# **A** Compact MIMO Antenna for Wireless Internet access Application

Prof. Sachin s. Khade[1]
*Yashwantrao chavan college of Engg. Nagpur , India,*
*sac_mob@rediffmail.com*

Priya G. Chore[2]
*Yashwantrao chavan college of Engg. Nagpur, India,*
*priyachore14@gmail.com*

Prof. S.L.Badjate[3]
*S.B.J.I.T., Nagpur, India*
*s_badjate@rediffmail.com*

***Abstract***—A compact multiple-input-multiple-output (MIMO) antenna loaded with split ring resonators (SRR) for the miniaturization of the antenna size is proposed. SRR basically improves the reflection coefficient and VSWR to achieve miniaturization. Proposed antenna consists of two symmetric monopoles at the top and on the ground plane, metal strip with a removal of two triangles, a square ring is presented. Metal strip acts as a reflector which separates the radiation patterns of two monopoles to decrease the unwanted mutual coupling. A square ring helps to improve the reflection coefficient and total antenna gain with slight increment in isolation. In this way, a bandwidth of 2 GHz with S11< -10 dB and S21< -17 dB is achieved, which covers 3.6 GHz, 4.9 GHz and 5GHz bands of IEEE 802.11 workgroup for WLAN, 2.5/3.5-GHz WiMAX and the lower UWB band (3.1–4.8 GHz) operation. This shows that given antenna can serve as a phone antenna to avoid multipath fading by providing spatial and pattern diversity.

***Index Terms*—Multiple-input multiple output (MIMO) antenna, phone antenna, Defective ground structure (DGS), Voltage standing wave ratio (VSWR), Split ring resonator (SRR).**

## I. INTRODUCTION

IMO technology has recently emerged as a new Mparadigm to achieve very high bandwidth efficiencies, large data rates and reliability in modern wireless communication. The MIMO technology was first studied by the Pioneer Foschini (1998). It consists of multiple antennas at both transmitter and receiver along with proper MIMO encoding and decoding algorithms. MIMO antenna designing aspects like radiation pattern of antenna array configuration, mutual coupling reduction techniques, correlation between the antennas, polarization of the pattern and their impact on channel capacity etc. plays an important role in achieving high data rate. Out of these mutual coupling reduction techniques are the most important aspects in which this paper focus on diversity techniques, DGS (Defective Ground Structure).

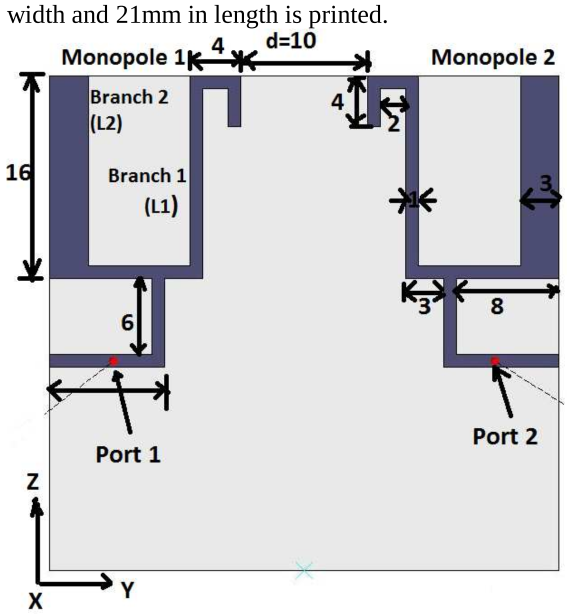
Various techniques have been introduced to enhance isolation between the elements of a MIMO antenna. The mutual coupling between the antenna elements is reduced by using two novel bent slits etched on GP.[1] Antenna structure loaded with Complementary split ring resonators (CSRR) reduces the area of individual patch.[2] Defected ground plane structure is used to enhance the isolation between antenna elements.[3] Two U shaped slots are used to reduce the mutual coupling effect between two dual-broadband antenna elements.[4] Three slits etched into the ground plane reduces the mutual coupling effect introduced between two antenna elements.[5] Parasitic elements were added to improve the port isolation of a MIMO antenna.[6] Inverted L and T shaped Ground branches were applied to achieve low mutual coupling within a narrow frequency band.[7] Two simple stubs and ground strips were applied to achieve isolation between two elements and increase the bandwidth.[8] All of the aforementioned techniques decreases the reflection coefficient, and therefore a wide impedance bandwidth with high isolation is difficult to obtain.

