A Compact 2-Port Half-Shaped Cubical PIFA Design for Pattern Reconfigurable MIMO Terminal

Surentiran Padmanathan, Azremi Abdullah Al-Hadi, Ping Jack Soh, Mohd Faizal Jamlos
Advanced Communication Engineering (ACE)
Center of Excellence
School of Computer and Communication Engineering
Universiti Malaysia Perlis
01000 Kangar, Perlis, MALAYSIA

***Abstract* – This paper presents a pattern reconfigurable Multiple Input Multiple Output (MIMO) Half Shaped Cubical Antenna (HSCA) in user terminal. Two HSCAs were designed where a single HSCA is formed by combining 3 Planar Inverted F Antenna (PIFA) elements. PIN diodes are used to perform the pattern reconfiguration. All the 3 PIFA elements at both ports are operating at LTE-U band at 5.3GHz, 5.6GHz and 5.7GHz respectively. The reflection coefficient for all PIFA elements are less than -10dB. The maximum realized gain for each PIFA element at both ports are 4.32 dB, 7.18 dB and 6.91dB respectively. The Envelope Correlation Coefficient (ECC) between 2 ports is smaller than 0.1. The high gain and low envelope correlation make the MIMO antenna suitable for mobile terminal applications.**

***Index Terms* — Mobile terminal, reconfigurable MIMO, PIFA, envelope correlation Coefficient, radiation pattern.**

1. Introduction

With the great achievement of Multiple Input Multiple Output (MIMO) technology and Long Term Evaluation (LTE) in mobile communications [1], the usage of smart mobile phones among users has become more popular. However, the bandwidth allocated for LTE band is becoming more populated as the number of mobile devices increases rapidly [2]. Since the industries are preparing to provide connectivity of Gigabit per second (GBps) to mobile devices in the near future, it's become a huge challenge for them to provide higher data with the limited size of bandwidth and higher number of mobile devices.

Utilizing the large bandwidth in the unlicensed spectrum at 5GHz would become a promising solution to provide higher data rate for mobile devices. Industries are looking forward to extend the benefit of LTE communications in the unlicensed spectrum or simply called as LTE-U [3]. The channel capacity, also can be further enhanced by using the reconfigurable antennas which capable of changing the direction of the radiation pattern. The signal to noise ratio (SNR) of a mobile terminal can be increased by switching the radiation pattern of the antenna towards the higher signal strength direction [4]. Since the LTE-U and reconfigurable antennas are becoming more popular among telco industries, in this paper, we proposed a reconfigurable radiation pattern MIMO half shaped cubical PIFA that provides different radiation patterns with high gain at 5GHz spectrum. The reconfiguration of radiation pattern is achieved by using the PIN diodes to switch the radiation pattern.

