GHz
b) 0.16GHz to 0.365 GHz
c) 0.454GHz to 0.477 GHz
d) 0.538GHz to 0.56 GHz

The simulated return losses versus frequency graph shown in fig.4. The Impedance matching is shown in smith chart is shown in fig.6, its shows proper impedance matching, VSWR is near about 1 as shown on fig.3.

(1) VSWR VS FREQUENCY

VSWR IS effective and minimum between 0 to 0.6 GHz

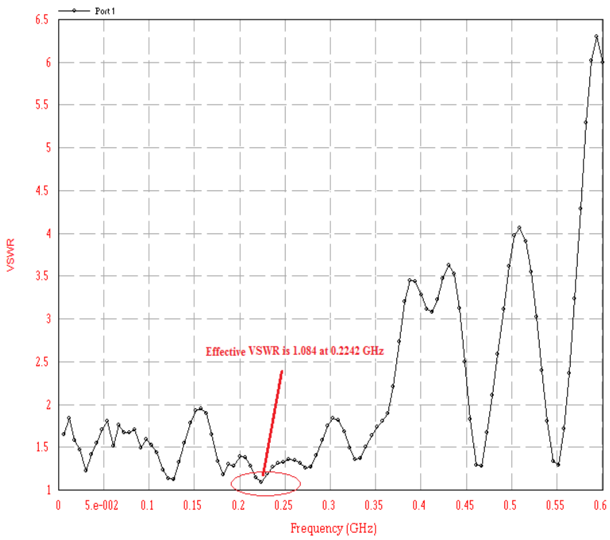

Fig.3. VSWR Vs Frequency (in GHz**)**

For proposed design the value of VSWR is effective between 0GHz to 0.35GHz, for this value return loss is minimum. At 0.1224 GHz return loss is -25.88dB and VSWR is 1.107, which is minimum value.

(2) RETURN LOSS VS FREQUENCY (IN GHz)

At frequency of 0.1224 GHz the value of return loss is -25.88 dB

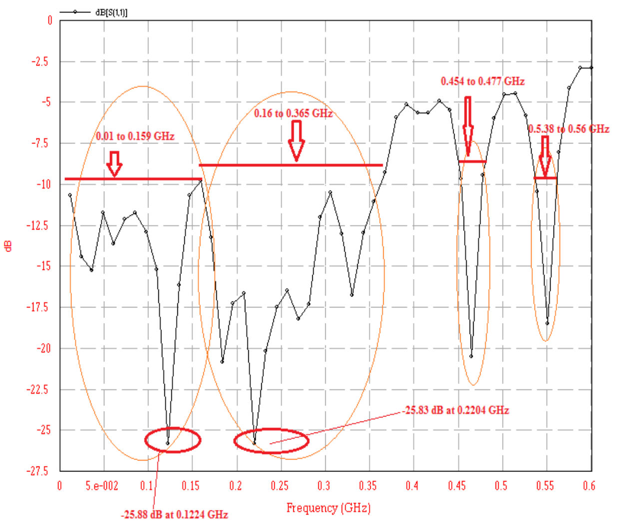

Fig . 4. Retrun loss vs Frequency (in GHz)

(3) S PARAMETER (magnitude in dB and phase) VS FREQUENCY (IN GHz)

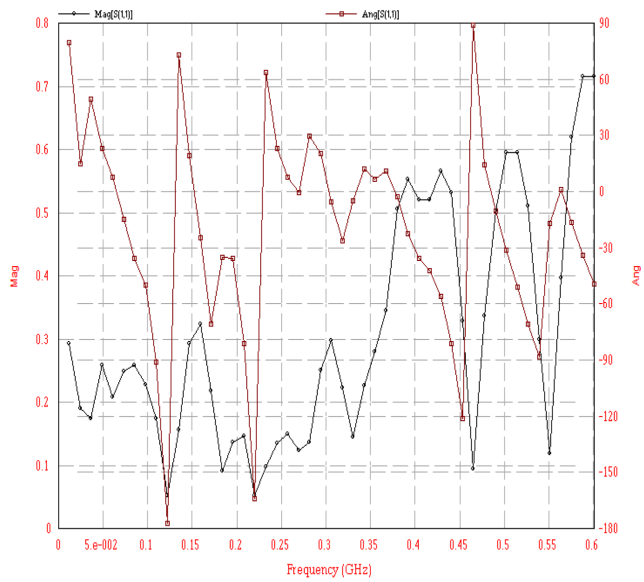

Fig**.**5.S Parameters Vs Frequency (in GHz)

