Design and Analysis of Dual E-Shaped Antenna for Wireless Applications

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Abstract: In this paper, simple triband Multiple Input and Multiple Output (MIMO) antenna is proposed for wireless communication technology. This antenna consists of two symmetric monopoles which are placed at a distance of 0.106λ_0 and for board area it occupies 0.25λ_0*0.26λ_0. By integrating a stub in the ground plane and adding the stub in the feed line, isolation is achieved more than 20dB.This triband MIMO antenna operates under 2.5GHz, 3.3GHz and 4.4 GHz. The proposed antenna gives Radiation Patterns and Stable Gain. Mean effective gain (MEG) and Diversity Gain (DG) are also measured.

Index Terms: Dual E shaped Antenna, MIMO Antenna WI-Max.

I. INTRODUCTION

Multiple Input and Multiple Output (MIMO) has become common microwave/radiofrequency communication technology over the past several years. Examples like Wi-Fi networks and cellular 3G /4G long term evolution using at homes and in business. Multiple input and Multiple output antennas are mainly used in wireless technology with multiple Antennas which are used both at Transmitter and Receiver. There are many fundamental parameters of cross correlation of the Antenna transfer functions [1]. In the present world wireless communication systems are mainly shifting towards multiple input and multiple output (MIMO) from the single input and single output (SISO) and single input and multiple output (SIMO) systems. Development of Multiple input Multiple output (MIMO) antennas and its performance estimation for the modern wireless communication terminals have attracted to improve bandwidth, gain, polarization diversity, channel capacity and mainly to reduce the coupling between the inter elements. MIMO wireless communication systems are mainly using Multi Element Antenna (MEA) and Multi Port Antenna (MPA).Where multi element antenna can synthesize more effectively a large number of radiation patterns as to increase the throughput of the information between the source (transmitter) and destination (receiver).

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Where capacity analysis is used in the multi element antenna for various observations [2].Antennas play an important role in converting electronic signals into electromagnetic waves. Mainly there are four types of antennas-short dipole antenna, dipole antenna, monopole antenna, and loop antenna. These antennas are developed and designed with different elements and parameters. MIMO antenna is designed with the frequency of 2.65GHz with three equilateral triangular microchip patches. Based on the correlation and mutual coupling between each and every pair of the antenna ports, it is projected that antenna achieves better polarization and the high diversity gain [3].

In past there is a single radio frequency (SRF) chain for the Wi-Fi devices. To process the radio signal, multiple antennas uses the same hardware as only one antenna can transmit one signal at a time and receive the signal where all the radio signals go through the single radio frequency chain. Where as in multiple input and multiple output (MIMO) there will be a separate radio frequency chain for each and every antenna which allows more number of radio signals to co-exists. wireless local area network (WLAN), metropolitan area network (MAN), wireless telephone equipment are based on multiple input and multiple output (MIMO) technology[4].For increasing the gain, bandwidth and to reduce the mutual coupling between antennas four - port multiple input and multiple output antenna is designed for 3G and 4G applications. PIFA-MIMO antenna application is developed by considering the frequency of 2.45GHz [5-6]. MIMO antenna is used in different applications. The compact multiple input multiple output antennas with dual notched band characteristics are used for ultra-wide band applications. This antenna consists of two square shape monopoles and T-shaped described ground structure with 2 strips for the elimination of interference and for the better isolation purpose [7]. Within certain limits the Compact planar multiband antenna structure which allows independent adjustment and tuning of each and every frequency. This antenna consists of a pair of horizontal strip patches and a pair of vertical strip patches as a parasitic element to get the resonant frequency [8]. Multiple Input and Multiple Output antenna is proposed covering 1710-2690 GHz for wireless communication technology. It consists of two identical elements, radiating strip and coupled feeding plate where the volume of each element is 24.5×15×1.2 mm^3. This antenna has good potential for high band wireless mobiles [9].

