Printed Hexagonal Patch Monopole Antenna with Hexagonal Slot for Wide Band Frequency Applications

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Abstract- In this paper a hexagonal patch microstrip antenna with hexagonal slot behaves as a wide band monopole antenna having great return loss. It is designed for 1.1194-2.7078 GHz frequency band with wide bandwidth of 1.5884 GHz and return loss of -73.63dB. A hexagonal patch with etched ground plane monopole antenna with hexagonal Slot is fabricated on the glass epoxy (FR4 lossy) of dielectric substrate with relative permittivity (ε_r) of 4.3, thickness of 1.6mm, loss tangent of 0.02 with a ground plane, fed with a 50Ω rectangular microstrip feed line. This prototype antenna having an omnidirectional radiation pattern is measured for frequency range of 0-3 GHz. The novelty of this antenna is that hexagonal patch with hexagonal slot gives it uniqueness in design and also getting a bandwidth approx 1.6 GHz with -73dB Return loss is big achievement in 0-3 GHz frequency Band itself. As the antenna is designed only in 0-3GHz band, having all such properties in one antenna proves its novelty and uniqueness. The measured reflection coefficients are far below of -10dB.The simulated result and experimental results are analyzed and verified after comparison.

Index Terms- Hexagonal patch, Hexagonal slot, Monopole Antenna, Return Loss,Bandwidth,Gain,Slot Diameter, Efficiency,CST.

I. INTRODUCTION

Modern and future wireless systems are placing greater demands on antenna designs. Printed monopole antennas are widely used in wideband communication systems. Among the printed monopole antennas of various shapes [1], hexagonal monopole antenna is simple in geometry and its radiation patterns are Omni-directional with wide bandwidth. Antennas, which can work properly in more than one frequency region either for transmitting or receiving electromagnetic (EM) waves, are termed as Multiband antennas. Multi-band antennas are much more complex than the single band antennas in their design, structures and operations [2].

Printed monopole antenna can be optimized to provide extremely wide impedance bandwidths with acceptable radiation performance [3-4]. They can be developed to cover various functional frequency bands of wireless communication, such as GSM900, DCS, Personal Communication System, and Universal Mobile Telecommunication [5].

CST MICROWAVE STUDIO is a fully featured software package for electromagnetic analysis and design in the high frequency range. The software contains four different simulation solver techniques which are transient, frequency domain, Eigen mode and modal analysis which best fit their particular applications. The most usable and popular tool is a transient solver, which can provide the entire broadband frequency behavior 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 various kinds of high frequency applications such as connectors, transmission lines, filters, various antennas and many more. This antenna is applicable in the Global Positioning System Carriers, telecommunications for use in GSM mobile phones operate at 800±900 MHz and 1800±1900 MHz Presently there are many other government and commercial applications such as mobile radio and wireless communications. [6]

II. ANTENNA DESIGN

The hexagonal disc having a diameter of 50 mm monopole antenna with hexagonal shaped slot is printed on the front side of FR4 substrate & the etched ground plane is located on the back side of the substrate. The proposed design of the antenna is printed with a length of 46 mm and the width of 3 mm feeding strip on one side of the substrate & the etched ground plane having a length of 47.5 mm and width of 100 mm on the other. Hexagonal Slot is having a diameter of 24.5 mm.Here the position of Hexagonal slot is set as to achieve a greater radiation efficiency & Omni directional radiation pattern with minimum return loss. Hexagonal slot is located at the (0, 20) axis coordinate of hexagonal disc monopole patch. The design of the printed hexagonal disc monopole antenna with hexagonal slot is shown in figure1.

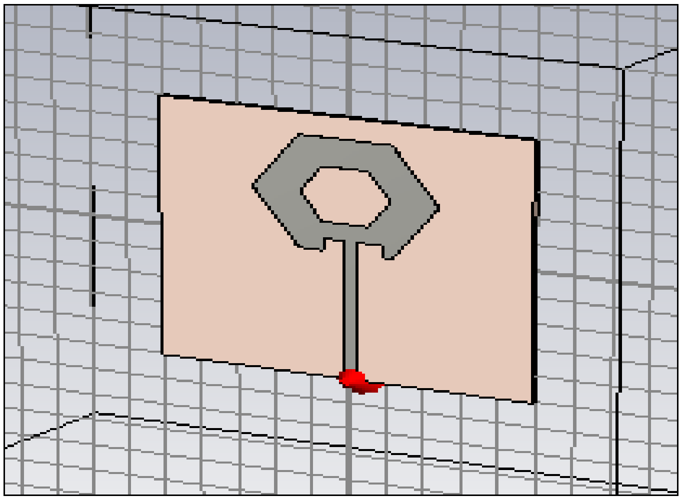

Fig1 General View of Proposed structure

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The dimensions of the antenna are shown in tabulated form in Table 1.

