Probe and Edge Fed Miniaturized Meander Slot Antenna Using IE3D

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***Abstract* -Microstrip patch antenna is a lightweight, inexpensive antenna on which electronics like LNA's and SSPA's can be integrated easily. It is applied to different applications such as Bluetooth, WLAN, satellite communication, biomedical applications, telemedicine and so on due to its Compact size. This work aims at reducing the size of the antenna using meander slot. In this work we explored reduction, which makes it appropriate to apply for more applications. Meander slot follows an asymmetrical path which increases the path for current flow. The simulated results show 71.34% of size reduction for 3.3GHz resonating frequency and 25.04% for 5.5GHz as compared to rectangular patch. This work also analysis the probe and edge feeding techniques and comparative results are tabulated feeding techniques.**

***Keywords-* Microstrip patch antenna, Meander Slot, Size reduction, Edge Feeding , Probe Feeding.**

I. INTRODUCTION

The Microstrip Patch Antenna is a single-layer design which generally consists of four parts they are patch, ground plane, substrate, and the feeding part. The patch is a very thin radiating metal strip located on one side of a thin, non conducting substrate, the ground plane is the same metal located on the other side of the substrate, feeding is provided using various methods. The objective of our project is to reduce the size of microstrip patch antenna using meander slot. The application we are targeting is WLAN. The resonating frequency required is 3.3 GHz and 5.5 GHz. We achieved the results closer to the record. In our design we have added meander slot to achieve size reduction. We simulated the results using IE3D software. IE3D is an integral equation and method of moment based EM simulator. It is very efficient, accurate and flexible for such structures.IE3D can also model 3D dielectric structures such as dielectric resonator antennas.Various softwares are explained below.[2][6][8]

II. SOFTWARES

There are various soft ware's that can be used to design and simulate antennas. Some of them are given below along with the method they use for solving equations. The software used by us for simulation is IE3D. It is an antenna designing software by which different parameters like s-parameters, VSWR, impedance, resonating frequency and gain were observed. [8]

TABLE I.
Comparison Between Various Softwares.

Software Names	Therotical Model	Company
Ensemble	Moment method	Ansoft
IE3D	Moment method	Zeland
Momentum	Moment method	HP
EM	Moment method	Sonnet
PiCasso	Moment method/Genetic	EMAG
HFSS	Finite Element	Ansoft
Micropatch	Segmentation	Microstrip Design, Inc.

III. SIZE REDUCTION TECHNIQUES

There are various size reduction techniques such as shorting wall/shorting pin, quarter-wavepatch, U-slot, L-probe and meander slot. In each technique size is reduced but has some disadvantage along with it. In the following table we have put forth their comparison. We can observe that meander slot has a minimum disadvantage as compared to others. [5]

TABLE II.
Comparison of Different Size Reduction Techniques.

SrNo	Techniques	Remarks
1	Shorting wall/ Shorting pin	Size reduction with high cross polarization levels.
2	Quarter-wave Patch	The size is reduced but bandwidth is halved.
3	U-slot	The size is reduced up to 77%, but bandwidth is halved.
4	L-probe	The size is reduced & bandwidth is increased, but substrate used can only air or foam.
5	Meander slot	Size reduction up to 64%-86% & bandwidth is increased according to the requirement.

IV. FEEDING TECHNIQUES

We have studied different types of feeding techniques such as edge feeding, probe feeding, proximity feeding and aperture feeding. The comparison of different feeding techniques is tabulated as shown below. We have simulated our design using edge feeding and probe feeding. [13]

TABLE III.
Comparison of various feeding techniques

Sr. No	Characteristics	Edge feeding	Probe feeding	Proximity feeding	Aperture feeding
1	Return loss	Less	More	More	Less
2	Resonant frequency	More	Less	Highest	Least
3	VSWR	Lower than 1.5	Between 1.4 to 1.8	Less than 1.23	Approximately up to 2
4	Ease of fabrication	Simple	Soldering & drilling needed	Alignment require	Alignment require
5	Reliability	Better	Poor due to soldering	Good	Good
6	Impedance matching	Easy	Easy	Easy	Easy
7	Bandwidth	2-5 %	2-5 %	13 %	21 %

V. DESIGN CONSIDERATIONS

The proposed design has dimensions as shown in the figure below. The rectangular patch has dimensions 16 x 12 mm. The substrate used is FR4 having thickness 1.6 mm. The ground plane has dimensions 50 x 40 mm.

