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Miniaturized Microstrip Patch Antenna Array at 3.8 GHz for WiMax Application

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Abstract : *The aim of this work is to miniaturize microstrip patch antenna array resonating at 3.8 GHz suitable for WiMax application using defected ground structure (DGS).The DGS has been employed to shift the resonance frequency of an initial microstrip antenna array from 5.2 GHz to 3.8 GHz by disturbing the antenna's current distribution. The proposed DGS is integrated in the ground plane under the patch antenna array for size reduction. Finally, the miniaturization up to 45% with respect to the conventional microstrip antenna is successfully accomplished. A prototype of the antenna was fabricated with the RT-Duriod substrate. This technique has been validated experimentally and measured results were found to be in good agreement with simulated results.*

Keywords *- Microstrip patch antenna array; defected ground structure (DGS); Miniaturization;WiMax*

I. Introduction

The recent wireless communication system requires cost effective, high quality and miniaturized antenna devices with improved characteristics. In the recent past, the performance of the microstrip patch antenna is extensively developed and analyzed for various practical applications. Microstrip antenna used widely in wireless communication due to their light weight, low profile, low cost, ease of fabrication and cost effective. Efforts were made to design a compact microstrip antenna with a higher percentage of miniaturization, as the demand of small size antennas at low frequency have drawn much interest from researchers [1]. Many studies have been conducted in order to achieve the size reduction such as using a dielectric substrate of high permittivity [4], Defected Microstrip Structure (DMS) [5]. PBG etched on grounded substrate turned to limited numbers of defects, commonly known as a defected ground structure (DGS) [6], or a combination of them. Due to this technique, various effects in the microstrip antenna are observed, which make the antenna to operate in the lower frequency band. Mainly DGS is an etched periodic or non-periodic cascaded configuration defect in the grounds of a planar transmission line (e.g., microstrip, coplanar and conductor backed coplanar waveguide) which disturbs the shield current distribution in the ground plane because of the defect in the ground. The defect geometry is easy to implement and does not need a large area. These features enable such structures to acquire a great relevance in microwave circuit design [3]. In particular, DGS is employed to design microstrip antennas for different applications, as, for instance, cross polarization, mutual coupling reduction in antenna arrays and harmonic suppression. Moreover, DGS has been widely used in the development of miniaturized antennas [7].
In this paper new shaped DGS is used to design a miniaturized microstrip patch antenna array as compared to conventional one, resonating at 3.8 GHz suitable for worldwide interoperability for microwave access (WiMAX) GHz application [12]. Initially, the proposed antenna resonates at 5.2 GHz. DGS is employed to shift the resonance frequency to 3.8 GHz. Finally, the size reduction about 45% without much degrading the antenna performance is carried out and also compared with the conventional one.

II. Microstrip patch antenna array without DGS

The proposed 2 by 1 element array microstrip patch antenna is shown in Fig.1. In this design, the substrate RT-Duroid was used due to its advantages. The substrate of height 0.762 mm with dielectric constant of 2.2 and the loss tangent 0.0004 was used. The dimensions of the antenna were optimized by using CST Microwave Studio tool. On the top of the substrate, a metal patch with dimension Lp =18.6 mm and Wp =22.80 was connected to 50 ohm feed line with an insect. The dimension of insect feed were Li=11 mm and Wi =2.3 mm. The simulation result of reference antenna is shown in Fig. 2. The radiation plot is shown in Fig.3. The design and simulation of the reference antenna have been carried out using full wave EM simulator CST Microwave Studio. Fig. 2 shows [S11] dB of the antenna without any DGS in ground plane resonates at 5.2 GHz with the gain 10.2 dBi.

