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# A Wideband Low-Profile Antenna for LTE/5G

Rajesh Kumar Singh, Andrea Michel, Paolo Nepa, and Giuliano Manara
Department of Information Engineering, University of Pisa, Italy
rajesh.singh@dii.unipi.it

## Abstract

A wideband low-profile antenna for Long Term Evolution (LTE) and 5G technology is presented in this paper. It is designed to be mounted on a car roof underneath the shark-fin cover. Proposed antenna operates at a wide frequency range from 617 MHz to 5.5 GHz. Wide frequency band is obtained without using any matching network in the design. Antenna has an omnidirectional radiation pattern throughout the band. Antenna prototype is fabricated and preliminary measured results in terms of input impedance matching are shown.

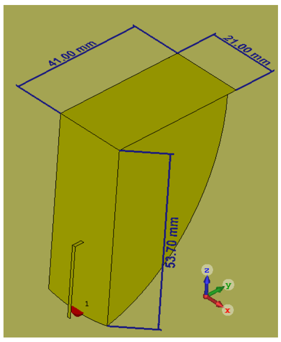
## 1 Introduction

Long Term Evolution (LTE) technology allows transferring data with high rates. Also, rigorous research toward 5th generation (5G) wireless communication networks is growing in many fronts. 5G technology is expected to be in use very soon throughout the world and each region has its operating frequency or frequency bands [1], [2]. There are a large number of allocations reserved for frequency division duplex (FDD), LTE use. Operating frequency of modern cellular communications starts from 617 MHz up to 5 GHz with guard bands in between the required bands. To cover all the frequency bands, so allowing the proper operability in different geographical areas in the world, an antenna must operate in all these assigned frequency bands. This demand makes antenna design more challenging because antenna must fit in a given volume with good matching, good gain, and omnidirectional radiation pattern throughout the band. Nevertheless, for the 5G technology, the cellular system requires more antennas on the transmitting and receiving side to implement the Multiple Input Multiple Output (MIMO) technology, so getting higher data rates. Various antennas have been designed earlier to fulfill these requirements. In [3], Rabinovich et al. thoroughly examined traditional and new advanced automotive antennas, including the designs and techniques used to reduce antenna dimensions without significant degradation of the quality. Few LTE bands were covered by designing a side-edge LTE smartphone antenna [4]. Car roof antennas have also been reported in [5]-[7]. In [5], the LTE/DAB-L antenna operated at frequency bands from 698 MHz to 960 MHz and from 1427.9 MHz to 2700 MHz covering available LTE frequencies, while antenna given in [6] covered from 698 MHz to 960 MHz and from 1470 MHz to 2700 MHz. A low profile wideband automotive antenna for 5G/LTE has been presented in [7]; the geometrical dimensions of the antenna were 80 mm × 60 mm × 30 mm and printed on a FR4 substrate, the design had losses due to the substrate and because of that antenna efficiency was not so good.

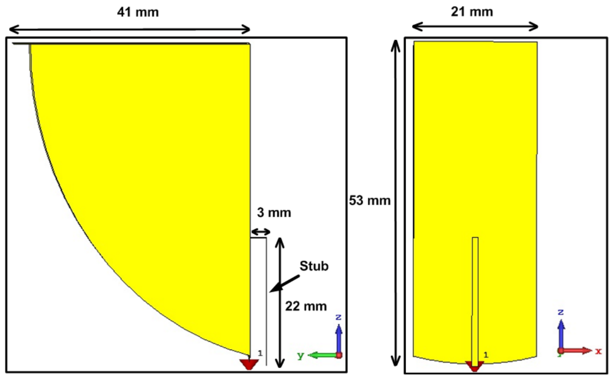
In this paper, a 3D metal-sheet wideband antenna which can fulfill these requirements is presented in this paper. It offers wide frequency bands with good gain, high radiation efficiency and omnidirectional patterns in almost all desired frequency bands for mobile communication. The antenna layout and simulated performance in terms of reflection coefficient, gain and radiation pattern is described. Preliminary measured reflection coefficient is also compared to the simulation results, showing a quite good agreement.

