Multiband Planar MIMO Antenna for GSM1800/LTE2300/WiMAX/WLAN Applicatons

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***Abstract*— This paper presents a multiband planar antenna covering the 4 frequency bands for wireless communication system. The antenna system consists of a two L-shaped monopole antenna and spiral structure, rectangular open ring resonator. They covering the frequency band GSM 1800, LTE 2300, Wi- MAX and Wi-LAN.In the ground plane M-shaped neutralization line a ground branches used to improve the bandwidth and isolation. The Mutual coupling is achieved higher than -12db in upper band and lower than-30db in lower band. This antenna is simulated using CST and fabricated, tested for S-Parameters and the performance is used for wideband applications.**

Keywords*— *Multiband antenna; Multi input and output antenna; S-Parameter ; Mutual coupling ; Printed Monopole antenna.

I. INTRODUCTION

Multiple input multiple output technology used the multiple antennas to use the reflected signals to provide gains in channel robustness and throughput .MIMO is a RF technology that is being used in many new technologies nowadays such as Wi-Fi, LTE and many other radio wireless RF technologies are using the new MIMO wireless technology to provide increased in capacity and spectral efficiency combined with improved link reliability.

To add parasitic elements the planar antenna radiates low frequency bands. The slots are embedded in a main radiating element to create many frequency bands and create many multi resonating path. This technique increase the antenna size in order to create more bands [1].The antennas based on a dual-feed concept that provides extra degree of freedom to control the frequency band and support multiple polarization and patterns [2].The design of planar slot antenna covers three bands GPS 1.575GHZ, 2.45GHZ, Wi-MAX, 3.5GHZ [3].The MIMO antenna issued for laptop multiband LTE services. They covers two LTE bands LTE17/13band(704 787MHZ),LTE20/7(791-862MHZ,2500-

2690MHZ).Theimpedance bandwidth is 20.2% can be achieved to cover LTE17/13/20/7.The total efficiency for all operating bands is higher than 51%[4].This monopole planar

T-Shaped antenna covering two frequency band, 2.4GHZ and 5GHZ [5].The antenna have the low profile. It is useful for multiband mobile communication system.The compact reconfigurable antenna is electronically selecting different antenna modes, so that total antenna volume can be reused and overall antenna can be made compact [6].Printed MIMO antenna for mobile terminals with UMTS at 2.4GHZ WLAN applications is proposed [7].The WiMAX diversity antenna covers frequency band from 2.4-4.2GHZ [8].Multiband antennas covering the frequency band GSM/DCS/PCS/UMTS/LTE [9-12].

In our paper, we propose a compact planar multiband MIMO antenna for GSM1800, LTE2300, WiMAX and WLAN applications. In the design of antenna structure consists of a two inverted L-shaped inverted branches from the ground plane and M-shaped neutralization line are used to achieve the mutual coupling below -15db for all frequency bands. Below the inverted L-shaped patch line drawn the resonant open ring resonator and spiral ring structure used to achieve the resonant frequency.

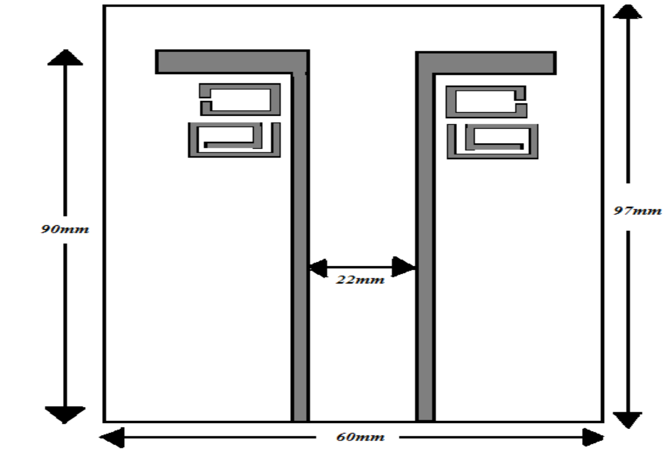
II. STRUCTURE OF ANTENNA AND PERFORMANCE

A. Structure of Antenna

The proposed multiband MIMO antenna structure shown in fig.1.The MIMO antenna is fabricated on a low cost using FR4 substrate with 4.4 and 0.8mm thickness, tangent=0.02.The total size of the antenna is 97x60mm2.The proposed MIMO antenna system consists of a two printed inverted L-shaped monopole antenna with capacitive coupled rectangular open ring resonator(RORR) and a spiral structure on top surface along with M-shaped utilization line printed between the two ground branches on the bottom side.

