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Wide Band 3-D Novel flange Microstrip Patch Antenna Design employing Flexible Teflon Substrate

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Abstract: This paper encapsulates a novel microstrip patch antenna design over flexible Teflon substrate having dielectric constant εr= 2.1. The designed antenna exploits a rectangular patch (0.05mm thick) on the radiating patch along with microstrip feed line and defected ground plane on the other side of the substrate. The radiating element of the flexible flanged antenna design has a finite ground plane to accomplish an excellent impedance matching for maximum power transfer. The proposed antenna has an operating bandwidth of 2.9226 GHz which ranges from 15.197GHz-18.12GHz with a resonant frequency of 15.72GHz. This flexible flanged microstrip patch antenna design covers various applications including Radio Astronomy (15.35GHz-15.4GHz), Radiolocation/Airborne Doppler navigation aids (15.4GHz-15.43Hz), Radiolocation(civil)/Airborne Doppler navigation (15.43GHz-15.63GHz), Radiolocation(military) (15.7GHz-17.7GHz), FSS Earth Stations (17.7GHz-20.2GHz), Weather Satellite(18.1GHz-18.3GHz), Broadcasting(Satellite) (21.4GHz-22GHz). The proposed antenna operates for acceptable voltage standing wave ratio (VSWR) less than two. The characteristics of the proposed antenna fabricated on a flexible PVC and analyzed its performance at different antenna parameters like Return loss (dB), Impedance Bandwidth, Gain(dB), Directivity(dBi), VSWR and antenna impedance. The antenna has been designed in CST Microwave Studio 2014. The proposed antenna has been fabricated and tested using an E5071C Network analyser and an anechoic chamber. It has been observed that the simulated results, legitimately match with the experimental results.

Keywords: Defected ground plane, Flexible antenna, PVC, Reduced shaped patch, Teflon.

1. Introduction

Microstrip patch antennas are extensively used in portable applications and wireless networking due to their characteristic advantages of low profile, less weight, low cost, and ease of integration with microstrip circuits [1]. The microstrip patch antennas are widely popular in modern digital networks, military systems, medical technology, mobile telephones and many other fields. It is easy to design and fabricate owing to its 2D physical geometry [2-3]. However, they also have some drawbacks, ranging from narrow bandwidth to low gain [4].Though as we know that the technology is unanimously getting innovative, mostly on a daily basis, so there is a need for more speed and efficiency in all communication systems.[5]. Conventional antennas have limitations in the hostile military environment or biomedical sectors [6]. In today's digitized world, the Flexible antennas are becoming enormously popular. Flexible materials can be molded into any shaped for better results for example in mobile phones, cars, robots, the human body, buildings and much more. The competence of flexible systems, mostly depends on the features of the integrated antenna [7-9].

The enhancement of the bandwidth is one of the most significant needs for many applications such as for high-speed networks. Owing to the paucity of bandwidth in the lower band, Ku/K-band antenna design gets important research attention recently [10]. As a consequence, the demand of satellite-based transportable communication devices is increasing remarkably, especially vehicle tracking, a portable satellite station, weather forecasting, etc. The antennas constructed on the waveguide orifices with a crenelated flange have an extensive series of applications [11]. The boundary specifications need association 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 an annual ring, triangle, ring, elliptical, circular disc, hexagonal and pentagonal antennas, the dipole configuration like bow-tie antennas [12]. In Satellite Communications circularly polarized radiation patterns are required to use on either a rectangular or circular patch[13].

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

2. 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 of flexible Teflon of thickness 1mm with a relative permittivity of ε_r=2.1.The proposed antenna geometry is determined by inclining two rectangular flanges vertically at 90 degrees with the radiating patch of dimension 50mm each. The wideband microstrip patch antenna had a radiating patch and defected ground of thickness 0.05mm. The radiating patch, lossless feedline and ground plane are made up of the 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 Flanged microstrip patch antenna on the radiating patch. The bottom view of the proposed antenna with defected 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 a ground plane on the opposite side of the substrate for electromagnetic waves to travel along the feed line.