## 2 Antenna Structure

The proposed antenna is developed to be fitted in a shark-fin formed cover placed on the roof of a car. The antenna is designed according to the given mounting volume which is limited in all three dimensions. The allowed volume is 53 mm × 50 mm × 40 mm (height × length × width). Geometry of the antenna is illustrated in Figure 1. Dimension of the antenna is 53 × 44 × 21 $mm^3$. Antenna is made by cutting and folding a metal sheet. Proposed structure consists of a modified monopole to get more bandwidth from it. One small stub of length 22 mm is soldered to the monopole as shown in Figure 1. It achieves low frequency band of LTE and provide stability to the structure as well. Stub is connected to the ground plane. Feed is connected to the monopole antenna and simulated in CST Microwave Studio®.




(a)




(b)

**Figure 1.** Proposed wideband low-profile antenna (a) 3D view of the antenna in CST Microwave Studio (b) Geometrical dimensions of the antenna.

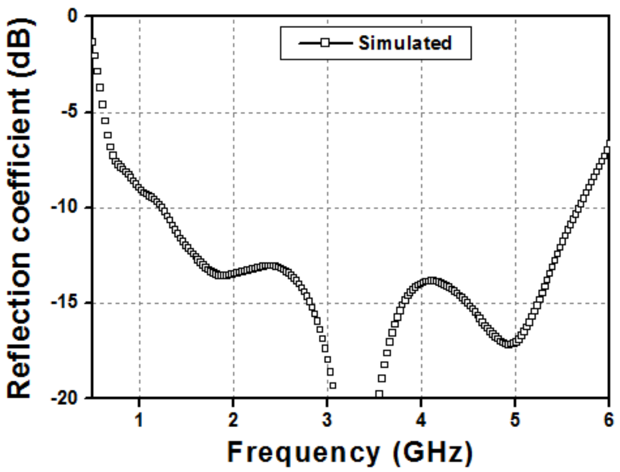



**Figure 2.** Simulated reflection coefficient of the proposed wideband low-profile antenna.

## 3 Results

Reflection coefficient is plotted in Figure 2. At the start of the LTE band (near 617 MHz), reflection coefficient is below -6 dB which is acceptable from the given specifications, after that (beyond 1150 MHz) it is well below than -10 dB, which is fairly good and acceptable value. Figure 3 shows the simulated input impedance of the antenna. The real part of the input impedance is nearly 50 Ω (well matched) throughout the LTE band and imaginary part is nearly 0 Ω, it shows good matching of the antenna with the 50 Ω input. Matching at lower frequency bands (617-698 MHz, 699-960 MHz) is obtained by connecting one end of a small stub to the elliptical-shaped folded monopole while other end to the ground plane as shown in Figure 1. Radiation patterns are depicted in Figure 4. From Figure 4 (a), (b) and (c), it is clear that the antenna has omnidirectional pattern.

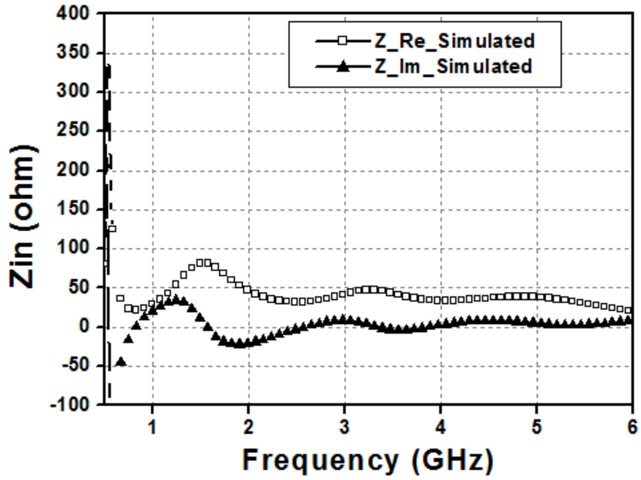
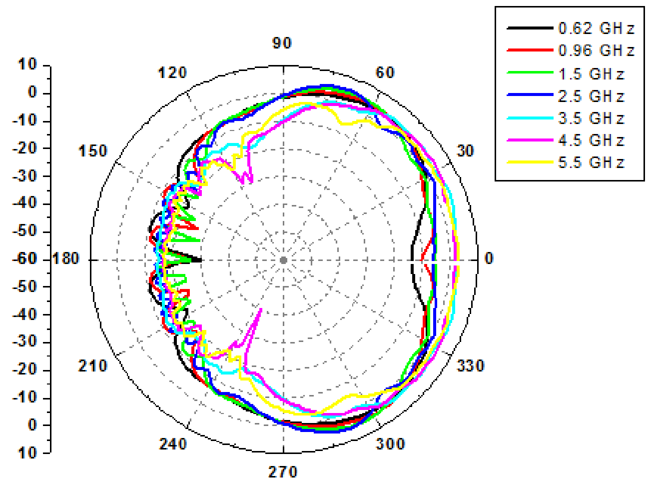
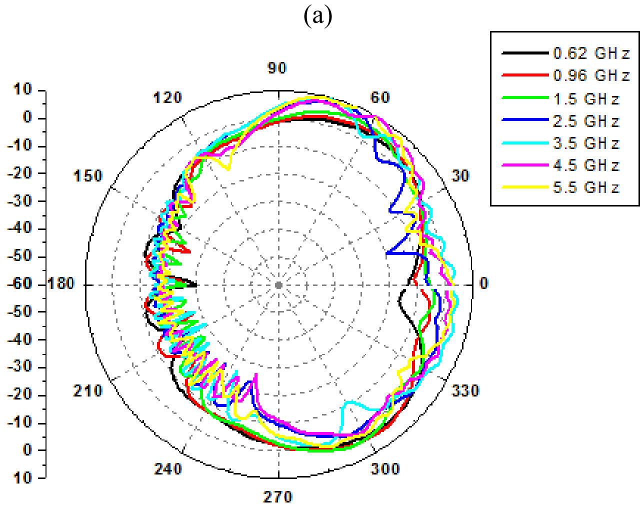