Component	Length(mm)	Width(mm)
Ground	47.5	100
Substrate	100	100
Feed Line	47	3
Feed Gap	9	16

Table 1 Dimensions of PCDMA

III. SIMULATION AND EXPERIMENTAL RESULTS

The printed hexagonal disc monopole antenna having hexagonal slot with etched ground plane is simulated using CST MW STUDIO 2010 software. Figure 2 shows comparison between the return loss of simulated result and measured result of proposed monopole antenna for 0 to 3 GHz range. The simulated result of the proposed antenna having hexagonal slot gives wide band frequency applications.

The monopole antenna is used for frequency range of (1.1194-2.7078) GHz with return loss of about -73.63 dB at a resonance frequency of about 2.139 GHz having a wide bandwidth of about 1.5884 GHz.

The simulated result using a CST Studio 2010 is shown Fig 2.

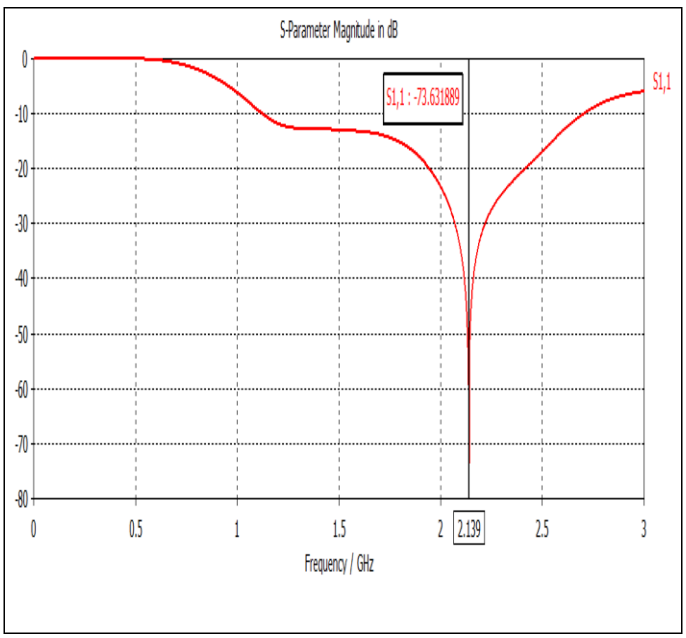


Fig 2 Simulated Response using CST studio 2010 software

Comparision of simulated and measured response of proposed monopole antenna is shown in fig 3.

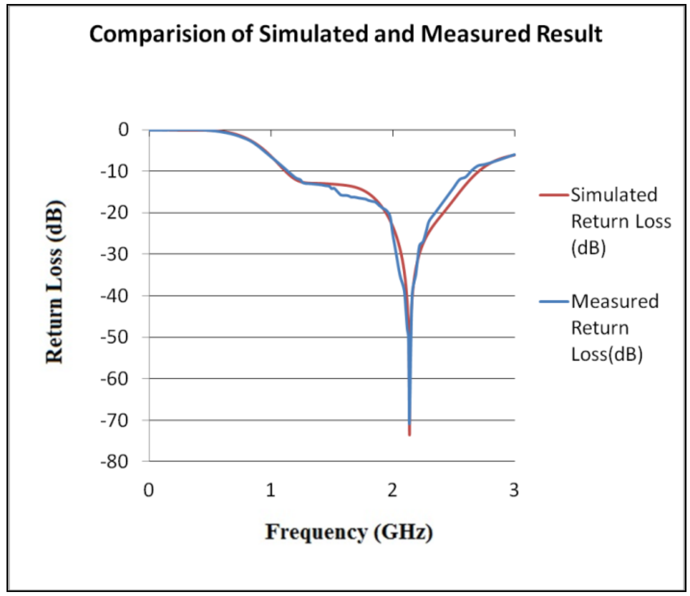


Fig3 Comparision of simulated and measured response

Here we can say that practical or measured response is approximately equal to simulated response using CST Studio 2010 software.

