ISOLATION ENHANCEMENT OF MINIATURIZED MIMO ANTENNA WITH SLOTTED GROUND STRUCTURE FOR ULTRA-WIDE BAND APPLICATIONS

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Abstract - A new ultra-wideband MIMO antenna with good isolation and miniaturized size is proposed. An antenna system consists of two c shaped elements in the upper layer and two transformed L jut branches and a line slot is etched on the ground. The proposed antenna is explicitly intended to operate at frequency bands ranging from 3.1 GHz to 10.6 GHz. The design is highly miniaturized using the slotting technique. The mutual coupling between the two elements is lower than -10 dB. The maximum gain of the proposed antenna is estimated as 4.16 dB.

Key Words: **MIMO; ultra wide band, Slotted ground, gain, ECC**

1. INTRODUCTION

The perspective of Ultra Wide Band (UWB) technology is enormous because of its remarkable advantages, for precedents, the ability to give high-speed data rates at short transmission distances with low power dissipation[1]. The hardest challenge in structuring a UWB antenna is to accomplish wide impedance bandwidth with high radiation efficiency. The concurrent surge of remote gadgets, with a high level of miniaturization and high frequency of operation, has upgraded the enthusiasm in designing high-performance antenna types. Thusly, there is a growing demand for small and low-cost UWB antennas that are able to provide good performance in both time and frequency domains [2]. Recently, there is an interest to build the data rate of existing wireless communication systems. The application of diversity techniques, most usually assuming two antennas in a mobile terminal, can increase the data rate and reliability without utilizing additional spectrum or transmitted power in high scattering environments. MIMO UWB systems can further improve the channel capacity when contrasted with conventional MIMO systems for narrowband applications [3]. The multipath fading problem in an indoor UWB wireless communication system, a UWB diversity antenna system is a promising candidate. With the increase of demand for wireless communication systems, personal communication devices are required to operate at multiple frequencies to take into account diverse applications. In addition to multiple frequency band operation, it is necessary that the antenna size is small, low profile and easy integration with other circuit structures.

An antenna is one of the important components in the RF system for transmitting or receiving signals from and into the air as a medium. Without proper design of the antenna, the radio signals created by the RF system won't be transmitted and no signals can be distinguished at the collector. Antenna design is a functioning field in correspondence for future development. Numerous kinds of antennas have been intended to suit with most devices. Improvement and wide utilization of personal communications and handheld devices, for example, smartphones, organizers, tablet, computers, navigation devices etc. which are using wireless access points to trade and exchange information opened vast enthusiasm for innovative work of small antennas and antenna miniaturization methods. From the designing perspective, the antenna is a fundamental part of any handheld or mobile wireless gadgets. On the other hand, for the designers and users, an antenna on the gadget is something inelegant which ought to be avoided if nothing else ought to be made invisible. These two solicitations are reconciled through the development of small antenna, generally incorporated in the handheld device body. On the opposite end of the wireless link, the base station or wireless access point must also have an antenna. The antennas are placed open air on buildings and indoor. For outdoor antennas wind burden and weight become a critical factor. Indoor antennas have to be integrated into buildings and made esthetically acceptable to the general public. The responses to these necessities are again small antennas. Antenna size and its performance are emphatically connected together. The antenna size is not essentially controlled by the technology utilized for its manufactures but instead by physical laws. Several strategies and methodologies have been acquainted with reduce antenna dimensions and maintain good radiation properties.

The basic idea of MIMO is to use multiple transmit or receive antennas with different fading characteristics. Since it is impossible that all the received signals will experience fading problems at the same time, the system reliability can be increased by appropriate selection/consolidating of the received signals. However, installing multiple antennas on the small space available in portable devices will definitely cause some mutual coupling and significantly degrade the diversity performance. Thus, one of the major difficulties to employ MIMO technology in portable devices is the design of the small MIMO antennas with low mutual coupling. Some MIMO antennas for UWB applications were proposed in a previous years [4]–[5]. In order to obtain the best performance of the MIMO systems, high isolation is obtained by symmetrically feeding [4]–[6], introducing DGS to stifle surface wave [6], [7], using directional antennas [7], adding protruding ground jut as reflective component [4], [5], [8], and adopting a neutralization line to offset the original coupling [9]. A miniaturized UWB antenna with improved band rejection characteristics in 5 GHz band [9] is designed for ultra-wideband applications. A compact UWB antenna with high impedance bandwidth with the possibility of a rectangular waveguide has been introduced [10].

