

A Novel Miniaturized Antenna for WIMAX Application

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Abstract— In this paper, we present the design of a compact, miniaturized patch antenna for WIMAX application. The conventional patch antenna is designed to resonate at 2.785GHz. The proposed antenna has two rectangular slots etched over the patch near the non-radiating edges. This antenna resonates at a lower frequency of 2.65GHz with a gain of 7.5dB. The percentage of miniaturization is found to be 10.7 %.

Key words: Rectangular microstrip antenna, slots, miniaturization, linear polarization, WIMAX

I. INTRODUCTION

Rectangular microstrip antennas are planar, printed, light weight antennas which find tremendous application in wireless systems. The main drawback of such antenna includes narrow bandwidth and surface waves [1-3]. Many attempts are continuously carried out by researchers to improve the gain and bandwidth of these antennas. Creating slots to miniaturize the patch, to make it suitable for onboard requirement is a traditional technique. Many researchers have created C shaped, E shaped, U shaped slots for miniaturizing such antenna as well as to create broad band and circular polarization [4-11]. In this paper, rectangular slots are created on patch antenna and their results are presented. Further, the paper is organized into five sections; section I starts with Introduction, section II presents the design of conventional patch, section III deals with modified patch antenna, sections IV elaborates all about the results obtained while the last section elucidates about the conclusion.

II. DESIGN OF RECTANGULAR MICROSTRIP PATCH ANTENNA (RMPA)

An Inset fed patch antenna is designed to resonate at 2.785 GHz. The design equations are given below [1]. A flexible substrate with ϵ_r of 2.2 and thickness of 120 mils is used in this modeling. The top view of model is shown in Fig.1.

The patch width is calculated using the following formula

$$W = \frac{c}{2 f_o \sqrt{\frac{\epsilon_r + 1}{2}}} \quad \dots (1)$$

Where c is velocity of light in free space, where f_o is resonant frequency in GHz, ϵ_r is relative permittivity.

The effective dielectric constant is given by

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \sqrt{1 + 12 \frac{h}{w}} \quad \dots (2)$$

Where h is thickness of substrate, w is the width of the patch

The incremental length is calculated as

$$\Delta L = 0.412 h \frac{(\epsilon_{reff} + 3) \left(\frac{w}{h}\right) + 0.268}{(\epsilon_{reff} - 0.268) \left(\frac{w}{h}\right) + 0.8} \quad \dots (3)$$

The patch length in general is given by

$$L = \frac{c}{2 f_o \sqrt{\epsilon_{reff}}} \quad \dots (4)$$

Effective length for a particular resonant frequency is given by

$$L_{eff} = L + \Delta L \quad \dots (5)$$

To calculate the resonant frequency of a patch

$$f_o = \frac{c}{2 \sqrt{\epsilon_{reff}}} \sqrt{\left[\frac{m^2}{L^2} + \frac{n^2}{w^2}\right]} \quad \dots (6)$$

Where m and n are mode numbers along and w respectively. A MATLAB program is developed for calculating the length and width of rectangular microstrip patch antenna – implementing the design equations above.

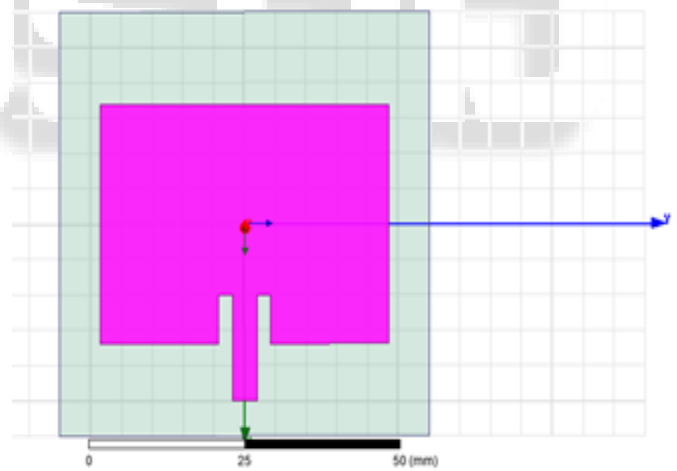


Fig. 1: Microstrip patch antenna model

The antenna resonates at 2.785 GHz with a return loss of -15.77dB as in Fig.2. The gain is found to be 7.5675 dB, which is shown in Fig.3. The pattern is omnidirectional with a difference of -40 dB between co and cross polarization levels.

