Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IJCSMC, Vol. 4, Issue. 1, January 2015, pg.426 – 432

RESEARCH ARTICLE

Bandwidth Enhancement of A microstrip Patch Antenna for C-band and X- band By Using New Structure of Defected Ground Technique

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Abstract— In this paper, defected ground structure (DGS) technique has been suggested for the rectangular microstrip patch antenna (RMSA) proposed in the previous study for bandwidth enhancement in C-band and X-band with good impedance matching. The aperture proposed in the ground plane has improved the bandwidth approximately six times the bandwidth in the reference antenna without DGS which is about 809 MHz. The value of return loss is also improved by using this technique. The microstrip patch antenna is simulated using high frequency simulation software FEKO version 5.5.

Keywords— DGS, RMSA, patch antenna, bandwidth

I. INTRODUCTION

Microstrip antennas have wide applications in mobile communication systems due to their excellent characteristics such as low cost, light weight and easy fabrication [1]. Surface waves are one of the drawbacks of the microstrip antennas because when a patch antenna radiates, a portion of the total available radiated power becomes trapped along the surface of the substrate. It can extract total available power for radiation to space wave. Surface waves increase the level of side lobes, reduce the efficiency and antenna gain, limit the bandwidth and increase cross polarization [2] [3].

All of these problems can be avoided by using a DGS structure in microstrip patch antennas; the proposed antennas in this paper are achieved multi-band and can operate at different frequencies in a single device [4]. Different shapes of defected ground structures provide many good performances in terms of reducing the size of the antenna and improving the bandwidth [5]. In this paper, the suggested DGS technique is used to enhance the bandwidth at the resonant frequency of C-band (4 to 8 GHz), which is used in the applications of long-distance radio telecommunications and in the range of X-band (8 to 12 GHz) which is used for the applications of satellite communications, radar, terrestrial broadband, space communications and amateur radio. The defected ground structure and the general design of the antenna is shown in Fig.1.

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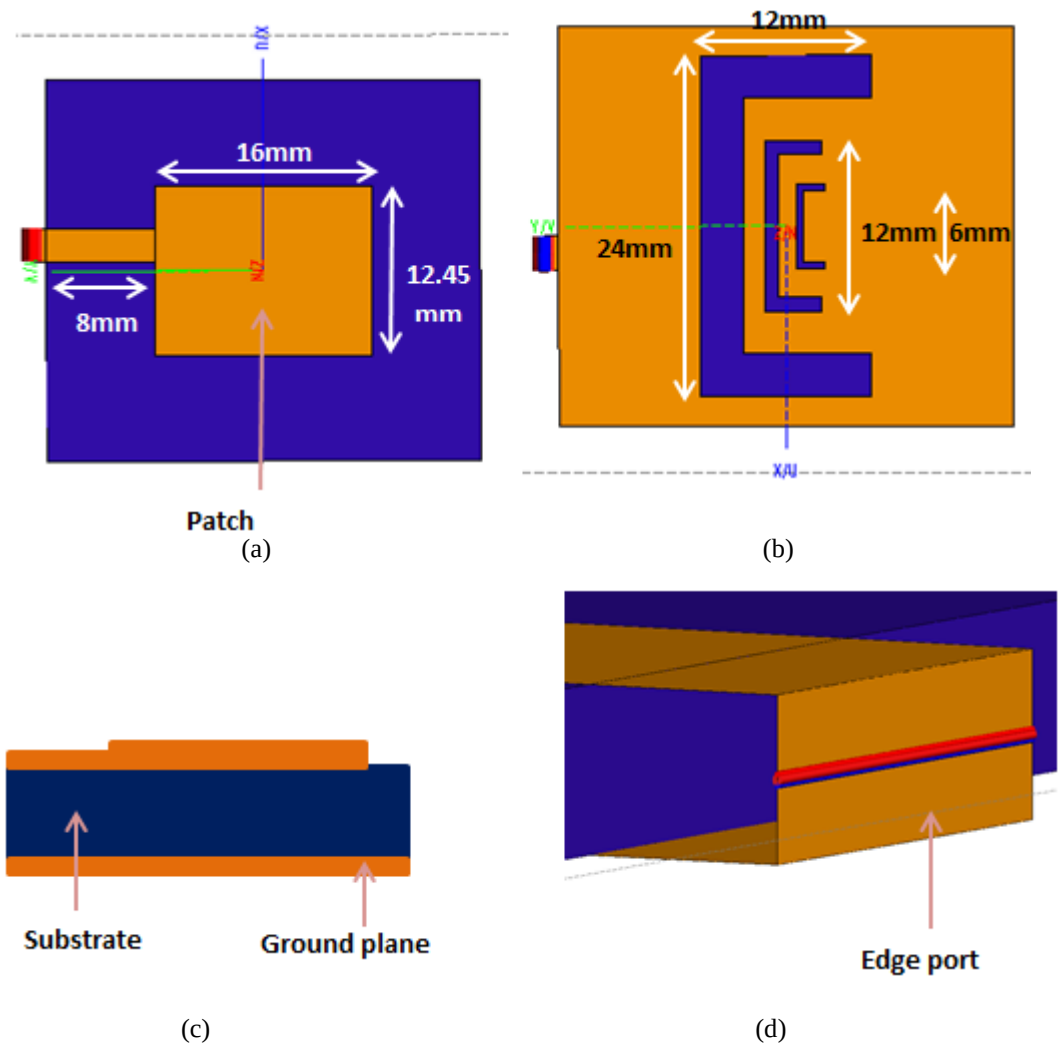

