# Bandwidth Improvement Using Four Slots In Octagonal Microstrip Patch Antenna

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*Abstract*- **The design and experimental demonstration of a Slotted Octagonal Patch MPA (Microstrip Patch Antenna) is presented which results in increases in Bandwidth from 3.95% to 12.5% at the range of 4.08GHz and the efficiency of 44.72 is also achieved. The geometry of slotted Octagonal MPA is designed on a FR4 substrate with a dielectric constant and tangent loss of 4.4 and 0.025 respectively.**

***Keywords***— **Bandwidth, Octagonal Microstrip Patch Antenna, Coaxial probe feed, 2D Radiation pattern**.

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## I. INTRODUCTION

For communication purpose antenna is widely used. An antenna is a conductor that can transmitt, send and receive signals such as microwave, radio or satellite signals. Many fields are there, where antenna is used like space technology, aircrafts, mobile communication, missiles tracking, remote sensing and satellite broadcasting [1].There are different types of antenna e.g. monopole, dipole , leaky-wave, aperture, reflector, microstrip antenna and many more . Type of antenna depends on the application. Due to development in communication systems, these systems require development of low cost, light weight, low profile antennas those are capable to give high performance over a wide band of frequencies[2][3]. To fulfill these requirements use of microstrip patch antenna is increasing day by day. Microstrip patch antennas are most widely used antenna in microwave frequency range. A microstrip patch antenna consists of conducting patch on a ground plane separated by dielectric substrate. Conducting patch is made of conducting material such as copper or gold. The shape of the patch could be square, rectangular, circular, elliptical, semicircular [4], hexagonal, triangular or other common shape.[5] Length, width, input impedance, gain and radiation patterns are main parameters to characterize a microstrip antenna. For proper matched input impedance there are four types of feeding techniques like Microstrip line feed, Coaxial feed, Aperture coupled feed, Proximity coupled feed. Main advantage of coaxial feeding technique is that the location of feed can be changed at desired location on the patch to match with its input impedance [6]-[8]. In this paper coaxial feed technique is used. Various methods are used to analyse the microstrip patch antenna these are transmission line model, cavity model and full- wave model. In this paper full-wave method is used to analyse the proposed geometry because this model is accurate, versatile and can work on single element, stacked element, different shaped element and coupling, other two models are complex in nature. Here new geometry of octagonal microstrip patch antenna is proposed. Narrow bandwidth and low gain is main limitations of a octagonal patch. These limitations can be overcome by some modification in the patch geometry. There are some examples that shows the work of researchers to overcome these limitations like bandwidth improved upto 4.15% by taking a gap between open end and patch edge[9] and in other example for dual band 3.82% & 4.65% bandwidth was obtained by changing two microstrip line feed location in the patch[10]. In this paper there is improvement in bandwidth upto 12.5% which is better than the past proposed results.

In this paper, a novel geometry is proposed and simulated results are compared with conventional patch results. The geometry was simulated using IE3D electromagnetic simulator [11]. This software is a full-wave, methods of movements based electromagnetic simulator solving the current distribution on 3D and multilayer structure of general shapes. The second section comprises of antenna geometry and in the third section of the paper simulated results are discussed followed by conclusion in the fourth section.

## II. ANTENNA GEOMETRY

Octagonal microstrip patch antenna is also a popular used antenna, after rectangular and circular microstrip patch antenna. Here conventional octagonal microstrip patch antenna is considered the reference antenna to compare the results of that simulated from single slot octagonal patch antenna.

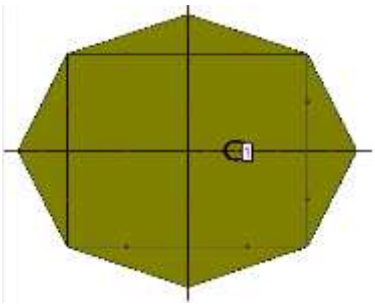

Fig.1. Octagonal Microstrip Patch Antenna.

The geometry of the conventional octagonal MPA is shown in Figure 1The patch has the dimension of 9 mm (each arm) A 50Ω coaxial probe is used to connect the microstrip patch at coordinates and it is made fixed for both the conventional and the single slot octagonal MPA.

