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Slotted Dual Arrowhead Multi-Band Rectangular Microstrip Patch Antenna

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Abstract— This paper presents design and implementation of dual arrowhead slotted multi-band microstrip patch antenna for mobile (1.9 GHz-IEEE 802.11b/g), WLAN (5.8 GHz-IEEE 802.11a) and other personal wireless applications.The radiating element of the proposed antenna consists of dual arrowhead slot on rectangular patch operating at multi-bands in the range from1.9 to 5.8 GHz..The antenna is probe feeded and it is simulated on IE3D Zeland software.The result of the antenna is analyzed by changing their flair angles (45,60,and 75 degree). The proposed antenna have directivity upto 11.5 dBi,Gain upto 7.5 dB and efficiency upto 80%.The software simulation results shows that the antenna can realize multi- band characters with each band having good impedance bandwidth (VSWR≤2) for all the resonant frequencies. The proposed antenna is also tested and verified through VNA network Analyzer and approximately appropriate matching is achieved between the simulated and measured results.

Index Terms— Microstrip antenna, multi-band, slot, Arrowhead, IE3D

1 Introduction

THE rapid development of various wireless communication systems has sparked the demand for compact microstrip antennas with high gain and multiband operating frequencies in the range of 2.4GHz ISM band (2.4–2.485GHz), and IEEE 802.11a which employs the 5GHz U-NII band and ISM band (5.15–5.825GHz). Microstrip patch antenna has advantages such as low profile, conformal, light weight, simple realization process and low manufacturing cost. However, the general microstrip patch antennas have some disadvantages such as narrow bandwidth and less gain etc. Enhancement of the performance to cover the demanding bandwidth is necessary [1-3]. There are numerous and well-known methods to increase the bandwidth of antennas, including increase of the substrate thickness, the use of a low dielectric substrate, the use of various impedance matching and feeding techniques, and the use of multiple resonators alongwith slot incorporation in the patch for improvement of impedance bandwidth and a large no of research papers are available on the same [4-7] A slot antenna has special advantages because of its simple structure, such as wider bandwidth, less conductor loss, and better isolation between the radiating element and feed network .It can also provide the merits of low profile, low cost, small size, easier integration with other circuits and conformability to a shaped surface. The placement of slots can may be coupled basis or tech of cross shaped.[8-10] Numerous slot antennas for 2.4/5GHz operations have been reported in the past few years [11–13].

In this paper a slotted dual Arrowhead shaped antenna on rectangular patch energized through a coaxial probe is presented and proposed, typical geometry shown in fig.1 whose results are varied by changing in their flair angles. Performance simulations of the antenna were performed with IE3D software, which is based on the method of moments [14] .Designed antenna with optimal dimensions, was fabricated and measured. An extensive comparison between experimental and simulation results is made, which demonstrates good agreement over approximately the entire operating frequency range

This paper is organized as follows. In Section 2, the geometry of the proposed antenna is presented. In Section 3, we present the simulated results and Section 4 presents measured results and discussion for the proposed fabricated antenna. Concluding remarks are given in Section 5. The simulations are carried out using method of moment based (MOM) software "IE3D: Ze-Land".

2. Proposed Antenna Geometry

The geometry and detailed dimensions of proposed antenna are shown in Fig. 1 which presents that the antenna having dual arrowhead slots in the rectangular patch of dimension 70x70 mm .The height of the dielectric substrate slab is 1.6 mm and having relative permittivity of 4.7and loss tangent .019. The antenna has variation of its slots angular position: termed as Flair angle variation and the optimization of parameters is performed on the basis of flair angle.

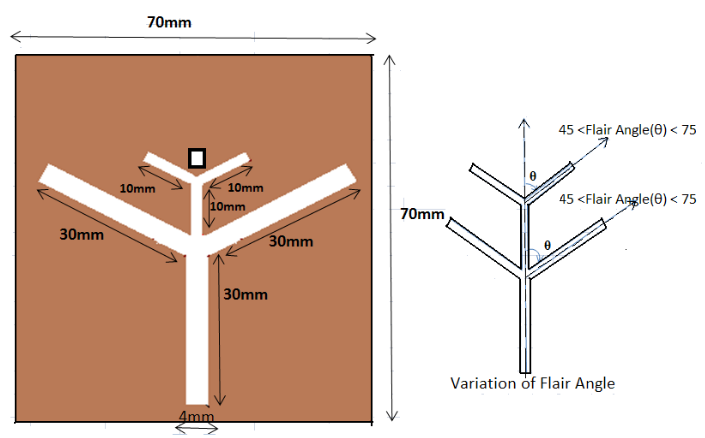

Fig.1 Proposed Antenna geometry and illustration of flair angle variation in slot.

