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Isolation Enhancement of MIMO Antenna for Wireless Routers in LTE band Applications

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Abstract: ***A compact wireless router multiple-input-multiple output (MIMO) antenna for Long Term Evolution (LTE) 2300 band (2300 – 2400 MHz) and 2500 band (2500-2690 MHz) applications is proposed. The antenna structure consists of two loop parasitic shorted strips and a slot cut between them. The isolating slot not only reduces the coupling between the two monopole antennas, but also improves the bandwidth and efficiency. Without the usage of any additional coupling elements between closely mounted antennas, the proposed antenna achieves isolation of higher than 20 dB, envelope correlation coefficient (ECC) of less than 0.01 and total efficiencies of higher than 82%. A prototype antenna was fabricated and tested for experimental verification. Both simulated and measured data are provided.***

Keywords: LTE, monopole antenna, meander-monopole antenna, multiple-input-multiple-output (MIMO), printed antennas, envelope correlation coefficient (ECC), isolation, mutual coupling

1. Introduction

With the emergence of new wireless standards such as long term evolution (LTE), multiple-input-multiple output (MIMO) technology which uses multiple antennas, has become a very promising technique for enhancing the performance of wireless communication systems [1],[2]. MIMO antennas are capable of inherently, mitigating the effects of multipath, resulting in improved link reliability. Due to this, MIMO systems have become incredibly popular. Wireless communication techniques employing spatial diversity has been developed using multiple transmit and receive antennas. Optimal MIMO performance requires low correlation between signals received by each of the antennas. It is a well known fact that achieving high isolation and low envelope correlation coefficient (ECC) between closely spaced antennas is important in portable MIMO embedded devices where antennas must be designed within a small volume. Various techniques have been studied for the enhancement of isolation between two closely mounted antennas [3]-[7]. An additional coupling element between the two antenna elements [3] and a suspended microstrip line that links the feeding or the shorting strips of the planar inverted-F antennas (PIFAs) [4]- [6] are used to obtain good isolation between the two antennas. Various approaches have also been used to reduce the mutual coupling between the antenna elements, such as neutralization technique, simultaneous matching, etching slits in the middle of the ground plane and using EBG substrates. These techniques either occupy a considerable space on the PCB or need special fabrication techniques.

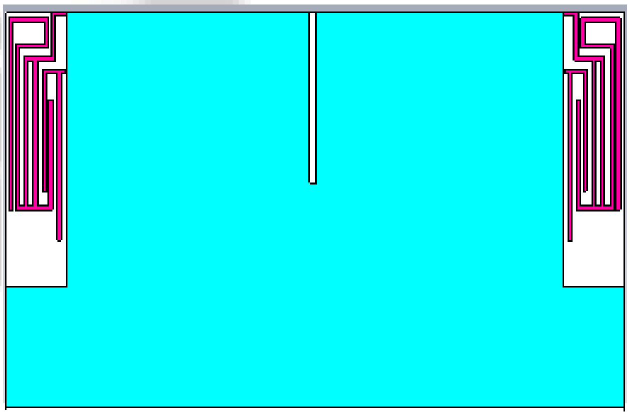


Figure 1(a): Proposed MIMO antenna for wireless routers

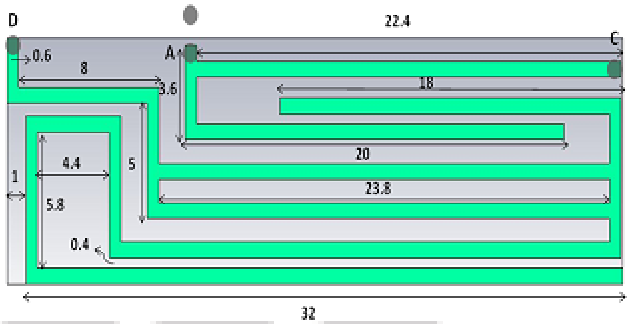


Figure 1(b): Detailed configuration of the proposed MIMO antenna for wireless routers

In this letter, a compact MIMO antenna for wireless routers to cover LTE 2300 and LTE 2500 bands applications are presented by obtaining high isolation and low ECC. Although two antennas are closely arranged, high isolation (>20 dB) can be achieved by an isolating slot introduced between the two antennas. Simulated and experimental results, including S-parameters, radiation patterns, total antenna efficiency and signal correlations are presented and discussed.

