A Wideband 4-Port MIMO Antenna Using Leaf-Shaped Notch Antennas

Jumpei Motohashi and Manabu Yamamoto

Graduate School of Information Science and Technology, Hokkaido University
Kita 14, Nishi 9, Kita-ku, Sapporo 060-0814, Japan

***Abstract* - This study presents a design of a wideband 4-port antenna array which is useful for MIMO applications. In the designed antenna array that operates over the frequency range from 7.25 to 10.25GHz, leaf-shaped notch antennas are employed as the radiating elements. In order to enhance the isolation between antenna elements, the radiating elements are arranged on the substrate such that polarizations of adjacent elements are orthogonal to each other. Characteristics of the designed antenna array are evaluated by the finite-difference time domain (FDTD) analysis. Over the above-mentioned frequency range, the designed antenna has the reflection coefficient of less than −10dB and the mutual coupling between ports below −19dB.**

***Index Terms* — MIMO Antenna, wideband antenna, leaf-shaped notch antenna.**

1. Introduction

In recent years, MIMO (Multiple-Input Multiple-Output) communication technology has been applied for various kinds of communication systems, such as Wi-Fi, LTE and WiMAX. Employing a wideband MIMO antenna [1], [2] is effective way for covering multiple communication systems for which MIMO technology is adopted.

In this paper, a design of a wideband 4-port antenna array being useful for MIMO applications is presented. In the designed antenna array that operates over the frequency range from 7.25 to 10.25 GHz, leaf-shaped notch antennas are employed as the radiating elements. These antennas are arranged on the same dielectric substrate such that the polarizations of adjacent antennas are orthogonal to each other. By adopting this arrangement, high isolation between the radiating elements are realized in the designed antenna.

In order to demonstrate the effective performance of the presented configuration, characteristics of the designed wideband MIMO antenna are evaluated by the finite-difference time domain (FDTD) analysis. Over the above-mentioned frequency range, the designed antenna array has the reflection coefficient of less than −10 dB and the mutual coupling between ports below −19 dB.

2. Antenna Strucutre

The configuration of the designed 4-port antenna array for MIMO applications is shown in Fig. 1. As the radiating elements of the antenna array, leaf-shaped notch antennas are printed on a dielectric substrate having the thickness of h, relative permittivity of ε_r. These antennas are the modified forms of leaf-shaped bowtie slot antennas which have been previously proposed by the authors [3]. These notch antennas are designed by rounding the corner of the square apertures with the curvature radius of R_n. The side lengths of the square apertures are denoted by L_n. Four notch antennas are arranged on the top side of the dielectric substrate such that the polarizations of adjacent radiating elements are orthogonal to each other. The tapered microstrip lines printed on the bottom side of the substrate are employed for the excitation of the notch antennas. The notch antennas are connected to the end of the microstrip lines by conducting posts. In order to obtain unidirectional radiation characteristics, a back reflector having the same dimension as those of the dielectric substrate is placed underneath the antenna array.

The structural parameters of the antenna array assumed in the following investigations are listed in Table 1. In this table, all dimensions are indicated in millimeters. These structural parameters are optimized to achieve the operation over the frequency range from 7.25 to 10.25 GHz, which corresponds to the UWB high band in Japan.

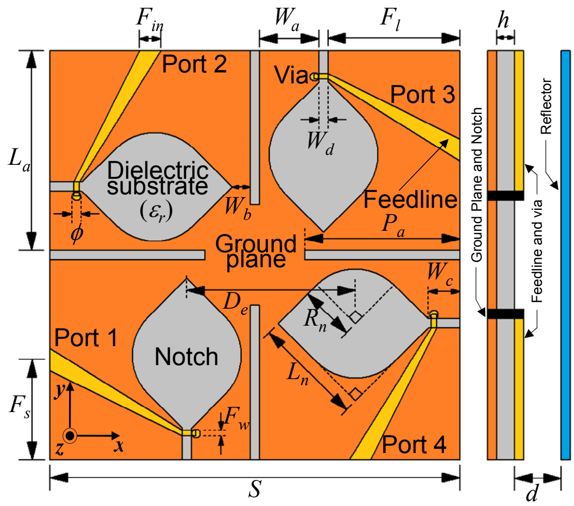


Fig. 1. Configuration of the MIMO antenna array.

TABLE I
Structural parameters of the MIMO antenna array.
(All dimensions are indicated in millimeter.)

ε_r	h	d	S	R_n	L_n	P_a	L_a	D_e
2.17	0.76	11	45	6	12	17	22	18.5

ϕ	F_{in}	F_l	F_w	F_s	W_a	W_b	W_c
0.6	2.4	14.5	0.4	11	6.5	2	3.5

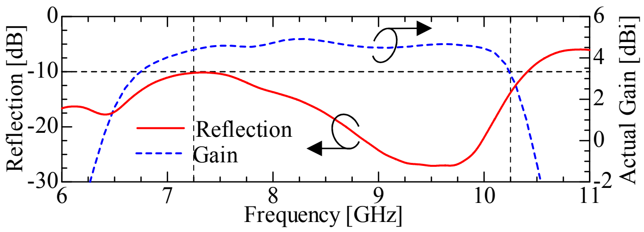


Fig. 2. Frequency response of reflection and actual gain.

