COMPACT MICROSTRIP PATCH ANTENNA ARRAY WITH DEFECTED GROUND STRUCTURE FOR WIMAX AND UAV APPLICATION

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Abstract- This paper presents a new miniaturized microstrip patch antenna array with defective ground structure at a centre frequency 3.8 GHz for WiMax and UAV application. The proposed DGS is integrated in the ground plane of the patch antenna array for size reduction. Finally, the resonance frequency of an initial microstrip antenna array shift from 5.2 GHz to 3.8 GHz and without much degrading the antenna performance miniaturization up to 45 % with respect to conventional microstrip antenna is successfully accomplished. A prototype of the antenna was fabricated with the RT- Duroid substrate. This technique is validated experimentally and measured results were in good agreement with simulated results.

Keywords- Microstrip Patch Antenna Array, Defected Ground Structure (DGS), Miniaturization, Wimax.

I. INTRODUCTION

Recent wireless communication system requires cost effective, high quality and miniaturized antenna devices with improved characteristics due to the increase in data rates and a trend of miniature electronics circuits. Microstrip antenna is attractive choice for wireless communication due to their light weight, low profile, low cost, ease of fabrication and cost effective. Microstrip single element antenna has several advantages however it also has few disadvantages such as narrow bandwidth, low efficiency, low gain and low directivity. Microstrip patch antenna arrays can overcome these disadvantages and made the antenna useful for various applications [1]. In the recent years as the demand of compact antennas at low frequency have increased, many efforts were made to design compact microstrip antenna with higher percentage of miniaturization [2]. Many miniaturization techniques, such as size reduction using a dielectric substrate of high permittivity [3], Defected Microstrip Structure (DMS) [4], PBG etched on grounded substrate turned to limited numbers of defects, commonly known as a defected ground structure (DGS) [5], or a combination of them have been proposed. Due to this technique various effects in the microstrip antenna are observed which make the antenna to operate at lower frequency band.
Unmanned Aerial Vehicle (UAV) has gain an immense popularity among researchers due to its surveillance, reconnaissance and sensing application. The antenna used in UAV should be low profile, compact and directional [6]. The present work deals with design and analysis of compact microstrip patch antenna array using DGS for WiMax and
UAV application. Initially the proposed antenna resonates at 5.2 GHz and then by integration of two defects in ground plane, the microstrip rectangular patch antenna array is made to resonant at 3.8 GHz without much degrading the antenna performance. Thus compact antenna with the size reduction of 45% compared with the convectional one is carried out in this work.

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 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.

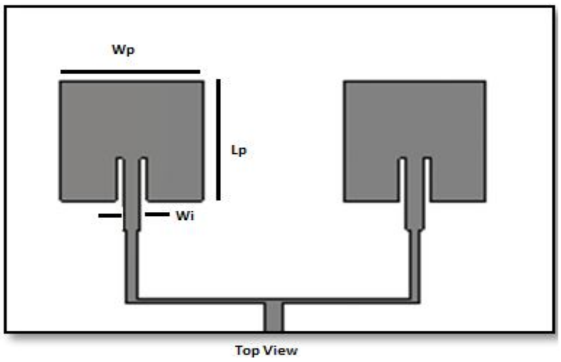


Fig 1:Referance 2 by 1 Element array antenna without DGS

The dimension of insect feed were Li=11 mm and Wi =2.3 mm. whereas the standard microstrip line 1:2 power divider is used to feed the two antennas and hence the line width are adjusted according to the power division. 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 has been carried out using full wave EM simulator CST microwave studio. Fig. 2 shows [S_{11}] dB of the antenna without any DGS in ground plane resonates at 5.2 GHz with the gain 10.2 dBi.

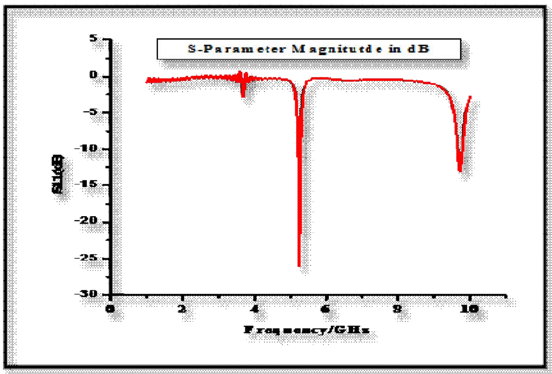


Fig 2: Simulated S_{11} versus frequency indicating fundamental resonant frequency

