# High Gain Reverse E-Shape Patch Antenna

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**Abstract:** In this work, a novel design technique for enhancing return loss of the proposed E shaped microstript patch antenna that covers TD-SCDMA and TD-LTE band is presented and discussed. Simulations are performed satisfactory with maximum achievable return loss of about -44.78 dB with help of Sonnet Suite [1] a planar 3D electromagnetic simulator. The bandwidth is approximately 3% between 2.345 – 2.425 GHz. A high gain of about 10.89 dB is also maintained. Details of the simulation results are presented and discussed.

**Keywords:** Microstrip patch antenna, reverse, E-shaped

## 1. Introduction

In this design study, the main purpose was to design a reverse E shape microstrip patch antenna. Previous works are also dealing with the bandwidth increasing techniques by changes on the geometry. Some articles and applications are examined about microstrip antennas [2]-[5]. There are another reverse E shape antenna which operates in similar bands as compared to this work, but they do have a wider bandwith [2]. In [3], an antenna with the same frequency band is designed in order to improve compactness. There is another inverted E shape antenna work that analyses different thickness [6], but we do have a better return loss**.** In that paper, the effects of the position of the feed point is an important step for their design. Our design consists of step by step changes on the geometry which improves the values required in specifications. Optimizations are performed on the geometry and substrate by changing several parameters.

## 2. Design Procedure

Figure 1 has the top view and Figure 2 has the 3-D view of the antenna. The antenna is in a 1000 x 1000 mm. box with 62 x 96 mm. patch dimensions. As a dielectric, air ($\varepsilon_r$ =1) is used.

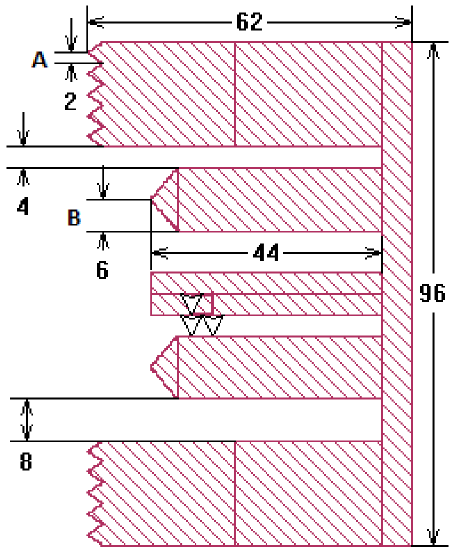


Fig. 1. Top view of the final design.

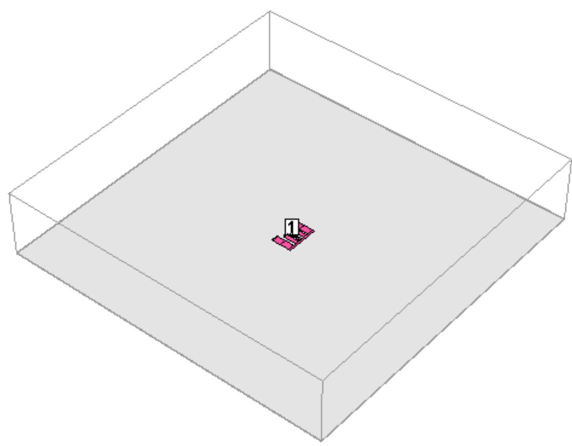


Fig. 2. 3-D view of the antenna.

**Design Steps:**

The design started with the reverse E shape. It is seen in Figure 3. There was only one resonance at 2.32 GHz as seen in Table 1. The antenna is in a 200 x 300 mm. box and the cell size is 1 x 1mm.

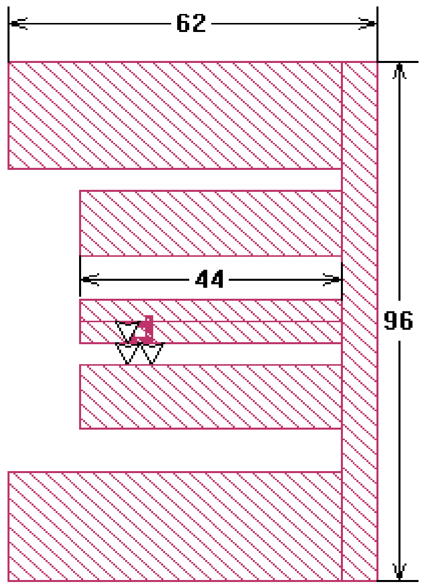


Fig. 3. Top view of the antenna

Table 1:Values of the parameters with design step 1

| PARAMETERS | $f_c$(GHz) | $S_{11}$(dB) | Gain(dB) |
|---|---|---|---|
| Step 1 | 2.32 | -23.9 | 10.72 |

The next step was to clip the lower and top part's ends. It is shown by letter A in Figure 1. The box size and cell size was same. The results are seen in Table 2. After that, the middle sections on each side of the center E leg was clipped. It is shown by letter B in Figure 1. The box size and cell size was same. The results are shown in Table 3.

