# DESIGN AND PERFORMANCE COMPARISON OF GRAPHENE BASED DIFFERENT SHAPED MICROSTRIP PATCH ANTENNAS

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***Abstract*— Graphene based different types of slotted antennas have been designed and compared with respect to slot position, return Loss, voltage standing wave ratio, bandwidth and radiation pattern. Different patch materials, patch shapes, position and inclination of slots in these antennas can alter their performance. This paper comprises with the performance comparison of different shaped microstrip patch antennas i.e. H shape, E shape, Z shape, L shape, T shape and P shape using CST Microwave Studio Suite to operate in the frequency limit of 2.6 GHz to 4 GHz. Among these antennas P-shaped antenna has better performance than others with both copper and graphene patch materials.**

***Keywords:*** *Graphene, H shape, E shape, Z shape, L shape, T shape, P shape, return loss,* voltage standing wave ratio.

## 1. INTRODUCTION

Graphene is a single layer of carbon packed in a hexagonal (honeycomb) lattice, with a carbon-carbon separation of 0.142 nm [1]. Graphene-based materials have some strange properties, like mechanical properties, thermal properties, rheological properties, electrical properties, microwave adsorption, environmental and toxicological impacts and gas barrier properties etc. [2]. These materials are used in biological applications, principally similar to toxicity, and in more applications like electrically-conductive adhesives and selective photo redox reactions. Microstrip patch antennas [3] in the frequency limit 2.6-4 GHz are used in various applications like Mobile Service (MS), Worldwide Interoperability for Microwave Access (WiMAX), Fixed Service (FS), Fixed Satellite Service (FSS) etc.[4].Graphene can increase the performances of microstrip patch antenna. It has better both electrical and thermal conductivity than copper [2]. This work presents an exhaustive comparative study of six popular types of slotted antenna topologies: H-shaped [5], E-shaped [6], Z-shaped [7], L-shaped [8], T-shaped [9] and P-shaped patch antennas with copper and graphene patch materials. P-shaped patch antenna has better performance compared to other proposed antennas. It provides -108.72 dB return loss (RL) and 91.3 MHz bandwidth with graphene patch.

## 2. ANTENNA MODELING

The effective dielectric constant can be calculated by

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-1/2} \quad (1)$$

where, $\varepsilon_r$ denotes dielectric constant of the substrate.
h denotes height or thickness of the dielectric.
and w denotes width of patch.

The extension length is determined by

$$\Delta L = 0.412h\frac{\left(\varepsilon_{reff} + 0.3\right)\left(\frac{w}{h} + 0.264\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{w}{h} + 0.8\right)} \quad (2)$$

Then the actual L, in meters is determined by

$$L = \frac{v_o}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta \quad (3)$$

Where, $\upsilon_o$ denotes velocity of light.
And the width W of the patch is determined by

$$w = \frac{v_o}{2f_r\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \quad (4)$$

Where, $f_r$ denotes resonant frequency.

**Table I.** Microstrip Patch Antenna Parameter

| Parameters | Value (mm) |
|---|---|
| Ground plane length, $L_0$ | 100 |
| Ground plane width, $W_0$ | 75 |
| Antenna length, L | 56 |
| Antenna width, W | 50 |
| Feeder length | 41 |
| Feeder width | 3.8 |
| Substrate thickness | 1 |

 

All these antennas are designed with same width, length, same feeding but different patch materials and different patch shapes. In order to justify the performance of the six antennas these are operated in same frequency limit from 2.6 GHz to 4 GHz. By changing the shape of antenna, the dimension of the slot and patch material performance can be improved. Fig. 1-6 show the different shaped microstrip patch antennas.