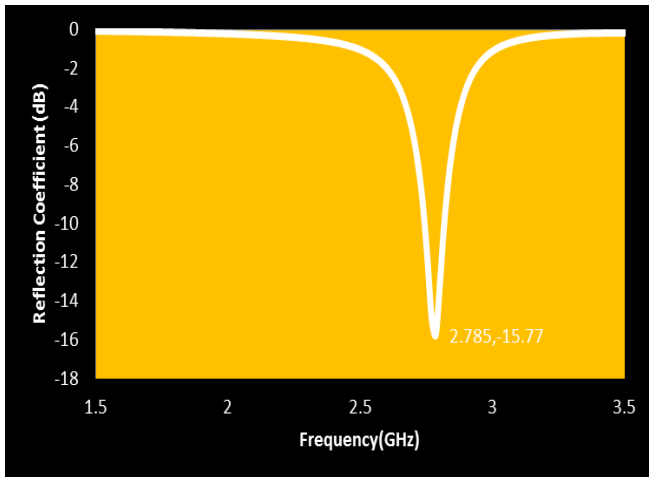


Fig. 2: Return loss characteristics of Conventional patch antenna

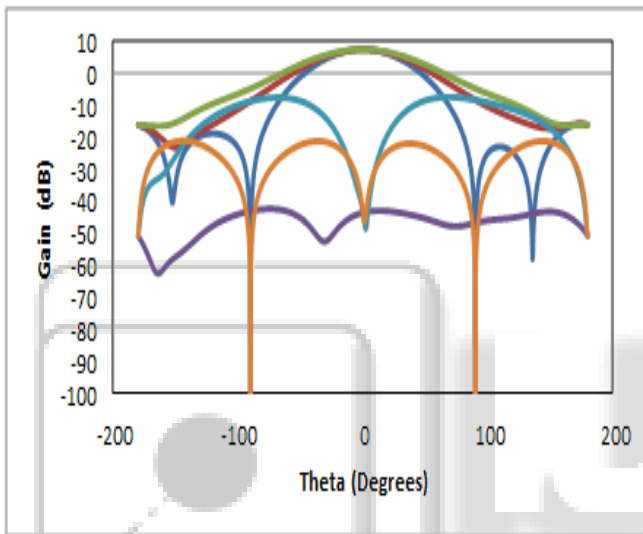


Fig. 3: Gain pattern of Conventional patch antenna

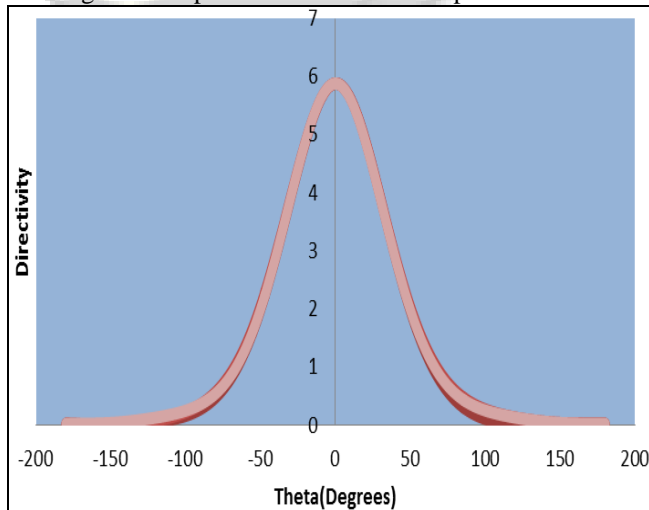


Fig. 4: Directivity of Conventional patch antenna

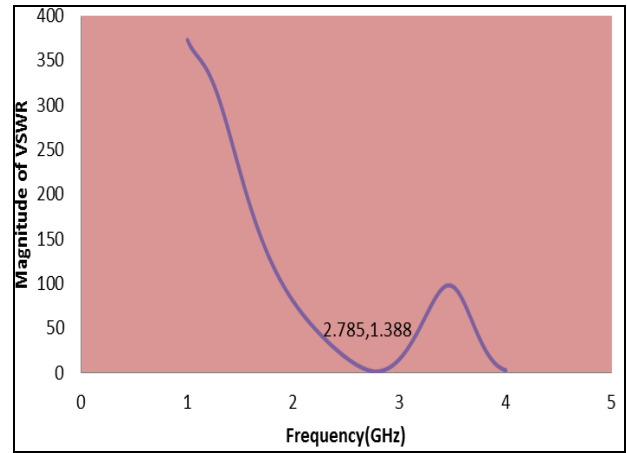


Fig. 5: VSWR of Conventional patch antenna

The directivity is found to be 5.8 while the VSWR is found to be 1.388 at resonant frequency. This can be noted from the Figs. 4-5. The simulated antenna parameters are also tabulated in Table 1 for the sake of clarity.

Antenna Parameter	Value	Unit
Max U	0.45452	W/sr
Gain	7.5675	dB
Radiation Efficiency	99.887%	
