Volume 2, No.4, July – August 2013
International Journal of Microwaves Applications
Available Online at http://warse.org/pdfs/2013/ijma02242013.pdf

PW fed Circular Microstrip Patch Antenna with Defected Ground Structure

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ABSTRACT

This paper emphasizes the use of defected ground structure (DGS) technique in microstrip patch antenna. The use of this technique has resulted in gain enhancement as compared to conventional microstrip antenna of the same size. The patch antenna designs are simulated using HFSS software. The antennas are fed by coplanar waveguide (CPW) line which makes the antennas easily used with MMIC and microwave circuits. The reflection coefficients of the antenna with and without DGS are measured with VNA. The simulated and measured results are in close agreement which validates the role of the designed antenna for operation in wireless applications from 5-15GHz. The antennas are simple and compact, FR4 is chosen as substrate which makes it cost effective for usage. A comparison is drawn between the performances of the antennas in terms of gain, return loss, VSWR of the antennas

Keywords: Broad band, Coplanar waveguide, Defected ground structure, Microstrip patch antenna

1. INTRODUCTION

As the process of miniaturization of devices is in full swing, antennas cannot remain as standalone devices. Compact designs have to be implemented to cope with the demands of the industry. In today's scenario of wireless system and booming demand for a variety of new wireless application, there is great need to design broadband antennas which offers complete package of minimal cost, light weight and high performance to cover a wide frequency range. With increasing requirements for personal and mobile communications [1], the demand for smaller and low-profile antennas has brought the microstrip antennas to forefront.

Present time is witnessing a very rapid growth of wireless communications, for which compact antennas are in strong demand as they can be easily integrated with wireless devices. For good antenna performance, broadband antennas are in strong demand as they provide access to various wireless communications in single time.

The care should also be taken to protect microstrip antennas from dielectric and surface wave losses. Surface wave occurs due to the trapping of total available radiated power along the surface of the antenna substrate [4]. These waves reduce the antenna gain, efficiency and bandwidth.

All these problems can be removed by using DGS structure in microstrip patch antennas which supports multiband that can operate at different frequencies for one device [6]. The antenna is designed with dielectric substrate having dimensions of 18 x 20 x 1.6 mm and circular patch of radius 5 mm. Circular shape slots are created in the ground plane as defects. The CPW feed is used as it exhibits less dispersion, low radiation loss and uniplanar configuration [9]. The proposed antenna finds its application in WLAN IEEE 802.11 and X-band. Depending upon the geometry, design and size of the defects in the ground plane, DGS produces different cut off frequencies and -10 dB bandwidth.

2. ANTENNA STRUCTURE

Figure 1, Figure 2 shows the geometry of the proposed circular microstrip patch antenna with and without DGS together with its geometrical dimensions. The proposed antenna structure is a circular patch of radius 5 mm. A circular slot is etched in the patch. The main radiation elements of the antenna, which are etched on the ground plane, are circular shape defects which make the antenna to achieve better gain.

Table 1 shows the optimized design parameters obtained for the proposed patch antenna. These design parameters are obtained by parametric analysis performed on various dimensions of the antenna in HFSS. The FR4 epoxy dielectric substrate with dielectric permittivity 'ε_r' of 4.4, dielectric loss tangent of 0.02 and thickness 'h' of 1.6 mm has been used in this research. The metal patch has been printed on one side of the dielectric substrate where as the other side of the dielectric substrate does not have metallic printing this makes the geometry truly planar. These monopoles can be integrated with other components on printed circuit board, have reduced size on dielectric substrate, are without backing ground plane and are easy to fabricate. Printed antennas, commonly fabricated on FR4 substrate, are very cost effective, which is ideally suited for UWB technology-based low-cost systems [8].

