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RECTANGULAR SHAPED MICROSTRIP PATCH ANTENNA WITH DAMRU DESIGN SLOT FOR L - BAND APPICATIONS

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Abstract

A printed rectangular microstrip patch antenna with a DAMRU shape slot with an edged ground plane is designed for a L – band applications. Two equilateral triangle of 30mm side length is arranged in such a manner to achieve a bandwidth a 900MHz having a centre frequency of 1.074GHz. 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 -35db is achieved with a good antenna gain. Another parameters such as bandwidth , antenna gain , VSWR are also analysed with different values of ground plane length and feed gap. Details of antenna design are described and experimental results are discussed. The proposed antennas may find applications for the systems operating at S and C-bands.

Keywords – Microstrip patch antenna (MPA), Rectangular Microstrip patch antenna (RMPA) L – Band Applications, wideband antenna.

I. INTRODUCTION

The microstrip patch antennas (MPA) 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 [1]. However, the major disadvantage associated with MPA is their narrow bandwidth [1-2] 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 microstrip patch shapes [3].

In this paper, L-band rectangular MPA with feeding line and an etched ground plane is presented which is actually a single band antenna in the 1-2 GHz frequency bands. Two equilateral triangle of 30mm side are arranged as a mirror image vertically with a small rectangular slot to join the together which gives this slot a shape of DAMRU. This particular slot increases the bandwidth of the antenna which is lie on the L – band application. The proposed printed MPA achieves the bandwidth of 900MHz(0.92GHz – 1.82GHz) having a centre frequency of 1.074GHz.

The proposed printed MPA is a simple configuration fed by 50 ohm SMA connector placed under the etched 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 can be optimizing to provide extremely wide impedance bandwidths with acceptable radiation performance. They can be developed to cover several operating frequency bands of wireless communication from GSM900: 890-960 MHz, DCS: 1.71-1.88 GHz, Personal Communication System (PCS 1.85-1.99 GHz). Satellite navigation Global Positioning System (1176.45 MHz (L5), 1227.60 MHz (L2), 1381.05 MHz (L3), and 1575.42 MHz (L1) frequencies).[4-6]

CST MICROWAVE STUDIO is a fully featured software package for electromagnetic analysis and design in the high frequency range [7]. The software contains four different simulation techniques (transient solver, frequency domain solver, Eigen mode solver, modal analysis solver) which best fit their particular applications. The most flexible tool is the transient solver, which can obtain the entire broadband frequency behaviour of the simulated device from only one calculation run (in contrast to the frequency stepping approach of many other simulators). This solver is very efficient for most kinds of high frequency applications such as connectors, transmission lines, filters, antennas and many more.

II. ANTENNA DESIGN

RMPA with DAMRU shaped slot 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 27.2 mm and width of 3 mm feeding strip from the one side of the substrate which is connected to a RMPA. The proposed structure of the PRMA with DAMRU shaped slot is designed on CST [7] is shown in the Figure 1.

The dimensions of lengths and widths of the RMPA with ground plane layer are shown in tabulated form in Table 1.