In this paper, simple triband Multiple Input and Multiple Output (MIMO) antenna is proposed for wireless communication technology. This antenna consists of two symmetric monopoles which are placed at a distance of 0.106λ_0 and for board area it occupies 0.25λ_0*0.26λ_0.By integrating a stub in the ground plane and adding the stub in the feed line isolation is achieved more than 20dB.This triband MIMO antenna operates under 2.5GHz ,3.3GHz and 4.4GHz.The applications based on these frequency bands are, the range between (2.3-2.5 GHz) frequency bands are used for WiMAX technology, and frequency band of (3.3-3.7 GHz) are used in mobile applications like wireless data transmission. The proposed antenna gives Radiation Patterns and Stable Gain. Mean effective gain (MEG) and Diversity Gain (DG) are also measured [10].

II. ANTENNA THEORY

A tri-band monopole proposed antenna can be designed using five branches. The longest arm of the antenna resonates at the most reduced frequency, while the briefest arm resonates at the most noteworthy frequency. The resonating frequency relies upon the length, while the bandwidth of a frequency relies upon the width of an arm. Accordingly, the five arms of a dual E-shaped antenna can autonomously control the three bands. Since the dual E-shaped antenna is symmetrical, one portion of the dual E-shaped antenna can be expelled, and half dual E-shaped antenna still offers the tri-band activity. In this manner, to have a smaller MIMO antenna, a two-component half dual E-shaped monopole antenna is planned as shown in Fig.1.

Alongside the smaller size, high segregation between the antenna components is a critical necessity of MIMO antenna. Since the electrical separation between the two components is least at lowest working band, it is basic to plan a MIMO antenna to work at lowest band (2.1– 2.7 GHz) with high seclusion. In this way a solitary rectangular arm monopole antenna is intended to resonate at lowest alluring frequency. The length of the antenna is resolved utilizing Eq. (1) [11]. The resonant frequency relies upon the length while the bandwidth relies upon the width of the rectangular monopole. To oblige the other component, the length of the ground plane is expanded. To plan a minimized MIMO antenna, the second component is put at about 0.1λ0 separated from the main component, where λ0 is the wavelength in free space corresponding to the lowest working frequency. The expansions long of the ground plane reductions the resonant frequency of antenna. The length of monopole is diminished to 70% of its unique length in order to make the antenna to resonate at its underlying frequency. The bandwidth of the antenna relies upon the width of the rectangular arm.

To accomplish something like 20 dB segregation between the two components of antenna, a ground stub is incorporated to the ground plane. This ground stub goes about as reflector to the close fields and gives a decoupling path. The length of ground stub ought to be about 1.2 occasions the length of rectangular monopole in order to have the segregation in excess of 20 dB.

For antenna to work over another band (3.3– 3.7 GHz), a second arm is added to the primary arm. Length of the arm is resolved utilizing Eq. (1) to reverberate over centre band. However the length of the arm is diminished to counter the impact of expanded ground plane length. Separation > 20 dB can be accomplished over centre band because of increment in the physical and electrical separation between the centre arms resounding at 3.5 GHz. Now, the third arm can be coordinated to resound at higher band (4.9– 5.35 GHz). Antenna impedance matching, resonant frequency and bandwidth of three bands are tuned by integrating a λ/4 open circuit stub in the feed line. This stub is intended to go about as a band notch filter over the higher band. The stub length, width and position decide the resonant frequency furthermore, bandwidth of band notch filter [12, 13]. The resonant frequency of the band notch filter ought to be more than the resonant frequency of higher band and its bandwidth ought to be streamlined to get the wanted bandwidth of the higher band. The stub goes about as a capacitor below its resonant frequency and subsequently influences the resonant frequency of the considerable number of bands. The impact is increasingly noticeable in the higher band and little in the lower band. In view of this design theory, a tri-band MIMO antenna is designed which offers S11 < −10 dB and S12 < −20 dB over 2.1– 2.7 GHz, 3.3– 3.7 GHz and 4.9– 5.35 GHz.

