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Wideband Compact Dual Frequency Dipole Microstrip Patch Antenna

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Abstract: *A small size and very thinwideband dipole microstrip patch antenna for dual frequency operation is designed and analysed in this paper. The dimension of the proposed antenna is 40×30×1.6 mm^3.The proposed antenna is designed using a low cost and reliable FR4 substrate. This FR4 substrate material has a thickness of 1.6 mm, dielectric constant of 4.4 and loss tangent of 0.02. The proposed antennaresonates at 2.19 GHz and 2.5 GHz frequencies with a -10 dB impedance bandwidth of 4.37 GHz, ranging from 1.8 GHz to 6.17 GHz.This shows the proposed antenna bandwidth is increased to 200%. The VSWR of the proposed antenna is less than 2 for entire operating frequency range. Radiation efficiency is above 70% at both of the resonance frequencies. A very low cross polarization is found at all resonance frequencies. CST Microwave Studio is used to design and analyse the proposed antenna.*

Keywords*:Wideband, Dipole, Microstrip patch antenna, CST Microwave Studio*

I. Introduction

To meet the need of high channel capacity for modern wireless communication systems in recent days wide bandwidth has become a necessity.Planar microstrip patch antenna is extensively used in modern communication systems due its various advantages[1].But at the same time due to its narrow impedance bandwidth its use is limited for different wireless applications. Earlier multiple antennas were used to tackle this situation. But again due to multiple antennas area and cost requirement were also very high. Obviously a single antenna may solve this problemwith high impedance bandwidth. That is whyrecently design of wideband microstrip patch antenna having large impedance bandwidth is one of many challenges of the researchers. A no of methods have been studied to design wideband antenna.These are staggering effect[2], introduction of slots on the radiating patch[3, 4] incorporation of slots of appropriatedimensions in radiating and the ground plane at appropriate positions[5, 6,7]. In the process of broad banding antenna gain, radiation patterns, cross-polarizationetc. are compromised. Various types of broadband antennas have been studied to maintain moderate to high gain, stable radiation patterns,low cross polarizations etc.[8, 9, 10, 11].

This proposed work utilizes the defected ground structure in combination with loaded slot in the radiating plane to achieve wideband characteristics. A large impedance bandwidth of 4.37 GHz with a percentage bandwidth of 200% and a simulated peak gain of 4.2 dBi are obtained for the proposed antenna. The CST Microwave studio is used to simulate the proposed antenna. All the simulated results are studied and analysed for confirming the quality of proposed antenna.

II. Design of The Antenna

Thetraditional equations[12] are studied and used to determine the Width and Length of the proposed antenna. The radiating patch of the proposed antenna comprises of two overlapping ellipses and a rectangle. These two ellipses have different dimensions. The dimension of the upper ellipse is larger than the lower ellipse. The lower ellipse has a major axis of 28 mm and minor axis of 12 mm. the upper ellipse has a major axis of 30 mm and a minor axis of 24 mm. The rectangular portion of the radiating patch has a dimension of 22x8 mm^2. Also an elliptical shaped slot is cut from the rectangular portion of the radiating patch. This structure of the radiating plane is printed on the top of FR4 substrate having the dimension of $Ls \times Ws \times h$. A micro-strip line of length $L_f$mm and width $W_f$mm is feeding the patch of the proposed antenna. To make 50Ωcharacteristics impedance,the width $W_f$of micro-strip feed line is varied and finally chosen as 2.92 mm. The proposed antenna utilizes a low cost and reliable FR4 substrate having relative dielectric constant (ϵr) of 4.3 and loss tangent (tan δ) of 0.02. On the bottom of the substrate, a rectangular conducting ground plane with a dimension of $L_G \times W_G$ is taken. The ground plane also contains two rectangular slots andeach of which has a length of E and width of X. The length, width and position of the slots have been varied and optimized to obtain the wideband characteristics of the proposed antenna. The detail geometry of the radiating plane of the proposed antenna is shown in Fig.1 and that of ground plane is shown in

