International Journal of Pure and Applied Mathematics
Volume 120 No. 6 2018, 1189-1200
ISSN: 1314-3395 (on-line version)
url: http://www.acadpubl.eu/hub/
Special Issue

http://www.acadpubl.eu/hub/

Bandwidth enhancement of Rectangular microstrip antenna with theta slot DGS for wireless applications

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November 1, 2018

Abstract

This paper is to design a rectangular microstrip patch antenna which is operating at 2.4 GHz.The rectangular microstrip antenna is designed and simulated using HFSS software.To improve the bandwidth of rectangular microstrip antenna ,a theta slot defective ground structure is introduced on the ground plane.The antenna performance is measured in terms of return loss,bandwidth,Gain and VSWR. Simulation results have shown that the return loss of the antenna is reduced from -20 dB to -25.62 dB and the bandwidth of the antenna is enhanced from 56 MHz to 75 MHz by inserting a theta slot defect on the ground plane .

Key Words::Microstrip, Defective Ground Structure, HFSS, Return Loss, Gain

1 Introduction

Due to the development of modern wireless communication systems,there is an increase in the demand for antennas which can be embedded in portable devices. There is a demand for small, broadband antennas due to the development in communication industry and also to meet the consumer demand in the modern wireless world.[1], [2].The main advantage of using microstrip antennas in wireless communication systems are due to their less weight,low cost,low profile and as it can be easily integrated with microstrip circuits. Microstrip antennas can also be easily integrated into arrays or it can be integrated into microwave printed circuits. microwave printed circuits. Due to the above applications ,microstrip antennas are preferred. Microstrip antennas have rapidly developed over the last twenty years.[3]. Even though ,micostrip antenna has a narrow bandwidth,it is preferred for most of the wireless applications.[4] There are many techniques to overcome the disadvantages of microstrip antennas such as increasing the thickness of the substrate,by employing proper feeding techniques,by using defective ground structures etc.[5] To improve the bandwidth of antenna,many techniques have been suggested and investigated. In this paper, a defective ground structure technique is introduced on the ground plane . The DGS geometry can be one or few etched structure and a large area is not required to implement it. [6].There are many shapes of DGS slot which has been discussed in many planar microstrip antenna deigns[7-9], In this proposed work, the rectangular microstrip antenna is designed at an operating frequency of 2.4 GHz.In order to improve the bandwidth of antenna,a theta slot defect is introduced on the ground plane.The antenna performance is measured in terms of return loss,bandwidth,Gain and VSWR.

2 DESIGN OF A RECTANGULAR MICROSTRIP ANTENNA

The proposed rectangular microstrip patch antenna is designed on FR4 glass epoxy substrate with relative permittivity of 4.4.The rectangular microstrip is designed with a dimension of 28.33 mm x 37.26 mm.The ground plane is designed with a dimension of 67.5 mm x

65.5 mm.The substrate height is taken as 1.6mm.Themicrostrip line feed is used as the feed for the rectangular microstrip antenna with a length of 22.65mm and a width of 1.2 mm.The geometry of rectangular microstrip antenna is shown in fig1.

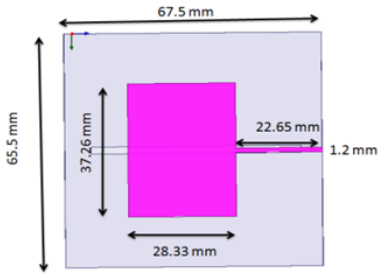

Fig1 Geometry of rectangular microstrip antenna

The rectangular microstrip antenna is introduced with a theta slot DGS on the ground plane..The theta slot DGS is designed by considering an elliptical structure with a major axis of 52.79mm and a minor axis of 24.36mm.In between a capacitance is introduced to form a theta slot DGS.The geometry of theta slot DGS is shown in fig2.

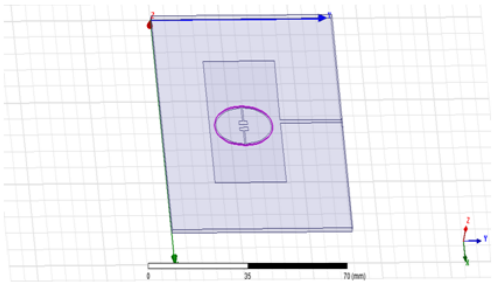

Fig2.Geometry of theta slot DGS

3 RESULTS AND DISCUSSION

The proposed rectangular microstrip antenna is designed with a resonant frequency of 2.4 GHz .The substrate is made of FR4 glass epoxy substrate with a dielectric constant of 4.4. The simulation is carried out using HFSS which is a finite element method

solver for electromagnetic structures.The simulated rectangular microstrip without any defective ground structures is shown in fig3.