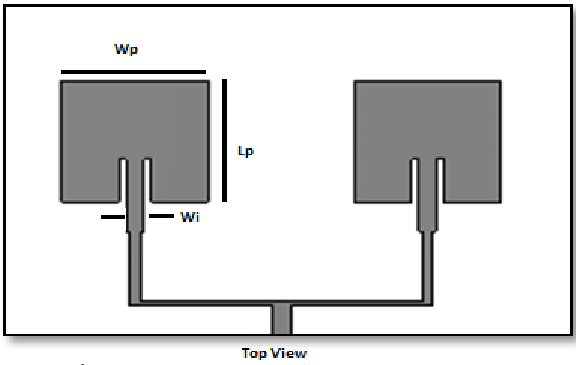

Fig 1: Referance 2 by 1 Element array antenna without DGS

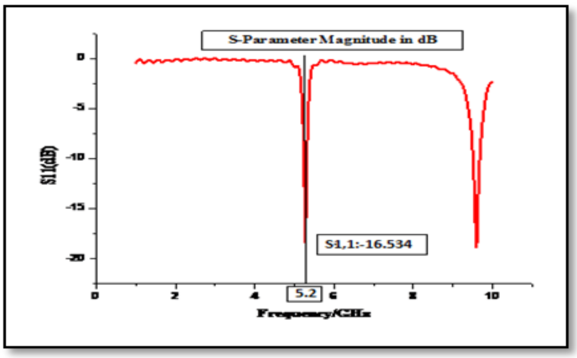

Fig 2: Simulated S11 versus frequency indicating fundamental resonant frequency

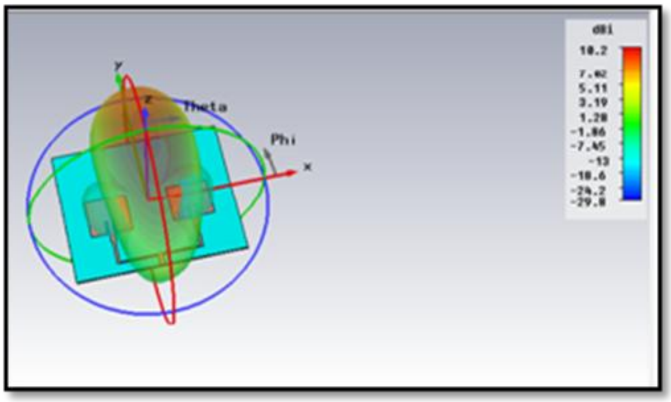

Fig. 3 Radiation pattern without DGS at 5.2GHz.

III. Microstrip patch antenna array using DGS

The proposed antenna is shown in Fig.5. In order to shift the resonance frequency of the microstrip antenna array shown in Fig 2.a U-shape dumbbell DGS geometry is etched on the metallic ground plane of the antenna as shown in Fig.4. and Fig. 5 shows the back view for the same antenna.

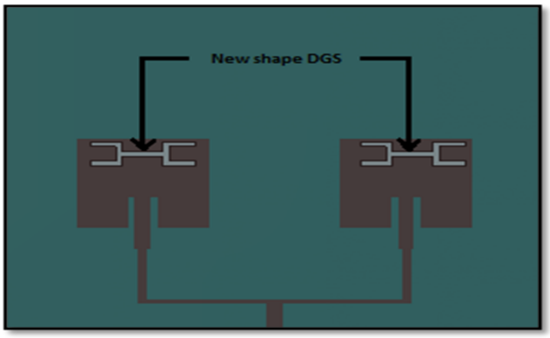

Fig 4: Microstrip 2 by 1 element array antenna with DGS

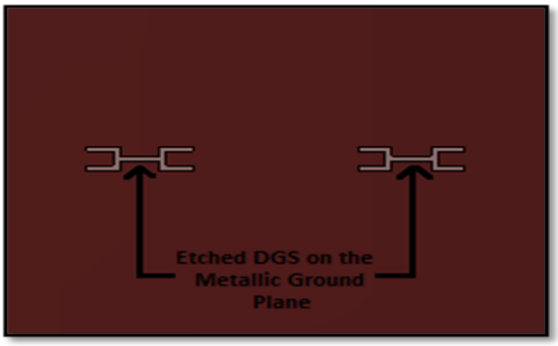

Fig 5: Back-view of Microstrip 2by1 element array antenna with DGS.

DGS is introduced on the metallic ground plane of microstrip patch antenna array. Fig.6 shows the detail geometry with the specified dimensions. Fig.7 shows the antenna performance with DGS. It is observed that the resonance frequency has been significantly influenced by the DGS and it has been shifted to 3.8 GHz. When DGS is introduced in a microstrip antenna, the defect geometry etched in the ground plane disturbs its current distribution [9]. This disturbance affect the transmission line characteristics, such as the line capacitance and inductance. In other words, introducing DGS in a microstrip antenna can result in an increase in the eff ective capacitance and inductance [7] which influences the input impedance and current flow of the antenna and thus reducing its size [6] with respect to a given resonance frequency.