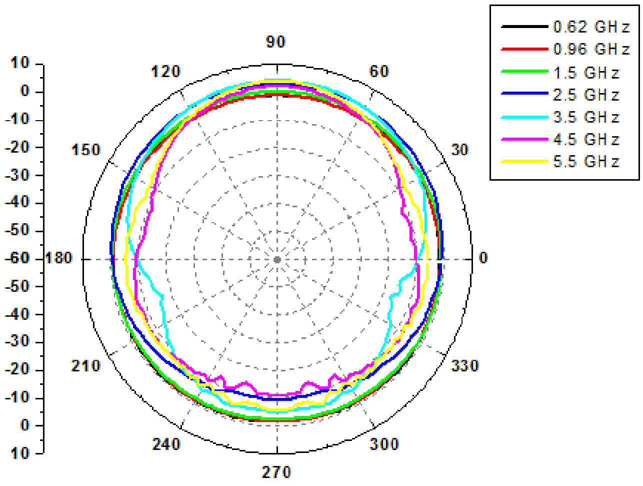

**Figure 3.** Simulated input impedance of the proposed wideband antenna.




(a)




(b)




(c)

**Figure 4.** Simulated radiation patterns of the proposed wideband low-profile antenna (a) Phi=$0^0$ (b) Phi=$90^0$ (c) Theta =$90^0$.

