Designing Micro-strip Patch Antenna for LTE Mobile Application

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***Abstract*: - The design of single band (2.5 -2.69 GHz) micro-strip antenna for Long Term Evolution (LTE) mobile application is presented in this paper. The dimensions of the proposed antenna are 49.5 × 28.4 mm^2 with thickness of 1.6 mm. The proposed antenna is simulated using FEKO software to study its performance in term of Bandwidth ,return loss, VSWR and gain. The antenna design is fabricated on FR-4 substrate. The results show significant improvement over existing designs.**

***Keywords*: *LTE, Micro-strip line feed, Bandwidth, Micro-strip patch, Slots*.**

I. INTRODUCTION

In the present-time communication, antennas cover a wide range of applications in different areas, such as mobile communication, satellite navigation, internet services, automobiles and radars. Antennas are metallic structure which radiate and receive waves.
Mobile phone handsets are generally required to be small in size. On mobile phone , current needed is more in terms of parameters such as shape, performances, qualities and its technology. There are various new technology arriving in wireless communication now a days that has brought a lot of devices which are portable in the future, such as a mobile phone that will posses function for fast data transmissions.
LTE (Long Term Evolution) is the project related to high performance air interface for mobile telephony. LTE is the latest new technology that ensures competitive edge over existing standards: GSM, UMTS, etc. It improves user experience with full mobility. LTE minimizes the system and user-equipment complexities.

In this paper, a micro-strip patch antenna for LTE band i.e. 2.5 – 2.69 GHz has been presented. Antenna performance characteristics such as bandwidth ,return loss , VSWR and gain characteristics have been evaluated through simulations using FEKO simulation software.

A micro-strip patch antenna (MPA) consists of a patch on one side of a dielectric substrate and a ground plane on other side. .They are compact, light in weight , posses planar geometry and has low fabrication cost. The patch is made of conducting material such as copper, gold, tin, nickel. These metals are used widely because they are easy to solder. A feedline is used for excitation. There are 4 main feedings techniques used which are coaxial probe feed, micro-strip line feed, aperture coupling and proximity coupling. Among all the feeding techniques , micro-strip line feed is the most common and widely used technique.
Micro-strip slot antennas are created by cutting slots on metal surface. There are variety of shapes of slots available such as T slot , U slot, C slot, S slot etc. With the introduction of slots , there is improvement in Bandwidth , gain , reduction in size etc.. Both micro-strip patch antenna and slot antennas have thin profile .Both are easy to fabricate . The bandwidth of micro-strip patch antennas are 2-50 % whereas of micro-strip slot antennas are 5-30 %.
Thus how to downsize an antenna without degrading its bandwidth is the design policy while designing compact antennas.

II. ANTENNA DESIGN

The design is simulated on FEKO v 6.1 software. There is CADFEKO and POSTFEKO. CADFEKO is used to design antenna and POSTFEKO to view the results of simulation. The designing of micro-strip antenna requires resonant frequency(f_0), dielectric material and height of substrate(h). The proposed antenna is designed for frequency band 2.5 – 2.69 GHz. The substrate used is FR-4 having dielectric constant (ϵ_r) 4.34 and height (h) 1.6 mm. High dielectric constant is used for size reduction. The antenna is fed by 50 Ω micro-strip line feed. It has a width W_f and length L_f . The design formulas as given in [2] are as follows

1. Length of the patch (L)= $\frac{c}{2f_0\sqrt{\epsilon_r}}$

where c = speed of the light in m/sec =$3 * 10^8$ m/sec

2. Width of the patch (W) = $\frac{c}{2f_0\sqrt{\frac{\epsilon_r + 1}{2}}}$

3. Length of the micro-strip line feed (L_f)= λ /4 where

Wavelength (λ)= c/f_0 .

4. Width of the micro-strip line feed =

$W_f = 7.48\, h \,/\, e^{\sqrt{0.33\,(\varepsilon r\ +1.41)}}$

5. Position of inset feed (y_0) = R_{in} = $\cos^2(y_0 / L)$

The position of the inset feed is calculated from the above formula . Where R_{in} = input resistance = 50Ω .

TABLE 1 : DESIGN PARAMETERS

L	43.3 mm
W	28.4 mm
y_0	9.25 mm
L_f	6.2 mm
W_f	3.4 mm

.Fig.1 shows the geometric Design of the proposed LTE antenna. T slot and c slot are introduced in the design because by loading slots on the conducting patch element of antenna, reduced size with improvement in bandwidth is obtained .

