A Compact Notch Band Filter With Multi Serrated Mimo Antenna For Wimax Applications

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Abstract — *The paper deals with Compact Notch band filter with multi serrated MIMO antenna for Wi MAX applications, the antenna designed for a circular patch for Wi MAX applications, then portable monopole MIMO antenna was designed and tested for it applications in Wi MAX and finally an antenna proposed for notch band with multi serrated for Wi MAX applications. The simulated and measured results of the multi serrated notch band MIMO antenna is studied with comparision with a perpendicularly placed monopole antenna. The proposed antenna shows excellent radiation characteristics in Wi MAX region and going with 2.1 GHz – 12.8 GHz band with mutual coupling S21 < -15 d. Result clearly justifies this model as a perfect candidate to be employed for WiMAX-MIMO systems. Two notch bands are created in 3.3-3.7 GHz and 5.15-5.85 GHz to eliminate interference in the WiMAX and WLAN band respectively. At the center of the notch frequency in the WLAN band the simulated and measured results showed that proposed antenna has excellent performance in impedance bandwidth and radiation pattern. The simulations were done in ANSYS HFSS tool.*

Keywords — *Compact Antenna, MIMO, WiMAX World Wide interoperable microwave access, multi serrated.*

I. INTRODUCTION

A basic idea of antenna to be termed as Microstrip appeared in 1953 which later acquired a patent in 1955 has sown seeds for the development of microstrip antennas. Significantly, it gained attention in the late 1970's. In the functioning of High performance application, microstrip antenna meets the demand where weight, size compactness and installation are key features of requirement. Until the advent of microstrip antennas all the earlier antennas were bulky and occupied more size and space. The requirement of low cost and low size has pushed the microstrip antennas to the fore front which ultimately gained demand for handheld and mobile applications. Micro strip model of antennas are also termed as patch antennas. Basically, the microstrip patch antenna comprises of a substrate filled with dielectric material and primary etched elements as a patch which is radiating and feed lines on one dimension and the ground portion on the other dimension side as shown in Fig.1.1.The radiating patch specified can take the form of various shapes namely square, elliptical, rectangular, circular and is made up of copper or gold which possess conducting properties.

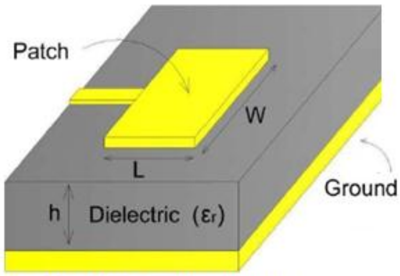

Fig:1.1 Micro Strip Patch antenna

Radiating property of this kind of antenna is accounted to the fields fringing in nature which develop between the edge of the patch and the ground portion. A variety of substrates materials are used in the design procedure of microstrip antennas with a dielectric constant in the located range of $2.2 \leq \varepsilon_r \leq 12$. A more substrate height and low dielectric constant are required for the design of an antenna with larger bandwidth and good efficiency. The lower dielectric constant characteristic is justified as it provides fields which are loosely bound which ultimately leads to the emission of higher amounts of radiation into space, ultimately leading to an increase in antenna size. On the other hand, substrates which exhibit relatively more dielectric constants and less thickness are employed in the areas involving waveguides and microwave circuitry which require tightly bound fields. But use of high dielectric constant will cost lower efficiency and lesser bandwidth.

1.1 Feeding techniques

The feeding methods of microstrip patch antennas are partitioned as contacting method and non-contacting method. Considering the latter model a microstrip line which acts as a connector power is used to feed power to the microstrip patch. In the latter method, power is shifted to the radiating patch from the microstrip line by means of electromagnetic field coupling. The contacting schemes are the most commonly used feeding techniques comprising of microstrip line feeding and the probe feeding. On the other hand, the non-contacting scheme of feeding techniques comprise aperture coupled and proximity coupled feeding. The strategies by which power coupled to and fro from the antenna are comprehensively classified as contacting and non-contacting. The Contacting feeds employ technique where straight connection is established between the patch antenna and transmission line. Within these boundaries on the patch exact location of connection determines the input impedance. Most importantly we have four types of feeding techniques in these antennas which are classified as below

- Microstrip line feeding technique
- Probe coupling technique
- Aperture coupled microstrip feeding and
- Proximity coupling technique

II. MIMO TECHNOLOGY AND ITS APPLICATIONS IN WIMAX SYSTEMS

The proposed antenna is a MIMO antenna for UWB applications and the basics of the MIMO to study.