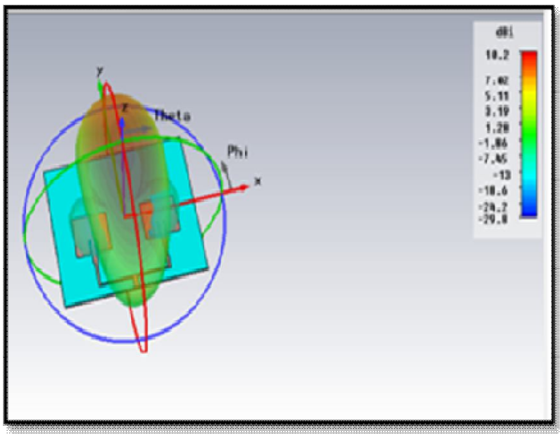


Fig. 3 Radiation pattern without DGS at 5.2GHz

III. MICROSTRIP PATCH ANTENNA ARRAY USING DGS

The proposed antenna is shown in Fig.4. In order to shift the resonance frequency of the microstrip antenna array as shown in Fig 2, two identical swastik shape DGS with one slot are introduced in ground plane. Fig.5 shows the detail geometry of etched swastik shape DGS with the specified dimensions. Fig.5 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 resonates at -32.5dB. When DGS is introduced in a microstrip antenna, the defect geometry etched in the ground plane disturbs its current distribution [7]. This disturbance affects 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 effective capacitance and inductance which influences the input impedance and current flow of the antenna and thus reducing its size with respect to a given resonance frequency [8].

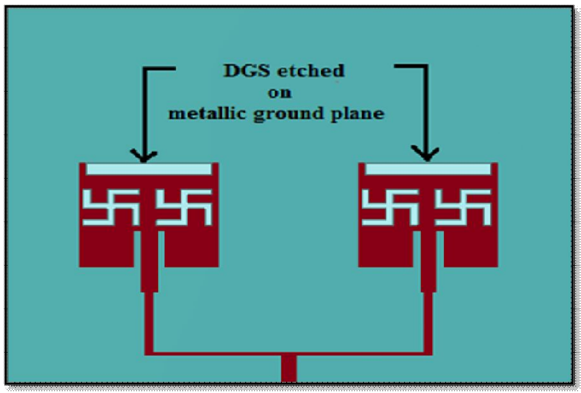


Fig. 4 Microstrip 2 by 1 Eelement array antenna with DGS

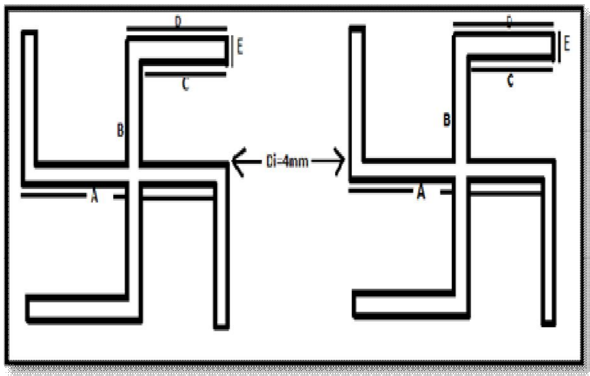


Fig. 5 Swastik shape DGS Geometry (A=8mm, B=8mm, C=3.5mm,D=4mm, E=1mm, Di=4mm)

Fig.6 indicates that the resonance frequency shifted around 3.8 GHz. Thus the Microstrip patch antenna array with DGS structure at the shift of resonance frequency around 3.8 GHz obtaining 45% size reduction was designed.

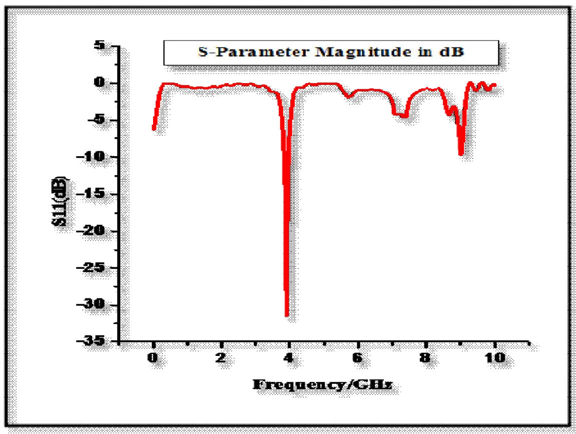


Fig. 6 Simulated S_{11}versus frequency indicating shift in resonance frequency at 3.8 GHz.