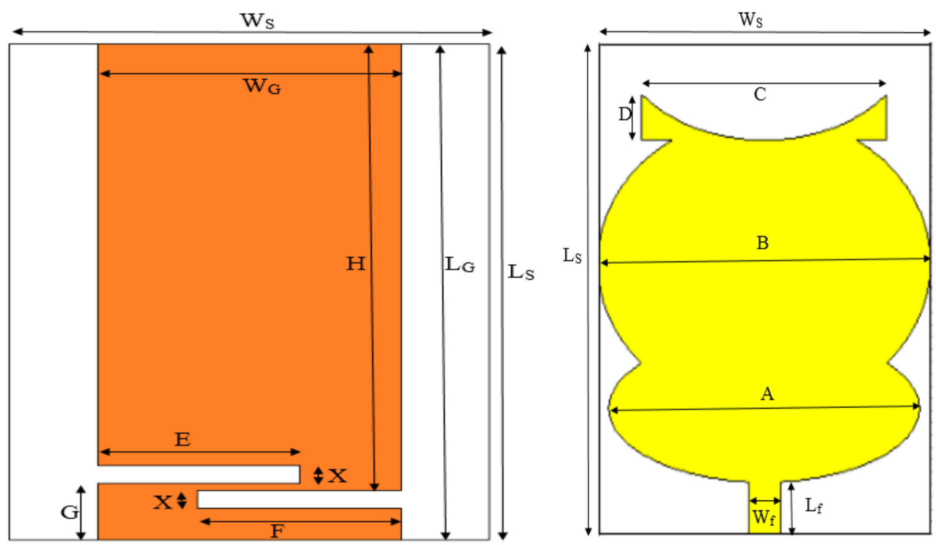


Fig.2. The proposed antenna characteristics parameters and also the design parameters along with dimensions are summmarized in Table no.1. Fig. 1. Structure of radiating plane of the proposed. Fig. 2. Structure of the ground plane of the proposed antenna

Table no. 1. Antenna design parameter Specifications and Dimensions

Antenna Parameter	Value	Design Parameter	Value (mm)	Design Parameter	Value(mm)
Operating bandwidth	1.8GHz-6.17 GHz	W_S	30	E	12.7
Substrate	FR4 epoxy	L_S	40	F	12.7
Substrate Thickness (h)	1.6 mm	W_f	2.92	G	4.5
Relative permittivity	4.3	L_f	5	H	36
Loss Tangent	0.02	A	28	X	1.5
Characteristic Impedance	50Ω	B	30	L_G	40
		C	22	W_G	19
		D	3		

III. Antenna Simulation Results and Discussions

The proposed antenna is simulated by using CST Microwave Studio to obtain all the simulation results. To obtain the final model three antennas have been designed. The reflection coefficients of three designed antennas have been illustrated in Fig. 3. In this figure the effect of width of the ground plane on the reflection coefficient of the proposed antenna has been studied. When the width of the ground plane is 30 mm that is same as the substrate width, the proposed antenna shows dual band characteristics. It is shown in Design 1.The design 1 has dual frequency bands of (2.53 GHz -2.62 GHz) and (4.71 GHz – 4.86 GHz).When the ground plane width is modified to 22 mm then the reflection co-efficient of the proposed antenna shows slightly modified dual band characteristics. It is shown in Design 2. The Design 2 has dual frequency bands of (2.4 GHz-2.6 GHz) and (4.67 GHz-4.92 GHz). Finally the width of the ground plane is modified to 19 mm (proposed) to obtain wideband characteristics. It is shown in Design 3. The simulation result of the design 3 shows the broadband (1.80 GHz – 6.17 GHz) characteristics of the proposed antenna. The proposed antenna (design 3) has two resonance frequencies at 2.19 GHz and 2.50 GHz with reflection coefficients of -47.00 dB and -29.00 dB respectively.

