INTERNATIONAL JOURNAL OF SCIENTIFIC PROGRESS AND RESEARCH (IJSPR) ISSN: 2349-4689
Issue 173, Volume 73, Number 01, July 2020

Compact Octagon-Shaped Broadband Microstrip Patch Antenna for Wideband Applications

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Abstract- Microstrip Patch Antenna finds large number of applications due its compact in shape and small in size. In this research work broadband Octagon-shaped antenna has been proposed. As a structure of antenna is simple, low profile and broadband antenna is presented . By combining a Octagon-shaped patch and partial ground structure. As per as results are concern this antenna provides a frequency band from 3.07 to 11.88 GHz. Simulation results shows that this antenna achieves a good broadband characteristics. This antenna has a two resonance frequency at 3.833 GHz and 10.437 GHz. This antenna is feasible to provide broadband applications. The proposed antenna offers 10-dB impedance bandwidth is 73 % that is far better than previous research work. The antenna has been designed on FR-4 substrate, Loss Tangent ($tan(\delta) = 0.02, dielectric\ constant\ (\varepsilon_r) = 4.3$) with the thickness of 1.6 mm. The presented antenna has been examined on CST Microwave Studio. To make the antenna broadband the dimensions of Octagon-shaped patch and partial ground.

Keywords: Microstrip Patch Antenna, Broadband applications Octagon-shaped Antenna, CST - Computer Simulation Technology.

I. INTRODUCTION

Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. For good performance of antenna, a thick dielectric substrate having a low dielectric constant is necessary since it provides larger bandwidth, better radiation and better efficiency. A typical configuration leads to a larger antenna size. In order to reduce the size of the Microstrip patch antenna, substrates with higher dielectric constants must be used which are less efficient and result in narrow bandwidth. Hence a trade-off must be realized between the antenna performance and antenna dimensions.

Advantages of Microstrip Patch Antennas

Microstrip patch antennas are mostly used in wireless applications due to their low profile structure. Therefore they are extremely compatible for embedded antennas in handheld wireless devices such as cellular phones, pagers etc... Some of the principal advantages are given below:

- *Light weight and less volume.*
- *Low fabrication cost, therefore can be manufactured in large quantities.*
- *Supports both, linear as well as circular polarization.*
- *Low profile planar configuration which can be easily made conformal to host surface.*
- *Can be easily integrated with microwave integrated circuits (MICs).*
- *Capable of dual and triple frequency operations.*
- *Mechanically robust when mounted on rough surfaces.*

II. ANTENNA GEOMETRY & PARAMETRIC ANALYSIS

Geometry and all dimensions of the presented antenna have been shown in below. The presented antenna structure has been placed in the x-y plane and symmetric about the longitudinal axis. Octagon-shaped patch along with the 50ohm microstrip line are printed on the top of Fiberglass Polymer Resin (FR-4) substrate with the thickness 1.6 mm.

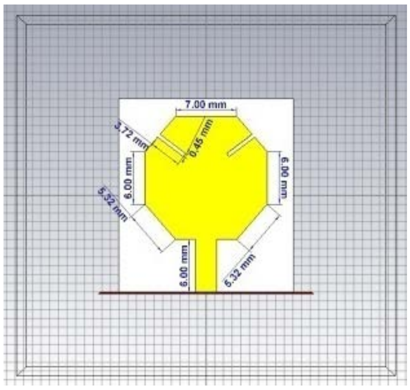


Fig. 1 Geometry of the Octagon-shaped Patch (Front).

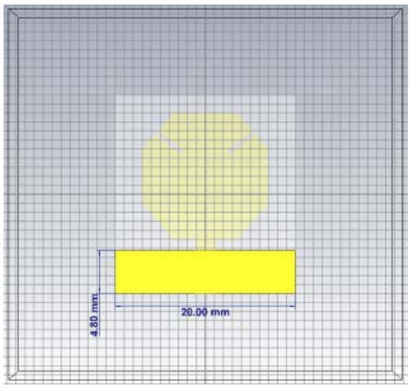


Fig. 2 Geometry of the Partial Ground Structure (Back).

On the bottom side of the substrate partial ground has been designed. The presented antenna is energized by SMA port through a microstrip feed line. Optimized dimensions of presented antenna shown in figure. The overall volume of antenna is (20 × 22 × 1.6) mm3. All Optimized dimensions of Octagon-shaped patch structure has been shown in figure 1. Partial ground structure has been shown in figure 2 and the combined optimized patch and ground antenna structure has been presented in figure 3.