The photograph of a fabricated PHDMA with Hexagonal slot with etched ground plane for wide band frequency application is shown in fig 4.

Fig 4(a) Front View

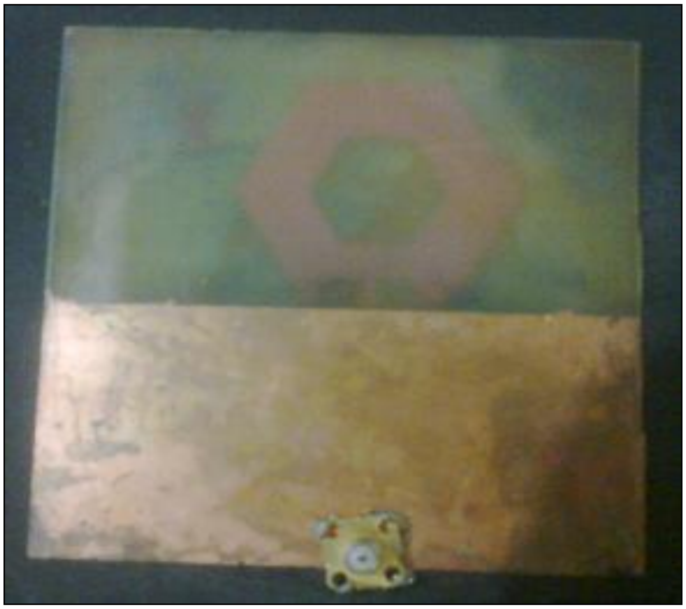
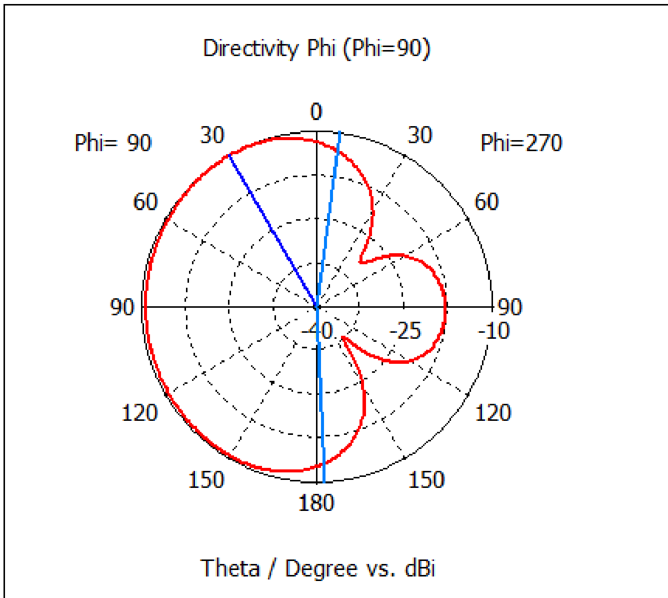


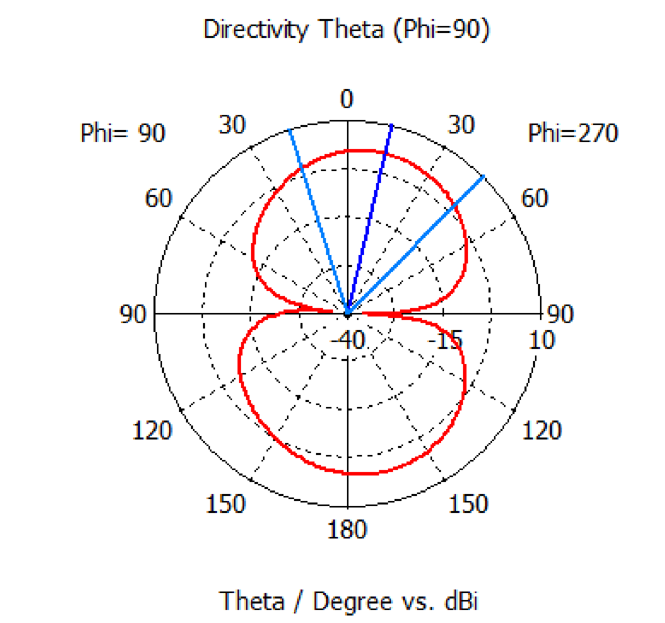
Fig 4(b) Rear View



5(ii) H-Plane

Fig 5 Radiation Patterns for Resonant Frequency of 2.139 GHz

The far field radiation patterns for proposed antenna are shown below in fig 5.



