

New Design of 60 GHz MIMO 2x4 Patch Rectangular Antenna Array for Wireless Gigabit (Wi-Gig) Application

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Abstract—Nowadays, most antenna researchers over the world are focusing on the design of the antenna for the fifth generation (5G) application (indoor and outdoor). High intensive research on 60 GHz antenna for high data rate indoor communication is becoming a trending topic. The high propagation loss at this band is the most challenging. The antenna needs to have higher gain to overcome the loss. Such antenna designs have been proposed recently. This paper, a new MIMO 2x4 patch rectangular antenna operating at 60 GHz is designed for Wi-Gig application. The rectangular patch antenna has 1.75 mm x 1.54 mm of size, printed on Rogers Duroid RT 5880 substrate, the dielectric constant of 2.20 and loss tangent of 0,0009. The antenna was designed and simulated using CST simulation software. The simulated return loss showed a very consistent characteristic. The return loss reached -30 dB at 60 GHz. The broad bandwidth obtained is 4.3 GHz concerning -10 dB. The omnidirectional radiation pattern with 13.4 dBi of gain is obtained. This antenna meets the Wi-Gig requirement.

Keywords— 5G antenna, Array antenna, MIMO antenna, Wi-Gig application

I. INTRODUCTION (HEADING 1)

Recent years, high concentrated energies and explores on high data rate 60 GHz wireless communication system were done [1]. Planar antenna arrays, as one of the most critical subsystems, require to have high efficiency due to the enormous advantages that are introduced by antenna arrays such as high directive beam, reconfigurable structures, and beam scanning capabilities. Series fed antenna arrays have a simple, low loss, and compact feeding network as compared to corporate feeding network. Designing series-fed array antennas, microstrip feeding network is used [2].

Dimension, cost, performance, ease of installation are restrictions in high performance 5G wireless application. Microstrip antenna meets the requirement. However, it has several disadvantages such as low gain, narrow bandwidth with low efficiency [3]. Research papers on microstrip

antenna operating at 60 GHz are listed in [1, 3, 4, 6, 7, 13, 14, 16].

Multi-gigabit per-second for indoor communication is the first desired application of 60 GHz devices. It is called as Wireless Gigabit (Wi-Gig) application. The high propagation loss at (68 dB for 1 m range), it causes the maximum output power limited by regulatory and technology. The antenna gain should be more than 5 dBi to ensure the wireless link inside a regular room established [4].

Massive multiple-input-multiple-output (MIMO), as a candidate technology for 5G wireless communication systems, intends utilizing a large number of antennas to multiplex messages for several devices on each time-frequency resource [5]

A patch antenna in array configuration is mostly fed by microstrip feed-line. With a compact broadband microstrip feed-line, wide bandwidth and high-gain are achieved at the same time [17]. Smallness and beam-width improvement of the patch are the two main focus presented in [12, 13]. The compact technology is obtained by using the two layers of the antenna array. Mass production using a standard low-cost PCB is possible for this technology. With the total size of the integrated array antenna and the size of the radiating aperture is similar, the miniaturization is performed. The millimeter-wave frequencies are used as candidates range for future 5G technology. Designing the higher gain antenna arrays to overcome the path loss is desired due to the higher frequencies losses. Recent publications on designing 5G antennas arrays have been performed [8–17].

In this paper, microstrip MIMO 2x4 patch rectangular antenna array operating at 60 GHz is designed to be suited for Wi-Gig application. CST simulation software is applied in antenna design. The MIMO 2x4 antenna elements are composed of four double-patch rectangular array antenna. The proposed antenna shows the simulated gain is higher than 5 dBi as required. A simple microstrip feeding line feeds the antenna. The structure of this paper as follows; part I is an introduction that presents the current research on 60

GHz antenna with their issues, then part II describes the proposed antenna design. In this part, the design starts with double patch rectangular antenna and their simulated results. The MIMO 2x4 antenna elements are resulted from the first design by multiplying the number of patch elements. Last is the conclusion that concludes the research activity.

II. DESIGN OF 60 GHZ ANTENNA

A. Double Patch Rectangular Array 60 GHz Antenna

The design used double patch rectangular antenna to achieve larger bandwidth and higher gain for the antenna in 5G implementation. In this design, a two-patch rectangular structure is used to construct a MIMO antenna. The antenna is designed using Rogers RT5880 (lossy) dielectric substrate having relative permittivity = 2.2 and a thickness of 0.16 mm.