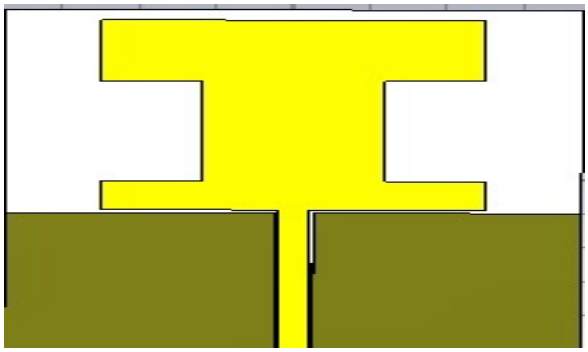

**Fig. 1.** H-shaped microstrip patch antenna.

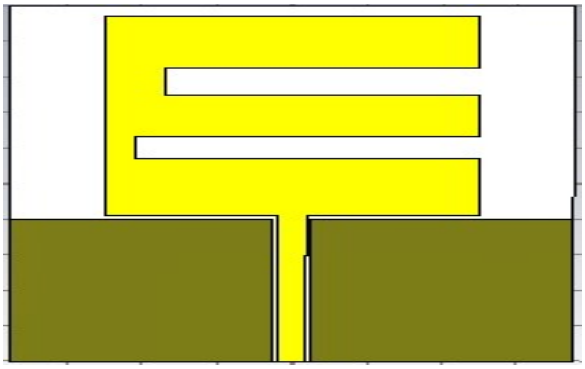

**Fig. 2.** E-shaped microstrip patch antenna.

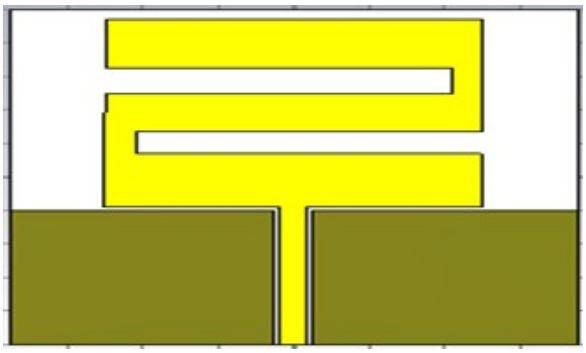

**Fig. 3**. Z-shaped microstrip patch antenna.

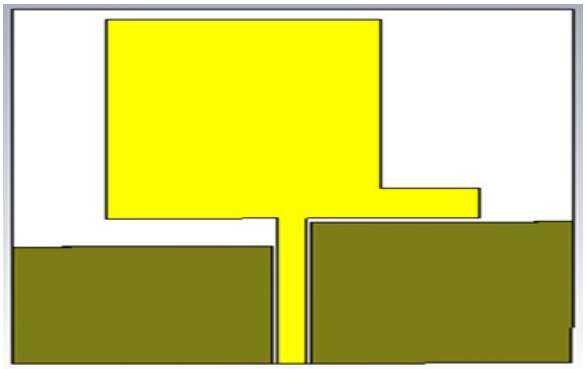

**Fig. 4**. L-shaped microstrip patch antenna.

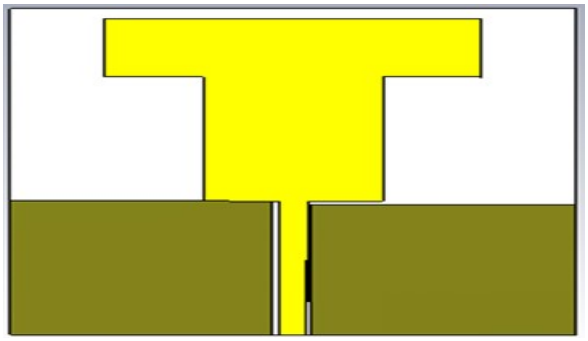

**Fig. 5.** T-shaped microstrip patch antenna.

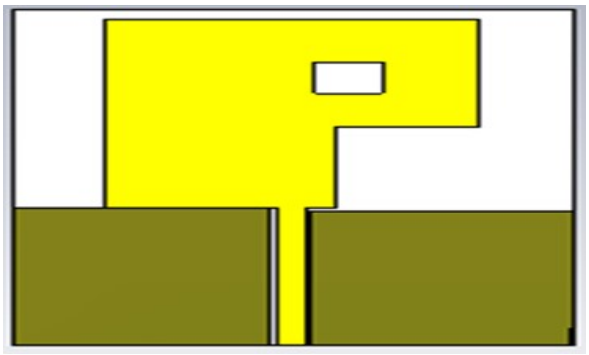

**Fig. 6.** P-shaped microstrip patch antenna.

## 3. COMPARATIVE RESULT ANALYSIS

The assimilation of these antennas has been classified into four main areas: different antenna slots, bandwidth, return loss and voltage standing wave ratio (VSWR). In Fig. 1-6 it has been shown different types antenna slots. From Fig. 7 it can be shown different shaped antennas have different performances. It indicates the bandwidth and return loss of the six antenna types under study. Here -10 dB is used as reference return loss which is acceptable for wireless communication. The T shaped antenna has 155.7 MHz bandwidth with copper patch which is highest compared to other shaped antennas. So it can

 

be used in wideband applications. Again the P shaped antenna has -108.72 dB return loss and 1.000007 VSWR with Graphene as patch material. So P shaped antenna can be used in perfect impedance matching applications. These difference in results were obtained for different shaped slotted antennas.

