A 24GHz micropatch antenna array for human hand gestures detection

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***Abstract*—This paper proposed the design of a new 24GHz transmitting/receiving antenna module for human hand gesture detection. The transmitting antenna consisted of 16 microstrip elements and the receiving part consisted of four independent microstrip arrays with 8 elements each in order to support multi-channel signal receiving. This module had a dimension of 79.8×59 mm^2 and its performance was verified and proved to be satisfied with the pattern and portability required by human hand gesture detection.**

Keywords—miccrostrip array; Dolph-Chebyshev current amplitude distribution; human hand gesture detections;

I. INTRODUCTION

Soli is a new, robust, high-resolution, low-power, miniature gesture sensing technology for human-computer interaction based on millimeter-wave (60GHz) radar proposed by Google ATAP group in 2015[1]. This revolution sensor delivers the potential of ubiquitous gesture interaction across a huge number range of applications, including virtual reality, wearables and smart garments and game controllers. However, this technology is still in the verification phase and many institutes have involved in this project to accelerate its development and extend its potential applications. This paper introduced the design of a microstrip antenna module for the same purpose with one transmitting antenna and four receiving antenna operating at 24GHz, rather than 60GHz. To promote gesture detection technology, 24GHz band has been widely supported by MMIC vendors[2-4]. The antenna was also evaluated in CST Microwave Studio. The paper finally proposed a new 24GHz transmitting/receiving antenna module for human hand gesture detection.

II. ANTENNA CONFIGURATION

Compared with traditional microstrip antenna such as monostatic automobile radars, the antenna module for human hand gesture detection consists of one transmitting antenna and four receiving antennas deployed around the transmitting antenna. This deployment is able to provide new features for recognitions such as the phase shift of the different signals received by different receiving antennas. These new features can contribute to increasing the accuracy of hand gesture recognition. According to this concept, Figure 1 shows the geometry of the proposed antenna module. The module consists in a single transmitting antenna, and four receiving antennas, all of which operate at 24 GHz. To meet the practical commands, reducing the antenna size and the mutual coupling between the transmitting antenna and the receiving antenna to increase the portability and the recognition accuracy of the gesture recognition device. In the design, the antenna module was etched on a 79.8×59 mm^2 Rogers 4003C substrate, ε_r =3.55, height of which is 0.508 mm. The transmitting antenna is a microstrip antenna array with 16 elements and the current amplitude distribution complies with Dolph-Chebyshev distribution[5]. The receiving antenna is a microstrip antenna array with 8 elements for low side lobe levels. The numbers of elements can be adjusted and optimized for the appropriate gain and side lobe levels, However, human hand gesture detection does not require a high gain pattern but cares more about the side lobes, which may distort the area of the scenario and have the reflected signals leaked into the antenna array.

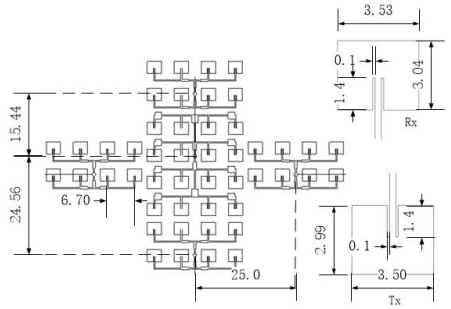


Fig. 1. Antenna configuration(unit: mm)

III. ANTENNA PERFORMANCE EVALUATION

A. Return loss

In order to evaluate the performance of the proposed antenna, numerical simulations were performed in CST Studio Suit. Fig. 2 shows the return loss characteristics of transmitting antenna module. The calculated bandwidth is 1.9 GHz over 23.0 GHz to 24.9 GHz for return loss less than -10 dB. It also shows the simulated return loss characteristics for four receive antennas. The calculated bandwidth is 1.6 GHz over 23.0 GHz to 24.6 GHz for return loss less than -10 dB.

B. Radiation patterns

Fig. 3-(a) and (b) respectively show the transmitting antenna radiation patterns at 24GHz on the E-plane and H-plane. The simulated antenna gain is 15.3dB. Moreover, the HPBW and side lobe level for E-plane is 31.7° and -30.9dB respectively. For H-plane, the result is 27.5° and -14.3dB.