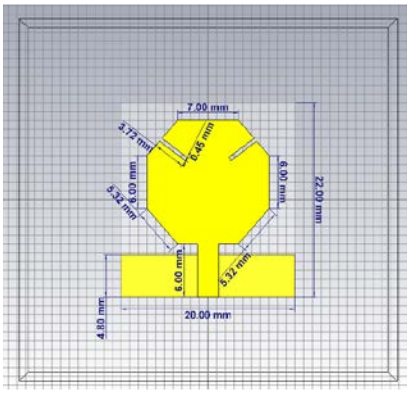
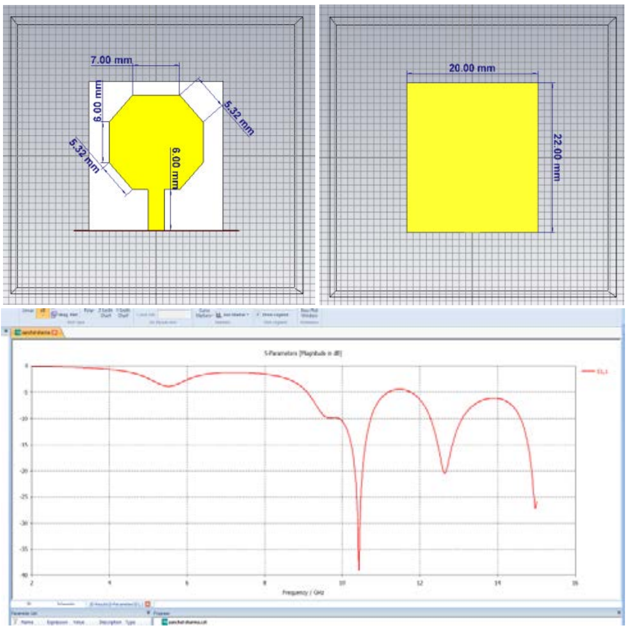


Fig. 3 Geometry of the Combined Patch and Ground Structure (Front & Back).

III. ANTENNA EVOLUTION & PARAMETRIC ANALYSIS

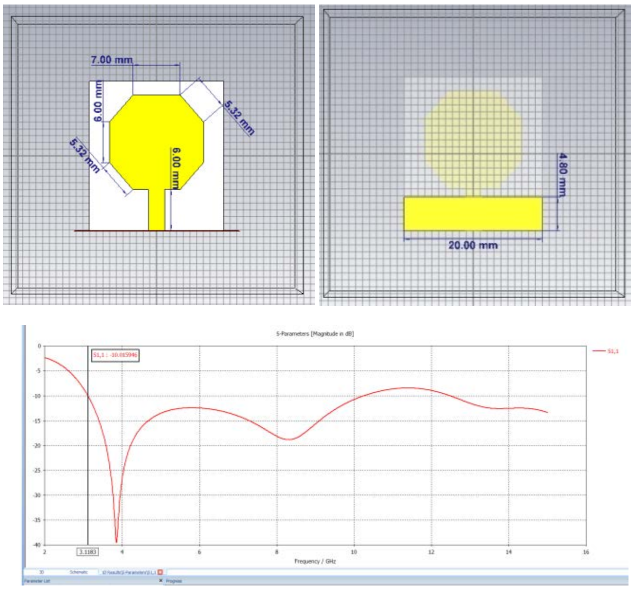
Comparison of Antenna 1, Antenna 2 and Antenna 3 has been presented below section. In antenna 1 has big size Octagon-shaped patch with full ground structure the S11 or return loss is not good for broadband applications as it is clear that the impedance matching between patch and ground is not up to mark.

Antenna 1

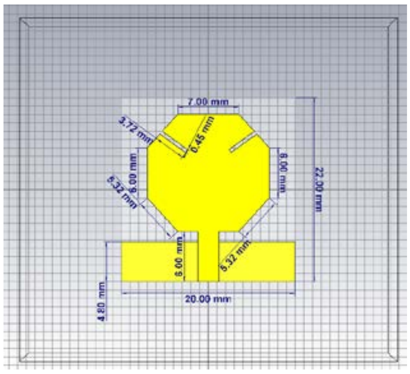


In Antenna 2 the Octagon-shaped structure has been made smaller in size with full partial ground structure in order to make impedance matching between Patch and ground by doing this the return loss from 3.1375 GHz to 10.176 GHz or S11 has been lowered down from -10 dB so from here it is clear that still the impedance matching between patch and ground could be reach to its optimized value.