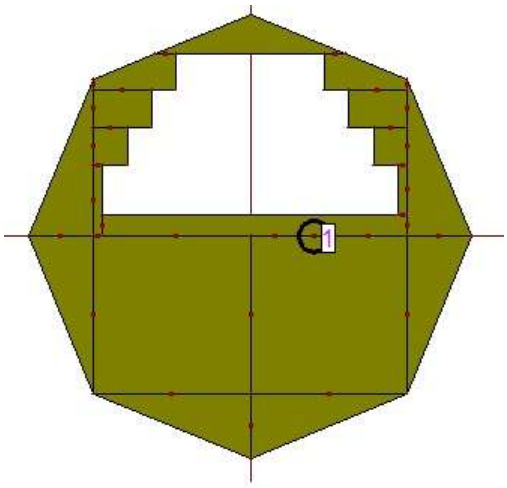

Fig.2.Proposed geometry of octagonal MPA

The geometry is proposed to improve the radiation parameter of probe-fed patch antenna with single four slots are shown in Fig. 2. The dimension of slot 1 is 0 mm, 1.9 mm with 12 mm length and 2 mm width, for slot 2 dimensions are 0 mm, 3.4 mm with 10 mm length and 2 mm width, for slot 3 dimensions are 0 mm, 4.9mm with 8 mm length and 2 mm width and for slot 4 dimensions are 0 mm, 6.4 mm with 6 mm length and 2 mm width. Impedance bandwidth of about 12.5% can be obtained from the above geometry. Main advantage of this geometry is that it produces wider bandwidth than the conventional octagonal patch with simple topology.

## III. SIMULATED RESULTS

After simulation of conventional octagonal MPA and single slot octagonal MPA on IE3D software, following results are obtained for antenna:

*A) Results of conventional octagonal microstrip patch antenna.*

*1) Radiation Pattern:* A plot through which it is visualizes where the antenna transmits or receives power. The microstrip antenna radiates normal to its patch surface. So, the elevation pattern for φ= 0 and φ= 90 degrees are important for the measurement.

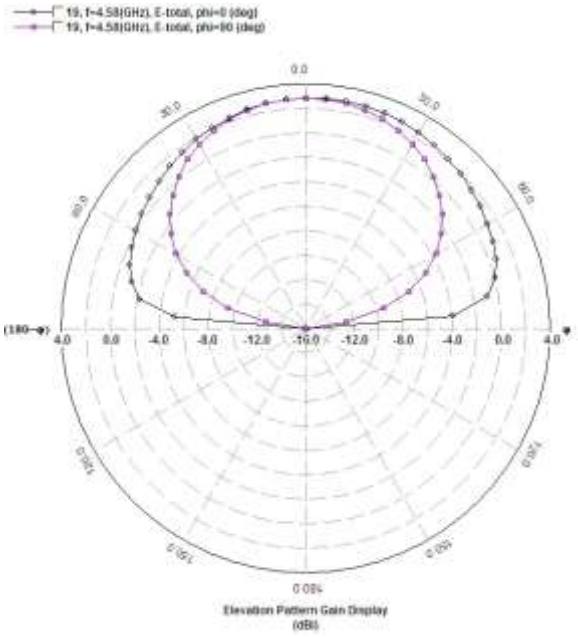


Fig.3. 2D Radiation Pattern for octagonal MPA

The simulated E-plane and H-plane pattern, 2D pattern view the octagonal MPA is illustrated in Fig. 3. Radiation pattern is smooth and uniform over the band of frequencies.

*2) Return Loss and Bandwidth:* Return Loss is a measure of how much power is delivered from the source to a load and measured by $S_{11}$ parameters. Bandwidth is the range of frequencies over which the antenna can operate effectively. Bandwidth can be calculated by going 10 dB down in return loss.

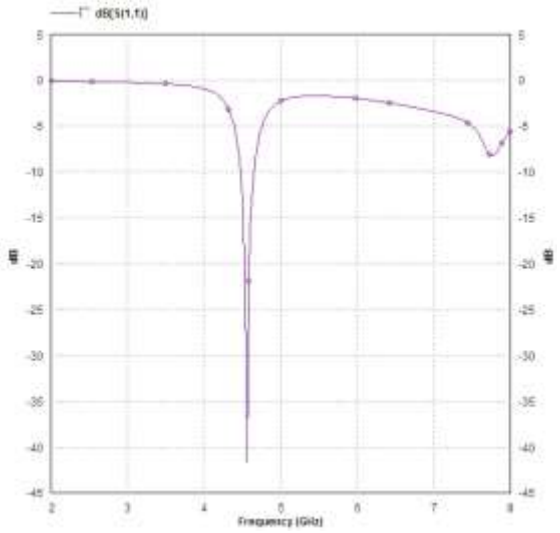


Fig.4. Simulated Return Loss for octagonal Microstrip Patch Antenna.

Return Loss shown in Fig. 4 of the octagonal microstrip patch antenna is -41.64 dB at resonating frequency 4.56 GHz and from the Return Loss curve the bandwidth obtained is 3.95%.

