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Design and Analysis of Simple Compact MIMO Antenna for Ultra-Wide Band Application

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***Abstract:** The proposed research presents a compact two ports Multiple Input Multiple Output (MIMO) antenna for the Ultra-Wide Band Application. The two symmetrical radiators consist for presented antenna and developed on an FR4 substrate for the overall size of the antenna is 20 × 44.1 × 1.6mm³. The microstrip line is fed with a 50Ω for the proposed antenna. The lower than isolation is < −25 dB from 3.1 to 10.6 GHz. The gain is 4.3dB and The Envelope Correlation Coefficients (ECC) < 0.01. The radiators for the better isolations used for the F-shaped stub. The size of the vertical block of stub is 12.3 X 5 mm. Antenna parameters are evaluation for the return loss, ECC, DG, gain, radiation pattern and isolation.*

***Index Terms:** Compact, ECC, Isolation, MIMO, and UWB antenna*

I. INTRODUCTION

In the year 2002, the US FCC allocated the UWB spectrum from 3.1 to 10.6 GHz to be used for short distance wireless communication system. In this wireless technology to develop and transfer to the high data rates and short distance very low power densities for the current interest for the area UWB applications. Figure 1.1 shows spectrum utilization of UWB system and conventional narrowband system.

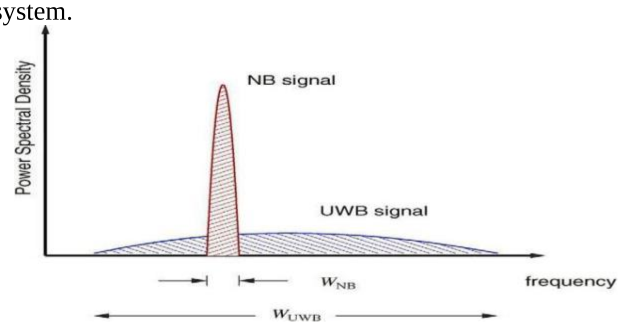

Figure 1. Spectrum Utilization by UWB Systems

As an important part of the UWB system, the UWB antenna must be compact in size and have large impedance bandwidth. The ever-developing UWB system and the short-range civil applications, working in the frequency band from 3.1–10.6 GHz created demand for a compact transmitter and receiver module.

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The size of the transmitter and receiver can be made compact by a small size of the antenna. The multiple Input-multiple-Output [MIMO] for the communication system used for multiple antenna elements for the mutual coupling reduced the transmitter sides and receiver sides [20][21]. In the improves the data rate for the MIMO antenna and link reliability for the multipath communication system. In narrowband system there are number of channel capacity compared with UWB MIMO antenna. However, there are several other existing narrow bands for other communication within the designated UWB bandwidth such as WiMAX (3.3-3.7GHz) and WLAN (5-6GHz), and downlink of X-band satellite (7.25-7.75GHz) Band-notched characteristics for the UWB antenna. For realizing UWB antenna with band-notch characteristics, several methods have been proposed [1-6][17][19]. After fabrication of UWB MIMO antenna band notch frequency is fixed, static and uncontrollable. Therefore, reconfigurable UWB band notch MIMO antenna is current demand and interest. Several reconfigurable band notch MIMO and have been studied and investigated [7-15][18]. Reconfigurability can be achieved from various methods such as using of varactor diodes, PIN diodes, RF switches, N-Type, P-Type, unable materials, RF MEMS.

The fifth generation of communication (5G), the internet of things (IoT), and vehicular communication are only a few elements of the complex applications and protocols that have advanced. Technologies for mobile communications and computing are developing quickly to keep up with customers' growing demands. The fifth generation (5G) communication standard, which operates in the sub-6 GHz band, aims to provide faster and more reliable communication services with increased network capacity. The goal of the 5G network is to provide connectivity to any system or application that may advantage from being connected 5G antennas should be strong and capable of working across a wide frequency range. It should also be suitable with long-term evolution (LTE). In comparison to the millimetre-wave spectrum, frequencies below 6 GHz facilitate infrastructure improvements and future network deployment as a future band, New Zealand uses 3.4-3.59 GHz, Australia uses 3.4-3.7 GHz, and the United States has already implemented the 3.5 GHz spectrum as a 5G band Wi-Fi, GPS, Bluetooth, and GSM are examples of modern devices that can support multiple applications at the same time. These applications use different frequency bands and require the use of antennas designed for each. A single device serving multiple applications has the disadvantage of requiring a high data rate or additional bandwidth.