Antenna 2



In Antenna 3 the ground structure has been cut down to below the Octagon-shaped patch to down below microstrip feed line and two I section slots cut down at upper section on the patch . After simulated this antenna the return loss (S11) curve shows that the Impedance matching between Patch and ground has been achieved. As the return loss reached below -10dB from the 3.07 GHz frequency range to 11.88 GHz which made this antenna feasible for broadband applications.



Antenna 3

IV. RESULT ANALYSIS

Return loss characteristics shows that the optimized Antenna 3 is providing good return loss curve the lower cut-off frequency is 3.07 GHz and the higher cut-off frequency is 11.88 GHz. So this antenna became a Broadband Antenna. It can be observed that the presented antenna is resonating at 3.833 GHz and 10.437 GHz in figure 4. Proposed antenna has provided the impedance bandwidth of 117.85% from 3.07 to 11.88 GHz.

$$Antenna\ Bandwidth\ = 2\left(\frac{f_H - F_L}{f_H + F_L}\right) \times\ 100)\ \%$$

$$= 2 \times \left(\frac{11.88 - 3.07}{11.88 + 3.07}\right) \times 100\ \%$$

$$= 2 \times \left(\frac{8.81}{14.95}\right) \times 100\ \%$$

$$Antenna\ Bandwidth\ = 117.85\ \%$$

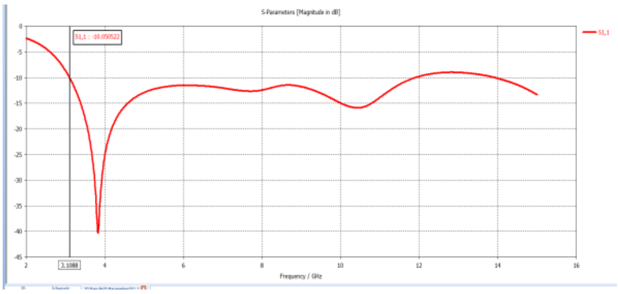


Fig.4 S_{11} Return Loss Characteristics of Proposed Antenna

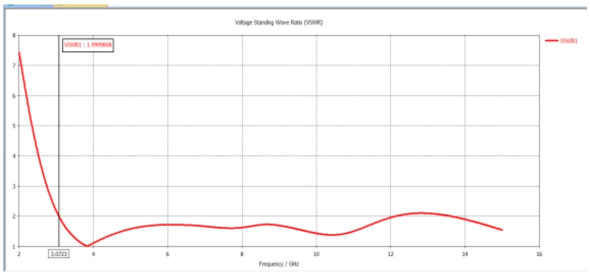


Fig.4 VSWR Curve of Proposed Antenna

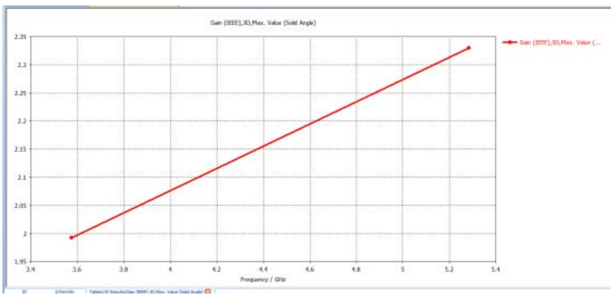


Fig.5 Proposed Antenna Gain Curve

2D Radiation Pattern of presented antenna has been shown in figure. At 3.833 GHz omni-directional radiation pattern has been analyzed.

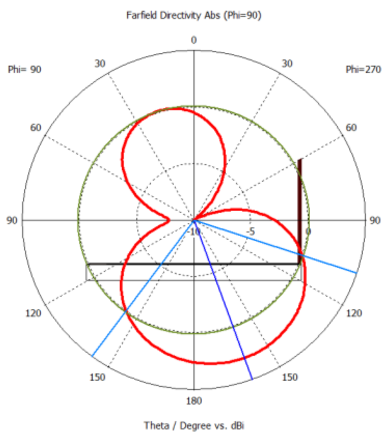


Fig. 6 2D Farfield at 3.833 GHz

3D Radiation Pattern of presented antenna has been shown in figure. At 3.833 GHz omni-directional radiation pattern has been analyzed.

