A Dual-band MIMO Antenna for Wi-Fi 6E / 7 System in a Small Base Station

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***Abstract*—In this article, a 6 × 6 MIMO patch antenna design is proposed for application in the dual-band Wi-Fi 6E / 7 system. This antenna model covers the Wi-Fi 6E / 7 frequency bands of 2.38-2.44 GHz and 4.9-7.125 GHz. And, the proposed antenna provides measured peak gains and antenna efficiencies close to 6.4 / 10 / 8.6 dBi and 75 / 80 / 70 % across the 2.45 / 5.5 / 6.5 GHz operating bands, respectively. Also, the measured envelope correlation coefficient (ECC) is less than 0.3 across the operating bands for the MIMO patch antennas.**

***Keywords*—MIMO, Wi-Fi 6E/7, patch antenna, probe-feed**

I. Introduction

The amount of data transmission required today is increasing, and future transmission rates are expected to be even faster. Through MIMO technology, different signals can be simultaneously processed, utilizing different antennas for transmission and reception at the same time. This effectively maximizes the use of time. Furthermore, multiple antennas receiving signals can be likened to multiple individuals cooperating, increasing stability during reception. Recently, 5th generation wireless system has been promoted, using small cell to create cellular network, and provides better connection and higher throughput. Due to the high throughput we provide to the user, multi-input multi-output antenna is needed to be set into a small cell. For Wi-Fi applications including the 2.45 GHz (2.4 –2.484 GHz) and 5 GHz (5.125–5.825 GHz) bands, the presented antenna designs have been reported in [1]–[7]. However, the above antenna designs only focus on the Wi-Fi 6 band operation. Also, it is scant for the related antenna designs applied to the Wi-Fi 6E / 7 bands. Simultaneously, small cell must solve two big problems: heat from IC and noise from circuit. The high heat will affect CPU from working normally and high noise from circuit will reduce the signal-to noise level for the antenna radiation performance. Therefore, in this article, referred to [8]-[9], the present work proposes a Wi-Fi 6E / 7 patch antenna design for a small base station. To achieve high coverage, the design adopts a cellular structure, incorporating antennas applicable to Wi-Fi 6E / 7 frequency bands on each face. The antennas employ a patch with a pair of slits for bandwidth enhanced design. The goal is to enhance the gain efficiency of individual antennas and achieve optimal impedance matching. The design of multiple antennas can be adjusted based on user space, ensuring optimal coverage and stability. From the related measured results, it provides relatively wider impedance bandwidth to meet the specification of 2.38-2.44 GHz and 4.9-7.125 GHz requirement with the measured peak gains and antenna efficiencies close to 6.4 / 10 / 8.6 dBi and 75 / 80 / 70 % for the 2.45 / 5.5 / 6.5 GHz bands, respectively. Also, to comply with the MIMO requirement, this work also analyzes the measured ECC between two ports of the proposed MIMO antenna. Details of the proposed antenna design are described in this study, and the related results for the obtained performance operated across Wi-Fi 6E / 7 bands are presented and discussed. This study describes the details of the proposed antenna design and presents and discusses results related to the performance obtained operating in the Wi-Fi 6E / 7 bands.

II. Antenna design

Fig. 1 illustrates the geometry of the proposed Wi-Fi 6E / 7 multi-band patch antennas with MIMO operation in a small base station. In this study, the dual-band Wi-Fi 6E / 7 antenna employs a probe-fed circular patch to excite the fundamental resonance mode at 2.4GHz (TM_{11} mode) with a diameter of 56.9 mm. The slit alters the original current path, and high-order modes at 4.6 GHz (TM_{21}), 5 GHz (TM_{01}) and 5.6 GHz (TM_{31}) are also effectively excited due to the asymmetric slit, without apparent weaknesses in radiation patterns. The circular patch antenna is etched on the FR4 substrate of dielectric constant $\varepsilon_r = 4.7$ and loss tangent tan $\delta = 0.0245$. The hollow characteristics of this work allow it to integrate with many active devices available on the market. Due to the design of a large inner layer with extensive grounding, the external antennas are protected from the impact of central circuit noise, thereby achieving optimal performance. With the high-gain advantage of this work, even when placed in a small corner of the home, signal stability can be maintained.

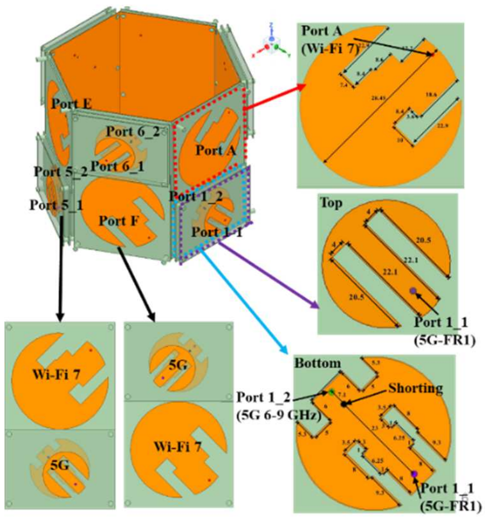

Fig. 1 Geometry of the proposed Wi-Fi 6E/7 multi-band antenna in a small base station.