2.1 Basic Concept of MIMO

The basic concept of MIMO technology is that it simultaneously employs many elements of antennas in the section of transmitter and receiver. The single input single output (SISO) and multiple input single output (MISO) are treated as special cases of MIMO systems as they employ a single antenna either in the transmitter or in the receiver. The system performance is improved by employing the MIMO technology through diversity and multiplexing which is explained below. Multiple antennas offer diversity to combat multipath fading. A single transmitting and single receiving antenna provides a single signal path. In the case of MIMO consider n transmitting and receiving antennas thereby providing the number of signal paths equal to n2. As each of these paths experience different fading characteristics the possibility that all signals experience fading simultaneously is almost null. Therefore, the reliability of the system is improved. In addition, MIMO systems increase channel capacity by employing spatial multiplexing. The number of sub-streams that is supported by MIMO is min (M,N) if M transmitting and N receiving antennas are employed.

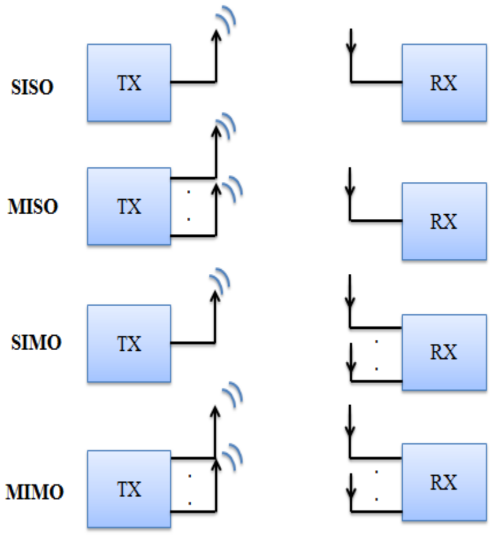

Fig. 2.1 SISO, MISO, SIMO, MIMO MODELS

Since UWB possess a extensive range of applications in the domain of wireless communication which cover WBAN, WPAN, RFID's, networks of sensors, radars etc, it stood as a favourable technology for wireless communications restricted to a short domain paving way for high rate of data communications. A Revolutionary importance has been pointed out to Multiple Input Multiple Output technology in digital communication systems. All wireless technologies are posed by the provocation of fading in the strength of the signal, increase in intervention, restrained spectrum and multipath. A key advantage of MIMO technology is that without consuming extra radio frequency it provides higher data throughput and improvement in range and reliability by making use of multipath phenomenon. In addition, MIMO systems make use of antenna diversity to improve the quality of transmitted signal strength and thereby improving the signal to noise ratio. Additionally, Multiplexing in the spatial domain helps to enhance the data rate. Although UWB offers rich time diversity due to its abundant multipath, the primary doubt which arises is why to combine UWB with MIMO. No matter MIMO technology would provide an increase in channel capacity and also an increase in range of communication when short distance communication is chosen. Also, this combination of UWB with MIMO can be explained by specific reasons rather than motivations.

III.A NOVEL COMACT NOTCH BAND SERRATED ANTENNA FOR UWB APPLICATIONS

Desirability of a compact antenna is needed for portable wireless communication devices.
A suitable candidate for such devices is a planar monopole antenna with a low profile and Omni directional radiation pattern. To be specific, for

UWB-MIMO systems, the antennas must meet the impedance matching (i.e. S11= -10 dB) requirement and also lower mutual coupling parameter in terms of S21 between the input terms throughout the large bandwidth. An adequate value of S21= -15 dB is preferred. As already experimented, for portable devices the antenna should have a compact size. Different designs were proposed for such UWB planar monopole antennas. Specifically, some designs possessing very large sizes were not suitable for wireless devices. An insight of a MIMO antenna with compactness in size is presented in detail. We propose a compact serrated notch band MIMO antenna for applications involving UWB. This model is designed using Ansys HFSS, fabricated and tested using ZNB 20 VNA Network Analyzer.

3.1 Antenna Geometry

The basic model of the proposed MIMO antenna on a defected ground structure (DGS) is as observed in Fig.3.1(a).The antenna possess compactness in size of 22 mm*36 mm*1.6 mm which is smallest of all the MIMO antennas proposed for applications covering UWB. The radiating monopole elements of the basic antenna is initially square shaped which further lead to the modification of serrated edges along three sides of the patch.

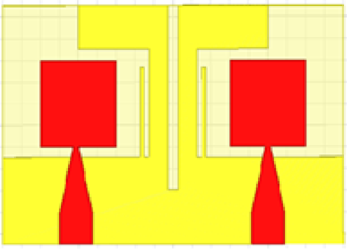

Fig: 3.1 MIMO Basic Antenna

The proposed antenna dimension is shown in Table 3.1 In our MIMO antenna proposed in Fig.3.1(b) as observed from the model that square shape monopole radiators are converted to serrated edges along the unfed sides of the square.

