ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 5, Issue 3, March 2016

Design and Development of Multiband Circular Microstrip Antenna with Resonating Slot in the Ground Plane

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***Abstract*-The paper proposes a frequency tuned circular microstrippatch antenna withdefective slots in the ground plane. The antenna without the ground defect resonates at 5.2 GHZ. Due to the presence of the defects introduced in the ground, the antenna resonates at three distinct frequency ranges of 3.5 Ghz which is in the WiMAX band, 4.74 Ghz which is used for defence and security, high data rate point-to-point and point-to-multipoint applications and 5.83 Ghz which is in the WLAN band.**

I. INTRODUCTION

Extensive research on microstrip antenna has yielded its substantial applications in wireless communication because of ease of fabrication, less weight, low price and excellent compatibility with planar and non-planar surfaces[1,2,3]. The increasing demand for portable systems leads to more compact antennas operating in low frequency[4,5]. The various miniaturizing techniques used are the use of high permittivity dielectric substrate, ground plane defect or a combination of these[6,7,8,9]. In this paper the ground surface is defected purposely for the microstrip antenna to work in lower frequency. Segmented angular defects are etched out on the ground plane as is evident from the diagram given. Initially the microstrip patch antenna without any ground defect is made to resonate at 5.2 GHz which is in the WLAN range. By etching out two DGS of identical shape the antenna is made to resonate at multiple frequencies of 3.5 GHz that is in the WiMAX range, 4.74 GHz which is used for defence and security, high data rate point-to-point and point-to-multipoint applications and 5.83 GHz which is in the WLAN band.

II. DESIGN PRINCIPLE

The design produced here indicates the dimensions of the microsrtip antenna proposed. The dielectric used is FR4_epoxy which is commercially available and has a dielectric constant 4.4 and loss tangent as 0.002. The electromagnetic (EM) software Zeland IE3D has been used to stimulate the antenna according to the proposition. At first the co-ordinate point on the circular patch is found out where the resonance occurs at 5.2 GHz for the given parameters. Then two holes etched out on the ground plane as per the figure are positioned such that the resulting microstrip patch antenna resonates considerably on three frequencies of 3.5 GHz, 4.74 GHz and 5.83 GHz simultaneously. Thus a microstrip patch antenna is proposed that can work in multiband. The frequency 3.5 GHz is the WiMAX (Worldwide Interoperability for Microwave Access) band. The frequency of 5.83 GHz is in the WLAN (Wireless Local Area Network) band and the frequency of 4.74 GHz is used for defence and security, high data rate point-to-point and point-to-multipoint applications.

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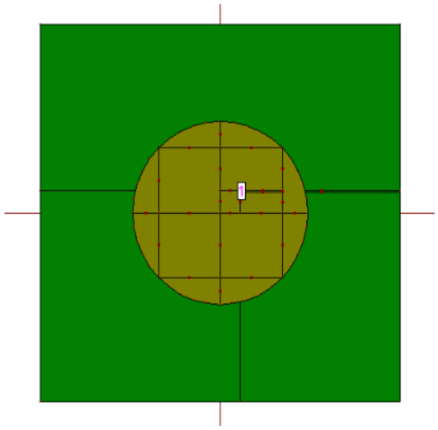

Figure 1: Basic Microstrip Antenna Resonating at 5.2 GHz

The length of the square ground taken is 32mm. The circular patch placed at the middle of the dielectric has a radius of 7.77 mm. The co-ordinate of the feed is found to be at (5.3, 0.78)

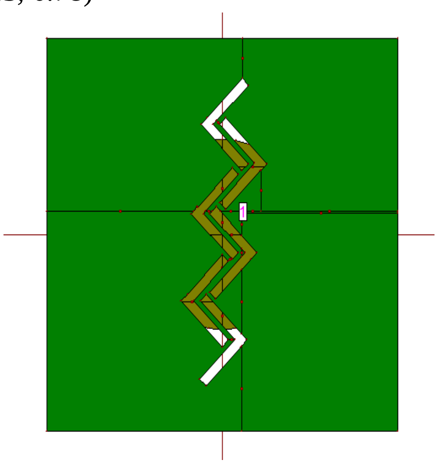

Figure 2: DGS etched out to resonate the antenna at 3.5 GHz

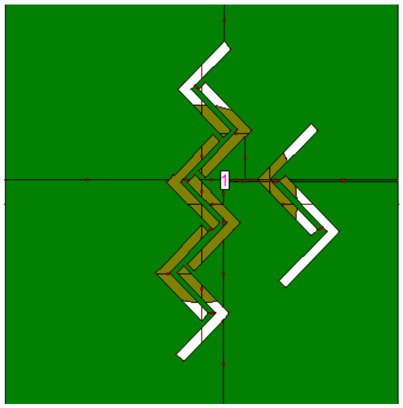

Figure 3: Two DGS etched out to resonate the antenna at 3 particular frequencies simultaneously

