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Rectangular Slot Antenna for WI-Max

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Abstract: *A printed rectangular patch antenna (RPA) with a multiple rectangular shape slots with a rectangular ground plane has been proposed. Four rectangles of dimensions 7.3mm x 1mm is arranged in such a manner to achieve a bandwidth of 200 MHz having a centre frequency of 3.498GHz. This antenna is fabricated on the glass epoxy (FR4 lossy) of dielectric substrate with relative permittivity (€r) of 4.3, thickness of 1.6 mm. Simulated Return loss of -41.7dB is achieved with a good antenna gain. Other parameters such as bandwidth, antenna gain, VSWR are also analysed with different values of ground plane length and feed gap. The simulation and measurement results show that the designed antenna is capable of operating over the 3.399–3.599GHz frequency band. The proposed antenna finds application in Wi-Max which works around 3.5GHz.*
Keywords : *RPA (Rectangular patch antenna), Rectangular slot, Wi-Max, S – Band Applications.*

I. Introduction

The rectangular patch antennas are the most widely used for the last few years due to their attractive features such as light weight, low volume, ease in fabrication and low cost. Some wireless communications applications of antennas are required to simultaneously operate for Wireless Local Area Network (WLAN) and Worldwide Interoperability for Microwave Access (Wi-MAX) technology. The specified spectrum for WLAN is centred at 2.4, 5.2, and 5.8 GHz, and for Wi-MAX at 2.5, 3.5, and 5.5 GHz [1]. In recent years, several reports have appeared about the development of low-profile multiband antennas. However, most of them are relatively large and/or do not provide desired bandwidths. One method of improving the bandwidth and reducing the size is to use a planar monopole antenna with slots on the patch and ground plane. However, the major disadvantage associated with RPA is their narrow bandwidth [2-3] which restricts their many useful applications.

Among different shapes of radiating patches such as square, rectangular, circular, ellipse etc. the rectangular radiating patch was found to exhibit good radiation characteristics, simple to design and compact in size when compared to other patch shapes [4].

In this paper, RPA with feeding line and a ground plane is presented which is actually a single band antenna in the S frequency band. Four rectangles of dimensions 7.3mm x 1mm are arranged as a mirror image horizontally placed parallel to length of the antenna. These slots increase the return loss of the antenna. The proposed printed MPA achieves the bandwidth of 200 MHz (3.399GHz – 3.599GHz) having a centre frequency of 3.498GHz.

The proposed printed RPA is a simple configuration fed by 50 ohm SMA connector placed under a ground plane of the antenna. The properties of the antenna such as return loss, radiation patterns, directivity and gain are determined via a simulation process using CST (Computer Simulation Technology) Microwave Studio Software. Printed MPA is optimized to achieve good return loss with acceptable radiation performance. They can be developed to cover several operating frequency bands in S band.

II. Antenna Design

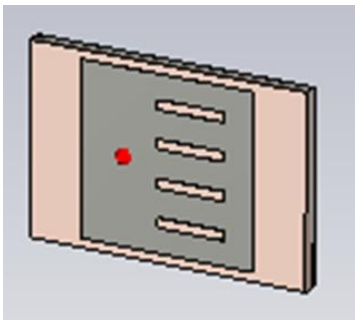
RPA with rectangular shaped slots is printed on the one side of the FR4 lossy substrate and the ground plane is located on the other side of the substrate. The proposed design of the antenna is printed at a length of 18.95 mm and width of 18.3 mm. The proposed structure of the RPA with rectangular shaped slot is designed on CST [8] is shown in the Fig. 1(a)&(b).The dimensions of lengths and widths of the RPA with ground plane layer are shown in tabulated form in Table 1.

Table 1: Dimension's of proposed RPA

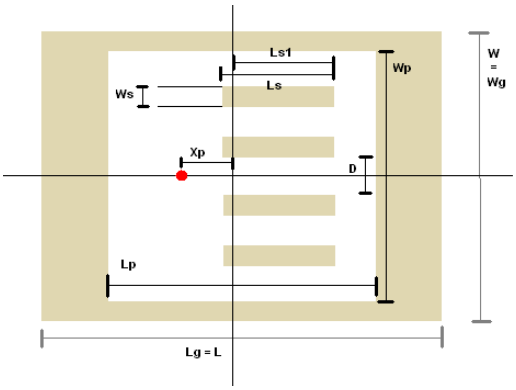
Component	Length (mm)	Width (mm)
Patch	Lp = 18.958	Wp = 18.3
Substrate (FR4 Lossy)	L = 30.6	W = 20.2
Ground (Rectangular)	Lg = 30.6	Wg = 20.2
Slot	Ls = 7.3, Ls1 = 1	Ws = 1
Others	Xp = 4.92	D = 3

The antenna is taken as rectangle in shape with the same dimension as of substrate. Ground is rectangular plate of length 30.6 mm and width 20.2 mm.