The two inverted L-shaped monopole antennas are shown in fig.1 (a).It will be used to cover GSM1800 MHZ band. The inverted M-shaped neutralization line are mounted on the ground plane are shown in fig.1(b).For WiMAX and WLAN bands one spiral and RORR structure with effective length and half of guided wavelength at respective resonant frequency are placed near the transmission line. The structure optimized using CST Microwave Studio to achieve the desired multiband.

The proposed MIMO antenna covers the four bands GSM1800MHZ,LTE 2300MHZ,WLAN 2500MHZ ,WiMAX 3500MHZ,WLAN 5500MHZ. In our antenna using the substrate of FR4 material because it is low cost and it is suitable for student's purpose. The material rogers4350b also used for design a multiband antenna.



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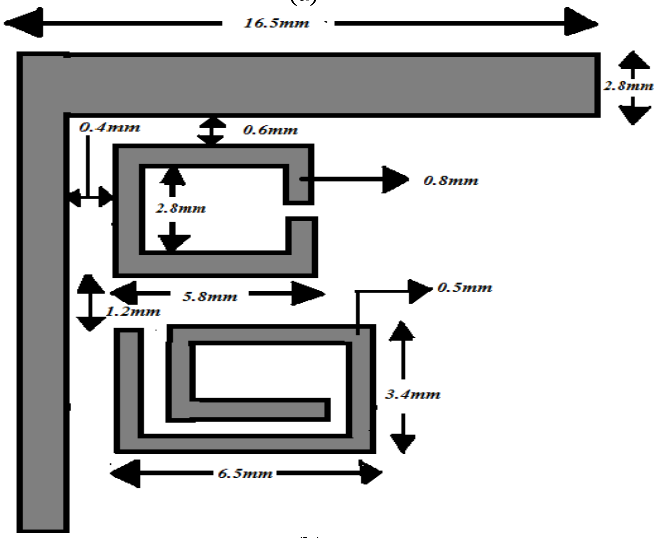

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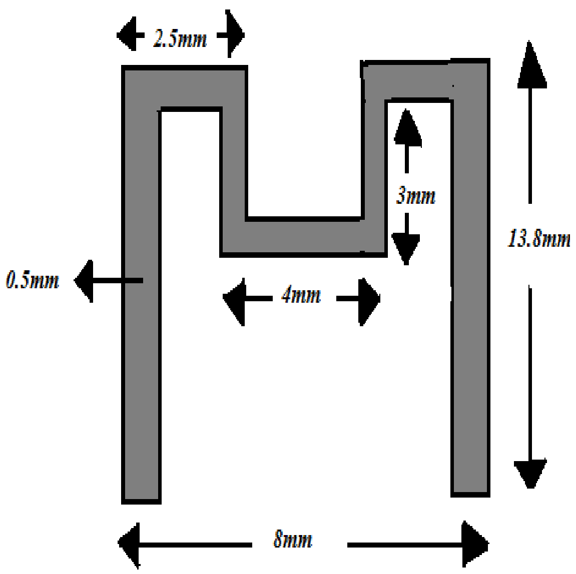

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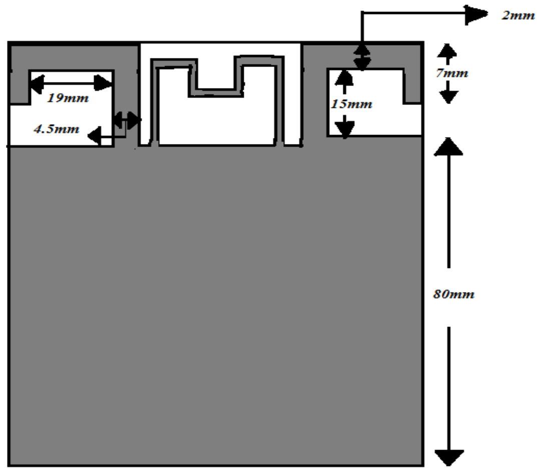


