Available online at www.ispacs.com/acte
Advanced Computational Techniques in Electromagnetics
Volume 2012, Year 2012, Article ID acte-00107, 5 Pages
doi: 10.5899/2012/acte-00107
Research Article

Compact Wideband Circular Ring Defected Ground Antenna

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ABSTRACT

A novel compact design of a wideband defected ground circular ring antenna is presented in this communication. The return loss and input impedance are measured experimentally and compared with the simulated results. Parameters like impedance bandwidth, VSWR, and antenna gain are calculated and discussed. It is observed that the designed antenna provides a wide band in frequency range of 8 – 12 GHz with an impedance bandwidth of 20.2%. The antenna gain for the design is 6.8 dBi with reduced side lobe level to −18.9 dB.

Keywords: Wideband; Defected ground; Microstrip antenna.

1. Introduction

In recent years, there have been several new concepts applied to distributed microwave circuits. Microstrip patch antennas are very useful in microwave and radio frequency designs because of their advantages such as light weight, low cost, and simplicity in design. Antennas are important contributors for the overall radar cross-section. Efforts have been devoted to minimize the size of microstrip antenna, with a lot of methods proposed recently, such as cutting slots on the patch, using stacked patch, adopting the substrate with high permittivity, and etc. Moreover, some structures are engraved in the patch or ground plane to miniaturize the size of antenna [1]. The rapid advancement in wireless communication has attracted the interests in microstrip antennas. Nowadays, defected ground microstrip patch antennas have been rapidly developed for multiband and broad band in wideband communication systems. The use of microstrip defected ground geometry antennas in electromagnetic radiations has been a recent topic of interest in the world [2–4]. A defected ground antenna can be designed to receive and transmit over a wide range of frequencies. In this defected ground structure (DGS) technique, the ground plane metal of a microstrip (or strip-line, or coplanar waveguide) circuit is intentionally modified to enhance performance. An intentional defect is introduced in the ground material of the microstrip antenna give rise to DGS and is a convenient way to realize the band rejection characteristics from the resonant properties. This technique has been widely used in the development of miniaturized antennas. In [5], the compact, broadband microstrip antenna with defective ground plane has been realized; the impedance bandwidth of the proposed antenna could reach about 4.3 times that of the conventional microstrip antenna. Several slots are embedded in the ground of the microstrip antenna so that the size is reduced, and the impedance band and gain are enhanced [6–8].

In the present communication, a compact circular ring microstrip antenna with DGS is proposed. The proposed antenna design is analyzed by simulation software CST Studio Suit and the experimental verification is also carried out using Vector Network Analyzer.

2. Theory

DGSs have been developed to improve characteristics of many microwave devices. Because of their properties, these DGSs have found many applications in microwave circuits such as filters, power amplifiers, dividers, microwave oscillators, and harmonic control in microstrip antennas. When DGSs are used in the design of antennas, cross shape may be required for good radiation patterns or polarizations.

In the present structure, the ground plane is partially removed in such a way that the two parts of the ground plane are not physically connected. Both the cases, antenna structure without defected ground plane and antenna structure with defected ground plane are presented.

The properties such as return loss and input impedance are simulated and experimentally measured. The impedance band-