A compact wideband MIMO antenna with high isolation is presented in this paper. The MIMO antenna consists of two dual-branch monopoles of size $18\times15\, mm^2$. Traditionally, slits were mainly used to reduce mutual coupling of MIMO antennas, but this approach usually deteriorate the reflection coefficient. In this design, square ring along with a SRR on the ground plane is applied, which can avoid this problem. At the lower frequencies, they can reduce the mutual coupling resulted from surface currents and have slight effect on the reflection coefficient. Two triangles are cut from the ground plane to change the distribution of the ground surface currents, and therefore the reflection coefficient and isolation of the system are improved. Moreover, a metal strip located between the two monopoles is used to decrease the mutual coupling caused by near-field.[1] Thus, the mutual coupling between the two monopoles is further reduced. This antenna resonates at 2.59 GHz, 4.5 GHz and 4.76GHz with a total bandwidth of about 2 GHz with S11< -10 dB and S21< -17 dB from 3 to 5 GHz is achieved.

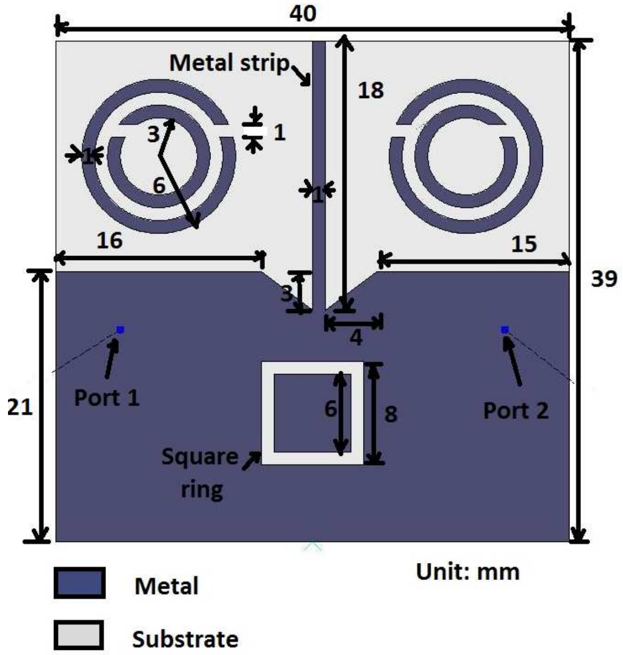
The structure of the proposed MIMO antenna is shown in Section II. In Section III, the working mechanism of the MIMO antenna is investigated. In Section IV, the simulated results of impedance, VSWR, radiation pattern, total maximum gain are discussed. Finally, a conclusion is given in Section V.

## II. CONFIGURATION OF THE PROPOSED MIMO ANTENNA

The geometry of the proposed MIMO antenna is illustrated in Fig. 1. The MIMO antenna consists of two symmetric dual-branch (branch 1 with length of L1=30 mm and branch 2 with length of L2=28 mm) monopoles. It is printed on the upper part of a partially grounded FR4 substrate with dimensions $39 \times 40 \times 1.6\, mm^3$ and relative permittivity 4.4. On the back surface of the substrate, the main rectangular ground plane of 40mm in width and 21mm in length is printed.




(a)




(b)

Figure 1 Structure of proposed MIMO antenna (a) front view (b) back view

In order to reduce the mutual coupling caused by the surface currents and improve the impedance matching, a square slit with a length of 16mm are etched into the ground plane. Split-ring resonators (SRR) are introduced on ground plane to improve the reflection coefficient and VSWR so that miniaturization can be achieved. Two triangles with height 3 mm and width 4mm are cut from the ground plane to change the distribution of the ground surface currents. A metal strip of size $18 \times 1\, mm^2$, which is placed between the two monopoles, is applied to decrease the mutual coupling caused by near-field.