Slots of four rectangles of 1 mm side length and 7.3 mm width are placed mirror image to each other at a centre of rectangular patch and they are kept parallel to each other as well as parallel to length of the patch as shown in the Fig. 1(a). Rectangular slots are placed 3 mm apart from each other.



(a)



(b)

Fig. 1: Structure of proposed RPA (a) CST design, (b) dimensions

The proposed RPA is fed with a probe feed (50 ohm SMA connector) placed at 4.92 mm from the centre on the left side at x-axis as shown in Fig. 1(a)&(b).

III. Formula For Rectangular Patch

The width of the rectangular patch can be calculated by the following formula,

$$w = \frac{c\sqrt{2/(\varepsilon_r+1)}}{2fr} \qquad (1)$$

Here, w = width of rectangular patch
c = speed of light
ε_r = relative permittivity of substrate
fr = resonant frequency

In order to include the effect of fringing field relative permittivity is modified to find effective permittivity. It is given by the formula,

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + 12\left(\frac{h}{w}\right)\right]^{-\frac{1}{2}} \quad \{w/h>1\} \qquad (2)$$

here, h = height of rectangular patch
ε_{eff} = effective permittivity of substrate

Correction in length by considering effective permittivity is given by,

$$\frac{\Delta L}{h} = 0.412\left(\frac{\varepsilon_{eff}+0.300}{\varepsilon_{eff}-0.258}\right)\left(\frac{w/h+0.264}{w/h-0.258}\right) \qquad (3)$$

Here, ΔL = correction in length of rectangular patch

Effective length after correction is given by,

$$L_{eff} = L + 2\Delta L \quad (4)$$

Here, L_{eff} = effective length of rectangular patch
L = length of the rectangular patch

Length of the rectangular patch after deducting correction is given by,

$$L = \left(\frac{c}{2fr\sqrt{\varepsilon_{eff}}}\right) - 2\Delta L \quad (5)$$

IV. Results And Discussion

The RPA with rectangular shaped slots and a ground plane is simulated using the CST Microwave Software. Fig. 2 shows the simulated return loss of the proposed antenna from 0 to 6 GHz. The achieved simulated return loss of the proposed RPA is -41.7dB at a frequency 3.498 GHz having the lower frequency (f_L) and higher frequency (f_H) of the bandwidth as 3.399 GHz and 3.599 GHz respectively. The obtained bandwidth of proposed antenna is 200 MHz.

The 2D radiation pattern of proposed RPA at a frequency of 3.498 GHZ in polar plot and 3 dimensional plot is shown in Fig. 3(a) & (b).

Antenna Gain of proposed antenna structure is 3.7 dB. Antenna gain is plotted for different values of frequency as shown in Fig. 4(a). Directivity of the RPA is 4.965 dBi at a frequency of 3.498 GHz. Directivity of RPA is plotted for different values of frequency as shown in Fig. 4(b).VSWR obtained is nearly 1 as shown in Fig. 5.