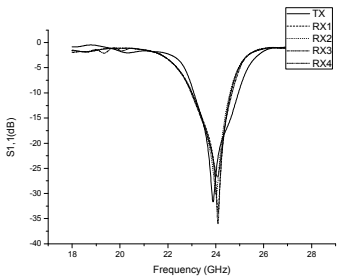
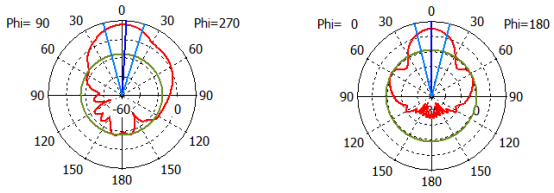
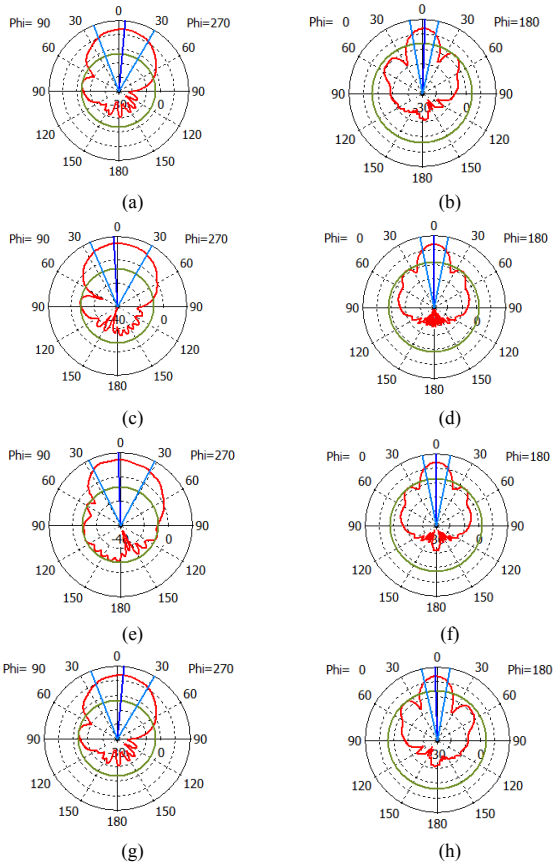


Fig. 2. Antenna return loss characteristics



(a) (b)

Fig. 3. Radiation patterns for Tx antenna (a) H-plane (b) E-plane



(a) (b) (c) (d) (e) (f) (g) (h)

Fig. 4. Radiation patterns for Rx antenna (a) R1 H-plane (b) R1 E-plane (c) R2 H-plane (d) R2 E-plane (e) R3 H-plane (f) R3 E-plane (g) R1 H-plane (h) R1 E-plane

Fig. 4-(a) to (h) respectively show the receiving antenna radiation patterns at 24GHz on the E-plane and H-plane. The reported gain for R1 is 13.84 dB, and the side lobes are -17.5 dB and -9.7 dB on the E and H planes, respectively. The reported gain for R2 is 13.75 dB, and the side lobes were -21.9 dB and -12.0 dB on the E and H planes, respectively. The reported gain for R3 is 13.88 dB, and the side lobes were -22.3 dB and -11.4 dB on the E and H planes, respectively. The reported gain for R4 is 13.86 dB, and the side lobes were -17.5 dB and -9.7 dB on the E and H planes, respectively.

C. Mutual coupling

The distance between transmitting antenna and receiving antennas should be limited in an appropriate range to fulfill the antenna miniaturization and portability required by the hand gesture detections. Fig. 5 shows the mutual coupling in the proposed antenna module. At 24 GHz, the mutual coupling between the transmit antenna and four receive antennas was below -60 dB.

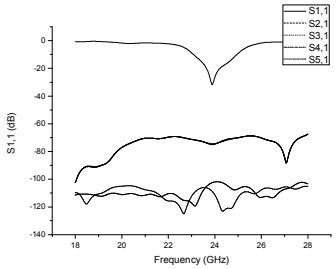


Fig. 5. Mutual coupling between antennas

IV. CONCLUSION

This paper introduced a 24GHz antenna module design for human hand gesture detection. This module included one transmitting antenna with 16 elements and four receiving antennas. The antenna module can provide high gain, low side lobe levels and weak mutual coupling patterns for human hand gesture detection.

ACKNOWLEDGMENT

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