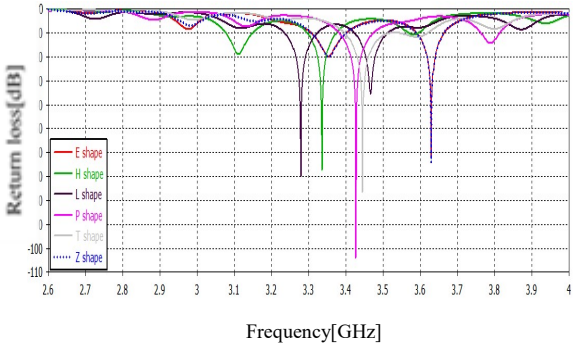


**Fig. 7.** Comparison of Return loss vs Frequency curves for different shaped antennas with copper patch.

From Fig. 8 it can be noticed that voltage standing wave ratio (VSWR) of P-shaped antenna is minimum (i.e VSWR=1.00001) and near to ideal value with copper patch. So these antennas can be used in case of matched antenna application. For wireless communication VSWR≤2 is acceptable.

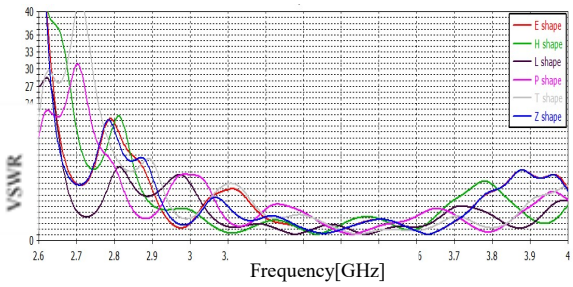


**Fig. 8**. Comparison of VSWR vs Frequency curves for different shaped antennas with copper patch.

The effect of Graphene as patch material on antenna performance such as return loss, VSWR and bandwidth has been shown in Fig. 9 & Fig. 10.

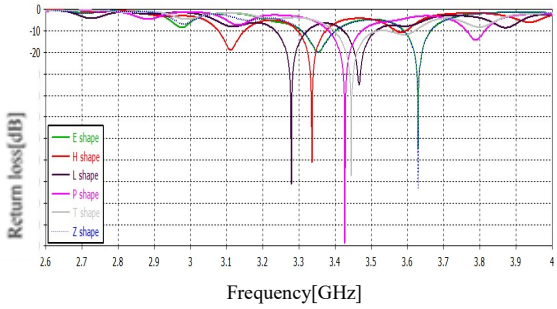


**Fig. 9.** Comparison of Return loss vs Frequency curves for different shaped antennas with Graphene patch.

With Graphene patch P-shaped antenna has better performance. It has -108.72 dB return loss, 1.000007 VSWR and 91.3 MHz bandwidth. In case of bandwidth consideration T-shaped antenna has highest bandwidth which is about 143.6 MHz.

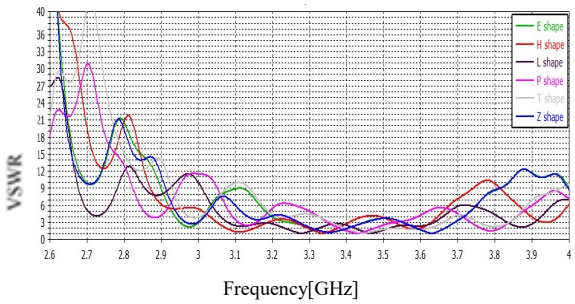


**Fig. 10.** Comparison of VSWR vs Frequency curves for different shaped antennas with Graphene patch.

**Table II.** Comparison of Return Loss, VSWR, Bandwidth of Different Shaped Microstrip Patch Antennas with Copper patch.

| Antennas | Resonant frequency [GHz] | Return Loss [dB] | VSWR | Bandwidth [MHz] |
|---|---|---|---|---|
| H shaped | 3.34 | -67.38 | 1.0008 | 81.2 |
| E shaped | 3.63 | -62.03 | 1.0016 | 81.2 |
| Z shaped | 3.63 | -64.17 | 1.0012 | 79.7 |
| L shaped | 3.28 | -70.03 | 1.0006 | 85.3 |
| T shaped | 3.45 | -76.62 | 1.0002 | 155.7 |
| P shaped | 3.43 | -104.07 | 1.00001 | 92.1 |

**Table III.** Comparison of Return Loss, VSWR, Bandwidth of Different Shaped Microstrip Patch Antennas with Graphene patch.

| Antennas | Resonant frequency [GHz] | Return Loss [dB] | VSWR | Band width [MHz] |
|---|---|---|---|---|
| H shaped | 3.33 | -71.03 | 1.0005 | 78.1 |
| E shaped | 3.63 | -64.70 | 1.0012 | 73.3 |
| Z shaped | 3.63 | -83.15 | 1.0001 | 73.3 |
| L shaped | 3.28 | -81.15 | 1.0002 | 89 |
| T shaped | 3.45 | -77.25 | 1.0002 | 143.6 |
| P shaped | 3.43 | -108.72 | 1.000007 | 91.3 |

## 4. RADIATION PATTERN

Radiation pattern or far field pattern means the directional dependence of the strength of the radio waves which comes from the antenna or other sources. Fig. 11-16 show the radiation pattern of H-shaped, E-shaped, Z-shaped, L-shaped, T-shaped and P-shaped antennas. We have simulated the radiation pattern for φ= 0 degree to φ= 360 degree in the 90 degree interval with Graphene patch material.