Table 2:Values of the parameters with design step 2

| PARAMETERS | $f_c$(GHz) | $S_{11}$(dB) | Gain(dB) |
|---|---|---|---|
| Step 2 | 2.35 | - 21.03 | 10.66 |

Table 3:Values of the parameters with design step 3

| PARAMETERS | $f_c$(GHz) | $S_{11}$(dB) | Gain(dB) |
|---|---|---|---|
| Step 3 | 2.38 | - 18.93 | 10.58 |

In the fourth design step; decreasing the cell size to 0.5 x 0.5 mm, and increasing the box size to 500 x 1000 mm. gave the results shown in Table 4. This helped to reduce the S11 and increase the gain, but caused unwanted frequency shift.

Table 4:Values of the parameters with design step 4

| PARAMETERS | $f_c$(GHz) | $S_{11}$(dB) | Gain(dB) |
|---|---|---|---|
| Step 4 | 2.28 | - 27.32 | 10.81 |

After that, decreasing the cell size to 0.25 x 0.25 mm, caused results that are shown in Table 5. Finally, increasing the box size to 1000 x 1000 mm is clearly helped to improve the input match as seen in Table 6.

Table 5:Values of the parameters with design step 5

| PARAMETERS | $f_c$(GHz) | $S_{11}$(dB) | Gain(dB) |
|---|---|---|---|
| Step 5 | 2.38 | - 27.33 | 10.81 |

Table 6:Values of the parameters with design step 6

| PARAMETERS | $f_c$(GHz) | $S_{11}$(dB) | Gain(dB) |
|---|---|---|---|
| Step 6 | 2.385 | - 44.80 | 10.79 |

The next work was to make a tolerence analysis by changing the dielectric thickness. This is seen in Table 7.

Table 7:Comparison of the dielectric thickness.

| Dielectric thickness (mm) | Magnitude (S11:dB) | Resonance Freq. (GHz) | Gain (dB) |
|---|---|---|---|
| 2.85 | -23.51 | 2.39 | 10.77 |
| 2.9 | -28.45 | 2.395 | 10.77 |
| 2.95 | -37.11 | 2.39 | 10.78 |
| 3 | -32.78 | 2.39 | 10.79 |
| 3.05 | -44.78 | 2.385 | 10.79 |
| 3.1 | -40.04 | 2.38 | 10.78 |

## 3. Simulation Results

Simulation result of the S11 is in Figure 4, and minimum S11 level of -45 dB is shown in caption. Real part of the input impedance is in Figure 5. Imaginary part of the input impedance is in Figure 6. Those two values are very close to the best results since the input match is very good. Figure 7 has theta-polarized electric field radiation pattern gain of almost 11 dB. Cross-pol. level is under 20 dB. Figure 8 shows that, the current is intense near the feeding, and around the leg-edges of the shape E.

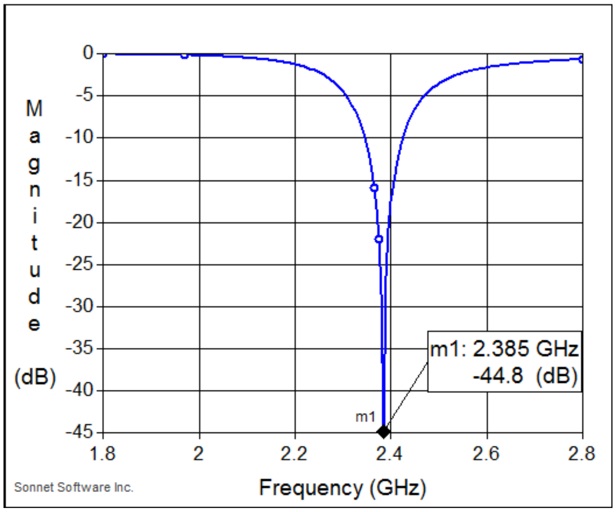

Fig. 4. Return loss of the final design.

