A Compact Two-Port Handset MIMO Antenna with High Isolation for 5G mm-Wave Applications

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Abstract— **In this paper, a novel design of a compact coplanar waveguide (CPW) fed multiple-input-multiple-output (MIMO) handset antenna operating in a wide frequency range at the 5G New Radio (NR) millimeter wave (mmWave) band extending from 23.5 GHz to 41 GHz. The planar geometry results in a small, compact structure with a wide operating bandwidth, high gain, and high radiation efficiency. The utilized antenna was a single-layer surface-mounted CPW in a pin-clamp-like (PCL) structure fed with a wide ground slot. The two-element MIMO antenna consists of closely-spaced parallel elements placed $\lambda_0/16$ apart from the closest edge, wherein λ_0 is the free space wavelength at the 28 GHz operating frequency. A novel inverse S-shaped (IS) decoupling strip structure was used. The proposed antenna element was designed on a Rogers RT5870 substrate using CST Microwave Studio and further validated using Ansys HFSS software. The simulated frequency bandwidth was confined to (23.5-41) GHz, showing both software good agreement results. At 37 GHz, the antenna array provides a maximum simulated gain of 6.6 dBi, while its lowest was 1.5 dBi at 24 GHz, and its minimum radiation efficiency was 93% over the whole band. This array revealed excellent MIMO performance metrics, such as envelope correlation coefficient ECC, diversity gain DG, and mean effective gain MEG, of excellent results, making this array a good choice for emerging 5G communications applications.**

Keywords—**Two ports, MIMO, 5G, mmWave, high isolation, ECC**

I. Introduction

The rapid progress of cellular wireless communication systems has increased the importance of similar developments in the design of modern antenna systems, which are essential components of any wireless device. The ever-increasing has greatly influenced the current telecommunication system, increasing data consumption and demand for faster data speeds. To address the increasing demand for faster and more reliable connectivity, researchers are exploring new 5G communication technologies. The World Radio-communication Conference (WRC) has allocated many mmWave frequencies for future 5G systems since they provide a high data rate [1].

5G is focused on the centimeter and mmWave spectrums, which may enable attaining the larger bandwidth with a data rate of several Gbps. There are several advantages of using these frequencies: The lower portion of the spectrum has already been occupied by many different types of wireless networks and applications, such as Wi-Fi, WiMAX, Bluetooth, and industrial, scientific, and medical (ISM), while the upper portion is mainly underutilized and ready for 5G technology [2]. The 5G spectrum is addressed by many countries, as shown in Fig. 1. 5G networks using multiple-input-multiple-output (MIMO) as an enabling technology to provide significant improvements in channel capacity, data rates, latency, efficiency, link reliability, and energy conservation compared to single input, single output (SISO) systems [3], [4], without increasing the power or bandwidth. Wireless communication systems are influenced by multipath fading. MIMO technology is one solution for taking advantage of multipath fading by operating multiple independent data sub-channels. Thus, wide bandwidth MIMO technologies are critical to 5G systems and beyond because they can use the multipath feature to maximize spectrum efficiency and channel capacity without increasing power transmitted [5, 6]. For a desirable performance, a MIMO system should also have strong isolation among the transmitting and receiving antenna elements and wideband properties [7]. An increase in the inter-element mutual coupling might degrade the performance of a MIMO antenna system. Developing a miniaturized MIMO antenna system with a high element isolation level while having a common ground structure is a challenging design problem [8].

The researchers devised many ways to increase the isolation among antenna elements in MIMO applications. These include stubs, Defected Ground Structure (DGS), Electronic Band Gap (EBG), and Split Ring Resonator (SRR), among other techniques [9–12]. A dipole with V-shaped branch ground [13] or a monopole antenna with SRR and ground with a ring-shaped resonator was utilized

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