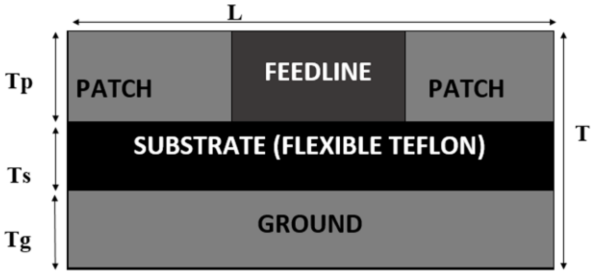

Fig.1 (a) Side view of the proposed antenna design

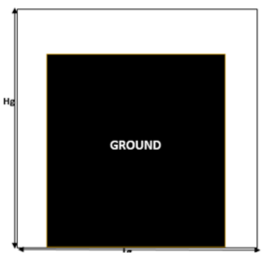

Fig. 1(b) Bottom view of the proposed antenna

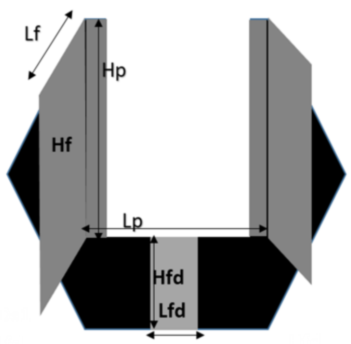

Fig.1 (c) Top view of the proposed antenna design

Table I. Antenna Dimensions

Antenna Dimensions	Description	Value (mm)
L	Length of substrate	30
T	Total thickness of antenna	1.05
Tp	Thickness of patch	0.05
Ts	Thickness of substrate	1
Tg	Thickness of ground	0.05
Hg	Height of ground	28
Lg	Length of ground	25
Lp	Length of patch	30
Hp	Height of patch	36.9
Hf	Height of flange	50
Lf	Length of flange	36.9
Lfd	Length of feedline	4.2
Hfd	Height of feedline	26

3. 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 regarding return loss, impedance bandwidth, gain, directivity, VSWR and antenna impedance.

The proposed wide band antenna has an impedance bandwidth of 6.8001GHz with an operating frequency range of 15.2GHz-22GHz at resonating frequency 16.08GHz as shown in fig. 2(a). Return loss is one of the most efficient and convenient methods to evaluate the input and output of the signal sources; when the load is mismatched the complete power is not delivered to the load, and there is a return/reflection of the power, and that is known as the 'Return loss.' The return loss (S_{11}) for this flexible flange antenna design at 16.08GHz resonant frequency is observed to be -42.676215dB.

Directivity is the ability of an antenna to direct energy in a particular direction. The definition of the directivity according to IEEE Standard 145-1983: "Directivity (of an antenna) (in a given direction) is the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions. The red colour shows the maximum field intensity in the broadside direction. The 3-D plots illustrate that the proposed antenna has a Omni-directional radiation pattern. The far-field 3D directivity plot is shown in fig. 2(c) and 2(d). The maximum gain of the antenna is 7.475dB at resonant frequency 16.08GHz. In fig. 2(c), it has been shown that the proposed antenna design has directivity of 7.447dBi at resonant frequency 6.08GHz

The HPBW is defined by the angles at which the antenna element power pattern falls 3dB below the main beam peak. The half-power beam width (HPBW) of the Flanged microstrip patch antenna with a resonant frequency at 16.08GHz has observed to be 41.6 degrees.

The significance of VSWR parameter is to show maximum power transfer from transmitter to the antenna to the antenna to achieve maximum power transfer at the receiver end. This happens only when the impedance Zin is matched to the transmitter impedance, Zs. In this research paper, the VSWR value lies below the maximum acceptable value of 2 as shown in fig. 2(e). The coaxial probe feeding fixed at a specific site of the point where input impedance is approximately 50 Ω. Coaxial feeding chosen for the excitation of the proposed antenna. Fig. 2(f) demonstrates the impedance of the proposed microstrip patch antenna, that is observed to be 49.41Ω.