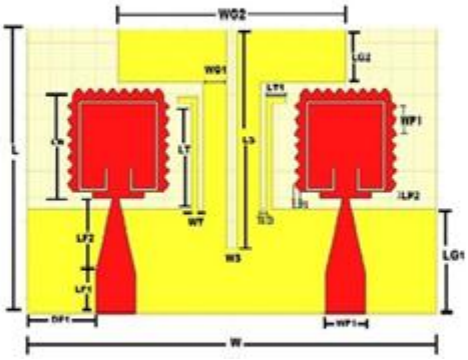

Fig: 3.1(b) MIMO Proposed Antenna

L	LG1	LG2	LT	LS	LT1	LF1	LF2	LR	LP2
22	8	4	8.3	17	1.75	3	6	8	0.4
W	WG1	WG2	WT	WS	WD	WF1	WP1	DF1	LP1
36	2	20	0.5	1	0.5	3.5	2	6	0.25

Table: 3.1 Dimensions of the proposed Model

3.2 *Simulation and Analysis*

The simulation and analysis of the antenna was done by using HFSS most powerful Electro Magnetic Soft ware for antenna. HFSS(High Frequency Structured Simulation), The model first done for a circular patch antenna at UWB applications and it is further applied for rectangular patch portable monopole antenna with DGS and studied for various frequencies. After we designed and tested for the proposed antenna for serrated array as shown in Fig: 3.1(b). The above Fig.3.2 depicts the fabricated prototype of the discussed compact serrated notch band MIMO antenna for UWB applications. The antenna front view and back view are visible from the above figure. The characteristics of the fabricated model are carried out by using ZNB 20 VNA network analyzer. The measured outcomes are compared with those of the obtained ones. This model of antenna is thus appropriate for the proposed UWB application.

Fig:3.2 Proto Type antenna (a) Front View

Fig: 3.2 (b) Back View of the proto type

3.3 Antenna Study

To explore how the notches in the band can be regulated by the parameters of the slot, the help of computer simulation. An inverted U shape slot is responsible for creating a notch in the WiMAX band. Also, a parametric analysis is performed for the slot structure using the computer simulation which best fits the notch in the required WiMAX (3.3-3.7 GHz) band. In addition, the inverted L strips are also responsible for creating a notch in the WLAN (5.15-5.85 GHz) band.

IV. RESULTS AND HFSS ANALYSIS

4.1 VSWR & S-PARAMETER ANALYSIS

The model is tested by experimentation and the results are obtained as below. The S parameters such as reflection coefficient of the fabricated model is observed in Fig.4.1.1 are measured using ZNB 20 VNA. Result clearly justifies this model as a perfect candidate to be employed for UWB-MIMO systems. Two notch bands are created in 3.3-3.7 GHz and 5.15-5.85 GHz to eliminate interference in the WiMAX and WLAN band respectively. At the center of the notch frequency in the WLAN band S11 has a high value of -1.75 dB, indicating very effective suppression. In addition at the center of the notch frequency in the WiMAX band S11 has a value of -2.4 dB, also indicating very effective suppression.

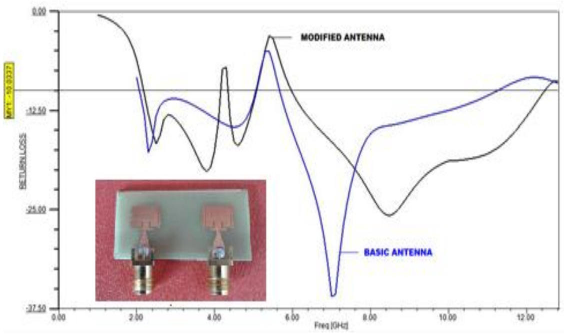

Fig 4.1.1 Reflection Coefficient Proposed Antenna

The VSWR attained for the basic model and the proposed model are depicted in Fig.4.1.2. These results of simulation clarify that the VSWR lies in the desired range (1< VSWR <2) operating in 2.4 GHz to greater than 12 GHz covering full UW band. Specifically, the deep two notches are observed in the frequency band covering the UWB application band.

