A Compact Octagon Shaped Patch Antenna for Terahertz Applications

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***Abstract*: In this research article, design and simulation of a compact octagon shaped patch antenna on a low dielectric loss material Rogers RT/ duriod 5880 tm which is suitable for higher frequency range were done. The designed antenna has an operating bandwidth at terahertz band frequencies which is from 0.75-10 THz. It is useful for Terahertz applications like product inspection (industry), spectroscopy (chemistry, astronomy), and material characterization (physics). The design and simulation of the proposed antenna such as radiation pattern and return loss was performed by Ansoft-HFSS.**

***Index Terms*: Ansoft-HFSS; Microstrip antenna; Terahertz applications; Terahertz**

I. INTRODUCTION

The Development of next-generation wireless communication network requires extreme broadband capabilities in various types of applications like Astronomy, Sensing, Biology, Screening of weapons and wireless applications. Microstrip patch antenna [7-21] is a very crucial component for wireless communication due to its geometrical characteristics (small-size, lightweight, adaptability). The THz regime is also used in satellite communications to employ small transmitter and receiver antennas. THz electromagnetic spectrum range includes both microwave and optical frequencies i.e. 0.1 THz- 10 THz, moreover it has a wider bandwidth for high data rates to transfer the data with a low transmission power and less probability of error occurrences to provide good spatial resolution. It obeys high data rate (>10 Gbps) with high security.

In [1], a rectangular microstrip patch antenna is presented which is operating at THz frequency band which ranges from 0.7- 0.85 THz, used for short-range wireless applications and satellite applications. The proposed antenna designed on the RT Duriod 6006 having the dimensions of 1000μm × 1000μm × 200μm size with the relative permittivity of 6.15 and the is loss tangent 0.019. Simulated results are performed by using CST (MWS) simulating software. The square shaped proposed antenna with 2-Dimensional photonic crystal at air gaps is presented in [2]. Arlon AR 600 material with $\mathcal{E}_r$=6.0 is chosen as a substrate. 200 × 200 μm2 size square shape patch is connected with 50 × 93 μm^2 feed line, fed by simple microstrip feed. Proposed antenna satisfies to operate in the frequency ranges of spectroscopy, astronomy and security applications. Double band rectangular shape microstrip patch antenna is proposed in [3] for surveillance system applications at THz applications. Two layers 500 × 500 μm^2 size substrate is used to design proposed antenna with 170 × 270 μm2 area radiating patch. It operates at 600 GHz and 800 GHz frequencies. A rectangular shape microstrip antenna having size 500 × 300 μm^2 fed by microstrip feed, designed on a two-dimensional electromagnetic crystal substrate, size of 1000× 1000 × 200 μm3. The proposed antenna generates impedance bandwidth of 0.6 – 0.95 THz. In [5], trapezoidal shape radiating microstrip patch antenna was presented for high-speed THz applications. It is designed on the photonic crystal Rogers RO 3003 substrate with tan δ=0.013 and $\mathcal{E}_r$=3, fed by microstrip feed. Return loss, gain and VSWR simulation results have been achieved over the operating frequency range. In [6], a microstrip feed antenna designed on LTCC substrate. It is operated at 350 GHz frequency for high speed wireless THz applications.

In this article, an octagonal shaped microstrip patch antenna is designed and simulated over the frequency ranges of THz applications. The proposed antenna is simulated by using HFSS followed by Finite Element Method (FEM).

II. ANTENNA DESIGN

The couple of parallel conducting layers are mounted in dielectric medium and it acts like a substrate as shown in Fig. 1 and 2. In the structure, upper conducting layer acts as a source. The radiating electromagnetic energy does not occur towards edges of a substrate but it occurs in substrate. The below conducting layer is acting like a perfect reflected ground plane and it reflects the radiating energy back through the substrate and in free-space. The size of antenna generally relies upon the operating frequency band. There are a few different factors that can be added to choosing of dimensions of the antenna and its performance, for example, the thickness of the substrate is utilized and the radiating element influences a throughput of the proposed antenna, this kind of substrate plays the main role in while calculating the dimensions of antenna. The excitation of micro strip patch is expert in micro strip feed line. This type of feeding technique is supply an electrical signal into the patch; it should be changed into an electromagnetic wave along with a patch. The patch is energized by the feed, at one point of time and the ground plane is distributed by the positive

