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A MIMO Dual Band-Notched Monopole Antenna For UWB Applications

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Abstract: **-- A Compact monopole Multiple-Input-Multiple-Output(MIMO) dual band-notched Ultra Wide Band Antenna is proposed. This microstrip-fed antenna has a compact size of 22×36×1.6 mm3, consisting of two square radiating patches with a defected ground structure. The designed antenna operates over the frequency band between 2.6 to 11.6 GHz with dual band notched characteristics in between 2.6-3.8 GHz for WiMAX, 5.19-5.95 GHz for WLAN with mutual coupling obtained is less than -15 dB through the entire UWB frequency range except at the notched frequency bands. The Envelope Correlation Coefficient(ECC) is almost less than 0.02 over the entire UWB frequency range except at notched frequency bands. The proposed antenna is simulated by using the CST Microwave studio. Details of the proposed antenna design and simulated results are presented.**

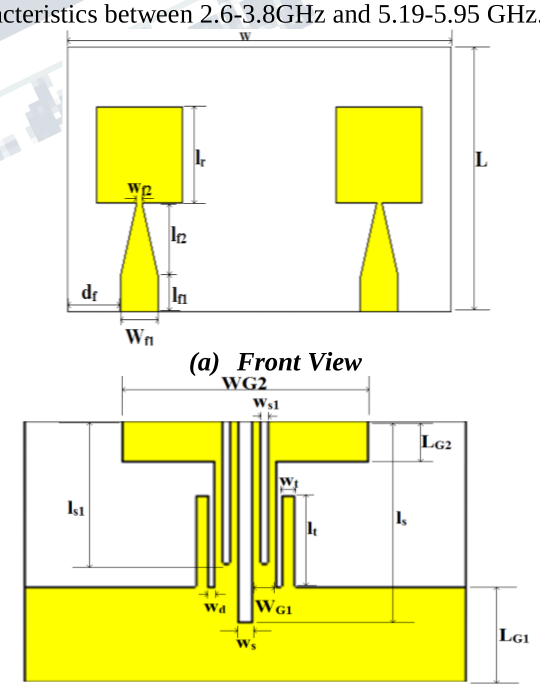
Keywords: **- Microstrip-fed, MIMO, Monopole Antenna, Ultra Wide Band.**

I. INTRODUCTION

A MIMO communication system consists of multiple antennas are installed at transmitter side and receiver side with low coupling between them. However portable devices will have less space between them, installing MIMO antennas with low coupling[1] is always a great challenge for antenna designers. Various MIMO antennas have been studied for the usage of portable devices in different wireless systems such as, LTE[2], UMTS[3],WLAN[4]. The MIMO technology used in ultrawideband (UWB) system would provide superior channel capacity over that used in narrow band systems[5].

The UWB frequency range from 3.1-10.6 GHz can be assigned by the US federal communications commission (FCC) for unlicensed use, overlaps with the WLAN frequency band from 5.15-5.85 GHz and WiMAXfrequency band from 3.3-3.7 GHz. Thus the UWB system, WLAN systems could interfere with each other and reduce mutualcoupling between antenna elements[6]-[8]. One of the possible solutions to this problem is to design the UWB antenna with band notched characteristic[9]-[11] were studied to suppress the interference from the WLAN systems [12]-[16]. The UWB technology has been used widely in various wireless communication applications because of low cost, low complexity, high data transmission rates etc.., However the design of UWB antennas is not easy because the requirements such as Omni directional radiation pattern, easy manufacture, ultra wide impedance banding, high radiation efficiency, constant gain, etc.

The present work is focused on designing of an UWB MIMO dual band notched antenna even smaller than the before designing[14]. It has a compact size of only 22×36×1.6 mm^3. A strip on the ground plane is used to create the band notch with a total efficiency of only 5.65% much smaller than previous results[12]-[16]. The simulated and measured results show that the proposed MIMO antenna has good impedance matching, high isolation, and good diversity performance throughout the UWB with a band notched characteristics between 2.6-3.8GHz and 5.19-5.95 GHz.