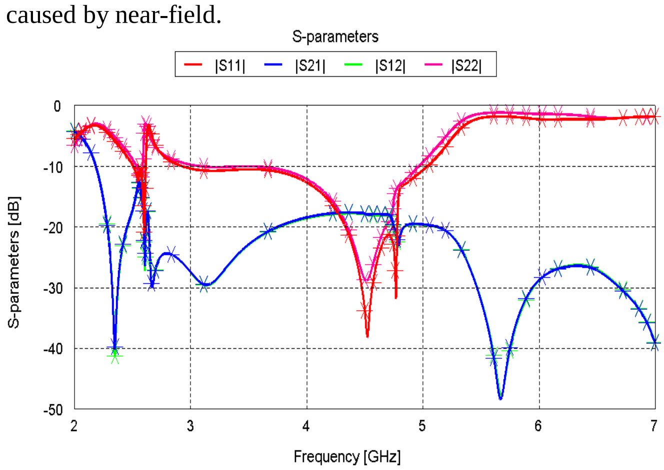


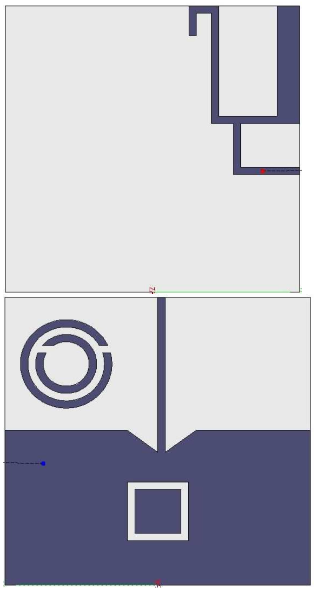
Fig. 2. Simulated S parameters of proposed MIMO antenna

## III. WORKING MECHANISM

The proposed MIMO antenna shown in Fig. 1 has been simulated using CADFEKO 5.5 software. It resonates at 2.595 GHz, 4.5 GHz and 4.76 GHz frequencies with a bandwidth of 2GHz from 3GHz to 5 GHz. S11< -10 dB and S21< -17 dB is achieved which covers the following bands 2.5/3.5-GHz WiMAX and the lower UWB band (3.1–4.8 GHz). The actual working mechanism is explained below.

### *A. Dual-Branch Monopole Antenna*

The dual-branch monopole antenna shown in Fig. 4 can help to understand the requirement of the proposed MIMO antenna. The radiation pattern shown in figure 6 and 8 shows that MIMO antenna radiates more power in specific direction and can also provide more gain.



(a) (b)

