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A Framework for the analysis of 3-D Novel flange Microstrip Patch Antenna Design employing Flexible Teflon Substrate

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***Abstract*—*This paper summarises a novel microstrip patch antenna design over flexible Teflon substrate having dielectric constant $\varepsilon_r = 2.1$. The proposed antenna exploits a King shaped slot (0.05mm thick) on the radiating patch along with microstrip feed line and reduced ground plane on the other side of the substrate. The radiating element of the flexible flanged antenna design has a King-shaped slot and a finite ground plane to accomplish an excellent impedance matching for maximum power transfer. The proposed antenna has an operating bandwidth of 550.7MHz (3.1244GHz-3.675GHz) with resonant frequency at 3.42GHz and has also an operating bandwidth of 369.1MHz (8.3507GHz-8.7198GHz) with resonant frequency at 8.3609GHz. This flexible flanged microstrip patch antenna design covers various applications including Radio astronomy/ Radiolocation (military&civil)/ UWB/PMSE/FSS Earth stations applications (3.3GHz-3.6GHz), Radio-determination/ Space-research/Fixed applications (8.4GHz-8.5GHz), activesensors (satellite)/ Radiolocation (civil&military)/ Aeronautical-navigation applications (8.5-8.55GHz). The proposed antenna operates for acceptable voltage standing wave ratio (VSWR) less than two. The characteristics of the proposed antenna fabricated on a flexible Teflon with different bending angles have been successfully measured. The antenna has been designed in CST Microwave Studio 2014. The proposed antenna has been fabricated and tested using E5071C Network analyser and anechoic chamber. It has been observed that the simulated results legitimately match with the experimental results.*

Keywords*—*Flexible antenna, King shaped patch, reduced ground surface, Teflon.

I. INTRODUCTION

The microstrip antenna was first designed and analyzed in 1950's. It came in use later in 70's after the development of printed circuit boards (PCB) [1]. After then it became very popular among the data oriented individuals. The microstrip patch antennas are widely popular in mobile phone market, military systems, medical appliances and in more fields. It is easy to design and fabricate owing to its 2D physical geometry [2-3]. They are booming in commercial sectors as they are low in cost, low profile, light in weight, small in size and have high competence [4]. But as we are well aware of the fact that the technology is ubiquitously getting advanced mostly on a daily basis, so there is a need of high efficiency in all communication fields. Conventional antennas have limitations in hostile military environment or biomedical sectors [5]. For today's modern electronic world, the Flexible antennas are becoming highly popular. Flexible materials can be molded in any shaped for better results for example in mobile phones, cars, robots, human body, buildings and many more. The competence of flexible systems mostly depends on the features of the integrated antenna [6-8].

Presently there has been an increase in the demand of transportable wireless communication devices and it is essential to be dual/multi band compatible to use in different areas or countries. The antennas constructed on the waveguide orifices with a crenellated flange have an extensive series of applications [9]. The boundary conditions require a relationship between the tangential electromagnetic fields, which leads to an integral equation. The need of satellite based portable communication devices are increasing bizarrely, specifically in areas like portable satellite station, vehicle tracking, aeronautical navigation, weather forecasting etc. Plentiful sorts of patch antennas have been ascertained and inspected by several investigators due to their exceptional properties. The Microstrip patch antennas utilize the monopole configuration such as annual ring, triangle, ring, elliptical, circular disc, hexagonal and pentagonal antennas, the dipole configuration like bow-tie antennas [10].In satellite Communications circularly polarized radiation patterns are required using an either a rectangular or circular patch[11].

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In this paper, a dual band slotted antenna has been designed on a rectangular shaped flexible Teflon substrate. The geometry of the antenna has been discussed in section II, followed by theoretical observations and results in section III and experimental results in section IV. Finally, section V illustrates the conclusion.

II. GEOMETRY OF THE ANTENNA

The novel design of flexible flanged microstrip patch antenna has been designed and simulated using the CST (Computer Simulation Technology) Microwave Studio 2014. The proposed antenna is constructed on flexible Teflon of thickness 2mm with relative permittivity of ε_r =2.1.The proposed antenna geometry is determined by inclining two rectangular flange vertically at 90 degrees with the radiating patch of dimension 50mm each. The dual-band microstrip patch antenna has a radiating patch with king shaped slot and reduced ground of thickness 0.05mm. The radiating patch, lossless feedline and ground plane are made up of copper material of thickness 0.05mm. The fig.1(a) shows the side view of the substrate. The fig. 1(b) portrays the top view of the King shaped slot on the radiating patch. The bottom view of the proposed antenna with reduced ground structure is shown in fig. 3(b) The dimensions of the radiating patch, substrate, reduced ground and the feed line have been listed in Table I. Microstrip-type antennas need aground plane on the opposite side of the substrate forelectromagnetic waves to travel along the feed line.

