IOSR Journal of Electronicsl and Communication Engineering (IOSR-JECE)
ISSN: 2278-2834-, ISBN: 2278-8735, PP: 46-50
www.iosrjournals.org

Design & Simulation of Circular Microstrip Antenna with Defected Ground Structure (DGS) for WLAN Applications

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Abstract: In this paper, a circular microstrip patch antenna with Defected Ground Structure (DGS) has been analyzed and simulated for the WLAN applications. The proposed antennas have been simulated at 2.45 GHz frequency using co-axial feeding technique. Actually, we design two circular microstrip antennas i.e. conventional CMSA and CMSA with L-shape DGS. These antennas are simulated by the High Frequency Structure Simulator (HFSS). For study purpose we analyze the proposed antennas and simulated results compared on bandwidth, return loss, VSWR and radiation pattern. The resultant antenna with Lshape DGS has improved in parameter performance mostly in enhancement in Bandwidth (B.W.).
Keywords: Circular Microstrip Antenna (CMSA), Defected Ground Structure (DGS), High Frequency Structure imulator (HFSS) v 11.

I. INTRODUCTION

Communication play important role in worldwide society now days and the communication system are rapidly switching from wired to wireless. The telecommunication always tries to reach the best performances, the reliability and the efficiency with the lowest possible costs. In this domain, antennas establish a basic element allowing the transmission of the electromagnetic waves in free space. We find several types of antennas which different by cuts, geometrical shape, capacity of transmission. A Microstrip patch antenna is a type of antenna that offers a low profile, i.e. thin and easy manufacturability, which provides a great advantage over traditional antennas.

Patch antennas are planar antenna used in wireless links and other microwave applications. The Microstrip technique is a planar technique used to produce lines conveying signals and antennas coupling such lines and radiated waves. A patch is typically wider than a strip and its shape and dimension are important features of the antenna. Microstrip antennas are particularly suitable when we use microstrip patch antenna the problems which will occurs are high loss and surface waves in the substrate layer, as the losses will always occur in the radiation as the antenna is transmitting the signals. Microstrip patch antennas are probably the most widely used type of antennas today due to their advantages such as light weight, low volume, low cost, compatibility with integrated circuits and easy to install on the rigid surface. Furthermore, they can be easily designed to operate in dual-band, multi-band application, dual or circular polarization. They are important in many commercial applications. But, microstrip patch antennas inherently have narrow bandwidth and bandwidth enhancement is usually demanded for practical applications, so for extending the bandwidth many approaches have been utilized.We design circular microstrip antenna using the dielectric constant of substrate FR4 Glass Epoxy is 4.4 with 50 micron copper thickness, FR4 epoxy for microstrip antennas at different frequencies (2, 4, 6, 8and 10GHz). FR4 has been chosen for this study because of its low cost and convenient availability hence can be used for microstrip antenna array prototyping.

DGS is realized by introducing a shape defected on a ground plane thus will disturb the shielded current distribution
depending on the shape and dimension of the defect .The disturbance at the shielded current distribution will influence the input impedance and the current flow of the antenna. It can also control the excitation and electromagnetic waves propagating through the substrate layer. The losses are due to the surface wave excitation will cause decrease in the antennaefficiency, gain and the bandwidth because when surface waves occur, it can extract total available power for radiation to space wave. Thus the microstrip antenna without DGS, the bandwidth is narrow and the return loss is high. On the other hand, microstrip antenna with DGS will provide higher operating bandwidth and less return loss. Therefore, the DGScan be integrated onto the ground plane for increased in bandwidth.

There are different feeding techniques for designing microstrip antenna. We used co-axial feeding technique which
is mostly used for proper impedance matching at 50Ω.

II.ANALYSIS OF CIRCULAR MICROSTRIP ANTENNA

The actual radius of the circular patch can be obtained by

$$a = \frac{F}{\sqrt{\left\{1+\frac{2h}{F\pi\varepsilon_r}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}}} \quad (1)$$

Where,

$$F = \frac{8.791 \times 10^9}{f_r\sqrt{\varepsilon_r}} \quad (2)$$

The effective radius of the antenna is given by

$$a_e = a\sqrt{1+\frac{2h}{\pi a}\left[In\left(\frac{a}{2h}\right)+1.7726\right]} \quad (3)$$

Where,

f_r = operating frequency

a_e = effective patch radius

a = patch radius

h = thickness of the substrate

ε_r=dielectric permittivity of the substrate

The circular microstrip antenna designed at operating frequency 2.45 GHz, having FR4 substrate with height of 1.59 mm,dielectric constant 4.4 and tan δ=0.02. The radius (a) of circular patch is 16.9mm; also effective radius is 17.41 mm. coaxial feed point is used to excite the antenna, which islocated at the 6.24 mm from patch center to provide impedance matching at the operating frequency. The feed radius is kept 1.12mm as shown in fig.1. We simulate ircular microstrip antenna on HFSS.

