iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** IX **Month of publication:** September 2017

DOI:

www.ijraset.com

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue IX, September 2017- Available at www.ijraset.com

Defected Ground Multi-Band Antenna for Surface Movement Radars

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***Abstract:** This paper presents a compact multiband micro strip patch antenna with defected ground structure (DGS).The patch and ground are made on top and back side of the FR-4 substrate. The designed antenna has multiple resonating bands because of a loaded slot on ground plane. Designed antenna operates in the frequency bands of 16.9–21.1 GHz, 23.4-25.1 GHz and 28.65-37.56 GHz with centre frequencies of 20, 24, and 32 GHz respectively. The fractional bandwidth of designed antenna is 21%, 7%, and 27.8% at centre frequencies orderly. These resonating bands are applicable in surface movement radars (SARs) and satellite communications. The group delay of the proposed antenna is in the range of -0.5 n-sec to 0.5 n-sec for all bands. It is shown that the designed antenna has appropriate gain and good radiation efficiency over operating bands. The frequency ratio of antenna for proposed dimension is above 1.2 and VSWR is below 2 for all bands.*

***Keywords:** DGS, multiband antenna, SAR antenna, HFSS*.

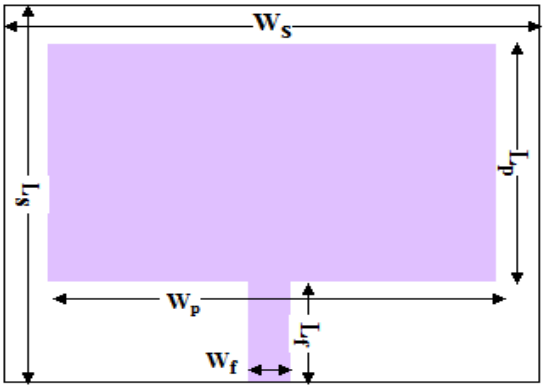
I INTRODUCTION

Microstrip antennas are unduly renounced antennas for transmitting and receiving electromagnetic waves. These antennas have ability to integrate with printed and active devices [1]. These antennas find applicability in military applications like missile, fighter planes and rockets as well as commercial applications like global positioning system (GPS), remote sensing and direct broadcasting [2]. These days, the avail of micro strip antennas are not only bounded in single band operations but also scaled for multiband operations[3-4].Defected ground structure (DGS) is prominently used in high frequencies antenna design to reduce the antenna size and to enhance the bandwidth [5]. The slots and notches in the ground plane disturb the current distribution in the ground plane and increase the effective inductance and capacitance of input impedance that results to enhancement in bandwidth [6]. In former decennary several multiband antennas for radars and satellite communications are introduced. A multi-band array antennas operating at either Ku- band or Ka-band with the need of switching for air- platforms has been reported[7]. A microstrip patch antenna operated at two distinct resonating frequencies around 20 GHz has been reported for K-band applications [8]. A stacked CPW-fed antenna operated in Ku, K, and Ka-bands has been presented for satellite applications [9].

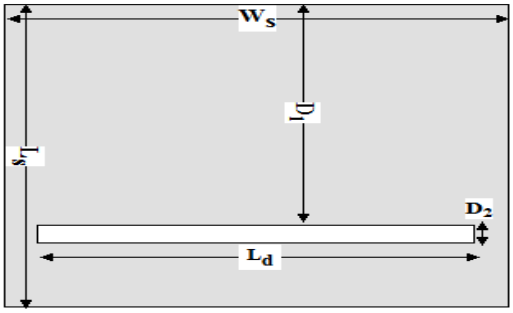
In this paper a defected ground multi-band operated in the frequency range of 15 - 40 GHz has been presented. The rectangular defect in the ground plane is responsible for multi-band behavior of designed antenna. The designed antenna is simulated using HFSS simulation software and has good antenna characteristics.

II ANTENNA DESIGN

Designed antenna structure shown in fig.1 Feed patch is made on FR-4 substrate with dielectric constant of 4.4 and loss tangent of 0.02 [cf. fig. 1]. A rectangular DGS is loaded on the ground plane of substrate. The geometrical parameters of the proposed antenna arement n Table 1.



