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Radiation Performance of an Elliptical Patch Antenna with a Circular for Modern Communication Systems

D.Bhardwaj, Vishwas Bhardwaj, Komal, D. Bhatnagar, & S. Sancheti*
Microwave Lab., Department of Physics, University of Rajasthan, Jaipur -302004
*National Institute of Technology, Suratkal (Karnataka)
Email: dbhatnagar_2000@rediffmail.com

***Abstract* - The paper presents the radiation performance of an elliptical (a=15mm, b=10.5mm) patch antenna having circular slot (R=4.8mm) designed on glass epoxy FR4 substrate and its performance is compared with a simple elliptical patch antenna without slot. The simulation results for this antenna are obtained with available IE3D simulation software by varying semi major axis (a) and semi minor axis (b). The elliptical patch antenna with circular slot of specific radius not only resonates at two different frequencies but also presents a relatively wide bandwidth, higher directivity and enhancement of gain. By designing antenna on low permittivity substrate, a much higher bandwidth may be achieved.**

***Index Terms*— Microstrip antenna, return loss, bandwidth and gain**

I-INTRODUCTION

Microstrip antennas have found extensive applications in satellite, mobile and wireless communication systems due to their attractive features like their small size, lightweight, low profile and conformability on host surface. Extensive analysis of different geometries of microstrip antennas including rectangular, circular, triangular and square-ring shapes has been carried out but in practical applications circular and rectangular geometries are more widely analyzed due to their simple geometries. It has been found that a patch antenna having regular shape resonates only at a single resonance frequency and has very poor bandwidth (1 to 2%) and gain values [1-3]. Recent advancements in wireless communication systems particularly in wireless data communication and cellular phones, has increased the demand for wide band, multi frequency and multi band patch antennas. Microstrip antennas for dual frequency applications may be realized by exciting patch geometry by using a single [4] or dual feed [5]. In this paper we propose an elliptical patch microstrip antenna with a circular slot. The antenna is simulated with available IE3D simulation software by considering parameters of glass epoxy FR4 substrate having relative dielectric constants $\epsilon r = 4.37$, loss tangent $\tan\delta = 0.025$ and substrate thickness 'h' = 0.158 cm.

I. ANTENNA GEOMETRY AND RESULTS

First we have considered a simple elliptical patch antenna and tested its performance with available e.m. simulation tools considering the parameters of Glass epoxy FR4 substrate ($\epsilon r = 4.37$, $\tan\delta = 0.025$, substrate thickness 'h' = 0.158 cm) with copper as its ground plane. Here we considered the patch major axis a=15mm, minor axis b=10.5mm and antenna with inset feed with suitable SMA connector and 50 ohm coaxial cable.

II. ANTENNA GEOMETRY AND RESULTS

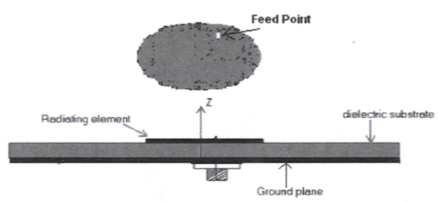

Figure 1: Geometry of antenna element with feed

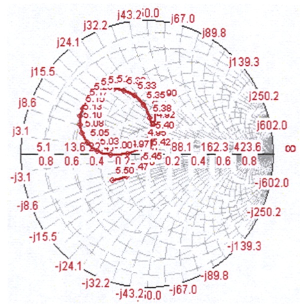

Figure 2: Variation of input impedance of antenna with frequency

The variation in input impedance of antenna with frequency as shown in figure-2 indicates that antenna resonates at two frequencies 4.95 GHz and 5.425 GHz but has narrow band width. The bandwidth at each frequency is not better than 2.5%. The feed point is located very precisely which can be visualized from both figures 2 and 3. The VSWR corresponding to these two resonance frequencies is close to unity. The out come of the performance indicates that though antenna is resonating at two closely spaced frequencies still it is not suitable for modern communication systems.

We therefore applied a circular slot at the center of this elliptical geometry and by varying radius of this inner circle; we optimize the performance of this antenna geometry. For this optimization, each time we

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simulated antenna geometry by using IE3D simulation software till received best performance with the antenna.

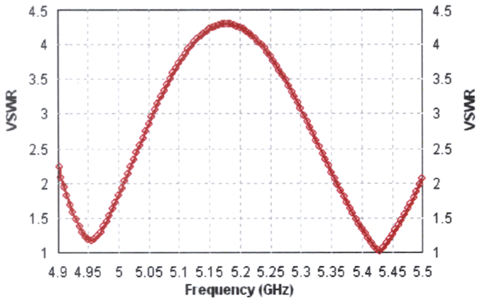


Figure 3: Variation of VSWR of antenna with frequency

It is observed that on making radius of circular slot equal to 4.8mm, the first sharp dip obtained at frequency 4.95 GHz (in figure-3) almost disappears while a shallow dip appears at a little higher frequency in comparison to that we have detected in the absence of circular slot. The two resonance frequencies are not little closer to that we obtained in the previous case.

