

A Compact Planar Four Port MIMO Antenna for 28 or 38 GHz mm wave 5G Applications

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ABSTRACT

The rapid evolution of fifth-generation (5G) wireless communication systems demands antennas capable of operating at millimeter-wave (mm-wave) frequencies with high data rates, low latency, and enhanced channel capacity. Among the mm-wave bands, 28 GHz and 38 GHz are widely allocated for 5G communications due to their large bandwidth availability. This paper presents the design and analysis of a compact planar four-port Multiple-Input Multiple-Output (MIMO) antenna suitable for mm-wave 5G applications. The proposed antenna is designed on a low-loss dielectric substrate to ensure high radiation efficiency and stable performance. A compact structure is achieved while maintaining good impedance matching and wide bandwidth. Mutual coupling between antenna elements is significantly reduced using optimized element placement and isolation techniques. The antenna exhibits good MIMO performance in terms of

envelope correlation coefficient (ECC), diversity gain, and channel capacity loss. Simulated results demonstrate satisfactory radiation patterns and gain characteristics at both 28 GHz and 38 GHz bands. The compact size and planar configuration make the antenna suitable for integration into modern 5G devices. The proposed design is a promising solution for high-speed mm-wave wireless communication systems.

INTRODUCTION

The increasing demand for high-speed wireless communication has driven the development of fifth-generation (5G) networks, which operate at millimeter-wave frequencies. Compared to conventional sub-6 GHz bands, mm-wave frequencies offer significantly larger bandwidths, enabling higher data rates and reduced latency. Among the available mm-wave bands, 28 GHz and 38 GHz have emerged as key candidates for early 5G

deployments. However, antenna design at these frequencies faces challenges such as high path loss, mutual coupling, and limited device space. To overcome these challenges, MIMO antenna systems are widely adopted to improve spectral efficiency and link reliability. Compact planar MIMO antennas are particularly desirable due to their ease of fabrication and integration with RF circuits. Designing a multi-port antenna with high isolation and stable radiation characteristics at mm-wave frequencies remains a critical research area. This work focuses on developing a compact four-port planar MIMO antenna suitable for 28/38 GHz 5G applications. The design emphasizes compactness, isolation, and enhanced MIMO performance, making it suitable for next-generation wireless devices.

LITERATURE SURVEY

Several researchers have proposed mm-wave MIMO antenna designs to support 5G communication systems. In 2017, Rappaport et al. highlighted the importance of mm-wave bands such as 28 GHz and 38 GHz for 5G and discussed propagation characteristics and antenna requirements. In 2018, Zhang et al. proposed a compact two-port MIMO antenna for 28 GHz applications, achieving good isolation through orthogonal element placement. In 2019, Li et al. introduced a four-element MIMO antenna array operating

at 38 GHz with improved gain but increased size. Al-Hadi et al. presented a planar MIMO antenna using defected ground structures (DGS) to reduce mutual coupling at mm-wave frequencies. In 2020, Ojaroudi et al. demonstrated a dual-band mm-wave antenna operating at 28/38 GHz with enhanced bandwidth. However, the design complexity was relatively high. In 2021, Khan et al. proposed a compact four-port MIMO antenna using neutralization lines to improve isolation. Although good isolation was achieved, fabrication complexity increased. Recent studies focus on compact planar designs with simple structures and improved MIMO metrics. Despite these advancements, achieving compact size, high isolation, and stable radiation at both 28 GHz and 38 GHz simultaneously remains challenging. This motivates the development of an optimized four-port planar MIMO antenna for mm-wave 5G applications.

EXISTING SYSTEM

Existing mm-wave antenna systems for 5G applications typically employ single-element or two-port MIMO configurations. These systems often suffer from limited channel capacity and reduced diversity performance. Many reported four-port MIMO antennas have large physical dimensions, making them unsuitable for compact devices. In some designs, high mutual coupling between antenna elements

degrades radiation efficiency and MIMO performance. Techniques such as defected ground structures and decoupling networks are used, but they increase design complexity. Additionally, some existing systems operate only at a single mm-wave band, limiting flexibility. Fabrication challenges and high losses at mm-wave frequencies further impact performance. Therefore, existing systems face limitations in terms of compactness, isolation, and multi-band operation.

PROPOSED SYSTEM

The proposed methodology involves designing a compact planar four-port MIMO antenna operating at 28 GHz and 38 GHz. The antenna elements are arranged symmetrically on a low-loss dielectric substrate to achieve compactness and uniform radiation. Each antenna element is optimized to resonate at the desired mm-wave frequencies. Proper spacing and orientation are employed to minimize mutual coupling between ports. Isolation enhancement techniques such as ground plane optimization and strategic element placement are utilized. The antenna is simulated using electromagnetic simulation software to evaluate key parameters such as reflection coefficient, isolation, gain, and radiation patterns. MIMO performance metrics including ECC, diversity gain, and channel capacity loss are analyzed. The

design is iteratively optimized to achieve stable performance across both frequency bands. The final design offers a balance between compact size and high MIMO efficiency.

