# Design of H-Shaped Multiband Slot Antenna for LTE Applications

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**Abstract – An efficient design for H-shaped slot antenna has been proposed which resonates for 2 to 5 GHZ. As the technology becomes more prominent the demanding need of designing an antenna for multiple applications is greatly increased. To enhance the developing technology, H-shaped slot antenna has been designed to provide multiband applications like WIFI, Bluetooth, WLAN, LTE. Here the patch is sketched for a thickness of 2 mm, length of 29 mm and a width of 38 mm. The prototype of the proposed antenna has been fabricated and measured results show that narrow band operation has been obtained for multiple frequencies. The substrate material of the antenna is Flame Retardant-4 (FR-4), with the relative permittivity of 4.4. The antenna structure has been modelled and its performance has been evaluated using an Advanced Design System (ADS) software.**

**Index Terms – Multiband applications – WIFI, Bluetooth, WLAN, LTE, FR-4, Advanced Design System(ADS).**

## 1. INTRODUCTION

LTE stands for *Long Term Evolution* and it was started as a project in 2004 by telecommunication body known as the Third Generation Partnership Project (3GPP). SAE (System Architecture Evolution) is the corresponding evolution of the GPRS/3G packet core network evolution. The term LTE is typically used to represent both LTE and SAE.

Antennas sketched with high radiation, low return loss and high efficiency validate the idea behind optimal antenna design to ensure high device performance.

The main important property of microstrip patch antenna is that it can be designed in any shape and sizes. The design of MPA provides a low profile and low cost. The proposed H-shaped antenna is designed for Wireless Communication and its application. The method proposes the design of H-shaped and inverted H-shaped antenna combined with the help of a strip line which is of 2mm width. The proposed shaped is designed and simulated using Advanced Design System 2009 (ADS 2009). The system is designed to operate at 2.4GHz (IEEE 802.11 standard).

Each patch is designed using FR-4 substrate which has a relative permittivity of 4.4 and the patch's dimensions are altered in order to resonate at a frequency nearly 2.4 GHz. The technique used for simulation is the Method of Moment (Mom) technique.

The designed antenna considers the following electrical parameters,

- Operating frequency
- VSWR and Return Loss
- Gain
- Radiation pattern.

The impedance and radiation characteristics of the antenna are over viewed. The antenna parameters such as return loss, gain and directivity are investigated for the H-shaped, a minimum return loss of -10dB is achieved for the obtained design at its resonant frequency (2.4 GHz). The gain of the patch is obtained for the values greater than 5dB.The stimulated patch is fabricated by converting them to respective Gerber files and the corresponding hardware output of the antenna patch are tested using Network Analyzer and the simulation results are compared.

The smart antenna technology significantly improves wireless system performance and economics for range of users, it enables operators of Pcs, cellular and wireless networks to realize significant increases in quality, then 2GHz, they take the advantage of the ability to adapt to operating environment to combat jamming.

## 2. RELATED WORK

One type of an antenna that fulfils most of the wireless system requirements is the microstrip patch antenna. These antennas are widely used on base stations as well as handsets. The existing microstrip patch antennas have a variety of configurations. The low profile, low volume and conformity makes them more outstanding in real-time applications. The requirements are such that these systems must radiate low power and provide reliable communication.

Presently, the patch antennas are available only in certain shapes and only for attaining single application. This becomes a limitation in certain expertise. The antennas used in wireless communication have been recognized as crucial elements that can either improve or limit the system performance, especially in terms of bandwidth and efficiency. The existing antenna systems have patches which resembles complex shape and wide band characteristics. Having different antenna for different application which becomes the disadvantage for the existing design. The present system suffers from the following drawbacks.

Limitations of the related works:

- Low efficiency.
- Low gain.
- Low polarization purity.
- Low power handling capacity.
- Less impedance matching.

## 3. PORPOSED MODELLING

The proposed model is to design combined patch in H-shape and the inverted H-shape using the Advanced Design System 2009 (ADS 2009) simulation software and to achieve multiband applications using the designed patch antenna with a very good return loss and a valuable amount of gain. The patch antenna is simulated and its characteristics are observed. Fabrication of the simulated patches are done with copper layout and FR-4 substrate material with a thickness of 1.6 mm. Testing of antenna characteristics is carried out using Network Analyzer and the simulated test results are recorded. A conclusion is made based on the obtained results from both simulation and fabrication.