(a)



(b)

Fig. 1: Geometry of proposed antenna. (a) Top view of proposed antenna, (b)Bottom view of proposed antenna

TABLE 1 :Geometrical Parameters of proposed antenna

Antenna Parameters	Value
Length of substrate (L_s)	20mm
Width of substrate (W_s)	20mm
Length of patch (L_p)	14mm
Width of patch (W_p)	18mm
Length of feed line (L_f)	5mm
Width of feed line (W_f)	2mm
Length of slot in ground plane(L_d)	18mm
Width of slot in ground plane (W_d)	1mm
D_1	14.5mm
D_2	1mm

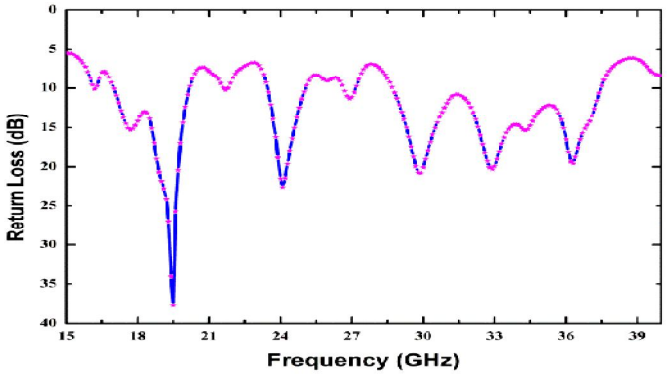


Fig. 2: Return loss vs frequency plot.