A planar dipole antenna comprising of two semielliptical-ended arms connected by a shorting bridge equipped for enhancing the antenna's impedance and gain throughout UWB operating bandwidth is analyzed [11]. A few methodologies concerning miniaturization of antennas are self-similar and space-filling fractal geometries [12], DGS [13], slots and notches [14], reactive impedance surfaces [15], short circuits to the ground plane, loading antenna with lumped elements, etc. Slots can enhance miniaturization in terms of electrical length of the patch to obtain wide bandwidth and directivity too [16-17]. So as to obtain the ultra-wide bandwidth, omnidirectional radiation pattern, and small size antenna, there are several matching techniques are applied to the proposed UWB antennas, such as the use of slots, the use of notches at the bottom of the patch, the truncation ground plane, and the slotted ground plane[18].

This paper introduces a MIMO antenna in a compact volume using slotted ground with UWB ability. The proposed antenna in this paper would have the accompanying improvements:

1) The operating frequency bands cover 3.1 GHz to 10.6 GHz.

2) The mutual coupling between the antenna elements can be removed by utilizing a slotted ground plane.

3) The return loss is lower than -10 dB over the operating bands with a gain of 4.16 dB.

2. ANTENNA DESIGN

UWB technology has been viewed as a standout amongst the most encouraging wireless technologies that guarantee to reform high data rate transmission and empowers the personal area networking industry prompting to new developments and more prominent quality of services to the end users. Wireless communication systems with multiple transmitting and receiving antennas are outstanding for accomplishing a greater system capacity than the customary ones employing only a single antenna at two sides of a communication link. Thus, MIMO technology can be used as a proficient innovation to solve the multipath fading problem in UWB framework. The UWB and MIMO technologies have been incorporated into the proposed antenna design for enhancing the performance regarding high data rates. By uniting the UWB wireless communication system with the MIMO technique, the multipath issue is treated as a favorable factor and the channel capability of the UWB communication system can be improved without additional bandwidth consumption.

The proposed antenna configuration is represented in fig I. The design was built on an FR4 substrate with relative dielectric constant of 4.4 and a thickness of 0.8mm. The antenna comprises two C-shaped symmetrical radiating elements printed on the upper part of the substrate.

Antenna design contains double U shaped slots, two inverted L protrude branches and a line slot on the ground plane. Detailed measurements of the element and slots are shown in fig II.

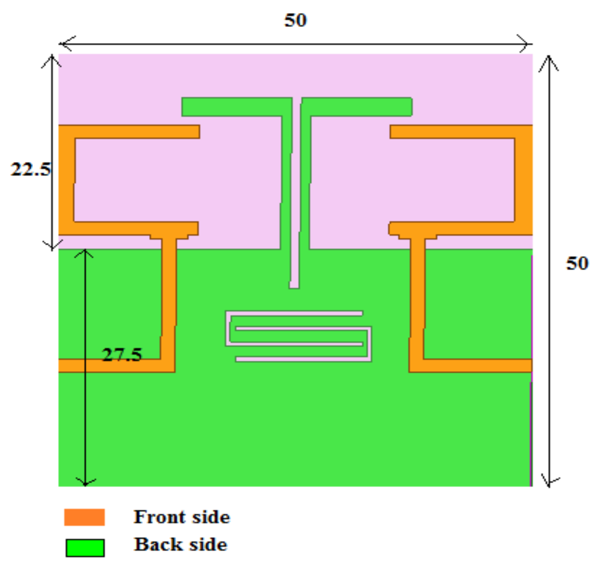


Figure 1. Proposed antenna design

The slotted ground plane is utilized to get ultra wide bandwidth, omnidirectional pattern, and miniaturization of an antenna. The size of the slots impacts the impedance bandwidth of the antenna. Another preferred standpoint of using slots on the ground plane is to reduce mutual coupling between antenna elements.