### 3.1 BLOCK DIAGRAM

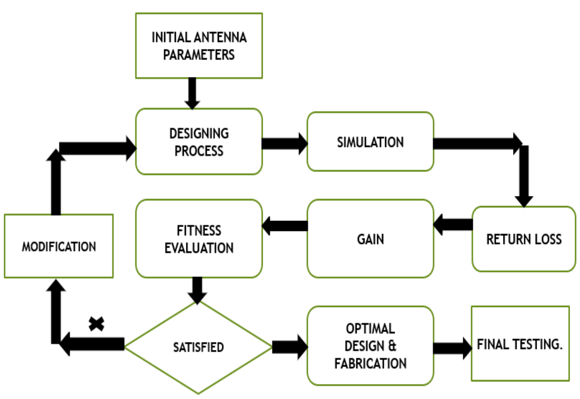



Fig.1 Block Diagram

### 3.2 DESIGN FORMULATION, CALCULATION.

Operating frequency ($f_0$) = 2.4 GHz

Velocity of lights (c) = $3x10^8$ m/sec.

FR-4 relative permittivity($\varepsilon_r$) = 4.4

Substrate thickness (h) = 1.6mm

Width W of patch is given as:

$$W=\frac{c}{2f_0}\sqrt{\frac{2}{\epsilon_r+1}}$$

$$W=\frac{(3*10^8)}{2*2.4*10^9}\sqrt{\frac{2}{4.4+1}}$$

$W \approx 38$mm

Effective dielectric:

$$\epsilon_{reff}=\frac{\epsilon_r+1}{2}+\frac{\epsilon_r-1}{2}[1+12\frac{h}{W}]^{\wedge -1/2}$$

$$\epsilon_{reff}=\frac{4.4+1}{2}+\frac{4.4-1}{2}[1+12\frac{1.6}{3.8}]^{\wedge -1/2}$$

$\epsilon_{ref}$ =3.39

$\epsilon_{reff} \approx 3.39$

The effective length of the patch $L_{eff}$:

$$L_{eff}=\frac{c}{2f_0\sqrt{\epsilon reff}}$$

$$L_{eff}=\frac{(3x10^8)}{2(2.4x10^9)\sqrt{3.39}} = 0.0339$$

The length of patch:

$$L = L_{eff} - 0.824h\ [\frac{(\epsilon reff+0.3)(\frac{W}{h}+0.264)}{(\epsilon reff-0.258)(\frac{W}{h}+0.8)}]$$

$$L = 0.0339 - (0.824*1.6)\ [\frac{(3.39+0.3)\ (\frac{38}{1.6}+0.264)}{(3.39-0.258)\ (\frac{38}{1.6}+0.8)}]$$

L = 29.42*10^-3

$L \approx 29$ mm.

**Antenna Design Measurements:**

Width (W) = 38 mm

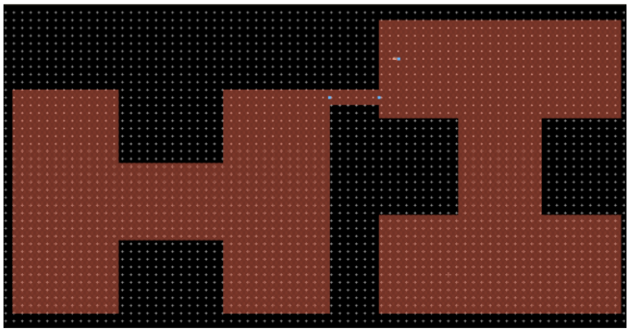
Length (L) = 29 mm

Copper thickness = 70 µm

Overall dimension = 73×38mm

### 3.3. ANTENNA COFIGURATION

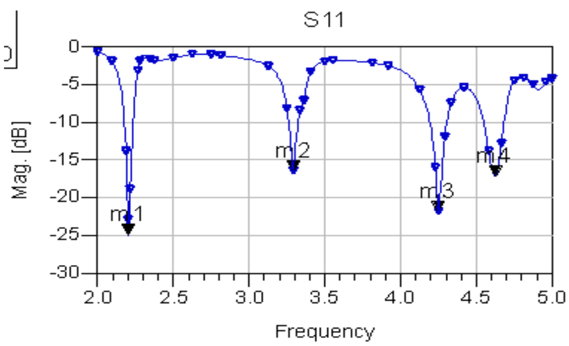
Our final microstrip antenna has been designed by using a patch of length 29mm and width of 39mm and the overall dimension of the combined H and inverted H-shape design is 73×38mm whose model is shown below. As said before patch is having a H shape and inverted H shape connected using a strip line of width 2mm and the dimensions of H shape alone is 29×38 mm and the inverted H shape has 38×29 mm respectively. The substrate used is of FR-4 with a dielectric constant of 4.4 and the thickness is of 1.6mm.



*(a) Proposed Combined H & Inverted H Shape Design*

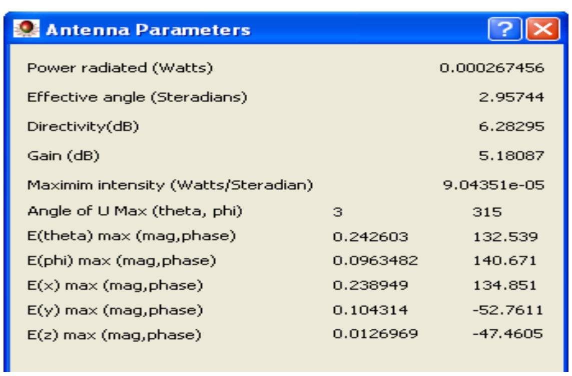
Figure (a) shown above is the proposed design of multiband application which has an overall dimension of 73×38 mm. Both H and inverted H are connected by a strip line of width2mm.