Fig. 1 (a): Top view of the antenna (b): Ground plane with DGS (c): Side view of antenna (d): Edge port

II. ANTENNA DESIGN

Geometry of the antenna consists of a patch antenna with dimensions 12.45 x 16 mm, a substrate dielectric material of dielectric constant 2.2 with thickness 0.794 mm.

Microstrip feed line with edge port is used to fed the antenna. All the parameters of the design are given in TABLE 1 [6]. Antenna is simulated in FEKO 5.5 software.

TABLE 1. DESIGN PARAMETER OF MICROSTRIP PATCH ANTENNA

Parameter	Value
Patch width	16 mm
Patch length	12.45 mm
Substrate dimensions	32 x 28.1 x 0.794 mm
Dielectric constant	2.2
Feed line width	2.46 mm
Feed line length	8 mm

All the values of the essential parameters for the design is explained based on the transmission line model (TLM).

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Step 1: Calculation of the Patch Width (W)

The width of the microstrip patch antenna is given by (1)

$$W = \frac{c}{2f_o}\sqrt{\frac{2}{\varepsilon_r + 1}} \tag{1}$$

Step 2: Calculation of effective dielectric constant (ε_{reff})

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}(1 + 12\frac{h}{w})^{-\frac{1}{2}} \tag{2}$$

where h is the thickness of the substrate.

Step 3: Calculation of the effective length (L_{eff})

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}} \tag{3}$$

Step 4 Calculation of the length extension (ΔL)

$$\Delta L = \frac{\left(\varepsilon_{reff} + 0.3\right)\left(\frac{w}{h} + 0.264\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{w}{h} + 0.8\right)} \tag{4}$$

Step 5: Calculation of the actual patch length (L)

$$L = L_{eff} - 2\Delta L \tag{5}$$

For finite and infinite ground plane it can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery [7].

The geometry of the suggested shape of DGS consist of vertical and horizontal arms as shown in TABLE 2 .

TABLE 2. DESIGN PARAMETER OF DGS

Parameter	Value
Length of the first vertical arm	24 mm
Length of the second vertical arm	12 mm
Length of the third vertical arm	6 mm
Width of the first vertical arm	3 mm
Width of the second vertical arm	1 mm
Width of the third vertical arm	0.5 mm

III.RESULTS

Return loss is a measure of extent matched between devices or lines, It can be defined in dB. TABLE 3 shows the return losses results for both antennas with and without DGS.

