Performance of Miniaturized 6-port MIMO Antenna Using Orthogonal Polarization

Kazuya Takahashi[1], Naoki Honma[1], Kentaro Murata[2], and Yoshitaka Tsunekawa[1]
[1]Graduate School of Engineering, Iwate University
4-3-5 Ueda, Morioka, 020-8551, Japan
[2]Graduate School of Engineering, National Defense Academy
1-10-20, Yokosuka, Kanagawa, 239-8686, Japan

Abstract **– In this paper, miniaturized 6–element MIMO (Multiple-Input Multiple-Output) antenna using T-shaped inverted-F antenna and reactance-loaded notch antenna is experimentally evaluated. Combination of T-shaped inverted-F antenna and reactively loaded notch antenna offers both miniaturization and orthogonalization of antenna elements. The experimental results showed good matching and low mutual coupling characteristics. Furthermore, MIMO channel capacity was evaluated and it is found that the proposed antenna significantly outperforms monopole-array in capacity.**

Index Terms **— MIMO, Antenna, Miniaturization, Capacity**

I. Introduction

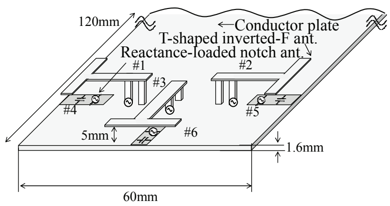
MIMO (Multiple-Input Multiple-Output) communication technology has widely applied even for mobile communication terminals. However, mutual coupling among antennas becomes a problem for such terminals. Increase of the mutual coupling between antennas leads to degradation of antenna performance such as high correlation and low radiation efficiency. Therefore, MIMO antenna that achieves both low mutual coupling and compact geometry is required. However, decoupling method using parasitic elements and decoupling circuit require additional components that are not desirable for small terminals [1] ~ [3].

Authors have proposed a compact 6-port MIMO antenna using orthogonal polarization elements [4]. In this configuration, both low mutual coupling characteristics and miniaturization are realized. However, the experimental verification and impact on MIMO channel capacity have not been investigated.

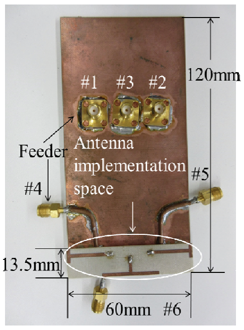
In this paper, the experimental results of a compact 6-port MIMO antenna that exploits both polarization orthogonality and miniaturization technique of antenna element are presented. It is shown this antenna configuration can achieve not only low mutual coupling characteristics, but also high channel capacity.

II. Antenna Configuration

Fig. 1(a) and (b) show the proposed antenna configuration and a photo of fabricated antenna based on [4]. The fabricated antenna consists of the substrate whose relative permittivity, ε_r, is 2.2, thickness is 1.6 mm, and center frequency, f_c, is 2.4 GHz. The fabricated antenna has been optimized to make reflection coefficient of all elements lower than −10 dB, where the loading reactance at notch antennas, #4, #5, #6, are 0.8 pF, 0.8 pF, and 1.5 pF, respectively. The size of the antenna elements is $13.5 \times 60 \times 5$ mm^3 which is quite small in terms of the handset size.