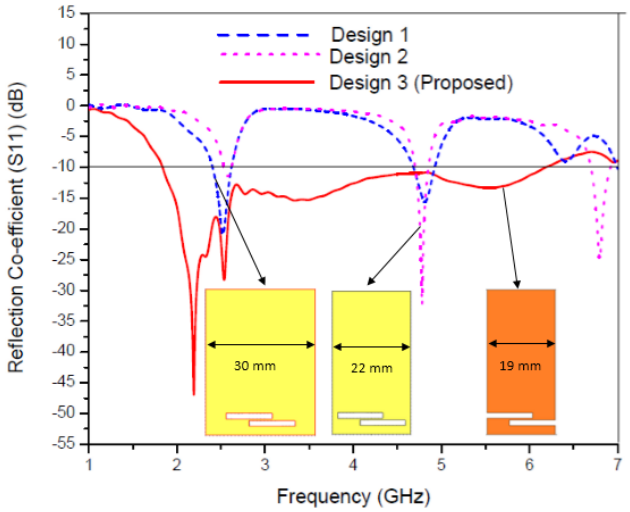


Figure. 3. Reflection coefficient vs. Frequency of the proposed antenna

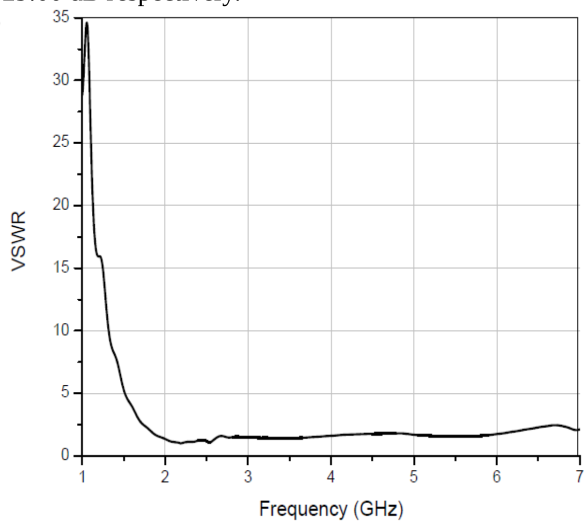


Figure 4. VSWR vs. Frequency of the proposed antenna

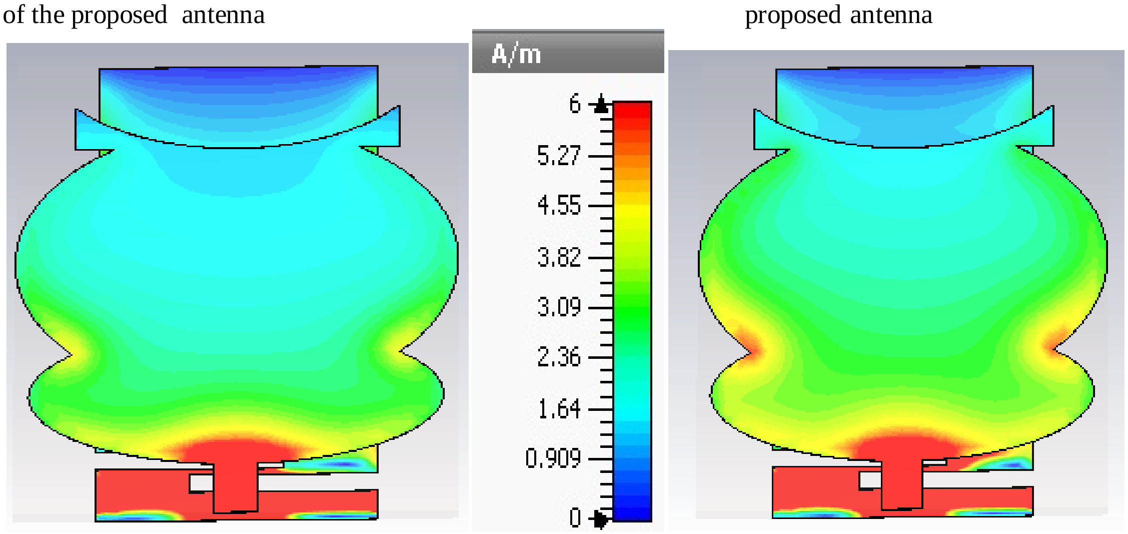


Figure 5. Surface Current distribution of the proposed antenna at a) 2.19 GHz b) 2.5 GHz

The VSWR of the proposed antenna lies in between 1 and 2 in the entire operating frequency region of the proposed antenna. It is shown in Fig. 4. Fig. 5(a) and Fig. 5(b) describe the surface current distributions of the proposed antenna forboth the resonance frequencies at 2.19 GHz and 2.5 GHz respectively. Thesesurface current distributionsguarantee that there is no null point in the microstrip feed line of the proposed antenna. It is also found that at both the resonance frequencies of the proposed antenna the current intensity is sufficiently stable.

