Design of a Dual-Band LTE MIMO Antenna to be Embedded in Automotives

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***Abstract*—A dual-band MIMO antenna is designed for automotive-based LTE communication. Basically, a monopole antenna is modified to resonate at a 900-MHz LTE band and a 1.9-GHz area, and to occupy a small real estate. Due to the dual-band resonance and radiation as one physical body, when this antenna is extended to the MIMO structure, the overall volume is relatively small to fit the space under the navigation monitoring box of a car. The design shows the antenna gain over 1 dBi and the return loss below -10 dB for the two LTE bands**

Keywords—Dual-bnad antenna; LTE; MIMO antenne; Automotive antenna

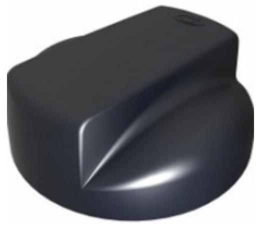
I. Introduction

Various types of automotive antennas including the classic monopole antenna mounted on the roof or boot of a car have been introduced for the last few decades[1]. FM and AM antennas were printed on the rear window and evolved to lumped-element loaded helices under the name of size-reduction. Since GPS and DMB functions were demanded, the shark-fin antennas highly populated with the radiating elements and their feed circuitry have been actively developed[2]. Let alone, WiFi or LTE communication antennas have started to show up on the cars[3]. Keeping abreast with the trend that handset antennas are embedded as intennas, automotive antennas are required to be placed inside the car or engraved on the chassis and hidden.

To pursue car-based LTE communication robust against the urban environment, multi-band and MIMO antennas are needed[4,5]. To the authors' knowledge, no such thing has been reported in academia. Therefore, in this paper, we propose the preliminary design of an LTE dual-band MIMO antenna for automobiles. Considering the volume of the space where the first of its kind is possibly placed, one radiating element is designed to resonate and receive the signals of a low LTE-band (900 MHz) and another(1.9 GHz) just below the ISM-band. Furthermore, this radiating element is expanded to the MIMO configuration by keeping the overall size acceptable to the empty cavity under the navigation system of a modern car. The design is verified by presenting the antenna gain over 1 dBi and the return loss less than -10 dB at the target frequency bands.

II. Desogn and Results

First, the figurative description of conventional and proposed car-based mobile antenna systems is given as follows.



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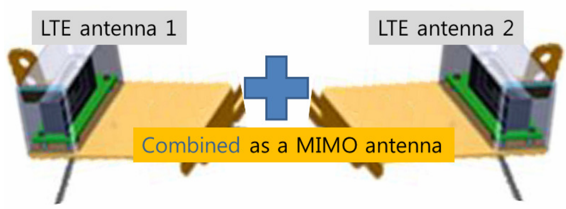
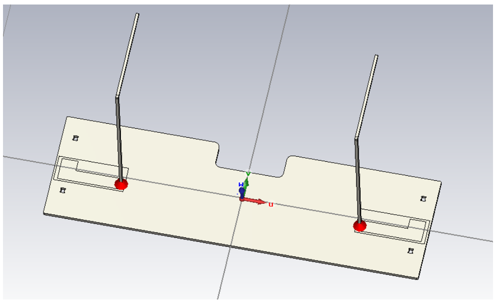
(b)



(c)

Fig. 1. The current and prposed mobile antennas (a)3G/4G/WiFi/GPS antenna box from In-CARPC, UK (b)e392/4G LTE antenna from Huawei (c)our scheme

Fig.'s 1(a) and (b) are two examples of the vehicle mountable mobile antennas available on the market, good for the placement on the external surface of an automobile. Nonetheless, the current demand is in need of an LTE MIMO antenna as the combination of two radiating elements to be embedded inside the car as Fig. 1(c). Realizing this scheme, the design is unfolded with two procedures. Separate designs of the 900-MHz and 1.9-GHz LTE MIMO antenna are conducted at the first stage, and they are integrated in the second stage.