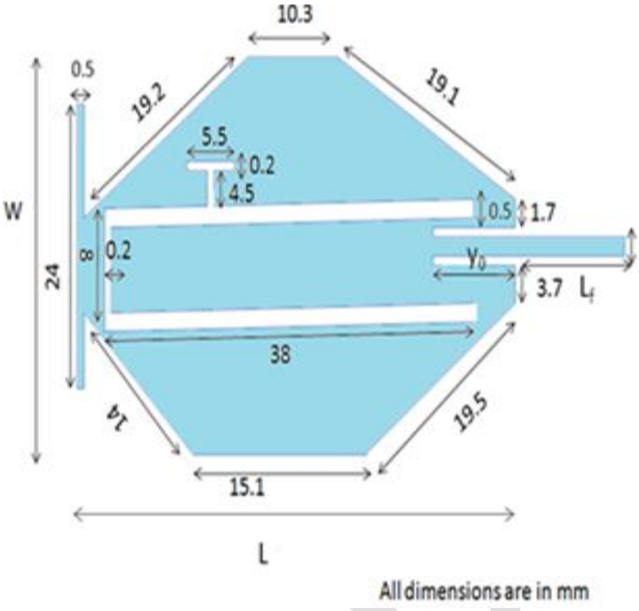


Fig 1. Design of LTE antenna

Fig.2 shows the current distribution of the proposed antenna design at f = 2.59 GHz. The current is mainly distributed around C slot and T slot and around the feed point.. Since the current distribution on the patch antenna is dense , this reveals that matching between the inset line and the patch is well and the current is transferred from the feed line to the patch.

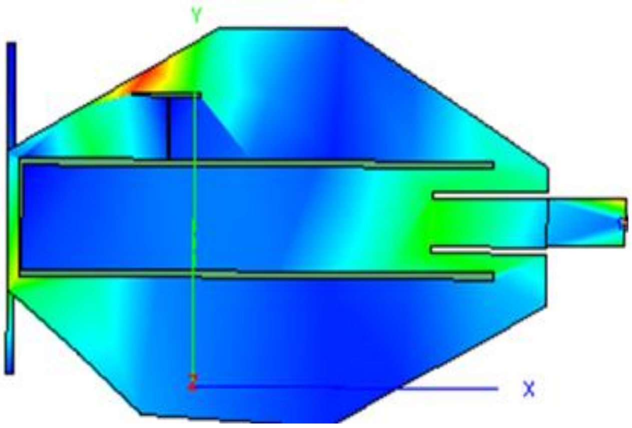


Fig 2. Current Distribution of LTE antenna

III. ANTENNA FABRICATION

The simulated design is fabricated as shown in Fig.3 The antenna is fabricated using FR-4 substrate of thickness 1.6 mm .The desired shape is achieved by preparing the mask of the simulated design and then the prepared mask is printed on PCB for etching process and finally the SMA port is soldered for power supply.

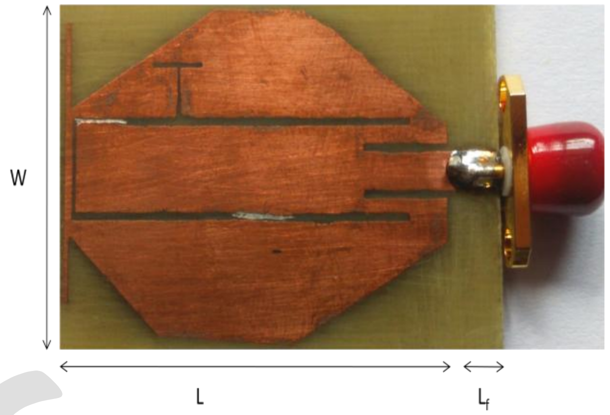


Fig. 3: Fabricated Antenna

W= width of the patch

L= length of the patch

L_f = length of the micro-strip line feed

After fabricating the antenna, it is tested on Vector Network Analyzer (VNA). Return Loss is measured on VNA .

IV. RESULTS AND DISCUSSIONS

The simulated results of the proposed LTE band micro-strip patch antenna design are discussed here. The results of the fabricated antenna obtained after VNA testing are also discussed in this section.

A. Return loss

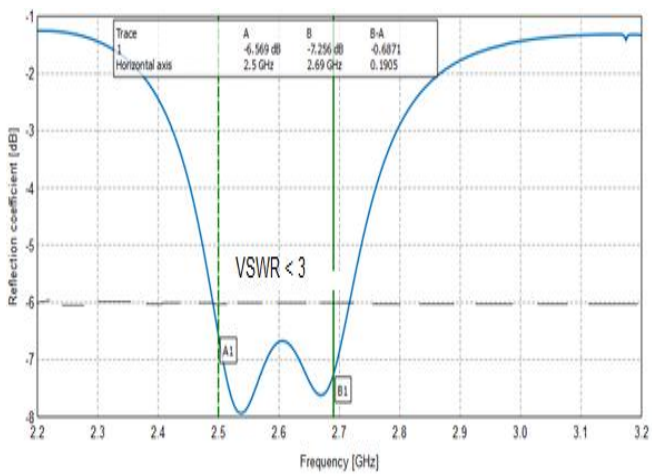


Fig. 4: Plot between Return loss [dB] and frequency for LTE antenna

Fig 4 shows the plot between return loss and frequency for LTE antenna. It reveals that VSWR less than 3.0 is achieved for the frequency band 2.5 -2.69 GHz. The value of return loss at 2.5 GHz is nearly -6.569 dB and at 2.69 GHz is nearly -7.256 GHz