2. Antenna Configuration and Design Considerations

Fig.1 (a) shows the structure of the proposed MIMO antenna. It consists of two symmetrical meandered microstrip monopole antenna with an isolating slot printed on a low cost single sided copper-clad FR4 (εr = 4.4, tan δ = 0.02) of 0.8 mm thickness. Overall circuit size is 150 x 150 mm^2. The ground plane at the center of the board is 150 x 130 mm^2. On the either side of the board, 10mm space was reserved to accommodate compact antennas while preserving the rest of the board space for other circuit components. The proposed monopole antenna size is 35 x 10 x 0.8 mm^3. Meanwhile, to minimize manufacturing defects and simplify the dimensional parameters, all monopole strip s in this study have the same width (0.6 mm). Fig.1 (b) shows the detailed geometry of the proposed antenna along with its dimensions. The width of the isolating slot is 1mm and its total length is optimized at about quarter of the wavelength at the center frequency, which is around 30mm using Finite Difference Time Domain commercial software.

3. Results and Discussion

The prototype antenna is shown in Fig. 2. The antenna was fabricated on 0.8 mm thick single sided copper-clad substrate sheet. To feed each antenna element, 50Ω double shielded RG-316 coaxial cables with SMA connectors were used. The cables were stripped and soldered to each monopole antenna and the shielding was grounded.

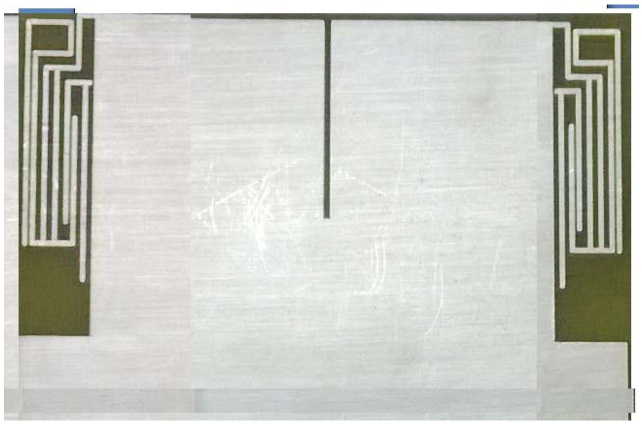
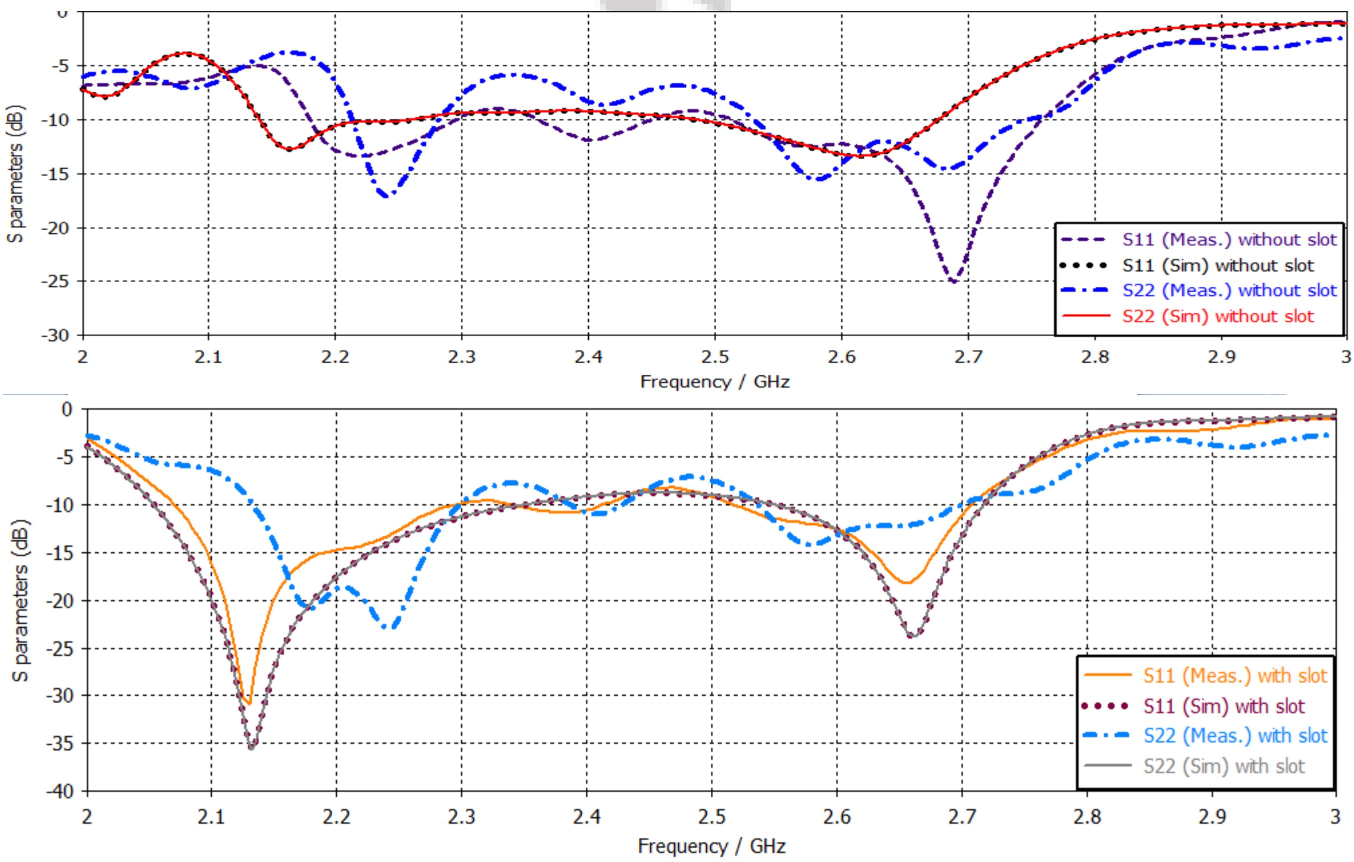