2. Antenna Design

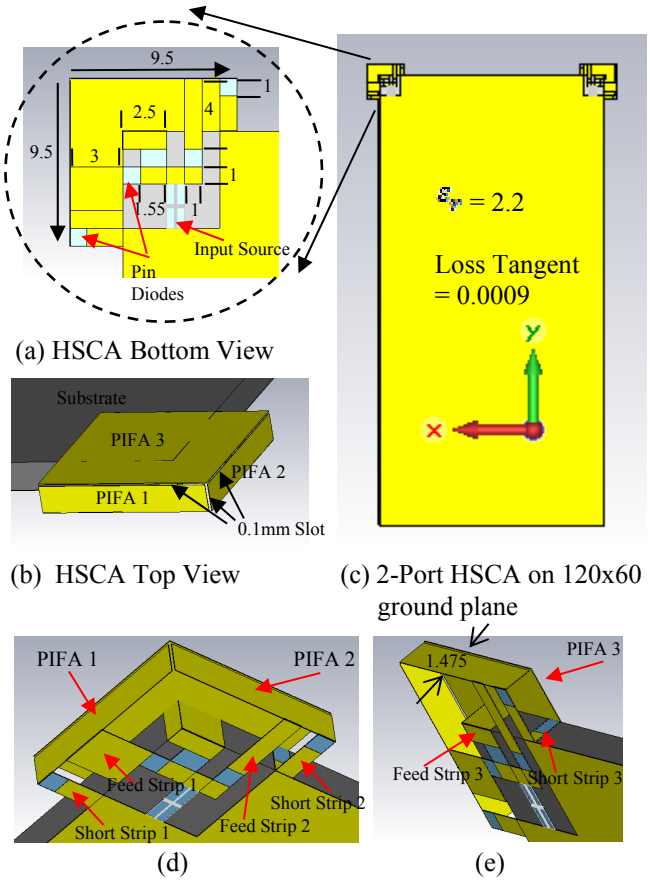
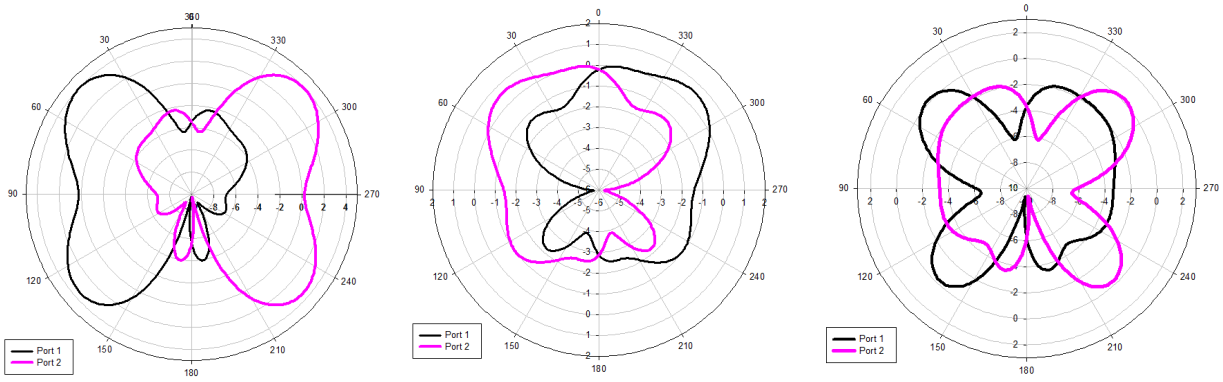


Fig. 1. The geometry of the proposed antenna. All dimensions are in millimeter

The proposed pattern reconfigurable MIMO Half Shaped Cubical Antenna (HSCA) is shown in Fig. 1. The dimensions of the MIMO antenna have been detailed in millimeter unit. Two proposed HSCAs were placed on the top edge of a RT 5880 substrate with the dimension of 120mm x 60mm x 1.575mm.



(a)5.6GHz (b) 5.7GHz (c) 5.3GHz

Fig. 3. The radiation pattern (xz-plane) for each PIFA element activated at port1 and port 2 (a) PIFA 1 (b) PIFA 2 (c) PIFA 3

As shown in Fig. 1(d) & (e), each HSCA is consisting of 3 PIFA element which are combine together to form a half cubical shape with a slot of 0.1mm between them. The input source which is fed into the HSCAs at port 1 and port 2 respectively is divided into 3 PIFA elements. The branching technique is controlled by the PIN diodes which are acting as ON/OFF switch. The PIN diodes at the branch activated to ON state to allow the input source to be fed into one PIFA element at one time. The shorting strip of each PIFA element is controlled by one PIN diode to avoid multiple grounding while the remaining PIFA element is being fed with input source. Therefore, two PIN diodes are activated to exhibit resonance of a single PIFA element.

