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Reconfigurable MIMO Antenna for Wireless Communication Based on Arduino Microcontroller

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***Abstract* — Wireless communication is common use on devices to send or exchange information such computer peripheral, mobile device, home appliances, etc. Every device embedded with wireless module and contribute electromagnetic, thus high possibility of occurring interference. One of method how to control interference is by controlling signal to transmit as well as power, thus in this research designed reconfigurable MIMO antenna to control antenna radiation pattern to reduce interference issue in wireless communication. The antenna designed in 2.4 GHz band because most and common use of devices peripheral using unlicensed band as well as for Wireless Fidelity (Wi-Fi). The designed antenna is 4×4 MIMO which operate at 2.4 and 2.6 GHz for Wireless Local Area Network (WLAN) and Long Term Evolution (LTE). The system radiation pattern is configured using an Arduino Microcontroller to driven PIN diode to switch he beam. Simulations and measurements are in good agreement with the configuration of the single antenna and 2×2 and 4×4 MIMO. The antenna is operational between 2.387 and 2.628 GHz, whereas the simulated and measured reflection coefficients are obtaining at least -24.3 dB. The MIMO antenna designed to improve data communication, especially in mobile communication systems.**

Index Terms — Antenna, MIMO, Reconfigurable, Arduino Microcontroller, Wireless Communication

I. Introduction

The application of reconfigurable antenna for communication system very useful to suppressing interference issues that currently facing. Signal strength and data throughput can be further improved by implementing a reconfigurable system using MIMO antenna for Wireless Communication System (WCS) front end. A means for such improvement is dynamically changing the characteristics of antenna radiation. The change can be accomplished in line with the user's preferences, such as mobility, data usage, and method used to access WCS. Hence, the introduction of the MIMO antenna system based on a reconfigurable front end considerably enhances the data capacity and directivity of WCSs. Research on MIMO antenna based on frequency configurability for mobile devices has been conducted in [1]-[3]. Research on frequency re-configurability have been carried out to control or steer radiation patterns for MIMO antenna designs. Furthermore, in these proposed frequency configurations, the design is mostly for switching the antenna beam. MIMO antennas which are reconfigurable in terms of polarization and radiation are proposed in [4]-[6]. Designs, such as used slot, array, or butler matrix, are utilized to control radiation pattern and polarization. In these designs, only the receiver side controls the radiation of the antenna beam. References [7]-[8] present the use of dielectric resonators as MIMO antennas for LTE bands. However, the design covers a single frequency band at 700 MHz.

Proposes of reconfigurable MIMO antenna for a wireless transceiver system, the system is designed to operate at 2.4 and 2.6 GHz. A single element antenna can be configured to form a single 4 × 4 MIMO antenna, either as two 2 × 2 antennas or a single 4 × 4 array. The microstrip line on the reverse side of the patch layer is fed coaxially and fitted with PIN diodes to enable switching via a microcontroller module. To optimize space, an air gap is introduced between the ground and radiating elements to produce a high gain antenna. This technique can control the transmitter antenna radiation pattern for efficiency and reduce interference. Adaptive radiation pattern can be achieved by controlling the antenna configuration using either a 4×4 or two 2×2 MIMO antennas. Alternatively, single antenna that combines all elements can be used to obtain high gain with a narrow beam radiation pattern.

II. Reconfigurable Antenna Design

In the proposed design, individual antennas are cascaded to form the MIMO antenna system. The antenna is implemented using a low-cost FR-4 board with a relative permittivity of εr=4.7, h=1.6 mm (and height), tan δ =0.019 (loss tangent). The single element and 2×2 MIMO antenna are designed based on the procedures described in [9] and [10] which result in the optimized structure illustrated in Figure 1(a) presents the location of the radiating elements. Meanwhile, Figure 1(b) shows the bottom antenna layer comprising transmission lines. 6 PIN diodes are employed to connect or disconnect these lines by on/off the DC power for each PIN diode with a microcontroller unit.