B. VSWR

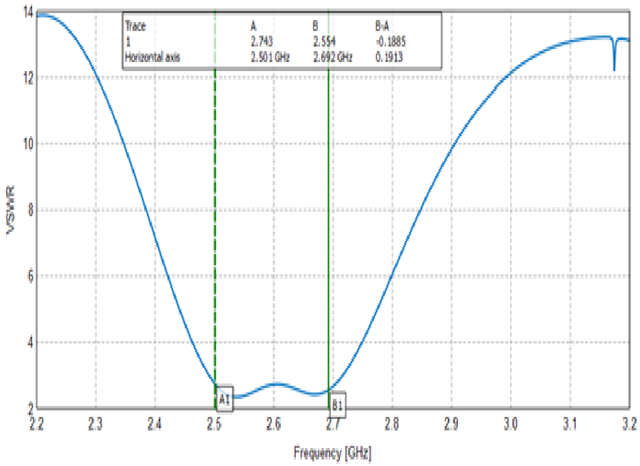


Fig. 5.: Plot between VSWR and frequency for LTE antenna

Fig.5 shows the plot between VSWR and frequency. It agrees with the return loss characteristics of the antenna which were shown in Fig. 4 The VSWR is less than 3.0 for the frequency band i.e. 2500-2690 MHz .

C. Gain

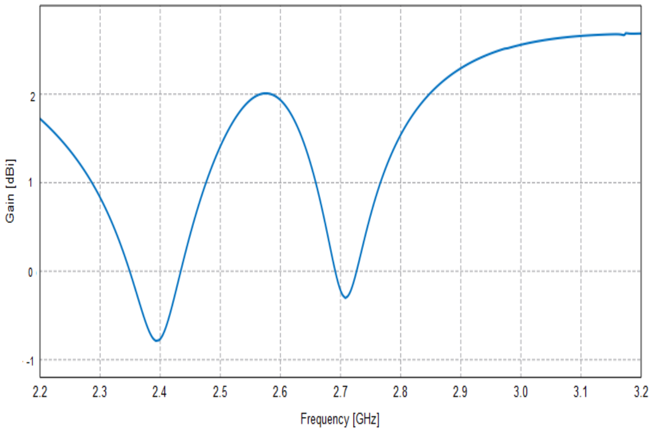


Fig. 6 : Plot between Gain and frequency for LTE antenna

Fig. 6 shows the plot between antenna gain and frequency. It reveals that the antenna gain is 1.5 dB at 2.5 GHz and 0.5 dBi at 2.69 GHz Peak gain in the LTE band is approximately 2 dBi at 2.57 GHz.

D. Radiation Pattern

Fig.7 shows the 3-D view of radiation pattern for the LTE band at 2.59 GHz frequency .The pattern in the 3-D view reveals that antenna exhibits nearly omnidirectional radiation pattern.