3. Simulation Results & Discussion

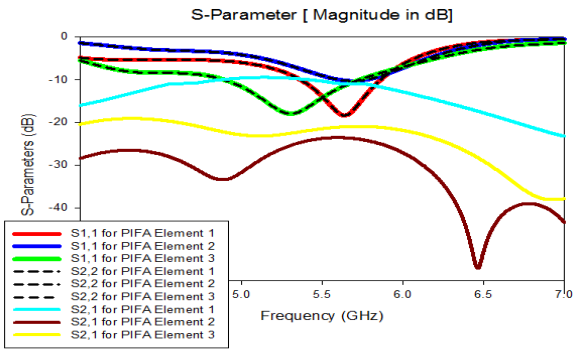


Fig. 2. Simulated scattering parameters for each PIFA element at both HSCA

The antenna was modeled and simulated using CST software. Fig. 2 shows the simulated scattering parameters for the MIMO antenna structure. It is found that all 3 PIFA elements are resonating at 5GHz spectrum with wider bandwidth of 18.16 %, 15.04 % and 40.1% respectively. The PIFA element 1, 2 and 3 at both ports are resonating at the frequency of 5.6GHz, 5.7GHz and 5.3GHz respectively. The radiation pattern of PIFA elements at both ports are shown in Fig. 3. This figure shows that the radiation pattern changes when the PIFA elements at both ports are activated by the PIN diodes. The maximum realized gain for PIFA element 1, 2 and 3 at both ports are 4.32 dB, 7.18 dB and 6.91 dB respectively.

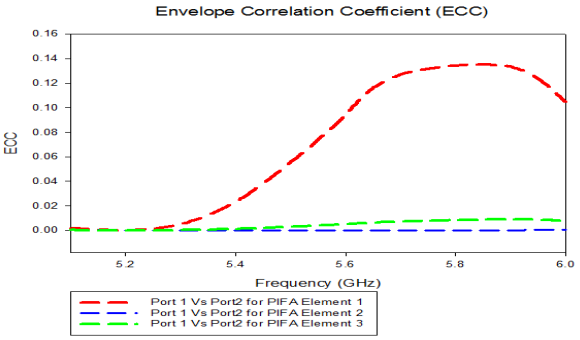


Fig. 4. The simulated ECC results between port 1 & port 2

The Envelope Correlation Coefficient (ECC)s are used to evaluate the correlation between the radiation patterns of the MIMO antenna. Fig. 4 shows that both HSCAs have a very low ECC value that close to 0 which indicates that the antenna elements are almost non-correlated to each other.

4. Conclusion

The proposed MIMO antenna design consists of 2 HSCAs where each HSCA is divided into 3 PIFA element. All the PIFA elements at both HSCA are activated by the PIN diodes to operate at 5GHz spectrum. A wider bandwidth and higher gain is achieved which can be used to accommodate higher data rate. The low ECC between two HSCAs proves that this proposed design is much suitable for MIMO mobile terminal applications.

References

[1] F. Ahmed, Ying Feng and Ronglin Li, "Dual wide-band four-unit MIMO antenna system for 4G/LTE and WLAN mobile phone applications," *Antennas and Propagation Conference (LAPC), 2013 Loughborough*, Loughborough, 2013, pp. 202-207.

[2] S. Zhang, K. Zhao, Z. Ying and S. He, "Investigation of Diagonal Antenna-Chassis Mode in Mobile Terminal LTE MIMO Antennas for Bandwidth Enhancement," in *IEEE Antennas and Propagation Magazine*, vol. 57, no. 2, pp. 217-228, April 2015

[3] Y. Lan *et al.*, "A Field Trial of Unlicensed LTE (U-LTE) in 5.8 GHz Band," *Vehicular Technology Conference (VTC Fall), 2015 IEEE 82nd*, Boston, MA, 2015, pp. 1-5.

[4] C. G. Christodoulou, Y. Tawk, S. A. Lane and S. R. Erwin, "Reconfigurable Antennas for Wireless and Space Applications," in *Proceedings of the IEEE*, vol. 100, no. 7, pp. 2250-2261, July 2012.