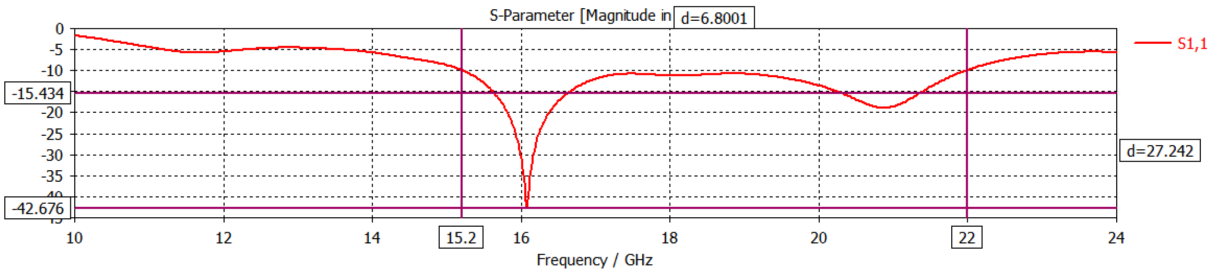

Fig. 2(a) Return loss (S11) plot of the proposed antenna design

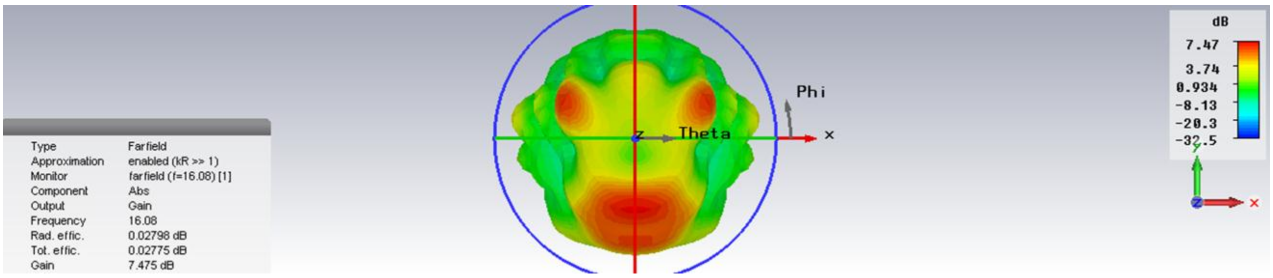

Fig. 2(b) Gain of proposed antenna design

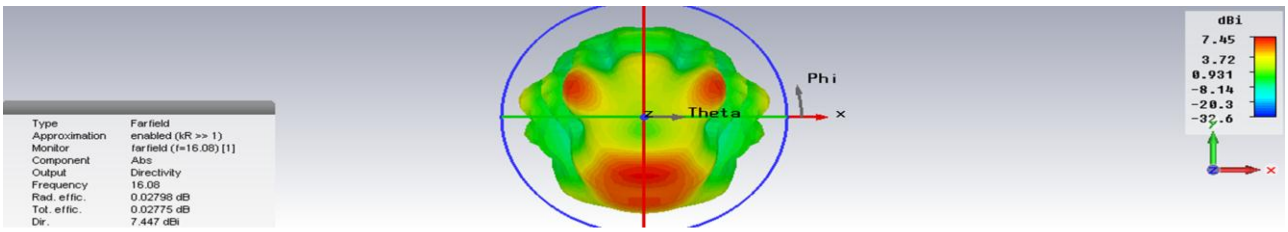

Fig 2(c) Gain of proposed antenna design

Fig 2(d) HPBW plot of proposed antenna design

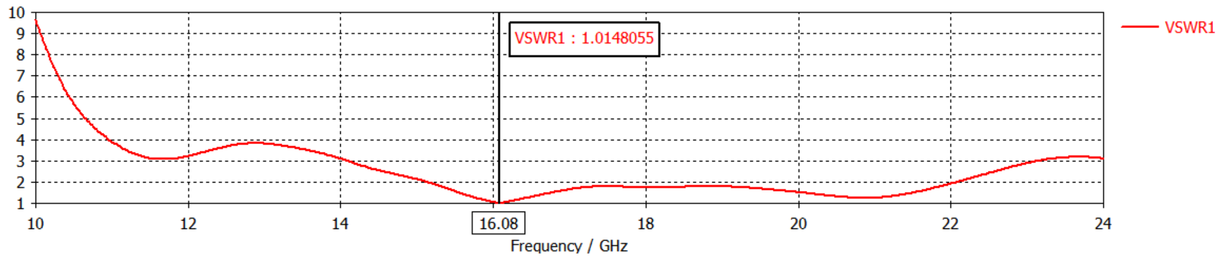

Fig 2(e) VSWR of proposed antenna design

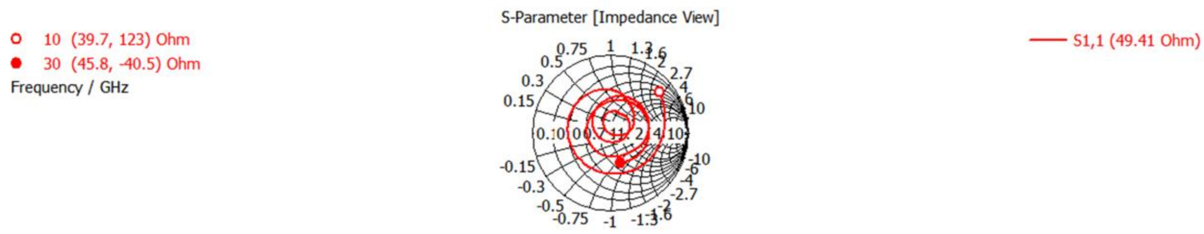

Fig. 2(f) S parameter plot of proposed antenna design

4. 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 1.00mm with dielectric constant 2.1 has been used. From the above discussion, it has been concluded that the broadband flanged microstrip patch antenna has an operating frequency range from 15.12GHz-22GHz at resonating frequency 16.08GHz. In the proposed antenna the defected ground has been used to increase the return loss and enhance the impedance bandwidth.The resonant frequency of the proposed wide band flexible antenna design has been simulated to be 15.72GHz with a return loss of-42.676215dB. The directivity measured at resonating frequency 16.08Ghz has been observed to be 7.447dBi.The Gain at resonating frequency 16.08Ghz is observed to be 7.475dB.This flexible flanged microstrip patch antenna design covers various applications including Radio Astronomy (15.35GHz-15.4GHz), Radiolocation/Airborne Doppler navigation aids (15.4GHz-15.43Hz), Radiolocation(civil)/Airborne Doppler navigation (15.43GHz-15.63GHz), Radiolocation(military) (15.7GHz-17.7GHz), FSS Earth Stations (17.7GHz-20.2GHz), Weather Satellite(18.1GHz-18.3GHz), Broadcasting(Satellite) (21.4GHz-22GHz).

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