Figure 2: Photograph of the fabricated antenna prototype

Fig. 3 shows the simulated and measured scattering parameter results for antennas 1 and 2. Simulated results show matching (S11 ≤ - 10 dB) from 2050 MHz to 2720 MHz. The simulated isolation is higher than 20 dB and this is generally acceptable for practical MIMO antenna applications. The measured results show matching (S11 ≤ - 10 dB) from 2050 MHz to 2700 MHz. As shown, the slot has increased the isolation between the two ports from -23 to 33 dB, and the isolation is more than -33 dB across the entire bandwidth. It is also observed that the slot has increased the bandwidth of the antennas at 10 dB return loss. However, overall, there is reasonable agreement between the simulation and measurement results.



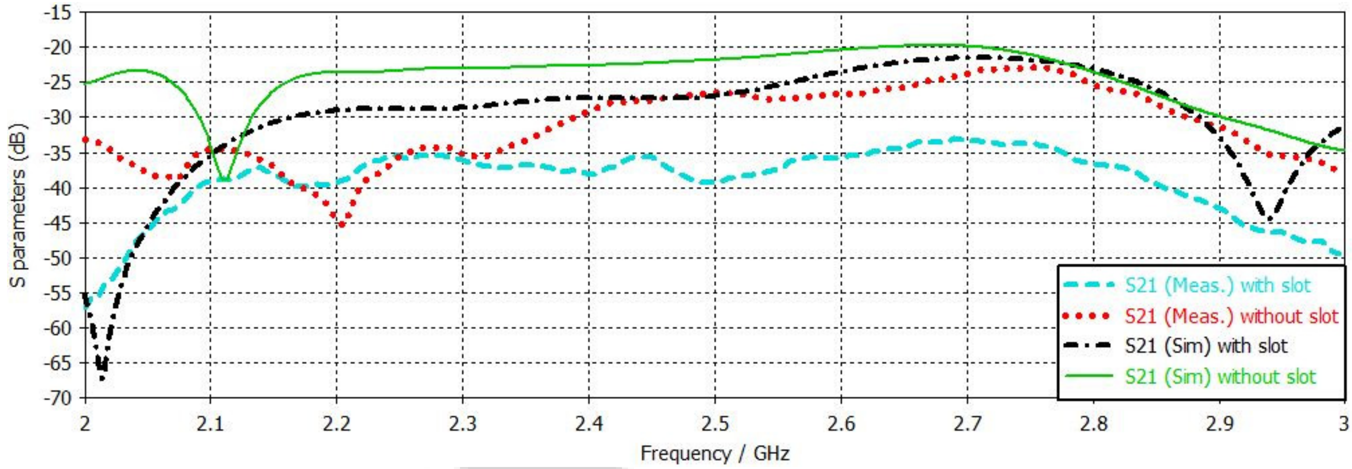


Figure 3: Simulated and measured scattering parameters response versus frequency for antennas 1 and 2 with and without isolating slot

Fig. 4 shows the simulated total antenna efficiency and peak realized gain, which includes losses, for antennas 1 and 2. Efficiency ranges from 82% to 89% in the 4G LTE 2300 and LTE 2500 bands. The peak realized gain ranges from 3.05 to 3.36 dBi in the 4G LTE 2300 and LTE 2500 bands.