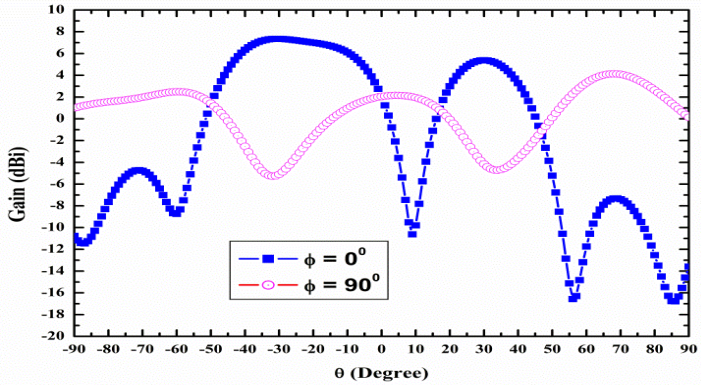


Fig. 3: Gain vs Theta plot for 20 GHz resonance frequency

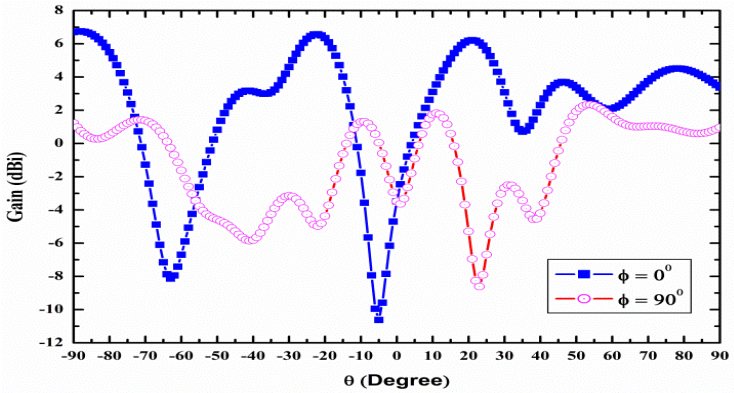


Fig.4: Gain vs Theta plot for 24 GHz resonance frequency

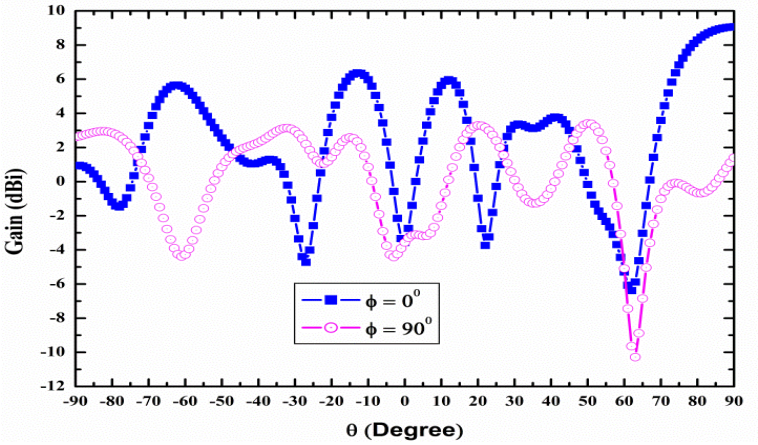


Fig. 5: Gain vs Theta plot for 32 GHz resonance frequency

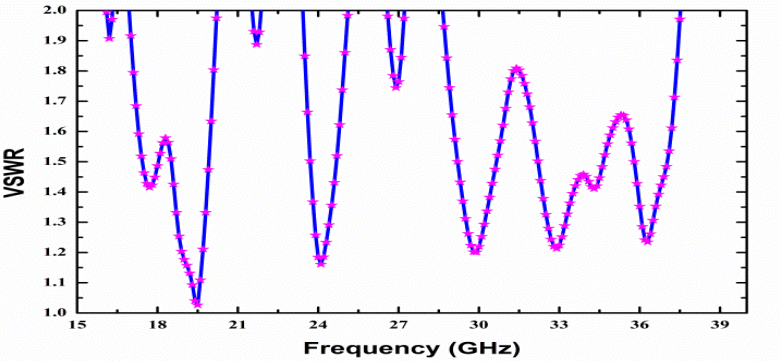


Fig. 6: VSWR vs frequency plot

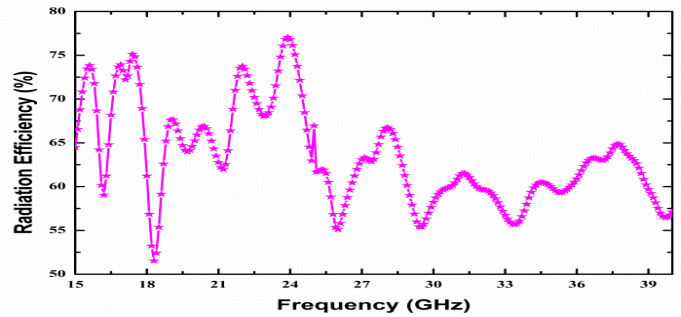


Fig. 7: Radition efficiency vs frequency plot.

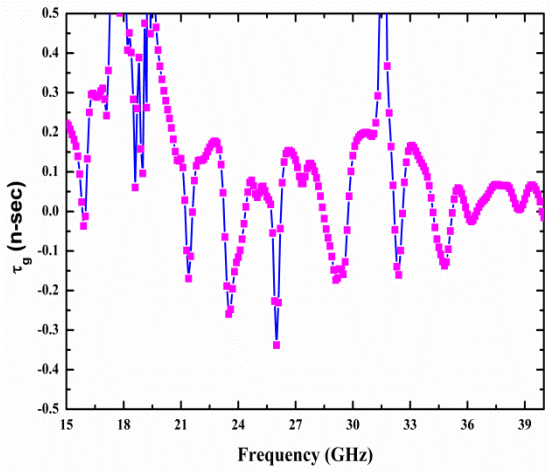


Fig. 8: Group delay vs frequency plot

III RESULT ANAD ANALYSIS

The proposed antenna is designed and simulated using HFSS.v13 software for high frequency application atrange of 17 GHz to 37 GHz frequency. From the simulation of proposed antenna, three resonating bands are obtained at resonance frequency of 20 GHz, 24 GHz and 32 GHz with impedance bandwidth of 21%, 7% and 27.8% respectively shown in figure 2. From the figure it is seen that the first and third band is obtained wide band by using a rectangular defected ground structure.

Figure 3, figure 4 and figure 5 show the gain vstheta plot for 20GHz, 24 GHz and 32GHz resonant frequency respectively. The peak gain is obtained at $\varphi=0^0$ for all three band. For 20GHz, the peak gain is obtained 7dBi at $\theta = -40^0$, and for 24 GHz the peak gain is obtained 7dBi at $\theta = -25^0$ and $+25^0$ shown in figure 3 and 4 respectively. For 32 GHz the peak gain is obtained 9ddBi at $\theta = 90^0$ shown in figure 5.

The mag. of VSWR at 20 GHz , 24 GHz and 32GHz resonating band is obtained less than 1.5 Shown in figure 6. The radiation efficiency and group delay plot are shown in figure 7 and figure 8 respectively. Figure 7 shows that the average radiation efficiency is obtained 75% at lower frequency range (15 – 25 GHz)and for higher frequency range (25-39 GHz) the average radiation efficiency is obtained up to 65%.