III. RESULTS

1) Return loss versus Frequency

Two separate graphs of return loss versus frequency of the circular microstrip antenna are drawn. One of the graphs is with defects while the other one is without defect in the ground plane. In absence of the defects the antenna s resonating at 5.2 GHz (i.e. WLAN band) is -26.54dB. The introduction of defect results in the microstrip patch antenna resonating at 3.5 GHz, 4.74 GHz and 5.83 GHz simultaneously as per the figure shown. The return loss for 3.5 GHz is -32.14 db, 4.74 GHz is -23.125 db and 5.83 GHz is -10.06 db.

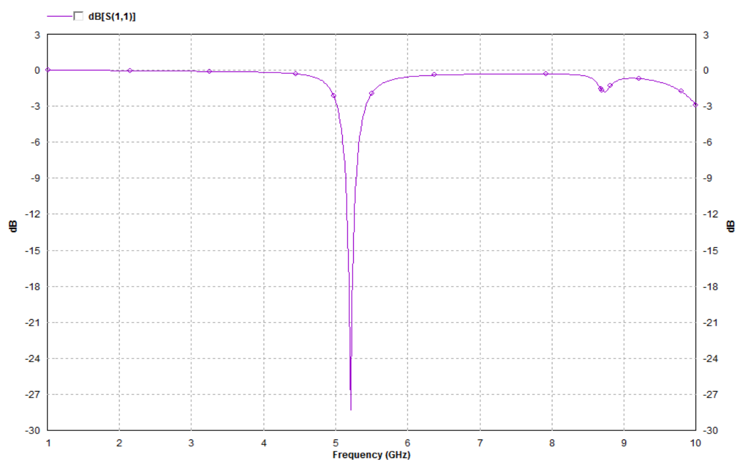

Figure 4: S11 versus frequency graph for the microstrip antenna resonant at 5.2 GHz

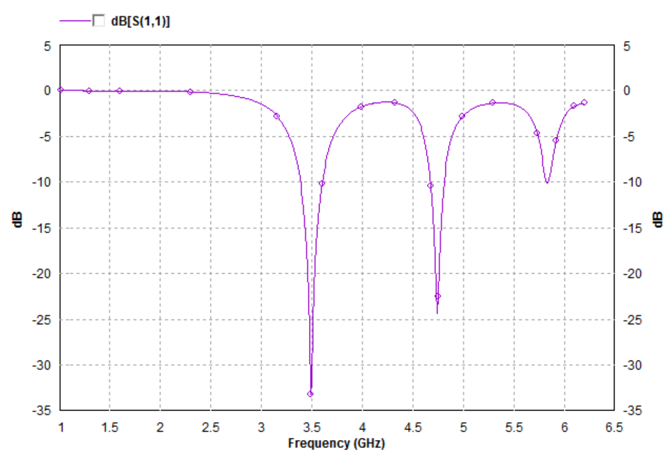

Figure 5: Antenna resonating at 3 frequencies after DGS is etched out

2) Impedance versus Frequency

The microstrip antenna's impedance must be approximately around 50 ohm for the antenna to be used for any practical purpose. The imaginary part of the impedance needs to be close to 0 ohm for the antenna to resonate. Here also two graphs are drawn one with the defects in the ground plane while the other without any defect.

