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Low Profile Circular Ring Antenna with DGS

Pramod Kumar[1], Dr. D.K. Srivastava[2]

[1]PhD Scholar, Department of ECE., Mewar University, Chittorgarh (Rajasthan), India

[2]Professor, Department of ECE., Bundelkhand Institute of Engineering and Technology, Jhansi (UP), India

Abstract- In this research investigation, the compact circular ring triangular hybrid structure wideband microstrip patch antenna has been proposed. The proposed antenna provides the broadband frequency response from the lower cut off frequency f_{low}=2.966GHz, 6.818GHz to higher cut of frequency f_{high} =6.818GHz, 7.97GHz. The impedance bandwidth of 1.326GHz, 1.152GHz and the fractional bandwidth of $\mathbf{36.539\%, 15.580\%}$ have been achieved for $|S_{11}|$ < -10dB. Wide band characteristics has been achieved by designing a circular ring with proper impedance matching between radiating patch element and partial ground element. Good Omni-directional radiation pattern, low VSWR and wide band have been achieved.

Keywords – planar, microstrip, patch, circular, return loss, gain.

I. INTRODUCTION

Antennas with cheap cost, excellent performance, compact size, wideband, and low profile frequently fulfill the severe criteria of current wireless communication systems [1-3]. Modern communication necessitates the availability of efficient, small, and portable devices capable of high data speeds and minimal signal power [4-5]. Microstrip patch antennas often have a limited bandwidth, a single operational frequency, a bigger size, poor gain, and polarization issues. Stacking, alternative feeding approaches, Frequency Selective Surfaces, Electromagnetic Band Gap, Photonic Band Gap, Metamaterial, and other ways for improving the characteristics of traditional microstrip antennas have all been documented. Because of its easy structural design, the microwave component with Defected Ground Structure has acquired favor among all the ways documented for boosting the parameters [6-8]. Defected Ground Structure refers to etched slots or faults on the ground plane of microstrip circuits. DGS can refer to a single or numerous flaws on the ground plane. DGS was first documented for filters below the microstrip line. To achieve band-stop characteristics and decrease higher mode harmonics and mutual coupling, DGS was utilized beneath the microstrip line [9-10]. Following its successful deployment in the field of filters, DGS is currently in high demand for a wide range of applications. DGS has been utilized in the field of microstrip antennas to improve the radiation properties of the microstrip antenna by increasing the bandwidth and gain of the microstrip antenna and suppressing higher mode harmonics, mutual coupling between neighboring elements, and cross-polarization [11-13]. The use of DGS in microwave technology is growing by the day.

In this research investigation, compact circular ring triangular hybrid structure wideband microstrip patch antenna proposed and fabricated. Micro-strip feed antenna consists circular ring triangular strucure radiating patch element and partial ractangular ground plane has been presented for wideband Applications (3.0129 to 7.97 GHz). The proposed compact antenna occupies a physical size of 26x26x1.6 mm^3. The designed antenna has been fabricated on FR-4 substrate ($tan\,(\delta) = .02,\ \varepsilon_r = 4.3$) whereas width of 1.6 mm and so low manufacturing cost. The performance of proposed antenna have been investigated using Computer Simulation Technology simulator (CST-Studio). The proposed antenna is suitable for integrated within wireless portable devices for wideband applications.

II. ANTENNA GEOMETRY AND DESIGN

Figure 1 shows the geometry of a circular ring microstrip patch antenna. This suggested antenna is placed on the X–Y axis. A Circular-ring radiating patch element, a 50 ohm microstrip feed line, with partial ground plane make up the suggested arrangement. The structure's l length and w width have been designated as the Circular-ring patch's specifications. This radiating patch is intended for applications that require a wideband range of resonance frequencies. The width of the feed (W_f) and length of the feed (L_f) are the parameters of the microstrip feed line (L_f). The bottom of the radiating element is where the microstrip feed line is terminated. The radiating patch is etched on the top edge of the ground element, where the microstrip feed line and radiating patch are inserted. This junction is extremely important in order to have better impedance matching. The proposed antenna has been made on a FR-4 substrate with a dielectric constant of 4.4, a tangent loss of 0.02, and a thickness of 1.6mm. The antenna's total dimensions are 26x26 mm^2. The rectangular wave guide feed approach has been used to excite the proposed antenna. The copper annealed conductor's thickness (top and bottom layers) is measured (0.035 mm). Parametric analysis has been done to optimise the size of all the components in order to achieve the superwide band impedance bandwidth. Table 1 shows the detailed antenna dimension of the optimized design.

