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An Ultra-Wide-Band non-Conventional two Element MIMO Antenna

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Abstract

This paper describes a planar Multiple-Input-Multiple-Output (MIMO) antenna designed for Ultra-Wide-Band (UWB) applications. The configuration consists of two identical non-conventional parallel pieces. Each element is optimized using Genetic Algorithm code created in the CST microwave studio's visual basic scripting (VBS) environment. T-shaped is appropriate for parallel and. The suggested MIMO antenna attains operating band of over 171.4% on (2 - 26 GHz), ECC less than 0.01 and Diversity Gain (DG) more than 9.98 were obtained. The proposed structure is designed on the Rogers RT6002 substrate with a dielectric constant of 2.94, a height of 1.52mm, and a loss tangent of 0.0012. The simulated isolation between ports is better than -20 dB in most bandwidth. The proposed antenna is well-suited for UWB MIMO applications.

Keywords: MIMO, Ultra-Wide-Band, diversity gain, ECC, isolation enhancement, non-conventional antenna.

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1. Introduction

Wireless communications continue to progress strongly, requiring new technologies to offer improved performance, coverage, quality of service, and capacity. Printed antennas are necessary in mobile terminals due to their low weight, cost, and flexibility.

However, conventional printed antennas are faced with challenges like electromagnetic coupling between MIMO systems, leading to interference and degradation of signals. MIMO diversity and UWB technology offer remedies, but new designs are always in need.

Antennas enable wireless communication by converting electrical energy to electromagnetic energy and vice versa. They radiate signals during transmission and capture signals during reception, operating in both modes [1]. A microstrip antenna consists of a conducting patch on a dielectric substrate, with the opposite side covered by a large metallic ground plane. It is created through photoetching, printing, or similar methods [2]. Microstrip antenna patches come in various shapes, such as rectangular, circular, and triangular, chosen based on size, radiation pattern, gain, and bandwidth requirements. Operating modes depend on patch dimensions, substrate properties, and feeding configuration. Various dielectric materials are used as substrates [3]. Single-input, single-output (SISO) antennas are not suitable with high channel capacity demands and data rates in wireless systems. Printed multiple-input, multiple-output (MIMO) antennas have proven to be the right selection for high-speed communication technologies [5-6].

Individual feeding systems are utilized by MIMO antenna structures to transmit and receive information on different radiating elements. Port coupling diminishes performance, yet with the employment of other methodologies, isolation is strengthened. An efficient solution [7-8] is to design MIMO structures based on metamaterial. A periodic electrically coupled square split-ring resonator (SRR) metasurface is used over the antenna array to improve decoupling [9]. A split ring with an inductive line electrically coupled with a capacitive gap electrically coupled enables magnetic and electric coupling, forming the decoupling structure [10]. Orthogonal MIMO antenna structure yields high isolation [11]. Massive MIMO systems reduce latency in MIMO [12]. A rectangular strip decoupling structure improves isolation [13]. High terminal isolation in a MIMO system is required for the system to give high accuracy [14].

This paper emphasizes the design of a MIMO UWB patch antenna for WiMAX communication systems with the aim of attaining high data rates, a reliable transmission, compactness, and electromagnetic compatibility.

2. Antenna design and configuration

The fundamental antenna is an ultra-wideband (UWB) patch antenna which is used to construct a two-element MIMO antenna then simulated, with efforts to reduce coupling between elements. The design procedure, parametric study, and improvement in performance are performed using CST Microwave Studio (MWS).

Two parallel element MIMO antenna (fig.1) is tested using three distance parameters with reference to $\lambda/2$ ($\lambda = 62$ mm). Simulation experiments show that wider spacing (D) between the elements reduces mutual coupling (S21), lessening inter-antenna interference and improving spatial selectivity, Excessive inter-element spacing between MIMO antennas can impair spatial coherence and diversity, affecting performance. To reduce this, the research seeks to reduce the distance ($D < \lambda/2$) and coupling effects using a T-shaped parasitic structure. After optimization of the T-shaped element and the resizing of the ground plane, decoupling of the antenna elements is reduced.

