Design and Analysis of Microstrip Rectangular Patch Antenna With Defect Ground Structure For Wi-Max Applications

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Abstract:***In this paper, twoantennas; one is linearly-polarized microstrip patch antenna and other having defected ground structure in it,is designed and simulated with using HFSS simulation software for 3.9 GHz. Antenna parameters are examined in this which includesresonating frequency, impedances,VSWR, directivity and gainof the designed and comparative analysis is made with defect ground structure with probe feed. The antenna is proposed for wireless communication applications for WiMax of3.9 GHz provided with one more band for 3.6 GHz. This paper focuses on the designing of microstrip antenna with probe feed and analyses the results like return loss S_{11}, VSWR, impedance,etc. with defect ground structure.***

Keywords: ***Defect Ground Structure, Dual band, Rectangular MicrostripPatchAntenna, 3.9 GHz Antenna,Ground Slot Antenna.***

I. INTRODUCTION

The development of WiMax represented one of the principal techniques in the information technology and communication field. As per the present trends in communication systems has been to develop minimum in cost, profile, weight commonly used dielectric material ofFR4_Epoxy (ε_r=4.4) that are capable of maintaining high performance over a wide spectrum of frequencies [1]. With a simple and easy geometry, microstrip patch antennas provide many advantages not commonly exhibited in other antenna designs. Advantages of these microstrip resonating structures are low profile, lessexpensive, lightweight and easy to fabricate using modern printed circuit board technology, compatible with microwave circuits; and have the ability to match to structures [1]. In addition, once the shape, design and operating mode of the patch are selected, prototype become very selective in terms of operating frequency, return losses, polarization, radiation pattern, gain, VSWR and impedance. This is possible with Microstrip antenna probably exceeds that of any other type of antenna segment [2]. Using the Multi Band microstrip patch antenna concept, in this paper on dual band Microstrip antenna with defect ground structure is designed for 3.6 and 3.9 GHz WiMax application. Ansys HFSStool is used for the simulation of results.

The microstrip patch antenna in its basic mode is supposed to radiate linearly polarized waves. But some degree of orthogonally polarized, known as, cross-polarized (XP) fields has always been associated with main radiations. They are primarily occurring due to higher order modes predominantly over the H-plane [3]–[5]. This cross polarization radiation is a main concern for microstrip antenna arrays as well as single radiating antenna. In the last few decades, various techniques came to handle this issue in which the use of the defected ground structure (DGS) is the most new one. DGS, introduced to reduce XP radiation [6].

In this paper, a pair of shaped defects designs isaligned to the H-plane [6]–[13], which has been strategically inserted in close to the patch boundary. The idea was to use the orthogonally oriented higher modes of wave and, hence, close DGS was a necessary requirement. Because of the nearness, the defects had to be cut near the E-plane to maintain the primary radiation of the rectangular patch. This design is not desirable in some applications, like dual or circularly polarized designs. In this paper, a DGS has been used with a view to increase all of the limitations. The proposed design is basically meant for a rectangular/ square patch, where the defect is introduced surrounding the element maintaining uniform symmetry and considerable spacing from the patch boundary. Thus, the DGS takes a symmetric shape as shown in Fig. 1.

II. ANTENNA DESIGN

In particular, the microstripantenna structure using a defect ground antenna rather than a regular one have become better due dual band for 3.6 and 3.9 GHz applications. However, the design methods of this antenna using the dual-mode

defect ground structures are not common [4]. The design of the conventional rectangular patch antenna as shown in fig. 1 and proposed antenna with defect ground structure is shown in Figure 2, which is designed on aFR4_Epoxy (ε_r= 4.4, tan loss=0.01) substrate with a height of 1.575 mm. The antenna is comprised of a probe feed and a defect ground structure. The antennais of a rectangular patch of 34 x 38 mmas shown in Figure 1The magnitude of the transmission parameter S_{21} for the antenna is calculated by the commonly used electromagnetic simulation softwareHFSS. The radius of probe is chosen to1.3mm with impedance 50 Ω. Proposed design for DGS with parameters

L_p=14.22, ρ=2.45, g=6, w_1=9, a=4, t= 2.89, d=1.3, h=1.575

Finally, the whole size of the antennaincluding ground dimension is 50 x 50 mm [2].