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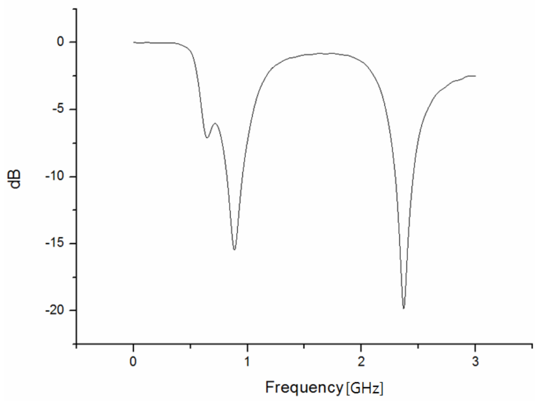

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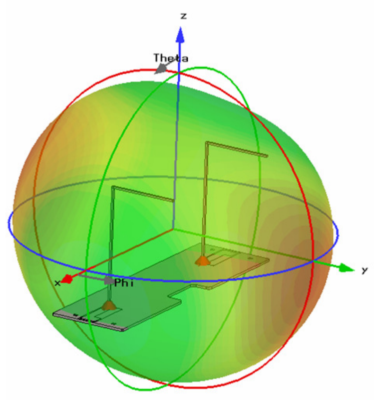
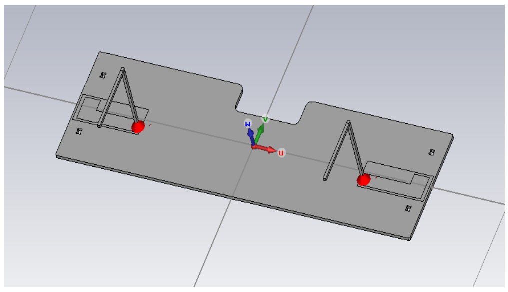


(c)

Fig. 2. The lower LTE band MIMO antenna (a)Geometry (b)Return loss (c)Far-field radiation pattern

The MIMO antenna is built on the ground suitable for the target space in the car. Fig. 2(a) has two monopole radiating elements modified from the straight vertical shape in order to be a lower profile. The impedance matching and resonance characteristics of this antenna are presented in Fig. 2(b) where the lower frequency resonance is created as desired. However, the second resonance occurs not at the 1.9-GHz band. This will be fixed at the stage of the integration. With regard to the antenna gain, it is over 2 dBi at the lower LTE service frequency as shown in the beam pattern of Fig. 2(c). Besides, the higher LTE band MIMO antenna is realized as follows.



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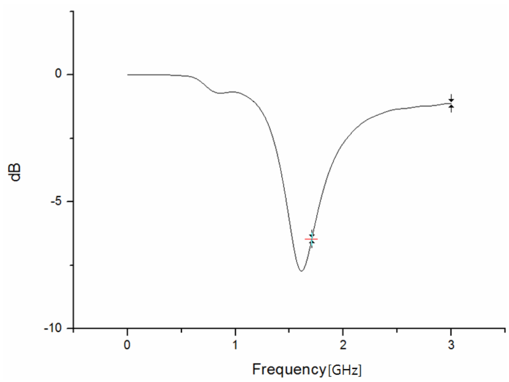

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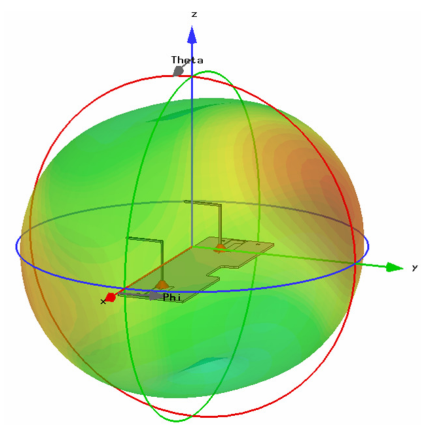
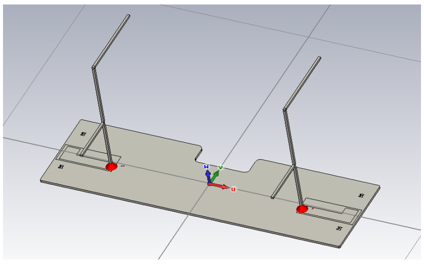