Table 1

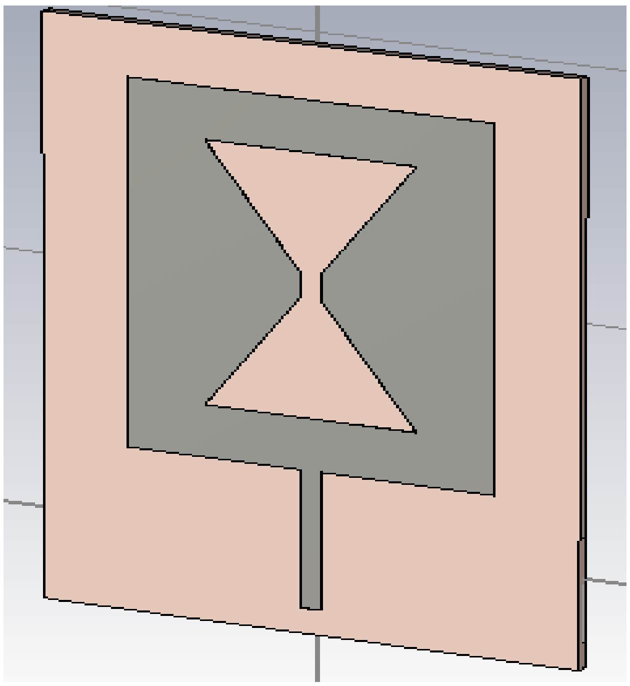
Dimension's of RMPA

Component	Length (mm)	Width (mm)
Patch	52	72.56
Feed Line	27.2	3
Substrate (FR4 Lossy)	76	115.5
Ground 1 (Rectangular)	76	20.5

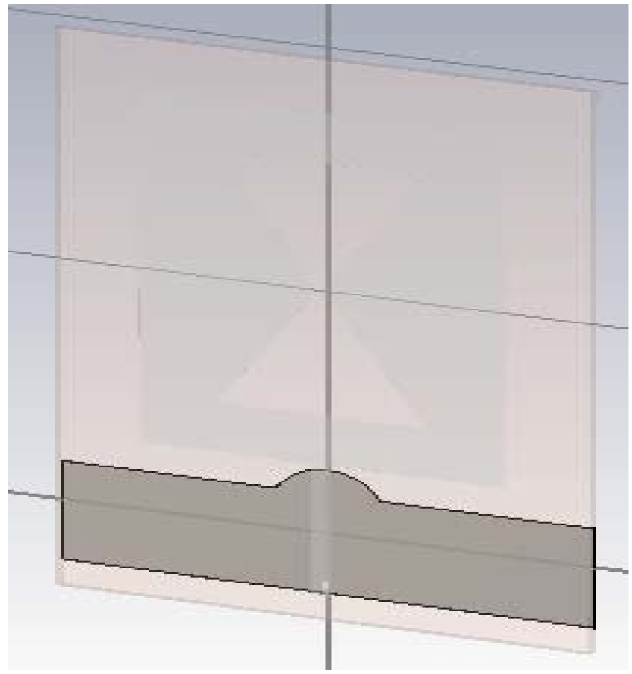
Ground 2 (Semi-Circle)	Radius	8mm

Ground 2 is circular in nature with a radius of 8mm. Ground 2 is placed at centre of the width of the Ground 1 but its centre is taken 3 mm below the ground 1.

Slots of two equilateral triangle of 30mm side length are placed mirror image to each other at a centre of rectangular patch and they are connected together by a rectangular slot of dimension having a length of 3mm and width of 5.2mm.



(a)



(b)

Figure 1: Structure of the RMPA with DAMRU shaped slot.
(a) Front View
(b) Back View

III. SIMULATION AND EXPERIMENTAL RESULTS

The RMPA with DAMRU shaped slots and an etched ground plane was simulated using the CST Microwave Software. Figure 2 shows the simulated return loss of the proposed antenna from 0 to 3 GHz. Using a 50Ω SMA (Sub Miniature version A) connector at the port 1. The achieved simulated return loss of the proposed RMPA is -35dB at a frequency 1.074 GHz having the lower frequency (fL) and higher frequency (fH) of the bandwidth is 0.92GHz and 1.82GHz respectively and obtain a bandwidth of proposed antenna is 900MHz.

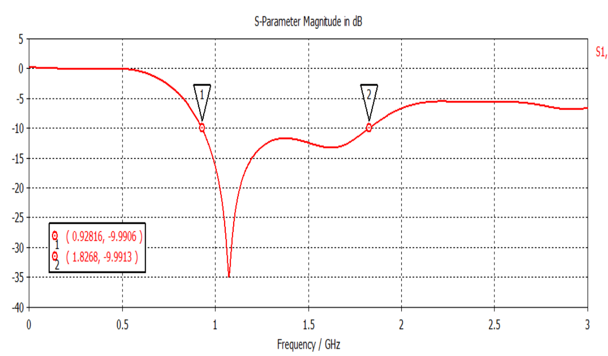


Figure 2: Simulated Result of the proposed RMPA.