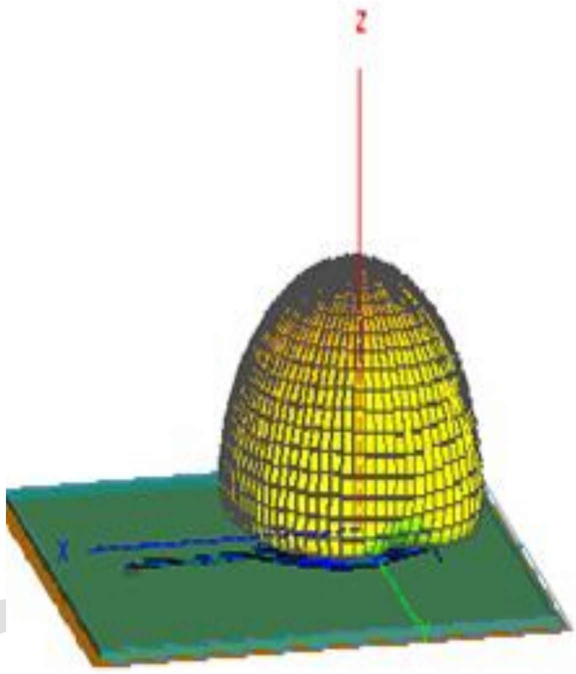
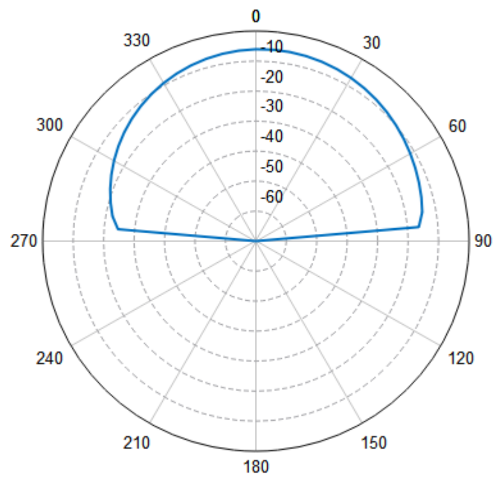
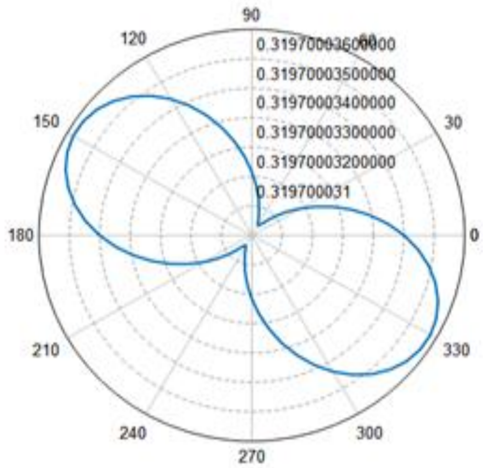


Fig. 7: 3-D Plot of Radiation Pattern





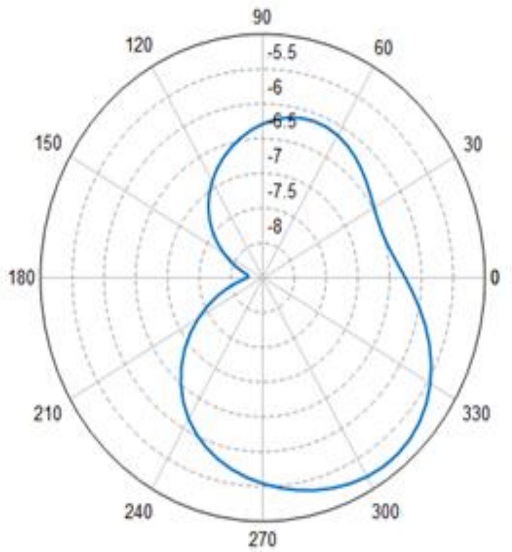


Fig. 8 Radiation Pattern of LTE antenna for (a) XZ plane (b) YZ plane (c) XY plane

Fig. 8 shows the radiation pattern in XZ , XY and YZ plane.

E. Testing design on VNA

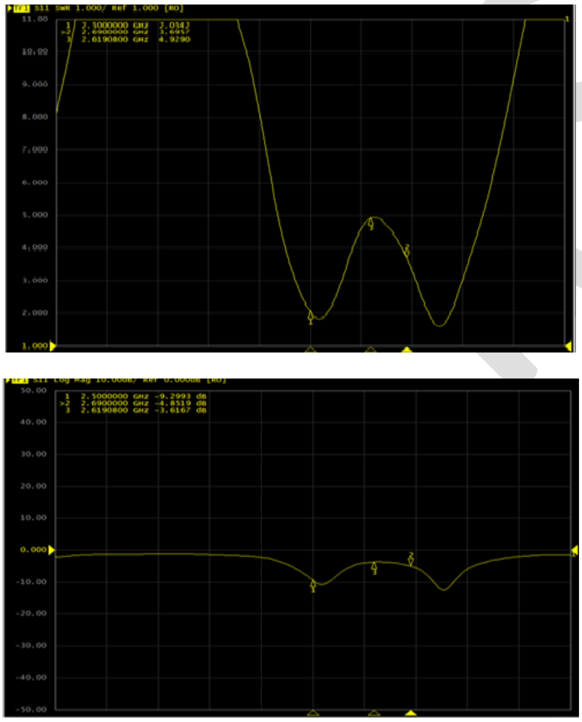


Fig. 9 : (a) Measured Return Loss vs frequency curve (b) VSWR vs frequency curve on VNA

Fig. 9 shows the plot of Return loss vs frequency curve and VSWR vs frequency curve on VNA. There are slight variation between simulated and measured results which may be attributed to fabrication defects and environmental disturbances.

V. CONCLUSIONS

In this paper, the design of LTE band (2.5-2.69 GHz) patch antenna was presented. The proposed antenna achieves bandwidth of 190 MHz for VSWR < 3 and there is significant reduction in size of the antenna by the introduction of C slot and T slot. The antenna exhibits omnidirectional radiation pattern with gain(max) is 2 dBi.

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