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Design of Compact Microstrip Patch Antenna with DGS Structure for WLAN & Wi-MAX Applications

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ABSTRACT

This paper present the design and performance of a microstrip fed circular patch antenna with defected ground plane. The overall size of antenna is 35mm × 30 mm × 1.59 mm. The proposed antenna is simulated by applying CST Microwave Studio simulator. This antenna provides broad impedance bandwidth of 2.70GHz (2.30 GHz – 5.01 GHz) with flat gain (close to 3dBi) in the desired frequency range. This antenna may be proved a useful structure for modern wireless communication systems include WLAN and Wi-Max bands as well as in lower band of ultra wideband (UWB) communication system.

Key words: WLAN & Wi-MAX band, CST simulation simulator, radiation patterns, gain

INTRODUCTION

The IEEE allocated three WLAN bands namely 802.11, 802.11b and 802.11g for 2.4 GHz operations and 802.11a band for 5-GHz operation. A high-speed 802.11n WLAN has been also offered for operation in both 2.4 GHz and 5 GHz bands [1-2]. Now days, Communication apparatus are compact in size and hence compact antennas with improved performance are required for these communication apparatus. Printed patch antennas have proved very useful tool due to compact size, light weight and low profile. A number of papers can be found in open literature in which the application of patch antenna as an optimum tool for various modern communication systems such as mobile communication, WLAN and Wi-Max is discussed [3-4]. But the main drawbacks of these patch antennas are narrow bandwidth, low gain and low power handling capacity. The efforts have been made to improve the performance of this type of antenna. Looking these advantages extensive efforts were made to improve their limitations [5-6].

Defected Ground Structure (DGS) is one of the methods which is used to enhance the bandwidth of the patch antennas. In 1999, Kim et al and park at el simply used a unit cell of dumbbell shape to achieve considerable stop band in C and X-bands for a microstrip line and in their introductory paper [7-8], they called it a ‘PBG unit structure.’ In their subsequent article [9], the same structure was termed as ‘Defected Ground Structure’ (DGS). With introduction of defected ground structure, depending on the shape and dimension of the defect, performance of antennas is further improved [10]. These defected ground planes may also control electromagnetic waves propagating through the substrate layer.

In the proposed work, a circular patch antenna with finite ground plane is modified with DGS structure to get much improved performance not only in terms of impedance bandwidth but also in terms of gain. The design analysis and performance of antenna with and without modification are presented in the next section.

ANTENNA DESIGN & ANALYSIS

The proposed antenna started with conventional circular patch antenna(overall size 35mm*30mm) with patch radius 13.0 mm which is designed on Glass Epoxy FR-4 substrate having relative permittivity εr = 4.4, substrate height h = 1.59 mm and loss tangent = 0.025. These dimensions were selected to design an antenna to resonate in the frequency band allocated for the lower band for WI-Max applications. We applied a 50ohm microstrip line having length 7.0 mm and width 4.6 mm for feeding purpose. In the first stage, a microstrip fed circular antenna with finite ground plane as shown in Fig.1a & 1b is simulated using CST Studio suite 2013 [11].

The simulation results shown in Fig. 2 indicate that antenna resonates effectively at frequency 6.13 GHz. The bandwidth presented at this frequency is very narrow (~3.8%), while gain of antenna is very low. The simulation results provide higher resonance frequency value than desired. Therefore this antenna in its present form needs further modification to find possible application in modern wireless communication systems.

