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Design and Simulation of Spoon Shaped Antenna using DGS

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***Abstract:** A planer spoon shaped antenna with defected ground structure (DGS) is designed and fabricated for wireless application. The proposed antenna design exhibits 1.6GHz bandwidth, 2.20dBi Avg. Gain and maximum return loss of -24.5dB, which offers better results in wideband application. The Proposed antenna structure is simulated by software CST MWS (CST Microwave Studio) version 2018 and later comparison results are also presented*

***Keywords**: DGS, Bandwidth, Return loss, Avg. Gain, CST MWS.*

I. INTRODUCTION

Microstrip antenna has fascinated lots of researchers in recent years. With the sudden boom in the field of wireless communication it draws the attraction in microstrip antenna. Several microstrip antenna designs with single feed wideband antenna have been proposed lately. Over the years many types of microstrip patch antennas were designed to reduce the requirement of number of antennas. Because of its low weight, low price and low maintenance, microstrip antennas have been always in demand [1, 2, 3]. There are various usage and advantages of using DGS, cross polarization and mutual coupling reduction etc. are few of them [4]. Capacitance and inductance are key parameters when it comes to characteristics of DGS, size of the defect and area is a significant reason which decides the value of such parameters [5].

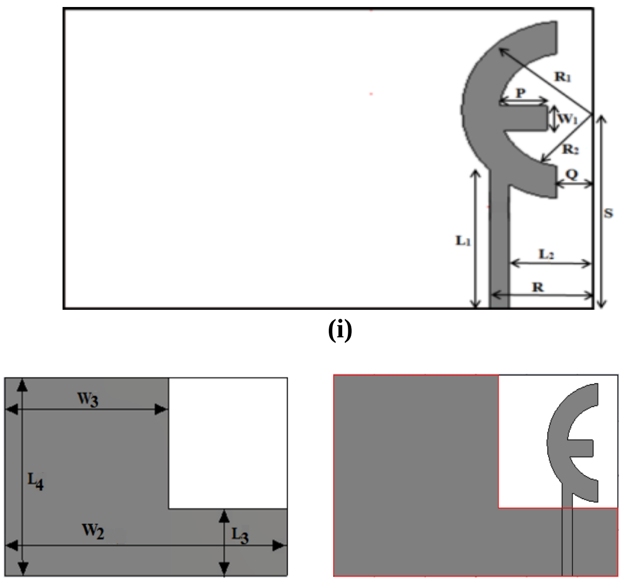
In [2] the multiband monopole antenna with DGS (conventional) has been proposed which exhibits bandwidth and Avg. Gain around 1.4 GHz and 1.75dBi respectively. Since in the wireless communication application, more bandwidth and gain are in demand. The proposed spoon shaped antenna offers the bandwidth of 1.6 GHz and Avg. Gain of 2.20dBi respectively. Both of the performance parameters of proposed design are better as compare to the conventional one. For achieving the better performance, the conventional design is modified by introducing the small strip of size 5×3 mm at the center of the spoon.

The wide bandwidth and small size are quality parameters which were emphasized in this particular paper. Proposed DGS structure not only improved the key parameters of the antenna but reduced the size as well. This proposed antenna was specially designed for wireless application where wideband is the main requirement. DGS was implemented to improve the characteristics of antenna. DGS plays a important role in the improvement of the antenna results, before applying DGS antenna was operating with ≥ 10dB return loss with negligible bandwidth [6, 7]. After introducing DGS on the ground surface of the antenna, it starts radiating at 2.7GHz with 1.6GHz bandwidth. By varying the size of the DGS it was found that parameters of antenna is changing at very fast rate, a maximum return loss of -40dB was also achieved by changing the size of the DGS.

II. ANTENNA DESIGN

Fig.1 represents the geometry of proposed antenna, where the front, back and transparent views are shown by Fig. 1(i), Fig. 1(ii), Fig. 1(iii), respectively. The software CST MWS (CST Microwave Studio) version 2018 is used for the design of proposed antenna and its simulation. With the aim of higher bandwidth and gain the conventional design [2] is altered by proposing a small strip at the center of spoon.

The proposed microstrip antenna design encompasses the spoon shaped patch on the front and DGS at the back of printed circuit board (PCB). The design parameters of the patch and DGS are depicted in Fig. 1.The dimensions of all these parameters are in millimeter (mm). For designing the values of these parameters are considered as; $R_1 = 11$, $R_2 = 7$, $W_1 = 3$, $W_2 = 56$, $W_3 = 32.5$, $L_1 = 17.5$, $L_2 = 9$, $L_3 = 12.5$, $L_4 = 37$, $P = 5$, $Q = 4$, $R = 11$, and $S = 24.5$.