(d)

Fig.1 Proposed MIMO antenna (a)Top layer,(b)Bottom layer, (c)Dimensions of RORR and spiral resonating element (d) M-Shaped neutralization line

We using CST simulation software analysis the parameters radiation pattern, gain, vswr, efficiency, h-field, e- field, s-parameters.If change the feed width in proper calculation the bands are increased, but that bands return loss is somewhat less. The rectangular open ring resonator and the spiral structure distance are used to improve the return loss of the WLAN 5400MHZ band.

The full simulation of our antenna is using CST MICROWAVE STUDIO 2014 software. It gives the results on very accurately. The CST software is user friendly and very fast. It is first and major tool in R&D department.

B.PERFORMANCE ANALYSIS

The MIMO antenna performance can be analyzed with its dimensional parameters.

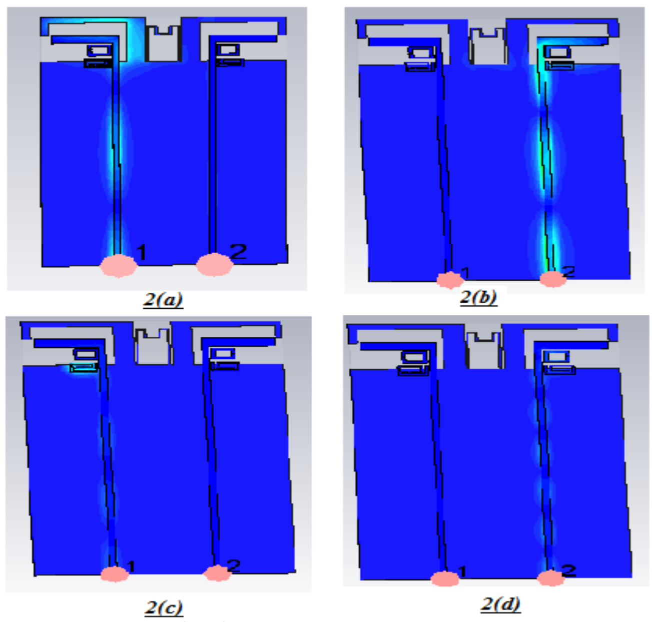


Fig.2. Simulation of surface current distribution at (a)1.7 GHZ at port1 excited(b)2.3 GHZ at port2 excited (c)3.3 GHZ at port1 excited (d)5.4 GHZ at port2 excited

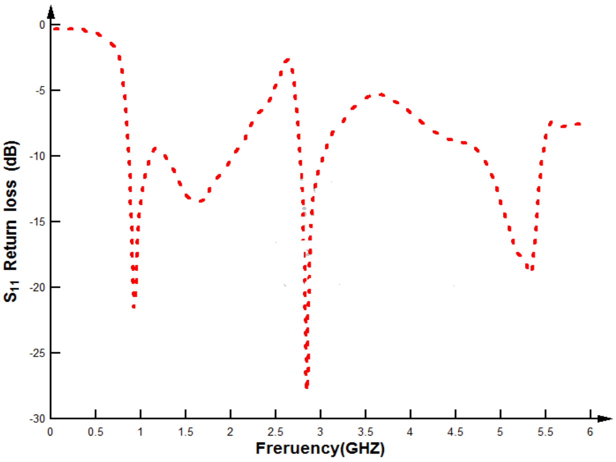
The proposed antenna is designed to operate in four individual bands and its resonant behavior is observed through the surface current distribution's-shaped neutralization lineal- shaped monopole antenna, spiral structure and Rectangular Open Ring Resonator (RORR). The fig.2 shows the magnitude of surface current is high at the proposed MIMO antenna at their respective resonant frequency. In fig.3 the simulated S-parameter of the proposed MIMO antenna are shown. They cover the four frequency bands. The antenna1provides narrow bandwidth because mutual coupling is not high. To avoid this problem the inverted L-shaped antenna are introduced in the ground branch at 1.8GHZ to improve the bandwidth .The novel M-shaped neutralization line with the thickness of 0.5mm is added in the ground plane to increase the mutual coupling at low frequency.