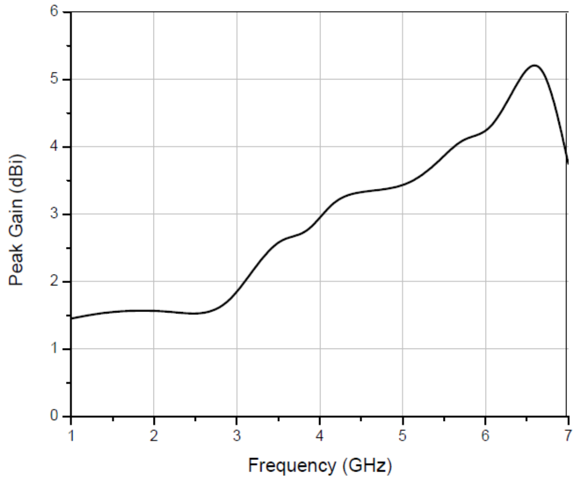


Figure 6. Peak gain vs. frequency of the proposed antenna

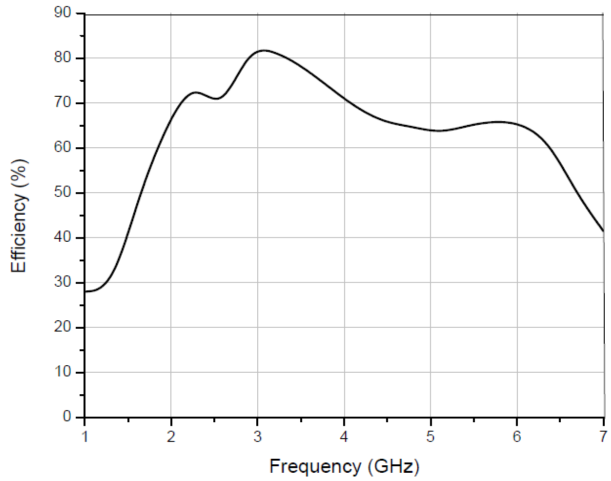
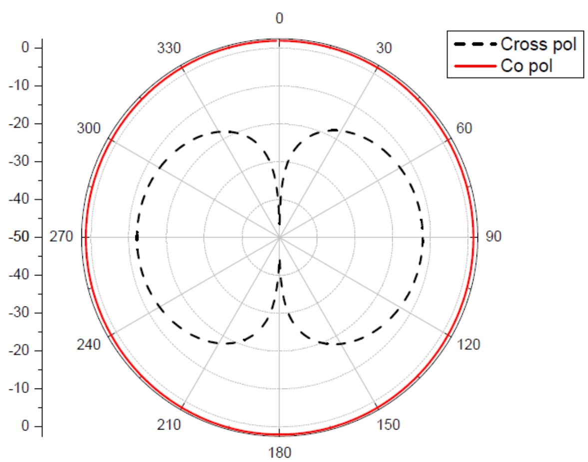
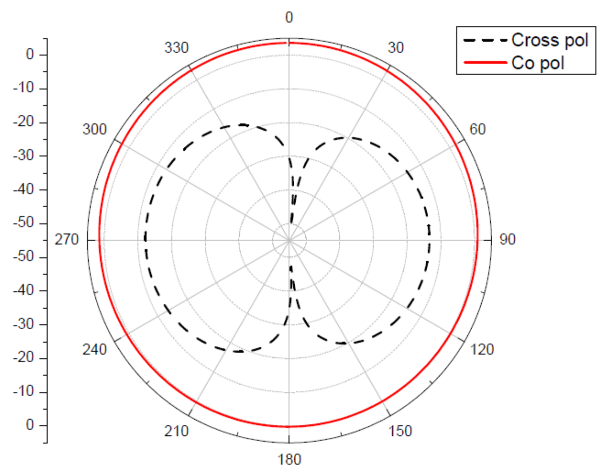


Figure 7 Efficiency vs. frequency of the proposed antenna

In Fig. 6 the simulated peak gain of the proposed antenna is plotted against frequency. It is found that a peak gain of 4.2 dBi is obtained at 6 GHz frequency. The radiation efficiency is shown in Fig. 7. It illustrates that the efficiency is more than 70% at both the resonance frequencies.The E plane co polarization and cross polarization radiation patterns are shown in Fig. 8(a) and Fig. 8(b). TheH plane co polarization and cross polarization radiation patterns are shown in Fig. 9(a) and Fig. 9(b). From the radiation patterns it is found that the average isolation between co polarization and cross polarization in E plane is about 20 dB and that of H plane is about 25 dB which are very fruitful.