The device is large and bulky due to the inclusion of separate antennas for various functions. As a result, current and future generation devices must have a single antenna that can operate in multiple modes within the desired band. Multi-band and reconfigurable antennas are the best options for such devices.

Table 1. Antenna Proposed for the Comparison Chart for the Literature

Reference. #	Antenna Size (mm)	Bandwidth (GHz)	Isolation (dB)	Gain	Efficiency	ECC
[32]	40 ×20	3–11	−15	2–5dB	80%	0.3
[33]	58.6 ×46	3.1–10.6	−13	NA	NA	0.02
[34]	45 ×45	3–12	−17	−4to2 dB	90%	0.01
[35]	45 ×25	3.1–12	−15	4.5dB	70%	0.2
Proposed work	**20x44.1x 1.6mm3**	**3.1-10.4**	**<-25**	**4.3dB**	**91%**	**<0.01**

II. DESIGN AND ANALYSIS OF MIMO ANTENNA WITH UWB APPLICATION

In this proposed paper there are Ultra-wide band (UWB) application designed for the two ports compact multiple Input Multiple Output (MIMO) antenna. The two symmetrical radiators, presented antenna consists of FR4 substrate and overall size of antenna is 20 × 44.1 × 1.6mm^3. The proposed Microstrip antenna is fed line is a 50Ω.The range for the UWB antenna band is good impedance matching. The lower than isolation < −25 dB from 3.1 to 9.4 GHz. The gain 4.3dB and the Envelope Correlation Coefficient (ECC) < 0.01

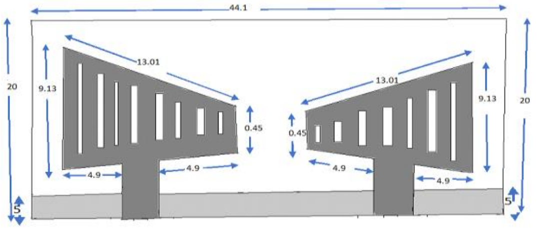

Figure 2. Structure of Conventional Ground in MIMO Antenna

The structure of the presented UWB MIMO antenna, for the effect conventional ground and discussed in this section with stub structures. Figure 2 shows the structure of the Conventional ground of the antenna etched on a dielectric FR4 substrate. The Low cost and easily available for the dielectric FR4 substrate. The overall antenna consists the system is minimizing which is appropriate for consumers. The proposed antenna is compact size 20 × 44.1 × 1. 6mm^3.The size of radiating components for the obtaining resonance minimum frequency and it will be a huge current path and large enough to demand. The proposed two radiating components MIMO antenna consists of the slot of an antenna.The slot in the radiating element is for enhancing bandwidth and increasing the current path.

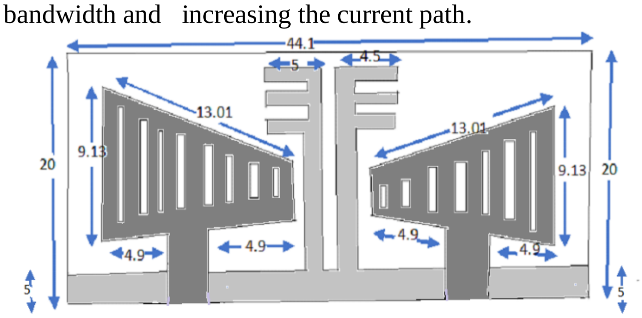

Figure 3. Structure of with Stub in MIMO Antenna

In this common ground structure is used for the radiating elements MIMO antenna is the minimize the size. The presented antenna is composed of two radiators and decreasing length slot. A 50Ω strip line is connected to the radiating patch. Due to the small size of an antenna are ground surface of the current there for the weak isolation exits between the two radiating components. In this F-shaped stub is used to overcome such a problem between the radiators for better isolation. The vertical block of stub size is *12.3mm X 5 mm*. After introduce for the F-Shaped stub, there is the not required for decoupling network and decoupling element. To all the simulations were carried out in HFSS software to validate the presented antennas.