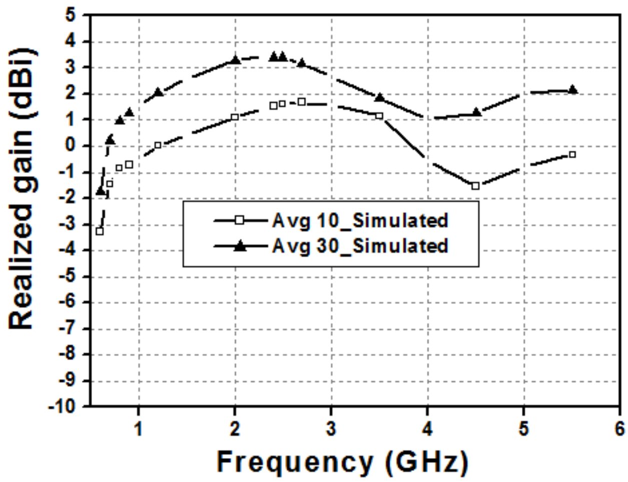



**Figure 5.** Simulated average realized gain with $10^0$ and $30^0$ of elevation.

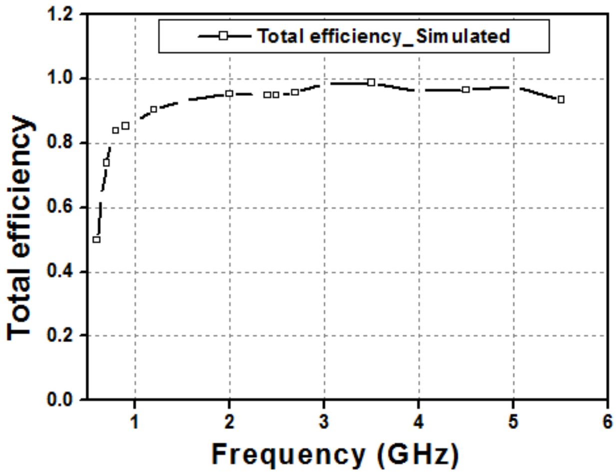



**Figure 6.** Simulated total efficiency of the proposed wideband low-profile antenna.

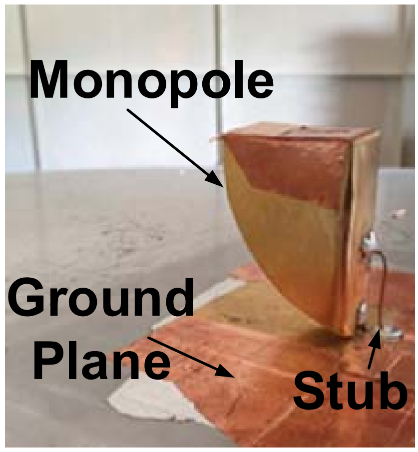



**Figure 7.** Photograph of the proposed wideband low-profile antenna.

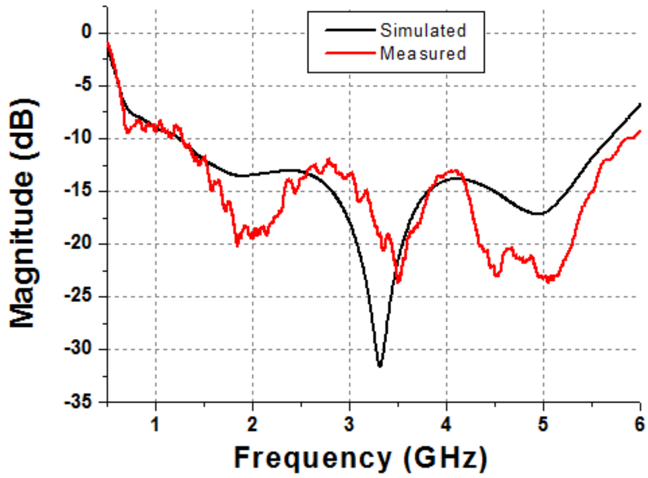



**Figure 8.** Measured reflection coefficient of the proposed wideband antenna.

A 1m-diameter circular ground plane is used to provide the same environment as it will be placed on a car roof (metal). In Figure 5, the average realized gain is plotted as a function of the frequency, for two different elevation ranges.

Specifically, this mean value is around the azimuthal plane ($0°<\varphi<360°$) and for 10 ($0°<\theta<10°$) or 30 ($0°<\theta<30°$) degrees of elevation. The average gain is a requirement typically considered to guarantee an almost omnidirectional radiation pattern of the antenna. Total efficiency is plotted in Figure 6. Efficiency is higher than 65% in the lower band (617-960 MHz) and 90% in the higher bands of LTE. Antenna prototype is made using a metal sheet and a small thin stub made from a copper wire is used. One end of a small stub is soldered to the antenna while other end to the ground plane as shown in Figure 7. Measurement is performed using vector network analyzer; reflection coefficient is plotted in Figure 8 and compared to the simulated one. From Figure 8, it is clear that measured reflection coefficient agrees well with the simulated result.

## 4 Conclusion

A 3D wideband low-profile antenna for LTE/5G is presented in this paper. Proposed antenna is simple in geometry; it is made by cutting and folding a metal sheet. One small stub is connected to obtain matching at low LTE bands and gives stability to the structure as well. Proposed antenna shows good performance in terms of reflection coefficient, gain, efficiency, and radiation patterns. It covers frequency range from 617 MHz to 5500 MHz. It is a good candidate as a car roof antenna and it can be easily fitted in the small volume under a plastic shark-fin cover.

## 5 Acknowledgements

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## 6 References

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