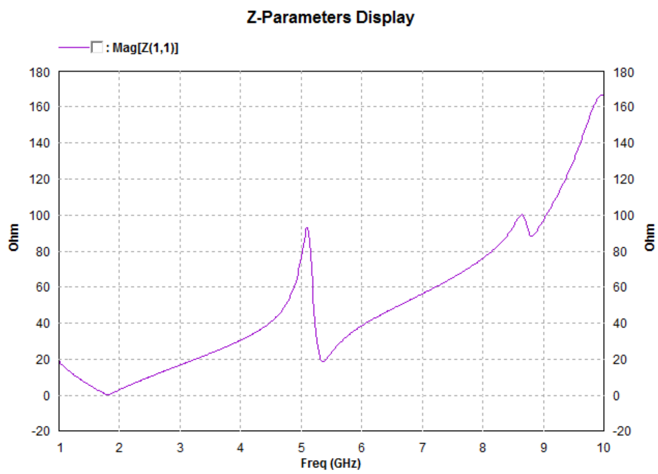

Figure 6: Z-parameter before DGS is etched out

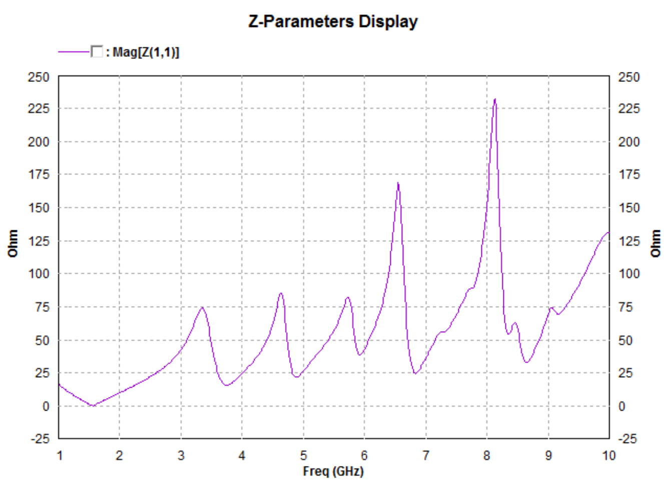

Figure 7: Z-Parameters after DGS is etched out

3) Radiation Pattern

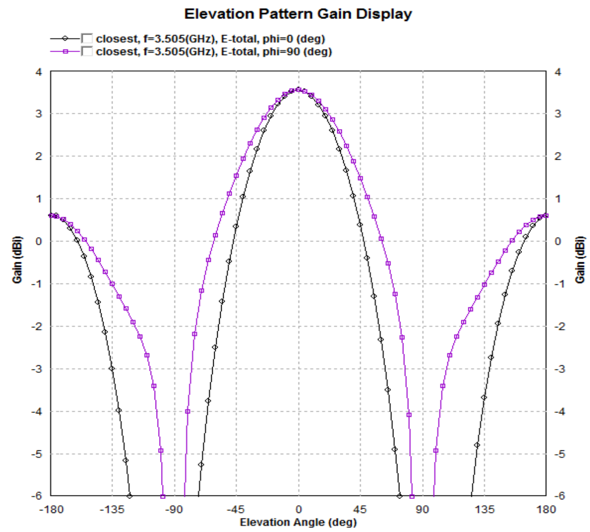

Figure 8: Gain at 3.5 Ghz

The direction of radiation of microstrip antenna is perpendicular to patch surface. For this reason the radiation patterns studied as for Φ=0 and Φ=90. As per the plots shown here it is evident that the microstrip patch antenna fulfils the conditions for effective radiation. The gain at 3.5 GHz, 4.74 GHz and 5.83 are -3.543 Dbi, 5.363 Dbi, and 0.1 Dbi respectively.

