CPW-Fed MIMO Smartphone Antenna Array with Radiation/Polarization Diversity for 5G Applications

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***Abstract*—A co-planar waveguide (CPW)-fed MIMO antenna design with compact resonators and diversity function is introduced for smartphone applications. Four pairs of the diversity monopoles with CPW feeding have been deployed at the mainboard's corners to arrange an 8×8 MIMO. The antenna elements of the introduced MIMO design were etched onto the same layer as the ground plane. The designed array occupies a relatively small area of the board. In addition, protruded arrow strips are placed to minimize the coupling among the adjacent elements. The MIMO antenna is designed for 3.6 GHz of sub-6 GHz 5G spectrum and provides a 3.4-3.8 GHz bandwidth. Overall, the planned MIMO array is capable of achieving optimal results and meeting the demand for future 5G portable devices such as smartphones.**

Keywords—5G, CPW-fed antenna, MIMO, smartphone applications, sub 6 GHz applications.

I. Introduction

Currently, Wireless service providers are facing previously unheard-of difficulties as they attempt to address a global bandwidth constraint due to the growth of mobile data and the widespread usage of smartphones. The available (4G) wireless systems are incapable of providing the high data rates needed for future mobile networks and wireless communications have evolved into the 5th generation (5G), which provides several enhanced services in response to these challenges [1].

The future 5G communication networks are increasingly relying on MIMO technology with multiple elements allowing high-speed transmission, high throughput levels, and high data rates [2]. In addition, using MIMO technology, it is possible to increase the data rate, capacity, and coverage by reducing multipath fading and lowering the coupling among the antenna elements [3]. In mobile and cellular communications, microstrip and printed antennas with compact sizes and simple structures are widely used due to their promising properties. However, in order to obtain an efficient performance of the MIMO array in cellular networks, numerous challenges must be considered and properly addressed [4-5].

An eight-element MIMO array with low-profile elements single-layer configuration and radiation/polarization diversity is presented in this paper. The antenna is covering more than 400 MHz bandwidth of sub-6 GHz cellular communications. Simple and straightforward design procedures are followed. For the designed diversity antenna elements, the CPW feeding technique is used in the ground plane. The suggested MIMO array design achieves sufficient results. As stated previously, a lot of literature does exist on the design of eight-element MIMO antennas but the suggested design's main purpose in this paper is to come up with a system having good MIMO and diversity characteristics and less complexity and compact size in terms of design and manufacturing. Its characteristics were investigated using CST 2020 [6]. The following sections provide the design schematic, its fundamental properties, and the study's conclusion

II. Design and Configuration Details

Figure 1 shows the proposed MIMO design in a perspective top view. As shown, the multi-feed antenna system has a rather straightforward and simple structural configuration and it contains eight CPW-fed radiators deployed at different PCB sides. The elements were etched onto the same layer as the ground plane constructed on the FR-4 substrate with a thickness of 1.6 millimeter. The antenna feed uses 50 Ω CPW feedlines and the proper dimensions of all parameters are listed in Table I.

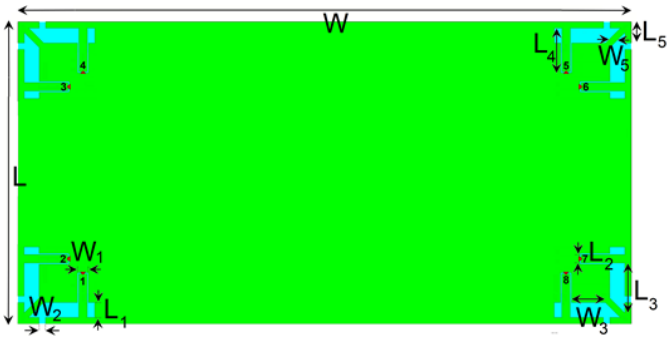

Fig. 1. Design details of the investigated MIMO smartphone antenna.

TABLE. I PARAMETER VALUES

Parameter	W	L	W_1	L_1	W_2	L_2
Value (mm)	150	75	1.5	2.5	0.5	1.5
Parameter	W_3	L_3	W_4	L_4	W_5	L_5
Value (mm)	5	7.5	1	7	1	3

III. ESSENTIAL CHARACTERISTICS

The S-parameters of the suggested phased array design have been depicted in Fig. 2 and show the main properties of MIMO array frequency responses including S_{11} (reflection-coefficient/impedance-bandwidth) and S_{mn} (transmission-coefficient). Based on the results of Fig. 2 (a), the S_{nn} characteristic for the -10 dB operates above 400 MHz impedance bandwidth, while for -6 dB this value exceeds 600 MHz. Furthermore, the designed antenna elements have suitable couplings, less than -11 dB as plotted in Fig. 2 (b).