(ii) (iii)

Fig. 1 Geometry of the proposed antenna (i) Front, (ii) Back, (iii) Transparent view

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Radiation of the antenna mainly depends on the substrate (FR4) and its key parameters (ε, σ, μ).The thickness of substrate is 1.6 mm. Bandwidth is directly related to thickness of the substrate and inverse relation with permittivity of the substrate [8, 9]. In this research work, the substrate used has the dielectric constant (ε_r) is 4.3. FR4 (Lossy) substrate has been used for designing the antenna with parameters as mentioned above. In Fig. 2 represents the simulated results of the proposed antenna. In Fig. 2(i) three different cases of S-parameter are analyzed for different value of R_1 (mainly R_1 = 11, 12 & 13). In Fig. 2 (ii) the effect of variation of R_2 (mainly R_2 = 6, 7 & 8) on S-parameter is considered. In Fig. 2 (iii) depicts the effect of variation in ground plane on S-parameter. While in Fig. 2(iv) depicts the finalized S11 of proposed antenna. By Fig. 2, it can be clearly seen that the maximum reflection coefficient (S11) -40dB, maximum bandwidth 1.8GHz and average realized Avg. Gain of 2.20 dBi can be achieved.

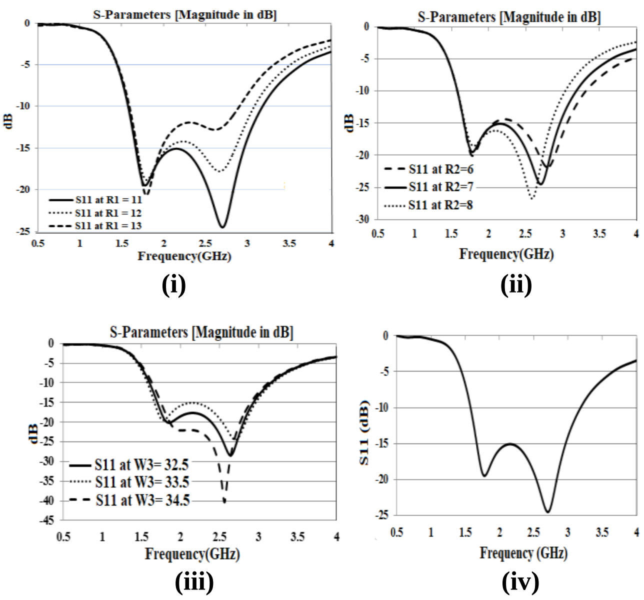


Fig. 2: Reflection coefficient (S11) of the proposed antenna (i) by varying R_1 (ii) by varying R_2, (iii) by varying DGS (W_3=32.5, 33.5 and 34.5mm) (iv) Finalized reflection coefficient (S11) of proposed antenna

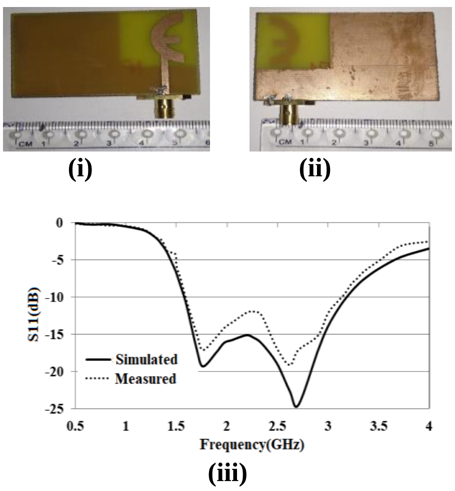
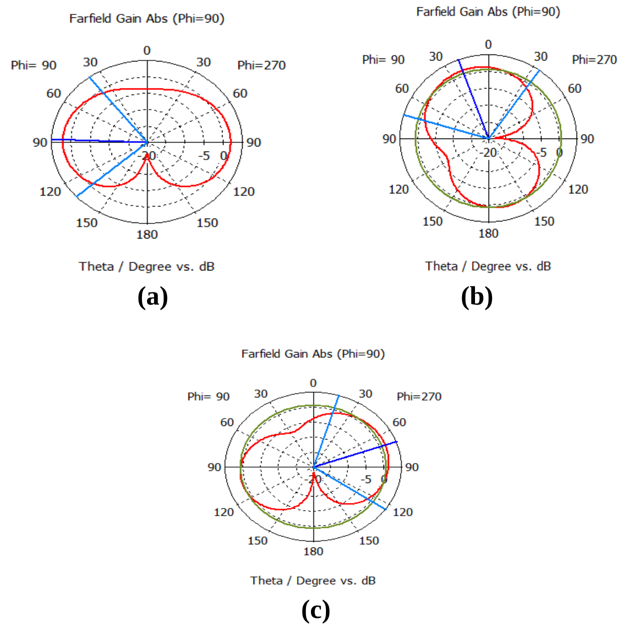
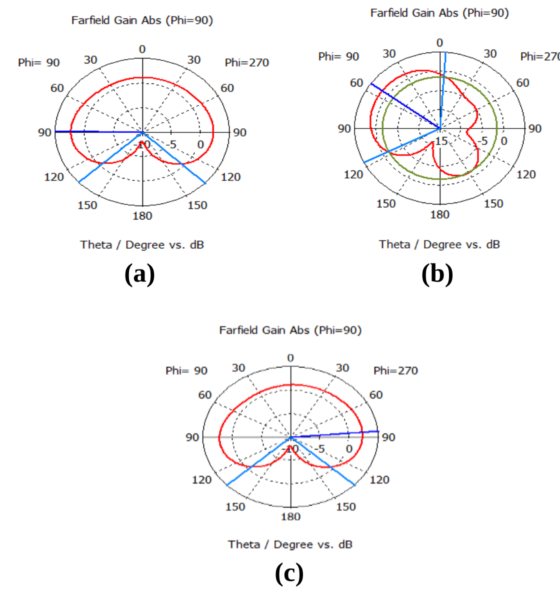