III. RESULT ANALYSIS AND DISCUSSION

The stub structure is evaluation process for the presented antenna is verified from Figure 2 and 3. In the first step, we will design for the simple results for conventional ground plane. In the second stage, modification for the ground plane for F-shaped stub is added. The result will be the desirable enhanced isolation for the F-shaped stub. Conventional ground is investigated with an antenna with the mutual coupling between the antennas is to near about -13dB for the UWB region. The conventional ground is modified and improve the results for the further F-shaped stub. Figure 4. S-parameters plot against frequency for ground G (Without Stub) Linear two-port (and multi-port) networks their transfer matrix, impedance matrix, admittance matrix, and scattering matrix are these characterized by a different parameter of the equivalent circuits. In this network analyser the connections can be reversed with the generator to port 2 and the load port 1.the impedance characteristics two segments line of the length |1,|2 and equal to the reference impedance Z0. Then, the wave variables a1, b1 and a2, b2 are recognized as normalized versions of forward and backward traveling waves. Figure 5. S-parameters plot against frequency for ground G (With Stub) and Figure 6. Radiation pattern for E and H plane (Without Stub) In electric circuits the waveguide is to often to be able split the circuit power into two or more fractions of low frequency electrical network it is possible to combine elements in circuit in series or parallel several circuits components of dividing the source of power. Microwave circuits the wave guide with three independent ports is called TEE junction.

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E-plane Tee output is 180^0 out of phase where the output of the H-plane Tee is in phase For a linearly-polarized antenna is the plane of the containing of the electrical field victor its sometime also called as E aperture direction of Maximum radiation. The E plane vertical/elevation plane is usually vertical polarization of antenna and the E-plane usually with the horizontal/azimuth plane are horizontal polarized antenna. It should be 900 apart from E and H plane. In the linearly polarization of an antenna same magnetic field vector and direction of maximum radiation. For a horizontally polarized antenna, the H-plane usually coincides with the vertical/elevation plane. Figure 7. Return loss S11_S12 (Without Stub) Figure 8. S21 Isolation (Without Stub) Figure 9. VSWR (Without Stub) Figure.10. Radiation pattern for E and H plane (With Stub) Figure 11. Return loss S11_S22 (With Stub) Figure Scattering parameter or S11 is basically ratio between Reflected power (Pr) to Incident power (Pi). So Scattering parameter or S11 is negative quantity S11 (dB)= 10log(Pr/ Pi). S11 is the measure of power returned back at port 1 for a given power input at port 1. 12. Isolation for S21 (With Stub)

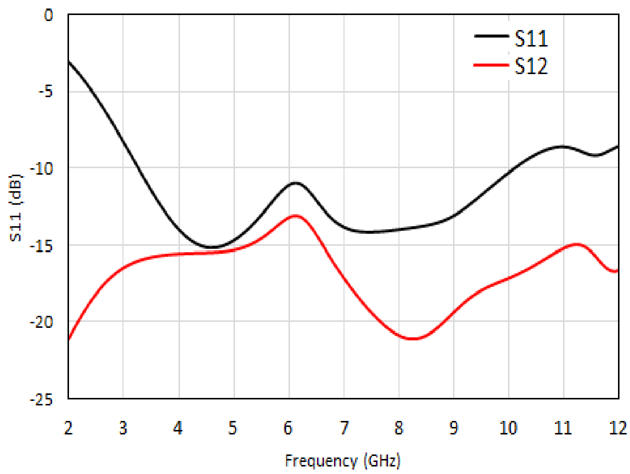

Figure 4. S-Parameters Plot Against Frequency for Ground G (Without Stub)

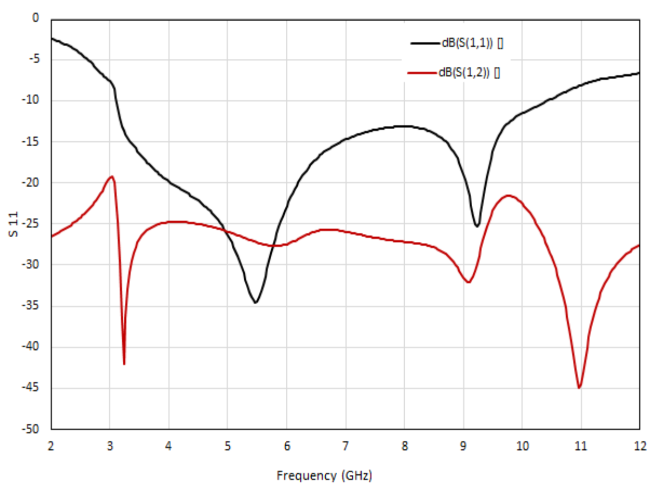

Figure 5. S-Parameters Plot Against Frequency for Ground G (With Stub)