Figure 1 shows the geometry of a double patch rectangular array antenna. The substrate size is 5 mm x 12 mm. The 50 Ohm microstrip line is attached to the patch. The substrate is fully grounded. The patch size is 1.75 mm x 1.54 mm. The simulated return loss and VSWR are shown in Figure 2 and Figure 3, respectively. As shown in Figure 2, the simulated return loss provides -29.889 dB at 60 GHz concerning -10 dB. The bandwidth obtained is 3.848 GHz. The simulated VSWR of 1.0662 is obtained at 60 GHz. The VSWR maintain less than 1.2 over the resulted bandwidth as shown in Figure 3. The directional radiation pattern is achieved with the maximum gain antenna of 9.66 dBi for 60 GHz as shown in Figure 4.

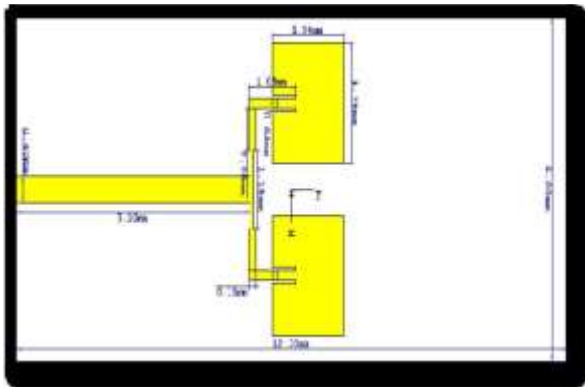


Figure 1: Geometry of double patch rectangular array antenna.

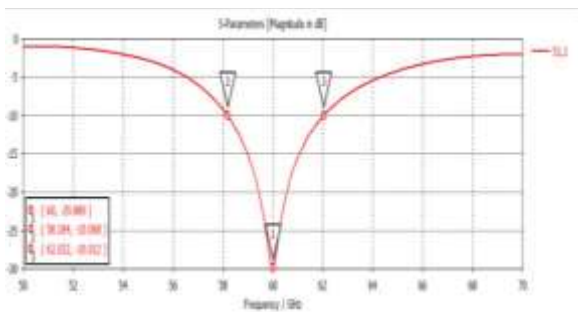


Figure 2: The simulated return loss of double patch rectangular array.

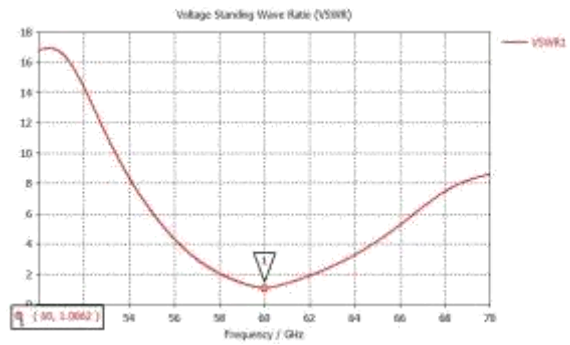


Figure 3: The simulated VSWR double patch rectangular array.

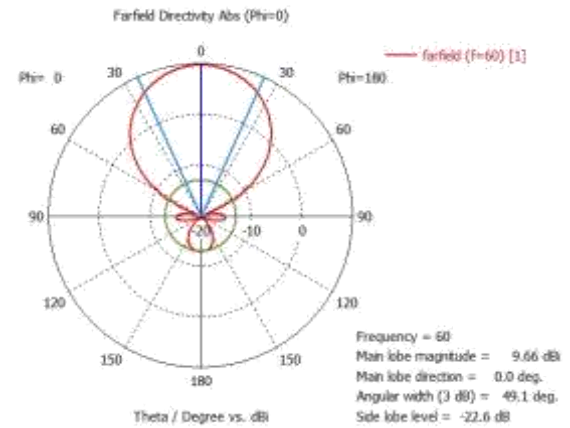


Figure 4: The simulated radiation pattern of E and H plane of the double patch rectangular array.

B. Design of 2x4 Patch Rectangular Array

Under the expected specification at the beginning, the antenna must have a high gain. Therefore, the MIMO 2x4 patch rectangular array antenna is proposed. The design is composed of four double-patch rectangular array antennas to meet the expected specification. The schematic of the 2x4 array is shown in Figure 5. The distance between each antenna is 4.60 mm. Four ports are fed by microstrip feedlines. The rectangular patch size is equal to the previous patch size.