Directivity	5.8	
VSWR	1.388	

Table 1: Parameters of Antenna

III. DESIGN OF MODIFIED PATCH

Two rectangular slots of dimensions 10×5 mm are etched on the non-radiating edge of the conventional patch. The proposed patch is targeted for WiMax applications. The resonant frequency varies with respect to the perimeter of the slots. Keeping this in mind the slot dimensions are fixed initially and they are optimized further with the help of e.m simulator for various feed positions. The proposed model and its reflection coefficient characteristics are shown in Figs.6-7.

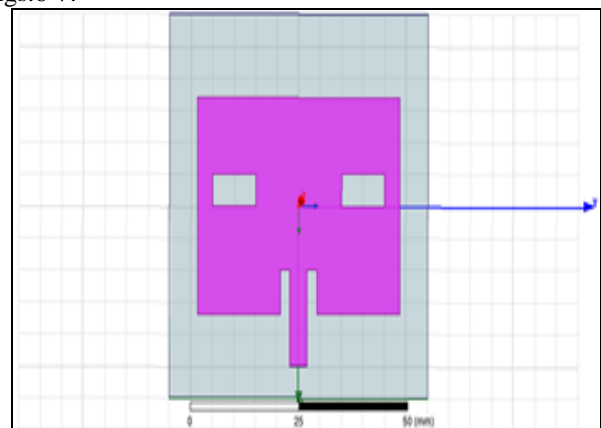


Fig. 6: Proposed antenna model with Rectangular slots on Patch (Top view)