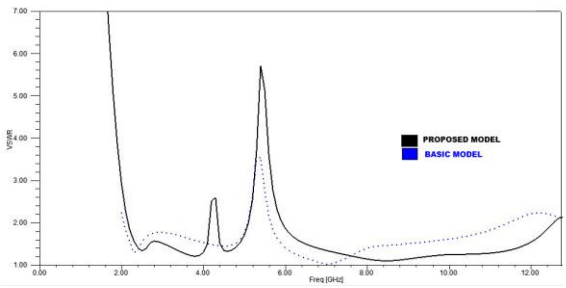

Fig: 4.1.2 VSWR of the Proposed Antenna

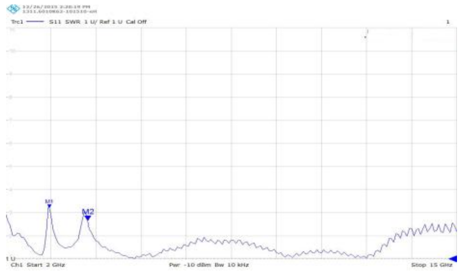

Fig: 4.1.3 VSWR - Proposed antenna on VNA

To investigate the performance of the MIMO antenna another important parameter of consideration is coupling coefficient parameter (S12). From the simulated results we observe that the coupling coefficient S12< -15 dB covering the 2.4 GHz and exceeding 12 GHz band.

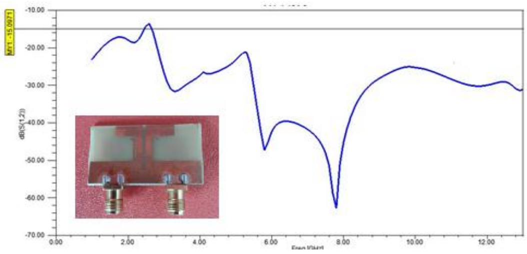

Fig: 4.1.4 Simulated S_{12} of the proposed Antenna

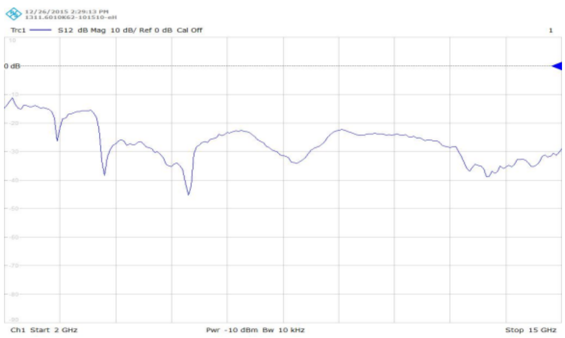

Fig: 4.1.5 S_{12} Measured value of proposed antenna in VNA

The final tested S12 of the fabricated model clearly indicates that the value is less than -15 dB (S12< -15 dB) covering the band from 2.4 GHz and exceeding 15 GHz covering full UWB band. The performance of MIMO antenna is investigated by comparing results of simulation and measurement. One of the important characteristics related to the MIMO is there by verified.

4.2 Radiation Patterns

The 2D radiation plots of the MIMO model obtained is verified by computer simulation.

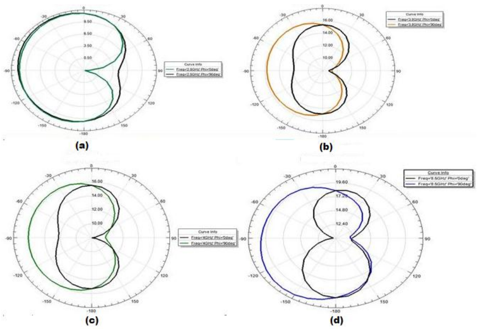

Fig.4.2.1. 2-D Radiation patterns with port 1 excited port 2 terminated with 50-ohm load:(a)2.5 GHz;(b)3.8 GHz;(c)4 GHz;(d)8.5 GHz

By exciting first port and terminating second port by a load impedance of 50-Ω, the radiation patterns at distinct of frequencies of 2.5 GHz,3.8 GHz,4 GHz and 8.5 GHz are shown in Fig 4.2.1 (a),(b),(c),(d) respectively. From the above simulated results, the radiation characteristics indicate a quasi omni directional pattern in the elevation plane and dumbbell shape pattern in the azimuth plane in the higher frequency bands. At the notched frequency the radiation patterns are very narrow. At a frequency of 8.5 GHz, we observe a dumbbell shaped pattern of radiation in the azimuth (or E) Plane and a directional pattern radiation in the elevation (or H) Plane.