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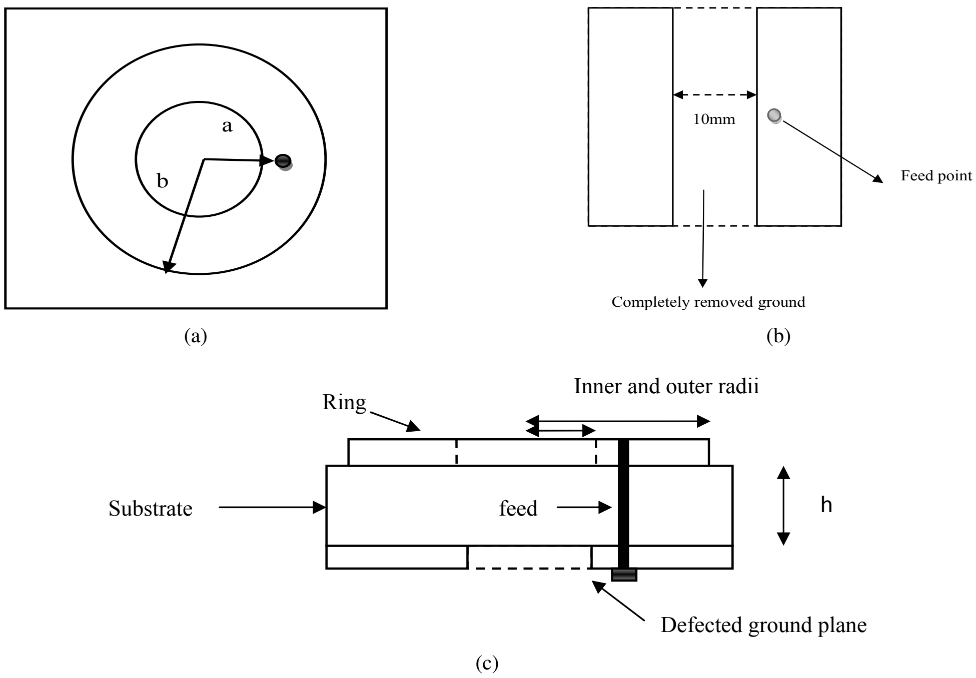
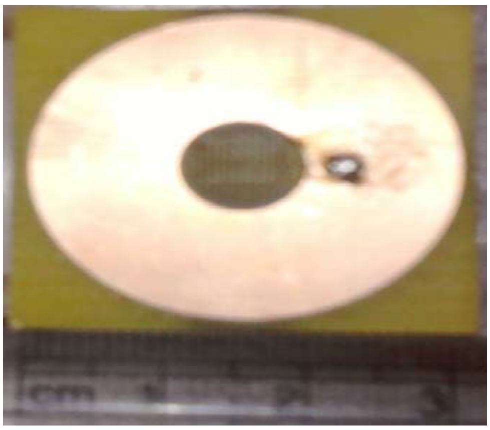
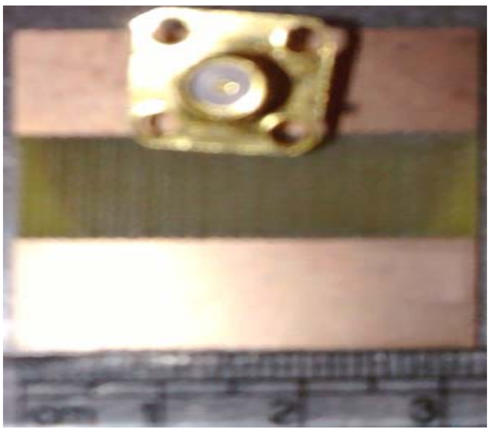


Figure 1: Geometry of defected ground circular ring microstrip antenna design; (a) top view, (b) bottom view, (c) side view.



(a)



(b)

Figure 2: Design of defected ground circular ring microstrip antenna; (a) top view, (b) bottom view.

width and voltage standing wave ratio (VSWR) are thus calculated. Radiation characteristics such as antenna gain, side lobe level, and back radiation are thereof discussed. A significant comparison of both the antenna structures is shown. The diagram of the proposed antenna is given in Fig. 1.

3. Antenna design

The geometry consists of a circular ring microstrip antenna with a defected ground. The circular ring antenna with DGS is designed on a commercially available glass epoxy substrate of dielectric constant 4.1 and height 1.59 mm. A circular ring of outer radius 15 mm and inner radius 5 mm is printed over the substrate material. A metal strip of 34 mm×10 mm is completely removed from the ground plane of 34 mm×34 mm just below the circular ring symmetrically and the ground plane lies at the two extreme ends only. The antenna is fed by a coaxial probe at 7 mm from the centre of the ring.