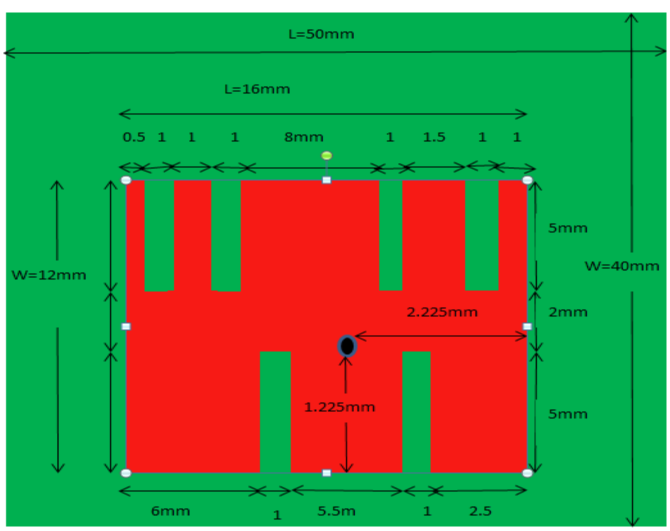

Fig . 1 Geometry of the proposed design.

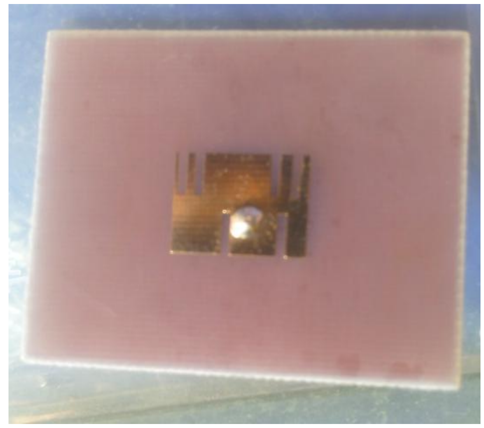

Fig . 2 Photograph of the fabricated antenna.

For fabrication first the mask for the antenna is designed. The mask image is then transferred on electroplated copper PCB board using photolithography. The feeding is then provided by giving either port for probe feeding or any other as required.

VI. TESTING

The design was simulated in IE3D and fabricated antenna was tested using a Vector Network Analyser. For testing, we used Agilent N9923A FieldFox RF network analyzer which has a range of 2 MHz to 6 GHz. It is handheld RF T/R VNA analyzer. It is used to observe-parameters, VSWR, smith chart, phase of the antenna under test. After connecting the antenna to port and setting the start and stop frequencies we can observe all the parameters of the antenna accurately.

Fig . 3 Field fox VNA

VII. RESULTS AND DISCUSSIONS

A. Design Using Probe Feeding .

The first design we tried was using probe feeding. Microstrip antennas can be fed from underneath via a probe as shown. The outer conductor of the coaxial cable is connected to the ground plane, and the centre conductor is extended up to the patch antenna. The results obtained when compared to edge feeding show that some parameters like VSWR,s-parameters are better in edge feeding but the radiation pattern is better in probe feeding.

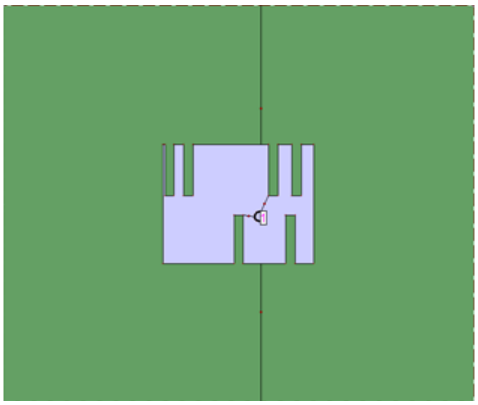

Fig . 4 Design using probe feeding

1) S Parameter : -

S11 is reflection coefficient, which represents how much power is reflected from the antenna. Ideally, it should be -10 dB. [10]

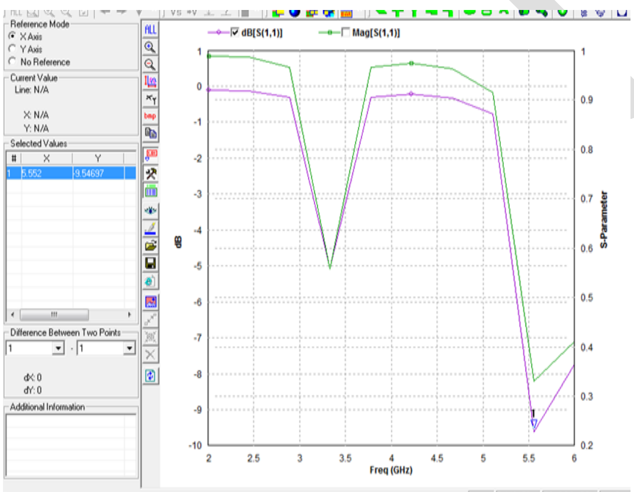

Fig . 5 Simulated S- parameter display

The s parameter s11 that we obtained from this was -6 dB at 3.3 GHz and -9.64 to 5.5 GHz.The fabricated antenna showed -14.13 dB at 3.3 GHz and -37.04 dB at 5.5 GHz.