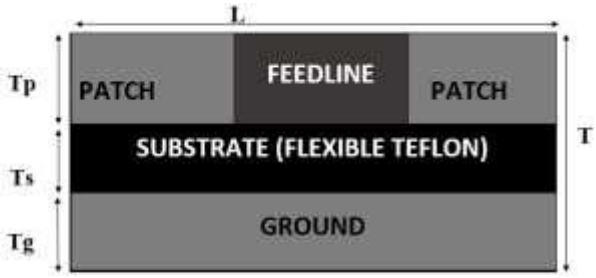

Fig.1(a): Side view of the proposed antenna design

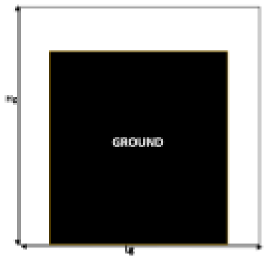

Fig. 1(b): Bottom view of the proposed antenna

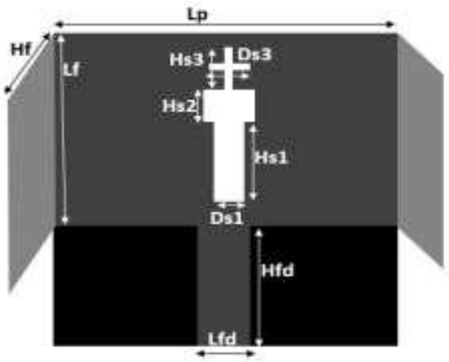

Fig.1 (c): Top view of the proposed antenna design

Table.I: Antenna Dimensions

Antenna Dimensions	Description	Value (mm)
L	Length of substrate	50
H	Height of substrate	50
T	Total thickness of antenna	2.05
Tp	Thickness of patch	0.05
Ts	Thickness of substrate	2
Tg	Thickness of ground	0.05
Hg	Height of ground	20
Lg	Length of ground	50
Lp	Length of patch	76
Hs1	Height of stride 1	3.3
Hs2	Height of stride 2	1.6
Hs3	Height of stride 3	2
Ds1	Distance to stride 1	2
Ds2	Distance to stride 2	2
Ds3	Distance to stride 3	4
Df	Distance to feedline	47.1
Ls	Length of slot	6
Hs	Height of slot	40
Lfd	Length of feedline	5.8
Hfd	Height of feedline	20
Lf	Length of flange	25
Hf	Height of flange	50

III. SIMULATED RESULTS

The proposed 3-D flexible patch antenna has been simulated and designed using CST(Computer Simulation technology) Microwave Studio 2014. A thorough parametric study of the designed antenna has been carried out in terms of return loss, impedance bandwidth, gain, directivity, VSWR and antenna impedance.

The proposed dual-band antenna has impedance bandwidth of 0.5507 GHz with operating frequency range of 3.1244GHz-3.6751GHzat resonating frequency 3.42GHz. It also has a resonant frequency at 8.42GHz with impedance bandwidth of 0.3691GHz and operating frequency range of 8.3507GHz – 8.7198GHz as shown in figure 2(a).The return loss (S_{11}) plot of the antenna design at 3.42GHz is observed to be -54.542792dB and at resonant frequency 8.36GHz is observed to be -47.587292.