(c)

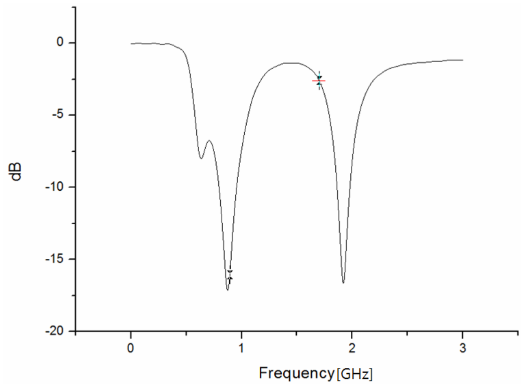
Fig. 3. The higher LTE band MIMO antenna (a)Geometry (b)Return loss (c)Far-field radiation pattern

In a similar fashion to the previous case, the physical shape of the MIMO antenna is modified from the typical monopole by taking into account that this geometry will be part of the 900-MHz resonating structure. The lamppost look-alike geometry is shown in Fig. 3(a). It resonates at 1.7 GHz as in

Fig. 3(b). Actually, this does not coincide with the target higher band, but it is not necessary to tune it to the 1.9 GHz at the current procedure, because it is helpful to moving the second resonance frequency(2.4 GHz) down to 1.9 GHz, when the longer and shorter resonant paths are put together. As the final step, we incorporate the geometries of Fig. 3 into Fig. 2 for the single structure with the dual-band property.



(a)



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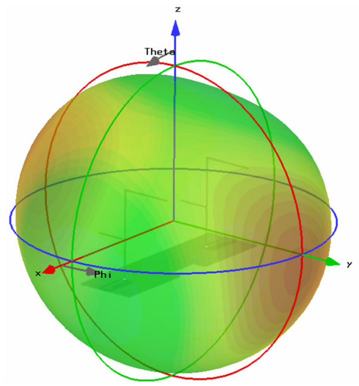

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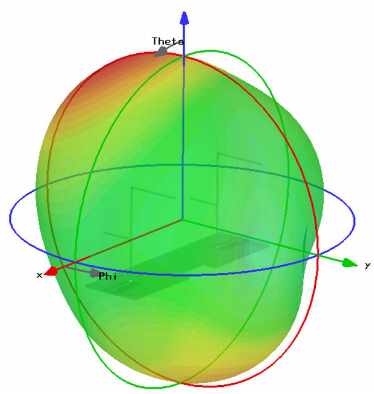

(d)

Fig. 4. The combined version of the lower and higher LTE bands (a)Geometry (b)Return loss (c)Far-field radiation pattern of the lower band (d)beam-pattern in the higher band

Seeing Fig. 4(s), each of the two radiating elements grows from the corresponding port and meets the junction from which the shorter arm goes in –y direction, and the longer one keeps heading to +z direction. The position of the junction is determined to generate the two resonance frequencies at 900 MHz and 1.9 GHz as mentioned before. This is confirmed by the two dips of the return-loss curve in Fig. 4(b). The far-field patterns of the dual-band antenna are visualized in Fig. 4(c) and Fig. 4(d). Both the lower and higher LTE bands turn out to be over 2 dBi in this experiment.

III. Conclusion

We have designed the prototype of a dual LTE-band MIMO antenna potentially adoptable to automobile-based 4G communication. At the 900-MHz and 1.9-GHz bands, the antenna gain over 1 dBi and $|S_{11}|$ below -10 dB were achieved. This will be the pedestal for developing the sophisticated car-embedded MIMO antenna.

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