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(a)

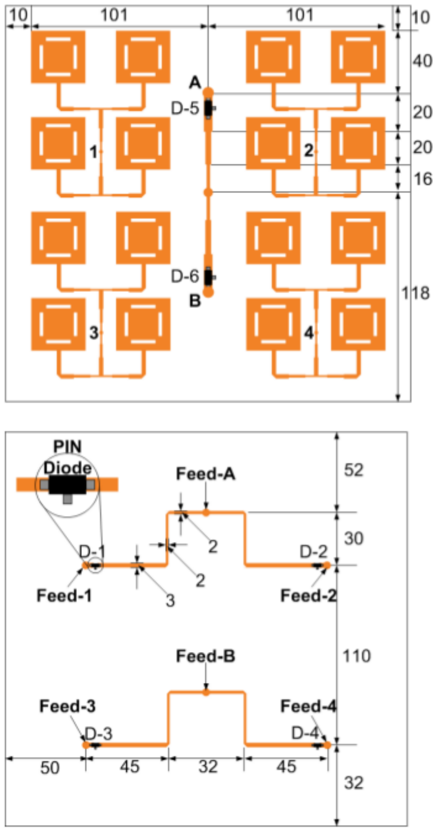


Fig. 1. Design of the 4×4 MIMO antenna (a) Top and (b) bottom views

The antenna elements are arranged and fed using a corporate feeding scheme. PIN diodes are used to connect the desired antenna feed to the main transmission line as shown in Figure 2. Each set element of the MIMO antenna has a transmission line that connects or disconnects other element. Figure 2 presents a side view of the proposed MIMO antenna system. An aluminum plane placed 10 mm from the FR4 layer is used as aground plane. The top layer consists of patch elements, whereas the bottom layer contains the transmission lines. SMA connectors are used to feed the MIMO antenna ports.

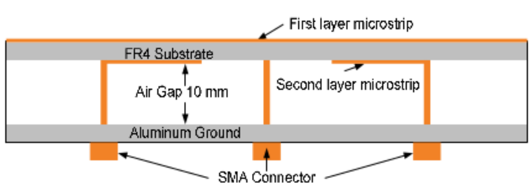


Fig. 2. Side view of the proposed antenna system

Arduino microcontroller were used for switching system of MIMO antenna, while radio transceiver received from user (client) signal, in this case Radio Signal Strength Indicator (RSSI) used as parameter to determine distance of user connected to base station. Once RSSI value received then analyze by controller to drive of antenna configuration. The MIMO antenna configurations currently only 2x2 or 4x4, else another configuration which is single antenna with fully high gain. Figure 3 shows a block diagram of MIMO antenna system connected to Arduino microcontroller to drive the PIN diodes.

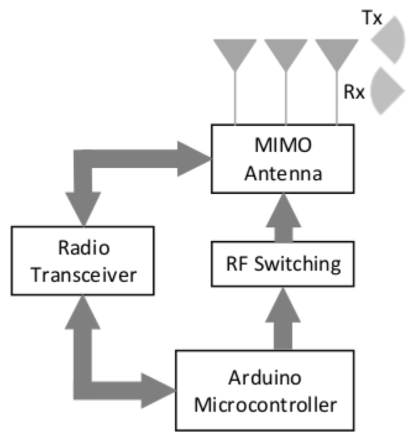


Fig. 3. Block diagram of microcontroller to drive MIMO antenna switching.

This designed antenna used PIN diode to switch the configuration of MIMO antenna, every port of the antenna connected to a diode to on/off the feeding line. Table 1 shows the operating of PIN diode to the antenna configuration, 6 sets of PIN diode used to cover all the 4x4 MIMO antenna:

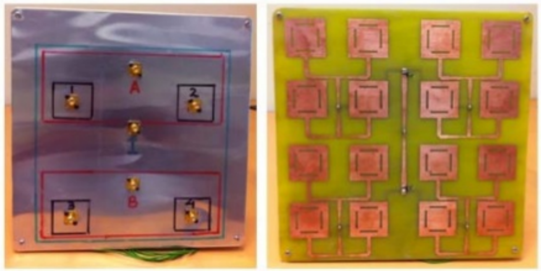
TABLE I

PIN DIODE SETTINGS FOR THE THREE ANTENNA CONFIGURATIONS

CONFIGURATION	DIODE					
	D-1	D-2	D-3	D-4	D-5	D-6
MIMO 4 × 4	Off	Off	Off	Off	Off	Off
MIMO 2× 2	On	On	On	On	Off	Off
Single Antenna	On	On	On	On	On	On

III. Results and Discussion

The MIMO antenna system is fabricated and integrated with a microcontroller to enable reconfiguration, figure 4 shows the system prototype. Antenna performance is first evaluated using a vector network analyzer and radiation pattern measurement system in an anechoic chamber. To properly evaluate the antenna reflection coefficient, radiation pattern, and antenna gain, each port is evaluated individually, whereas the rest is terminated.



(a) (b)

Fig. 4. Prototype of the MIMO antenna system (a) Top and (b) bottom views

The single MIMO antenna evaluated indicated a satisfactory agreement between simulation and measurement. The measured reflection coefficient of this antenna indicated operation from 2.387 GHz to 2.628 GHz for WLAN and LTE bands (see Figure 5). Simulations produced a minimum S11 of -27.8 dB at 2.45 GHz, whereas an optimal S11 of -24.3 dB is measured at a slightly higher frequency of 2.5 GHz.