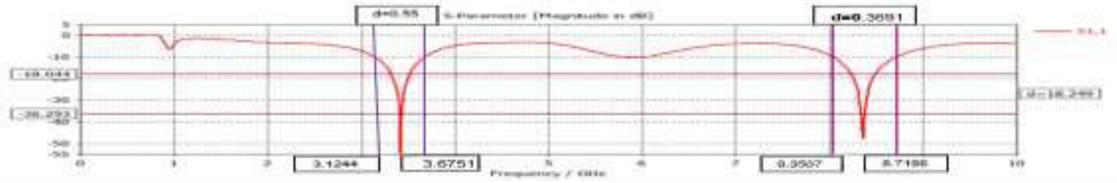

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Fig. 2(a): Return loss (S11) plot of the proposed antenna design

The far-field 3D directivity plot has been depicted in fig. 2(c) and 2(d). The maximum directivity of antenna obtained at resonant frequency 3.42GHz is measure to be 6.095dBiand 6.118dBi at resonant frequency 8.36GHz. In fig. 2(e) and fig. (2f), it has been shown that the proposed antenna design has gain of 6.252dB and 6.149dB at resonant frequency 3.42GHz and 8.36GHz, respectively.

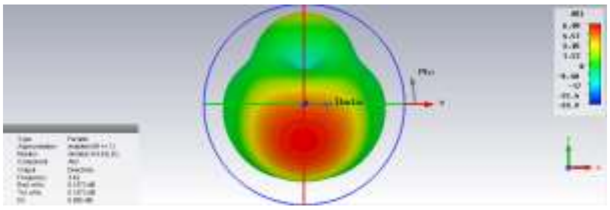

Fig. 2(c): Directivity of proposed antenna at 3.42GHz

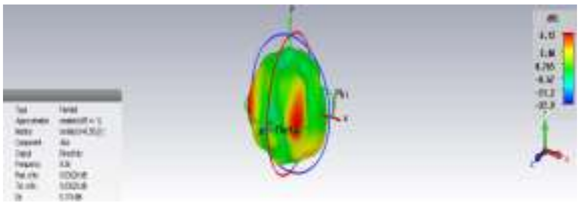

Fig. 2(d): Directivity of proposed antenna at 8.36GHz.

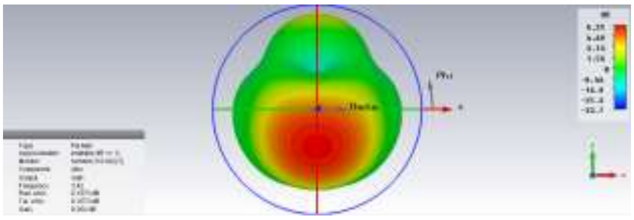

Fig 2(e): Gain of proposed antenna at 3.42 GHz

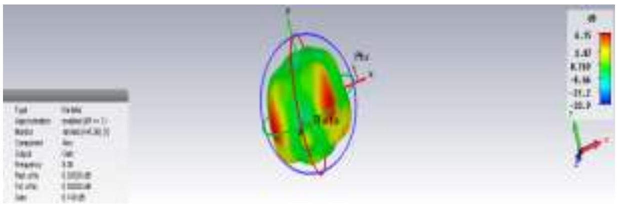

Fig 2(f): Gain of proposed antenna at 8.36 GHz

The half power beam width (HPBW) of Flanged microstrip patch antenna with resonant frequencies at 3.42 GHz and 8.36 GHz has been observed to be 60.0 degree and 55.4 degrees, respectively as shown in figure 2(g) and figure 2(h).