5(i) E-Plane

As we clearly seen from fig 5 that the radiation pattern of proposed monopole antenna is quite like an omnidirectional radiation pattern.

The final result of directivity, gain, bandwidth and efficiency is shown in a tabular form in Table 2 below:

Resonant Frequency (GHz)	Direct- -ivity (dBi)	Gain (dB)	BW (GHz)	Total Radiation Efficiency
2.139	2.737	2.522	1.5884	95.15%

Table 2

Comparison of above parameters after variation in feed gap of the proposed antenna is shown in a following figure 7 and in a tabular form shown in Table 3.

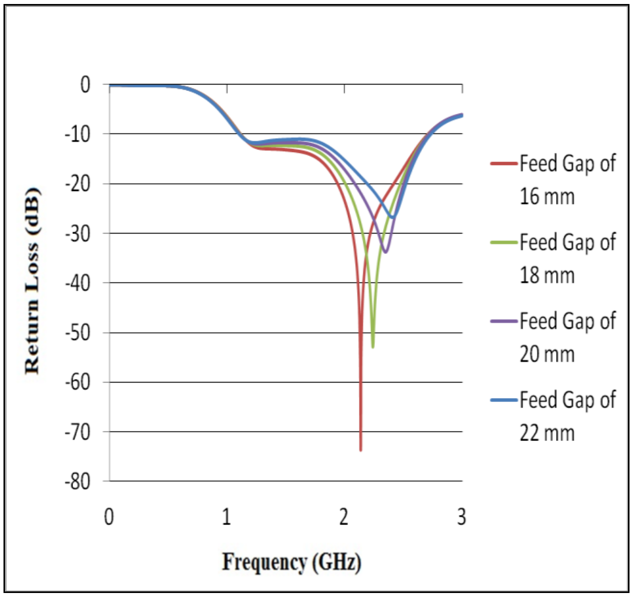


Fig 7 Comaprision of Feed Gap

S. No.	Feed Gap (mm)	BW (GHz)	Efficiency	Directi--vity (dBi)	Gain (dB)
1	16	1.5884	95.15%	2.737	2.522
2	18	1.5973	94.73%	2.870	2.635
3	20	1.604	93.27%	3.269	2.968
4	22	1.6276	92.51%	3.418	3.089

Table 3

It can be observed from the above comparison that as much as we increase the feed gap of the proposed monopole antenna, all the parameters i.e. Bandwidth, Directivity, Gain also increase but the efficiency is decreases along with Return loss magnitude, As we have measured the response only in 0-3 GHz, we can't increase the feed gap anymore because the upper band frequency is then crossed the 3 GHz limit.

Comparison of all the parameters after variation in Slot Diameter of the proposed antenna is shown in a following figure 8 and in a tabular form shown in Table 4.