III. ANTENNA GEOMETRY

The MIMO antenna is designed on a FR-4 substrate of 1.6 mm thickness with dielectric constant (εr) of 4.4 and loss tangent (tan δ) of 0.02. The MIMO geometry is shown in Fig. 1 while the point by point antenna dimensions are recorded in Table 1.The model of the proposed prototype is created to check the recreated outcomes. The top and the base view of the manufactured MIMO antenna are shown in Fig. 2. The antenna occupies 38×37 mm^2 board area and is acknowledged using printed circuit board etching procedure. The development stages of proposed antenna and the simulated S-parameters of each stage are shown in Fig. 3 and Fig. 4, respectively. 'Antenna 1', a single band rectangular monopole with f1 as lowest frequency (corresponding to VSWR = 2) is designed. Its dimensions L = 29.4 mm, W = 3 mm, g = 0 are resolved using below equation [11].

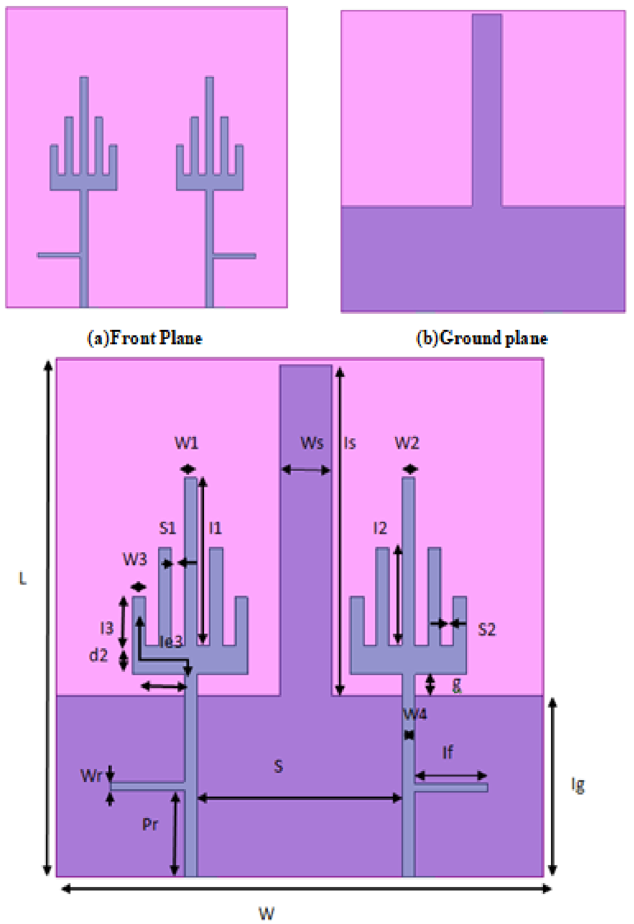
$$f1 = \frac{7.2}{(L + (W/2\pi) + g)Xk} GHz \qquad [1]$$

Here, value of k = 1.15 is considered for the FR-4 substrate. As illustrated in Fig. 4, the antenna offers a single band resonance at 2.1 GHz with higher request mode at 5.6 GHz. In any case, the radiation pattern at 5.6 GHz delineates higher request mode activity and thus needs concealment. To oblige the second component, ground plane measurements are expanded which results in 'antenna 2'.In monopole antenna, the ground plane dimensions influence the impedance bandwidth, therefore, the lower band movements to 1.6 GHz because of increment in the ground plane dimensions. The length of the monopoles of 'antenna 2' is diminished by 70% or 19.5 mm to build the least operating frequency and to smother the higher request mode. This outcome in 'antenna 3' as it maybe the inter-element dispersing of 0.106λ0 prompts critical mutual coupling. As to improve the isolation, a rectangular stub is jutted from the ground plane along these lines shaping 'antenna 4'. The length of the ground stub ought to be prominent more than the monopole length with the goal that it goes about as a reflector and reduce the mutual coupling due to close fields. This stub additionally gives a decoupling path and thus restricted measure of current couples to the neighbouring element because of surface waves. Fig. 5(a) portrays the surface current circulation in the 'antenna 4' at 2.4 GHz for various lengths (ls = 0.8l1 or l1 or 1.2l1) of the ground stub, when one port of