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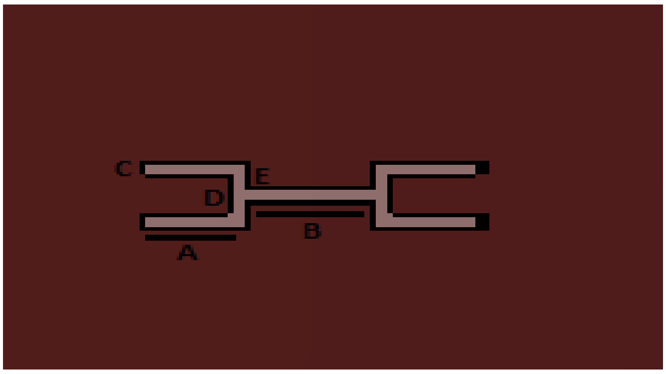


Fig.6:U-shape dumbell DGS geometry (A=E=4mm,D=3,C=0.5,B=4)

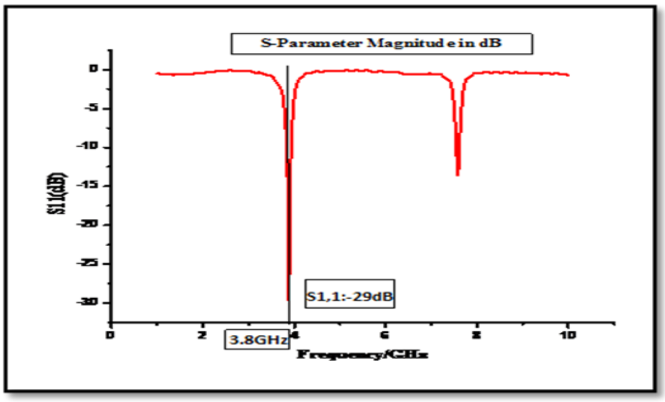


Fig 7: Simulated S11versus frequency indicating a shift in resonance frequency at 3.8 GHz.

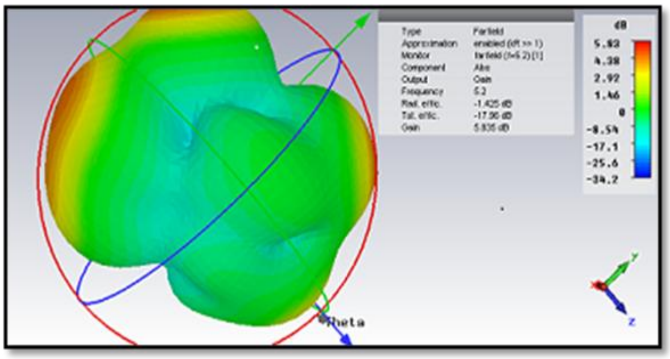


Fig 8: Radiation pattern for the DGS antenna.

Fig 7 indicates that the resonance frequency shifted around 3.8 GHz. Thus Microstrip patch antenna arrays with DGS structure at the shift of the resonance frequency around 3.8 GHz obtaining 45% size reduction was designed. It is also revealed from the result that with miniaturization the gain of the antenna is reduced to 5.94 dBi as shown in Fig.8.This is mainly because, with DGS in the ground plane, the antenna will radiate on both sides of the ground plane due to the aperture effciency resulting in a high back radiation level which explain the maximum gain reduces .This gain decrease is explained by the increase of lateral and longitudinal radiations due to the propagation of surface waves. Namely, these radiations adversely affects the main lobe power, and therefore a reduction of the gain is produced [7,8].

IV. Fabrication and Measurement

A prototype of designed microstrip patch antenna array without DGS and with DGS was fabricated as reference antenna and proposed antenna respectively. RT-Duroid substrate with relative dielectric constant 2.2 and the thickness 0.762 mm was used. Fig 9 shows the size of regular rectangular microstrip patch antenna array without DGS. Fig.10 (a) and (b) shows the size of the top and back view, respectively, of regular rectangular microstrip patch antenna array with DGS. In order to measure the various parameters of the antenna, the MS2028C vector network analyzer was employed with frequency range limited to 20 GHz. Thus S11 parameter was measured and compared to the simulated result. Fig.11 shows the comparison between measured and simulated results of microstrip patch antenna array with DGS structure. Experiment shows an excellent agreement of the measured result with the simulated result.

