

# A Compact Two Element UWB MIMO Antenna

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**Abstract:** In this Paper we design two- element MIMO antennas and various isolation structures and mechanisms to reduce the mutual coupling between the two elements, out of which two major antenna designs are proposed and analyzed separately for their isolation, bandwidth and radiation characteristics. The MIMO antenna system consists of two semicircular radiating elements on a single low-cost FR4 substrate of a compact size of 35 mm × 40 mm and is fed by a 50-Ω microstrip line. A T- shaped slot is etched on the radiating elements to enhance the impedance bandwidth. The proposed antenna system operates over a wide frequency range from 4.4 to 10.7 GHz. A fork-shaped structure is introduced in the ground plane to increase the isolation between the antennas. Simulated results of S-parameters of the proposed antenna system are obtained and a high isolation of -20 dB is achieved in most of the band, which is found suitable for MIMO applications.

**Key Words:** MIMO, S-Parameter, isolation, coupling etc.

## I. INTRODUCTION

Ultrawideband (UWB) technology has rapidly gained popularity and demand for recent wireless communication systems after the allocation of 3.1- 10.6 GHz by the Federal Communications Commission (FCC) for UWB applications. Since then, a myriad of research opportunities and challenges exist for the design of UWB antenna systems for application in high speed wireless devices.

Multiple-Input-Multiple-Output (MIMO) systems provide a significant increase in channel capacity without the need of additional bandwidth or transmit power by deploying multiple antennas for transmission to achieve an array gain and diversity gain, thereby improving the spectral efficiency and reliability. Since MIMO systems employ multiple antennas, they require high decoupling between antenna elements.

Overall UWB MIMO systems require a high isolation of less than -16 dB and also a compact size for compatibility with integrated circuits.

We focuses on the analysis and design of MIMO antennas with a compact planar profile that have an operating range in the entire UWB (3.1- 10.6 GHz) and desired antenna performance characteristics.

## II. ANTENNA DESIGN

In this paper we design and analyze a two- element MIMO antenna system is presented. The proposed MIMO antenna system has a compact size of 35 mm × 40 mm and has an operating band from 4.4 to 10.7 GHz, covering almost the entire UWB.

A fork-shaped structure is extended from the ground plane to enhance the isolation to < -20 dB in most of the UWB band. The geometry of the proposed UWB MIMO antenna system is shown in Fig 1. The antenna system consists of two radiating elements of similar geometry

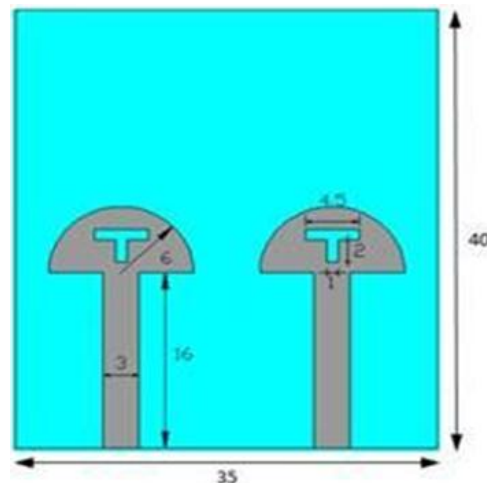


Fig.1. Geometry of the proposed antenna system (Front view)

printed on a common FR4 substrate of thickness 1.6 mm and a compact size of 35 mm × 40 mm. The relative permittivity of the substrate is 4.4. A semicircular disc monopole is chosen as the radiating element and each of the radiators is fed separately by a 50Ω microstrip line. Circular and semicircular monopole antennas have more impedance bandwidth than the rectangular, triangular, square and hexagonal monopole antennas. Semicircular geometry of the radiator provides more isolation between the radiating elements than most other existing geometries.

The two radiators are placed in such a way that distance between them is more than half of the wavelength of the lowest frequency in order to achieve the isolation between the radiating elements. The gap between the radiating element and the ground plane affects the impedance bandwidth and hence the distance is optimized at 1 mm. A central T-shaped slot of 1 mm width is introduced on each of the radiators to enhance the impedance bandwidth. A fork-shaped structure along with a single branch arising

from the center of the ground plane improves the wideband isolation between the radiating elements.