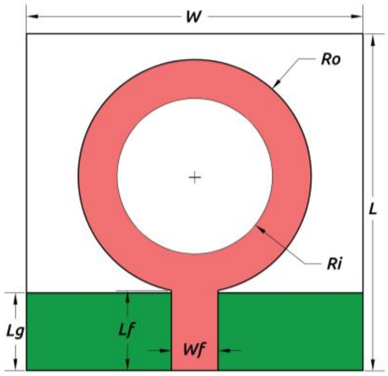

Figure 1. Two-dimensional geometry of a Circular-ring triangular-shaped hybrid structure planar antenna.

Table 1. Detailed dimensions of presented antenna

Dimension	Value(mm)	Dimension	Value(mm)
W	26	L	26
W_f	3.6	L_f	6.18
R_o	9	R_i	5
L_g	6	h	1.6

III. RESULTS AND DISCUSSION

In this section the overall antenna performance parameters have been analyzed through the simulation. The return loss curve shows in Figure 2 that a wideband impedance bandwidth has been achieved.

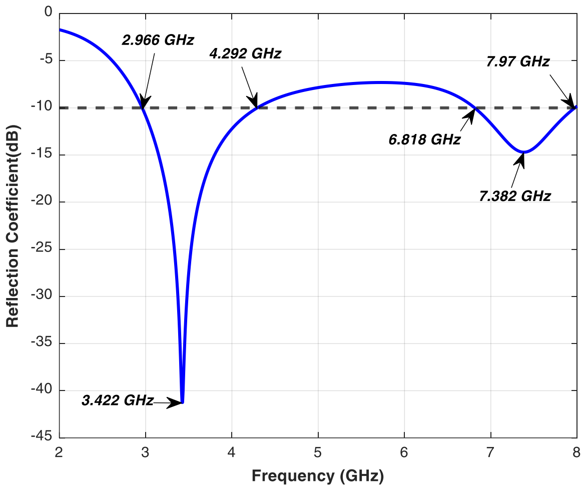

Figure 2 Reflection Coefficient characteristics (S_{11}) of optimized proposed antenna

The lower cut off frequency f_{low} is 2.966GHz, 6.818GHz and a higher cut of frequency f_{high} is 4.292GHz, 7.970 GHz whereas the fractional bandwidth of 36.539%, 15.580% impedance bandwidth of 1.326GHz, 1.152 GHz has been achieved for band 1 and band 2 respectively. The simulated return loss characteristics has been displayed in Figure 2.

3.1 Fractional Bandwidth (dB)

The fractional bandwidth of 36.539% and 15.580% of proposed antenna has been mathematically calculated from given below through equation1. Table 2 shows the frequency response of planner antenna.

$$\text{Antenna FBW} = 2 \times \left(\frac{f_H - F_L}{f_H + F_L}\right) \% \qquad (1)$$

Table 2. Frequency response of planner antenna.

Frequency (GHz)	Reflection Coefficient (dB)
f_{low}= 2.966, 6.818	-10
f_{r1} =3.422	-41.25
f_{r2} = 7.382	-14.7
f_{high} = 4.292, 7.97	-10

3.2 Three-Dimensional Radiation Pattern

Three-dimensional radiation patterns view at the frequencies of 3.422 and 7.382GHz have been represented in Figure 3. 3D views have been simulated through the CST simulator. It has been analyzed that the radiation patterns are bidirectional in E-field and H-Field at 3 GHz and 7 GHz.

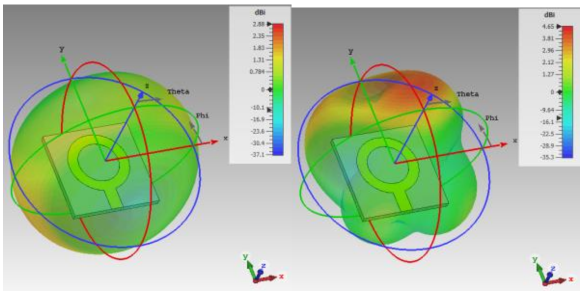

Figure 3. 3D Radiation Field at 3.422 and 7.382GHz

The Voltage standing Wave Ratio (VSWR) curve has been shown in Figure 4. It has been observed that the value of VSWR is below 2 throughout from 2.9 GHz and goes to 4.3GHz. The gain and directivity of proposed antenna have been shown in Figure 5. The highest gain of 3.847dBi at 6.49GHz and maximum directivity of 4.8dBi at 7GHz have been noticed.