III. RESULT ANALYSIS

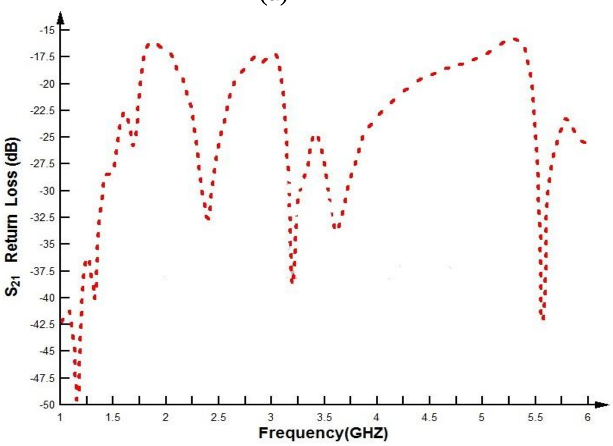
The proposed MIMO antenna is fabricated as per dimensions given in fig.1.The MIMO antenna is simulated and tested.

A. S-Parameters

Fig.3 shows the simulated S-parameters of the proposed MIMO planar antenna.



(a)



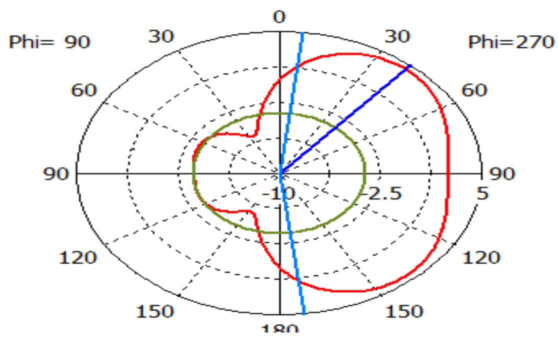
(b)

Fig.3.Simulation result of S_{11} & S_{22}

The S_{11} is measured through the port 1 at the time port 2 is terminated with a matched load. It can be observed that the proposed MIMO planar antenna is well matched at four frequency band with the mutual coupling lower than -15db at low frequency bands and less than -20db at high frequency band. S_{11} covers the frequency band GSM-1778.1 MHZ at mutual coupling -21db,LTE-2355.2 MHZ at mutual coupling -13db,WiMAX-3431.4 MHZ at mutual coupling -28db and WLAN-5452.2 MHZ at mutual coupling -18db.S_{22} covers mentioned four bands at some high mutual coupling compared to S_{11}.S_{21} and S_{12} covers all bands higher than -15db and lower than-50dB. S21 covers the all frequency band with mutual coupling below -15 dB and above -45 dB. At resonant frequency of 1122.8MHZ the Fig.4Simulted results of s11 and s21 mutual coupling is-49dB ,1301.7MHZ the mutual coupling is -42dB,1686.5MHZ mutual coupling is -26.3dB,2396.2MHz mutual coupling is -32.7,3195.8MHz the mutual coupling is -38.9dB,3624.5MHZ the mutual coupling is -34.1dB,5564.6MHZ the mutual coupling is -39.6dB. The s21 cover the five frequency bands. In s21 the smaller bands are present, but that bands bandwidth is very small.

B. Radiation and Diversity Performance

A radiation pattern defines the variation of the power radiated by an antenna as a function of the direction away from the antenna .This power variation as a function of the arrival angle is observed in the antenna's field. The radiation pattern is "Isotropic" if the radiation is the same in all directions. Antenna with isotropic radiation patterns don't exist in practice, but are sometimes compared with real antennas. The second category is "omnidirectional" antennas, which for an actual antenna means that the radiation pattern is isotropic in a single plane. The third category is "directional "which do not have a symmetry in the radiation pattern.