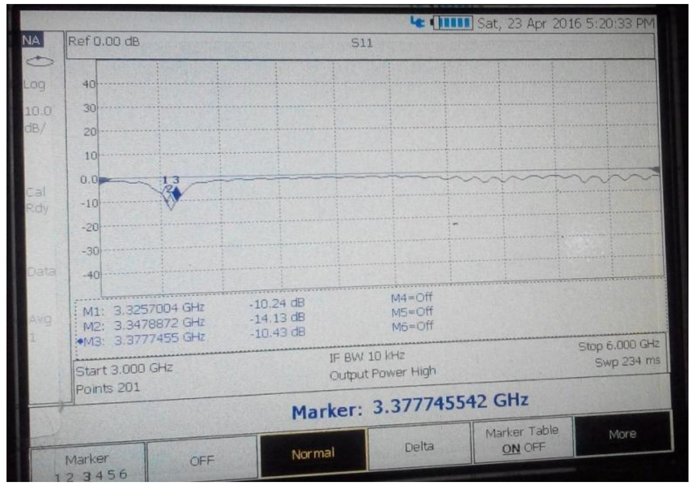

Fig . 6 Tested S- Parameter at 3.3 GHz

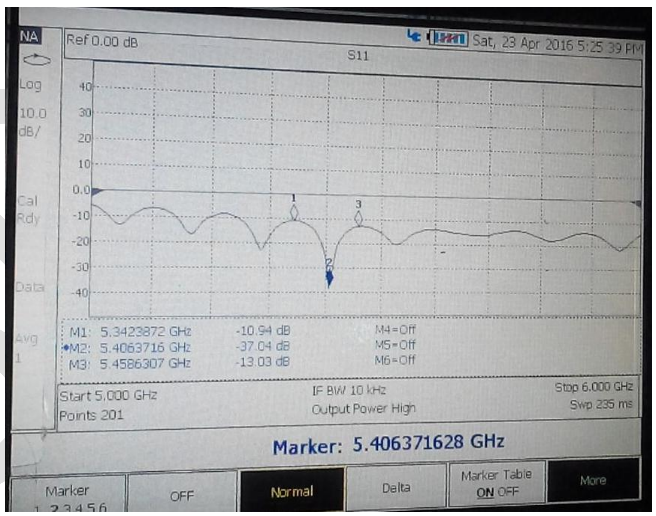

Fig . 7 Tested S- parameters at 5.5 GHz.

2) VSWR : -

VSWR is a voltage wave standing ratio, which checks whether there are any standing waves formed. It should ideally be one. [10]

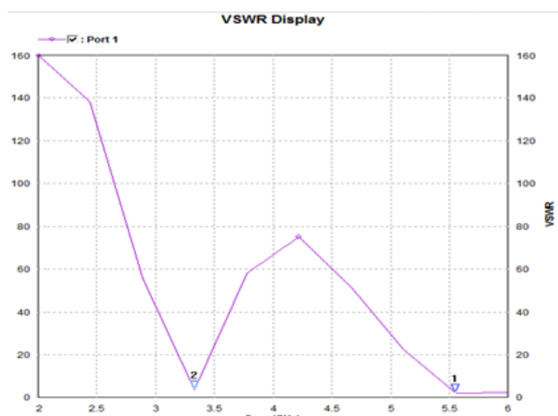

Fig . 8 Simulated VSWR display

In simulation, we obtained VSWR of 2.21 at 3.3 GHz and 2 at 5.5 GHz. The fabricated antenna had VSWR 1.54 at 3.3 GHz and 1.086 at 5.5 GHz.