The geometry for the circular ring microstrip patch without defected ground is same as for defected ground antenna except for the ground plane. The ground plane here covers whole of the substrate. Parameters like return loss, input impedance, bandwidth, gain, radiation patterns, and VSWR are studied for the proposed geometry by using commercially available CST Studio Suit simulation software. For the experimental verification of the simulated results, the prototype of the proposed antenna has been manufactured and tested on R & S ZVL Vector network analyzer.

Figures 1(a) and 1(b) show the top and bottom views of the antenna with the defect under study, respectively. The antenna design is also shown in Fig. 2.

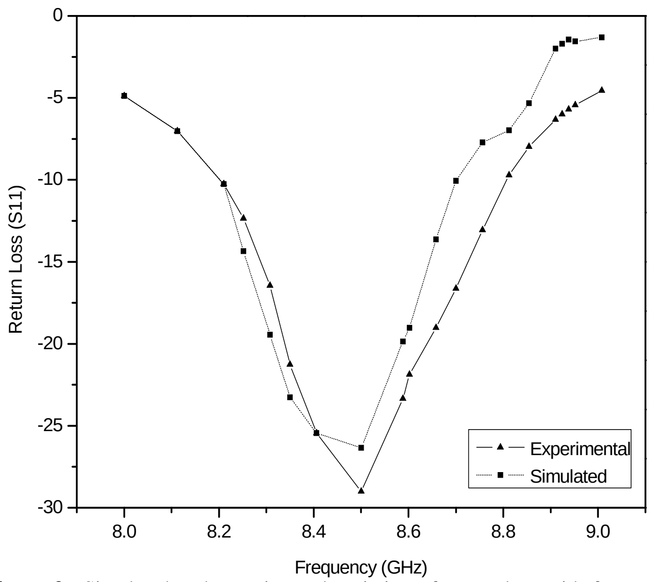


Figure 3: Simulated and experimental variation of return loss with frequency (without defect).

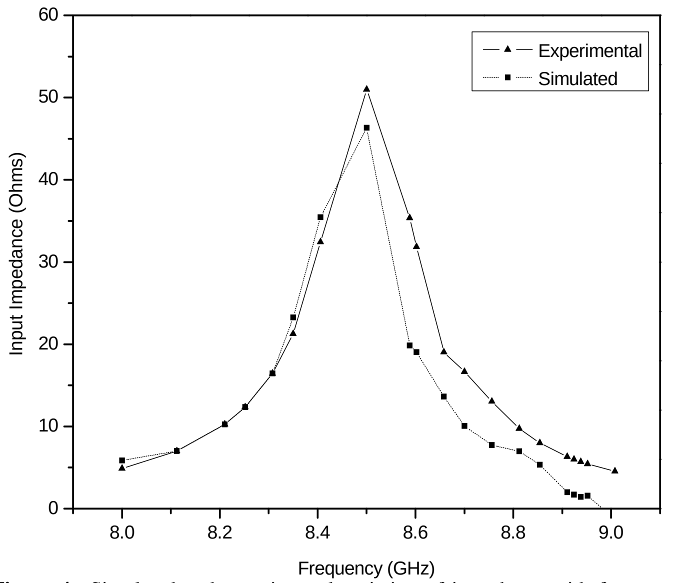


Figure 4: Simulated and experimental variation of impedance with frequency (without defect).