It is also revealed from the result that with miniaturization the gain of the antenna is reduced to 8.38 dBi as shown in Fig.7. However the gain of the reference antenna without DGS is 10.2dBi.

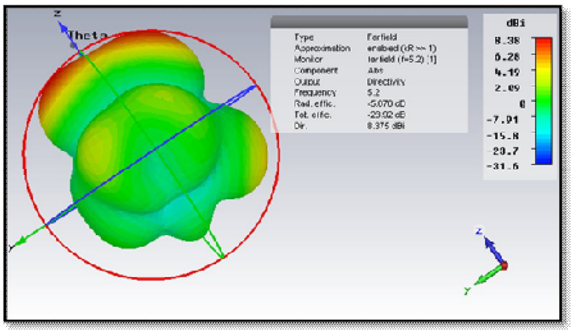


Fig. 7 Radiation pattern for the DGS antenna

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 efficiency resulting in high back radiation level which explain the maximum gain reduce. Indeed one of the major problems in microstrip antenna applications is to reduce the size by keeping antenna at good performance[8]. However, this miniaturization is at the cost of gain of the antenna. Whereas the proposed antenna with the etched DGS gives 45% of size reduction with very minimum reduction in gain and better impedance matching compared with the conventional one suitable for UAV and WiMax application.

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 8 shows the size of regular rectangular microstrip patch antenna array without DGS. Fig.9 (a) and (b) shows 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, 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 simulated result.

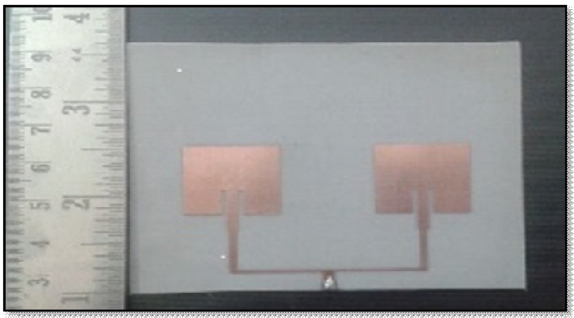
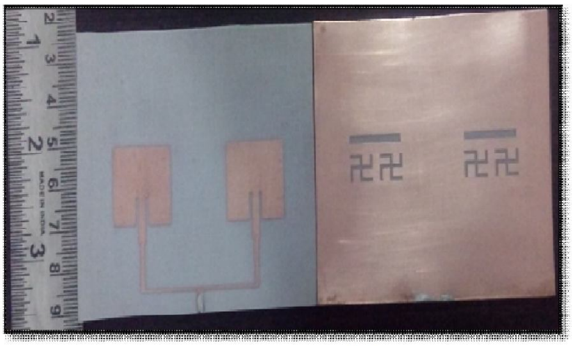


Fig. 8 Prototype of the fabricated 2by1 element regular rectangular microstrip patch antenna array without DGS



(a) (b)

Fig. 9 Prototype of the fabricated (a) 2by1 element regular rectangular microstrip patch antenna array with DGS (b) Back view with etched DGS

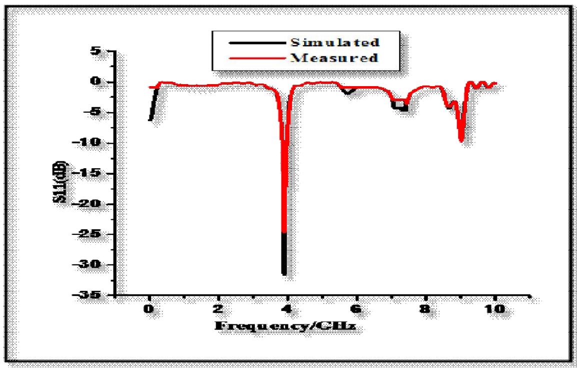


Fig.10 Measurement and simulation result of regular rectangular microstrip patch antenna array with DGS (resonating at 3.8 GHz)

CONCLUSIONS

The paper proposed compact rectangular shape patch antenna array with swastik and slot shape DGS structure for WiMax and UAV application. This antenna gives good performance even after 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 -32.5 dB with the gain 8.38 dBi .In this way we have been able to reduce the antenna size up to 45% as compared to conventional antenna without much degrading the performance of antenna mostly suitable for WiMax and UAV application.

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