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TABLE 3. RETURN LOSSES RESULTS OF MICROSTRIP PATCH ANTENNA

Case	Resonant frequency (GHz)	S-parameter (dB)
Without DGS	7.44	-13.77
	9.87	-12.75
With DGS	7.59	-17.06
	8.99	-12.4

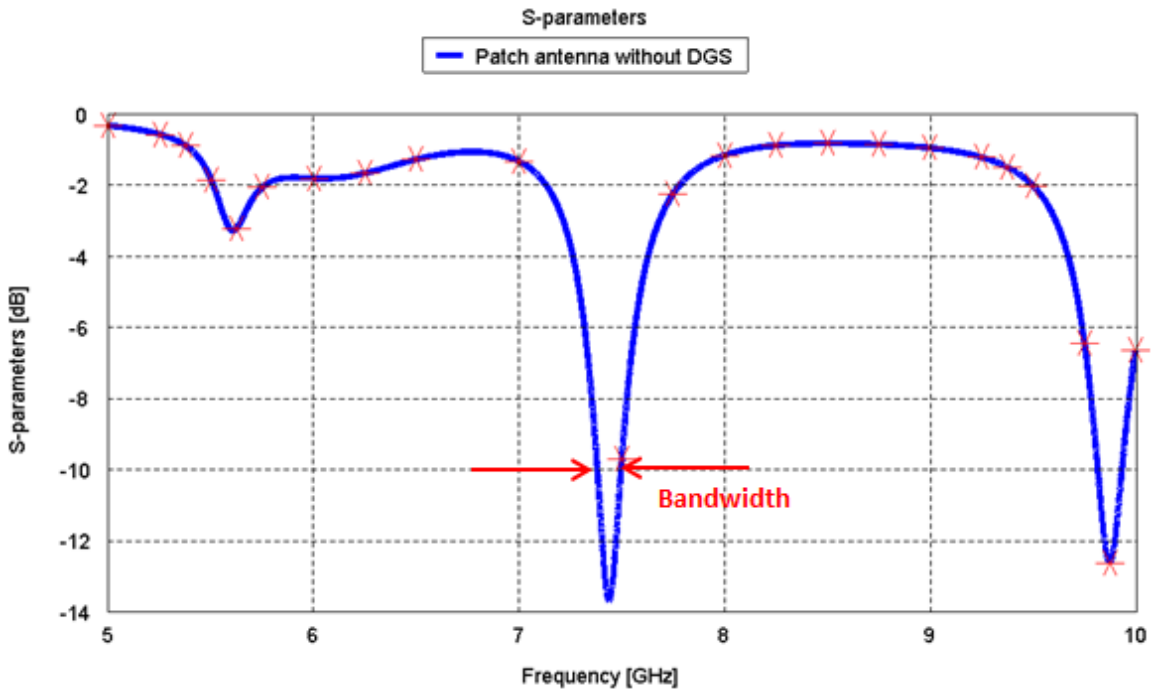

Fig. 2 S-parameter for microstrip patch antenna without DGS

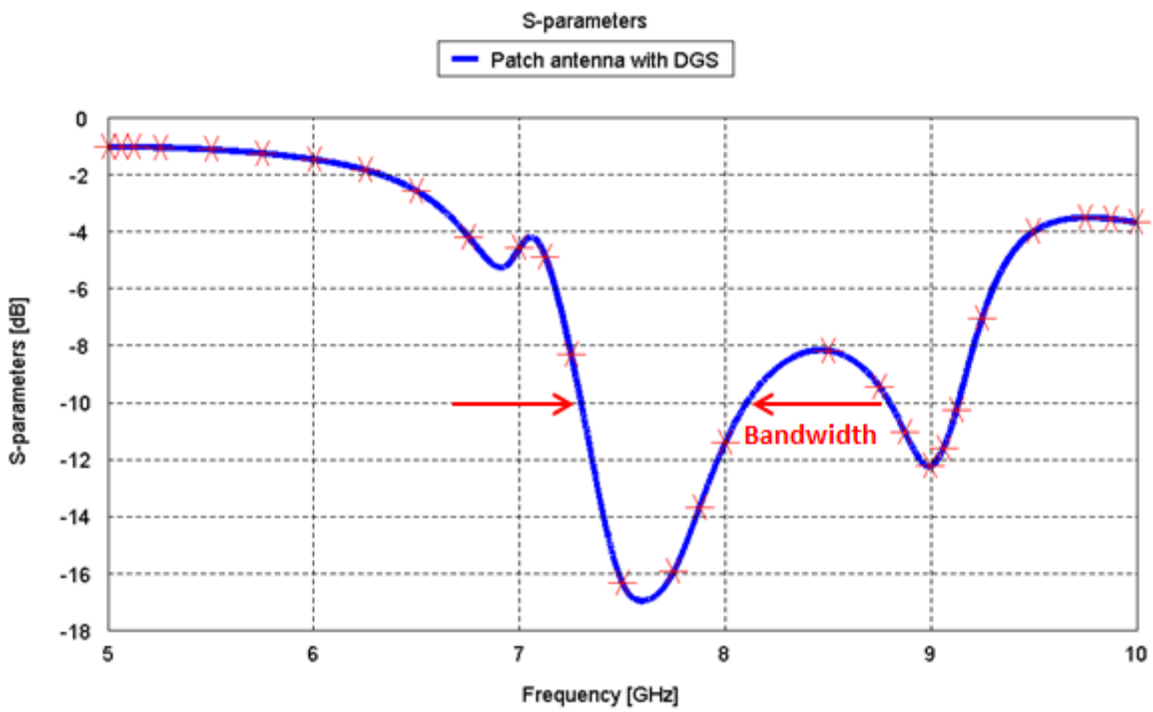

Fig. 3 S-parameter for microstrip patch antenna with DGS

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And the bandwidth is defined as the range of frequencies as shown in TABLE 4

TABLE 4. BANDWIDTH RESULTS IN MICROSTRIP PATCH ANTENNA

Case	F_{Lo} (GHz)	F_{Hi} (GHz)	Bandwidth (MHz)
Without DGS	7.37	7.49	120
	9.81	9.93	120
With DGS	7.298	8.107	809
	8.799	9.136	337

From the TABLE 4, it's observe that the values of the bandwidth for both C-band and X-band of microstrip patch antenna with defected ground structure are more better than the values of bandwidth of reference antenna without DGS. Other simulation results of the Voltage standing wave ratio (VSWR) and the real and imaginary parts of impedance are shown in the figures below respectively