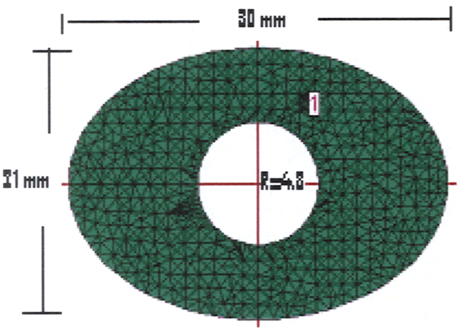


Figure 4: Designed elliptical antenna with a circular slot

The variation in the bandwidth of antenna as a function of patch radius is shown in figure 6. It indicates that initial presence of a circular slot of smaller radius do not effect the bandwidth of antenna but after approaching radius of circular slot equal to 4mm, the bandwidth of antenna start increasing and approaches to 6.58% when the patch radius is 4.8mm. Thereafter the bandwidth of antenna decreases as shown in the figure. The variation in input impedance and VSWR of antenna with circular slot of 4.8mm radius as a function of frequency are shown in figures 7 and 8 respectively. These figures also indicates less matching between antenna and feed network at the lower frequency but an excellent matching at higher frequency.

The simulated impedance bandwidth corresponding to VSWR 2:1 is around 6.5837GHz which is significantly higher than that obtained with simple elliptical patch antenna (2.374%). Though this bandwidth value is still small but it may be improved further by applying low loss substrate or by applying air gap between radiating element and the ground plane.

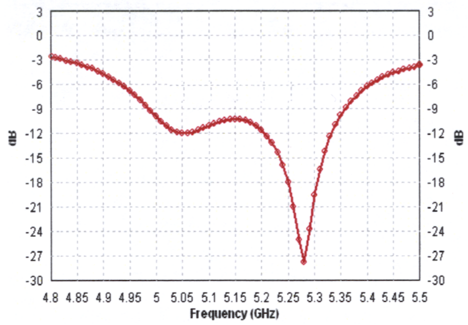


Figure 5: Variation of return loss of with frequency

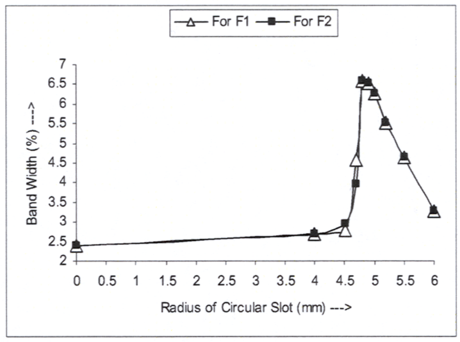


Figure 6: Variation in bandwidth with radius of circular slot

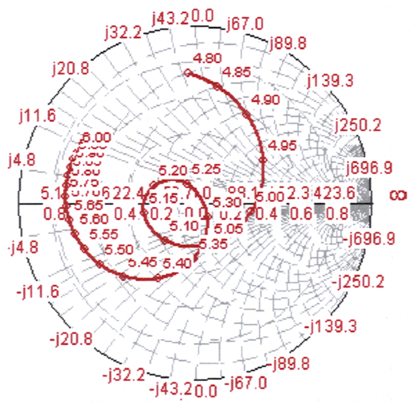


Figure 7: Variation of input impedance of antenna with frequency

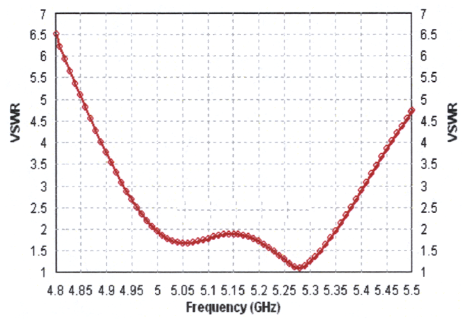


Figure 8: Variation of VSWR of antenna with frequency

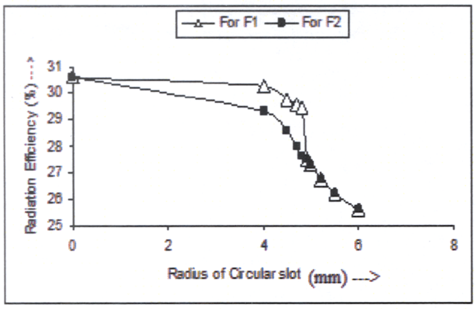


Figure 9:- Variation in radiation efficiency of antenna radius of circular slot

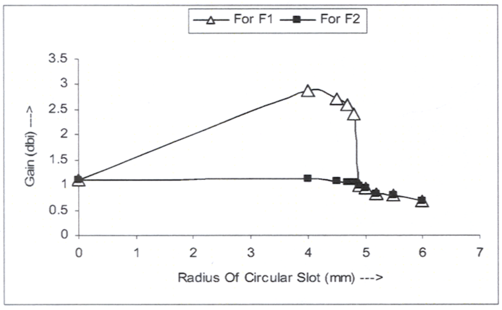


Figure 10: Variation in gain of antenna with radius of circular slot

The variation of radiation efficiency of antenna as a function of radius of circular slot is shown in figure 9. The radiation efficiency of antenna at both resonance frequencies is not good. The reason of these low efficiencies is obviously the presence of dielectric substrate material higher loss which we have applied for the simulation analysis of this antenna. The efficiency of antenna with circular slot is marginally better than that we have predicted in the presence of circular slot.