(4) SMITH CHART

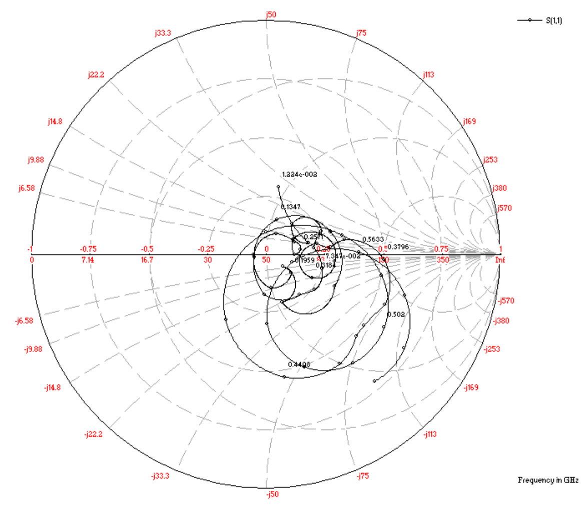

Fig.6. Smith Chart

(5) DIRECTIVITY VS FREQUENCY (IN GHz)

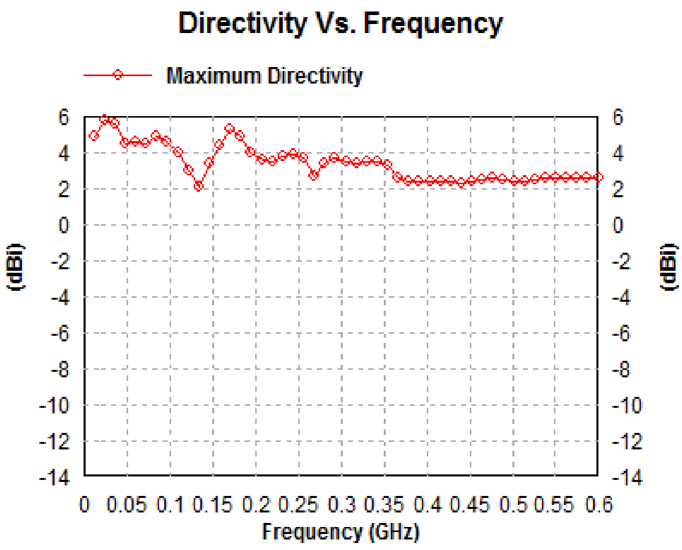

Fig.7. Directivity Vs Frequency (in GHz)

(6) RADIATION PATTERN:

