Mimo Antenna for LTE Advance Application

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Abstract. In this paper, the MIMO antenna design for LTE Advance Application is realized. The paper focused on designing high gain MIMO antenna for LTE Advance Application. The purpose of designing a MIMO antenna is to fix the problem of low/moderate gain of SISO antenna since to have higher gain in LTE Advance normally is by having array antenna which lead to larger antenna and higher cost and mutual coupling between MIMO before can cause loss of spectral efficiency and degrade performance of a MIMO system. The designed antenna used FR-4 board as the substrate material due to its good parameters for most application. It is also more available and much cheaper than any other PCB material. Meanwhile, copper has been chosen as conductive material which copper is high relative and also cheap. For the designing stage, Advance Design System (ADS) software has been used to design the antenna. The ADS software also has been used for the simulation of the designed antenna in terms of return loss (S11) and (S22), mutual coupling (S12) and (S21), gain, directivity, radiation pattern, power radiated and also impedance matching. For the measurement stage, the fabricated antenna has been using by Vector Network Analyzer (VNA). From this project, it can be seen that the measurement results were slightly different from the simulation results due to a few factors such as cable losses, and also soldering technique. However, the designed antenna still met the requirement of efficiency which is less than -10 dB of return loss and get at a frequency of 2.5 GHz.

1. Introduction
MIMO stands for Multiple Input Multiple Output which is an antenna technology for wireless communications that uses multiple transmitters and receivers to transfer more data at the same time. Wireless capacity can be increased by transmitting multiple data streams at the same time. Compare to a single antenna system, additionally of MIMO antennas can improve link reliability and experience less fading. The combination of antennas at each end of the communications circuit is to minimize errors and optimize data speed. MIMO is being used increasingly to improve levels of efficiency in many of high data rates technologies such as cellular technologies, Wi-Fi and others wireless. MIMO is one several forms of smart antenna technology for wireless communications, the others being SISO (Single Input Single Output), MISO (Multiple Input Multiple Output) and SIMO (Single Input Multiple Output) [1].
Long Term Evolution-Advanced (LTE-Advanced) is a cellular networking standard that offers higher throughput than its predecessor, the Long Term Evolution (LTE) standard. LTE-Advanced also is the next major step of our LTE networks and mobile broadband access technology founded as a response to the need for the improvement to support the increasing demand for high data rates. The Long Term Evolution-Advanced networks can deliver up to 1 GB per second of data, compared to a maximum of 300 MB per second over LTE networks. They begin on work of developing of LTE-Advanced standard is after the launch of the first LTE technologies, which did not meet the International Telecommunication Union (ITU) requirements for 4G [2]. LTE Advanced introduced a few new functionalities such as Carrier Aggregation (CA), enhanced use of multi-antenna techniques and support Relay Nodes. Designed of all these are to increase the stability, bandwidth and speed of LTE networks and connections.

In order for cellular telecommunications technology always able to keep pace with technologies that may compete, it is necessary to ensure that new cellular technologies are being formulated and developed. This is the reasoning behind starting the development of the new LTE Advanced systems, proving the technology and developing Advance standards. The main problem in this research is want to encounter is the low/moderate gain of SISO antenna for LTE Advance application. To overcome this problem, we need to apply MIMO antenna in order to have a high gain for LTE Advance communication [3]. Current practice to have higher gain in LTE Advance normally is by having array antenna which leads to larger antenna and higher cost whereby having MIMO antenna, array antenna could be avoided and resulted in small compact antenna and lower cost for implementation. Next, mutual coupling between antennas (electromagnetic interactions between the elements) can cause loss of spectral efficiency and degrade the performance of a MIMO system [4]. In order to overcome this problem, specific techniques need to be applied towards the antenna design in order to reduce the mutual coupling by MIMO antenna design [5].

2. Antenna Design, Fabrication and Performances

For the initial step, the MIMO antenna with Spatial Diversity technique was designed. MIMO capacity gains come from taking advantage of Spatial Diversity in the radio channel. Mutual coupling, which mainly arises due to the smaller spacing between the two antennas. By increasing the distance of the patch antennas, the mutual coupling can be reduced. However, the distance between the antennas cannot be maintained to large, since MIMO systems have their major applications. It was observed that the longer distance between edge to edge MIMO antenna, the higher gain and lower mutual coupling can get. But, a distance of antenna elements in practice cannot be extended beyond a certain level which limits the use of Spatial Diversity to achieve the desired spectral efficiencies and transmission qualities [6].