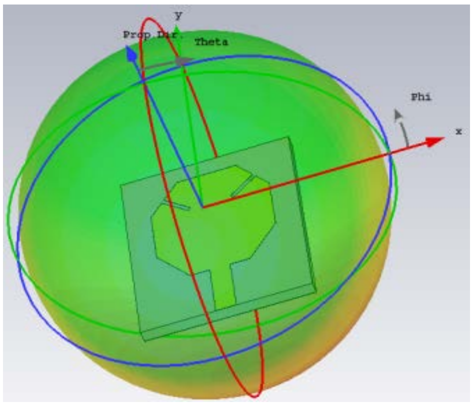


Fig. 7 Farfield 3D View with Antenna Structure at 3.833 GHz

2D Radiation Pattern of presented antenna has been shown in figure. At 10.437 GHz radiation pattern has been analyzed.

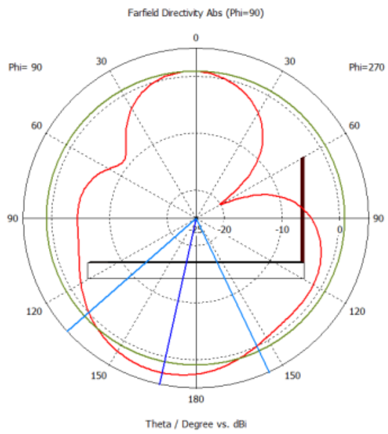


Fig. 8 2D Farfield at 10.437 GHz

3D Radiation Pattern of presented antenna has been shown in figure. At 10.437 GHz radiation pattern has been analyzed.

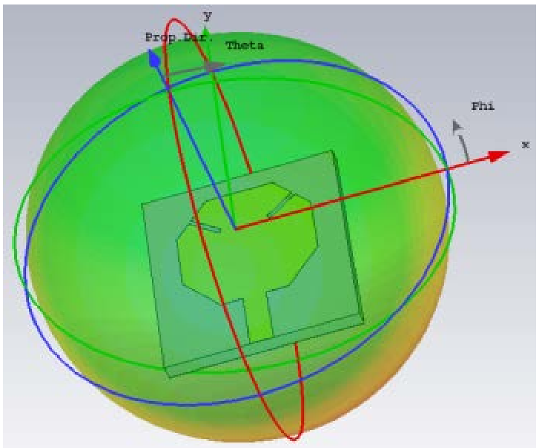


Fig. 9 Farfield 3D View with Antenna Structure at 10.437 GHz

Table 1 Comparison Table between Previous Research Work and Proposed Work

Parameters	Previous Research Work	Proposed Research Work
Antenna Size	20 mm * 24 mm	20 mm * 22 mm
Lower Operating Frequency	8.49 GHz	3.07 GHz
Higher Operating Frequency	11.30 GHz	11.88 GHz
Resonating Frequencies	9.9 GHz	3.833 GHz and 10.437 GHz
Bandwidth	28.25 %	117.85%
Return Loss	-35.48 dB	-40 dB
Applications	Wireless Applications	Wi-Max, Mobile Communication, Fixed-Satellite (space to earth), Aeronautical Radio Navigation, Radio Astronomy, Fixed-Satellite (earth to space) etc.

V. CONCLUSION

As the size of proposed Octagon-shaped antenna is smaller than the previous antenna this makes a compact antenna. S11 or Return Loss Characteristics shows that presented antenna has a good impedance matching between patch and ground cause a large radiation in air occurred . Proposed Microstrip patch antenna has confirmed that this antenna has several advantages over the previous research work and flexible for not only WiMAX (3.6 GHz) application as well as for Mobile Communication (3.65 to 3.7 GHz), Fixed-Satellite (space to earth 3.7 to 4.2 GHz), Aeronautical Radio Navigation(4.2 to 4.4 GHz), Radio Astronomy (4.99 to 5GHz), Fixed-Satellite (earth to space (5.15 to 5.25 GHZ) etc. so this antenna has a large number of applications so that this antenna is said to be a broadband antenna.

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