antenna is energized while the other port is coordinated end with a heap of 50 Ω. The surface current and the close fields which get coupled to second element, decline with increment in the length of ground stub [14-15]. The ground stub length, is about 20% more than the length
of the monopole antenna, results in mutual coupling < −20 dB over the lower band from 2.1 GHz-2.7 GHz. 'Antenna 5' is advanced by integrating two arms to the effectively existing monopole in 'antenna 4'. The viable length of the two arms le2 and le3 relating to two bands are determined utilizing (1). The viable lengths are decreased and streamlined because of the expanded ground plane dimensions [16-29]. This antenna works at 3.33 to 4.02 GHz and 5.32 to 5.89 GHz bands notwithstanding the 2.15 to 2.9 GHz band. S11 < −10 dB and S12 < −14 dB is acquired over 5.32 to 5.89 GHz in 'antenna 5'. Hence, an improvement in the isolation furthermore, the impedance matching is required for higher band. A stub in the feed line is acquainted with the improvement in the isolation in the higher band which results in the geometry of 'antenna 6'. The feed line stub is intended to go about as a λ/4 open circuit stub at 6.5 GHz thus carrying on as a short circuit. In same manner, return misfortune < 10 dB and isolation more prominent than 24 dB are accomplished over 4.9– 5.35 GHz. In expansion, the antenna additionally gives isolation in the excess of 20 dB over the lower and centre bands.

Parameters	Values In mm
L	37
W	38
S	16.2
L1	20.5
L2	12.3
L3	4.0
W1	3.5
W2	3.8
W3	1.0
Le2	16.5
Le3	11.3
D1	2.5
D2	2.9
G	2.5
W4	1.0
W5	8.0
Ws	5.0
Ls	28.5
Lf	6.8
Pf	7.8
Wf	1.5
Lg	16

Table 1: Dimensions of Proposed Antenna



(c) Proposed antenna

Fig.1 Proposed Dual E Shaped Antenna (a) Front Plane (b) Ground Plane (c) Proposed antenna

IV. RESULTS AND DISCUSIONS

In this section the two port dual E shaped antenna is proposed. The first parameter S11 has three resonating bands under -10db where -10db is the return loss. In S11 parameter first band we got frequency 2.5900 GHz and has return loss-11.2723db, second band occurs at frequency of 3.3900GHz and having return laws-13.0959db, third band is very narrow band of the three bands which comes at 4.9000 GHz frequency and return loss is -12.5459 , we can observe above values in Fig 2.
In S22 parameter we can observe values in Fig 1.In the second patch and this also have 3 bands. where first band we get frequency 2.7100 GHz and has return loss-13.7677, second band occurs at frequency of 3.3100GHz and having return laws -15.4173db, third band is very narrow band of the three bands which comes at 4.9000 GHz frequency and return loss is -15.6067 .The third and fourth parameters are same i.e. (S12and S21) that can be analysed from the

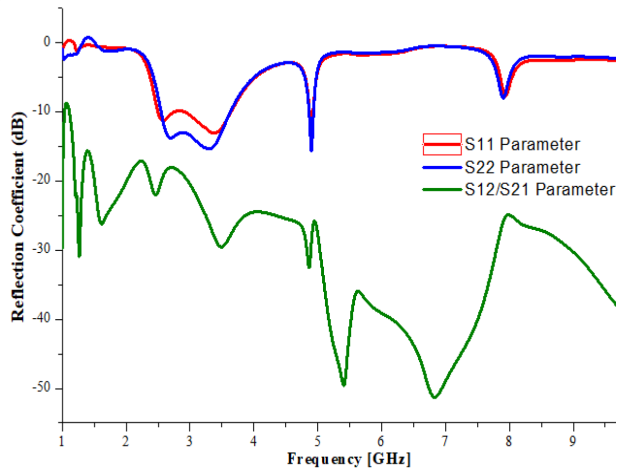
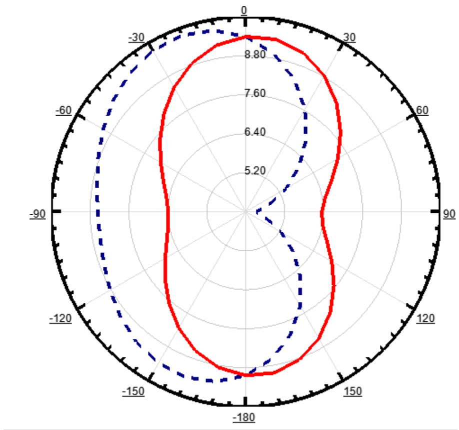
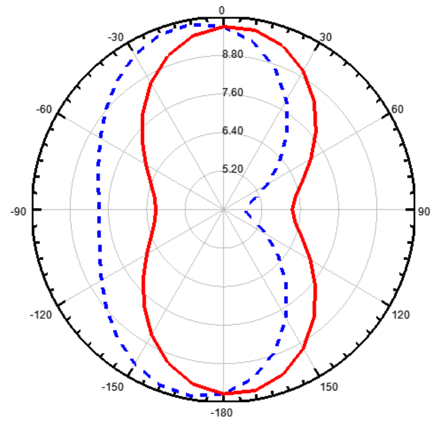