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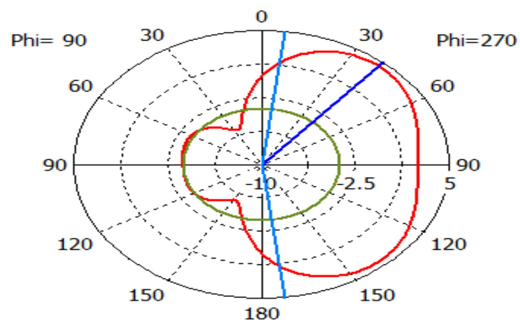

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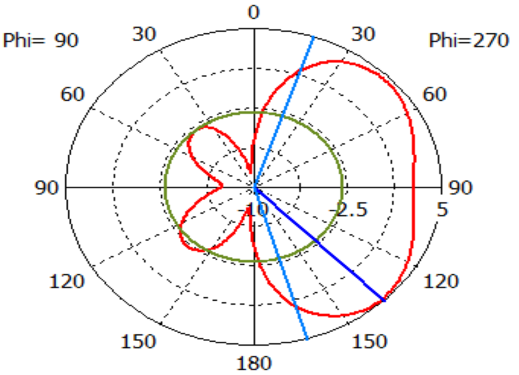

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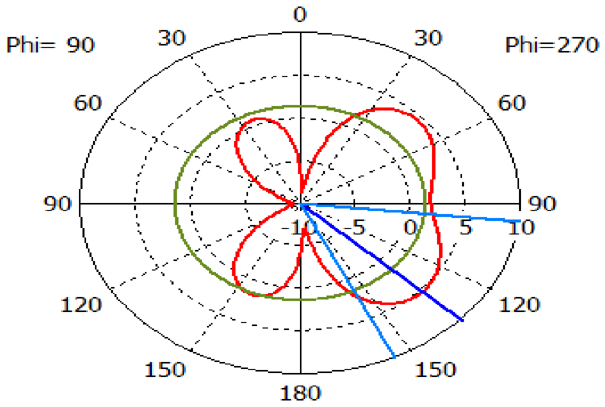

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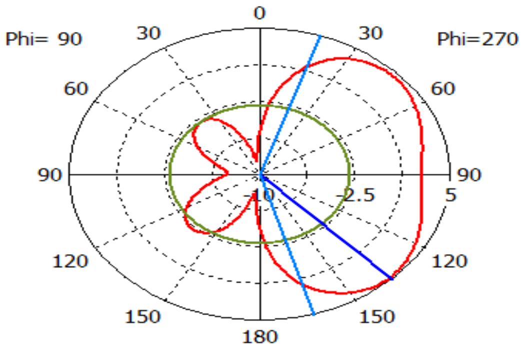

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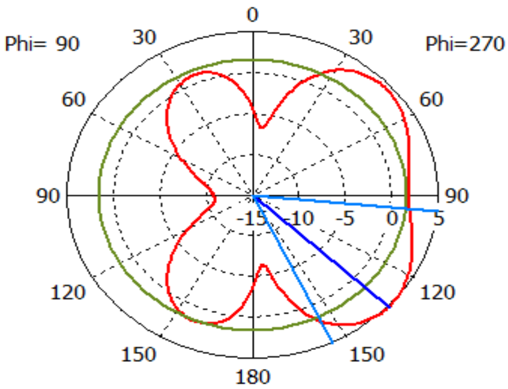

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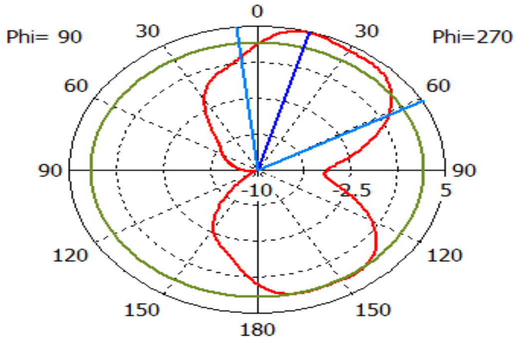