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and negative charges respectively. The Distinct substrate materials are accessible for RF and microwave frequencies; the choice is depends on the desired material attributes for an ideal performance at a desired frequency ranges.
The thickness of a substrate is very significant in when designing of a micro strip patch antenna.
The most attractive substrates for antenna performances are thick having a low dielectric constant. This leads to bring high efficiency and wider bandwidth in an antenna because of approximately bounded fringing fields and originate from the patch and it spread into a substrate. Despite, it comes at a high cost and low efficiency due to development of surface waves. On another side, a substrate having thin in size and high dielectric constant reduces general size of the antenna. Here the fringing fields are tightly bound into the substrate. Because of high dielectric loss tangent, it has lower bandwidth and less efficiency.

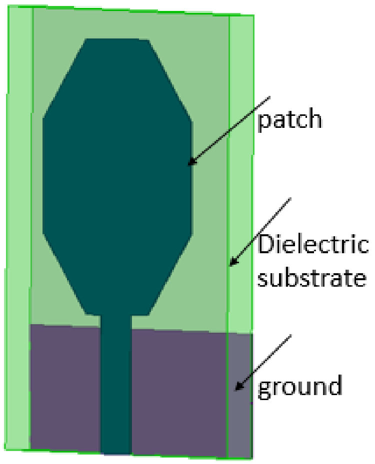

Fig 1: Proposed antenna geometry.

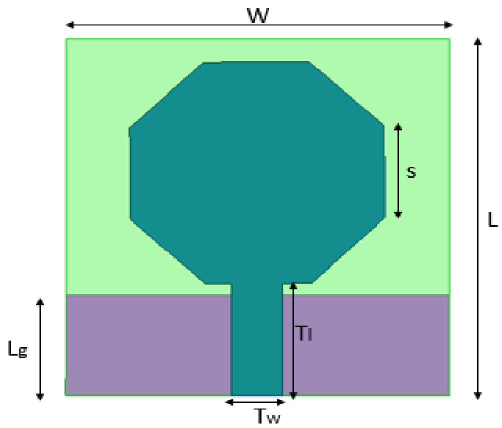

Fig 2: Layout of Proposed antenna.

The size of the substrate as shown in Fig 2. Octagon shape radiating patch having length of each side indicates as S, the length and width of feed line Tl and TW respectively. L_g is shown as length of ground plane. An Optimized dimensions of the proposed antenna as shown in Table I.

Table I: Overall dimensions of the proposed antenna.

Parameter	Length (μm)	Parameter	Length (μm)
L	160	L_g	46
W	150	T_l	50
S	41.21	T_w	20

III. RESULTS AND DISCUSSION

The performance of proposed antenna discussed in this section and simulation results has been performed by using Ansoft HFSS tool. The parameters like Return loss, VSWR and radiation patterns of proposed antenna as shown in below. Fig 3 shows return loss of the proposed antenna it shows that, it is operating in three bands i.e. lower, middle and upper frequency bands that are ranging from 0.75 THz-6.5 THz, 6.75 THz- 8.25THz and 8.45 THz. -10.25 THz respectively. The lower operating frequency band attenuation starts from 0.75 THz to 4.75 THz. The middle operating frequency band attenuation ranging 4.9 THz – 6.5 THz. The upper frequency band attenuates at 8.25 THz- 8.45 THz frequency. Fig 4 demonstrates that simulated VSWR plot under the condition of VSWR ≤ 2 the proposed antenna operate over the frequency range.

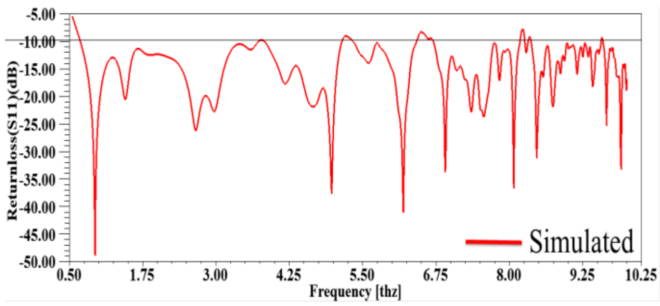

Fig. 3: Return loss of proposed THz antenna.