The radiation pattern of proposed RMPA at a frequency of 1.074 GHZ in polar plot is shown in figure 3.

simulated return loss is shown in the figure 4 with all the remaining parameters of the proposed antenna are same as the design.

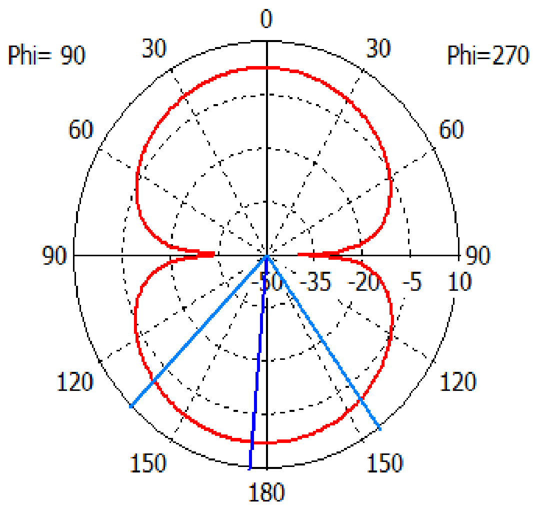


Figure 3: Simulated Polar View of Radiation Pattern Result of the proposed RMPA.

Antenna Gain of proposed antenna structure is 2.564dB and Directivity is 2.457dBi at a frequency of 1.074GHz.

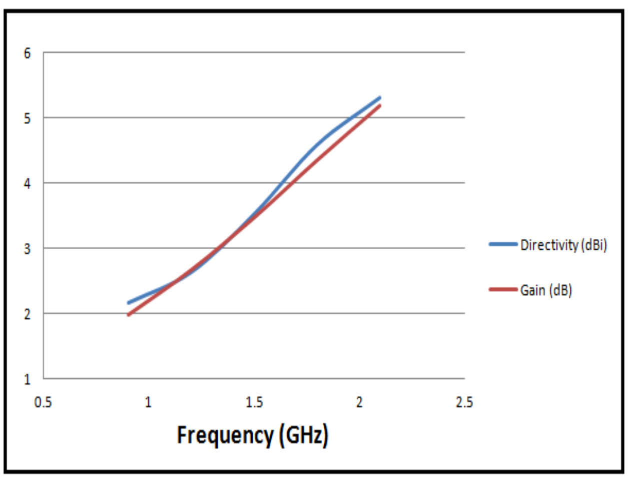


Figure 3: Directivity & Gain of the proposed RMPA in 0-3 GHz.

It is clearly seen that the directivity (in dBi) and gain (dB) of antenna are increases and almost constant as with the frequency increases in the range of 1-2GHz.

In this antenna structure, some portion of the ground plane is etched. The ground plane is a combination of rectangular shaped with a small semi-circle at the middle of the rectangular shape ground plane.

The position of the semi-circle (centre of a semi-circle) varies the bandwidth and return loss of the proposed antenna structure. The value of centre of semi-circle with respect to rectangular ground plane structure keeping the radius constant varies from 2mm to 6mm and their corresponding data in terms of antenna bandwidth is listed in the Table 2 and

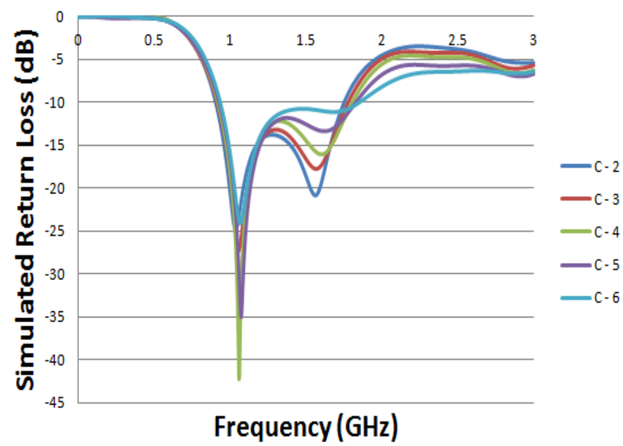


Figure 4: Simulated return loss of the proposed RMPA as a function of centre of semi-circle of the ground plane.