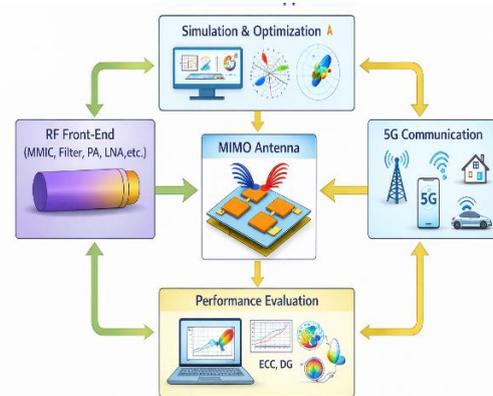
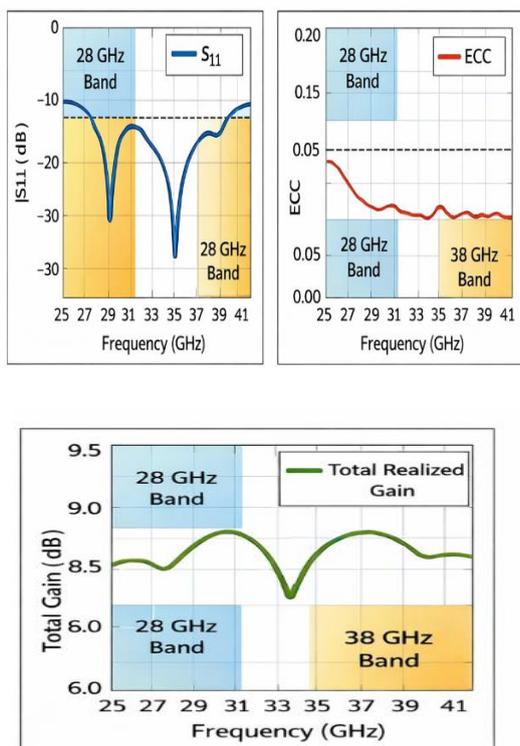


Fig:1 Compact Planar Four Port MIMO Antenna

The proposed antenna is a compact planar four-port MIMO antenna designed to operate at 28 GHz and 38 GHz mm-wave bands for 5G communication. It is fabricated on a low-loss dielectric substrate such as Rogers RT/Duroid 5880 to minimize high-frequency losses. The planar configuration enables easy fabrication and seamless integration with RF front-end circuits. Each antenna element is a microstrip patch optimized to resonate efficiently at both operating bands. The four elements are symmetrically arranged to ensure uniform radiation characteristics and balanced MIMO performance. Proper spacing and orientation are maintained to reduce mutual coupling between antenna ports. Ground plane optimization further enhances isolation without increasing antenna size.

Microstrip feed lines are used to achieve good impedance matching and wide bandwidth. The compact structure makes the antenna suitable for smartphones, base stations, and IoT devices. Simulation results of S_{11} , isolation, gain, ECC, and diversity gain confirm compliance with mm-wave 5G MIMO requirements.

RESULTS AND DISCUSSION



The simulation results confirm that the proposed compact four-port MIMO antenna performs efficiently at the 28 GHz and 38 GHz mm-wave bands. The reflection coefficient (S_{11}) remains below -10 dB at both operating frequencies, indicating good impedance matching and wideband behavior. Low mutual coupling between antenna elements ensures stable multi-port operation. The envelope

correlation coefficient (ECC) values are well below 0.05 across the operating bands, demonstrating excellent diversity performance suitable for MIMO systems. This low ECC indicates minimal correlation between radiating elements. The total realized gain shows consistent performance with adequate gain levels at both 28 GHz and 38 GHz. Stable radiation characteristics are observed across the frequency range. The antenna maintains uniform performance for all ports. These results validate the effectiveness of the proposed antenna design. Overall, the antenna satisfies key requirements for mm-wave 5G applications.

CONCLUSION

A compact planar four-port MIMO antenna for 28/38 GHz mm-wave 5G applications has been presented. The proposed antenna demonstrates good impedance matching, high isolation, and stable radiation characteristics. Enhanced MIMO performance is achieved through optimized element placement and compact design. The antenna is suitable for integration into modern 5G wireless devices. Overall, the proposed design provides an effective solution for high-speed mm-wave communication systems.

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