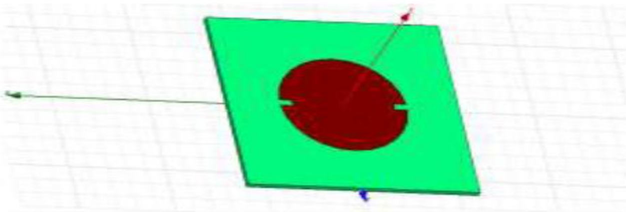

Fig.1: Circular Microstrip Antenna

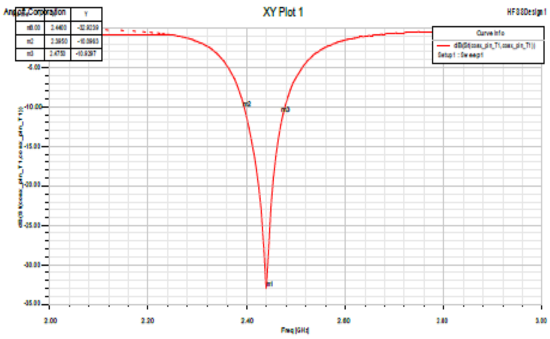

Fig.2: Return loss Plot

Fig.2 shows the return loss plot where at -10 db the higher and lower frequencies are 2.475 GHz and 2.395 GHz also central frequency is 2.44 GHz. The bandwidth calculated at -10 dB equal to 80 MHz corresponds to 3.27%. The structure of rectangular microstrip antenna with return loss S_{11} is equal to -32.9 dB.

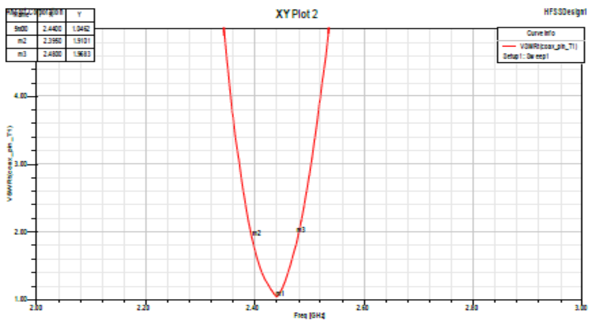

Fig.3: VSWR

Fig. 3 shows the Voltage Standing wave Ratio (VSWR) the results showed that the antenna had an acceptable performance with VSWR ≤ 2.

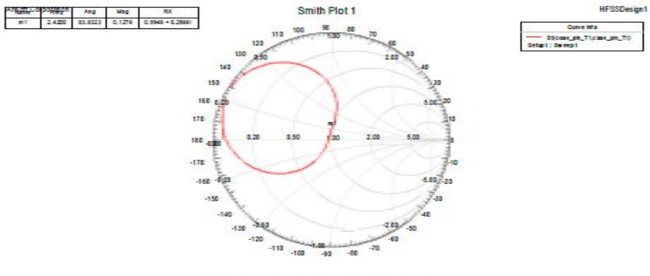

Fig.4: Smith Chart

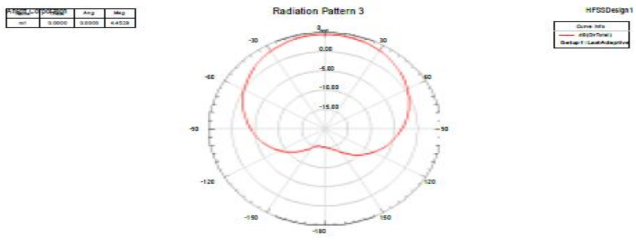

Fig.5: Radiation Pattern

Fig.4 and fig.5 shows the impedance matching of the proposed antenna exhibits good matching at 50 Ω using co-axial feeding technique, and radiation pattern of circular microstrip antenna we measured the gain is 4.45dB.

III.ANALYSIS OF CIRCULAR MICROSTRIP ANTENNA WITH L-SHAPE DGS

DGS is realized by introducing a shape defected on a ground plane thus will disturb the shielded current distribution depending on the shape and dimension of the defect .The disturbance at the shielded current distribution will influence the input impedance and the current flow of the antenna. It can also control the excitation and electromagnetic waves propagating through the substrate layer. The design of proposed patch antenna with DGS is shown in the figure 6.

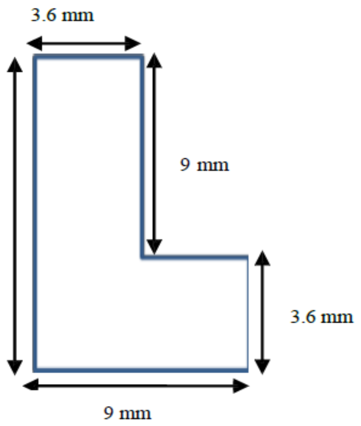

Fig.6: L-shape DGS

Fig.6 shows the design of new L-shaped DGS patch antenna. In this antenna design, a circular patch on the upper plane of the antenna and etched multiple L-shape structure on the ground plane. The dimension of L-shaped DGS as shown in above figure. We simulate circular microstrip antenna with Lshape DGS on HFSS.