Fig 2: Comparison of simulated S-parameters of the antenna

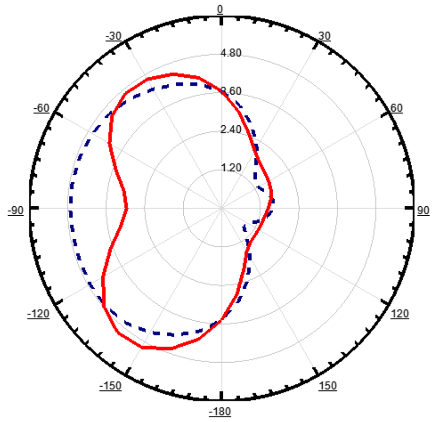
The simulated radiation patterns of dual E-shaped antenna by using HFSS software. The energy radiated by the antenna is characterized by the radiated patterns. The designed antenna radiation characteristics in E-plane and H-plane at the resonant frequencies of 2.5GHz, 3.3GHz , 4.9GHz which is in omni-directional pattern



(a)Freq at 2.5GHz



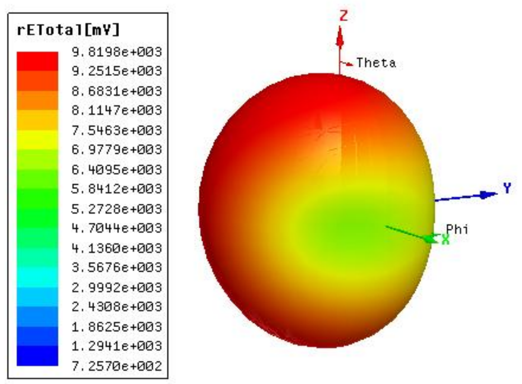
(b)Freq at 3.3 GHZ



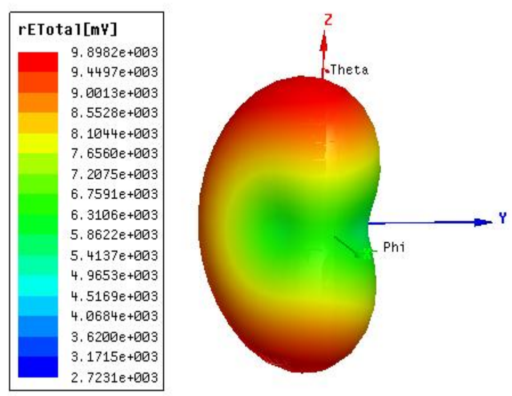
(c)Freq at 4.9

Fig3. Radiation Pattern of the proposed Antenna at different operating bands in E-plane and H-plane in 2D (a) 2.5 GHz (b) 3.3GHz (c) 4.9 GHz