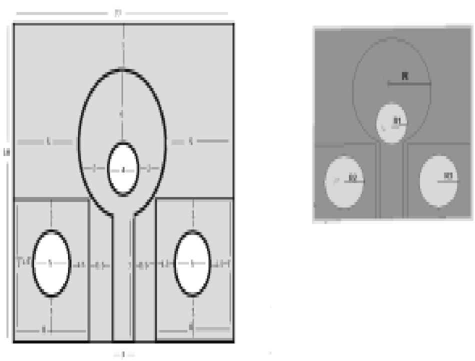

Figure 1 (a): Geometry of circular patch antenna with DGS

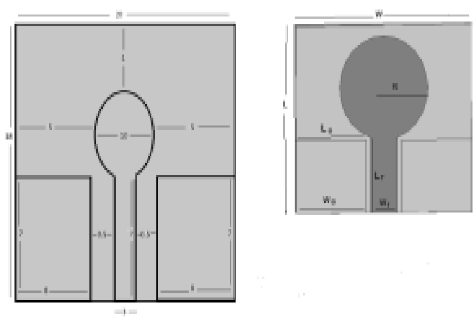

Figure 1 (b): Geometry of circular patch antenna without DGS

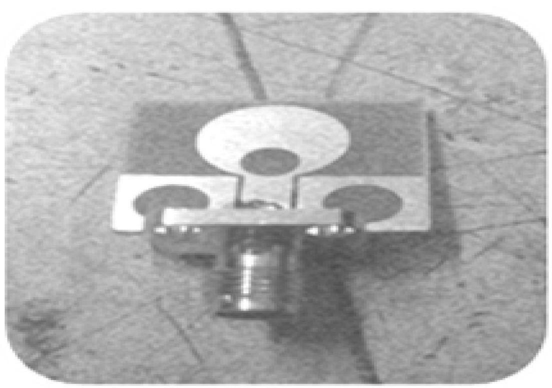

Figure 2 (a): Fabricated antenna with Defected Ground Structure

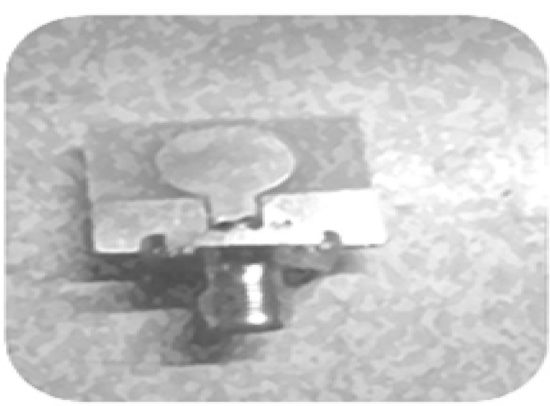

Figure 2 (b): Fabricated antenna without Defected Ground Structure

Table 1: Parameters of proposed antenna with DGS

Parameter	Value
Dielectric Constant of the Substrate	4.4
Dielectric loss tangent	0.02
Width of the substrate(W)	20 mm
Length of the substrate(L)	18 mm
Height(h)	1.6 mm
Radius of circular patch(R)	5 mm
R1	2 mm
Width of the feed line(W_f)	3 mm
Length of feed line(L_f)	7.3 mm
Length of the ground plane(L_g)	7 mm
Width of ground plane(W_g)	8 mm
R2	2.5mm
R3	5 mm

3. SIMULATION RESULTS

HFSS Simulator has been used to calculate return loss, VSWR, and gains. Figure 3 and Figure 4 depicts the simulated and measured return loss for both antennas. Figure 5, Figure 6, Figure 7, Figure 8, Figure 9 depicts VSWR and gain curves for both antennas respectively.

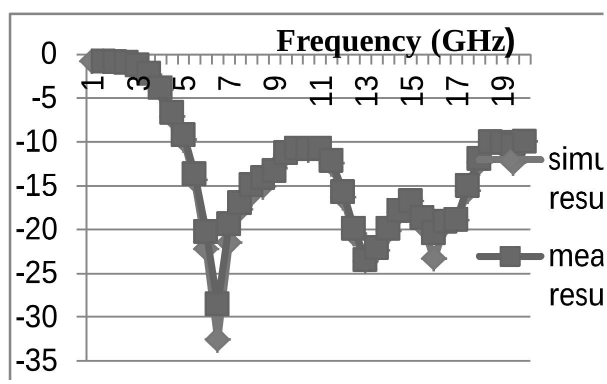

Figure 3: Return Loss Curve of simulated and measured results of the circular patch antenna without DGS

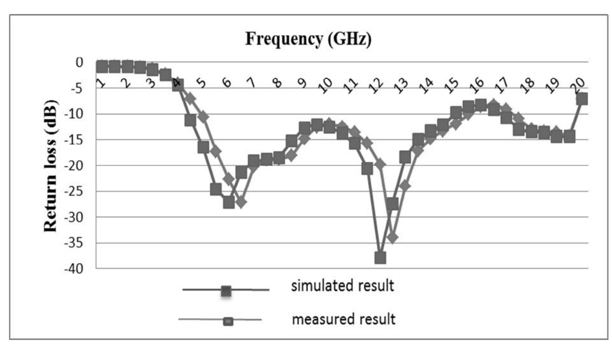

Figure 4: Return Loss Curve of simulated and measured values of the circular patch antenna with DGS