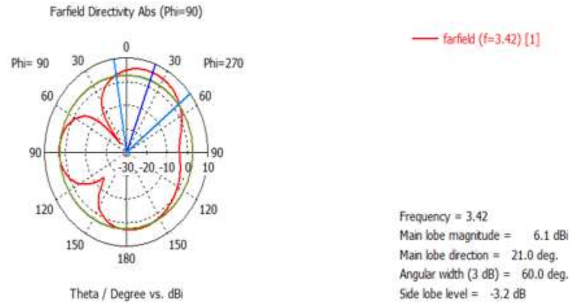

Fig. 2(g): HPBW plot of proposed antenna at 3.42GHz

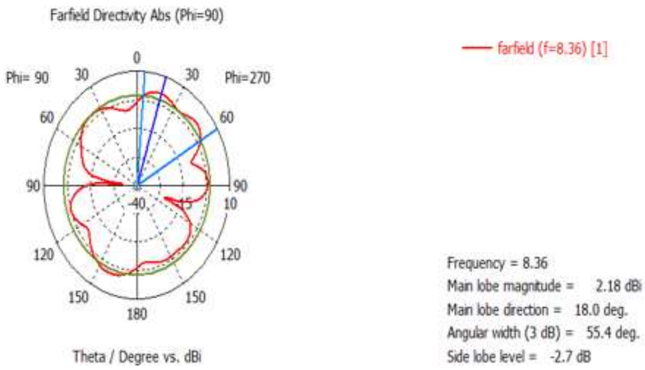

Fig. 2(h): HPBW of proposed antenna at 8.36GHz

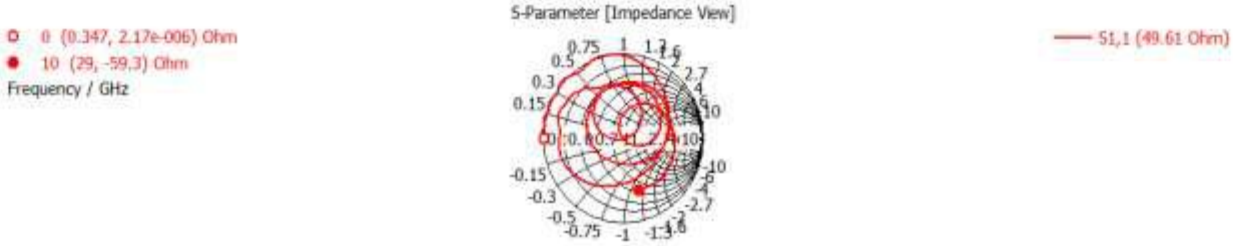

Fig. 2(i): VSWR plot of proposed antenna design

The reduced ground improved the return loss and also enhanced the bandwidth. The coaxial probe feeding is agreed at a specific site of the point where input impedance is approximately 50 Ω. Fig. 2(i) demonstrates the impedance of the proposed microstrip patch antenna which is calculated to be 49.3Ω.It has been observed that for both the resonant frequencies the VSWR value lies below the maximum acceptable value of 2 as shown in fig.2(j) and 2(k).

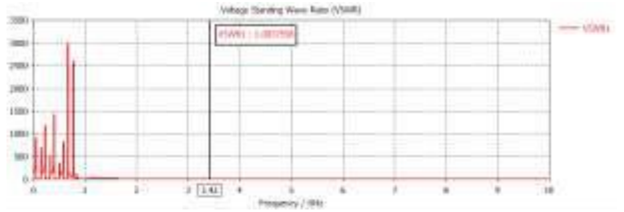

Fig. 2(j): VSWR plot of proposed antenna at 3.42 GHz

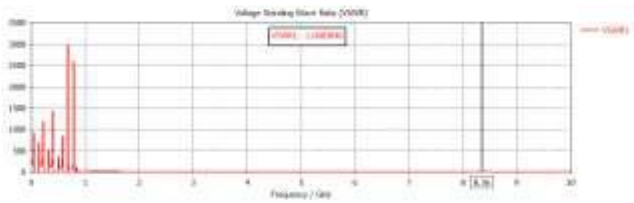

Fig. 2(k): VSWR plot of proposed antenna at 8.36 GHz

IV. CONCLUSION

The proposed flexible microstrip patch antenna has been designed and simulated using the CST (Computer Simulation Technology) Microwave Studio 2014.The proposed flexible flanged antenna has substrate thickness 1.05mm with dielectric constant 2.1 has been used. From the above discussion it has been concluded that the dual-band flanged microstrip patch antenna has operating frequency range from 3.1244GHz -3.6751GHz at resonating frequency 3.42GHz and operating frequency range of 8.3507GHz – 8.7198GHz at resonating frequency at 8.36Ghz. In the proposed antenna the reduced ground has been used in order to increase the return loss and enhance the impedance bandwidth.The resonant frequency of the proposed dual-band flexible antenna design has been simulated to be 3.42GHz with return loss of-54.542792dB and operating resonating frequency at 8.36Ghz with return loss of -47.587292. The directivity measured at resonating frequency 3.42Ghz and at 8.36Ghz has been observed to be 6.095dB and6.159dB, respectively.The Gain at resonating frequency 3.42Ghz and 8.36Ghz is observed to be 6.252dBi and 6.149dBi, respectively. This flexible flanged microstrip patch antenna design covers various applications including Radio astronomy/ Radiolocation (military & civil)/ UWB/ PMSE/ FSS Earth stations applications (3.3GHz-3.6GHz), Radio-determination/Space-research/Fixed applications (8.4GHz-8.5GHz), active sensors (satellite)/ Radiolocation (civil & military)/ Aeronautical-navigation applications (8.5-8.55GHz).

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