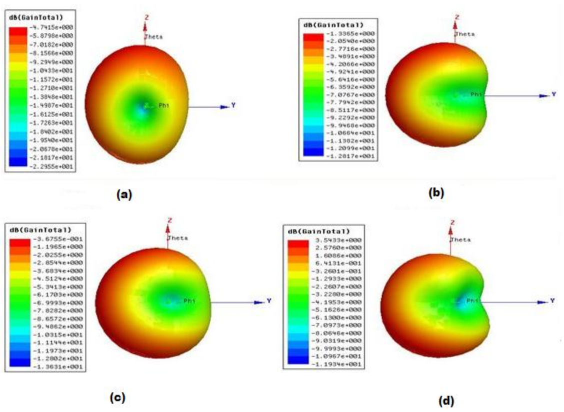

Fig.4.2.2. 3-D polar plots at (a) 2.5 GHz, (b) 3.8 GHz, (c)4GHz and (d) 8.5 GHz with port-1 excited and port-2 terminated with 50-ohm load

Fig.4.2.2 shows the 3-D polar plot characteristics of the proposed model at operating frequency bands. Finally, MIMO antenna can provide pattern diversity so as to attain improvement in reliability. Fig.4.36 displays the final antenna surface current densities at the midpoint of dual notched frequency bands i.e., 3.5GHz and 5.4GHz and also at 4.2GHz.It is clearly evident from the figures that current coupled from Patch element1 to patch element2 is less reducing coupling between the two ports. The area covered by the red portion is the first element of the monopole and also the feed line portion. The blue portion which is the last indicator in the current density meter is present along the second element of the monopole and also along the ground portion which illustrates the isolation property of the proposed MIMO model.

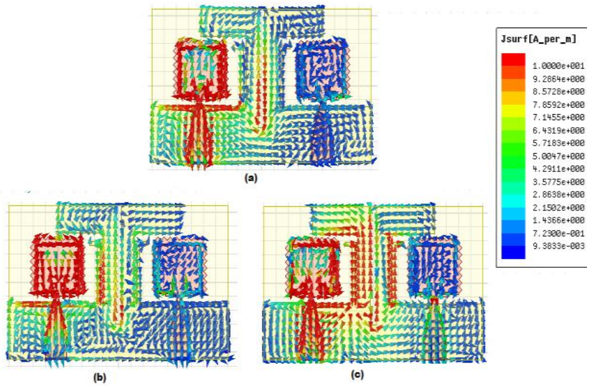

Fig.4.2.3 Surface Current Distributions at (a) 3.5 GHz (b) 4.2 GHz (c) 5.4 GHz

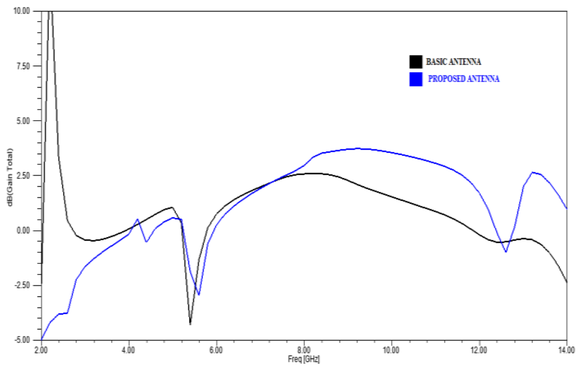

Fig.4.2.4 Simulated Gain vs Frequency of Basic antenna and proposed antenna

Fig.4.2.4 visualizes the gain picture of the proposed model with respect to the frequency of operations. A peak realized valued gain of about 4 dB is attained from the proposed antenna.

4.3 MIMO Performance

For a MIMO antenna we arrive at the diversity performance by calculating the envelope correlation coefficient ρe. Ideal diversity systems require a correlation coefficient close to zero. From the obtained result figures. we observe that the simulated correlation coefficients are below 0.03 throughout the UWB indicating very low correlation and hence good diversity performance.

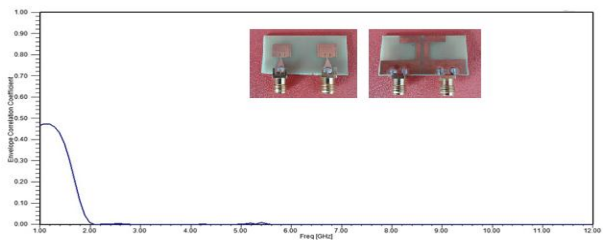

Fig: 4.3.1 Simulated ECC vs Frequency

V. Conclusions

The final proposed antenna is a compact serrated MIMO antenna with band notched characteristics for UWB applications.. The antenna provides dual band notches corresponding to the WiMAX and WLAN and strictly covers the frequency range thereby eliminating interference from the respective bands and also utilizing the available bandwidth. In the proposed antenna systems Envelope Correlation Coefficient (ECC) can be calculated. For a good diversity performance across the full UWB, optimized designs are to be carried out to yield ECC value below 0.01.

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