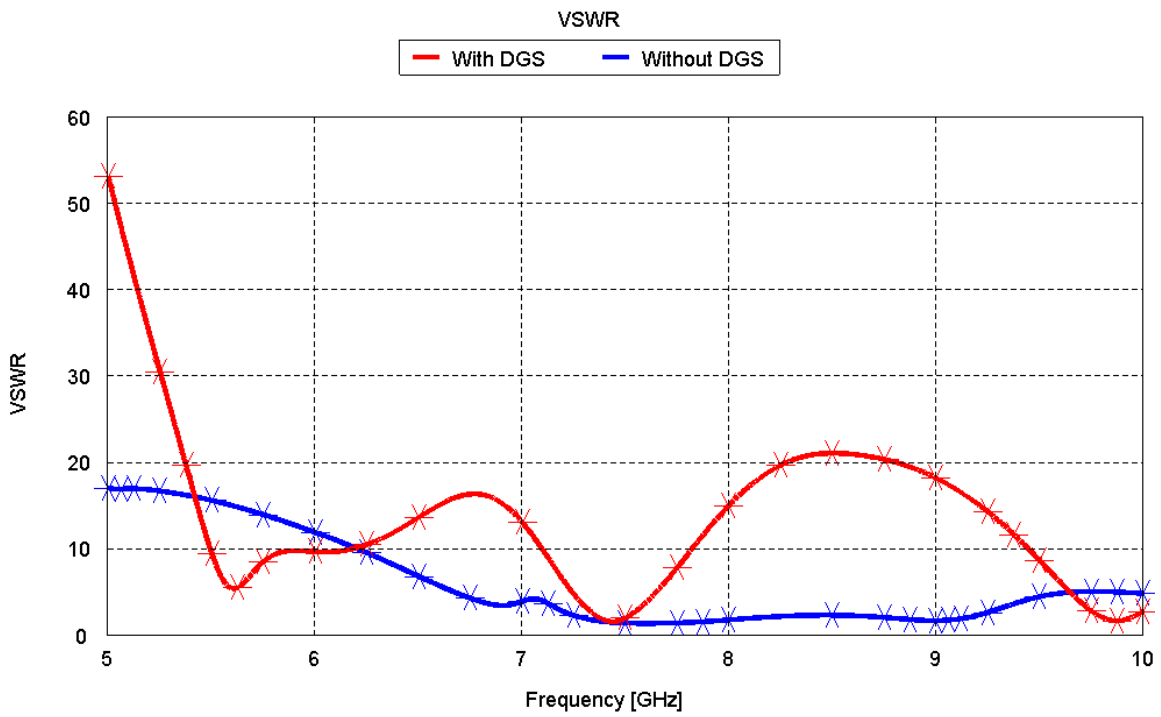

Fig. 4 VSWR for microstrip patch antenna with and without DGS technique

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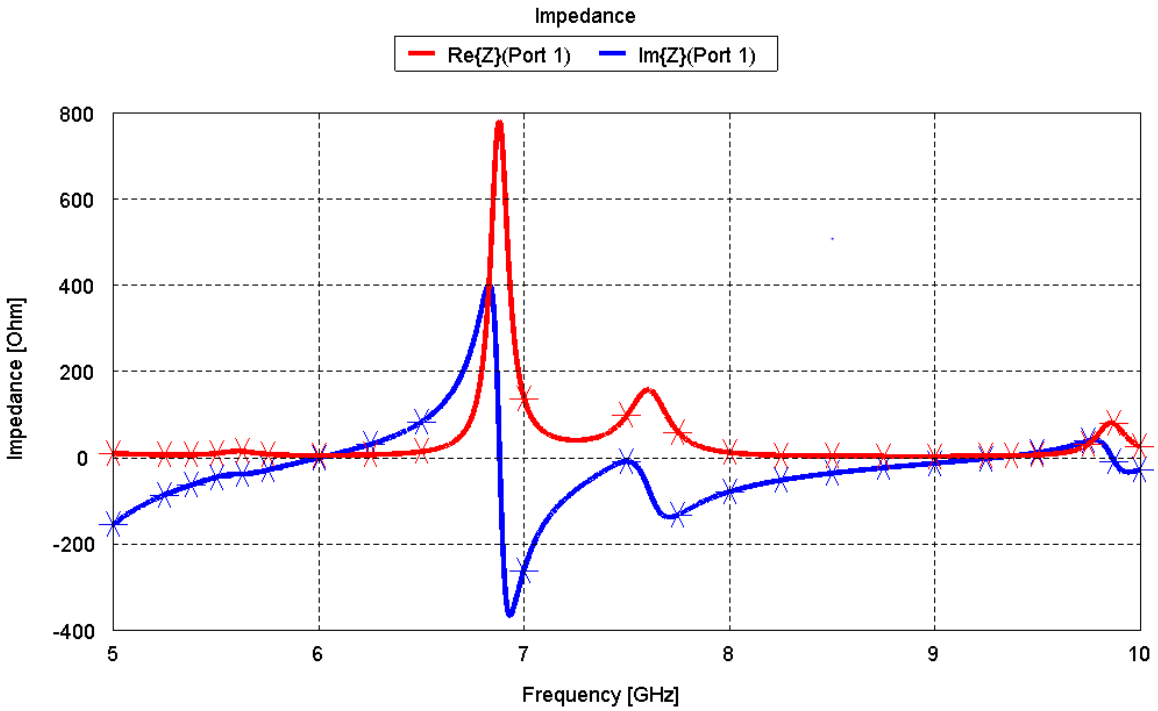