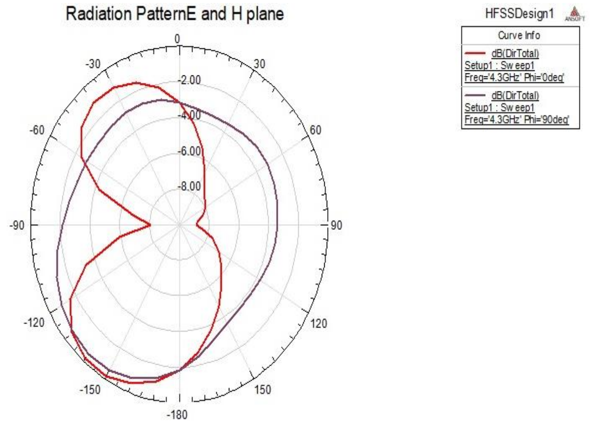

Figure 6. Radiation Pattern for E and H Plane (Without Stub)

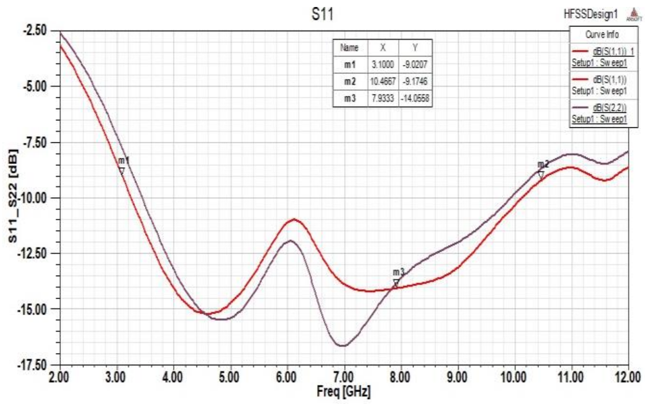

Figure 7. Return Loss S11_S12 (Without Stub)

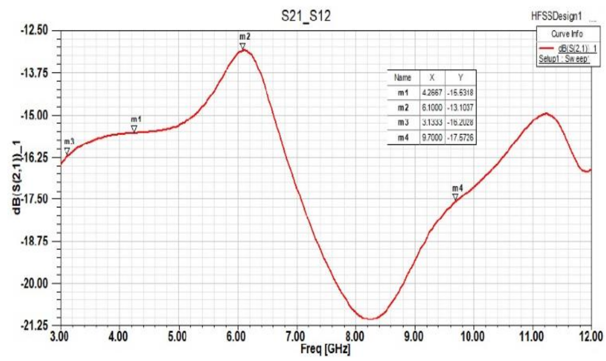

Figure 8. S21 Isolation (Without Stub)

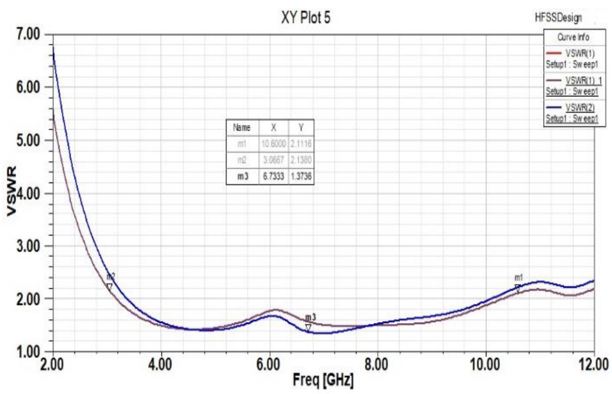

Figure 9. VSWR (Without Stub)

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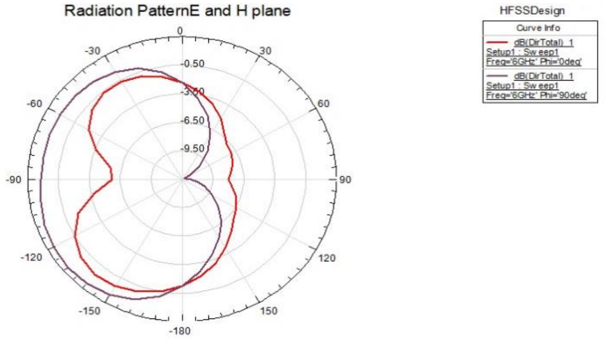