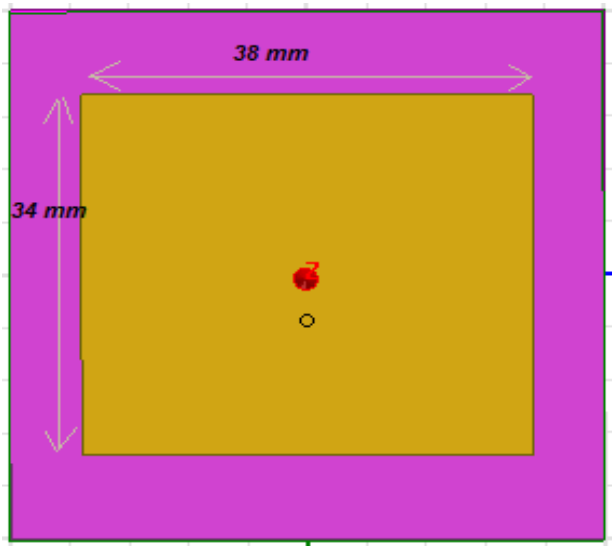

Fig 1 Conventional patch antenna

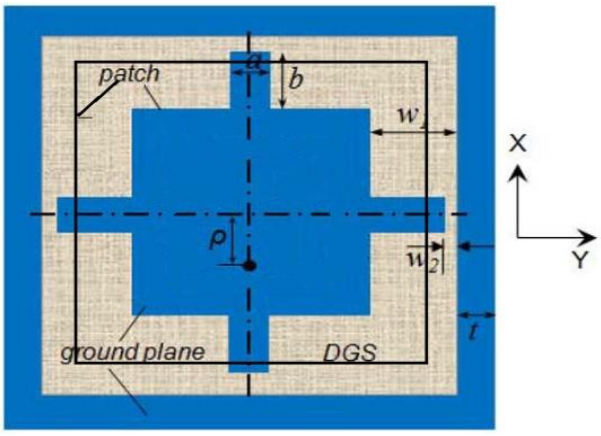

Fig 2 Proposed designs for DGS with parameters

L_p=14.22, ρ=2.45, g=6, w_1=9, a=4, t= 2.89, d=1.3, h=1.575

The simulated results are shown in Figure 4 and 5, i.e., the red line, where two resonant frequencies 3.6 GHz and 3.9 GHz can be clearly distinguished. The resonant frequencies of the MSR (Microstrip Patch with Defect Ground Structure).The selection of the dielectric material (here the Dielectric FR_4Epoxy ε_r=4.4, substrate of thickness 1.575 mm, is used which is common and easily available) is important for the performance characteristics of the patch antenna. Each dielectric material has a specific dielectric constant which affects the output characteristics and desired parameters of the microstrip antenna.

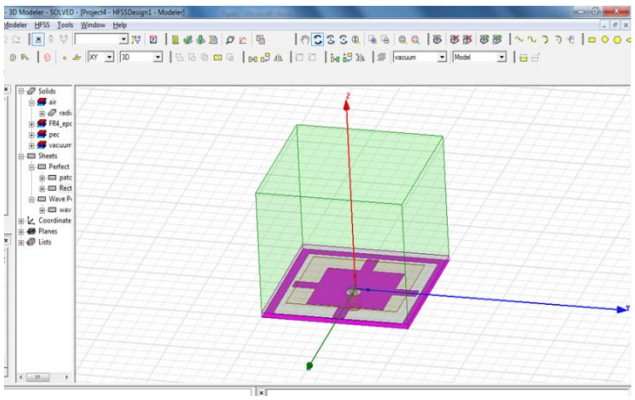

Fig. 3. The configuration of the proposed dual-band defect ground structuremicrostrip antenna