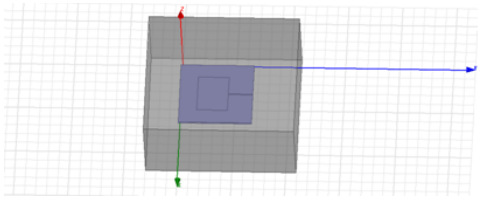

Fig3.Rectangular microstrip antenna without DGS

The rectangular microstrip antenna is introduced with a theta slot DGS on the ground plane.The simulated theta slot DGS on the ground plane of the rectangular microstrip antenna is shown in fig4.

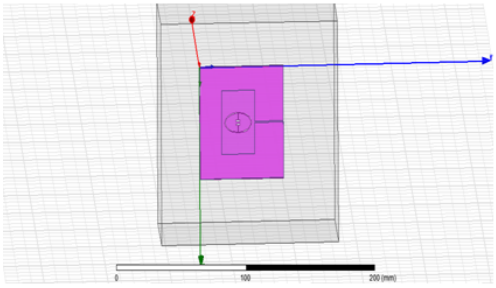

Fig4.Simulated theta slot DGS

The return loss plot of the rectangular microstrip antenna without any defective ground structure is shown in fig5.

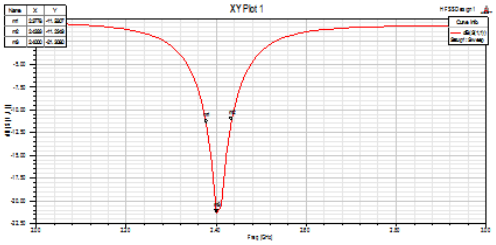

Fig5.Return loss plot of rectangular microstrip antenna without DGS

From fig 5,we can observe that the return loss of rectangular microstrip antenna without any defective ground structures is -21.3 dB.From the return loss plot,the bandwidth of the rectangular microstrip antenna is obtained as 55.5 MHz. The simulated VSWR plot of rectangular microstrip antenna without any defective ground structures is shown in fig6.

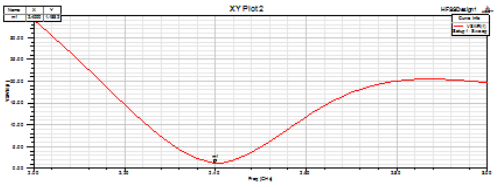

Fig6.Simulated VSWR plot of rectangular microstrip antenna without DGS

From fig 6,we can observe that the VSWR of simulated rectangular microstrip antenna is 1.8882 which shows that the VSWR is $\leq$ 2 which fulfills the parameters of microstrip antennas. The 3D radiation pattern of rectangular microstrip antenna without any defective ground structures is shown in fig 7.

Fig 7.3D radiation pattern of rectangular microstrip antenna

From fig8,we can observe that the gain of the rectangular microstrip antenna without any defective ground structures is 3.9 dB. The simulated return loss plot of rectangular microstrip with theta slot defective ground structure is shown in fig 8.

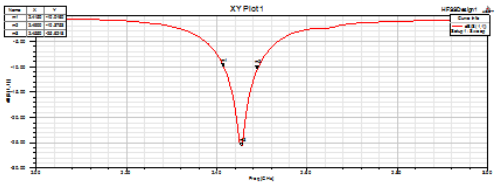

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Fig8.Simulated return loss plot of rectangular microstrip antenna with theta slot defective ground structures.

From fig 8,we can observe that the return loss of rectangular microstrip antenna with theta slot defective ground structures is -25.62dBand from the plot,we can observe that the bandwidth of the antenna is obtained as 80 MHz. We can also observe that upon the introduction of slot defect on the ground plane,there is a shift in the resonant frequency. As the defect is introduced,there will be a change in the effective permittivity (eff) [10], [11]. There will be a disturbance in the current distribution when a theta slot defect is introduced on the ground plane. [12].When a DGS is introduced in a microstrip antenna ,there will be an increase in the effective capacitance and inductance because of which the input impedance and current flow of the antenna is influenced [13]. When the defect is introduced antenna on the ground plane,due to the overlapping of the band gap of DGS and the resonant frequency of patch antenna, the surface wave propagation. is suppressed.Due to the surface wave suppression ,the performance of the antenna is improved in terms of banwidth and gain as there is a reduction in back radiation.. [14] Fig 9.shows the return loss plot of rectangular microstrip antenna with and without DGS.

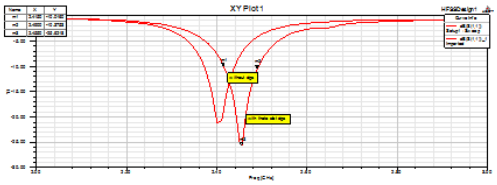

Fig9.Return loss plot of rectangular microstrip antenna with and without theta slot DGS

From fig 9,we can observe that there is a shift in resonance frequency when a theta slot DGS is introduced on the ground plane.There is an increase in bandwidth when the theta slot defect is introduced on the ground plane. The simulated 3D radiation pattern of rectangular microstrip antenna with theta slot DGS is shown in fig11.