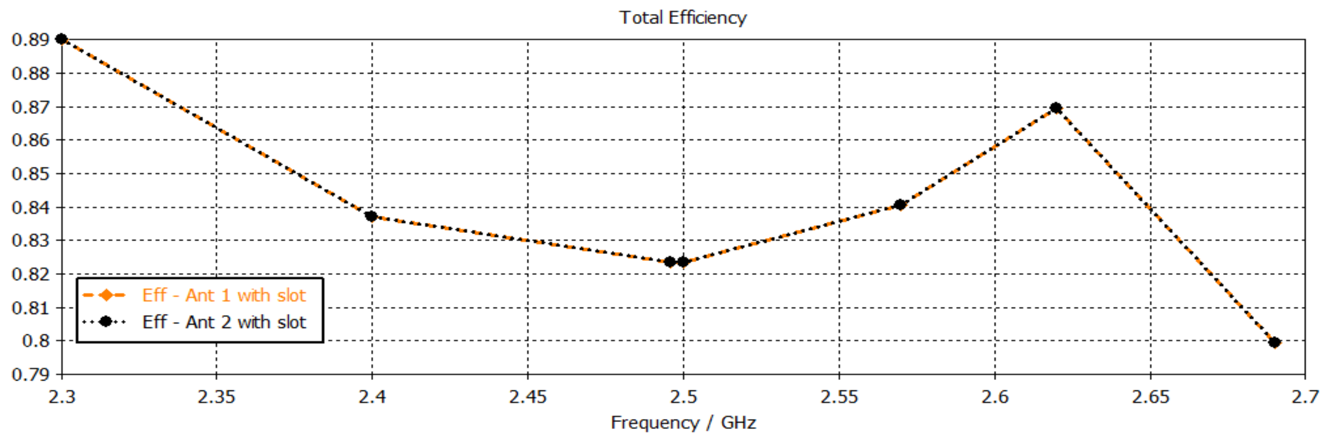


Figure 4: Simulated total antenna efficiency versus frequency of antennas 1 and 2

To demonstrate the effect of the slot on the performance of the antennas, the current distribution on the ground plane with and without the slot obtained at 2.3 and 2.5 GHz are shown in Fig. 5.

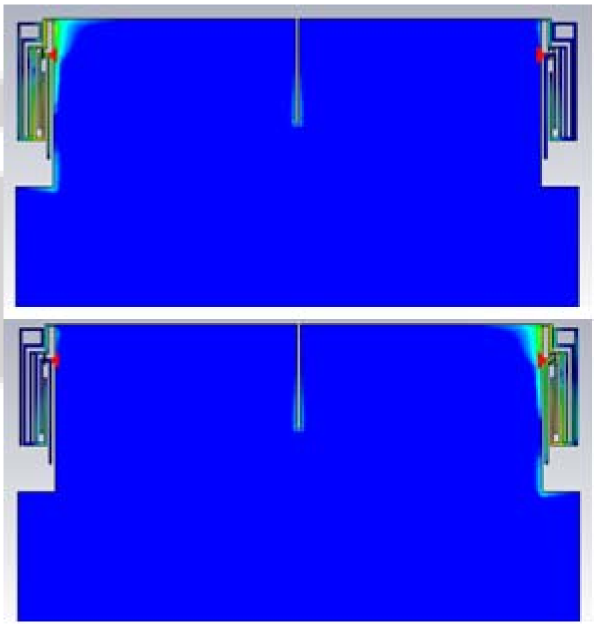


Figure 5: Simulated surface current distribution of the proposed antenna at f = 2.5 GHz

4. Diversity Performance

The envelope correlation coefficient (ECC) is used to evaluate the diversity performance of multi-antenna systems. Computing the envelope correlation coefficient between elements is one way to measure performance of the MIMO systems, which takes mutual coupling into account. In industry, an ECC less than 0.5 is acceptable for mobile portable systems. The ECC can be computed from far field radiation patterns or scattering parameters. The scattering parameter method is a simplified approach and is sufficient for circuit sizes such as a wireless router where antennas are not so tightly placed than in a handheld device such as a cell phone. The S parameters based ECC equation is as follows:

$$\rho_e = \frac{|S_{11}^* S_{12} + S_{21}^* S_{22}|^2}{(1 - |S_{11}|^2 - |S_{21}|^2)(1 - |S_{22}|^2 - |S_{12}|^2)}.$$