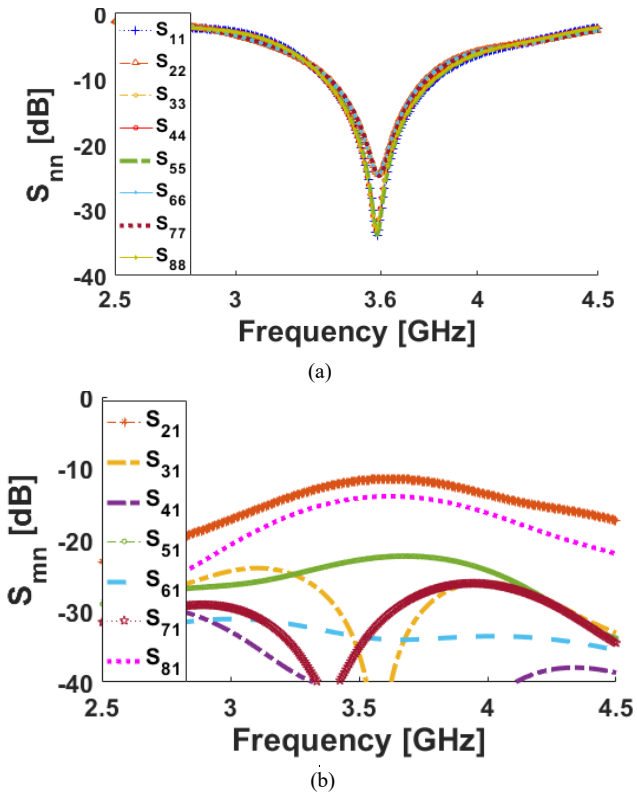

Fig. 2. (a) S_{nn} and (b) S_{mn} results for the studied MIMO antenna.

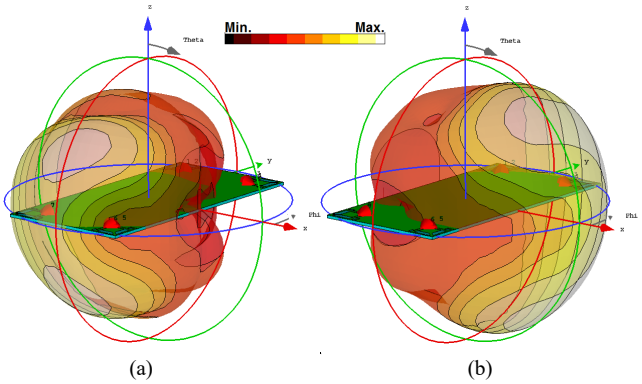

Fig. 3. Radiations of (a) first and (b) second resonators at 3.6 GHz.