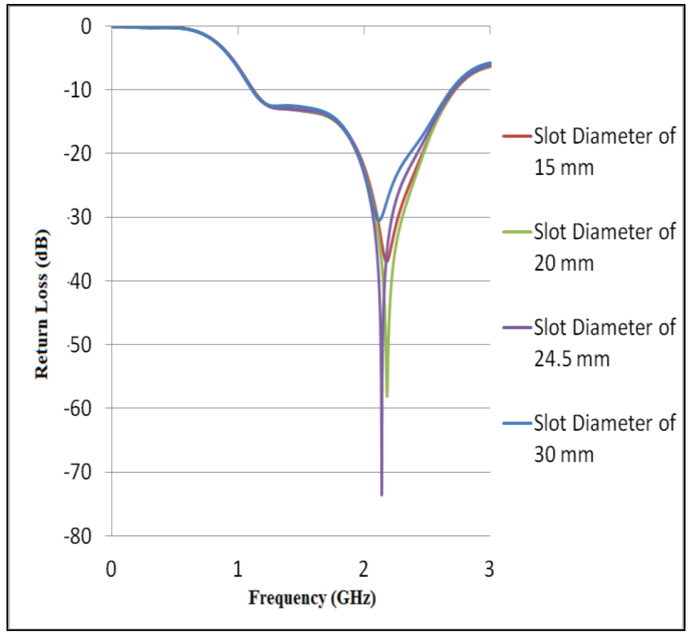


Fig 8 Comparison of Slot Diameter

S. No	Slot Diameter (mm)	BW (GHz)	Efficiency	Direc tivity (dBi)	Gain (dB)
1	15	1.595	95.10%	2.597	2.380
2	20	1.5935	95.17%	2.609	2.394
3	24.5	1.5884	95.15%	2.737	2.522
4	30	1.5787	94.77%	2.908	2.678

Table 4

It can be observed easily that slot diameter doesn't make much difference upon bandwidth or efficiency but there is an increment both in directivity and gain. We also see the magnitude of return loss is maximum for our standard slot diameter of 24.5 mm.We measured our proposed antenna only 0-3GHz interval so we can't get much opportunity above 3 GHz frequency so that we are unable to increase slot diameter above 30 mm.

We have also compared Directivity and Gain with respect to frequency and plotted the response curves in Fig 9.

In addition to that we also compared the Total Radiation Efficiency with respect to frequency and plotted the resultant curve in Fig 10 respectively.

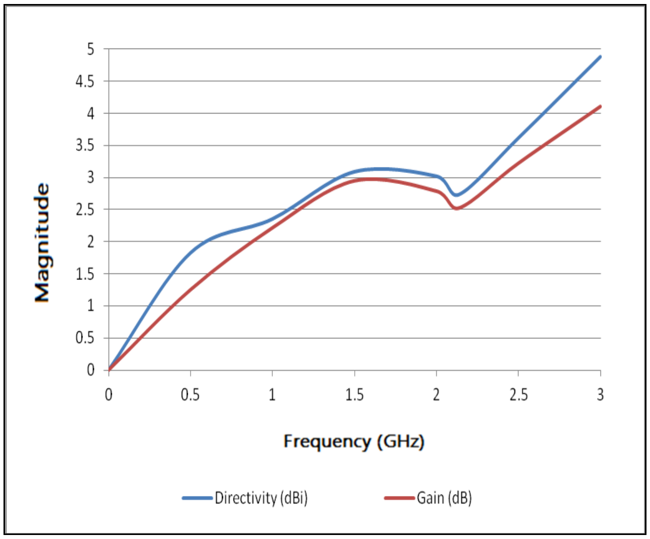


Fig 9 Gain & Directivity Vs Frequency Plot

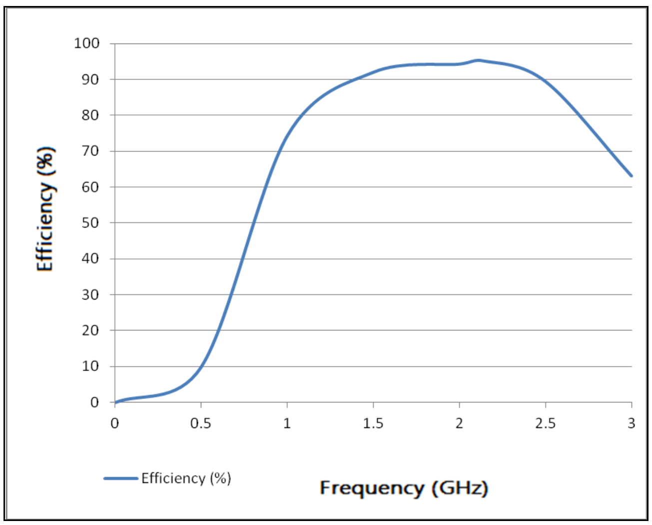


Fig 10 Total Radiation Efficiency Vs Frequency Plot

IV. CONCLUSION

Configuration of printed hexagonal disc monopole antenna with a hexagonal shaped slot on the FR4 lossy substrate with etched ground plane has been fabricated for the wide band frequency applications. After analyzing the measured response it has been noticed that optimum response for the wide band of frequency bandwidth and minimum return loss has been achieved. We also checked the effect of feed gap space and hexagonal slot diameter, we can conclude that both affect the response of the proposed antenna and optimum response has been achieved. Simulation results have been verified with experimental result with good degree of agreement.

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