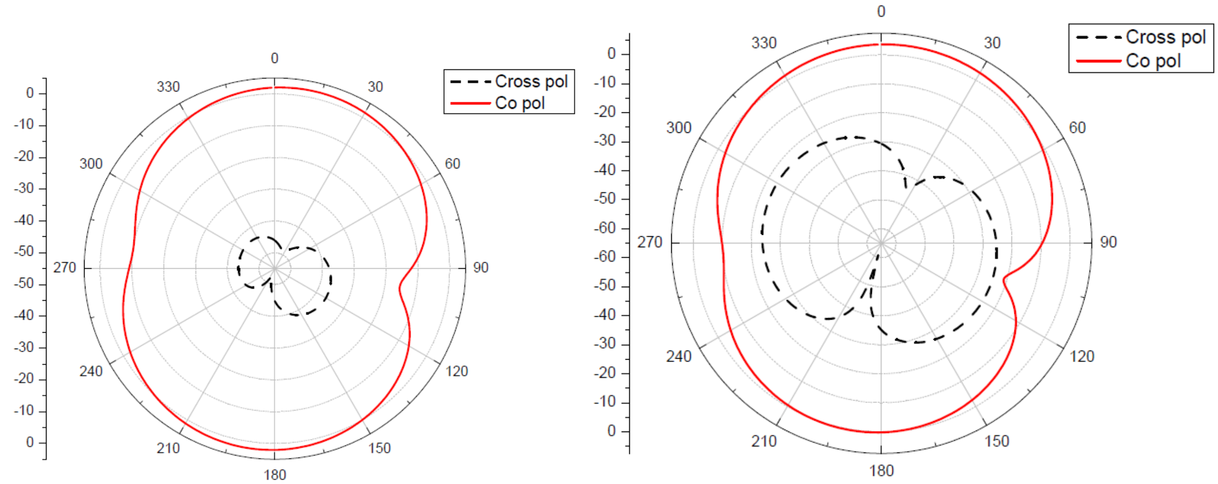


(a) E field at 2.19 Ghz



(b) E field at 2.5 GHz

Figure. 8 Radiation patterns of the proposed antenna: E plane (a) at 2.19 GHz (b) at 2.5 GHz



(a) H field at 2.19 GHz (b) H field at 2.5 GHz

Figure. 9 Radiation patterns of the proposed antenna: H plane (a) at 2.19 GHz (b) at 2.5 GHz

Table no 2. Results of the References and proposed work

Ref. No.	Max B.W.	% of B.W.	Dimensions (mm^2)
[1]	(0.64-2) GHz	138	80 x160
[2]	(1.01-2.01)GHz	66.2	120 x 120
[3]	(2.23-5.35) GHz	80	37 x 37
[4]	(1.38-3.5) GHz	86.9	65 x 30
[5]	(0.82-6) GHz	152	140 x 140
[6]	(4.53-12.6) GHz	94.22	30 x 20
[7]	(1.61-3.45) GHz	72.7	150 x 150
[8]	(1.46-1.68) GHz	25.31	120 × 120
[9]	(0.7-1.15) GHz	49	120 x115.2
[10]	(2.99-5.16) GHz	54.79	30 x 20
[11]	(0.93-2.48) GHz	92	20.3 x 20.3
proposed	(1.80-6.17) GHz	200	40 × 30

IV. Conclusion

From the Table no 2 it is obvious that the proposed antenna is a compact wideband dipole antenna which is designed, simulated and analyzed in this paper. CST Microwave studio has been used to design, simulate and analyze the proposed antenna. The simulation result of proposed antenna shows that the antenna bandwidth has been increased to 200% which is comparatively very high with respect to all the previously designed antennas which are described in Table no 2. Also the dimension of the proposed antenna for this operating frequency range is comparatively less than the previously designed antennas. The proposed antenna is designed using a low cost and reliable FR4 substrate. So this antenna model can easily be manufactured in large quantities and also can be integrated with ICs very easily. This antenna can be considered as a good radiating device for any C band applications.

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