MIMO Antenna with Notched Band Characteristics for UWB Applications

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Abstract – *In this paper, a compact notched MIMO antenna is presented. The proposed antenna have very compact size with the size of only 25x25mm². In order to get good diversity performance two symmetrical antenna elements are placed in vertical direction. The notched band weakens the interference between C band satellite uplink communication and UWB system. To obtain the enhancement in the return loss the optimization of the slot coordinates and dimensions is performed. And a multiband is obtained when a inset fed square is included. The result shows that it covers from 3.1 to 12GHz with S11 < −10 dB except rejected band, and the isolation is better than 15 dB in full UWB spectrum.These results manifest the antenna to be a superior candidate for UWB applications*

Key Words: **UWB, MIMO, Notched Band, Square Inset, Antenna**

1. INTRODUCTION

Ultra wide band(UWB) Technology is used for sending high amount of digital data for a short distance over high frequency range with least power consumption. In order to increase receiver signal capturing capacity effectively MIMO enable the antennas to add signals coming from different paths and at different instants. Thus this MIMO technology makes the antennas work smarter. These smart antenna systems use spatial diversity technology where spare antennas are put to good use. With the use of several antennas enables MIMO wireless technology to noticeably increase the capacity of the given channel. It is possible to augment the throughput of the channel with every pair of antennas added to the system. When MIMO and UWB are used together then it increases the efficiency of the system.

Meanwhile, smart devices are usually easy to take with, which need to have small size or be compact. It is very challenging to realize UWB MIMO antennas in compact size with high isolation between antenna elements, since typically the separated radiating structures have strong mutual coupling in limited spaces. In the last few years, various types of UWB MIMO antennas are proposed [1]. For instance, T-shaped ground-stub is utilized as a decoupling structure. However, the T-shaped ground stub should be longer than the antenna element to decrease the coupling, so the areas of above UWB MIMO antennas are often relatively large, for instance, 60×40mm² in [2], 35×30mm² in [3], 32×26mm² in [5]. New materials are also attempted for decoupling, for example, carbon black film [6] which could absorb electromagnetic signal, but the radiation patterns do not exhibit perfectly. Some complex decoupling structures, such as Minkowski structure, are employed in the ground [7], but still, the overall size of 26.75 × 41.5mm² has plenty of space to optimize, and the structures are difficult to fabricate. Neutralization line is also a way to reduce the coupling [8]. However, this technique is limited in bandwidth. Furthermore, there are some other narrowband communication systems over the entire UWB, such as C-band satellite uplink communications from 5.8 GHz to 6.5 GHz. So it is unavoidable for UWB antennas to interfere with these systems. The band-notched characteristic is required in the antenna design. In recent publications, many band rejection techniques have been used. For instance, in [2], they use C-shape strips as a filter to achieve the notched band, but it needs more copper material. The band notched L-strip structure is combined with the decoupling structure in [9]. The peak return loss of the rejection is just 5 dB.

In this letter, a compact UWB MIMO antenna with notched band characteristics is proposed. The overall size of the proposed antenna is 25×25mm², which is 27.1% of [10], 44.6% of [11] and 69.4% of [12]. The two orthogonally placed antennas will radiate with a different polarization. Thus high isolation can be achieved. The antenna may not fit in all propagation environment even it is suitable for polarization diversity system such as base station. To get higher isolation slit, slots are adopted. With an L shaped slit notch band is realized. At lower frequency antenna is equivalent to a slot antenna. At higher frequencies antenna act as a monopole antenna.Slots and square insets are introduced in patch in order to achieve multiple frequency bands. The designs were optimized, simulated and analyzed using ANSYS high frequency structure simulator version 15(Ansoft HFSS.15)

2. ANTENNA DESIGN

The structure of antenna is shown in Fig. 1 and Fig 2. High isolation can be easily achieved by placing two antennas in perpendicular direction. The antenna is designed on Fr4 dielectric substrate with relative permittivity(ε_r) 4.4, loss tangent 0.02 and height 1.6mm. A rectangular slot is made on the two symmetrical antenna elements. Each antenna elements consist of microstrip feedline and rounded printed patch. Square inset feed is provided in UWB MIMO antenna to enhance return loss. In the layout of UWB MIMO antenna W_s and L_s represents the width and length of substrate and L_3 and L_4 represents the width and length of the slot respectively. L_f is the feed width and microstrip line feeding is used.

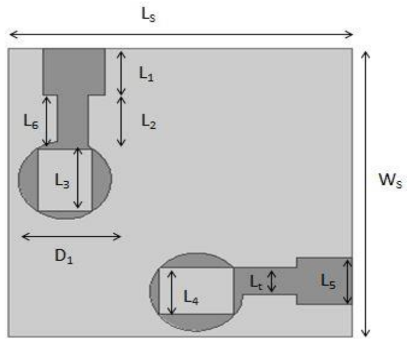

Fig-1: Top view of UWB MIMO Antenna

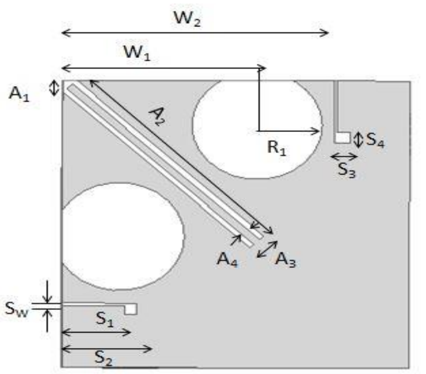

Fig-1: Bottom view of UWB MIMO Antenna

Table-1: Dimension of the Proposed Antenna

Parameter	L_1	L_2	L_3	L_4	L_5	L_6	L_S	W_S	L_t	D_1	R_1
Dimension (mm)	4	4.4	5.4	4	4	4	25	25	14	6.8	5.4
Parameter	A_1	A_2	A_3	A_4	S_1	S_2	S_3	S_4	S_w	W_1	W_2
Dimension (mm)	1	19.8	1.41	0.56	6.3	5.4	1	0.9	0.2	14	19.6

The decided dimensions of the proposed antenna are shown in table 1 in mm. Firstly quasi circular cut out on the ground is the initial antenna prototype. But isolation is not good. Then slit and slots are employed to get higher isolation.