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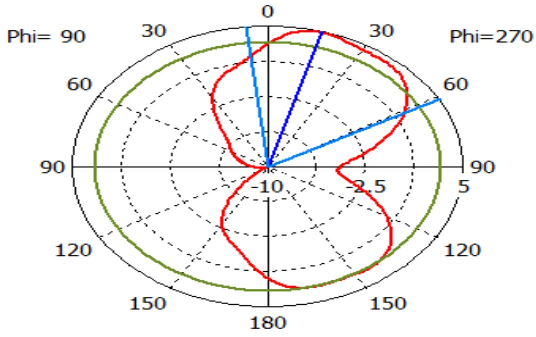


(h)

Fig.4 Simulated radiation pattern of the antenna element 1 at (a) 1.8GHZ simulated with port 1and port2 excited (b) 2.4GHZ simulated with port1 and port 2 excited(c) 3.4GHZ simulated with port 1and pot2 excited (d) 5.4GHZ simulated with port 1 and port2 excited.

Fig.4 Simulated radiation pattern of the antenna element 1 at (a) 1.8GHZ simulated with port 1and port2 excited (b) 2.4GHZ simulated with port1 and port 2 excited(c) 3.4GHZ simulated with port 1and pot2 excited (d) 5.4GHZ simulated with port 1 and port2 excited. The radiation pattern of the proposed MIMO antenna are analyzed at GSM1.8GHZ Frequency band and LTE2.3GHZ Frequency, Imax3.4GHZ band and WLAN5.4GHZ band based on two conditions. The antenna element is connected to port 1 while port 2 is terminated to a matched load as shown in fig.4.The other condition is the antenna element connected to port 2 while port 1 is terminated with matched load as shown in fig.4. The radiation pattern analysis is observed that the radiation pattern in XZ plane for antenna element connected to the port 2 is in a complementary position to antenna element with port 1. The table.1 gives the width of main and side lobe for different band of frequencies used for different applications.

Envelop Correlation Coefficient (ECC) is used to analyze the diversity characteristic of the proposed antenna .ECC is computed under the assumptions that the incoming signals are uniformly distributed .The antenna elements are lossless and well matched using S-parameters.

$$P\xi = \frac{|S11^*S12+S21^*S22|^2}{[1-(|S11|^2+|S21|^2)][1-(|S22|^2+|S21|^2)]} \quad (1)$$

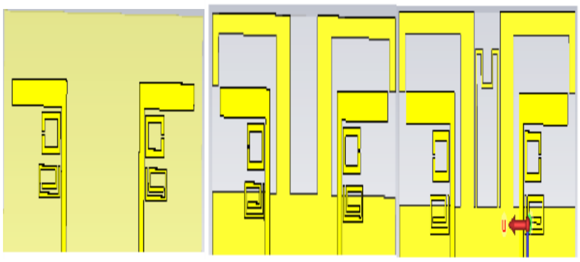
Table.1. Width of main and side lobe for different applications frequencies

Frequency(GHZ)	WIRELESS APPLICATIONS	Main Lobe Magnitude at Port1(dB)	Main Lobe Magnitude at Port2(dB)
1705-1883	GSM1800 (1710-1880MHZ)	4.41	4.4
2069-2735	LTE 2300 (2300-2400MHZ) WLAN (2400-2480MHZ)	4.65	4.65
3403-3649	WiMAX (3400-3600MHZ)	4.91	5.1
5345-5771	WLAN (5470-5725MHZ)	4.87	4.82