Fig. 3: Fabricated antenna and its result (i) Front view (ii) Back view (iii) Simulated and measured reflection coefficient (S11)



(i) 1.8 GHz



(ii) 2.8 GHz

Fig. 4: Simulated radiation patterns of the proposed antenna: (a) X-Y plane; (b) Y-Z plane; (c) X-Z plane at frequencies (i) 1.8,(ii)2.8GHz.

Fig.3 (i) & (ii) depicts the photograph of fabricated front and back view of proposed antenna while Fig. 3(iii) depicts the simulated and measured S11 of proposed antenna. Fig.4 (i) & (ii) depicts the radiation pattern of proposed antenna operating at frequencies 1.8 and 2.8 GHz respectively. The gain at different frequencies is shown below in Fig. 5. It exhibits the range of gain values from 1.65dBi at 1.5GHz to 2.63dBi at 3.3GHz. Maximum value of Gain is around 2.45dBi at frequency 2.6 GHz

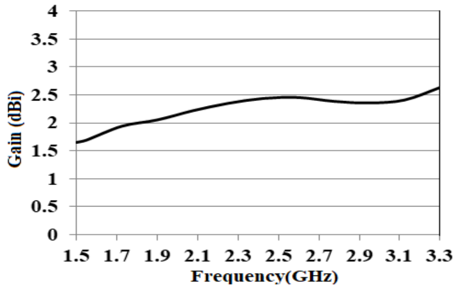


Fig.5: Gains of the proposed antenna

III. RESULTS AND DISCUSSIONS

The simulated and measured S-parameter of proposed antenna design are shown in Fig.4 (iii). By which it can be clearly observed that S_{11}< -10dB at two resonant frequencies 1.57 GHz to 3.18 GHz. The proposed design offers the impedance bandwidth of nearly 67.78% with central frequency at 2.375 GHz. It also exhibits a range of gain value approximately from 1.966 dB to 2.246 dB.

The Comparison between the proposed design and design given by [2] is shown in Table 1. It perceived that S-parameter, gain and bandwidth of proposed design have refined as compare to the conventional design and it offers large operating range of frequencies over which the antenna works. The value of Bandwidth, Avg. Gain and S-parameter of the proposed design are 1.6 GHz, 2.20 dBi and -24.5 dB, respectively.

Table 1: Comparison between proposed design with [2]

Performance Parameter	This Work	[2]
Bandwidth	1.6 GHz	1.4 GHz
Avg. Gain	2.20 dBi	1.75 dBi

IV. CONCLUSION

The proposed antenna design is a low cost and highly effective antenna design for wideband application which offers the efficiency of 93% and bandwidth of 1.6GHz. By varying the size of the DGS significant results could be achieved. This spoon shaped antenna is useful not only for wideband radiation but this antenna is efficient as well. This proposed antenna could be used in L and as well as S band applications as it has a wide bandwidth. Significant results could be achieved as it can be seen from the comparative results, indicates that the slight variation in the size and shape of the proposed antenna makes the commendable change in the results.

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