Meander line resonator is inserted between the radiating elements for better isolation with a minimum level of cross-polar power as shown in Figure 1. Design Meander line resonator act as a decoupling unit which is shown in Figure below. Meander line resonator has four long arms with an opposite current flow. Resonator designed to stop the surface current at the resonant frequency. A Meander Line Resonator act as a band resonator to stop the surface current from one unit cell to another unit cell in order to lower the mutual coupling [10]. The distance of $\pi/2$ was obtained to get the good performances of MIMO. A distance of $\pi/4$ is a minimum to get a significant change in the field distribution. In a standing wave pattern this would be enough to go from a node to an antinode, which would be perfect of MIMO. The coupling between the antennas a larger spacing is desirable, the $\pi/2$ would be a good rule-of-thumb [11].
Some important parameters of the designed antenna are optimized to obtain the best result in terms of compact size, high gain and wide bandwidth. The optimized dimensions for the antenna are tabulated in Table 1. Measurements of gain, patterns and s-parameter have been performed using the setup consisting of Agilent ENA 8051C and Anechoic Chamber. The horn antenna is used as the transmitting antenna, whereas antenna under test (AUT), MIMO as the receiver. Both antennas are placed at DAUT about 0.84 m apart.

### Table 1. Parameters Value of MIMO Antenna Design

| Parameter     | Quantity   |
|---------------|------------|
| Frequency     | 90.0 mm    |
| Patch width   | 45.0 mm    |
| Patch Length  | 7.50 mm    |
| Structure width | 8.00 mm  |
| Slot          | 32.0 mm    |

### 3. Simulation results
MIMO is multiple input multiple outputs which it’s has two ports when simulated. The return loss was observed at (S11) and (S22). Return loss or reflection coefficient describes how much of an electromagnetic wave is reflected by an impedance discontinuity in the transmission medium [12]. In order for the antenna to have a good performance, its return loss should be less than -10 dB at the desired frequency [7]. Based on Figure 2, the achieved value for return loss (S11) at 2.5 GHz is -17.919 dB. Next, for return loss (S22) at 2.5 GHz is -18.022 dB.
Figure 2. Plot for S11 and S22 of the MIMO Antenna
Mutual Coupling means the interaction between the antenna elements in an array. The current in which developed in each antenna elements of an array depends on their own excitation and also the contributions from adjacent antenna elements [8]. It’s also can be described by one antenna’s receiver when the other antenna nearby is operating. The good value for mutual coupling is should be less than -20 dB [9]. Figure 3 shows the good mutual coupling of MIMO antenna.

![S11 and S22 plots](image1)

(S12)  (S21)

Figure 3. Plot for S12 and S21 of the MIMO Antenna

The gain and directivity of the simulated result were observed at the ADS software. The result shows the gain of the MIMO antenna is 6.0 dB and the directivity 8.8 dBi where the gain is a double increase than in single antenna as it should be [10]. The radiation pattern for the simulated results was observed through the ADS software. The result is in 3D and 2D views in simulation as shown in Figure 4 and Figure 5 respectively. Figure 5 shows the radiation pattern in the azimuth plane for the proposed MIMO. The antenna is observed to be radiating uni-directionally due to its small side and back lobes [13].

![Gain and Directivity plots](image2)

Top view  Bottom view

![Front and Back views](image3)

Front view  Back view
4. Conclusion
The design of MIMO antenna for LTE Advance application is presented. This paper aimed at the design of a high gain MIMO antenna for LTE Advance using a special technique to produce MIMO antenna for gain enhancement to overcome the problem occurred in single element antenna that has initial of a low gain. The designed antenna will be fabricated. Isolation between the microstrip elements is increased by placing the metal structure between antenna elements. It is observed, at this project by using commercial software Advance Design System and measurement that the designed MIMO antenna system will have sufficiently high return loss and low mutual coupling. It is found that
the developed antenna system meets the requirement for LTE-Advanced (2.5 GHz – 2.57 GHz) at this project, the frequency that was decided for the design single element antenna initial is 2.5 GHz. The good return loss < -10 dB, Mutual Coupling < -20 dB was achieved to get the good performance of MIMO antenna. The antenna must be matched nearly to 50 Ω impedance in the frequency range covering LTE-Advanced band.

