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Planar LTE/sub-6 GHz 5G MIMO antenna integrated with mmWave 5G beamforming phased array antennas for V2X applications

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1. Introduction

To improve the vehicle-to-everything (V2X) interface, this paper presents a new planar LTE/sub-6 GHz 5G MIMO antenna design with mmWave 5G beamforming phased array antenna. This system is a combination of mmWave 5G phased array antennas and multi-band components that support LTE and sub-6 GHz 5G frequencies to provide 360-degree coverage. Traditional shark-fin antennas are still in use but the number of their drawbacks such as poor isolation, high correlation, and insufficient radiation patterns is quite high. As a solution, hidden-type antennas have been developed to offer high performance without compromising design aesthetics. These layouts come up with issues including weather space to accommodate electronic components and an appropriate antenna gain to meet the Third Generation Partnership Project (3GPP) standards. The semiconductor type of the antennas suggested in this article has double 5G arrays from the mmWave as well as multi-band LTE and sub-6 GHz 5G that produce the 5G bandwidth to a wide range of coverage. Providing the ability to be manufactured, the low-profile and IC-chip-compatible design targets the enhancement of V2X technology by overcoming the limitations in the existing vehicular antennas.

2. Results and Analysis:

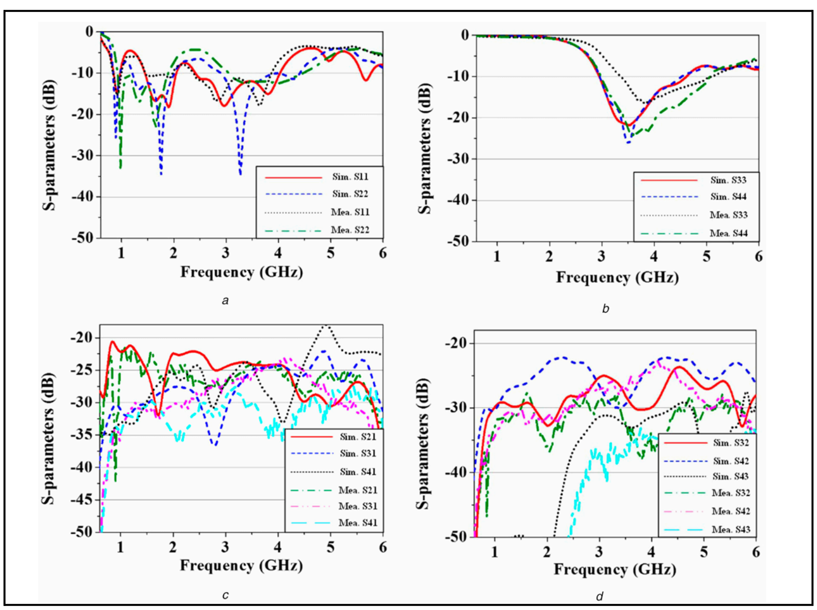

Figure 1: Simulatedand and measured S-parameters of the loop antennas: (a) Reflection coefficient, (b) Reflection coefficient, (c) Transmission coefficient, (d) Transmission coefficient (Ant.1-1: port 1, Ant.1-2: port 2, Ant.2-1: port 3, Ant.2-2: port 4)

The compact loop antennas (Ant. 1-1, Ant. 1-2, Ant. 2-1, and Ant. 2-2) were measured for reflection coefficients (S-parameters) and radiation patterns. The measurement's reflection coefficients closely corresponded with the simulated ones, and the model's accuracy was confirmed. The minimum isolation between the antennas was kept at 21.5 dB, so hardly any signal interfered between the antennas. The maximum peak gains for Ant. 1-1 were counted at 2.61 dBi at 0.88 GHz, 3.03 dBi at 1.8 GHz, and 5.38 dBi at 3.5 GHz. The highest gains at 0.88 GHz for Ant. 2-1 were 1.15 dBi, while the best results for 1.8 GHz and 3.5 GHz were 3.14 dBi and 3.41 dBi respectively. The eNodeBs used for the measurements of the AIRWAYS antennas revealed that for the two gain antennas of Ant. 2-1 and Ant. 2-2 at 3.5 GHz, the gains were 4.96 dBi and 5.12 dBi, respectively. The envelope correlation coefficients (ECCs) that went under 0.5 indicate the antenna's great diversity performance.

The mmWave 5G antennas were shown to have their S-parameters change a little from the resonance frequency but remain almost the same close to the simulated values. The discrepancies between the measured and simulated data were attributed to possible errors in the fabrication and measurement processes. The connectors, microstrip feeding networks, and dielectric housings influenced the radiation characteristics. Both simulated and measured gain patterns for subarrays with 0° and 45° fixed scan angles were studied. The independent antennas subarray 1 and subarray 2 with a 0° scan angle showed peak gains of 15.75 dBi and 15.8 dBi, while with a 45° scan angle, the maximum gains were 11.78 dBi and 11.36 dBi. By the way, the measured gain patterns conformed with the simulations that revealed the peak gains of 13.56 dBi and 12.41 dBi for subarrays with a 0° scan angle and 10.95 dBi and 11.54 dBi for the 45° scan angle.

The proposed antenna design is better than the previous works in terms of bandwidth, isolation, and gain. The improvements made to the antenna by integrating 4G/5G MIMO antennas within the same structure and the establishment of dielectric housing were the keys that played a role in these changes. The demonstration of more MIMO antenna elements than those of previous models and the higher gains at 28 GHz were the main features of the designs and achievable results. The efficiency of low bands was experienced better too, and among the MIMO antenna, which could attain 93% at 3.5 GHz while the isolation was 21 dB between the MIMO elements.

3. Conclusion:

This contribution introduces a new design for planar LTE/sub-6 GHz 5G MIMO antenna integrated with mmWave 5G beamforming phased array antennas. The design was specially optimized not only for the vehicle-to-everything applications but also interacted with the specific design of the operation. The proposed antenna system efficiently copes with the modern demands of the vehicular communication systems sector which provides wide coverage of different frequency bands such as LTE, sub-6 GHz 5G, and mmWave 5G. The compact multi-band and single-band loop antennas are the basis of the design for LTE and sub-6 GHz 5G MIMO, as well as Yagi phased array antennas for mmWave 5G, which ensure high isolation and low envelope correlation coefficients, which are critical for the MIMO performance. According to the data from the experiments, the device is successfully performing according to the specifications in terms of the superiority of the reflection coefficients, the high isolation level, and the major power gains throughout the mentioned frequency bands. Dielectric housing incorporation improves the strength and practical relevance of the antenna system. This approach stands ahead of others in terms of gain, efficiency, and bandwidth, it promises to be the ideal solution for V2X in the future.

Reference:

1. https://ietresearch.onlinelibrary.wiley.com/doi/10.1049/iet-map.2019.0849