(a) Front View

(b) Back View

Figure1.Geometry of the proposed antenna

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II. ANTENNA DESIGN

The geometry of the proposed MIMO antenna as shown in figure1 has two planar monopole elements denoted as PM1 and PM2, with a very compact area of only 22×36 mm^2. The size of the radiator must be large enough to allow a long current path to generate a low resonance for achieving a low cut-off frequency of lower than 3.1 GHz for the UWB. Designing the ultra wide band width for an UWB antenna is not such a problem and can be achieved through matching using etching a ground slot under the feed line, adjusting the gap between the ground and the radiator.

Table1. Dimensions of the Antenna (Units:mm)

W	**W_{G1}**	**W_{G2}**	**w_{f1}**	**w_{f2}**	**w_s**	**w_t**	**w_d**	**d_f**
36	2	20	3.5	0.5	1	1	0.5	5
L	L_{G1}	L_{G2}	l_{f1}	l_{f2}	l_s	l_t	l_r	l_{s1}
22	8	4	3	6	17	8.3	8	12
W_{s1}	--	--	--	--	--	--	--	--
o.55	--	--	--	--	--	--	--	--

From Figure1.(b) Back View, a T-shaped stub is etched at the ground plane between the two monopole elements. The T-shaped ground stub in the MIMO antenna has two functions. One I providing better matching for the antenna and another one is to enhance the isolation by reflecting radiation from the radiators. Mutual coupling between the two input ports is almost below -15db. The ground slot cut on the T-shaped ground stub plays an important role in enhancing isolation. It can be seen that the simulated impedance bandwidths of the antenna with and without the ground slot do not vary much and are from 2.8 GHz to more than 11 GHz. With the use of ground slot, a resonance at about 2.6GHz is generated lowering s_{21} down to below -15dB from 3.1 GHz to more than 11 GHz. The two notched bands are obtained between 5.2-5.95 GHz and 2.6-3.8 GHz which suppressed the interference due to WLAN band and WiMAX bands over the operating UWB frequency range. This is achieved by the use of two pairs of slots etched on the T-shaped ground stub. They form two open-end slots, which serves as $\lambda/4$- resonator at the notch frequency.

The antenna has a symmetrical structure so the two input ports have identical impedance. This makes the design procedure significantly easier because the antenna can be designed with either port excited. The MIMO antenna is designed using EM simulation tool CST on a Rogers R4350 substrate with a dielectric constant ε_r of 3.66, a loss tangent of 0.004.

III. SIMULATION REULTS AND DISCUSSION

The simulated reflection coefficient and mutual coupling s_{11} and s_{12} are shown in Figure2. From the graph of reflection coefficient S_{11}, the proposed antenna has the impedance band width from 2.6 GHz to more than 11 GHz and from the graph of mutual coupling $s_{12}$is below -15 dB from most of the portion of the impedance bandwidth curve except at the notched bands. This indicates that the antenna is suitable for MIMO operation throughout the FCC UWB frequency range. A notched band is obtained between 5.13 to 5.88GHz to suppress interference with the WLAN band. The notch has a very high value of s_{11} of -1.7dB and at the center frequency, indicating the very effective suppression. The another notched band is obtained from 2.6-3.8 GHz to suppress the interference with WiMAX band. The VSWR plot of the proposed antenna is shown in Figure3. From the graph it is observed that the voltage standing wave ratio (VSWR) of the proposed MIMO UWB antenna is having VSWR<2 except at WiMAX and WLAN bands. The E-plane and H-plane radiation patterns of the proposed antenna are shown at 4.5 GHz and 6.95 GHz frequencies. Also the gain, Total efficiency, Envelope Correlation Coefficient and the surface current distribution plot at 6.95 GHz of the proposed antenna are shown in Figure5, Figure6, Figure7 and Figure8 respectively.