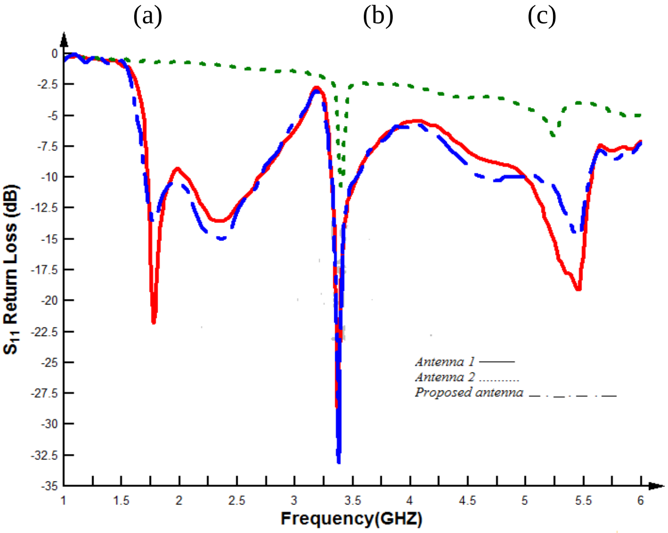
ECC should be less than 0.5 for all diversity applications. The proposed MIMO antenna value is less than 0.025 for all the desired frequency bands. The diversity gain is approximately 10dB for all bands in the simulated results.

C.Design consideration

The design of antenna 1 is the full ground. The result of s11 is only two narrow bands with very low return loss and s21 result shows the multiband with better return loss. So we need to improve the return loss of s11 in the ground side two l- shaped ground branches are introduced. The ground branches are used to improve the return loss .In antenna2 results shows the all return loss in below -15 dB and the s21 the same frequency band of antenna1 but the return loss is reduced.



(a) (b) (c)



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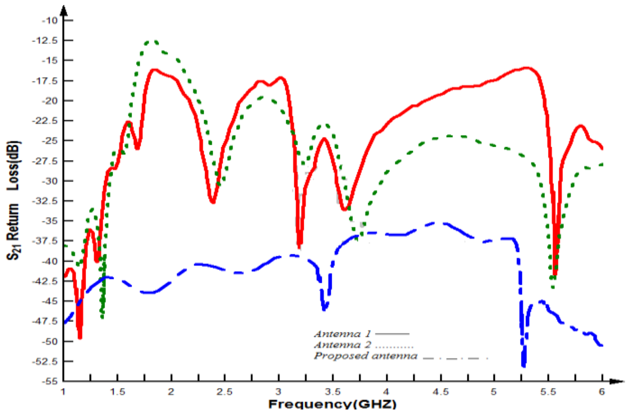


(e)

Fig.5. (a) Antenna1 (b) Antenna2(c) Proposed antenna (d) Simulated S11 and S21 of the antenna1, antenna 2, and proposed antenna compared results

The proposed multiband planar MIMO antenna having the ground plane m-shaped neutralization line in the ground plane. The M-shape neutralization line are used improve the mutual coupling and achieve all bands resonant frequency, isolation and bandwidth. Compared to antenna1 and antenna2 the proposed MIMO antenna having the good performance. The return losses of all the bands are below -15dB and above -30dB.

D.VSWR

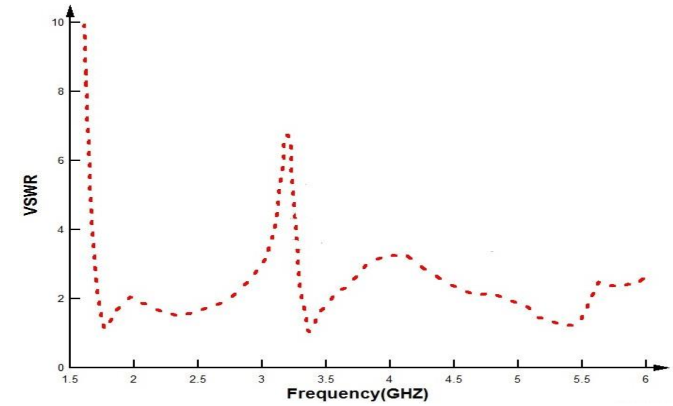
The Voltage Standing Wave Ratio (VSWR) is a measure that numerically describes how well the antenna is impedance matched to the radio or transmission line connected to it. It is also referred as Standing Wave Ratio. It is a function of reflection coefficient, which describes the power reflected from the antenna.