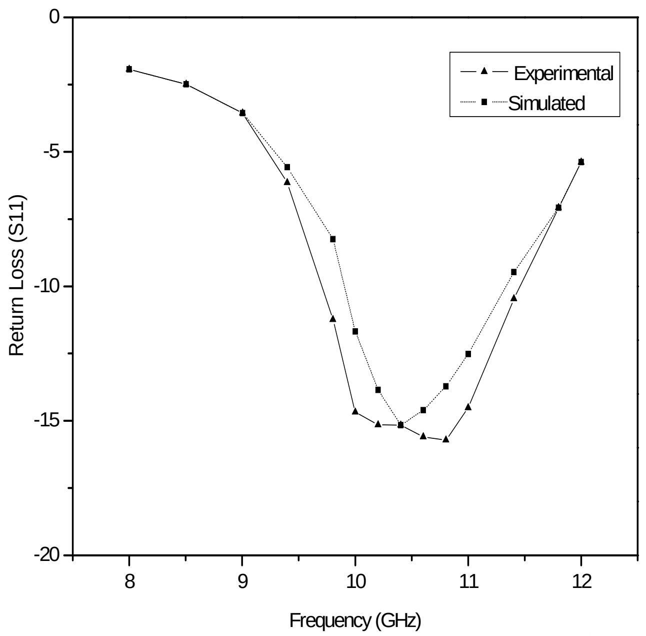


Figure 5: Simulated and experimental variation of return loss with frequency (with defect).

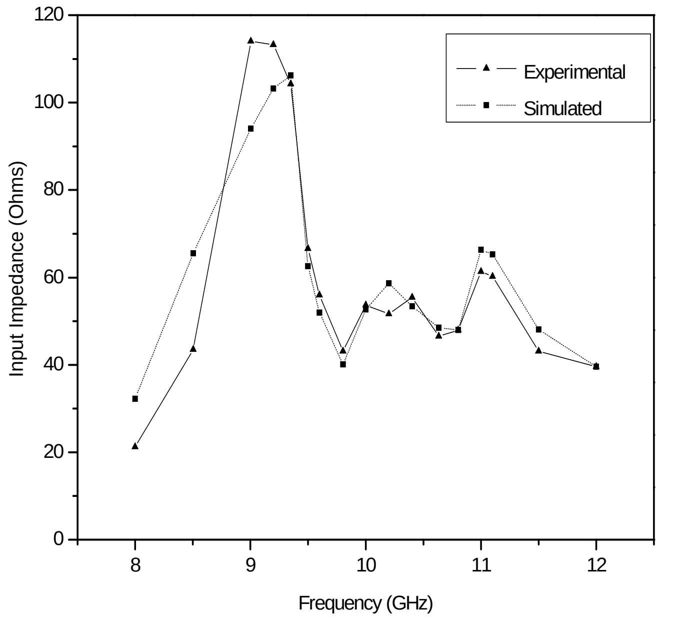


Figure 6: Simulated and experimental variation of impedance with frequency (with defect).

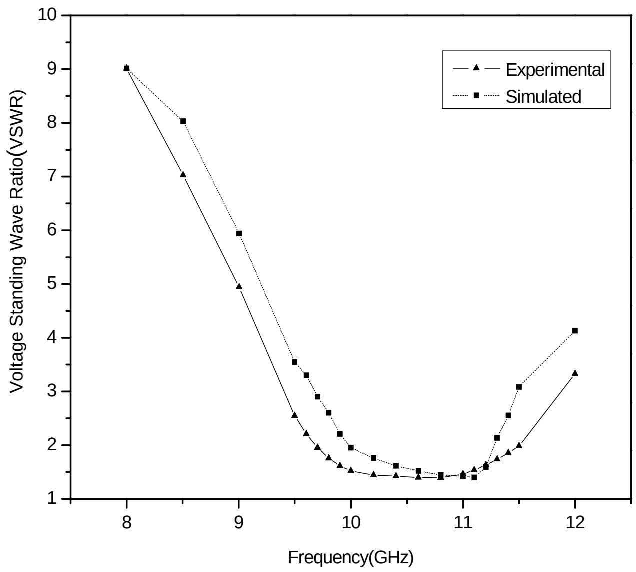


Figure 7: Simulated and experimental results for VSWR with frequency (with defect).