III. Results and Discussions

First, we used Ansys HFSS, an electromagnetic simulation software [10], in the design of the proposed Wi-Fi 6E / 7 antenna. Fig. 2 shows the related simulated and experimental return loss, with a standard of return loss ≤ 10 dB (VSWR 2:1) for the proposed Wi-Fi 6E / 7 MIMO patch antennas at port A and B. This antenna model covers the Wi-Fi 6E / 7 frequency bands of 2.38-2.44 GHz and 4.9-7.125 GHz. The performance of the impedance matching for Wi-Fi 6E / 7 antennas (@ Port A, B) can be observed from Figure 2. It is evident that the Wi-Fi 6E / 7 antennas have successfully achieved a bandwidth that fully meets the requirements. Figure 3 shows the surfce current distribution on the patch antenna at various excited modes. Next is the antenna gain and efficiency plot in Figure 4. The gain of this work in the Wi-Fi 6E / 7 frequency band consistently exceeds 7 dBi on average, and the overall trend aligns with the simulation results.

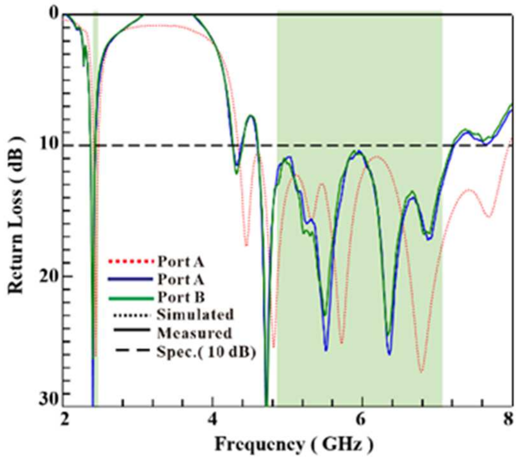

Fig. 2 Simulated and measured return loss against frequency for the proposed Wi-Fi 6E / 7 dual-band patch antenna.

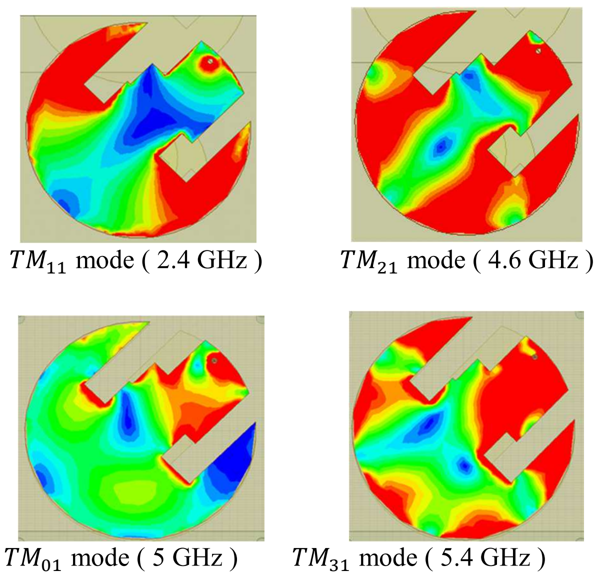

Fig. 3 Simulated input impedance against frequency for the proposed Wi-Fi 6E / 7 dual-band patch antenna.

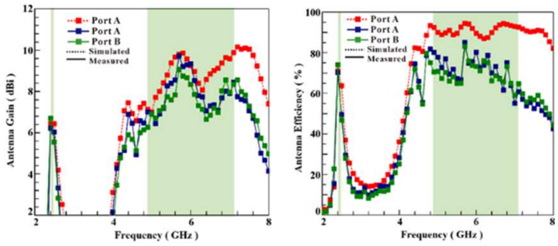

Fig. 4 Simulated and measured gain / efficiency against frequency for the proposed dual-band patch antenna.

Figure 5 presents the 2D radiation pattern of this work at Port A. Measurements were taken at four resonance mode frequency points. From the figure below, it can be observed that at all four frequencies, the radiation pattern in the XZ and YZ planes is outward. Although there is some deviation in the higher-order modes, they are still within usable ranges. This confirms the overall effectiveness of the design.