Fig. 5 Real and imaginary parts of microstrip patch antenna without DGS technique

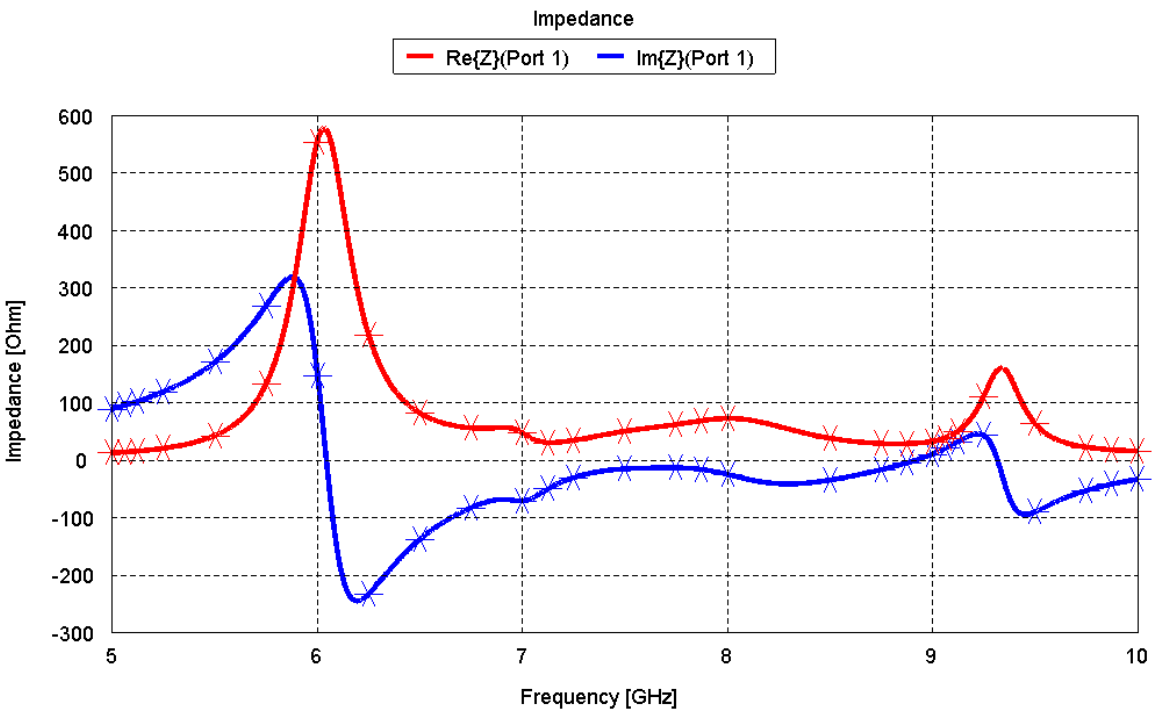

Fig. 6 Real and imaginary parts of microstrip patch antenna with DGS technique

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IV. CONCLUSIONS

A new structure of defected ground was suggested and simulated in this paper by using FEKO software to improve the bandwidth for both of C-band and X-band compared with the reference antenna in a previous study. The optimum value of bandwidth was obtained for C-band and X-band up to 809 MHz and 337 MHz respectively. Other shapes of the DGS for different dimensions can also be explored for further improvements.

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