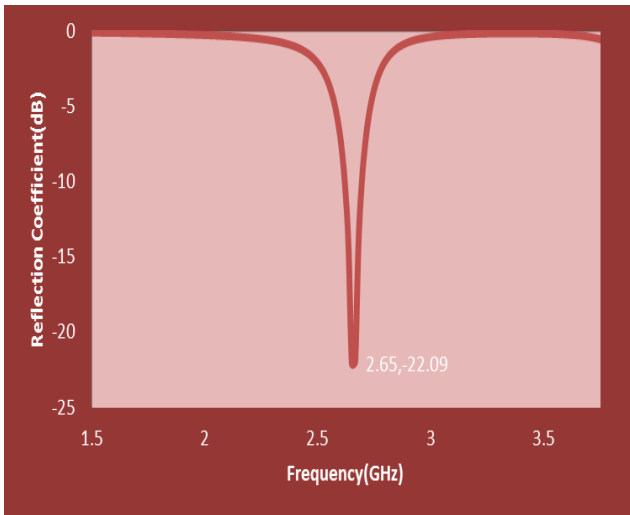


Fig. 7: Return loss characteristics of proposed antenna

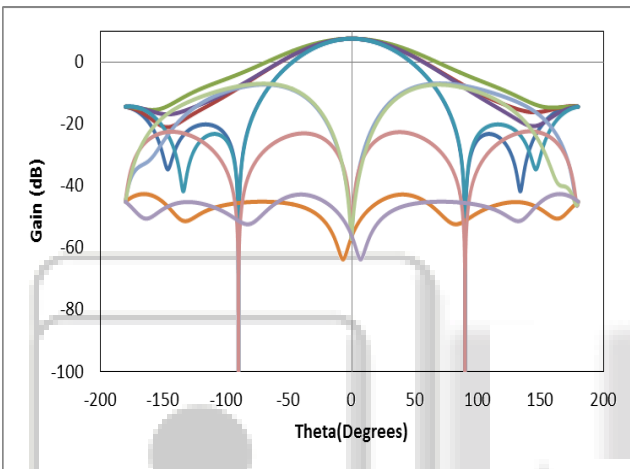


Fig. 8: Gain pattern of Proposed antenna

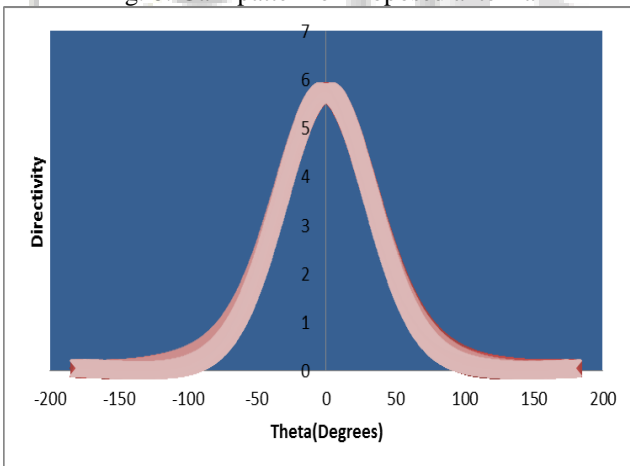


Fig. 9: Directivity of Proposed antenna

The gain of the proposed antenna is 7.52dB. The gain pattern is shown in Fig.8. The directivity characteristics and magnitude of VSWR over the resonating frequency are shown in Figs. 9-10. The directivity is found to be 5.7 while VSWR is only 1.17. The simulated parameters are shown in Table 2.

IV. DISCUSSION

By etching two rectangular slots on conventional patch the patch is conveniently modified to suit the chosen wireless application. The return loss feature is found to be improved

with a slight reduction in gain from 7.56 to 7.52dB. The proposed model has miniaturized up to 10.7% of conventional patch size. The surface current density plots for conventional patch as well as for the modified patch are shown in Figs 11-12 in order to make the readers understand the phenomenon of miniaturization.