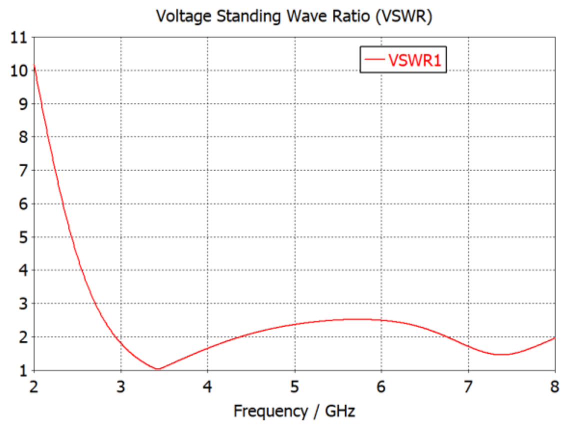

Figure 4. VSWR of proposed antenna

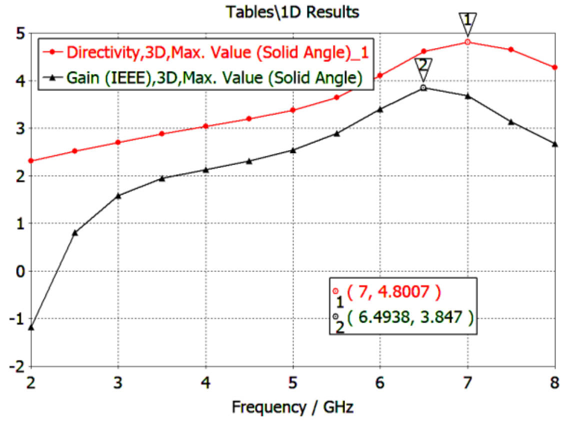

Figure 5. Gain and Directivity of Planer Antenna

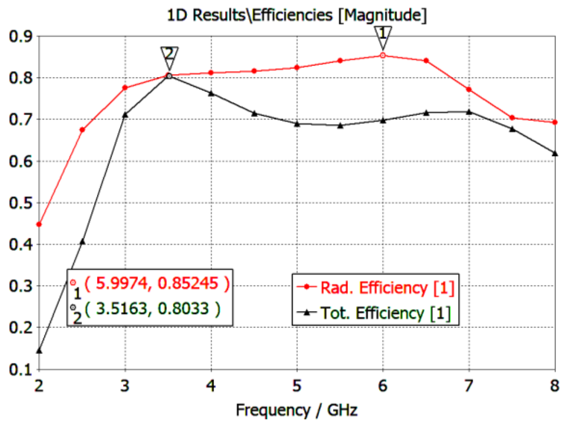

Figure 6. Efficiency of Antenna

Figure 6 shows the radiation and total efficiencies of the presented circle triangle antenna. The maximum radiation efficiency is 85.2% at 6GHz and total efficiency is 80.33% at 3.51GHz.

IV. CONCLUSION

The prototype of wideband compact circular ring antenna has been designed, analyzed and achieved the fractional bandwidth of 36.54% and 15.58% for $|S_{11}|$ < -10dB over the frequency band from 2.96GHz to 4.29GHz and 6.818GHz to 7.97GHz. The highest gain of 3.847dBi at 6.49GHz and -41dB maximum return loss at 3.422GHz have been achieved. The simulated results of proposed antenna make this antenna better candidate for WiMAX applications. In the future work the proposed antenna may get modified for further improvement in terms of compact in structure and also may work for the better gain of the microstrip antenna.

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AUTHOR’S PROFILE

Pramod Kumar had completed B.Tech in year 2006 from Barkullah University, Bhopal, India in Electronics and Communication. He had completed M.Tech in year 2011 from RKDF Institute of Science and Technology, Bhopal in Digital Communication. He is currently perusing Ph. D. from Mewar University, Rajasthan, India. He is an expert in antenna designing, fabrication, CST simulation software. He is currently working on bandwidth enhancement of Microstrip Antenna using hybrid structure.

Dr. D. K. Srivastava is Professor of Electronics and Communication Engineering in Bundelkhand Institute of Engineering and Technology (BIET), Jhansi. He has more than 15 years of experience in teaching, research and administrative work. He accomplished his Ph. D. in Electronics Engineering in 2010, earlier, he obtained M. Tech in Electronics Engineering in 1999 and B. Tech in Electronics Engineering in 1994. Dr. Srivastava has published more than 120 International/ National research papers and Supervised Ph. D. & M. Tech, thesis. He is reviewer in ‘Progress in Electromagnetic Research’ (PIER). He has long standing academic interests in microstrip antenna, digital electronics and optical communication. He had delivered many lectures/ keynote address and chaired various technical sessions during nation and international conferences and training programme.