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3. Proposed Antenna Design at different Flair Angles

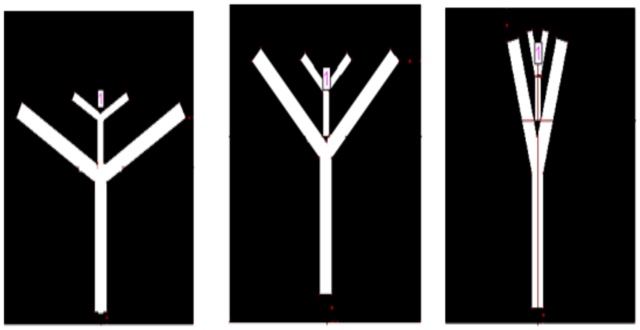


Fig.2 Designed Antenna geometries having different flair angles (a) 45^0 degree (b) 60^0 degree (c) 75^0 degree.

4. Simulation Results

The performance of this antenna was simulated and optimized by "IE3D" 14 version of Zeland. This was used to calculate the return loss, impedance bandwidth and radiation pattern alongwith directivity, gain and antenna efficiency etc for performance analysis of the antenna. Since the primary step is to measure the Return Loss parameter i.e (S11) for proposed antenna as given in fig.3 below

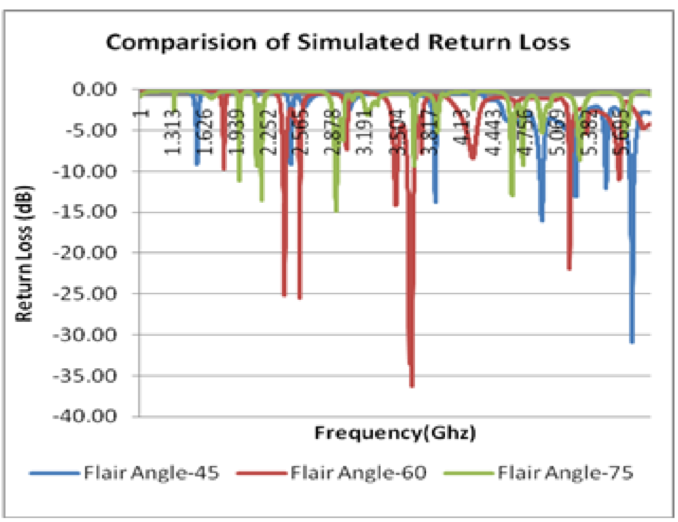


Fig 3 Comparision curve (simulated) of S_{11} (dB) for all the geometries of dual arrowhead slotted antenna for variation in flair angle.

From The fig.3 ,which shows the combined comparative curve for Return loss for antenna geometries having variation in flair angle and it is quite noticeable that resonance frequency falls from 3.8 Ghz (Blue colour) to 1.97 Ghz (Green colour) on incrementing the flair angle from 45^0 degree (Blue colour)to 75^0 degree (Green colour) .As the resonance frequency 1.97 at 75 degree flair angle is the optimized value and further increment in flair angle does not decrements the resonance frequency further. The same is also interprated through the table1, given below:

Table 1.0 Comparison of Return Loss for Antenna geometries having variation in flair angle

Antenna with Flair angle 45^0 degree		Antenna with Flair angle 60^0 degree		Antenna with Flair angle 75^0 degree	
Freq. (GHz.)	Return Loss (dB)	Freq. (GHz.)	Return Loss (dB)	Freq. (GHz.)	Return Loss (dB)
9.5	-14.23	2.412	-21.45	1.97	-10.19
4.9	-15.98	2.559	-20.22	2.19	-11.92
5.8	-31.2	3.63	-28.34	2.92	-14.7
		3.66	-27.67	4.63	-11.95
		5.2	-16.63		