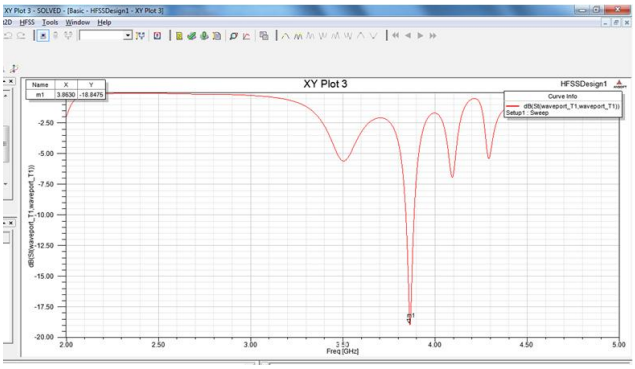

Fig. 4 Return loss for conventional patch antenna at 3.9 GHz

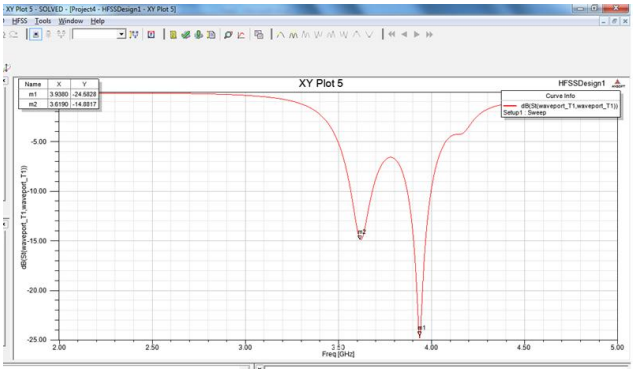

Figure 5 Return loss for conventional patch antenna at 3.9 GHz

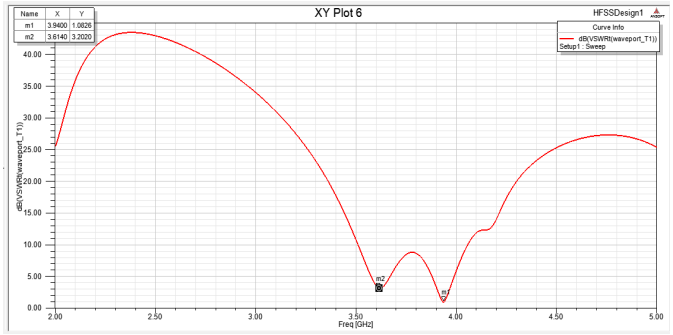

Figure 6 VSWR for proposed antenna

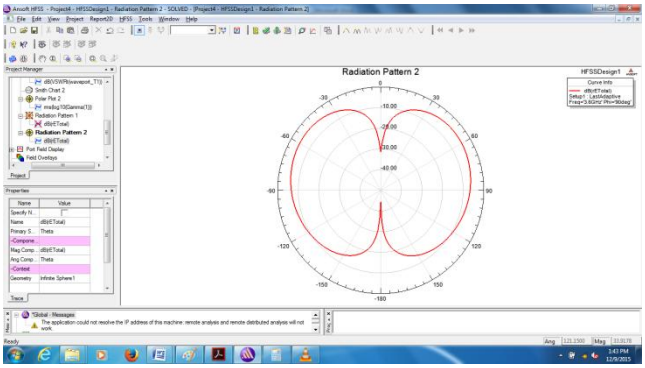

Figure 7. Radiation pattern at 3.6 GHz

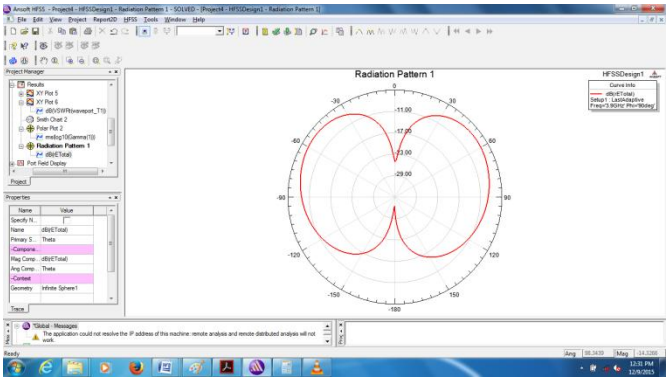

Figure 8. Radiation pattern at 3.9 GHz

III. SIMULATION AND RESULTS

The antenna simulation software HFSS, simulated and measured results of S11 are shown in figure 4 and 5 where two operating frequency bands are obtained for the designed antenna. The antenna exhibits the characteristics of the dual-band operation, i.e a measurement of -14 dB S11 of lower band frequency from 3.6GHz, -24 dB S11 at 3.9 GHz, covering the WiMax application. The outcome of return loss, VSWR and impedance are shown :

TABLE 1 RESULTS

Freq GHz	S_{11} (dB)	VSWR	Impedance (Ω)	Directivity (dBi)	B/W (MHz)
3.6	-14	3.2	50.5	4.47	114
3.9	-24	1.08	51.6	4.04	128

The presence of DGS did not affect the input impedance, which is proved from simulated results. Simulated shows marginal shift downwards compared with the conventional one, which is can be some degree of deviation during fabrications. Measured Radiation patterns, along with the simulated data, are examined in Figs. 7 and 8. Fig. 6 shows the results obtained at 3.6GHz also the center of the operating band of 3.9 GHz. The DGS shows no considerable change in the patterns [13]. Measured peak gain values with DGS are found to be 4.47dBi and 4.04dBi. As expected, the DGS results in as much as -9dB improvement in 3.6 GHz band.

IV. CONCLUSION

We have designed and simulated two band microstrip antenna with defect ground structure which has a resonating frequency 3.6 GHz and 3.9 GHz and the return loss being -14 dB and -24 dB. This proposed dual band antenna has wide application in WiMax of wireless communication. Further optimizations are also possible to achieve required operating frequencies. The unique feature of this microstrip structure antenna is that it is adding one more additional resonating frequency at 3.6 GHz apart from 3.9 GHz conventional patch antenna. This paper presents a geometric configuration for the Microstrip Patch Antenna with defect ground structure for WiMax wireless applications, which provides a mean, to get higher bandwidth and gain without using special techniques [9].

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