*3) Smith Chart:* Smith Chart provides the information about polarization and the impedance match of the radiating patch. The smith chart for the conventional octagonal MPA is given in Fig.5.

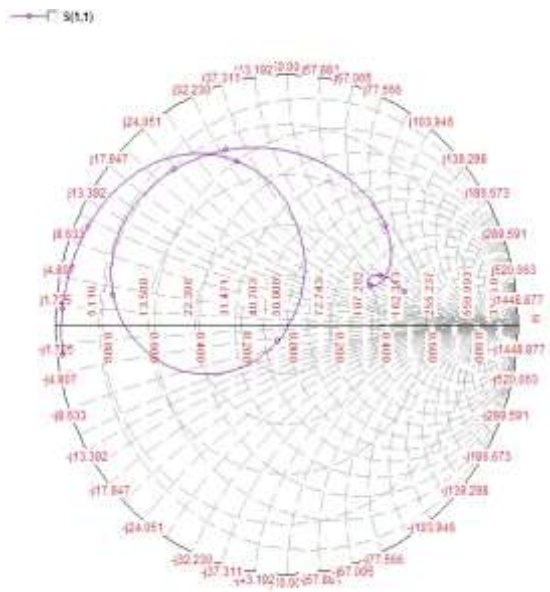


Fig.5. Smith Chart of octagonal Microstrip Patch Antenna

Fig 5 shows the input impedance of 50.48Ω –j0.67 at resonant frequency 4.56 GHz. This smith chart shows that the antenna is linearly polarized.

*A. Results of four slots octagonal micro strip patch antenna.*

*1) Radiation Pattern*: The 2D Radiation pattern is given in Fig. 6.

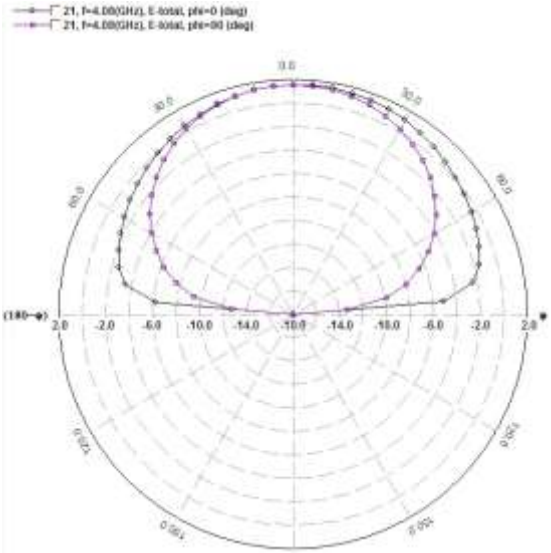

Fig.6. 2D Radiation Pattern for proposed geometry of octagonal Microstrip Patch Antenna.

Radiation pattern of single slot octagonal microstrip patch antenna is also smooth and uniform over the frequency range.

*2) Return Loss and Bandwidth:* The Return Loss shown in Fig.7 of the four slot octagonal micro strip patch antenna is -36.72 dB at resonating frequency 4.08 GHz and from the Return Loss curve the bandwidth obtained is 12.5%.

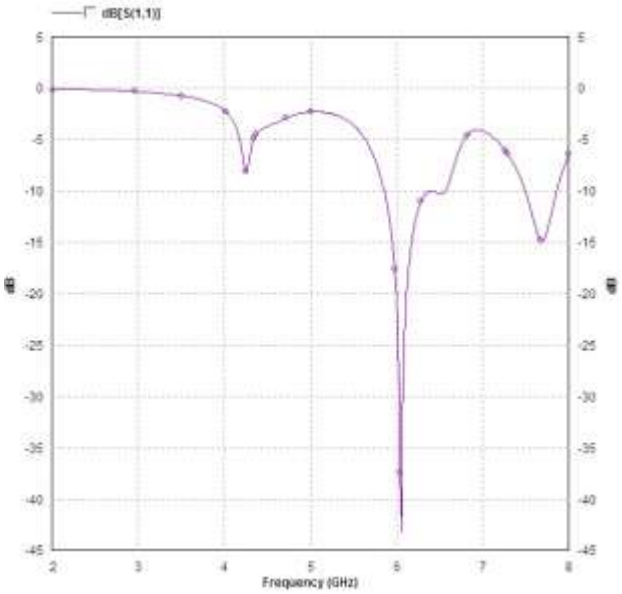


Fig.7. Simulated Return Loss for proposed geometry of octagonal Microstrip Patch Antenna.

Fig 7 shows that the band width of proposed microstrip antenna improves to 12.5% from the conventional antenna of 3.95%. and resonant frequency also decreased and bandwidth is wider compared to the conventional geometry.