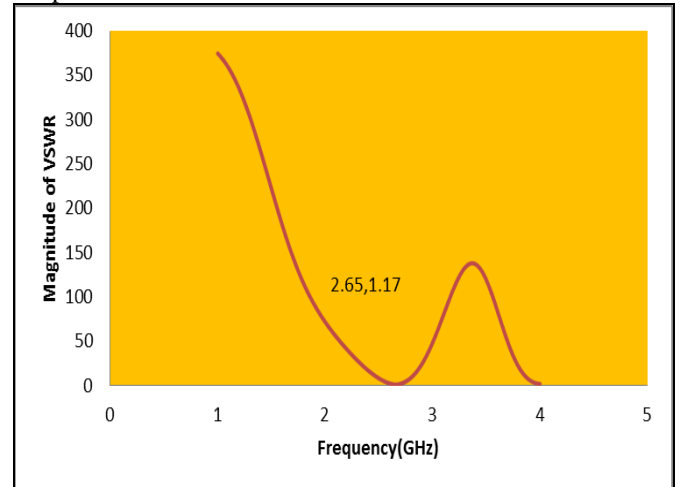


Fig. 10: VSWR characteristics of proposed antenna

Antenna Parameter	Value	Unit
Max U	0.4498	W/sr
Gain	7.52	dB
Radiation Efficiency	98.9%	
Directivity	5.7	
VSWR	1.17	

Table 2: Parameters of Proposed Antenna

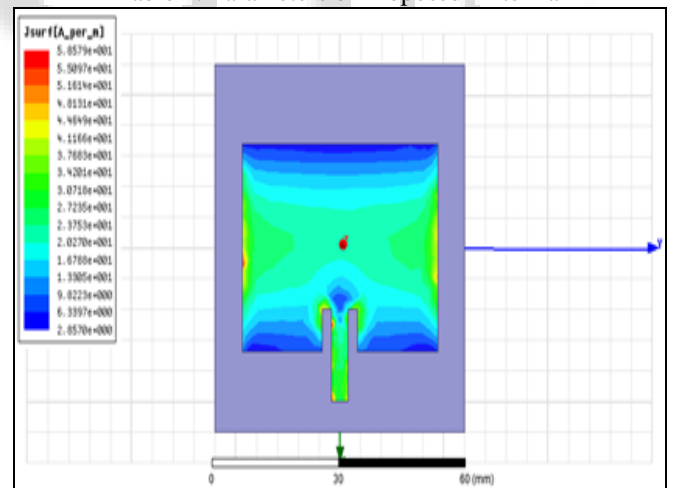


Fig. 11: Surface current density plot of Conventional patch antenna

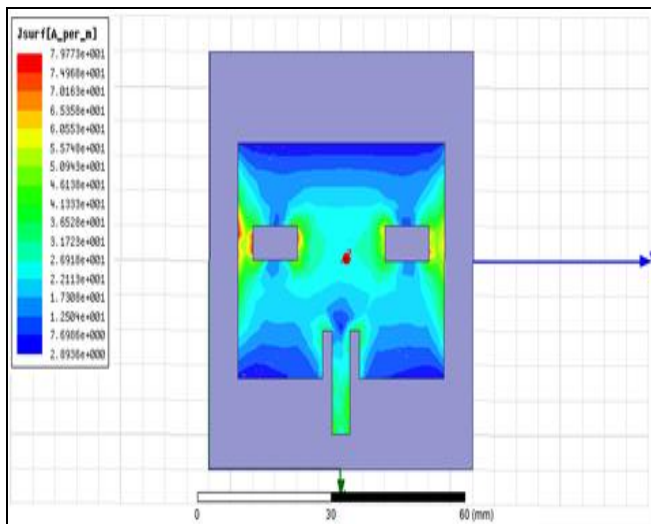


Fig. 12: Surface current density plot of Proposed antenna

V. CONCLUSION

Proposed patch antenna resonates at the WiMax frequency with a bandwidth of 72 MHz. The return loss is found to be improved by -7dB when compared with conventional patch. The antenna has an adequate gain of 7.52dB. The radiating efficiency is more than 95%. Hence the proposal is an excellent candidate for the chosen application which can be easily realized using PCB technique also it is cheap and compact in nature.

ACKNOWLEDGEMENTS

The authors wish to thank the authorities of Annamalai University for permitting them to carry out this work. The first author wishes to thank her Guru, Dr.K.K.Sood, Group Head, Satcom Systems and Technology Group (SSTG) & Satcom and Navigation Applications Area (SNAA), Space Applications Centre, Indian Space Research Organization, Ahmedabad, India.

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