The table has the values of Return Loss for different frequency points, from the table values it is is quite clear that the antenna suits for various commercially available frequency range applications such as for GSM / UMTS (1.9 Ghz & 2.1 Ghz),Wi-Fi-IEEE 802.11std.(3.6Ghz), for WLAN and Wi-Max and for ISM band (2.4/5.8 Ghz.).This shows that the proposed antenna has wide application range for commercial application**.**

Other important parameters such as Directivity, Gain and Antenna efficiency are also evaluated/simulated for the designed antennas. From fig 4.0, the curve is drawn in between Directivity and frequency and it is noticeable that average value of directivity stands at 8 dBi and approaches upto 11.5dBi as max for antenna design having flair angle 75^0 degree

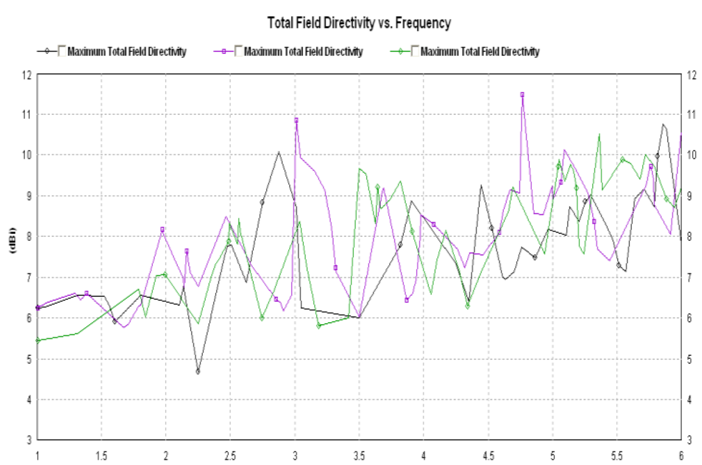


Fig. 4.0 Antenna Directivity Comparison curve: with, Flair angle 45^0 degrees (In black ink), Flair angle 60^0 degrees (In green ink), Flair angle 75^0 degrees (In violet ink).

Similarly other parameter such as Gain is compared for all the design geometries of proposed antenna having variation in flair angle in fig.5, given below the average value of Gain is 5 dBi and on some frequency points it approaches upto 7.5dBi. The value of Gain for patch antenna as it is known remain found low, yet the Gain of proposed antenna attains satisfactory value. Fig 6.0 shows Antenna efficiency w.r.t frequency variation. It is clearly shown that the antenna efficiency approaches upto 80% value in its respective frequency domain.

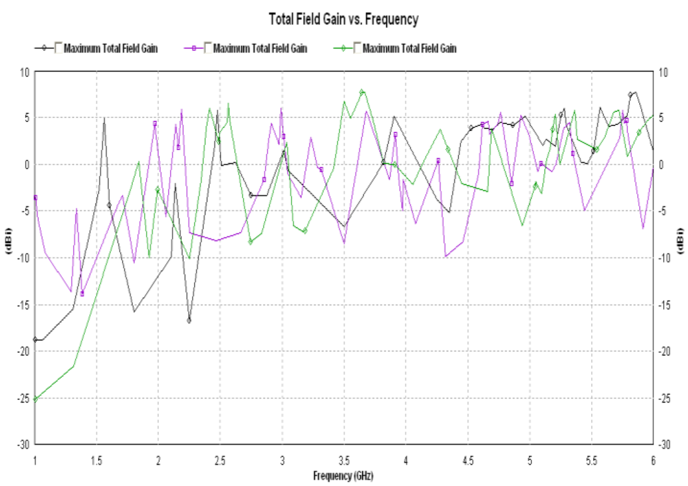


Fig.5.0 Antenna Gain Comparison curve: with, Flair angle 45^0 degree (In black ink), Flair angle 60^0 degree (In green ink), Flair angle 75^0 degree (In violet ink)