*3) Smith Chart:* The Smith Chart for four slots octagonal MPA is given in Fig.8.

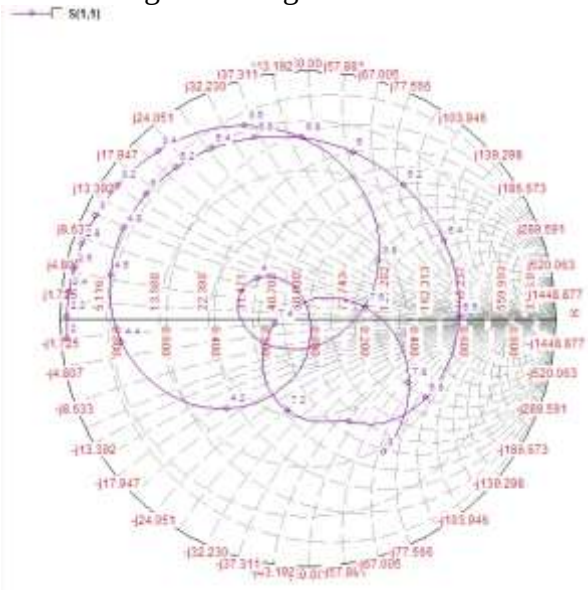


Fig.8. Smith Chart of proposed geometry of octagonal Microstrip Patch Antenna.

Fig 8 shows that the 49.78Ω –j3.25 input impedance is obtained for the proposed antenna and the antenna is circularly polarized with some impurity.

*4) Efficiency graph:* The Efficiency graph for octagonal MPA is given in Fig.9

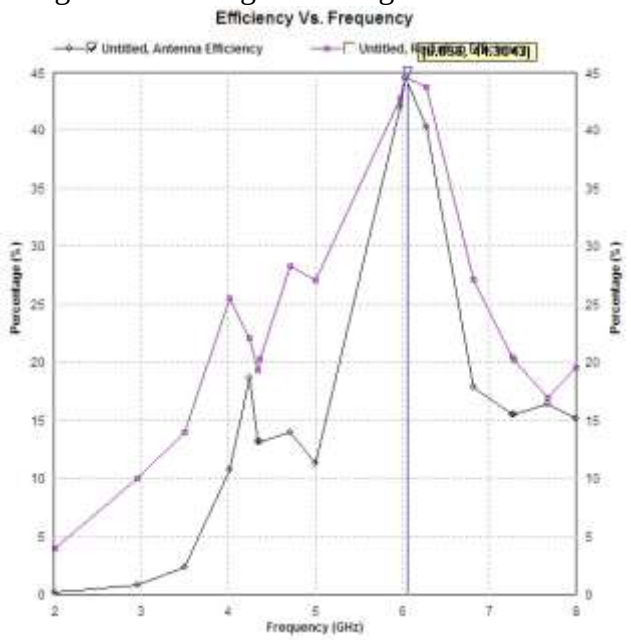


Fig.9. Efficiency graph of proposed geometry of octagonal Microstrip Patch Antenna.

Fig 9 shows the antenna and radiation efficiency of 44.72 and 44.77 at resonant frequency 4.08 GHz

Table I shows that the comparison of simulated result on conventional geometry and new proposed geometry.

| Sr. No. | Characteristics | Single Slot octagonal patch | Two slots octagonal patch | Three slots octagonal patch | Four slots octagonal patch |
|---|---|---|---|---|---|
| 1. | Resonant Frequency (GHz) | 7.68 | 7.54 | 7.43 | 4.08 |
| 2. | Return Loss (dBi) | -35 | -28.62 | -22.99 | -36.72 |
| 3. | Gain (dBi) | 0.87 | 1.14 | 1.23 | 1.55 |
| 4. | Bandwidth (%) | 4.53 | 5.567 | 5.95 | 12.5 |

| | | | | | |
|---|---|---|---|---|---|
| 5. | Efficiency | 28.92 | 34.76 | 38.17 | 44.72 |

## IV. CONCLUSION

In this paper, the radiation performance of four slots octagonal microstrip patch antenna using FR4 as dielectric with dielectric constant, $\varepsilon_r$= 4.4 and the thickness of the substrate, h = 1.59 mm., is simulated by applying IE3D full-wave electromagnetic simulator and compared with conventional octagonal patch antenna. This study on octagonal slotted microstrip patch antenna shows that the enhancement of its performance is possible by optimizing the antenna parameters. The approach described in this paper is of cutting the patch. In this paper, the new geometry proposed the improvement in the better bandwidth of 12.5% and was achieved by embedding slots in the antenna design. The radiation pattern of the antenna was stable over the entire bandwidth.

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