### III. ISOLATION MECHANISM

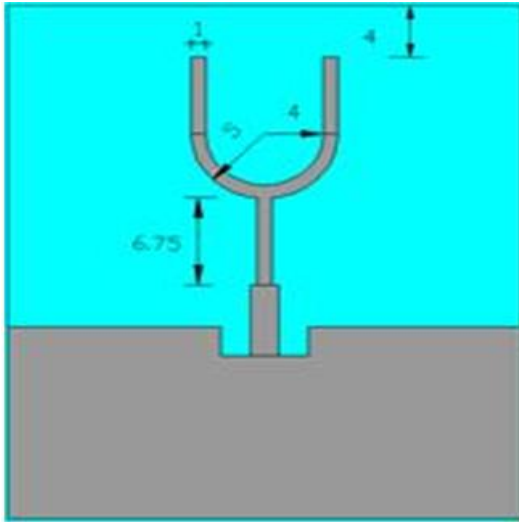


Fig 2(a)

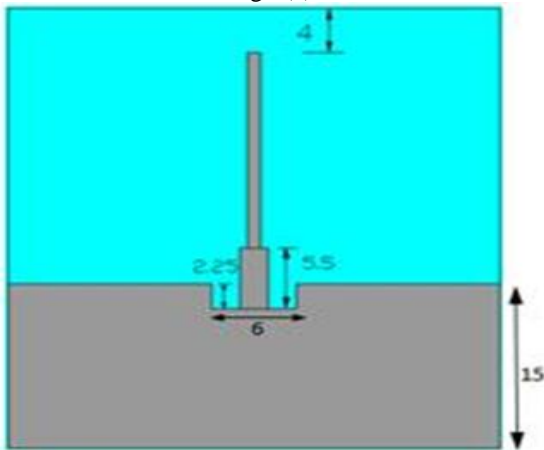


Fig 2(b)

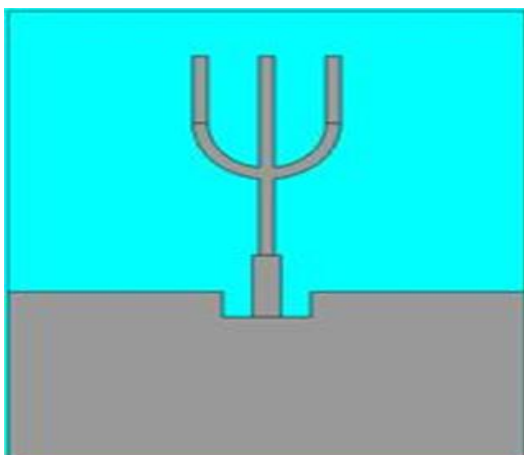


Fig 2 a,b,c Geometry of the proposed antenna system (Rear view)

Reflecting structures are introduced in the ground plane to reduce mutual coupling between the antennas. A single branch of length 16.75 mm extends from the center of a notched block in the ground plane [Fig 2 (a)], which acts as a reflector, thereby providing isolation between the

antennas. Then a fork-shaped structure is introduced instead of the center branch [Fig 2(b)].

When one of the ports feeding the radiators is excited, the designed structures extending from the ground plane obstruct the surface current flowing to the other radiator through the ground plane, thereby weakening the coupling between the radiators.

Finally, the fork-shaped structure is introduced along with the center branch [Fig 2 (c)]. The resulting isolation structure has a center reflector and two branches, introduced due to the fork-shaped structure. More resonances will be introduced when the number of branches or structures increase, and hence isolation is enhanced throughout the UWB.

### IV. SIMULATION RESULTS

The proposed antenna with the various ground plane structures is simulated using the commercial software IE3D. The simulated results of S-parameters and radiation pattern are obtained in the frequency range of 3-11 GHz and analyzed for isolation and bandwidth performance characteristics.

#### Bandwidth Characteristics:

Simulated results of  $S_{11}$  and  $S_{22}$  of the MIMO antenna system with and without the fork-shaped structure are shown in Fig 3. Both  $S_{11}$  and  $S_{22}$  are found to be same due to symmetry of the antennas.