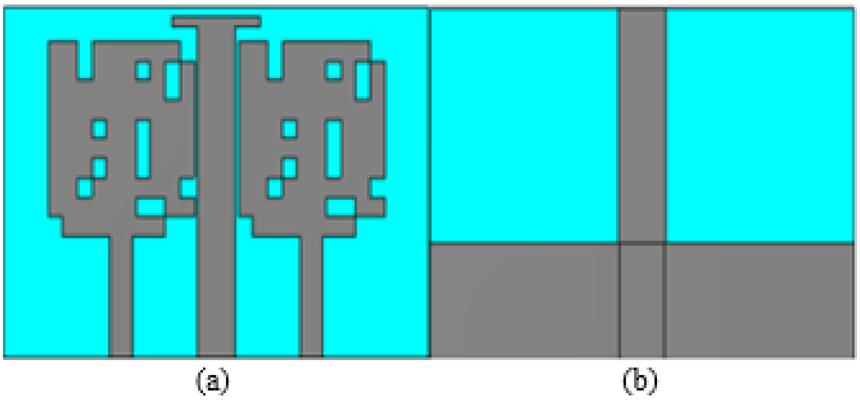

Figure 1. MIMO antenna with T-shaped structure: (a) Front view, (b) Back view.

3. Simulated results

The simulated MIMO antenna's return loss and mutual coupling are represented by figures 2 and 3. S11 and S22 parameters confirm the ultra-wideband characteristics of the antenna.

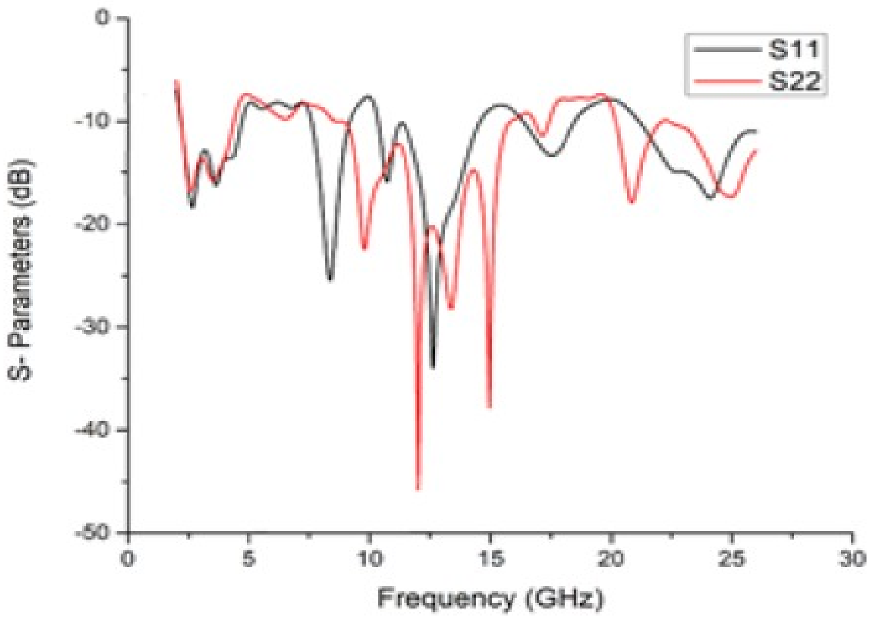

Figure 2. Simulated S11 and S22 parameters.

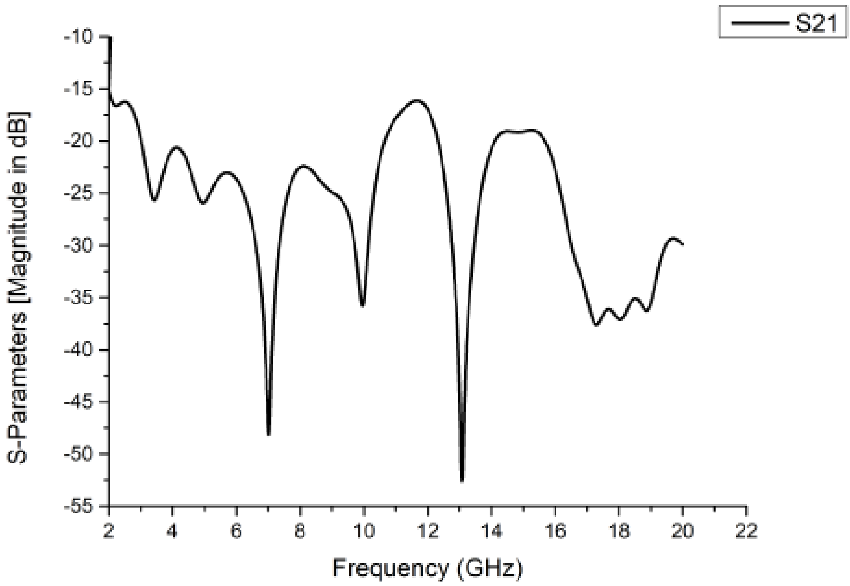

Figure 3. Simulated mutual coupling.