The different lower frequencies and upper frequencies are studied in the Table 2, which shows that feed gap is a frequency dependent parameter. Also figure 6 shows the effects of feed gap on the simulated return loss of the proposed RMPA.

Table 2

Position of Centre of Semicircle with different lower and higher frequencies of proposed RMPA

Centre of Semi-circle at	Bandwidth (GHz)	Resonant Frequency (GHz)
C = 2mm	0.849, (0.904-1.753)	1.04
C = 3mm	0.867, (0.913-1.780)	1.06
C = 4mm	0.888, (0.918-1.806)	1.06
C = 5mm	0.898, (0.928-1.826)	1.07
C = 6mm	0.919, (0.935-1.854)	1.07

Bandwidth of proposed antenna increases as the centre of semi-circle ground plane is approaches towards the rectangular ground plane structure with a almost same resonant frequency.

Another parameter which is studied is radius of semicircle of ground plane having a centre of semicircle to be constant. Figure 5 shows the simulated return loss of proposed RMPA as a function of radius of semicircle of ground plane with a rectangular portion of ground plane has to be assumed constant (not varied).

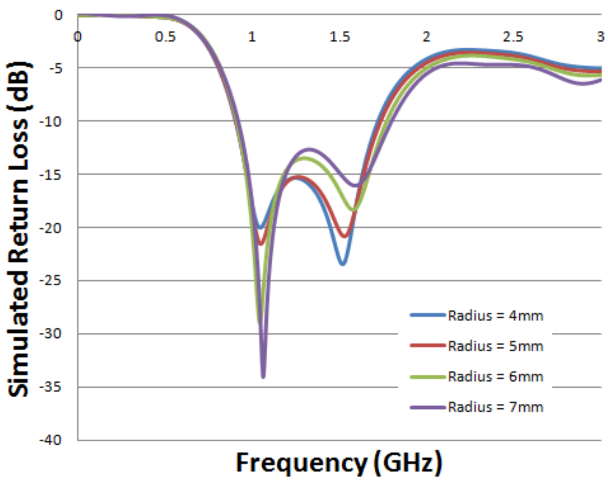


Figure 5: Simulated return loss of the proposed PRMA as a function of radius of semicircle ground plane.

From the figure 5, it is clearly seen that the return loss of proposed RMPA is more negative (better) as the increase in the radius of semi circle. Also, at the radius of 4mm and 5mm, the response of proposed antenna works on the dual resonant frequencies and after that only one resonant frequency exist.

The simulated data of antenna bandwidth and their respective resonant frequencies are also mentioned in the table 3 as a function of radius of semi circle ground plane structure.The bandwidth of proposed RMPA is monotonically increases as the increase in the value of radius of semi circle.

Table 3

Variation of radius of semicircle with different lower and higher frequencies of proposed RMPA

Radius of Semi Circle	Bandwidth (GHz)	Resonant Frequency (GHz)
R = 4mm	0.818, (0.903-1.721)	1.04,1.52
R = 5mm	0.830, (0.905-1.735)	1.04,1.52
R = 6mm	0.862, (0.909-1.771)	1.05
R = 7mm	0.882, (0.917-1.799)	1.06

IV. CONCLUSION

A configuration of printed rectangular microstrip patch antenna with a DAMRU shape slot with an edged ground plane which is a combination of rectangular ground plane and semi circle is designed for L – band applications has been investigated. It has been observed that antenna of bandwidth is increased either if the position of the centre of semicircle ground plane structure is vary or the radius of semicircle is increased having the rectangular portion of ground plane structure to be constant. So, centre and radius of semi circle are a frequency dependent parameter which affects the bandwidth of the antenna. Application of proposed antenna is designed to use in Aircraft surveillance. Aircraft can use Automatic dependent surveillance-broadcast (ADS-B) equipment at 1090 MHz to communicate position information to the ground as well as between them for traffic information and avoidance.

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