$$VSWR = \frac{1+|\acute{\Gamma}|}{1-|\acute{\Gamma}|} \quad (2)$$

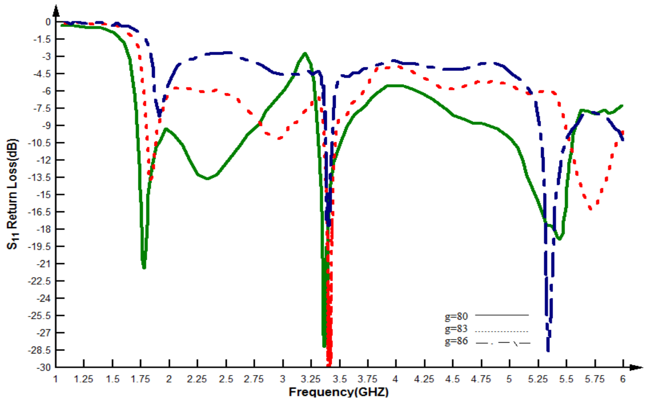
The proposed MIMO antenna having the four frequency bands. All the bands having the VSWR value below two. The efficient antenna having the VSWR 1 to 2.the proposed MIMO antenna having the all the VSWR value is 1 to 2 shown in fig. The values in below table.2 shows the parameters we obtained for different frequencies for our proposed antenna structure.

Table.2. Obtained parameters for proposed structure

Frequency (GHZ)	1.8	2.4	2.6	3.5	5.5
Radiation efficiency	84.3	84.8	81	69.1	64.2
Gain(dB)	4.5	4.43	4.08	2.86	2.65
VSWR	1.51	1.17	1.07	1.07	1.07



(a)



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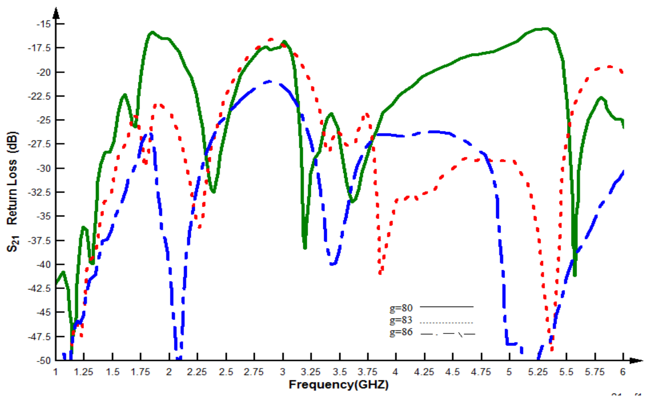

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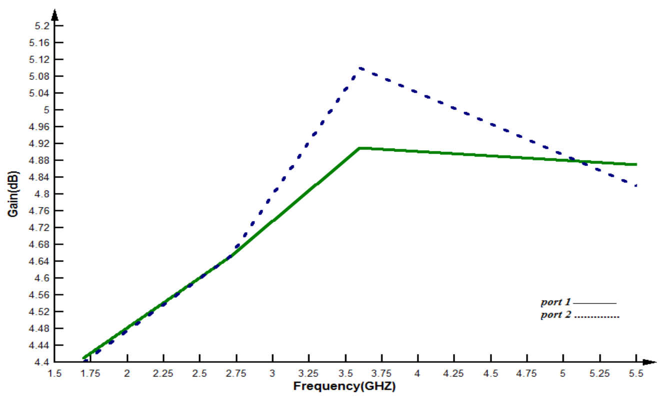

(d)

Fig.6. (a),(b) & (c) Frequency vs. VSWR (d) simulation results gain plot at port1 and port2 excitation. (Port1 excited, port2 excited ………..)

IV. CONCLUSION

A planar multiband antenna covering GSM1800, LTE 2300, WiMAX and WLAN has been explained in this paper. A proposed printed MIMO antenna consists of a two symmetric inverted L-shaped monopole antennas to improve the isolation. To validate the simulated results a prototype is fabricated and tested. The isolation achieved is greater than 15db for all desired frequency bands. The proposed multiband planar antenna is low cost and compact. The simulation result shows the good performance of MIMO antenna system.

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