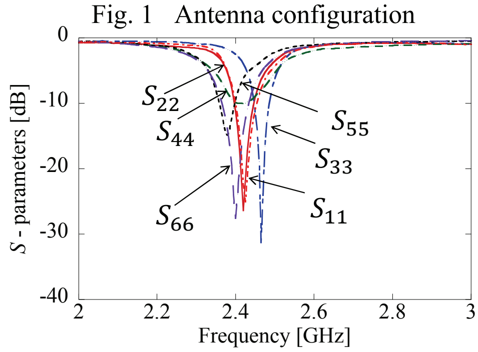


(a) Proposed antenna configuration

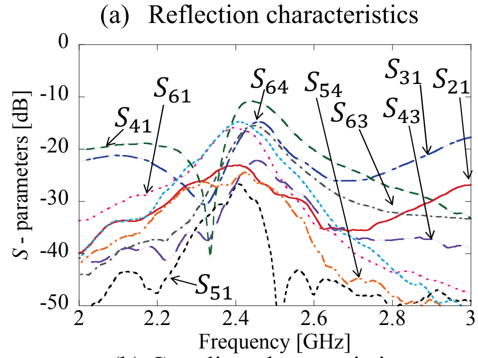


(b) Fabricated antenna

Fig. 1 Antenna configuration



(a) Reflection characteristics



(b) Coupling characteristics

Fig. 2 *S*-parameters of fabricated antenna

III. RESULTS

A. Antenna Characteristics

Fig. 2 shows *S*-parameters of the fabricated antenna. Fig. 2(a) and (b) are reflection and coupling characteristics, respectively. Reflection characteristics of all elements are confirmed to be lower than −10 dB at the center frequency. However, the highest coupling, i.e., $|S_{52}| = -8.2$ dB at the center frequency is observed. Whereas the proposed antenna configuration is symmetric, $|S_{52}|$ should have been same characteristic with $|S_{41}|$, whose value is – 11.2dB. This is considered due to the manufacturing error and existence of coaxial cable for feeding. Nevertheless, the impact of these characteristics on the communication performance needs to be investigated.

B. MIMO Characteristics

Fig. 3 shows CDF (Cumulative Distribution Function) of channel capacity of the fabricated antenna. Channel is calculated using geometric-based scattering ring model, where measured the 2-dimension directivities were used. The number of trials is set to 1000 and path distribution is assumed to be uniform in horizontal plane, i.e., Rayleigh environment were assumed. Further, polarization of channel rotates randomly at the scatters. Two types of six-element transmitting antennas were used. One is omni-directional antennas using vertical and horizontal polarizations, and other is omni-directional antennas only using vertical polarization. Here, element spacing in the transmitting antenna array is one wavelength. Also, two types of the receiving antennas were evaluated. One is the proposed antenna, and the other is monopole array with six elements that was configured in the same aperture width as proposed antenna. SNR (Signal-to-Noise Ratio) is set to 20 dB, and channel capacity is calculated at the center frequency. From this result, it is found that the channel capacity of proposed antenna compared with monopole array was improved by 2.62 Bits/s/Hz at 50 % value.

Fig. 4 shows CDF of SNR of the fabricated antenna. SNR is calculated using same channel model described above. SNR of proposed antenna is lower by 1.45 dB than that of the monopole array at 50 % value. This is because the average gain of the proposed antenna in horizontal plane is lower than that of 6-monopoles. Also, average spatial correlation of the proposed antenna and monopole array are 0.45 and 0.58, respectively. This is considered that the channel capacity is increased due to its low spatial correlation.

IV. CONCLUSION

This paper has experimentally evaluated the miniaturized 6-element MIMO antenna. The experimental results show good matching and low mutual coupling characteristics. Furthermore, the numerical analysis results using measured 2-dimentional directivities show channel capacity of proposed antenna compared with monopole array has been improved by 2.62 Bits/s/Hz at 50 % value. Even though SNR of proposed antenna compared with monopole array was deteriorated by 1.45 dB, spatial correlation of the proposed antenna is improved by 0.13. These results have shown that proposed antenna design can offer both miniaturization of overall size and improvement of the channel capacity.

ACKNOWLEDGMENT

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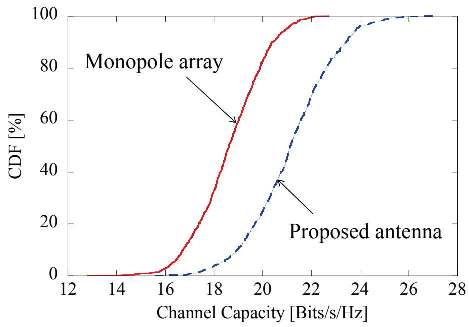

Fig. 3 CDF of channel capacity

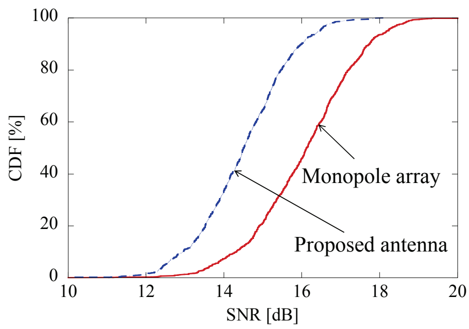

Fig. 4 CDF of SNR