Fig. 3. Structure of dual-branch monopole antenna (a) Front view (b) Back view

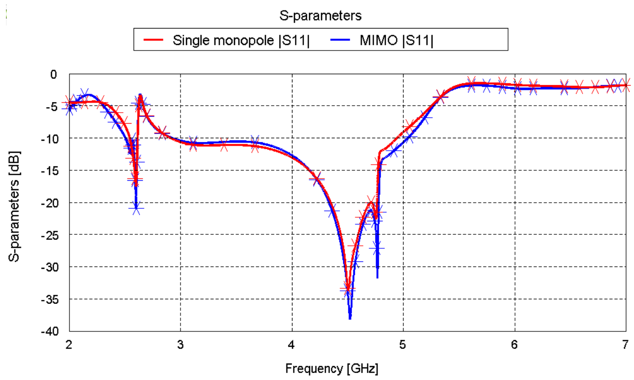



Fig. 4. Comparison between S11 of dual-branch monopole antenna and MIMO antenna

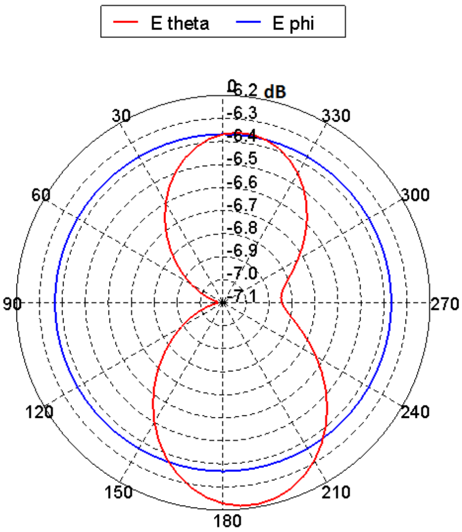



Fig. 5. Simulated radiation pattern of dual-branch monopole antenna

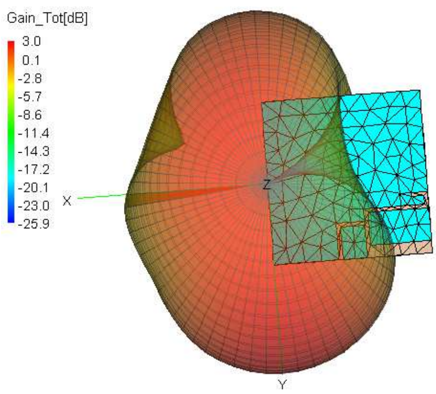



Fig. 6. Gain of dual branch monopole antenna

### *B. Implementation of a square ring*

To analyse the working mechanism of the square ring described in Section II, two more configurations will be investigated in this section. They are: 1) MIMO monopole antenna with a conventional rectangular ground plane and 2) MIMO monopole antenna with a square ring etched from a conventional rectangular ground plane. The S-parameters for the two configurations are given in Fig.7. Strong near-field coupling and surface current coupling are induced when the two elements are placed closely. In order to improve the reflection coefficient and the isolation, a square ring is applied as shown in Fig. 1. The antenna with a square ring has better reflection coefficient and higher isolation than the MIMO antenna with a conventional ground plane. Thus, it can be concluded that a square ring improves the reflection coefficient and also enhance the isolation effectively. In [3], slit was already used to improve isolation, although these slits had negative effect on the impedance matching, and a wide impedance bandwidth was difficult to obtain. However, a square ring applied in this paper can avoid this problem. A ring which has square structure, which can help to reduce the effect of surface currents on the ground plane and improve the current distribution at the lower part of the impedance bandwidth shown in fig 8 and 9 .

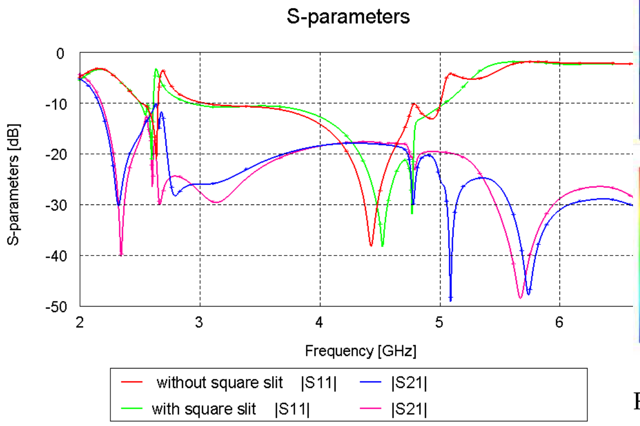



Fig. 7. Comparison between S parameters for antenna without and with square ring on ground plane.

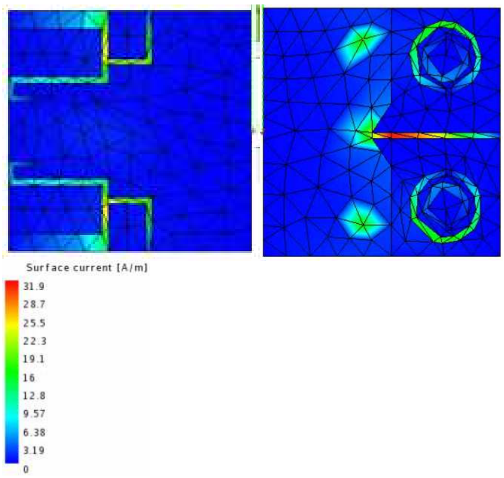



Fig. 8. Average current distribution of the MIMO antenna with conventional rectangular ground plane at 2.5GHz.

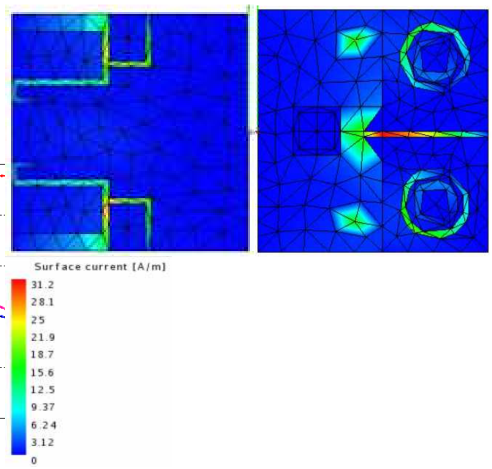



Fig. 9. Average current distribution of the MIMO antenna with a square ring etched from a conventional rectangular ground plane at 2.5 GHz.

*C. Discussion of Metal Strip and Cutting of Triangles*

There is strong near-field coupling apart from the ground surface currents coupling. In order to reduce the near-field coupling, the metal strip shown in Fig. 1 is used. The proposed MIMO antenna depicted in Fig. 1 provides an 8 dB improvement of isolation over the case with a square slit etched into a conventional rectangular ground plane (see Fig.). The metal strip can be treated as a reflector of electromagnetic wave [7]. The reflector separates the radiation patterns of the two monopoles to decrease the unwanted mutual coupling resulted from the near-field, thus the isolation is further enhanced. The cutting of two triangles of size from the ground plane is to change the distribution of ground surface currents.