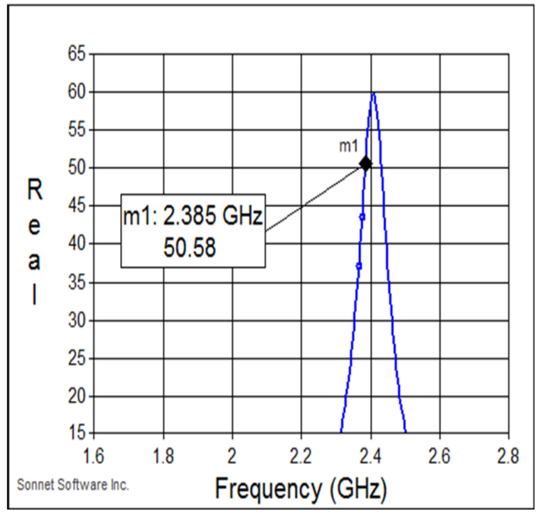

Fig. 5. Real part of the input impedance.

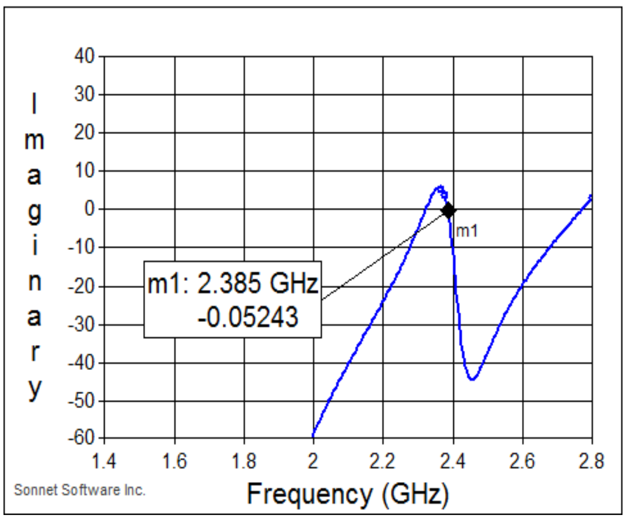

Fig. 6. Imaginary part of the input impedance.

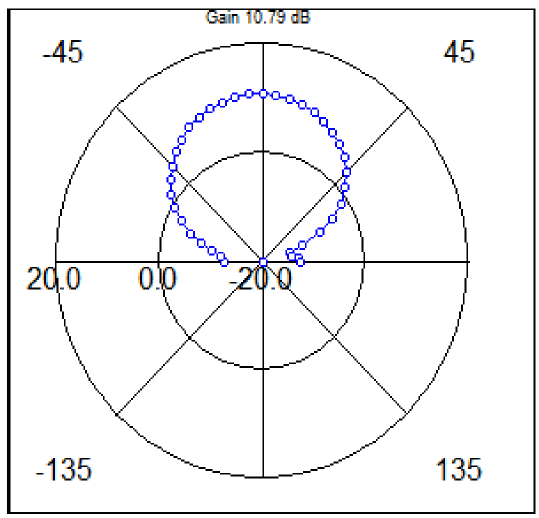

Fig. 7. Far field radiation pattern at 2.385 GHz.

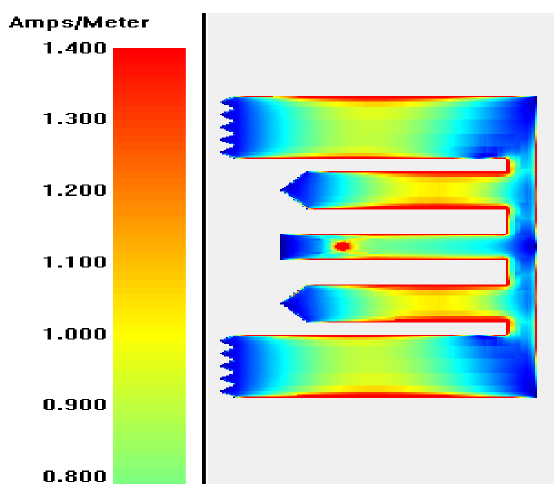

Fig. 8. Current distribution at 2.385 GHz.

## 4. Conclusions

In this paper, a novel design technique for enhancing return loss of the proposed E shaped microstrip patch antenna that covers the TD-SCDMA and TD-LTE band is presented, discussed and simulated. Modifications on the patch geometry helped too much to maintain and improve the specified design parameters such as; return loss, input impedance and gain. The proposed microstrip patch antenna achieves a fractional bandwidth of 3% between 2.345 – 2.425 GHz, and a very good return loss of -44.78 dB. The maximum achievable gain of the antenna is 10.79 dB. The next work would be a wide-band antenna between 4–8 GHz by increasing the bandwith around 4 GHz. Radiation pattern beamwidth enhancement is among another future goals.

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