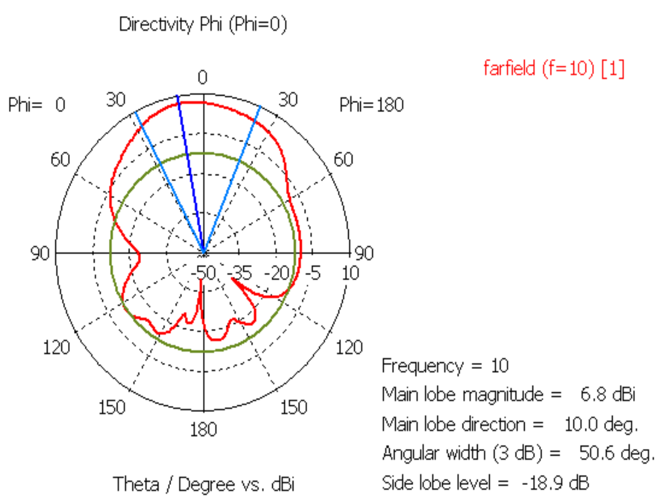


Figure 8: Simulated radiation pattern (DGS, directivity Phi (Phi = 0) Theta/Degree vs. dBi at frequency = 10 GHz)

4. Results and discussion

Results are compared for both the antenna structures, structure without defected ground plane and structure with defected ground plane. Parameters such as return loss, input impedance, bandwidth, and VSWR for both cases are measured and calculated. The radiation pattern is presented for the defected ground antenna structure. For the first case, when the ground plane for the designed antenna is not defected and covers whole of the substrate, the simulated and measured values of return loss are shown in Fig. 3. From the graph, we can see that the antenna shows a good return loss but not showing wide band characteristics. The antenna shows a simulated bandwidth of about 5.8% and experimental bandwidth of about 7.2%. The simulated and measured results show a good agreement. The input impedance for this case is reported in Fig. 4.

For the second case, when the defect in the ground plane is introduced, the antenna shows a wide band. The simulated and measured values of return loss are reported in Fig. 5. From this figure, we can see that the antenna shows a wideband in the frequency range of $8 - 12$ GHz. Both experimental and simulated results are in good agreement. The simulated impedance bandwidth calculated from the graph is 18.3% and the experimentally measured impedance bandwidth is 20.2%.

The input impedance for the second case is reported in Fig. 6. From the results, it is evident that the experimental and simulated values are in good agreement. The designed antenna shows a wide band in the given frequency range. The resonant frequencies in both cases also show a good agreement.

Figure 7 reports VSWR calculated from the simulated and experimental results for the defected ground plane antenna. For entire bandwidth, VSWR is reported less than or equal to 2. From this graph the calculated bandwidth is about 20% GHz.

The simulated radiation pattern for the antenna structure with defected ground at frequency 10 GHz is shown in Fig. 8. The polar plot of the radiation pattern is shown for Phi=0 between Theta/degree vs. dBi for both cases. At resonant frequency of 10 GHz (for Phi=0), the antenna gain is 6.8 dBi in the main lobe direction 10.0 degrees. Within 3 dB angular width in the direction 50.6 degrees the side lobe level is -18.9 dB. The radiation pattern shows that a reasonable antenna gain is obtained with improved radiation characteristics.

5. Conclusion

A compact novel defected ground microstrip circular ring antenna is presented and tested. It has been observed that by removing the complete portion of ground plane and optimizing antenna parameters, good impedance match is obtained with high bandwidth. The measured results are in good agreement with the experimental ones. It is also observed that a good antenna gain is obtained by introducing the defected ground plane. With about 6.8 dBi gain, bandwidth of the antenna is increased up to 20% which is very good for wideband applications. The side lobe level which is very important for better radiation is also reduced to -18.9 dB. The proposed antenna is applicable for various wideband communication systems.

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