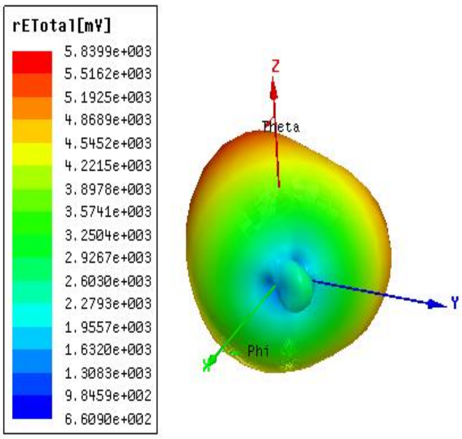
The efficiency of the antenna can be characterized by its gain plots. The antenna gain reports the transferred power in the peak radiation direction. The 3D polar gain resonating frequencies 2.5GHz, 3.3GHz, 4.9GHz are simulated as show in below Fig 4.



(a) 3D polar plot at 2.5GHz



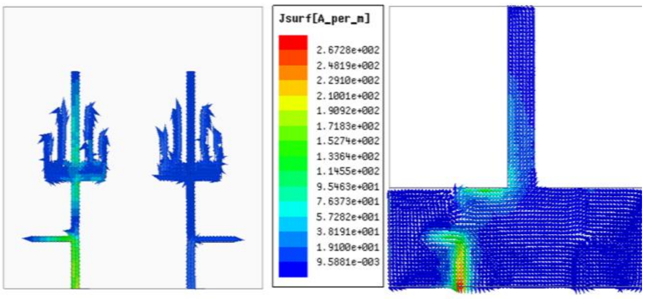
(b) 3D polar plot at 3.3GHz



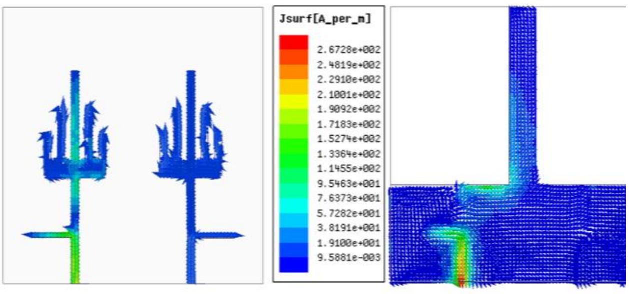
(c) 3D polar plot at 4.9GHz

Fig4. Radiation Patterns of the proposed Antenna at different operating bands in E-plane and H-plane in 3D (a) 2.5 GHz (b) 3.3 GHz (c) 4.9 GHz

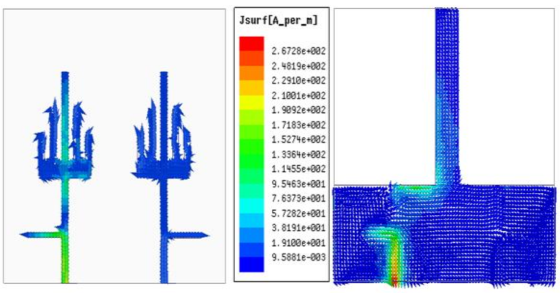
The proposed antenna with dual E-shaped currents is hugely concentrated. The maximum amount of current is appropriated along the feed element and dual E-shaped antenna. The distribution of current of the proposed antenna is good and uniform .Below, the current distributions of the proposed antenna are presented in below Fig.5.