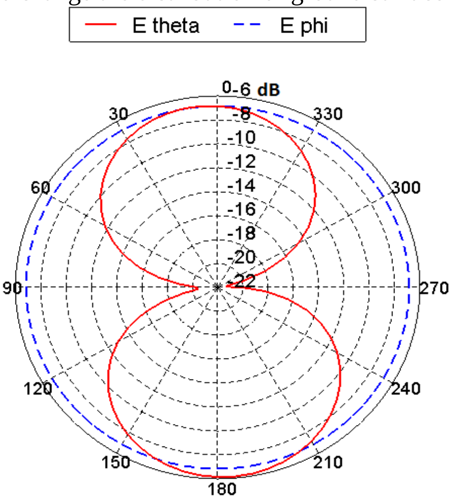



Fig. 10. Radiation pattern of MIMO antenna

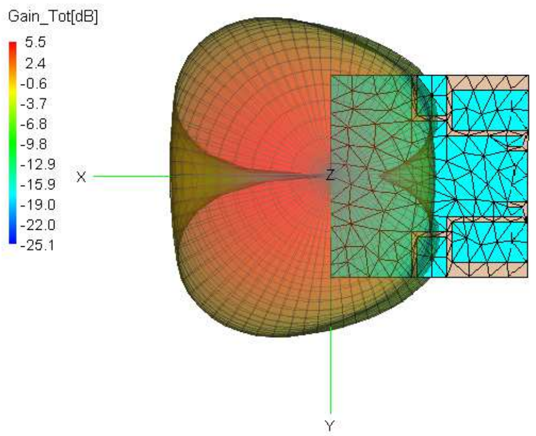



Fig. 11. Gain of proposed MIMO Antenna

### D. *Discussion of split ring resonators (SRR)*

It is made up of two concentric copper rings with slits in each ring. The smaller ring resides inside the bigger ring with spacing and the slits of both rings are opposite to each other. The SRR interacts with axial magnetic field and provides an effective negative permeability around the frequency of its resonance [11]. SRR can be easily fabricated on PCB. It is modelled as a shunt LC resonant circuit whose frequency of resonance depends on its dimensions. It improves the reflection coefficient and voltage standing wave ratio so that miniaturization of antenna size can be achieved. Fig. 12 illustrates the improvement in reflection coefficient due to addition of split ring resonator on the ground plane of antenna.

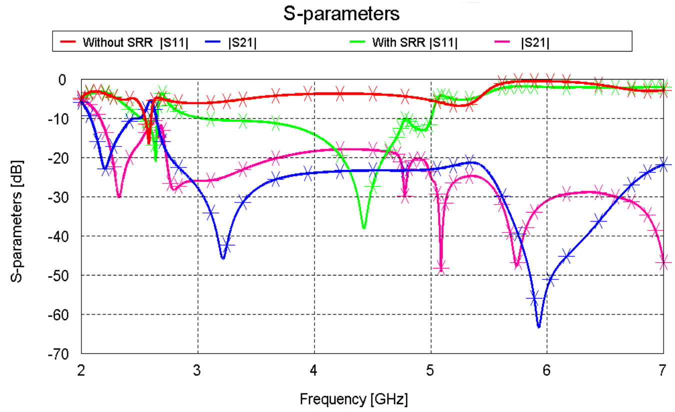
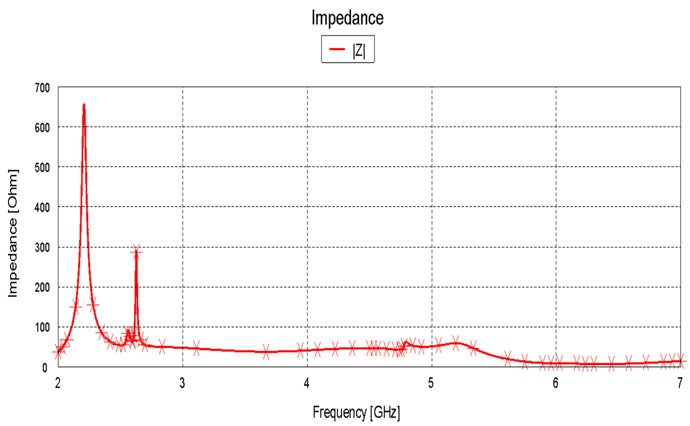