According to the simulated results,  $S_{11}$  (Return loss) is found to be less than -10 dB from 4.4-10.7 GHz after the addition of the fork-shaped structure. Hence the bandwidth is increased to cover almost the entire UWB by introducing the fork-shaped structure.

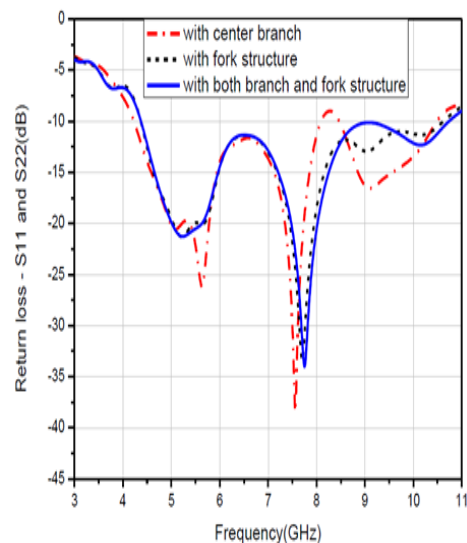


Fig 3. Simulated  $S_{11}$  and  $S_{22}$  of the proposed antenna system

### Isolation Characteristics:

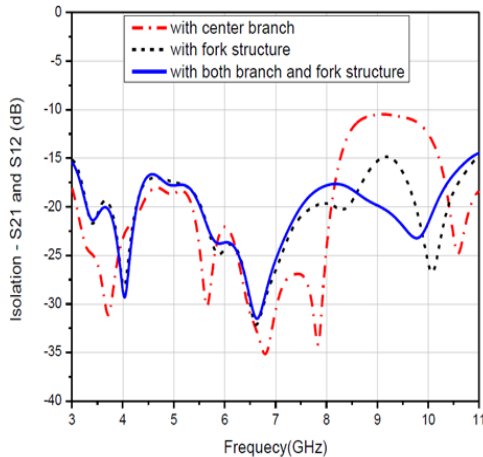


Fig 4. Simulated S<sub>21</sub> and S<sub>12</sub> of the proposed antenna system.

Simulated results of S<sub>21</sub> and S<sub>12</sub> are shown in Fig 4. S<sub>21</sub> is found to be less than -15 dB throughout the band after introducing the fork-shaped structure. With the center branch and the fork structure together, better isolation of more than -17 dB is achieved throughout the UWB and more than -20 dB in most of the band. This result satisfies the required condition that the mutual coupling between the antennas is to be lower than -15 dB for proper operation of the MIMO system in the UWB range.

### Antenna Gain:

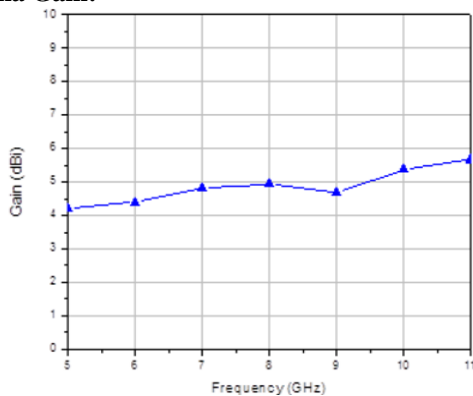


Fig.5 Simulated Antenna Gain.

The antenna gain has been simulated and plotted in Figure 5 in the UWB from 5 to 11 GHz. Due to symmetry of structure, the gains of two radiators are same. Hence the gain for one port is presented. The variation of antenna gain across the UWB is within 2 dBi.

### V. CONCLUSION

A novel compact UWB MIMO antenna system with high isolation has been proposed and investigated. Good isolation performance was achieved through the proposed fork-shaped structure. Isolation was found to be better than -17 dB throughout the UWB. The bandwidth of the proposed antenna covers almost the entire UWB from 4.4 to 10.7 GHz. The obtained results of isolation and bandwidth characteristics show that the proposed MIMO antenna system can work well in extremely wideband range and it is found suitable for application in UWB portable devices.

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### BIOGRAPHIES



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