Figure (b) shown below is the respective Gain and return loss of the proposed design after simulation. As shown in the figure we have achieved a very noble amount of return loss as required for an accurate radiating design.




*(b) Combined H & Inverted H-Shape Return Loss*

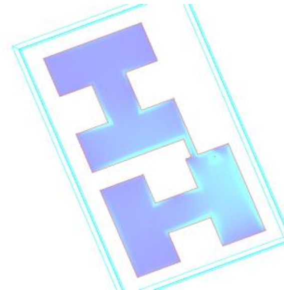
As shown in the figure above the proposed design radiates at the particular four frequencies with a great return loss individually.



| Antenna Parameters | | |
|---|---|---|
| Power radiated (Watts) | | 0.000267456 |
| Effective angle (Steradians) | | 2.95744 |
| Directivity(dB) | | 6.28295 |
| Gain (dB) | | 5.18087 |
| Maximim intensity (Watts/Steradian) | | 9.04351e-05 |
| Angle of U Max (theta, phi) | 3 | 315 |
| E(theta) max (mag,phase) | 0.242603 | 132.539 |
| E(phi) max (mag,phase) | 0.0963482 | 140.671 |
| E(x) max (mag,phase) | 0.238949 | 134.851 |
| E(y) max (mag,phase) | 0.104314 | -52.7611 |
| E(z) max (mag,phase) | 0.0126969 | -47.4605 |

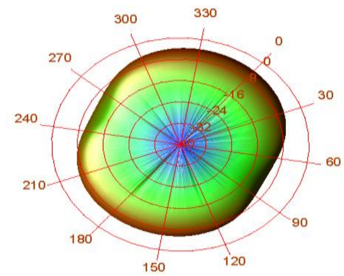
*(c) Combined H & Inverted H-Shape Antenna Parameters.*

From the figure above, we can see the gain, directivity, power radiated by the designed antenna. Gain radiated by the antenna is 5.1 dB and the directivity are 6.28 dB.



*(d) Combined H & Inverted H-Shaped Antenna Simulation.*

This figure shows the antenna's radiating power. As we can see here the antenna radiates well as we required.




*(e) Combined H & Inverted H- Shape Radiation Pattern*

The above figure shows the radiation pattern of the designed antenna.

## 4. RESULTS AND DISCUSSIONS

| DESIGN | FREQUENCY (GHZ) | GAIN (DB) | RETURN LOSS (-10DB) |
|---|---|---|---|
| Designed Antenna | 2.2 | 5.18 | -25 |
| | 3.2 | | -16 |
| | 4.25 | | -21 |
| | 4.62 | | -17 |

Table 1. Designed Antenna Frequency, Gain & Return loss

| OBTAINED FREQUENCY | APPLICATION |
|---|---|
| m1: 2.205 GHz | Bluetooth |
| m2: 3.292 GHz | WLAN |
| m3: 4.250 GHz | WIMAX |
| m4: 4.625 GHz | WIMAX |

Table 2. Obtained Frequency and its Application

The table gives the operating frequency and their gain and return loss of the respective antenna.

Now the following table furnishes the frequencies at which the proposed antenna radiates and their respective applications.

The result shows that we can come to a conclusion that the final combined model of H & inverted H shows better performance in both simulation at around 2.4 GHz and it satisfies the main importance of the intended concept.

## 5. CONCLUSION

The goal of this project is to design H shaped patch antennas that operate at 2.4 GHz frequencies using FR-4 substrate. The antennas fabricated expected of having comparable or better performance to the simulated one. The microstrip patch antennas are designed with coaxial line as a feed. The S11(input return loss) plot for this microstrip antennas have a magnitude of much less than -10 dB which means that matching impedance is achieved.

The fabricated output is to be comparable to that of simulation. The design not only resonates at 2.4GHz, it stimulates lower return loss even at 3-4 GHz where it finds its application in Bluetooth, WLAN, WiMAX and so on. As an overall conclusion, the objectives of this project which is to achieve multiband applications using a single antenna has been successfully implemented and achieved, with an improvement in impedance and radiation characteristics.

**FUTURE SCOPE**

This design can be further improved in terms of basic parameters such as type and thickness of the substrate, dielectric constant. This design would be integrated with filters and amplifiers and tested in the open-air environment; from those results, the best system would be used as a prototype in real-time applications.

Moreover, the designed antennas find application in wireless personal communication systems and indoor wireless communication; hence, it becomes imperative to study the effect of antenna radiation on the human body.

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