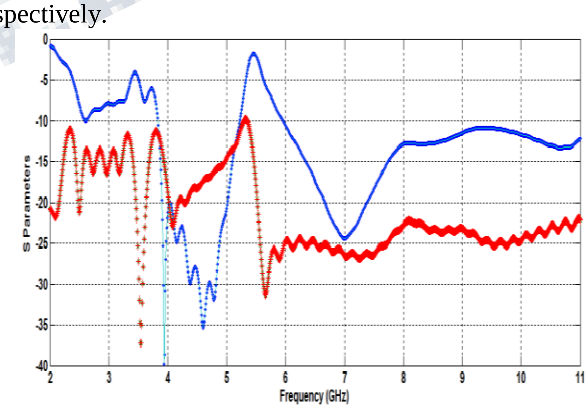

Figure2. Return Loss plot of the Proposed Antenna

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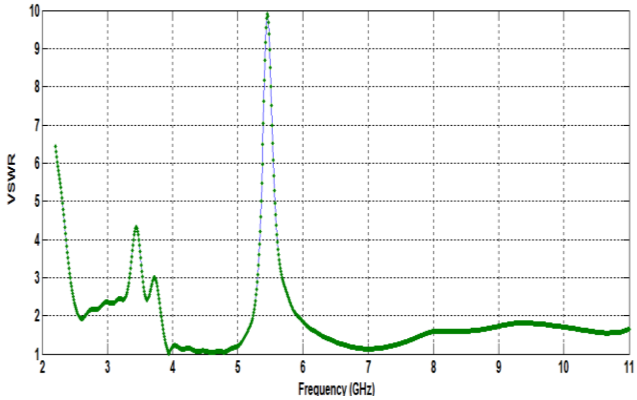
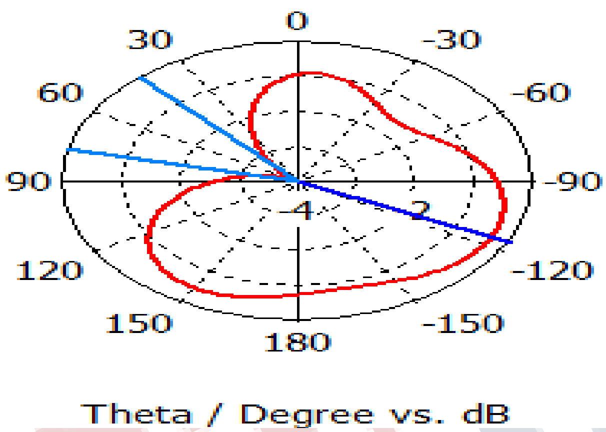
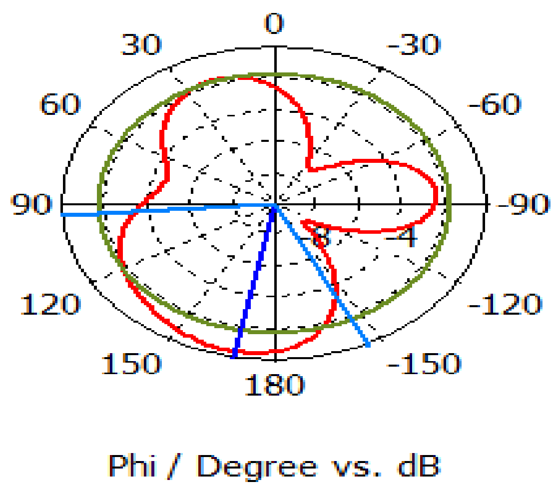


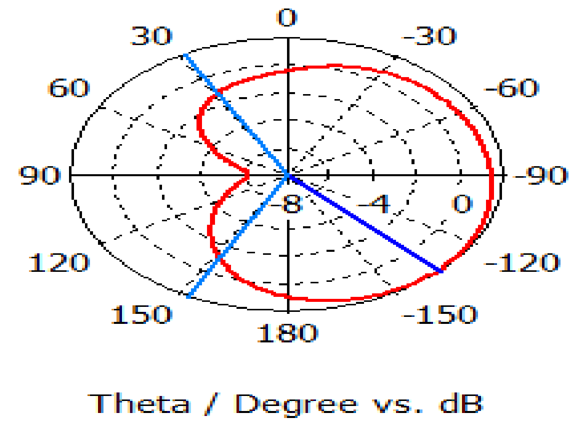
Figure3. VSWR plot of the Proposed Antenna.



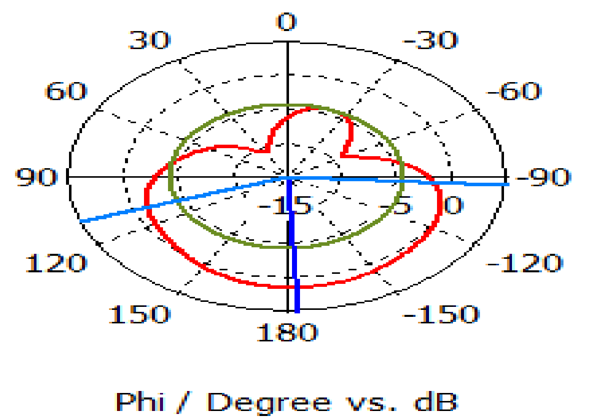
(a) E- Plane at 4.5 GHz



(b) H- Plane at 4.5 GHz



(c) E- Plane at 6.95 GHz



(d) H- Plane at 6.95 GHz

Figure4. Radiation patterns of the proposed antenna at 4.5 GHz and 6.95 GHz.