3. RESULTS

Parametric analysis is performed with respect to return loss to fine tune the dimensions of the structure. The length and width of the slot is varied from 4 mm to 3mm and maximum return loss is obtained for 4mm as shown in Fig. 3. The length and width of the square inset is increased linearly for a dimension of 4mm x 4 mm and reduced to the level of 1.15mm x 1.15mm and best results are obtained at a feed length of 4mm.

Fig. 3 shows the return loss of UWB MIMO antenna. The antenna resonates at two frequencies 2.6GHz, 10GHzwith return loss -15dB and -32.87dB respectively. A notch is created in 5.5-6.5 GHz range that is well suitable for C band satellite uplink communications and UWB systems.

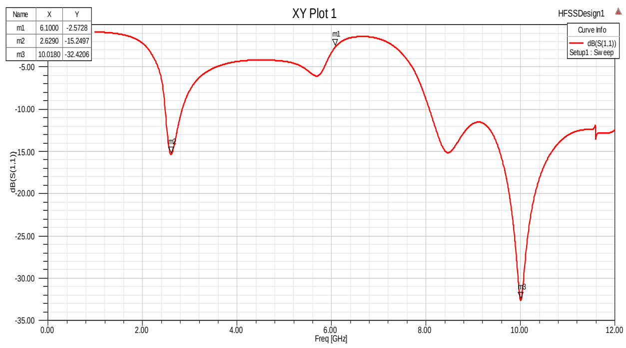

Fig-3: Return loss of UWB MIMO Antenna

Fig 4 shows s21 parameter and are above -15db.

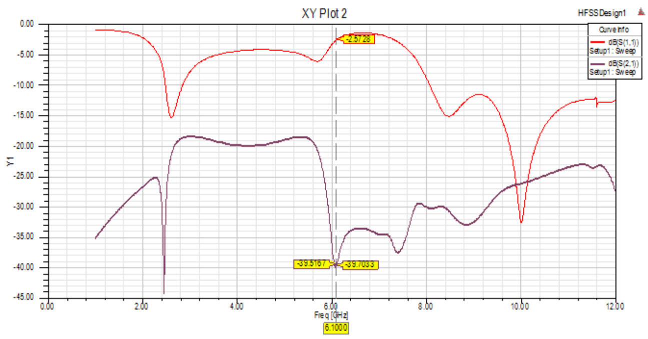

Fig-4: s21 of UWB MIMO antenna

Gain of the UWB MIMO antenna is shown in Fig. 5(a), Fig. 5(b) at resonant frequencies 6.1GHz, 10GHz, with maximum gain of –3.86dB, 5.63db respectively.

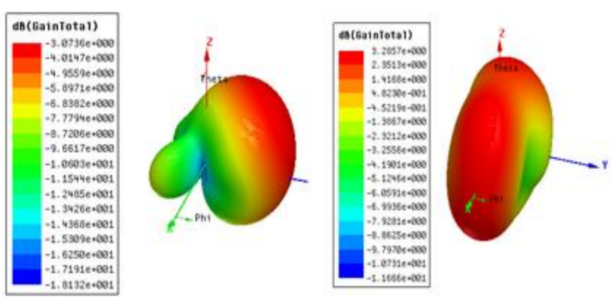

Fig-5: Gain of UWB MIMO Antenna at .a) 6.1Ghz b) 10Ghz

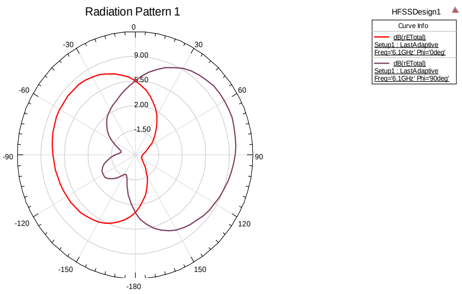

Fig-6: 2D Radiation pattern of UWB MIMO antenna

Fig. 6 shows the E-plane and H-plane radiation pattern at different azimuths 0^{o} and 90^{o} of UWB MIMO antenna at resonating frequencies 10GHz respectively. The radiations patterns in both E and H planes are satisfying the requirements of the proposed UWB application.

4. CONCLUSION

A UWB antenna with a novel design for the future UWB applications to improve the antenna parameters is presented. Different types of antenna structures are proposed to cover the UWB bandwidth of 3.1 to 10.6 GHz. Different performance parameters like VSWR, return loss, radiation pattern and gain are analysed. To obtain the enhancement in the return loss the optimization of the slot coordinates and dimensions is performed. And a multiband is obtained when a inset fed square is included. The UWB MIMO antenna shows good radiation pattern and high gain.

ACKNOWLEDGEMENT

For the successful completion of this project, I thank my guide Rajkumar P Assistant Professor in Department of Electronics and Communication Engineering, NCERC, Pambady, India for providing valuable suggestions during the project.

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