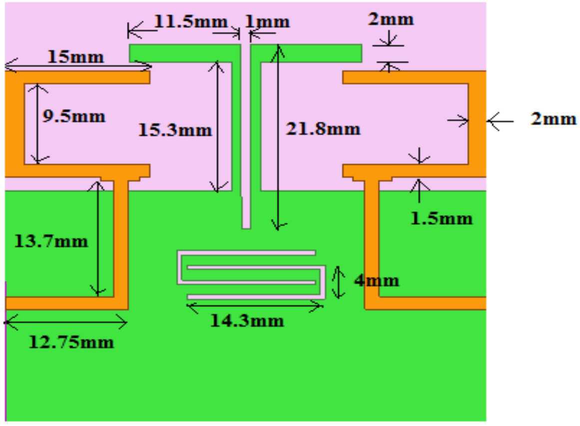
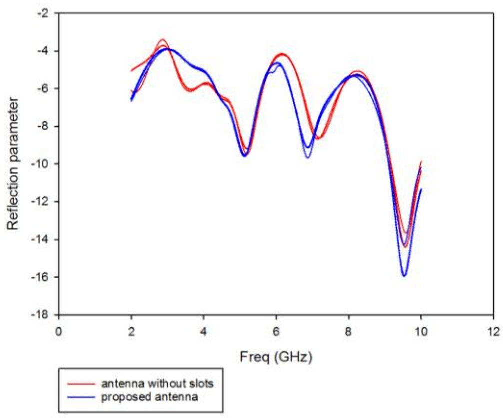


Figure 2. Detailed dimensions of the proposed antenna

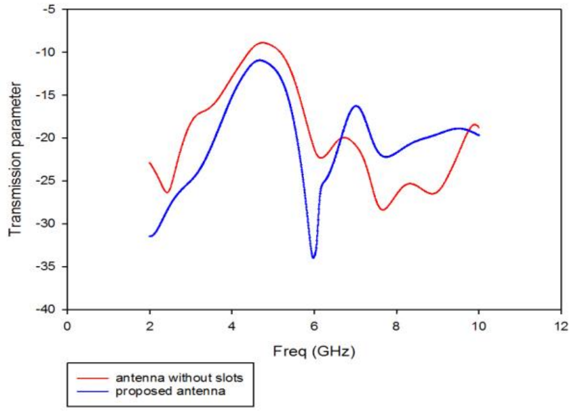
3. PRINCIPLE OF OPERATION

Two antenna element with and without slotted ground was first dissected. Fig 3 demonstrates the simulated S-parameters of the proposed antenna and two radiating elements without slotted ground. S-parameter depicts the info yield connection between terminals.

Fig 3.a represents reflection parameters s(1,1) and s(2,2), and fig 3.b shows transmission parameters s(1,2) and s(2,1) of the proposed antenna and antenna without slotted ground. S(1,1) would be the reflection coefficient of antenna element 1 and S(2,2) is the reflection coefficient of antenna element 2. Reflection coefficient depicts the amount of power reflected from the antenna. From fig 3.b antenna without ground plane has return loss is greater than -10 dB, that means mutual coupling is higher.



(a)



(b)

Figure 3. Simulated S-parameters of proposed antenna and antenna without slotted ground

4. SIMULATION RESULTS

Fig 4 demonstrates the deliberate and simulated S parameters for the design prototype. The antenna geometry is resonant at frequency bands starting from 3.1 GHz to 10.6 GHz. The minimal values of reflection coefficients are observed as -9.8dB at 6.8 GHz and -14.5 dB at 9.8 GHz respectively. The return loss is estimated as well under 10 dB for an overall frequency band. While designing a MIMO antenna system, the principle exertion achieved a lower value of transmission coefficient between antennas and this is seen as a key factor in design. The mutual coupling between two antenna elements in operating frequencies is well under -10 dB.