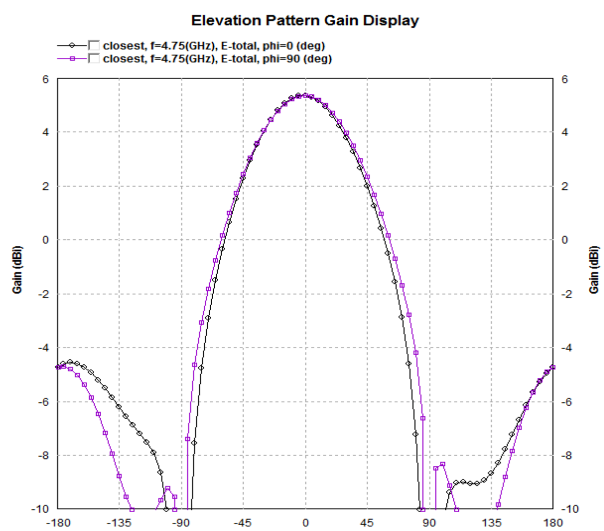

Figure 9: Gain at 4.74Ghz

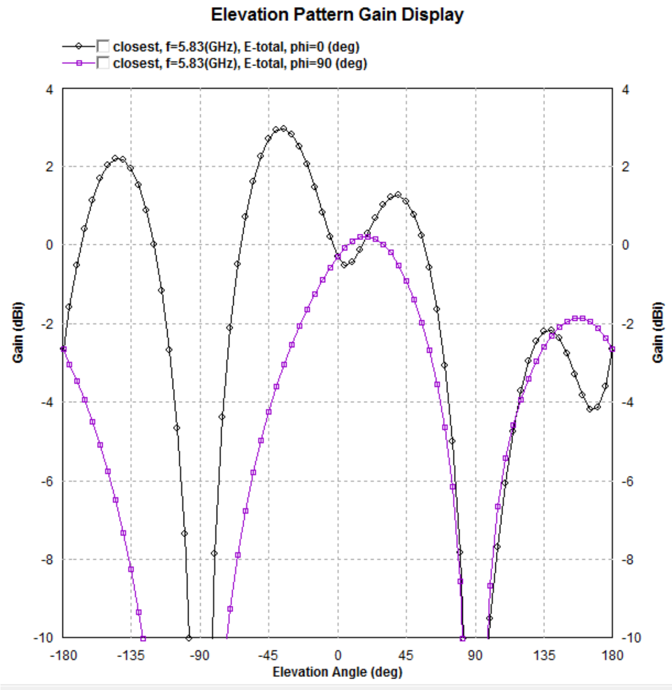

Figure 10: Gain at 5.83 Ghz

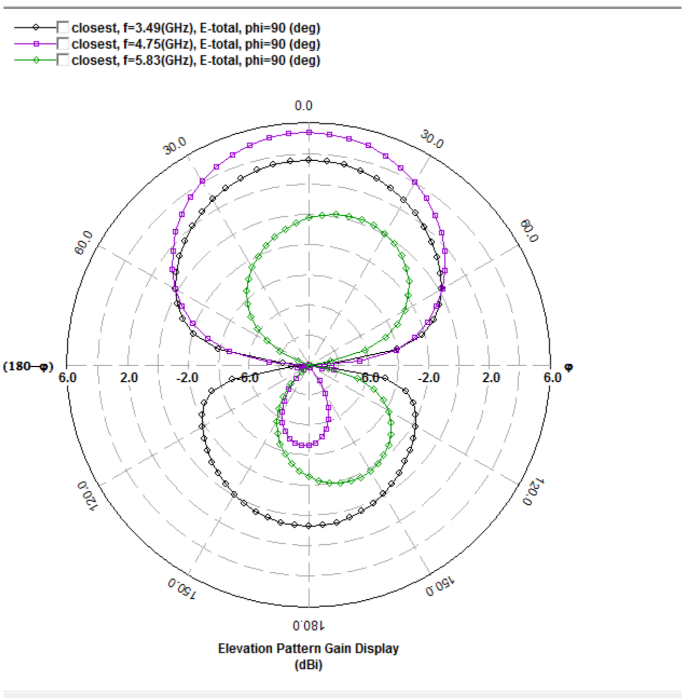

Figure 11: Gain Pattern in Polar Plot

IV. CALCULATIONS

The proposed frequency tuned microstrip antenna is found to resonate at f1 = 3.5GHz, f2 = 4.74GHz and f3 = 5.83GHz. To calculate the effective guided wavelengthλ_g, the effective dielectric constant, ε_{reff} can be given as[5],

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12.\frac{h}{W}\right]^{-0.5}$$

whereε_r= 4.4 , thickness of the dielectric h= 1.57mm and W= 2 X Radius of the patch (= 7.77mm). Thus,

$$\varepsilon_{reff} = \frac{4.4+1}{2} + \frac{4.4-1}{2}\left[1 + 12\,\frac{1.57}{2\ X\ 7.77}\right] = 3.843$$