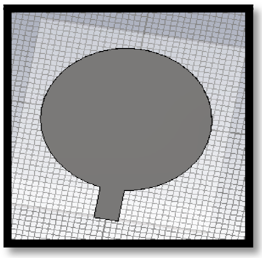

Fig.1a Front view of proposed antenna

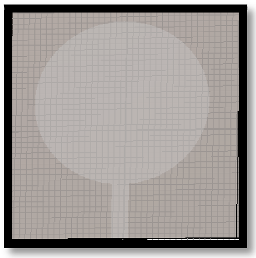

Fig. 1b Rear view of proposed antenna

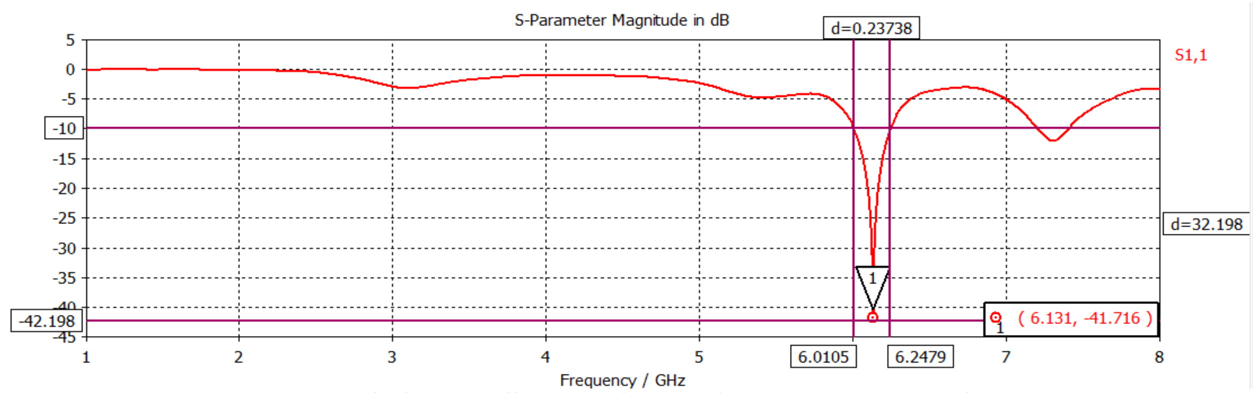

Fig. 2 Simulated variation of reflection coefficient with frequency for proposed antenna with finite ground plane

This antenna is further modified by using DGS technique, it is realized that defect in ground plane further modifies the performance of antenna to a larger extent [12-13]. A triangular slot of base length 20mm & height 18mm is applied in it as shown in fig. 3 (a-b). With introduction of this triangular slot, the current in ground plane gets modified and that change in turn improves the performance of antenna. For further improvement in antenna performance, an additional triangular notch is introduced in ground plane having base length 10mm and height 4mm. With these modifications; an additional resonance frequency close to 4.36 GHz is realized with further improvement in gain as well as in bandwidth values of antenna.

The return loss curves shows that modified antenna is resonating at two frequencies 2.70GHz and 4.36 GHz as shown in Fig. 4 and provides impedance bandwidth close to 2.70GHz or ~70% with respect to frequency 3.85 GHz. Fig. 5 depicts the simulated variation of gain with frequency for proposed structure. The maximum gain achieved in this case is close 3.22dBi with respect to frequency 3.47GHz which is improved considerably from previous case.