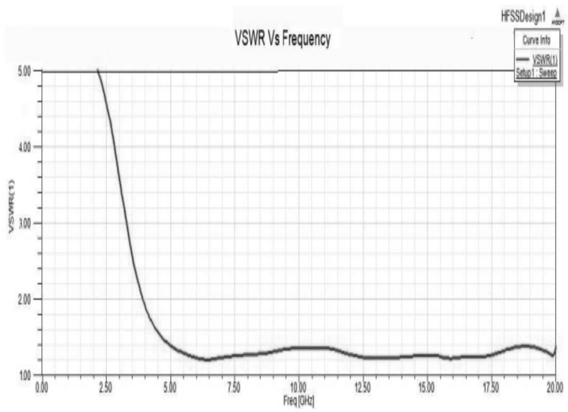

Figure 5: VSWR of the circular patch antenna without DGS

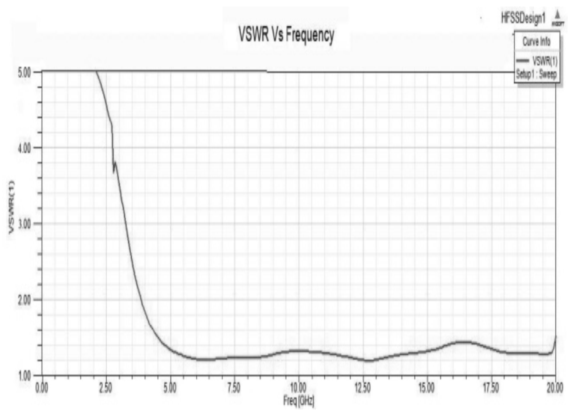

Figure 6: VSWR of the circular patch antenna with DGS

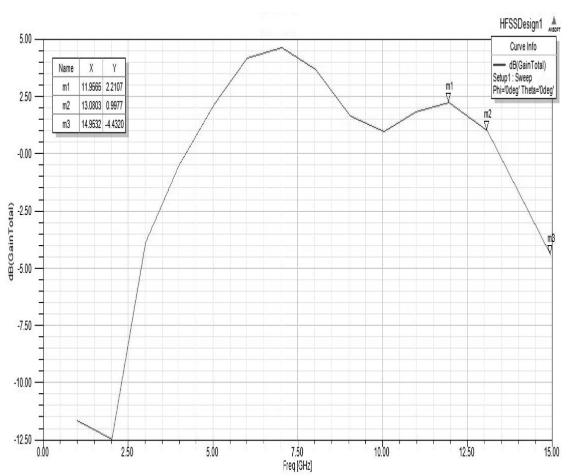

Figure 7: Gain of the circular patch antenna without DGS

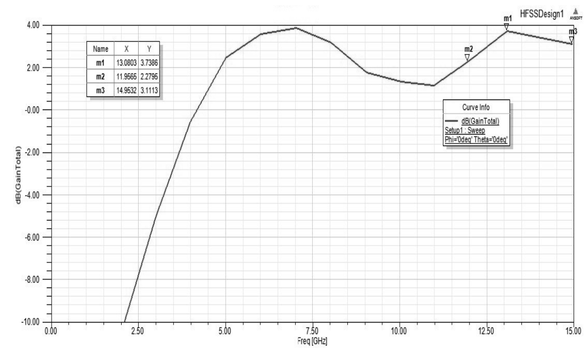

Figure 8: Gain of the circular patch antenna with DGS

Table 2: Result comparison of two antennas

Parameters	**Circular patch MSA(without DGS)**	**Circular patch MSA (with DGS)**
VSWR	Less than 1.5 from 5 GHz-18 GHz	Less than 1.5 from 5 GHz-18 GHz
Return loss (dB)	-32.85 at 6.4 GHz and -23.7 at 13 GHz	-28.9 at 6.2 GHz and -37.8 at 12.6 GHz
Gain (dB)	2.21, 0.997, -4.43, at frequencies 12 GHz, 13 GHz and 15 GHz respectively	3.7, 2.27, 3.111 at frequencies 12 GHz, 13 GHz and 15 GHz respectively

4. CONCLUSION

It can be concluded from the above analysis that both the antennas will meet the specifications of WLAN IEEE 802.11 and X-band applications .Due to enhancement of gain in design 2 using DGS structure this antenna will significantly suppress potential interference in existing systems i.e. WLAN applications, X- band [Zulkifli (2010)] uplink frequency band (for sending modulated signals) as from 7.9 to 8.4 GHz and for downlink frequency band (for receiving signals) as 7.25 to 7.75 GHz, X- band applications including short range tracking, missile guidance, marine, radar and airborne intercept. It will be useful for radar communication which ranges roughly from 8.29 GHz to 11.4 GHz. The feasibility of the design is proved by simulations and testing.

6. FUTURE SCOPE

This antenna can be considered as a potential candidate for cost effective communication applications. Below are the suggestions for future scope:

(i) The proposed antenna structure can further be modified for increasing the gain.

(ii) We can make use of different antenna structure which can be integrated by introducing slits in the patch in order to improve the performance of the antenna.

(iii) The design can be modified further by changing antenna dimensions on some different substrate and introducing different shapes as defective ground structure in ground plane.

(iv) The gain can be increased by using metal loaded superstrate.

(v) DGS provides excellent performances in terms of ripples in then passband, sharp-selectivity at the cut-off frequency and spurious free wide stopband. It can be used in designing filters.

ACKNOWLEDGEMENT

I would like to express my thanks to the department of ECE and management of Arya College of Engg. and IT for their continuous support and encouragement during this work.

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