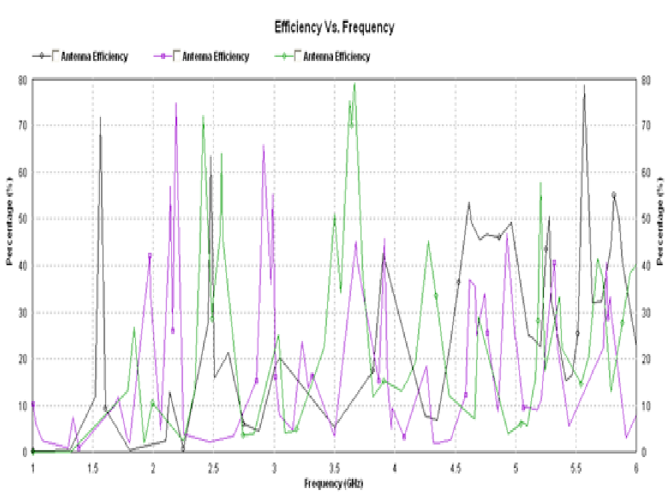
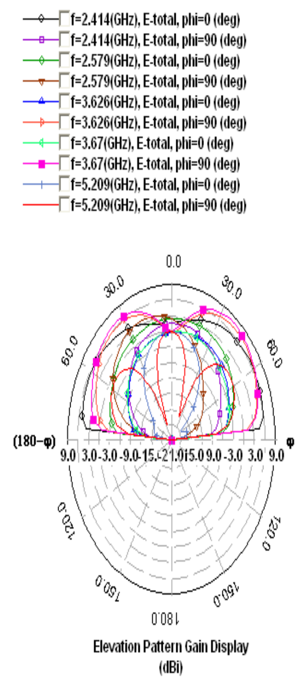


Fig.6.0 Antenna Efficiency Comparison curve: with, Flair angle 45^0 degrees (In black ink), Flair angle 60^0 degrees (In green ink), Flair angle 75^0 degrees (In violet ink).

Apart from above shown parameters the proposed antenna have the promising radiation patterns in 2Dimensional plane for elevation ($\Phi = 0^0$ deg. and $\Phi = 90^0$ deg.)-Fig.7 (a) and azimuth plane ($\theta = 90^0$ degree), Fig.7 (b). The radiation patterns in 3Dimensional plane are also illustrated for ter go through and are depicted in the fig. 8 given below.



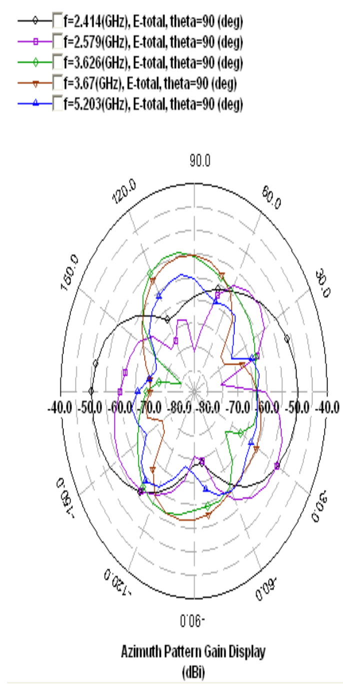
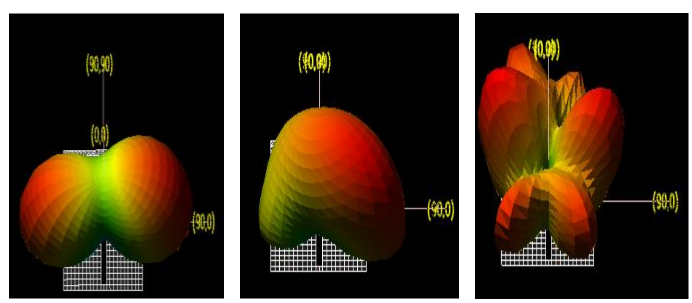


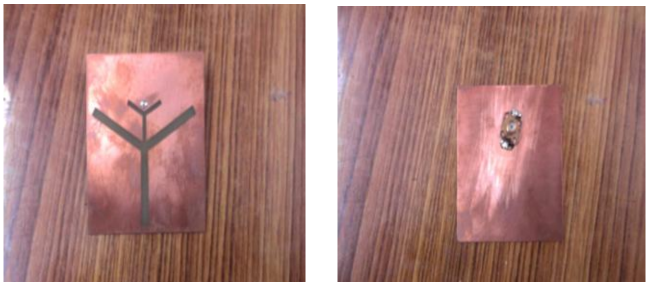
Fig.7 (a).Elevation pattern Gain Display Fig.7 (b).Azimuth Pattern Gain Display



At 2.414 GHz At 2.579 GHz At 5.209 GHz

Fig.8**:** 3 Dimensional Radiation Pattern Display: for Dual arrowhead Slotted antenna Geometry having 60 degree flair angle.