The E and H planes far-field radiation patterns of the proposed antenna at distinct frequencies i.e. 650 GHz, 700 GHz, 800 GHz, 2610 GHz, 4940 GHz and 6180 GHz shown in Fig 5. It illustrates that at 650 GHz frequency. E- Plane pattern satisfies Omni directional pattern around 360^0. H-Plane pattern shows like unidirectional pattern towards 0^0 and 180^0. Fig 5(b) and 5(c) shows that Omni directional pattern in E-plane and dumble shape pattern along H- plane. At 2610 GHz radiation pattern is shown in Fig 5(d), E-plane pattern is slightly distorted compared to 650 GHz, 700 GHz and 800 GHz, it generates null along 0^0 directions.
H-plane pattern shows more distorted along 0^0 directions. Fig 5 (e) and Fig 5 shows E- plane and H- plane pattern almost same and Omni directional pattern along E-plane, distorted pattern along H-plane respectively.

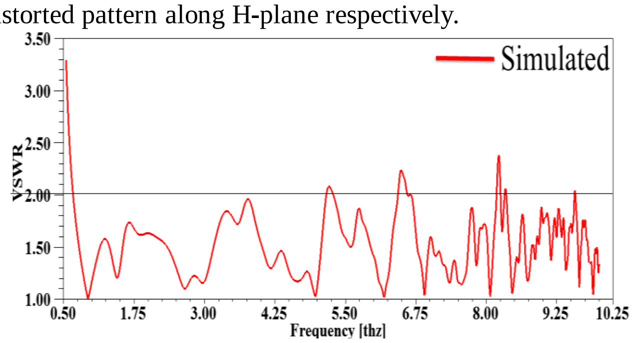

Fig. 4: Simulated VSWR of the proposed antenna.

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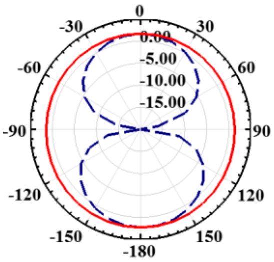
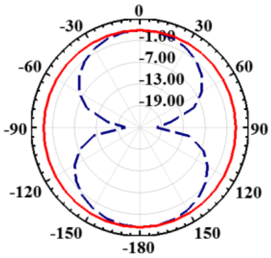
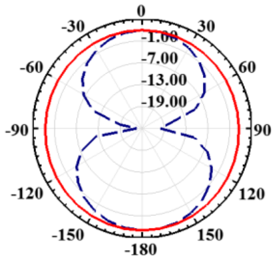


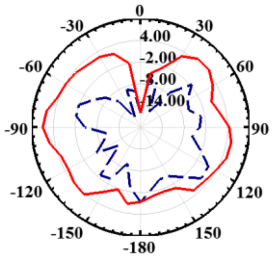
(a)



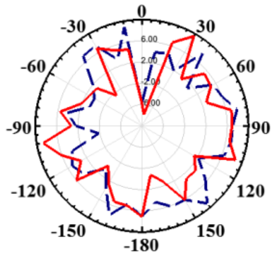
(b)



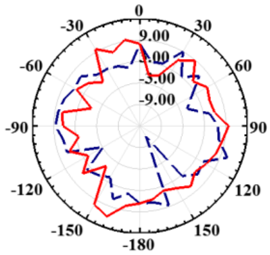
(c)



(d)



(e)



(f)

IV. CONCLUSION

An octagonal shaped radiating patch microstrip antenna is designed on Rogers RT/ duriod 5880 tm substrate. The simulation results have been presented in this paper. It satisfies that operating frequency spectrum ranging from 0.75 THz- 6.5 THz, 6.75 THz- 8.25THz and 8.45 THz- 10.25 THz. Radiation pattern at distinct frequencies presented. Simulation results of designed antenna useful in the THz applications.

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