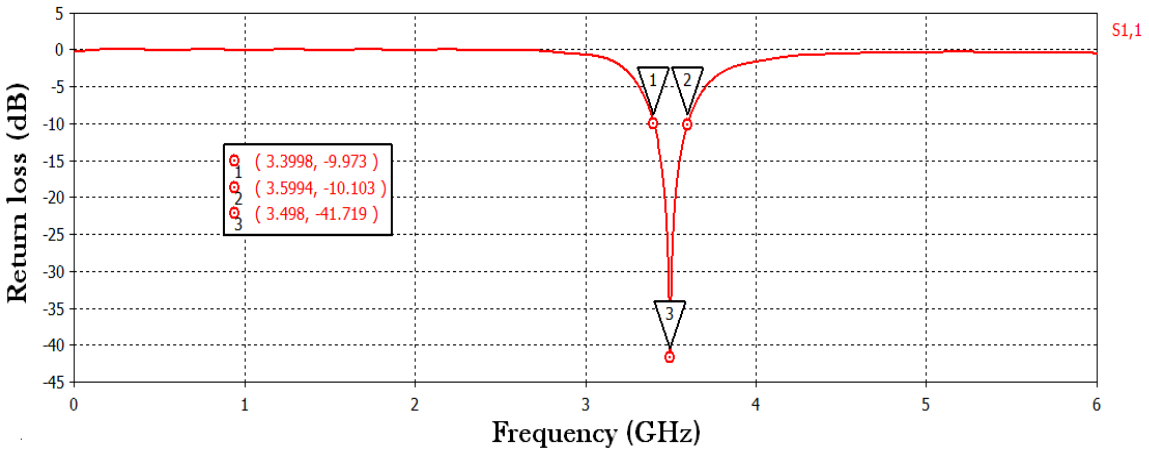
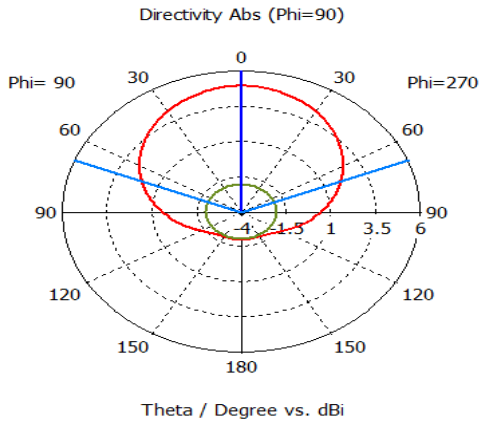
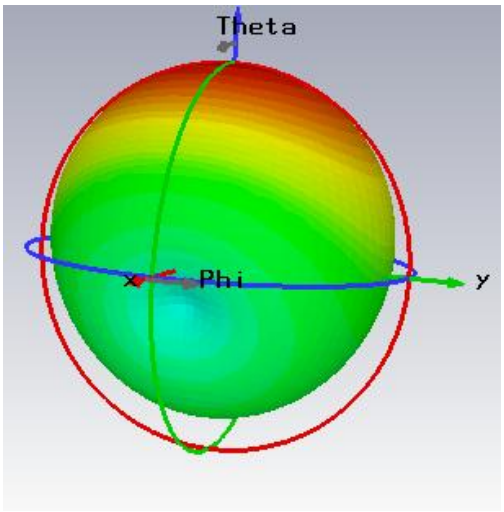


Fig. 2: Simulated return loss of the proposed RPA.

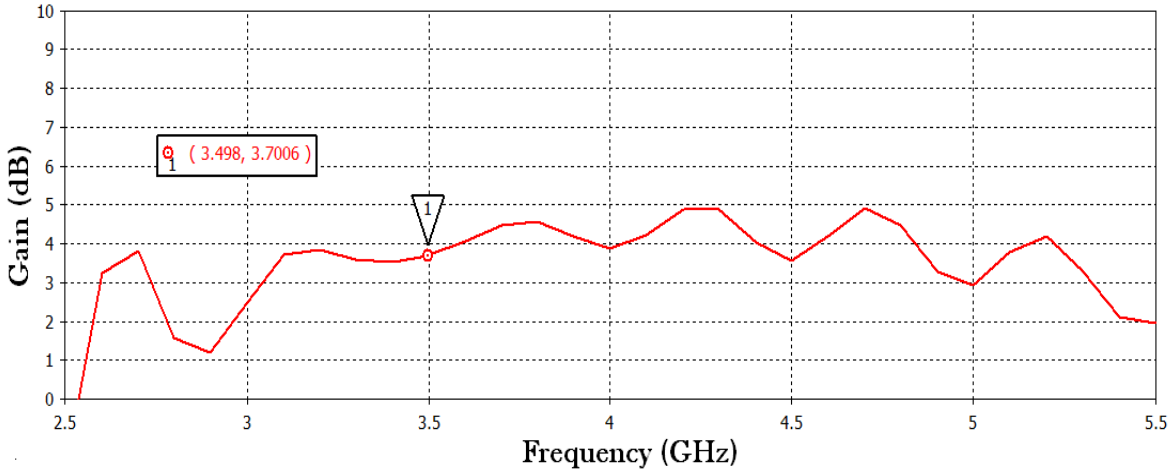


(a)