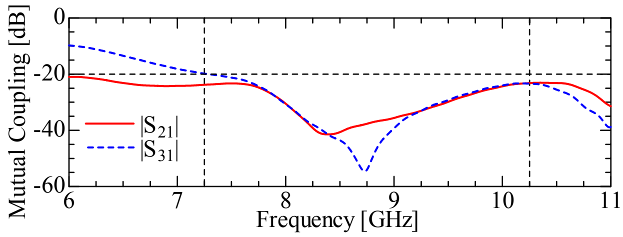


Fig.3. Frequency response of mutual coupling.

3. Numerical Evaluation of Antenna Performance

Characteristics of the designed antenna array have been evaluated by the FDTD analysis. In the first place, the frequency response of the reflection coefficient is evaluated for the case where one of the input ports is excited and the others are terminated with 50 Ω loads. The result is shown in Fig. 2 with the red solid line. It can be seen that the reflection is below −10dB over the frequency band of 7.25-10.25 GHz.

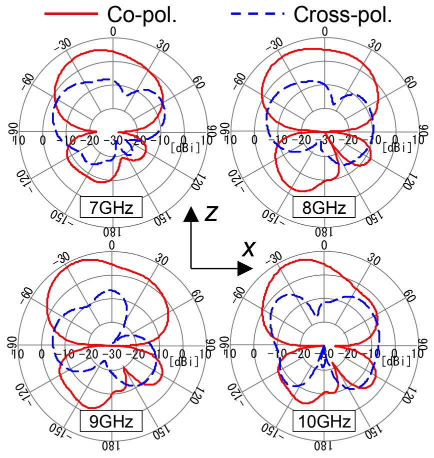
In the next place, mutual couplings between ports are evaluated. Fig. 3 shows the frequency response of the mutual couplings between ports 1 and 2, ports 1 and 3. The couplings are observed to be less than −19dB over the frequency range from 7.25 to 10.25 GHz.

Radiation patterns for the case where one of ports is excited and the other ports are terminated with 50 Ω loads have been evaluated at the frequencies of 7 GHz, 8 GHz, 9 GHz and 10 GHz. Simulated results are shown in Fig. 4 , where the solid and broken lines denote radiation patterns for co- and cross-polarization in each planes, respectively. It can be seen that the antenna exhibits quasi-unidirectional at each frequencies. Frequency response of the actual gain observed in +*z*-direction is shown in Fig. 2 with the blue broken line. Over the frequency range from 7.25 to 10.25 GHz, the actual gain is observed to be 3.5-4.5 dBi.

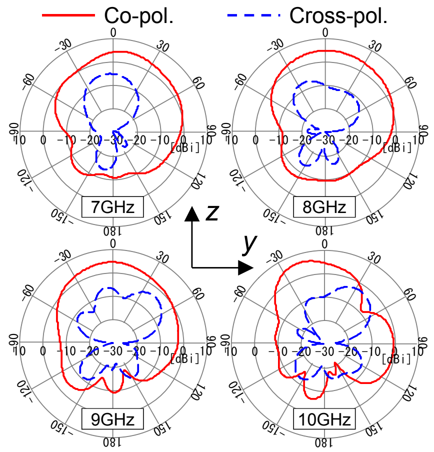
In order to evaluate MIMO performance of the antenna array, the envelope correlation coefficients among two antennas have been calculated by substituting the simulated scattering parameters into the following expression [4].

$$\rho_{ij} = \frac{|S_{ii}^* S_{ij} + S_{ji}^* S_{jj}|^2}{(1-|S_{ii}|^2 - |S_{ji}|^2)(1-|S_{jj}|^2 - |S_{ij}|^2)} \qquad (1)$$

Simulated envelope correlation coefficients are shown in Fig. 5. As suggested in [4], a good diversity effect can be obtained when the envelope correlation is less than 0.5. As can be seen from the figure, the envelope correlation values remain under 0.06 over the frequency range from 7.25 to 10.25 GHz. This leads us to expect good performance of the designed MIMO antenna array in terms of diversity.



(a) *zx*-plane (E-plane)



(a) *yz*-plane (H-plane)

Fig. 4. Simulated radiation patterns.

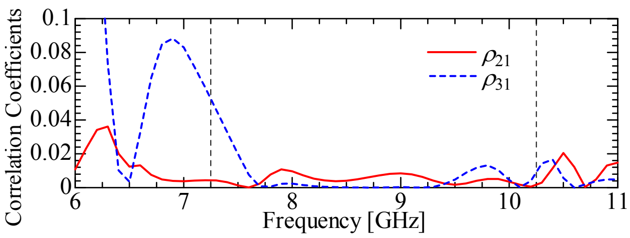


Fig. 5. Simulated envelope correlation coefficients.

4. Conclusion

In this paper, a wideband 4-port MIMO antenna array using leaf-shaped notch antennas has been presented. Over the frequency band of interest, the reflection coefficient is observed to be less than −10 dB and the mutual coupling between ports are less than −19 dB. The antenna port envelope correlation coefficients are observed to be less than 0.06, which are substantially smaller than the value of 0.5 being suggested for realizing the good diversity effect.

References

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