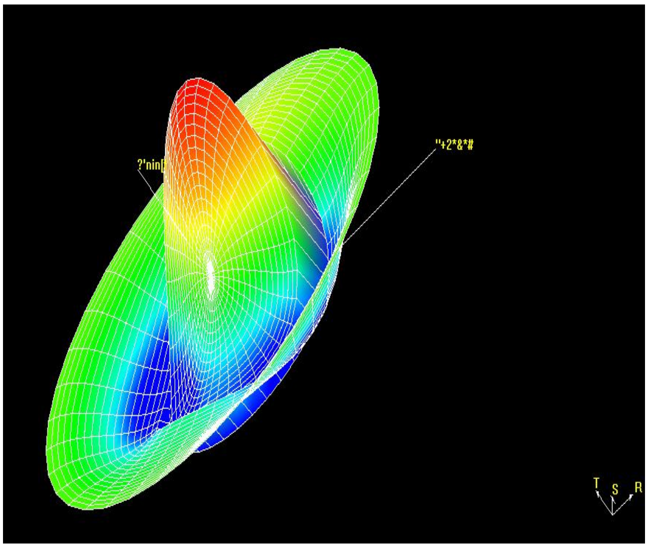

Fig.8. Radiation Pattern

(7) 3D PATTERN OF THE ANTENNA

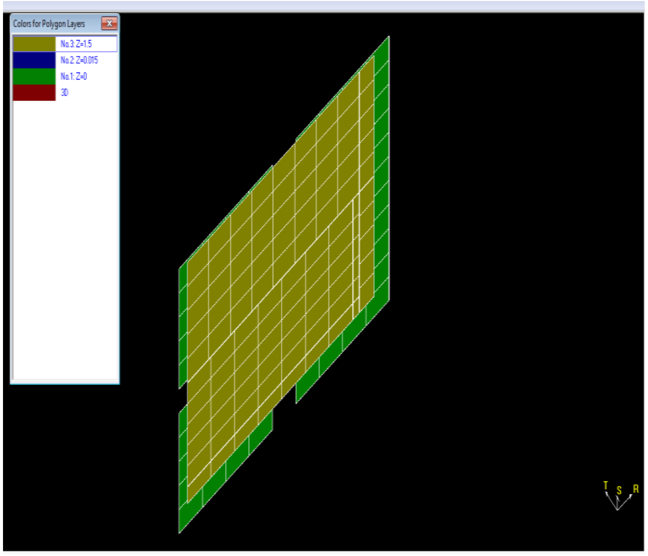

Fig.9. 3D Pattern

V.SIMULATION TABLE

Sn.	Frequency (in GHz)	Return loss (in dB)	VSWR
1	0.01224	-10.68	1.826
2	0.02449	-14.44	1.468
3	0.03673	-15.27	1.417
4	0.04898	-11.79	1.693
5	0.06122	-13.69	1.522
6	0.07347	-12.13	1.657
7	0.8571	-11.76	1.697
8	0.09796	-12.92	1.584
9	0.1102	-15.25	1.418
10	**0.1224**	**-25.88**	**1.107**
11	0.1347	-16.17	1.368
12	0.1469	-10.69	1.825

13	0.1592	-9.827	1.952
14	0.1714	-13.27	1.554
15	0.1837	-20.88	1.199
16	0.1959	-17.32	1.315
17	0.2082	-16.69	1.343
18	**0.2204**	**-25.83**	**1.108**
19	0.2327	-20.23	1.26
20	0.2449	-17.5	1.308
21	0.2571	-16.51	1.352
22	0.2694	-18.28	1.278
23	0.2816	-17.34	1.314
24	0.2939	-12.06	1.665
25	0.3061	-10.56	1.842
26	0.3184	-13.04	1.573
27	0.3306	-16.8	1.338
28	0.3429	-12.97	1.58
29	0.3551	-11.1	1.772
30	0.3673	-9.278	2.047
31	0.3796	-5.927	3.044
32	0.3918	-5.169	3.459
33	0.4041	-5.697	3.158
34	0.4163	-5.687	3.163
35	0.4286	-4.965	3.594
36	0.4408	-5.509	3.258
37	0.4531	-9.683	1.976
38	0.4653	-20.56	1.207
39	0.4776	-9.479	3.011
40	0.4898	-5.998	3.01
41	0.502	-4.529	3.922
42	0.5143	-4.514	3.934
43	0.5265	-5.844	3.084
44	0.5388	-10.5	1.852
45	0.551	-18.155	1.268
46	0.5633	-8.063	2.307
47	0.5755	-4.177	4.239
48	0.5878	-2.923	6
49	0.6	-2.926	5.993

CONCLUTION

A novel antenna with via holes at UHF is illustrated in this paper. It consists of a ground plane, a rectangular microstrip patch slot and a via hole connecting the rectangular patch and the microstrip feed-line. The better return losses are due to the slots cut in the rectangular patch and by connecting via hole. The antenna is resonant at 1GHz frequency and simulated up to 0.6GHz. The return loss obtained is -25.88 dBi at .1224 GHz VSWR is 1.107, which is minimum value. . The return losses at four frequency bands are -25.88dB at .1224 GHz , -25.83dB at .2204 GHz,-20.56dB at .4653 GHz and -18.55dB at 0.551GHz and The frequency bands for these with return losses(below -10dB) of the proposed antenna are:

a) 0.01GHz to 0.159 GHz
b) 0.16GHz to 0.365 GHz
c) 0.454GHz to 0.477 GHz
d) 0.538GHz to 0.56 GHz

This antenna is very easy to fabricate and implement in any circuit and also of low cost as this structure is not complicated. The antenna is successfully designed, constructed, and measured.

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