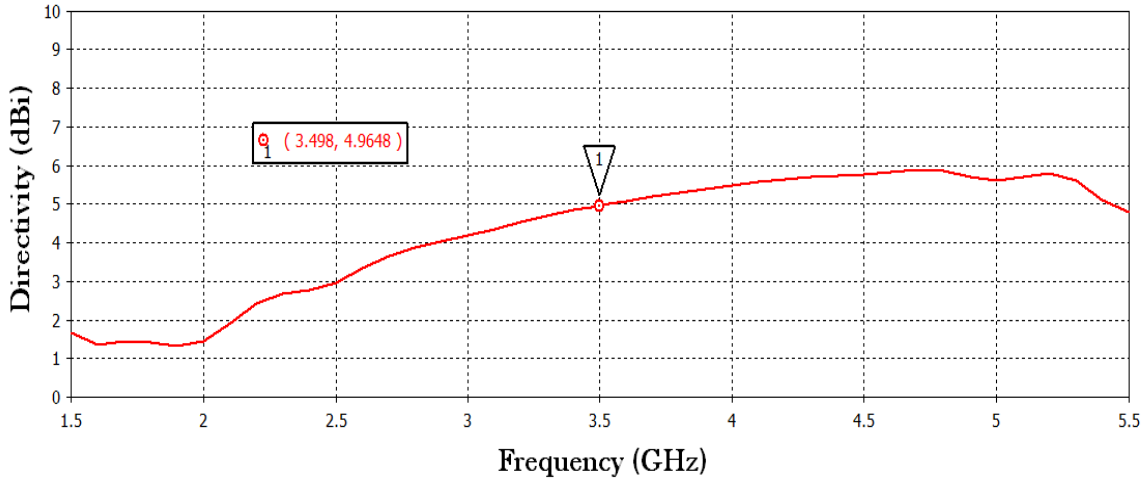


(b)

Fig. 3: Simulated Radiation Pattern of the proposed RPA (a) Polar View, (b) 3-D view.



(a)



(b)

Fig. 4: (a) Gain & (b) Directivity of the proposed RPA in 1.5-5.5 GHz range.

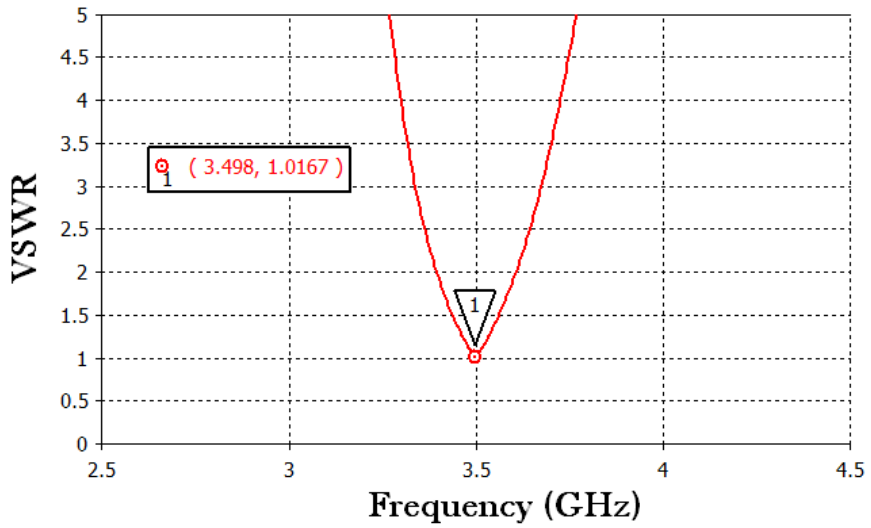


Fig. 5: VSWR of the proposed RPA in 2.5-4.5 GHz.

V. Conclusion

A configuration of printed rectangular patch antenna with a rectangular shape slot with a ground plane is designed for Wi-Max application has been investigated. It has been observed that return loss of the antenna is increased with increase in number of slots. Position of the port is a frequency independent parameter it only varies the return loss without affecting the centre frequency. The application of proposed antenna is found to be in Wi-Max. Rectangular patch with multiple rectangular slots are giving return loss of -41.7 dB at 3.498 GHz and providing bandwidth of 200 MHz. The proposed antenna covers the Wi-Max operational band of 3.4 to 3.69 GHz.

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