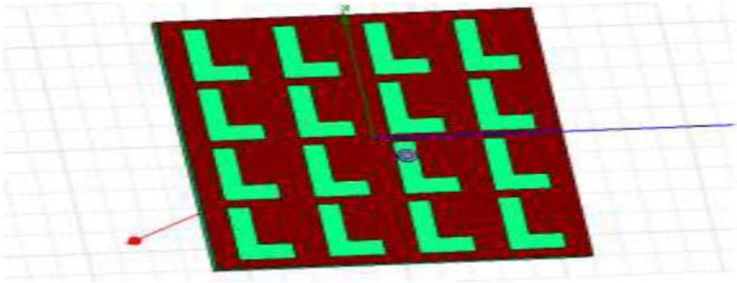

Fig.7: Circular Patch Antenna with L-shape DGS

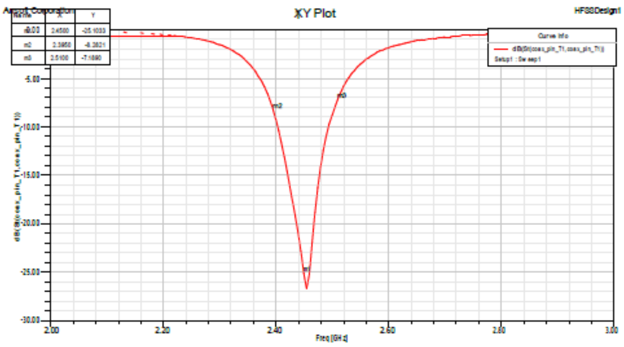

Fig.8 : Return loss Plot

Fig.8 shows the return loss plot where at -10 db the higher and lower frequencies are 2.4938 GHz and 2.4550 GHz also central frequency is 2.4023 GHz. The bandwidth calculated at -10 dB equal to 91.5 MHz corresponds to .727%. The structure of rectangular microstrip antenna with return loss S_{11} is equal to -27 dB.

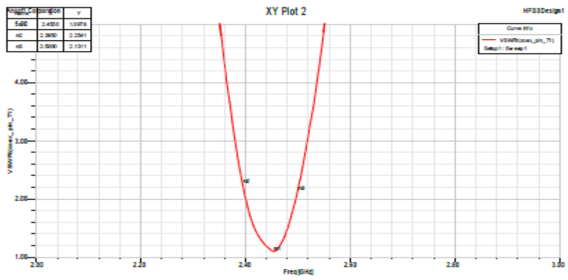

Fig. 9: VSWR

Fig.9 shows the Voltage Standing wave Ratio (VSWR) the results showed that the antenna had an acceptable performance with VSWR ≤ 2.

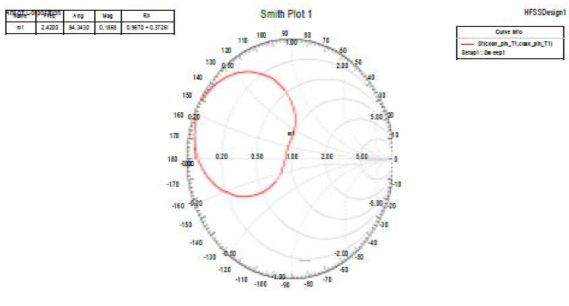

Fig.10: Smith Chart

Fig.10 shows the impedance matching of the proposed antenna exhibits good matching at 50 Ω using co-axial feeding technique

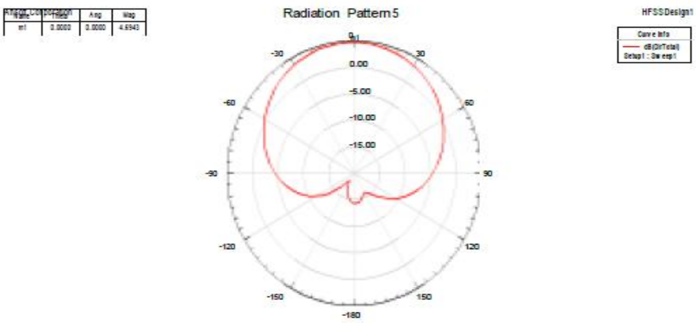

Fig.11: Radiation Pattern

Measured gain is 4.69dB from radiation pattern of circular microstrip antenna with L-shape DGS.

IV.RESULTS

Table 1. Comparision between CMSA and CMSA with L-shape DGS at 2.45 GHz

Parameters	CMSA	CMSA with L-shape DGS
Bandwidth (MHz)	80	91.5
Bandwidth (%)	3.27	3.72
Return loss (dB)	-32.9	-27
VSWR	1.12	1.09
Gain (dB)	4.45	4.69

IV. CONCLUSION

This study provided an insight in determining the performance of circular microstrip antenna with and without DGS.Abroaden the impedance bandwidth and gain of a conventional circular microstrip antenna using coaxial feeding techniqueswith dielectric substrate as FR4_expoxy,. By this new impedance bandwidth enhancement method, bandwidth is increased from 80 MHz to 91.5 MHz, yielding 3.727%bandwidth enhancement when compared with that of the circular microstrip antenna design. From the results presented it is observed that circular microstrip antenna with DGS using in wireless applications such as wireless local area network (WLAN) has been demonstrated.

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