Envelope correlation coefficient (ECC) and diversity gain of the proposed design are shown in figures 4 and 5, respectively.

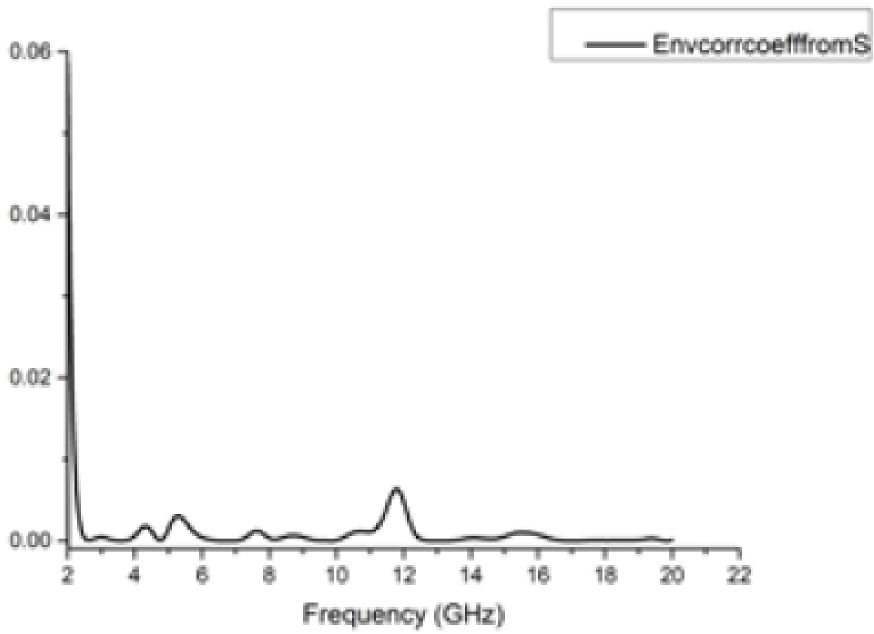

Figure 4. ECC simulated of MIMO antenna.

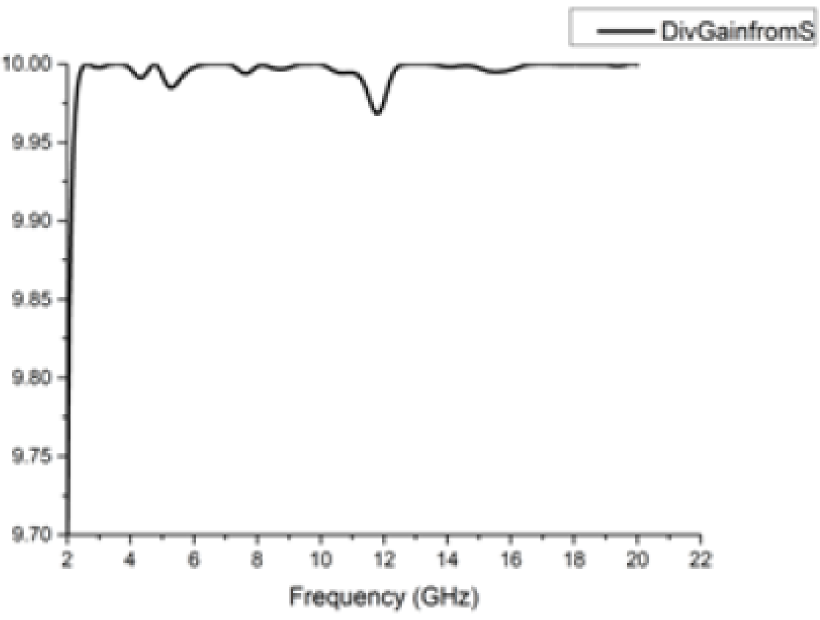

Figure 5. Diversity gain (DG) simulated of MIMO antenna.

We can see from fig.4-5 that both of the two MIMO performance metrics are well within the acceptable limit. The ECC should be at least 0.05 (our ECC value < 0.009), which is well acceptable.

4. Conclusion

The work presents design and simulation of an ultra-wideband MIMO antenna for WiMAX and other wireless communication systems through CST software and Rogers substrate. The size of proposed antenna is 58 x 36 mm² having two parallel elements and T-shaped structure, ECC = 0.0089 the simulation data gives a good performance. The paper bridges the theoretical research gap to practical implementation gap in MIMO antenna technology to pave the future for innovations in wireless communications.

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