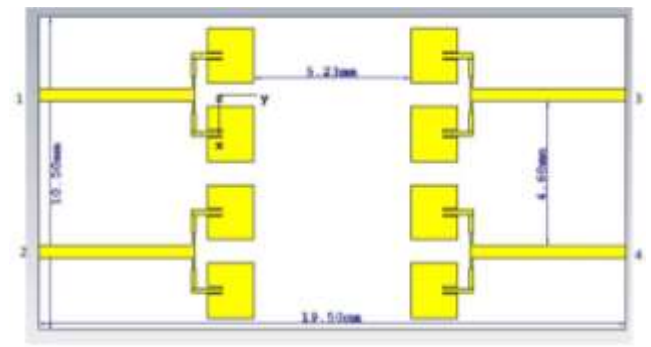


Figure 5: 2x4 patch rectangular array antenna.

As presented in Figure 6, all the 2x4 antenna elements perform very consistently with almost identical S11 with sufficient bandwidth to cover 60 GHz. The simulated return loss of -44 dB is achieved at 60 GHz. Also, the isolation between each port of linearly arranged antenna element's feeding point is lower than -30 dB for 60 GHz which can meet the antenna array's protection requirements between its antenna elements.

VSWR of 1.0792 is achieved as shown in Figure 7 with 4.3 GHz of bandwidth obtained. The large bandwidth is due to the MIMO technique used. The radiation pattern of this antenna is omnidirectional; thus it meets the requirements to be applied in Wi-Gig application. The Gain reaches 13.4 dBi with low sidelobe level of 5.1 dB as presented in Figure 8.

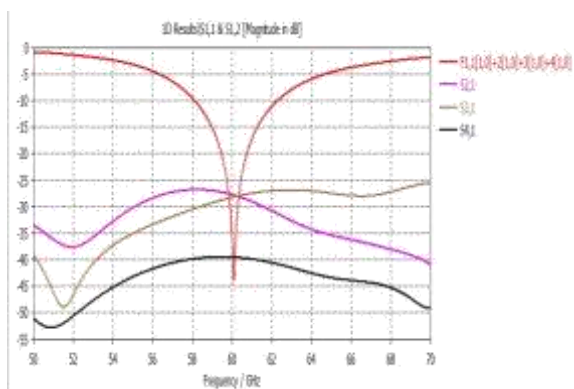


Figure 6: The simulated S-parameters of the 2x4 patch rectangular antenna array.

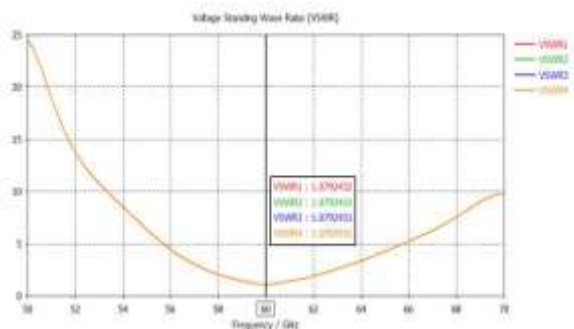


Figure 7: VSWR of 2x4 patch rectangular array antenna.

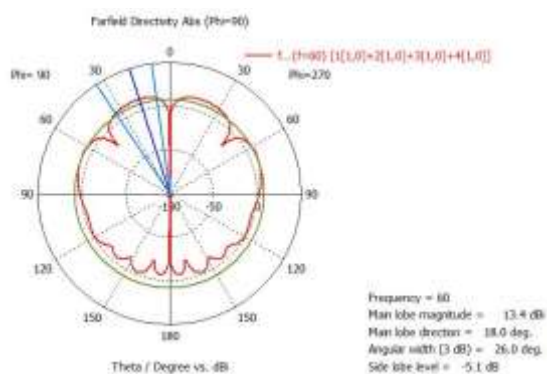


Figure 8: Simulated radiation pattern of E and H plane

III. CONCLUSION

In this paper, a new MIMO 2x4 patch rectangular array antenna has been designed. The antenna has a return loss of -44 dB at 60 GHz. The bandwidth obtained is 4.3 GHz. The radiation pattern is omnidirectional with a gain of 13.4 dBi with low side lobe of 5.1 dB. Our proposed antenna uses eight rectangular patch elements and four ports. The antenna is designed using Rogers RT5880 (lousy) dielectric substrate having relative permittivity = 2.2 and a thickness of 0.16 mm. This design meets the requirements for Wi-Gig applications.

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