Square Patch Microstrip Antenna with Single Notch Having an Air Gap

D.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 a modified rectangular patch microstrip antenna having a triangular notch in one of its straight arm and designed on dielectric material under the presence of variable air gap. The measured performances of this antenna without air gap are compared with those obtained through simulation results of this antenna under the presence of variable air gap. It is observed that the performance of antenna improves significantly.**

I. INTRODUCTION

Microstrip antennas are proved important geometries in recent mobile and wireless communication systems due to their inherent properties. However their low gain, narrow bandwidth and applicability at a single resonance frequency reduce their application in these systems. In recent times, the radiation performance of a square patch antenna with a single notch was reported [1] and it was observed that by varying notch angle, the radiation performance of antenna changes drastically. With the change in notch angle, resonance frequency of antenna changes which in turn changes the performance of antenna to a great extent. Earlier a simple scheme for changing the resonant frequencies, without resorting to a new antenna, was proposed by Lee and Dahele [2]. In that technique, an air-gap was introduced between the patch and the ground plane. In this communication, we have introduced both techniques together i.e. we introduced variable air-gap in the antenna and changed the notch angle to obtain an antenna with better performance. The two parameters are optimized to reach an antenna with much wider bandwidth, gain and efficiency.

I. ANTENNA GEOMETRIES AND RESULTS

The rectangular patch antenna notch angle θ with and without air gap are shown in figure-1. The geometry is considered designed on Glass epoxy FR4 substrate (Єr = 4.37, tanδ = 0.025, substrate thickness 'h' = 0.158 cm) with copper as its ground plane. Patch dimensions are taken as "2cm x 2 cm" with inset feed. The performance of this antenna with variation in notch angle is reported earlier [1]. It was observed experimentally that on varying notch angle, antenna resonates at a single frequency till notch angle reduces from 180^o to 164^o. On reducing notch angle further, antenna starts resonating at two different frequencies. One of these frequencies (f_1) is lower than the resonance frequency of square patch without notch while other one (f_2) is higher than the resonance frequency of square patch without notch. The variation in bandwidth of antenna as a function of notch angle indicates that at notch angle $\theta = 151^o$, maximum bandwidth up to 10.29% may be achieved. On further reducing notch angle θ, the bandwidth of antenna starts decreasing. The radiation efficiency is not a very sensitive function of notch angle.

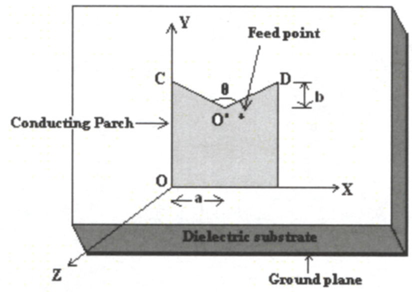

Figure 1a: Square patch antenna with a notch

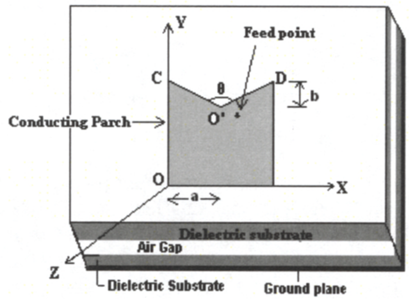

Figure 1b: Square patch antenna with single notch with air gap

The rectangular patch antenna notch angle θ with and without air gap are shown in figure-1. The geometry is considered designed on Glass epoxy FR4 substrate (Єr = 4.37, tanδ = 0.025, substrate thickness 'h' = 0.158 cm) with copper as its ground plane. Patch dimensions are taken as "2cm x 2 cm" with inset feed. The performance of this antenna with variation in notch angle is reported earlier [1]. It was observed experimentally that on varying notch angle, antenna resonates at a single frequency till notch angle reduces from 180^o to 164^o. On reducing notch angle further, antenna starts resonating at two different frequencies. One of these frequencies (f_1) is lower than the resonance frequency of square patch without notch while other one (f_2) is higher than the resonance frequency of square

978-1-4244-2690-4444/08/$25.00©2008 IEEE

patch without notch. The variation in bandwidth of antenna as a function of notch angle indicates that at notch angle θ = 151°, maximum bandwidth up to 10.29% may be achieved. On further reducing notch angle θ, the bandwidth of antenna starts decreasing. The radiation efficiency is not a very sensitive function of notch angle.

In the next step, we considered same patch antenna designed on one side of Glass Epoxy FR-4 substrate with no metal coating on other substrate and put it at a distance 'h_a' away from another sheet of Glass Epoxy FR-4 substrate also having copper layer on side of substrate. In the geometry, inner opposite sides of the substrate do not have any copper layer. Two sheets are separated using spacers and the gap between two sheets is variable. It is realized that in the absence of air gap since thickness of substrate material is doubled, the frequency of antenna reduces significantly as shown in figure 4.