 

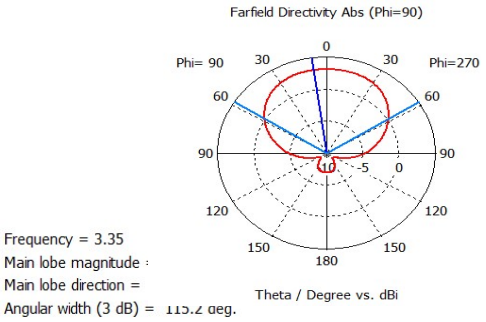


**Fig. 11.** Far field pattern of H-shaped antenna.

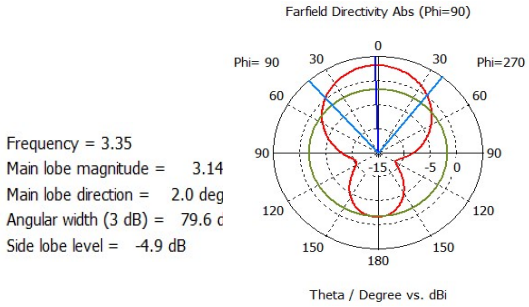


**Fig. 12.** Far field pattern of E-shaped antenna.

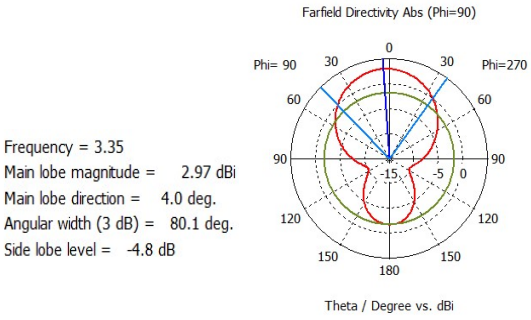


**Fig. 13.** Far field pattern of Z-shaped antenna.

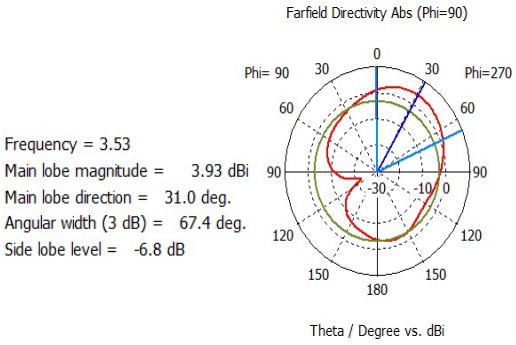


**Fig. 14.** Far field pattern of L-shaped antenna.

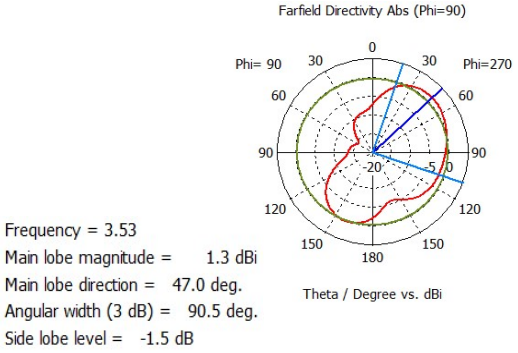


**Fig. 15.** Far field pattern of T-shaped antenna.

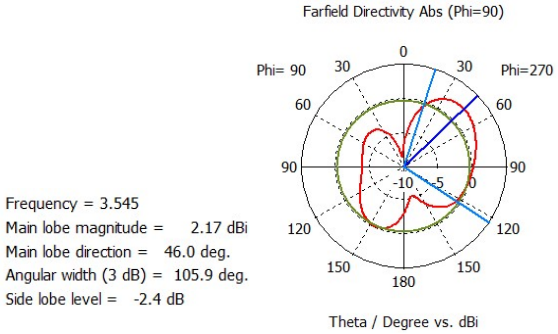


**Fig. 16.** Far field pattern of P-shaped antenna.

## 5. CONCLUSION

This paper gives a comparison of H-shaped, E-shaped, Z-shaped, L-shaped, T-shaped and P-shaped patch antennas topologies in terms of various performance parameters. A cream of this comparison is presented in TABLE II-III. It has been shown P-shaped antenna has the largest return loss and minimum VSWR. So it can be used in perfect impedance matching applications. In terms of bandwidth T-shaped antenna has the widest bandwidth which can be used in wide band applications. It is also observed from TABLE II-III that the antenna parameters such as return loss and VSWR are very close to ideal values and graphene increases the antenna performances considerably.

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