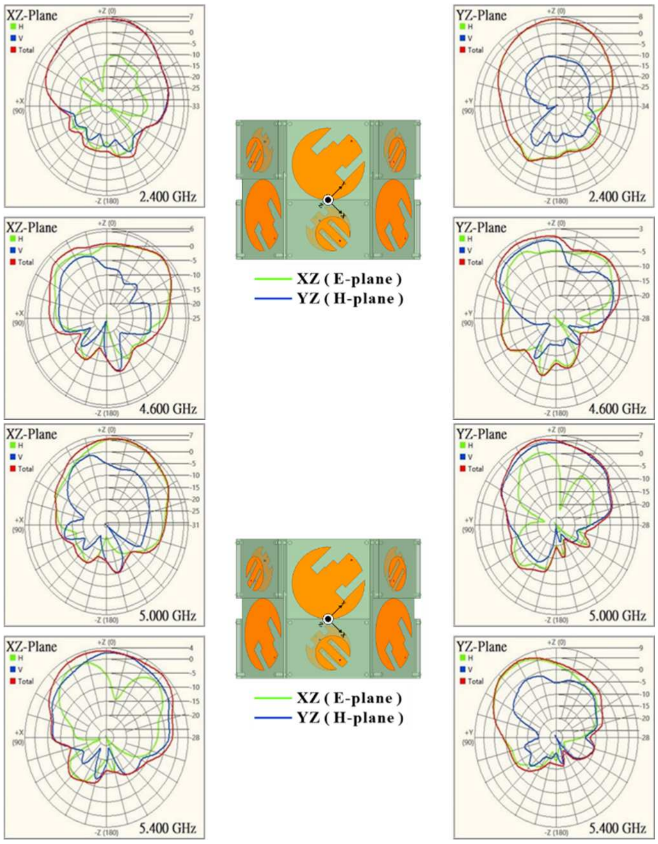

Fig. 5 Measured Radiation Patterns of the proposed Wi-Fi 6E / 7 dual-band antenna.

IV. Conclusion

A novel Wi-Fi 6E/7 dual-band MIMO patch antenna in a small base station has been proposed. This presented patch antenna covers the Wi-Fi 6E / 7 frequency bands of 2.38-2.44 GHz and 4.9-7.125 GHz. And, the measured peak gains and antenna efficiencies are close to 6.4/ 10 / 8.6 dBi and 75 / 80 / 70 % across the 2.45 / 5.5 / 6.5 GHz operating bands, respectively. Also, the measured envelope correlation coefficient (ECC) is less than 0.3 across the operating bands for the MIMO antennas.

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REFERENCES

[1] J. H. Lu, W. R. Chuang and B. M. Chen, “A Multi-band Metal-frame Antenna for Wi-Fi 6E System in a Terminal Device”, 2022 IEEE International Workshop on Electromagnetics: Applications and Student Innovation Competition, iWEM2022. (Chiba, Japan, Aug. 29-31, 2022).

[2] J. H. Lu, W. R. Chuang and B. M. Chen, “A 5G / WiFi MIMO antenna with dual-band operation in a small cell device”, 2020 IEEE International Workshop on Electromagnetics: Applications and Student Innovation Competition, iWEM2020. (Penghu, Taiwan, Aug. 26-28, 2020).

[3] J. F. Huang, M.T. Wu and J. Y. Wen, ‘‘A compact triple-band antenna design for UMTS, WLAN and WIMAX applications,’’ *Micro. Opt. Technol. Lett*., vol. 51, pp. 2207-2212, 2009.

[4] S. Zuo and Y. Yin, ‘‘A Coupling-Fed Multiband Antenna For WLAN/WiMAX Applications,’’ *Micro. Opt. Technol. Lett*., vol. 52, pp. 1283-1286, June 2010.

[5] S. Y. Lee and C. C. Yu, “A novel wideband asymmetric hybrid antenna for WLAN/WiMAX application,” *Micro. Opt. Technol. Lett*., vol. 51, pp. 1055-1057, 2009.

[6] K. G. Thomas and M. Sreenivasan, “Compact triple band antenna for WLAN/WiMAX applications”, *IET Electron. Lett.,* vol. 45, pp. 811-813, 2009.

[7] K. G. Thomas and M. Sreenivasan, “A novel triple band printed antenna for WLAN/WiMAX applications”, *Microwave Opt. Technol. Lett*., vol. 51, pp. 2481-2485, 2009.

[8] J. H. Lu, "Broadband dual-frequency operation of circular Patch antennas and arrays with a pair of L-shaped slots", *IEEE Transactions on Antennas and Propagation*, vol. 51, no. 5, pp. 1018-1023, May 2003

[9] J. H. Lu, "Bandwidth enhancement design of single-layer slotted circular microstrip antennas", *IEEE Transactions on Antennas and Propagation*, vol. 51, no. 5, pp. 1126-1129, May 2003

[10] http://www.ansoft.com/products/hf/hfss, HFSS version 12.0, Ansoft Software Inc., 2009.