Putting the values ε_{reff} can be calculated to be 3.843. From the relation between resonant frequency and guided wavelength ($\lambda_g = \frac{c}{f\sqrt{\varepsilon_{reff}}}$, where f is the resonant frequency,λ_g is the guided wavelengthand c is the speed of light in vacuum), the corresponding value of wavelength λ_g can be calculated as,

$$\lambda_{g1} = \frac{c}{f_1\sqrt{\varepsilon_{reff}}} = \frac{3\ X\ 10^{11}}{3.5\ X\ 10^9\ \sqrt{3.843}} = 43.72\ mm$$

$$\lambda_{g2} = \frac{c}{f_2\sqrt{\varepsilon_{reff}}} = \frac{3\ X\ 10^{11}}{4.74\ X\ 10^9\ \sqrt{3.843}} = 32.286\ mm$$

$$\lambda_{g3} = \frac{c}{f_3\sqrt{\varepsilon_{reff}}} = \frac{3\ X\ 10^{11}}{5.83\ X\ 10^9\ \sqrt{3.843}} = 26.25\ mm$$

The total lengths of the defective ground structure implemented in the microstrip antenna are measured to be 38.6622mm and 19.5167 mm respectively. It can be observed that the length of the DGS is inversely proportional to the frequency at which the microstrip antenna resonates in presence of the DGS. So the DGS of length 38.6622mm is responsible for the frequency f1 = 3.5GHz. Likewise the DGS of length 19.5167mm is responsible for the frequency f2 = 5.83GHz.From the calculated value of guided wavelengths it can be concluded that the corresponding guided wavelength λ_g is approximately 1.3 times the length of the specific defective ground structure. The values of λ_g are 43.72mm, 32.286mm and 26.25mm for the three frequencies 3.5Ghz, 4.74Ghz and 5.83Ghz respectively. The exact value of guided wavelength and the corresponding length of the defective ground structure are slightly altered due to the mutual coupling of the slots in the ground plane.

V. CONCLUSION

Segmented angular defectsetched out on the ground plane are integrated on the microstrip antenna which results in a size miniaturization of about 65.3%.

ACKNOWLEDGEMENT

The support of many of the faculty of Institute of Engineering and Management, Salt Lake is hereby acknowledged by the authors.

REFERENCE

[1] Srijita Chakraborty, Srikanta Pal, Mrinmoy Chakraborty,"High Performance DGS Based Compact Microstrip Patch Antenna",Proceedings of 1st International Science & Technology Congress 2014,ISBN: 9789351072485, Elsevier Publications 2014,Page-404-409

[2] Gurbazsingh, Jaswinder Kaur," Design a multiband Rectangular ring antenna using DGS for WLAN, WiMAX Applications", International Journal of Advanced Research in Computer and Communication Engineering Vol. 3, Issue 6,June 2014

[3] Bhanwar Singh Jadon, Rahul Vijay, Mukesh Nagar," Compact Octagonal Multiband Slotted Patch Antenna with Defective Ground Structure", Page(s):167-171, PISER14,Vol.02, Issue:04/06, July-August 2014

[4] Mrinmoy Chakraborty, BiswarupRana, P.P. Sarkar, AchintyaDas,"Design and Analysis of a Compact Rectangular Microstrip Antenna with slots using Defective Ground Structure", Elsevier Science Direct Procedia Technology 4 (2012) 411 – 416

[5] Mrinmoy Chakraborty, BiswarupRana, P. P. Sarkar &Achintya Das," Size Reduction of a Rectangular Microstrip Patch Antenna with Slots and Defected Ground Structure", International Journal of Electronics Engineering, 4 (1), 2012, pp. 61– 64

[6] Srijita Chakraborty, Sayan K. Moitra, SohamTewary, ArchanaKumari and MrinmoyChakraborty"Design and Analysis of Dual Band, DGS Integrated Compact Microstrip Antenna" Advances in Optical Science and Engineering Proceedings of the First International Conference IEM OPTRONIX 2014

[7] Srijita Chakraborty, Uddipto Chakraborty, Shayak Bhattacharyya, SohonSengupta , Malay Gangopadhyaya ,MrinmoyChakraborty"Design and Analysis of Frequency Tuned Application Specific Microstrip Antenna with Angular DGS for Wireless Communication" IEEE IEMCON 2015

[8] Rama SanjeevaReddy.B,Vakula. D "Bandwidth Enhancement of Circular Shaped Patch Antenna using H shaped Defected Ground Structurefor WiMAX/WLAN Applications" The 8th Annual International Conference ATMS -2015, Bangalore

[9] Preet Kaur, S. K. Aggarwal, Asok De "Reconfigurable Inverted Circular Patch Antenna for Wireless Applications"International Journal of Advanced Science and TechnologyVol.70 (2014)

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