Fig11.3D radiation pattern of rectangular microstrip antenna with theta slot DGS.

From fig11,we can observe that the gain obtained for rectangular microstrip antenna with theta slot DGS is 3.6557 dB. The simulated total gain radiation pattern of rectangular microstrip antenna with theta slot DGS is shown in fig 12.

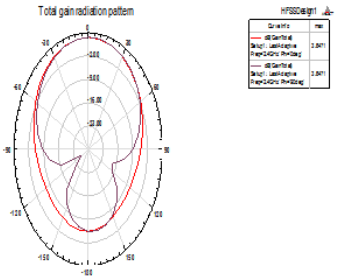

Fig12Total gain radiation pattern of rectangular micrsotrip antenna with theta slot DGS

From fig 12,we can observe that the total gain obtained for the rectangular microstrip antenna with theta slot DGS is 3.6471 dB. The simulated total gain radiation pattern of rectangular microstrip antenna without theta slot DGS is shown in fig 13.

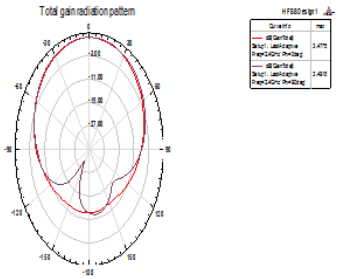

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Fig13Total gain radiation pattern of rectangular microstrip antenna without DGS

From fig13,we can observe that the total gain obtained for rectangular microstrip antenna without DGS is 3.4775dB. The smith chart plot for the rectangular microstrip antenna without DGS is shown in fig14.

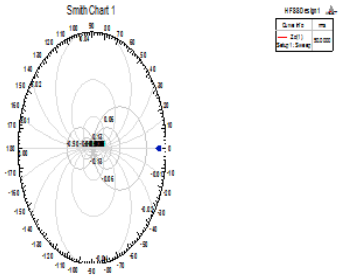

Fig 14.Smith chart of rectangular microstrip antenna without DGS

From fig 14,we can observe that the smith chart gives a clear picture on the impedance characteristics of the antenna.The port impedance of the antenna is obtained as 50. The smith chart for the rectangular microstrip antenna with theta slot DGS is shown in fig15.

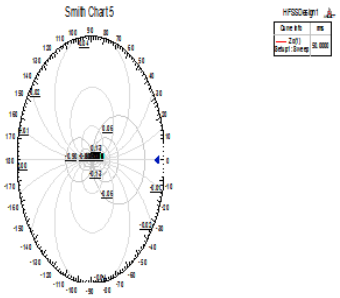

Fig15.Smith chart of rectangular microstrip antenna with theta slot DGS

From fig15,we can observe that the smith chart shows the impedance characteristics of the antenna and the port impedance is obtained as 50Ω.

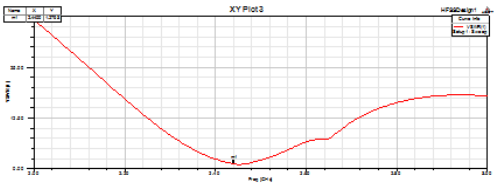

Fig17.simulated VSWR of rectangular microstrip antenna with theta slot DGS.

From fig17,we can observe that the resonant frequency is slightly shifted due to the introduction of the defect in the ground plane and the VSWR is obtained as 1.2793 which is ≤ 2. Table1.shows the simulated results of return loss,bandwidth,VSWR,gain of rectangular microstrip antenna with and without DGS.

Table1.Simulated results of return loss, bandwidth,gain,VSWR

Rectangular microstrip antenna	Return loss(dB)	Gain (dB)	Bandwidth (MHz)	VSWR
Without DGS	-21.3	3.9	55.5	1.882
With theta slot DGS	-25.62	3.655	80	1.279

From table1,we can observe that the performance of the antenna is improved by inserting a theta slot DGS on the ground plane.The return loss is reduced from -21.3 dB to -25.62 dB due to which the performance of the antenna in terms of bandwidth is enhanced from 55.5 MHz to 75 MHz. As there is a reduction in the reflection coefficient, most of the power will be radiated from the patch and there will be a small amount of reflected waves that were returned back to the source. The rectangular microstrip patch antenna with theta slot DGS is operating in the frequency band of 2.4150 GHz to 2.4950 GHz which find its application in wireless communication.

4 Conclusion

In this work,the rectangular microstrip antenna is designed and simulated using HFSS at an operating frequency of 2.4 GHz.The bandwidth of the antenna is improved by inserting a theta slot DGS on the ground plane.The simulation results shows that there is an improvement in bandwidth from 55.5 to 80 MHz when the theta slot

defect is introduced on the ground plane.The return loss is reduced to -25.62dB from -21.3 dB due to the theta slot defect This antenna with theta slot DGS can be used for wireless applications.

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