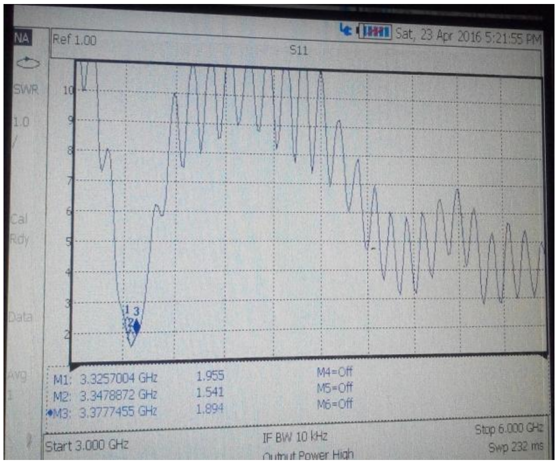

Fig . 9 Tested VSWR at 3.3 GHz

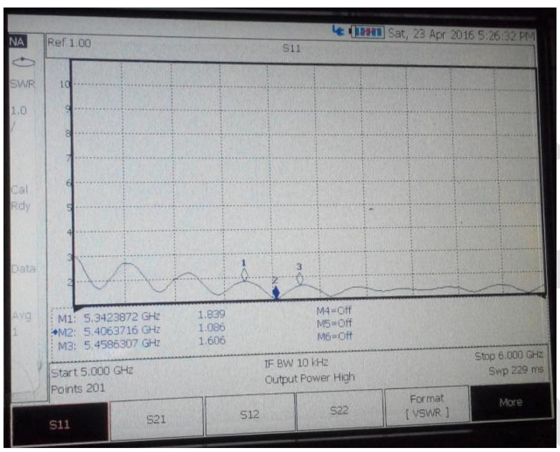

Fig . 10 Tested VSWR at 5.5 GHz

3) 3D Radiation pattern : -

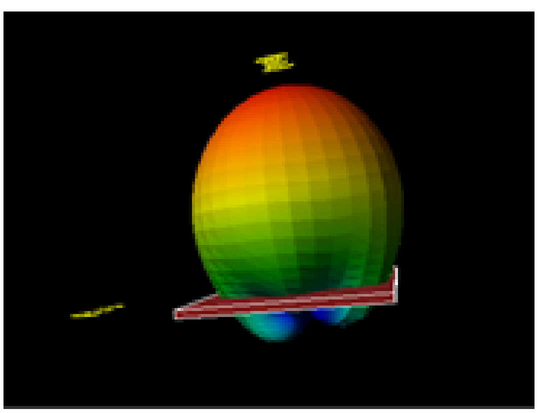

Fig . 11 3D Radiation pattern in IE3D

4) 2D Radiation : -

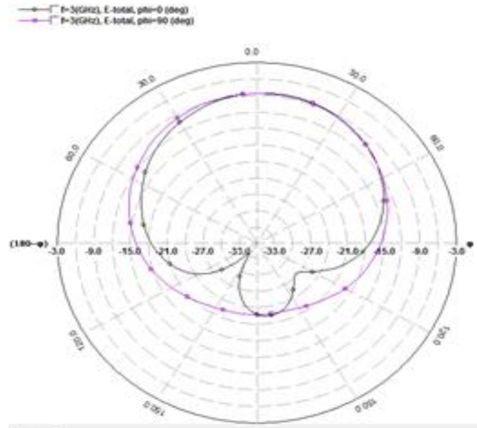

Fig . 12 2D Radiation Pattern

B. Design using edge feeding:-

We simulated the design using edge feeding to observe the results. The results are positive using edge feeding, but the radiation pattern obtained was not appropriate.

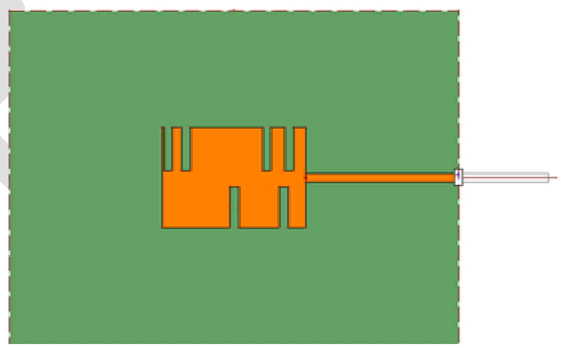

Fig . 13 Design geometry

1) S parameter : -

We obtained return losses of -13.8992 dB for 4.64 GHz, -8.37 dB for 5.5 GHz and -4 dB for 3.3 GHz.

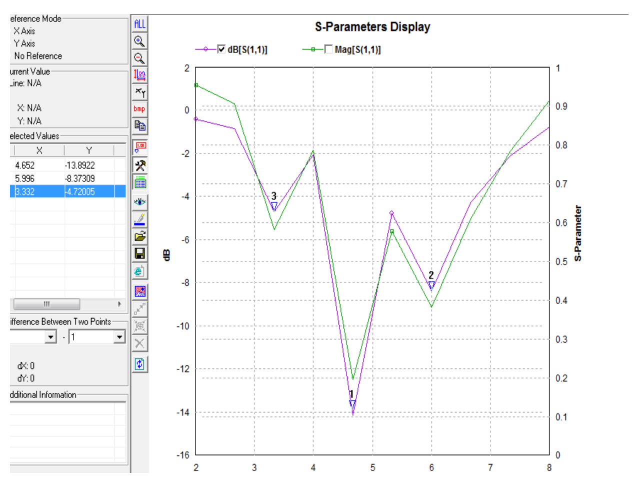

Fig . 13 Simulated s parameter display

2) VSWR : -

The VSWR obtained was 1.63 for 4.64 GHz.