Figure 10. Radiation Pattern for E and H plane (With Stub)

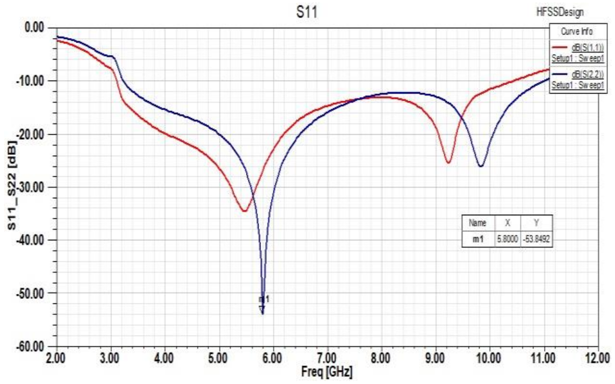

Figure 11. Return loss S11_S22 (With Stub)

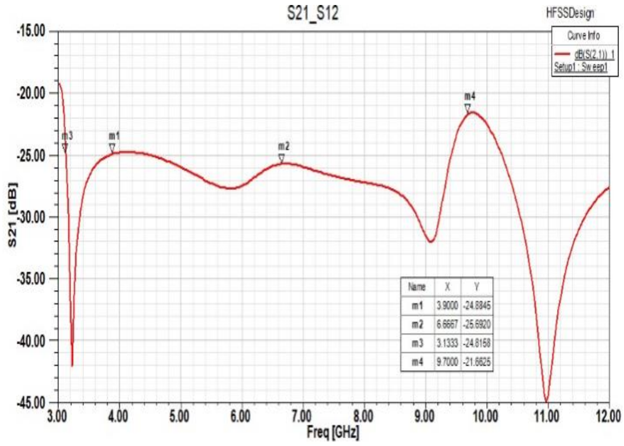

Figure 12. Isolation for S21 (With Stub)

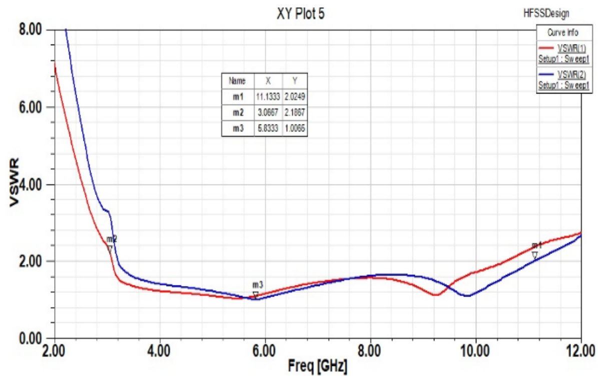

Figure 13. VSWR (With Stub)

IV. CONCLUSIONS

This study presents a unique 20 × 44.1 × 1.6mm3 small high isolation UWB MIMO antenna. Nonetheless, the use of an F-shaped decoupling stub improves isolation. An antenna's isolation is less than -25 dB, its ECC is less than 0.015, and its peak gain ranges from 1 to 9 dB in the 3.1 to 10.6 GHz frequency range. The agreement between the measurement data and the simulation is good. The antenna is inexpensive, low-maintenance, and has a straightforward design. Given that it provides consistent radiation patterns and meets the requirements for peak gain, ECC, DG, and TRAC diversity parameters, the intended antenna can be employed for MIMO UWB wireless applications.

ACKNOWLEDGMENT

Ultra-Wide Band (UWB) application has been proposed for the compact two ports Multiple Input Multiple Output (MIMO) antenna. The two symmetrical radiators the antenna present consists of the developed on an FR4 substrate and an overall size of the antenna is 20 × 44.1 × 1.6mm^3. The isolation is lower than < −25 dB from 3.1 to 10.6 GHz. The advantages of the proposed MIMO antenna is specify small size and it will be the used for UWB application.

DECLARATION STATEMENT

Funding	No, I did not receive.
Conflicts of Interest	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material	Not relevant.
Authors Contributions	All authors have equal participation in this article.

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