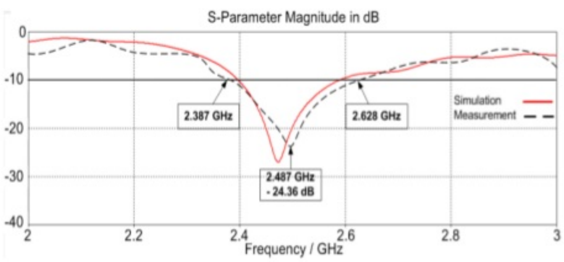


Fig.5. Simulated and measured reflection coefficients of the single MIMO antenna

Figure 6 assesses and summarizes isolation between the antenna ports, indicating a maximum isolation of approximately 15 dB.

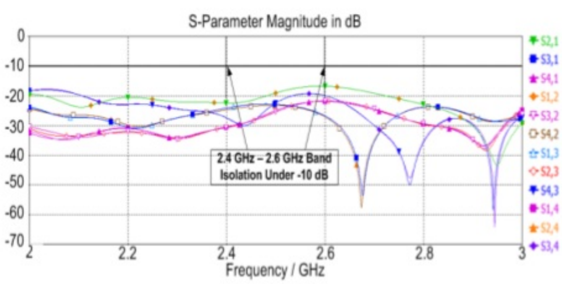
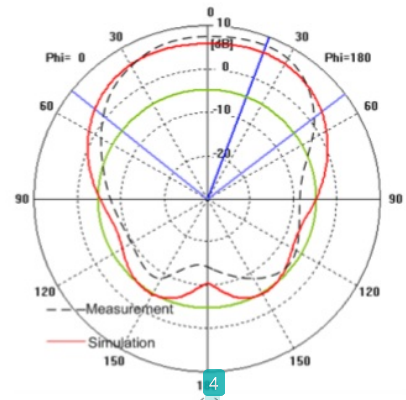
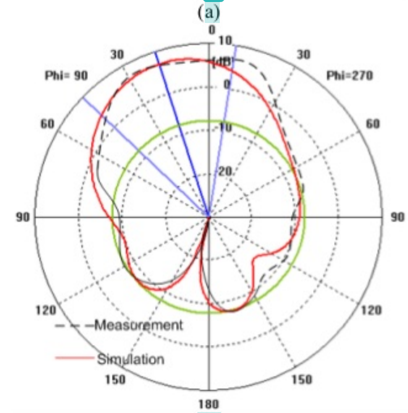


Fig.6. Isolation between different ports of the MIMO antenna

The radiation pattern of the first configuration using the 4×4 MIMO antenna is simulated and measured at 2.5 GHz, as shown in Figure 7, which indicates good agreement with both of results. A directional forward beam is generated for the E- and H-planes with minimal side lobes.



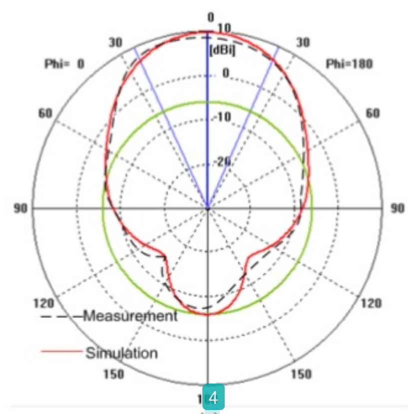
(a)



(b)

Fig.7. Radiation pattern of the 4x4 MIMO antenna (a) E- and (b) H-fields

Similar to the previous structure, the radiation pattern of the 2×2 MIMO is evaluated separately at 2.5 GHz and summarized in Figure 8. Note that the same forward radiation is exhibited with a beam width narrower compared to that of the previous single antenna due to additional array elements. The simulated and measured results are in agreement with slightly minor lobe disagreements.