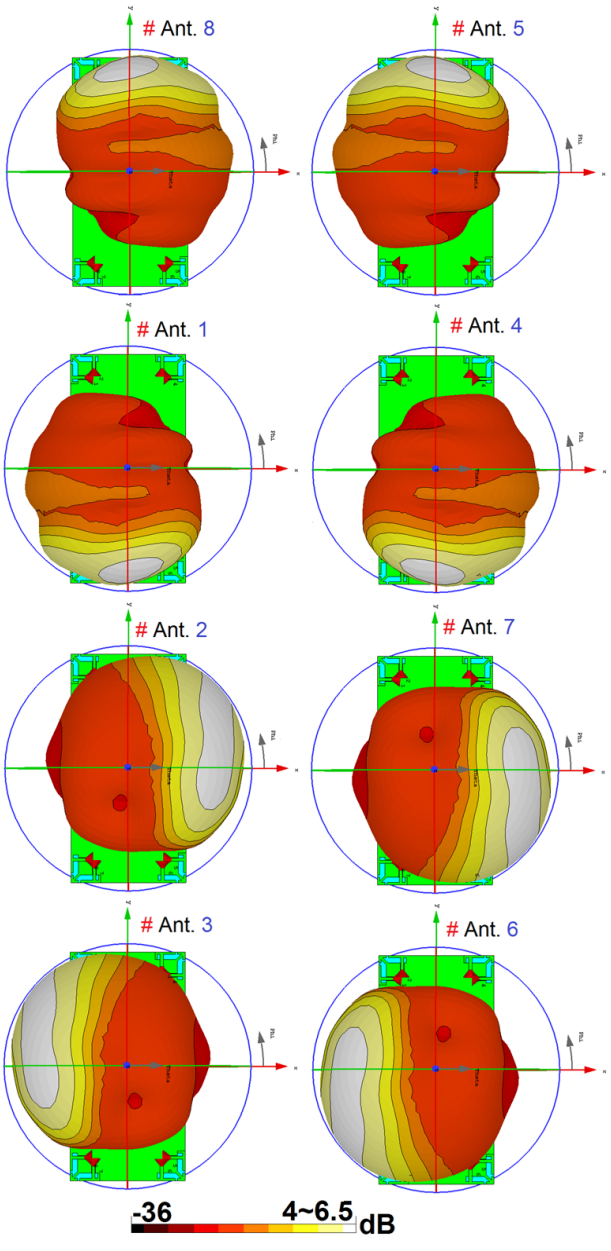

Fig. 4. Radiations of the CPW-fed diversity radiators at 3.6 GHz.

In Figs. 3 (a) and (b), side views of three-dimensional transparent radiation patterns are shown for two antenna elements (elements 1 and 2). As illustrated, the quasi-end-fire radiation generated by the elements on the PCB covers both top/bottom sides symmetrically. Figures 4 depicts the variations of the radiated field at the resonating operational frequency (3.6 GHz) for the elements of the suggested MIMO which verifies the well-defined radiation of the elements at the target frequency. As shown, highly satisfactory radiations which offer polarization diversity and various coverage of the mainboard with constant performances and sufficient gain levels [8]. The total active reflection coefficient: TARC and envelope correlation coefficient: ECC specifications are important characteristics in MIMO systems and should be at low levels [9-10]. Figures 5 (a) and (b) represent the calculated ECC and TARC characteristics for the closely spaced CPW-fed resonators. It is observed that these functions of the array appear very low within the operation band. As can be observed from Figs. 5 (a) and (b) at the target frequency resonance, the proposed design provides less than 0.005 ECC and -30 dB TARC characteristics.

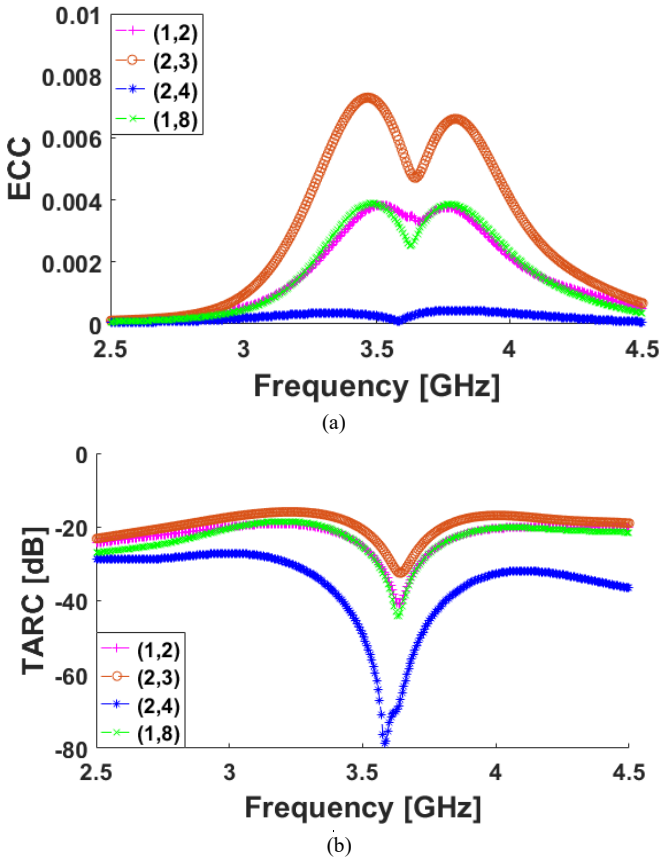

Fig. 5. (a) ECC and (b) TARC properties for the studied MIMO antenna.

IV. Conclusion

A new antenna array with CPW-fed resonators that are compact in size with radiation and polarization diversity is described for 5G handheld devices. According to the provided schematic, there are eight compact CPW-fed printed resonators deployed on various sides of the smartphone board to resonate at 3.4-3.8 GHz. The designed array occupies a relatively small area of the board. Various properties of the designed array including S-parameters, 3|D radiation, gain, and ECC/TARC were investigated and sufficient results have been achieved.

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