The above equation is based on three assumptions: 1) uniform distribution of incident waves in the environment, which is observed in indoor environments; 2) the antennas are excited separately, keeping the other antennas matched terminated; and 3) the antenna system is lossless. Between antennas 1 and 2, there is low envelope correlation as shown in Fig. 6, less than 0.01 in the target bands. This is highly desirable since its correlation may increase once RF circuitry is added. It is observed that the envelope correlation is close to zero over the bandwidth, which means that the patterns of the two antennas are de-correlated and demonstrates excellent diversity condition.

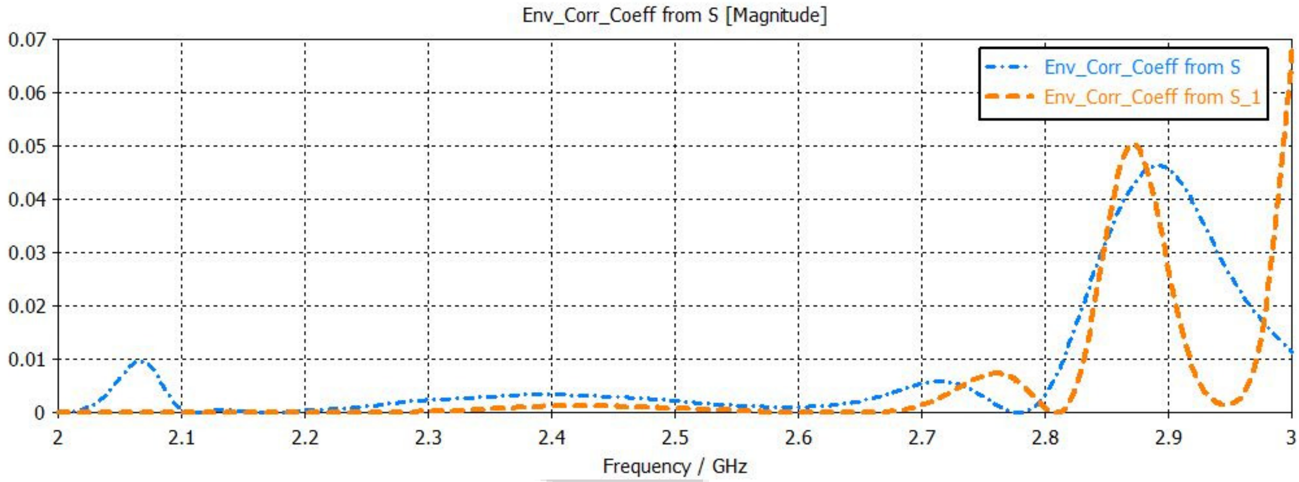


Figure 6: Simulated ECC versus frequency for antennas 1 and 2

The simulated 3-D total gain radiation patterns for antennas 1 and 2 at 2300 MHz, 2400 MHz, 2500 MHz and 2690 MHz are shown in Fig. 7 and Fig. 8. It shows a good omni directional pattern.

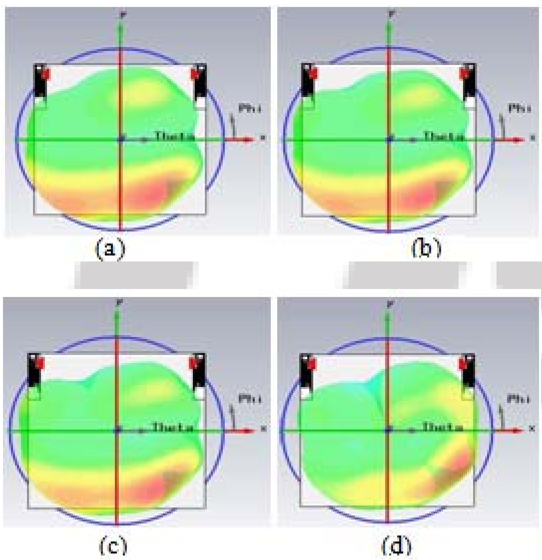


Figure 7: Simulated 3-D total gain radiation patterns of antenna 1 at (a) 2300 MHz (b) 2400 MHz (c) 2500 MHz (d) 2690 MHz