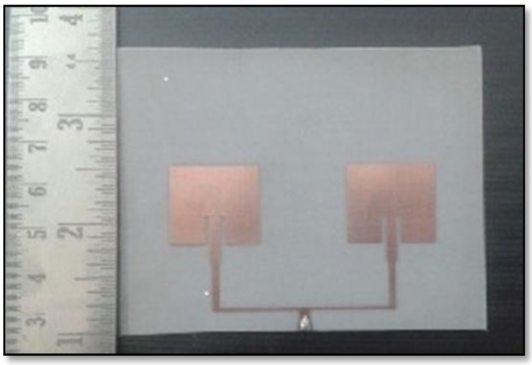
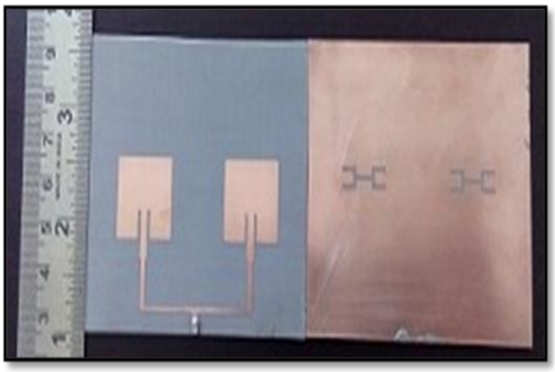


Fig. 9. Prototype of the fabricated 2by1 element regular rectangular microstrip patch antenna array without DGS



(a) (b)

Fig 10. Prototype of the fabricated (a) 2by1 element regular rectangular microstrip patch antenna array with DGS
(b) Back view with tched DGS

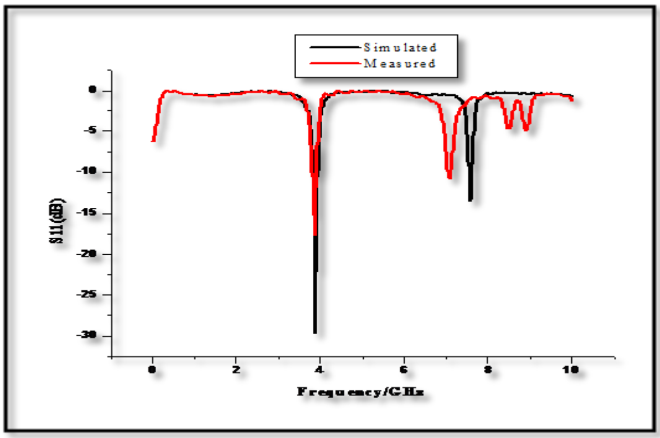


Fig 11. Measurement and simulation result of regular rectangular microstrip patch antenna array with DGS (resonating at 3.8 GHz)

V. Result and Discussion

Initially, an antenna without DGS was simulated which resonates at 5.2 GHz and with metal patch dimension Lp=18.6 mm and Wp=22.80 mm. Later the new structure was simulated with U-shape dumbell DGS etched on the metallic ground plane with same metal patch dimension Lp=18.6 mm and Wp=22.80 mm resonating at 3.8 GHz. DGS in a microstrip antenna result in an increase of the effective capacitance and inductance [8] which influences the input impedance and current flow of the antenna and thus reducing its size with respect to a given resonance frequency of the antenna. The maximum size reduction about 45% is achieved.

VI. Conclusion

The miniaturization procedure initiated with a typical rectangular patch shape array antenna with DGS gives size reduction up to 45%. As the resonance frequency of the initial antenna without DGS has been shifted from 5.2 GHz with the gain 10.2 dBi resonates at -16.53 dB to 3.8 GHz resonates at -29 dB with the gain 5.94 dBi suitable for WiMax application. In this way we have been able to reduce the antenna size up to 45% as compared to a conventional antenna without much degrading the performance of antenna.

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