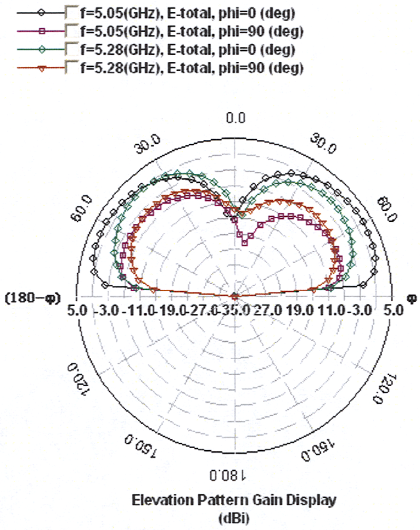
The gain of antenna elliptical antenna is very low but improves significantly at one of the two resonance frequencies from the value 1.121dBi to 2.86dBi but remains almost unchanged for the other frequency. In this work, we have concentrated mainly on bandwidth enhancement not on gain enhancement. As the bandwidth gain product remains constant therefore improvement in one will provide low value of other hence low gain value may be justified. To improve bandwidth we need to adopt some alternate methods.

The elevation gain pattern of elliptical patch antenna with a ring slot are plotted in figure-11. Both E and H plane patterns drawn at two frequencies indicate that that maximum radiation intensity of antenna is not directed normal to the patch as we have seen in an elliptical patch antenna without slot. The maximum radiation intensity is now inclined in at theta = 60°.

III. CONCLUSIONS

The work reported in this paper indicates that the presence of a ring slot on the elliptical patch antenn modifies the performance of antenna to a great extent.

The present work on this type of antenna is still underway and hopefully in near future we will be able in presenting some more interesting results with this antenna structure.



REFERENCES

[1] K. L. Wong, Compact and Broadband Microstrip Antennas, John Wiley & Sons. 2003.

[2] J. R. James, Handbook of Microstrip Antenna, Peter Peregrinus Ltd: London, 1989.

[3] R. Garg, P. Bhartia, I. J. Bahl and A. Ittipiboon, Microstrip antenna design handbook, Artech House: New York, 2001.

[4] Manju Paulson, Sona O. Kundukulam, C. K. Aanandan , P. Mohanan "A new compact dual band dual polarized microstrip antenna," Microwave and Opt. Technol. Lett . 29 (2001) 315.

[5] Binu Paul, S. Mridula, C. K. Aanandan, P. Mohanan, "A new microstrip patch antenna for mobile communications and Bluetooth applications," Microwave and Opt. Technol. Lett. 33 (2002) 285.

Table: Simulated results with considere3d geometry

Geometry of patch	Radius of Circular Slot (mm)	Resonance Frequency (GHz)	Radiation Efficiency (%)	Directivity (dbi)	Gain (dbi)	Band Width (%)
Ellipse with out slot	**0**	**5.43**	**30.613**	**6.23339**	**1.09177**	**2.37477**
Ellipse with slot R=4 mm	4	5.04	30.2488	8.09784	2.8602	2.69477
		5.36	29.3192	6.55634	1.121724	2.69477
Ellipse with slot R=4.5 mm	4.5	5.05	29.7647	8.04015	2.69969	2.7914
		5.31	28.5711	6.53872	1.08091	2.95563
Ellipse with slot R=4.7 mm	4.7	5.05	29.564	7.99582	2.5856	4.56
		5.29	27.987	6.65332	1.0608	3.95546
Ellipse with slot R=4.8 mm	**4.8**	**5.05**	**29.483**	**7.98582**	**2.40085**	**6.5837**
		5.28	**27.647**	**6.663434**	**1.0434**	
Ellipse with slot R=4.9 mm	4.9	5.27	27.486	6.60117	0.9809	6.5254
Ellipse with slot R=5 mm	5	5.255	27.2705	6.58747	0.92425	6.262607
Ellipse with slot R=5.2 mm	5.2	5.225	26.7263	6.62444	0.8205	5.49588
Ellipse with slot R=5.5 mm	5.5	5.185	26.2043	6.60183	0.7855	4.62912
Ellipse with slot R=6 mm	6	5.1	25.602	6.6098	0.6715	3.25843