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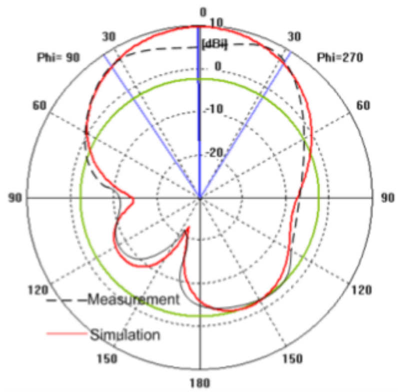
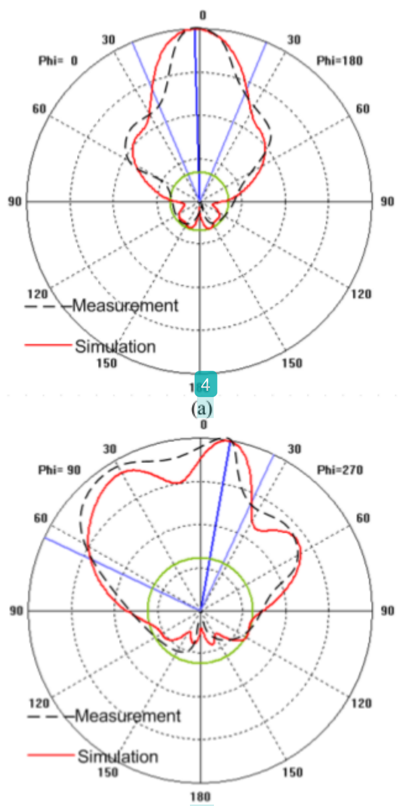


(b)

Fig.8. Radiation pattern of the dual 2x2 MIMO antenna (a) E- and (b) H-fields

The third antenna operating as a single, high gain 4 × 4 array is evaluated by activating all PIN diodes to enable each element's connection to the transmission line. The radiation pattern of this antenna is measured at 2.5 GHz, Figure 9 shows that the beam direction is narrower compared with that of the previous single and dual MIMO antennas.



(a)

(b)

Fig.9. Radiation pattern of single antenna (a) E- and (b) H-fields

IV. Conclusion

A reconfigurable MIMO antenna system for wireless communications with Arduino microcontroller designed which consisting of rectangular slotted microstrip antenna elements. They form an array antenna which can either be configured as a single, 2×2, or 4×4 MIMO antenna system. They can also be used as a conventional high gain directional array. Pattern configurability is achieved by switching the six PIN diodes in the microstrip transmission line. Measurements confirmed that the antenna is operational from 2.387 GHz to 2.628 GHz, which agree well with simulations with optimal reflection coefficients of -27.8 dB at 2.4 GHz and -24.3 dB at 2.6 GHz. MIMO antenna configurations produced narrow beam forward radiation patterns in E- and H-planes.

Acknowledgement

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References

[1] L.J. Hyuk, J.Z. Jun, S.C. Wook, and Y.T Yeoul, "Simultaneous Frequency and Isolation Reconfigurable MIMO PIFA Using PIN Diodes," IEEE Transactions on Antennas and Propagation, vol.60, pp.5939-5946, 2012.

[2] L. Haitao, S. Gao, and L.T. Hong, " Compact MIMO Antenna With Frequency Reconfigurability and Adaptive Radiation Patterns," IEEE Antennas and Wireless Propagation Letters, vol.12, pp.269-272, 2013.

[3] Z.J. Jin, J.H. Lim, and T.Y. Yun, "Frequency reconfigurable multiple-input multiple-output antenna with high isolation," IET Microwaves, Antennas & Propagation, vol.6, pp.1095-1101, 2012.

[4] R. Karimian, "Tri-band four elements MIMO antenna system for WLAN and WiMAX application, "Journal of Electromagnetic Waves and Applications, vol.26, pp.348-2357, 2012.

[5] B.A. Cetiner, E. Akay, E. Sengul, and E. Ayanoglu, "A MIMO System With Multifunctional Reconfigurable Antennas," IEEE Antennas and Wireless Propagation Letters, vol.5, pp.463-466, 2006.

[6] Q.P. Yuan, Y.J. Guo, A.R. Weily, and L.C. Hong, "A Pattern Reconfigurable U-Slot Antenna and Its Applications in MIMO Systems, "IEEE Transactions on Antennas and Propagation, vol.60, pp. 516-528, 2012.

[7] L. Zhengyi, D. Zhengwei, and G. Ke, "Compact Reconfigurable Antenna Array for Adaptive MIMO Systems," IEEE Antennas and Wireless Propagation Letters, 8:1317-1320, 2009.

[8] J. Sarrazin, Y. Mahe, S. Avrillon, and S. Toutain, "Pattern Reconfigurable Cubic Antenna," IEEE Transactions on Antennas and Propagation, vol.57, pp. 310-317, 2009.

[9] C.A. Balanis, "Antenna Theory: Analysis and Design, "John Wiley & Sons, 2005.

[10] A.K. Evizal, E.Supriyanto, T.A. Rahman,S.K.A. Rahim, and S.L. Rosa, "Multiple Bands Antenna with Slots for Wireless Communication System," Advances in Robotics, Mechatronics and Circuits, pp.173-177, 2014.

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