In order to validate the simulated results, a prototype of the proposed antenna was implemented and fabricated on FR4 substrate (εr= 4.50, tan σ = 0.02). The picture of a physically realized module is shown in Fig. 9. The return loss was measured using an Agilent 8722ES vector network analyzer Vidut Yantra Ltd. Modinagar, Ghaziabad, U.P)



Front view Back view

Fig. 9 fabricated prototype Dual slotted antenna having Flair angle, 60^0 degree (a) Front view (b) Back view.

Fig 9 shows the fabricated Dual arrowhead antenna on Glass Epoxy material Fig 9(a) shows the front view of the designed antenna, having dual slots in the form of arrowhead and similarly Fig9 (b) shows the Back view of the antenna having SMA probe placed and the prototype antenna is then analyzed with Network analyzer (VNA) for finding out Return Loss (S11) parameter in dB as shown in the Fig. 10 given below:

Fig. 10 Display of Return Loss curve on Network analyzer (**curtsey –** Vidut Yantra Ltd. Modinagar, Ghaziabad, U.P)

On comparing in between simulated results and measured results for return loss as depicted in fig. 11 given below and it is quite promising that for proposed antenna both the curves, for simulated and measured results follows each other with high degree of accuracy and are nearly the same, the variation in between these two curves can also be anticipated on the basis of design accuracy. Since it can also be understand that at high band, the measured result displays larger bandwidth and the resonant frequency shifts to a higher frequency. This may be caused by the little differences of the FR4 substrate between the practical and simulated models. In addition, the dielectric constant and dissipation factor are not stable Progress In Electromagnetic Research B, Vol. 8, 2008 323 when the frequency increases. In general, good agreement is observed between the measured and simulated results

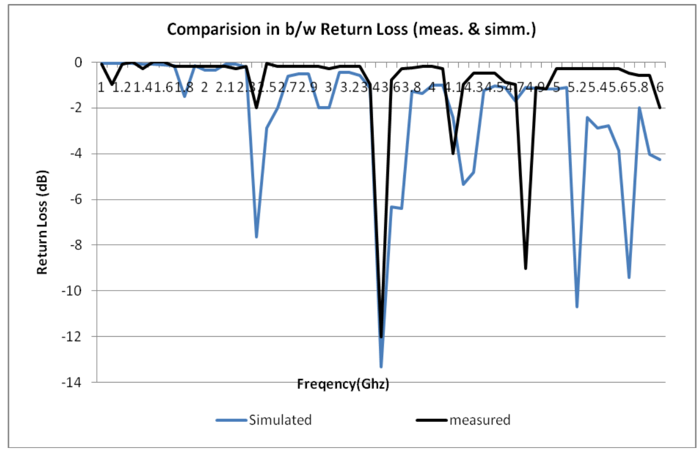


Fig.11 Comparison in between in b/w measured and simulated return loss curves for fabricated antenna having Flair angle, 60^0 degree.

6. Conclusions

A dual arrowhead slotted antenna for wireless application has been proposed, constructed, and tested. The proposed antennas have simple iterative geometry whose performances are studied by variation in their flair angles from 45 to 75 degree and the design provides adoptability of various frequencies ranging from 1.97GHz upto 5.8 GHz alongwith 80% radiation efficiency and gain and directivity upto 7.5 dB and 11.5 dBi respectively. The antenna also has good directional-radiation characteristics. Furthermore, this antenna has many advantages such as easy fabrication, low cost and compact in size. Therefore, such type of antennas can be useful for GSM / UMTS (1.9 Ghz & 2.1 Ghz),Wi-Fi-IEEE802.11std.(3.6Ghz), for WLAN and Wi-Max and for ISM band(2.4/5.8 Ghz.) type of applications in personal communication It can also fulfill the requirements of indoor wireless system applications .

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