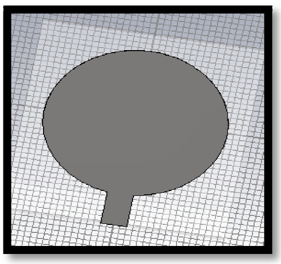

Fig. 3a Front view of modified proposed antenna

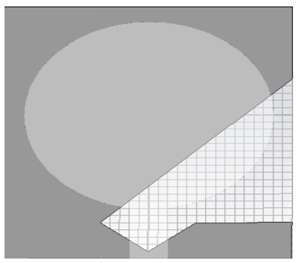

Fig. 3b Rear view of modified proposed antenna

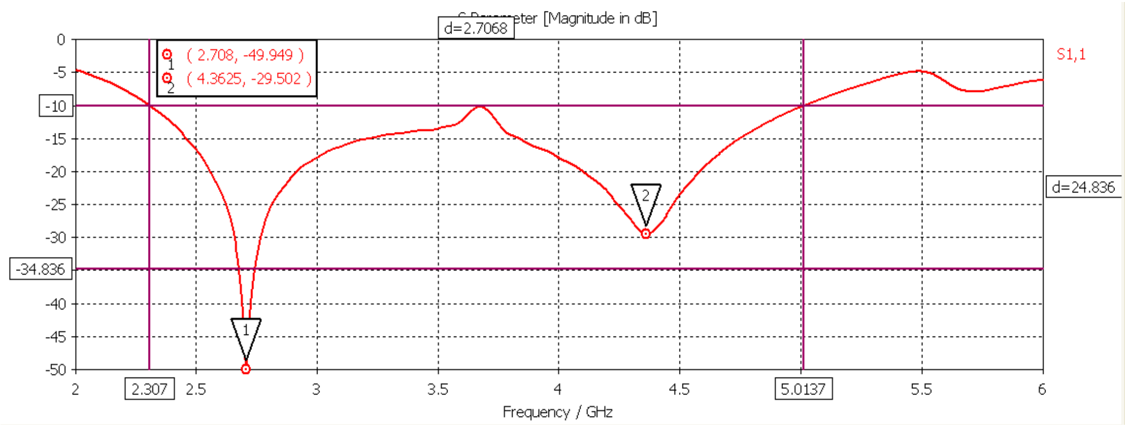

Fig. 4 Simulated variation of reflection coefficient with frequency

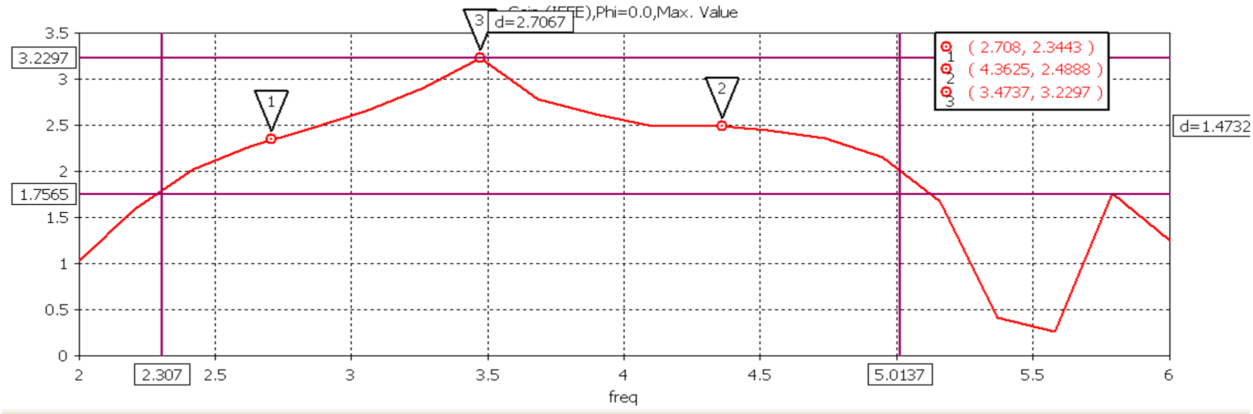

Fig. 5 Simulated variation of gain with frequency

RESULTS ANALYSIS

The strip line fed circular patch antenna with defected ground plane provides much improved impedance bandwidth ~2.70GHz or 70% with respect to central frequency 3.85 GHz as shown in Fig.4.The proposed antenna resonates at two frequencies namely 2.70 GHz and 4.36 GHz. The first frequency may be used for lower band in Wi-Max communication systems while the second frequency is suitable for lower band of UWB communication systems. The variation of gain of antenna as a function of frequency is shown in Fig. 5 indicates that gain of antenna in the operating frequency range is almost flat. The maximum gain of antenna is close to 3.22 dBi at frequency 3.47GHz. E and H plane radiation patterns of antenna at two resonant frequencies are shown in Figs. 6a – 6d. Fig. 6a indicates that antenna is radiating more power in back direction. However patterns are almost omni directional, three figures have dumble shape which suggests that radiation pattern resembles with that of a dipole antenna.

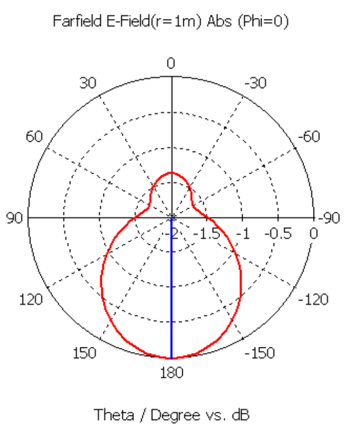

Fig. 6a E plane(Phi=0) radiation pattern at resonant frequency 2.70GHz

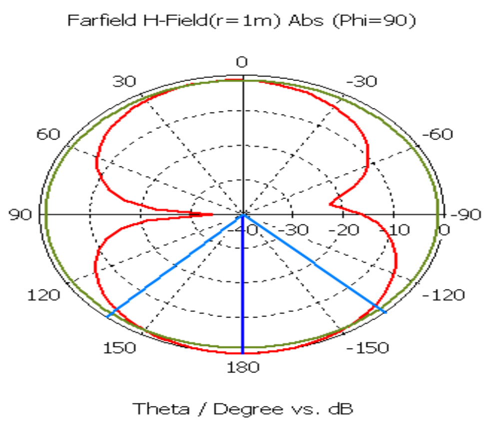

Fig. 6b H plane(Phi=90) radiation pattern at resonant frequency 2.70GHz

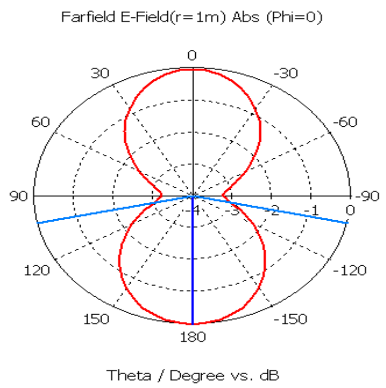

Fig. 6c E plane(Phi=0) radiation pattern at resonant frequency 4.36GHz

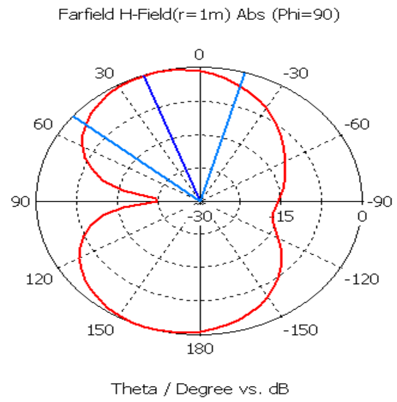

Fig. 6d H plane(Phi=90) radiation pattern at resonant frequency 4.36GHz

CONCLUSION

Circular patch antenna with defected ground structure provides broader bandwidth (~2.70GHz), desired VSWR (2:1) and nearly flat gain in desired frequency range in comparison to a conventional circular patch antenna. The maximum gain of antenna is close to 3.22dBi. The effect of modification of the ground plane of antenna has been successfully investigated. The antenna operates well at two resonance frequencies of operations. This antenna is useful for modern wireless communication systems including in lower band of Wi-Max communication systems and lower band of UWB communication systems.

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