The group delay plot of the proposed antenna is shown in figure 8 and from the figure it is seen that the group delay is vary between -0.4 to 0.5 nsec.

IV CONCLUSION

In this paper, a simple patch antenna with defected ground structure is presented. The proposed antenna obtained multi and wide band with high gain due to its DGS structure at higher frequency for surface movement radar applications.

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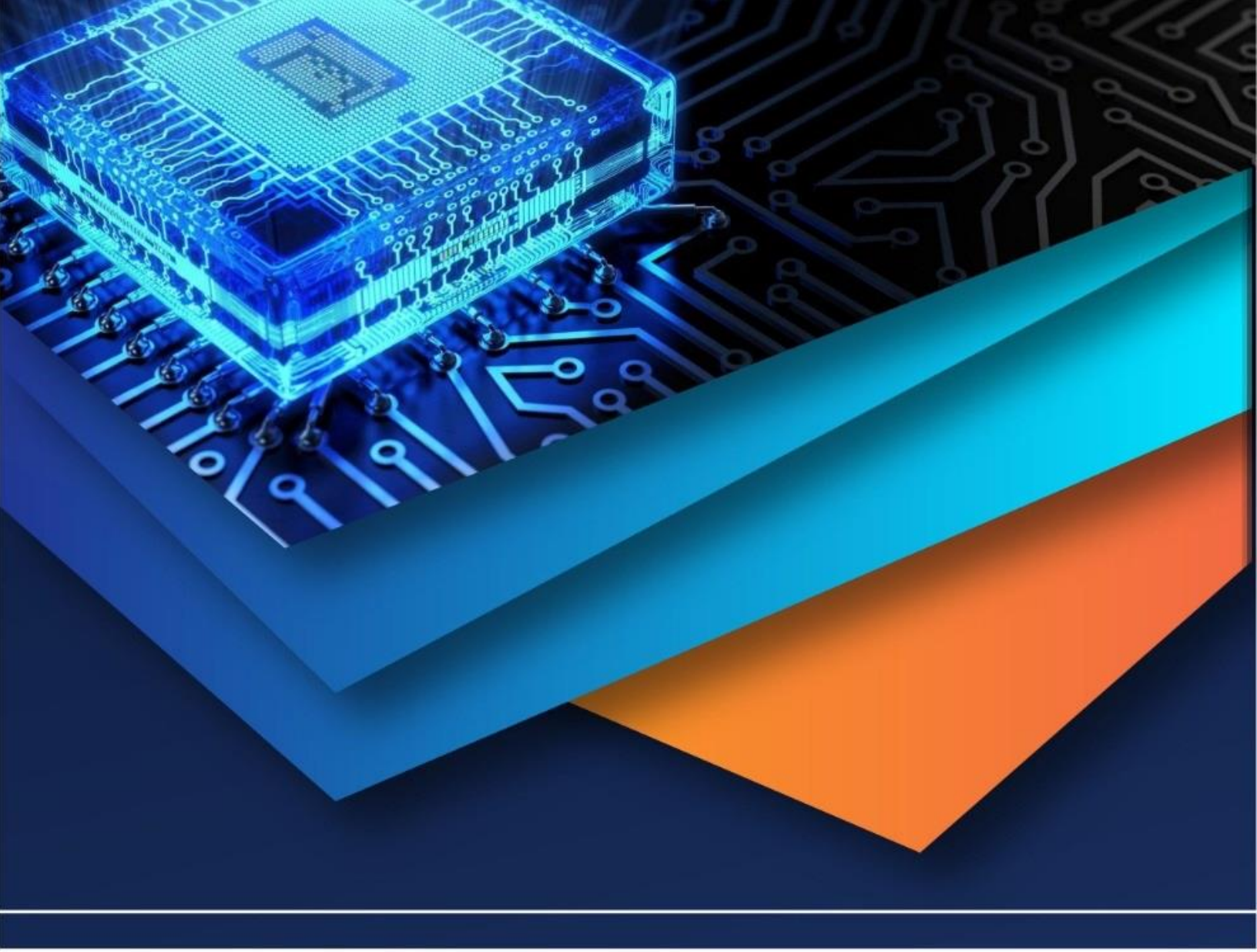

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