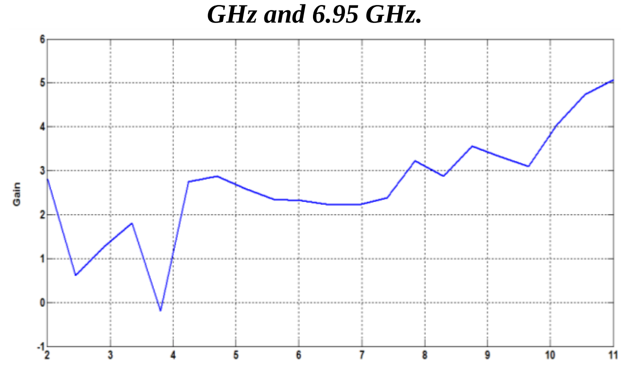


Figure5. Gain plot of the proposed antenna

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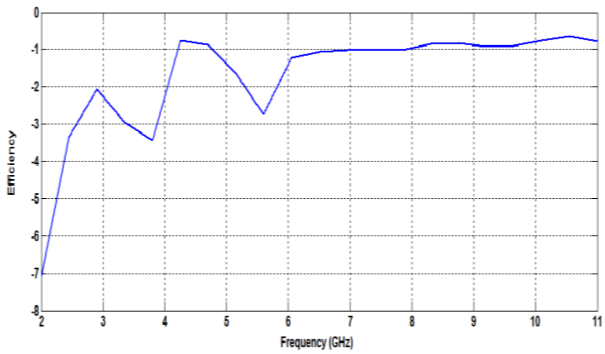

Figure6. Total efficiency plot of the proposed antenna.

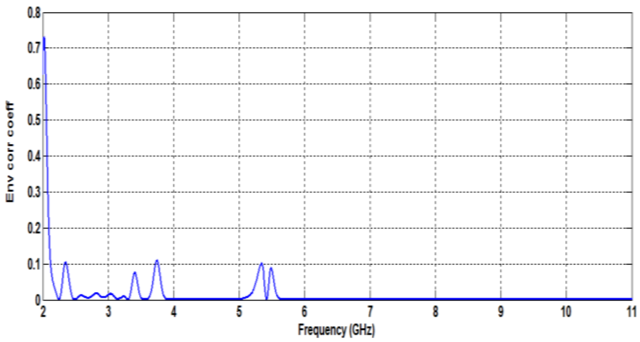

Figure7.Envelope correlation coefficient plot of the proposed antenna

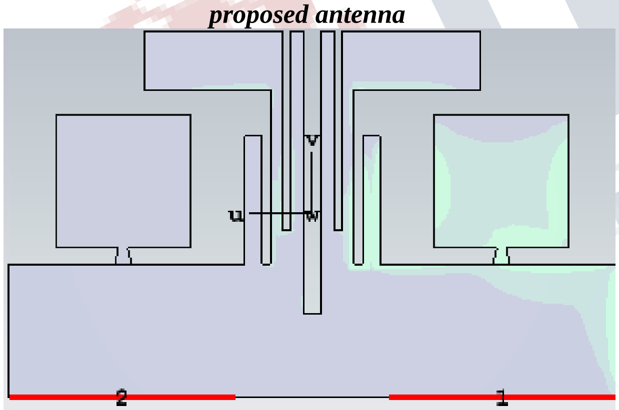

Figure8. Surface Current Distribution at 6.95GHz.

IV. CONCLUSION

An MIMO antenna with very compact size of 22×36 mm^2 has been designed for portable UWB applications. Two square monopole elements are used to provide UWB operation from 3.1 GHz-10.6 GHz and T-shaped stub is used to reduce the mutual coupling below -15dB. Two strips at the ground plane are used to obtain the notched band frequencies from 5.15-5.85 GHz and 2.6-3.8 GHz to suppress the interference in WLAN band and WiMAX band.

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