(a) 2.5GHz



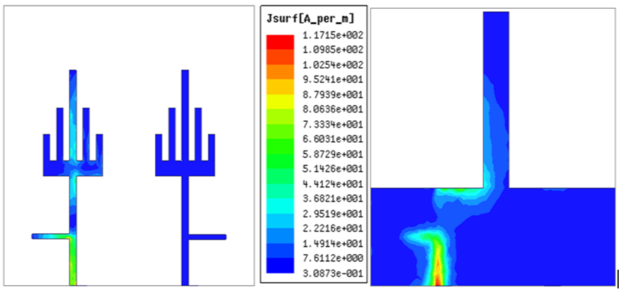
(b) 3.3GHz



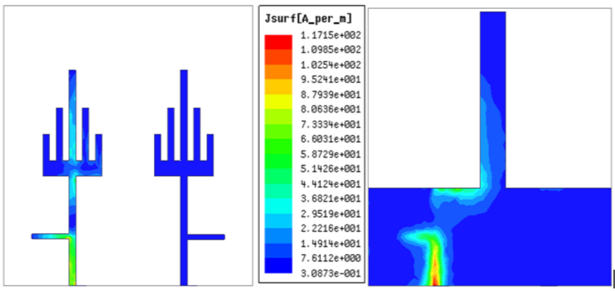
(c) 4.9GHz

Fig5 Current distributions at resonating frequencies (a) 2.5GHz (b) 3.3GHz (c) 4.9GHz

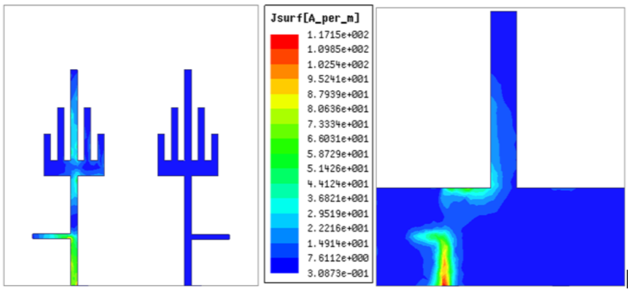
The proposed antenna with dual E-shaped currents is hugely concentrated. The maximum amount of current is appropriated along the feed element and dual E-shaped antenna. The distribution of current of the proposed antenna is good and uniform. Below, the current distributions of the proposed antenna are presented in below Fig.5



(a) 2.5GHz



(b) 3.3GHz



(c) 4.9GHz

Fig6 Surface distribution of resonating frequencies (a) 2.5GHz (b) 3.3GHz (c) 4.9GHz

The antenna gain characterizes how much of power is delivered in the direction of peak radiation. The simulated gain of our proposed antenna shows the peak gain of 19db at the resonant frequency of 2.5GHz. The Fig. 8 shows the prototyped fabricate antenna with measured results from the VNA (Vector Network Analyzer).

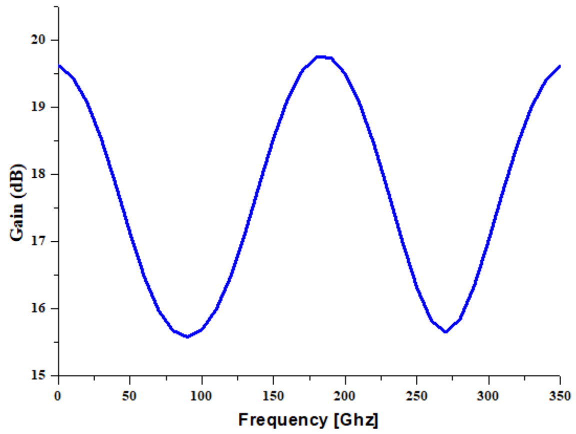


Fig.7 Frequency Vs Gain of the antenna

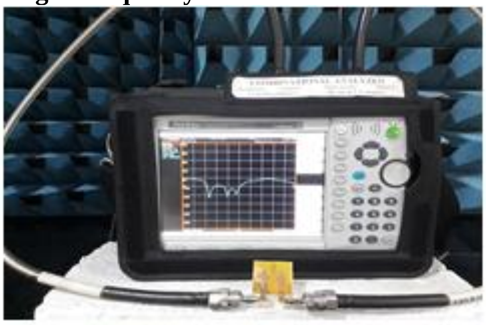


Fig.8 Prototyped Antenna with measured results

V. CONCLUSION

Simple Triband Multiple Input and Multiple Output (MIMO) antenna using a single ground stub is designed in this paper. The monopole which is radiating composed of three arms regulates the Tri-band operation at 2.5GHz, 3.3GHz and 4.4GHz Frequency bands where |S11|<-10dB. Isolation is attained of 20dB by using feed stub and single rectangular ground stub. Mean Effective Gain (MEG) and Diversity Gain (DG) are verified through the MIMO performance of the designed antenna.

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