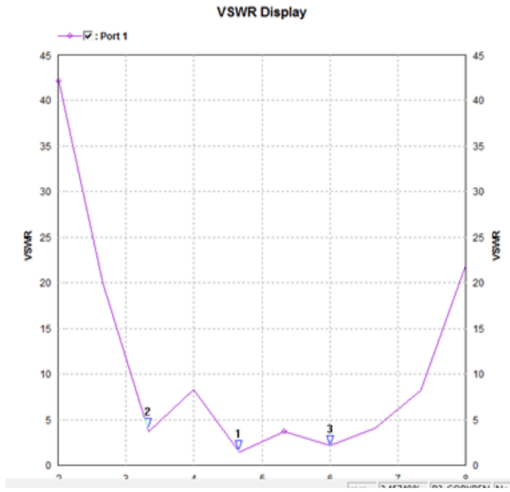

Fig . 14 Simulated VSWR display

3) 3D Radiation Pattern : -

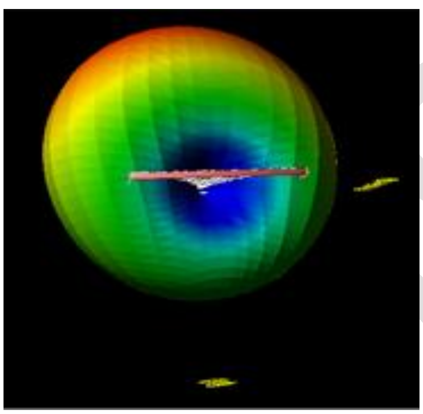

Fig . 15 3D radiation pattern

4) 2D Radiation Pattern : -

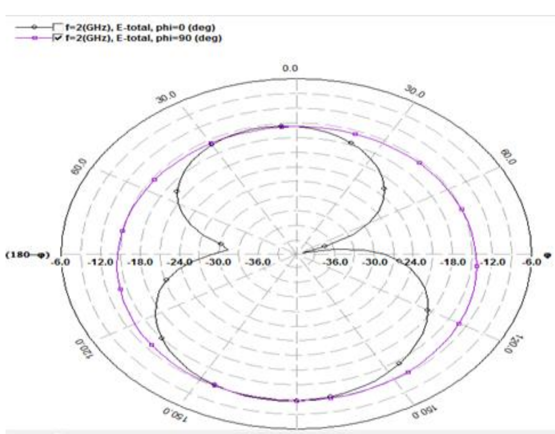

Fig . 16 2D Radiation pattern

VII. RESULT TABLE

Parameter	Frequency	Simulated	Tested
S –parameter	3.3 GHz	-6 dB	-13 dB
	5.5 GHz	-9.64 dB	-37.04dB
VSWR	3.3 GHz	2.1	1.54
	5.5 GHz	2	1.086

When the resonating frequency is lower the size of the antenna is more and vice versa. To obtain size reduction the resonating frequency is to be brought down. The dimensions for 3.3 GHz are 27.64 x 21.65 mm thus the size reduction in terms of area obtained is 71 % as we are obtaining the same resonating frequency at 12 x 16 mm. The dimensions for 5.5 GHz are 16.59 x 12.99 mm.The area reduction is 7 %.

VIII. CONCLUSION

We started this project with a simple rectangular patch antenna. To reduce its size, we added different slots. We added meander slot to achieve size reduction. We tried different feeding techniques. First, we went to edge feeding for which we got good return loss of -14 dB, but 3D pattern had back lobe which was undesirable. Then we tried probe feeding for which we got resonating frequencies as 3.3GHz and 5.5GHz and desirable 3D Radiation pattern and VSWR 2.25, Return loss -9.54 dB. We fabricated this design. The fabricated antenna has s11 parameter as -37.04 and -13 dB, which are as desired. This design can be used for WLAN application. The design can be further improved by varying the slot position or length. The gain obtained was 3 dB, which ideally should be 6 dB. This can be improved. HFSS software can be used to simulate to get more accurate results. A shorting pin can be further added to obtain further size reduction.

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