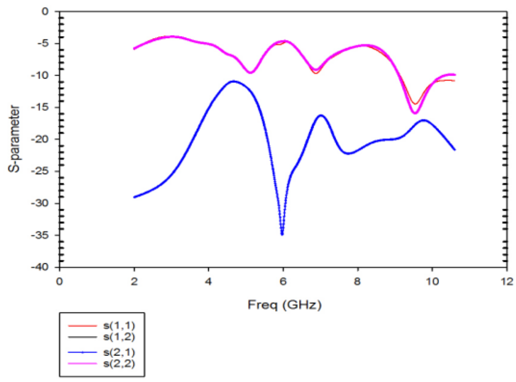
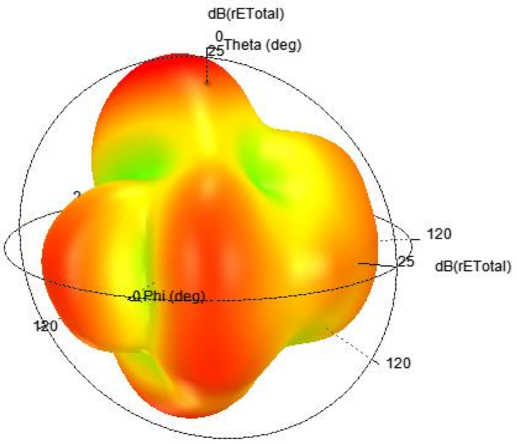
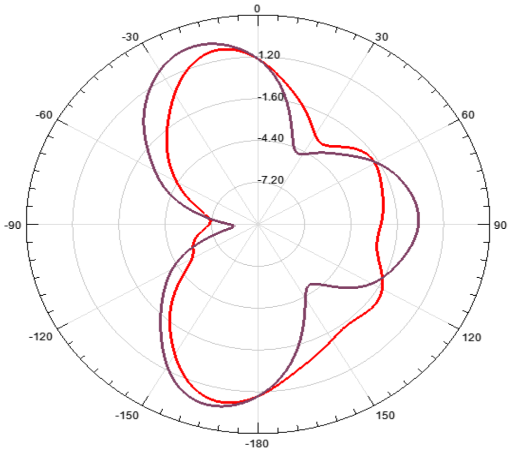


Figure 4. Simulated S-parameter of proposed antenna



(a)



(b)

Figure 5. Simulated (a) 3 dimensional and (b) two dimensional radiation pattern of proposed antenna

The radiation pattern of the proposed antenna is illustrated in fig 5. Fig (5. a) and fig (5. b) shows the 3-dimensional plot and the 2-dimensional plot of the radiation pattern respectively. The radiation pattern of an antenna is a plot of the far field radiation properties as a function of the spatial coordinates which are determined by the elevation angle and azimuth angle. The gain of the design prototype is 4.16 dB.

The current distribution of the proposed design as represented in fig 6. On account of antenna design without slotted ground, a strong surface current can be observed on the antenna on the right-hand side when the left side antenna element is excited. This surface current smothered by the introduction of slots on the ground plane. The slots altogether aggravate the fields and induced currents between the two antenna elements and reduce their mutual coupling. The current flow of UWB antenna with two slot structure is fundamentally diminished as contrasted with the UWB antenna with a conventional ground plane.

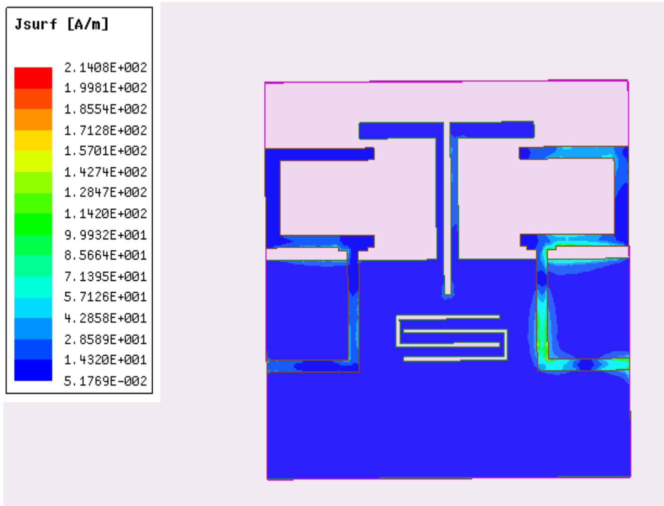


Figure 6. Current distribution of proposed antenna

5. CONCLUSION

An epic compact UWB MIMO antenna system has been developed in this paper. The MIMO antenna system consists of two symmetric antenna structure with an exceptionally compact fractured ground plane. By implementing the proposed double-u shaped slot and a line slot, the impedance bandwidth and isolation can be enhanced significantly. The coupling between both antenna elements over the total transmission bandwidth is under -10 dB. Simulated results shows that the proposed antenna guarantees an entire UWB bandwidth with high isolation and maximum gain of 4.16 dB.

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