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References

[1] A. A. Asaker, R. S. Ghoname, and A. A. Zekry, “Design of a Planar MIMO Antenna for LTE-Advanced,” Int. J. Comput. Appl., vol. 115, no. 12, pp. 27–33, 2015.

[2] B. K. Lau and Z. Ying, “Antenna design challenges and solutions for compact MIMO terminals,” Final Progr. B. Abstr. - iWAT 2011 2011 IEEE Int. Work. Antenna Technol. Small Antennas, Nov. Struct. Innov. Metamaterials, no. 1, pp. 70–73, 2011.

[3] C. R. Shah, “Performance and Comparative Analysis of SISO ,SIMO,MISO, MIMO,” Int. J. Wirel. Commun. Simul., vol. 9, no. 1, pp. 1–14, 2017.

[4] Katie, M.O., Jamlos, M.F., Mohsen Alqadami, A.S., Jamlos, M.A., "Isolation enhancement of compact dual-wideband MIMO antenna using flag-shaped stub", (2017) Microwave and Optical Technology Letters, 59 (5), pp. 1028-1032. Cited 5 times.

[5] M. A. Jamlos, M. F. Jamlos, S. Khatun, and A. H. Ismail, “High performance of coaxial feed UWB antenna for human brain microwave imaging,” ISTT 2014 - 2014 IEEE 2nd Int. Symp. Telecommun. Technol., pp. 72–75, 2015.

[6] Jusoh, M., Jamlos, M.F., Kamarudin, M.R., Sabapathy, T., Jais, M.I., Jamlos, M.A., "A fabrication of intelligent spiral reconfigurable beam forming antenna for 2.35 2.39GHz applications and path loss measurements", (2013) Progress in Electromagnetics Research, 138, pp. 115-131.

[7] M. Ezzat and C. S. Lee, “A simple optimization technique for reducing mutual coupling between two coupled antennas,” IEEE Antennas Propag. Soc. AP-S Int. Symp., vol. 2015-Octob, pp. 430–431, 2015.

[8] Nayan, M.K.A., Jamlos, M.F., Jamlos, M.A.," Mimo circular polarization array antenna with dual coupled 90° phased shift for point-to-point application", (2015) Microwave and Optical Technology Letters, 57 (4), pp. 809-814.

[9] J. Ghosh, S. Ghosal, D. Mitra, and S. R. Bhadra Chaudhuri, “Mutual Coupling Reduction Between Closely Placed Microstrip Patch Antenna Using Meander Line Resonator,” Prog. Electromagn. Res. Lett., vol. 59, no. April, pp. 115–122, 2016.

[10] Z. Wang, L. Zhao, Y. Cai, S. Zheng, and Y. Yin, “A Meta-Surface Antenna Array Decoupling (MAAD) Method for Mutual Coupling Reduction in a MIMO Antenna System,” Sci. Rep., vol. 8, no. 1, pp. 1–9, 2018.

[11] S. Dhamankar and S. Lopes, “Mutual Coupling Reduction Techniques in Microstrip Patch Antennas: a Survey,” Int. Res. J. Eng. Technol., pp. 2395–56, 2016.

[12] M. A. Jamlos, M. F. Jamlos, S. Khatun, and A. H. Ismail, “An optimum quarter-wave impedance matching feedline for circular UWB array antenna with high gain performance,” IEEE Symp. Wirel. Technol. Appl. ISWTA, pp. 165–169, 2014

[13] B. T. P. Madhav, J. C. Rao, K. Nalini, and N. D. Indira, “Analysis of Coaxial Feeding and Strip Line Feeding on the Performance of the Square Patch Antenna,” Int. J. Comp. Tech. Appl., vol. 2, no. 5, pp. 1352–1356, 2011.