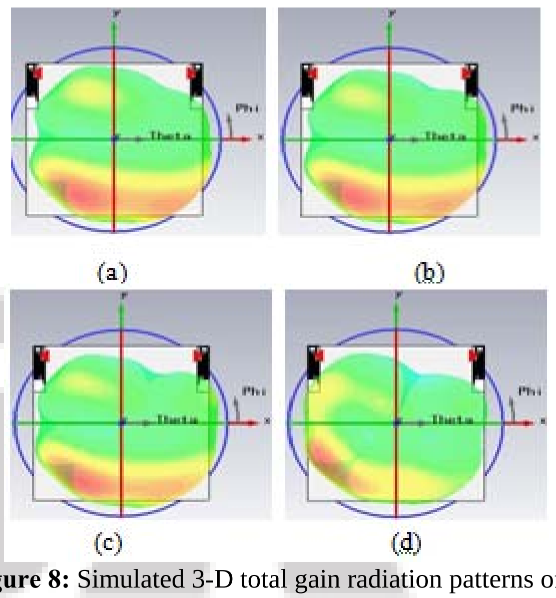


Figure 8: Simulated 3-D total gain radiation patterns of antenna 2 at (a) 2300 MHz (b) 2400 MHz (c) 2500 MHz (d) 2690 MHz

5. Conclusion

A low profile multiband monopole antenna for wireless routers with MIMO implementations is presented, which covers 4G LTE bands (specifically bands 7, 38, 40 and 41). An isolating slot has been used between the two antennas to isolate them. The measured and simulated S parameters show that the slot has improved the isolation. The fabricated antenna structure covers a wide bandwidth between 2.05 to 2.70 GHz, suitable for LTE 2.3 GHz and LTE 2.5 GHz bands. The designed antenna show very low envelope correlation coefficients, near omni directional radiation patterns, reasonable gain and acceptable total antenna efficiency values in almost all target bands.

References

[1] Sean C. Fernandez and Satish K. Sharma, "Multiband Printed Meandered Loop Antennas with MIMO Implementations for Wireless Routers," IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 12, 2013.

[2] Mina Ayatollahi, Qinjiang Rao and Dong Wang, "A Compact High Isolation and Wide Bandwidth Antenna Array for Long Term Evolution Wireless Devices," IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 60, NO. 10, OCT 2012.

[3] Jui-Han Lu and Jia-Ling Guo, "Small-Size Octaband Monopole Antenna in an LTE/WWAN Mobile Phone," IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 13, 2014.

[4] Reza Karimian, Homayoon Oraizi , Saeed Fakhte, and Mohammad Farahani, "Novel Shaped Quad-Band Printed Slot Antenna for WLAN and WiMAX MIMO Systems," IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 12, 2013.

[5] Byeong kwan Kim, Yongsoo Park, Hyunho Wi, Myun-Joo Park, Yonggyu Choi, Jeongkwan Lee, Woojae Jung, Daewoong Kim, and Byungje Lee, "Isolation Enhancement of USB Dongle MIMO Antenna in LTE 700 Band Applications," IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 11, 2012.

[6] Sang-Hyeong Kim, Zhe-Jun Jin, Yoon-Byung Chae, and Tae-Yeoul Yun, "Small Internal Antenna Using Multiband, Wideband, and High-Isolation MIMO Techniques," ETRI Journal, Volume 35, Number 1, February 2013.

[7] Yogesh Kumar Choukiker, Satish K Sharma, and Santanu K Behera, "Hybrid Fractal Shape Planar Monopole Antenna Covering Multiband Wireless Communications with MIMO Implementation for Handheld Mobile Devices,"

[8] Omar A. Saraereh, M. A. Smadi, A. K. S. Al-Bayati, Jasim A. Ghaeb, Qais H. Alsafasfeh, "A Novel Low-Profile Coupled-Fed Printed Twelve-Band Mobile Phone Antenna with Slotted Ground Plane for LTE/GSM/UMTS/WIMAX/WLAN Operations," International Journal of Electrical, Electronic Science and Engineering Vol:7 No:8, 2013.

[9] Xiang Zhou, XuLin Quan, and RongLin Li, "A Dual-Broadband MIMO Antenna System for GSM/UMTS/LTE and WLAN Handsets," IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 11, 2012.