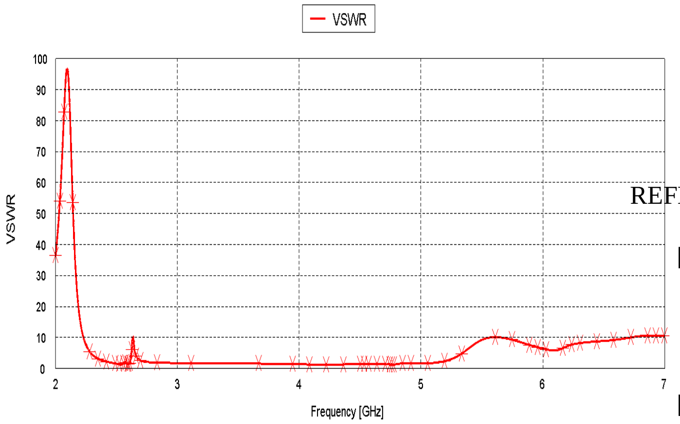

Fig.12. Comparison between S parameters for antenna without SRR and with SRR

## III. RESULTS

Antenna having a dimension of 30×40×1.6 $mm^3$ provides the impedance nearly equal to 50 ohm for the whole bandwidth which is shown in fig 11. Impedance matching at lower frequency is achieved using square ring on the GP explained using fig 8 and 9. Voltage standing wave ratio (VSWR) ranges between 1 and 2, see in fig 12. Antenna resonates at 2.595 GHz, 4.5 GHz and 4.76 GHz (see Fig 2). It provides large bandwidth of about 2GHz along with a total maximum gain of 5.5 dB (see Fig. 11). Proposed MIMO antenna radiates more in 0 and 180 degree direction (see Fig. 10).




(a)




(b)

Fig. 13. (a) Impedance (b) VSWR.

## V. CONCLUSION

A compact wideband MIMO monopole antenna has been investigated. The compact sizes of the monopole and the ground plane are 18×15 $mm^2$ and 21×40 $mm^2$, respectively. A bandwidth of 2GHz with S11< -10 dB and S21< -17 dB from 3 to 5GHz with a total maximum gain of 5.5dB is achieved. A square slit have been used. At the lower frequencies, they can reduce the mutual coupling resulted from the surface current, and has a slight effect on the reflection coefficient. The resonant modes at 4.5 and 4.76GHz are excited by the square ring to widen the impedance bandwidth. A cutting of two triangles from the ground plane has been introduced to change the distribution of ground surface currents. A grounded metal strip located between the two monopoles has been used to decrease the mutual coupling caused by near-field, and the isolation of the proposed antenna is further enhanced. The results show that the proposed antenna can be used for wireless internet access application which include WLAN, WiMAX and WiFi so it can serve as a phone antenna to avoid multipath fading by providing spatial and pattern diversity.

## REFERENCES

[1] IEEE Trans. on Antennas and Propagation, published, "A Compact Wideband MIMO Antenna With Two Novel Bent Slits", vol. 60, no. 2, Feb 2012.

[2]7th European Conference on Antennas and Propagation , "A 4-element MIMO Antenna System Loaded with CSRRs and Patch Antenna Elements" in 2013.

[3]IEEE Antennas and Wireless Propagation Letters, "A Dual-Element Dual-Band MIMO Antenna System With Enhanced Isolation for Mobile Terminals.", in vol. 11,2012.

[4]IEEE Antennas and Wireless Propagation Letters published a paper, "A Dual-Broadband MIMO Antenna System for GSM/UMTS/LTE and WLAN Handsets", in vol. 11, 2012.

[5]IEEE published a paper "Tri-Band Antenna with Compact Conventional Phone Antenna and Wideband MIMO Antenna", 2012.

[6]IEEE published a paper "A Dual-slot Diversity Antenna with Isolation Enhancement Using Parasitic Elements for Mobile Handsets" in 2009.

[7]IEEE Transaction on antennas and propagation, "Compact Dual Band-Notched UWB MIMO Antenna With High Isolation",vol. 61, no. 9, September 2013.

[8]IEEE Trans. on analysis and propagation, "A Novel Dual-Band Printed Diversity Antenna for Mobile Terminals", Vol. 55, no. 7, July 2007.

[9]7th European Conference on Antennas and Propagation (EuCAP),"A Compact Ultra wideband MIMO Antenna", 2013.

[10]IEEE published a paper, "A multi-band 2×1 MIMO antenna system consisting of CSRR loaded patch elements", 2013.

[11] IEEE Transaction on microwave theory and techniques, "Magnetism from Conductors and Enhanced Nonlinear Phenomena", Vol. 47, no. 11, November 1999.