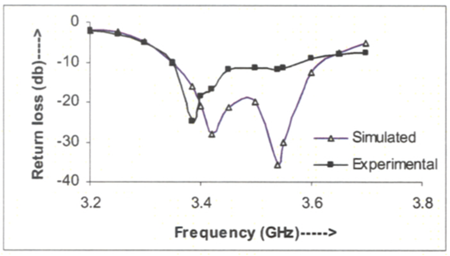

Figure 3: Variation of return loss with frequency of Square patch antenna having single dielectric layer

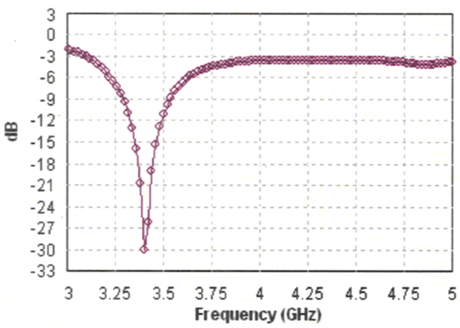

Figure -4: Variation of return loss with frequency in antenna with no air gap

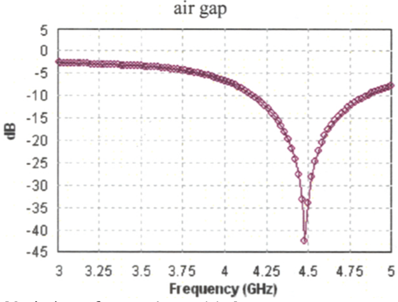

Figure 6: Variation of return loss with frequency in antenna having air gap h_a = 1.5mm

Now antenna is resonating at a single frequency. On applying air gap of 1.5mm, it is realized that resonance frequency of antenna again increases and the bandwidth of antenna now approached around 16% which was nearly 6.2% in the case when no air gap was applied. In the presence of air gap, effective permittivity of substrate is reduced considerably which is responsible in marked improvement in the resonance frequency and bandwidth of antenna geometry.

The radiation efficiency of a square patch antenna with a triangular notch reported in [1] is around 36%. On applying air gap in same geometry, radiation efficiency of antenna increase with increase in air gap and approaches to 49.28% for air gap h_a =1mm. There after radiation efficiency of antenna start decreasing. We observed that Efficiency is lowest for first type of antenna having with out air gap.

The directivity and gain of square patch antenna with a notch reported in [1] are quite low (6.4dBi and 2.5 dBi respectively). However is on applying another layer between the conducting patch and the ground plane, it improves marginally. On applying an air gap of thickness 1.5mm, the directivity and gain of antenna increases further high and approaches to 7.90 dBi and 4.33 dBi respectively. A comparison

III. DISCUSSIONAND CONCLUSIONS

The paper presents the radiation performance of a wide band microstrip antenna for the communication system. The simulation results of modified square patch antenna with and without air gap are presented systematically. This paper shows enhancement in bandwidth is from 36.037 % to 49.279% for modified square path antenna with a notch and air gap, which is much more in compared with the geometry without air gap .The gain is increased by the twice that is from 2.484dB to 4.3289dB whereas the efficiency is almost two times increased when compared. In the present analysis, glass epoxy FR4 substrate is applied which bears a high dielectric constant and loss factor. On application of low loss substrate much higher performance is expected.

IV. REFERENCES

[1] D. Bhardwaj, D. Bhatnagar and S. Sancheti, "Design of square patch antenna with a notch on FR4 substrate." *Proc. of Asia-Pacific Microwave Conference-2007, Bangkok, Thailand,* pp 2197 - 2200

[2]. K. F. Lee and J. *S.* Dahele, "Mode characteristics of annular-ring and circulardisc microstrip antenna with and without airgaps," in *IEEE Antenna Propagat.* SOC. *Int. Sum. Digest,* 1983, pp. 55-58.

Antenna Geometries	Air Gap (mm)	Resonance Frequency (GHz)	Radiation Efficiency (%)	Directivity (dbi)	Gain (dbi)	Band Width (%)
Square with Single notch single dielectric	With out Air gap	3.38 3.6	36.037 39.99	6.421 6.473	1.983 2.484	10.29
Square with Single notch double dielectric	$h_a = 0$	3.4	45.236	6.7854	3.3360	6.1697
Square with Single notch double dielectric	$h_a = 1$	4.26	49.279	7.72878	4.6509	12.849
Square with Single notch double dielectric	$h_a = 1.5$	4.48	43.889	7.9056	4.3289	15.30

Table-1: Comparative study parameters of different antenna with