Characteristic Current Based MIMO Antenna Performance Estimation in Chassis Mode Platform

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Abstract - **Characteristic mode theory (CMT) is an effective method for designing MIMO system. Establishing reliable channel is an important issue in communication systems. And MIMO system based on CMT is one strong candidate among the other approaches. In this paper, some design examples of MIMO antenna on chassis and its coupler structure is shown. The proposed coupler is useful to excite a desired mode from the other chassis modes. The estimation is conducted with Envelope Correlation Coefficient (ECC). The simulation results are also demonstrated.**

Index Terms — **Characteristic Mode Theory, Coupler, ECC, Chassis Antenna, MIMO.**

1. Introduction

Multi-Input Multi-Output (MIMO) system has been studied in many fields. In communication area, especially, MIMO is spotlighted for its reliable channel-capacity. One of its application is military-use small platform. To establish communication system on it, many approaches are proposed. Among these design methods, however, Characteristic Mode Theory (CMT) is practical and straightforward method for building MIMO system using the platform itself as an antenna [1]. CMT is a linear summation of eigen-currents. Because it has orthogonality between each mode, the designer can easily construct MIMO system than the other method [2]. Recently, several systematic design method is proposed [3]-[4] which considered electrically small structure (Booster) as an exciter to make better use of CMT. In this paper, we will propose practical H-shaped slit booster structure and construct MIMO on bug robot platform (See Fig. 1., 69.8mm × 52mm × 11mm) at 2.5GHz. Simulation data is shown and the system is estimated by Envelope Correlation Coefficient (ECC) [5].

2. Theory

CMA was proposed by Garbacz, Turpin [6], Harrington and Mautz [2]. After solving the method of moments (MoM), we can obtain the Z-matrix, which is then decomposed into the eigenvalue and the eigenvector (eigen-current). Solving the equation $[Z][I]=[E]$ for the Z-matrix, $[I]$, can be calculated as in [7].

Assuming the E-field E^i to be incident to the arbitrary PEC (perfect electric conductor) surface S and using the conducting boundary condition, the following formula is obtained:

$$[L(J)-E^i]_{\tan}=0. \quad (1)$$

Physically, $L(J)$ is the E-field, which is induced by J on the surface S. Eq. (1) has the dimension of impedance, so it can be expressed as follows:

$$[L(J)]_{\tan}=Z(J)=R(J)+jX(J), \quad (2)$$

where $R(J)$ and $X(J)$ are the real and the imaginary parts of the impedance operator, respectively. The characteristic currents are derived from Eq. (3) as a form of the eigen-current J_n.

$$X(J_n)=\lambda_n R(J_n). \quad (3)$$

In Eq. (3), λ_n and J_n are the eigenvalue and the characteristic current of the n_{th} mode, respectively.

The modal coefficient can also be derived, assuming that the total current is expressed by a linear combination of the characteristic currents. Therefore,

$$V_n^i=\langle J_n,E^i\rangle,\quad \langle A,B\rangle=\oiint_S A\cdot B\ dS. \quad (4)$$

Applying all the above mentioned results, we can express the total current as follows:

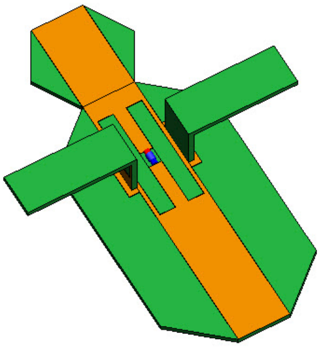
$$J=\sum_n \frac{V_n^i}{1+j\lambda_n}J_n. \quad (5)$$

The physical meaning of Eq. (5) is that the total current J can be composed by the linear combination of the characteristic current J_n, the coefficient of which is determined by V_n^i and λ_n. V_n^i is the correlation between E^i and J_n, where λ_n is expressed as the amount of reactive energy of the n_{th} mode.

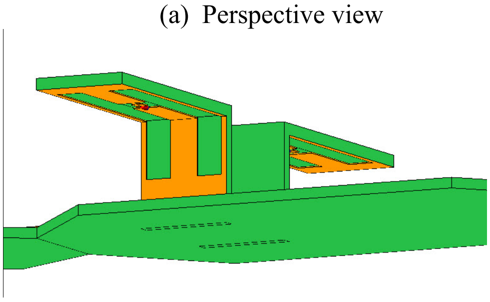
3. Model Design : Simulation Results

By using CMT, we can obtain two radiating modes from several modes on platform chassis (See Fig. 2). Based on characteristic current distribution, we can choose booster location to excite the desired mode (mode 1, 2). The H-shaped slit coupler are located at the bottom of the wing support and body part to enhance the mode excitation. The design adapted FR4 (er = 4.3), and copper coating. Applying this structure, mode 1, 2 was successfully excited with high isolation (See Fig. 3).

And whole system has low (< 0.1) ECC value throughout 2.05 to 2.8 GHz (See Fig. 4). So its mode diversity also established to use this as MIMO system with high isolation.



(a) Perspective view



(b) Side view

Fig. 1. Coupler applied military-use small platform

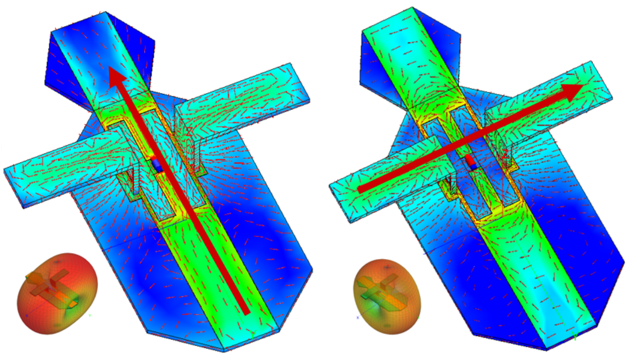


Fig. 2. Current distribution and radiating pattern of each radiating modes (Left: mode 1, Right: mode 2)

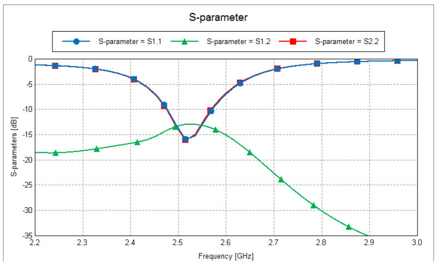


Fig. 3. S-parameter of the MIMO system.

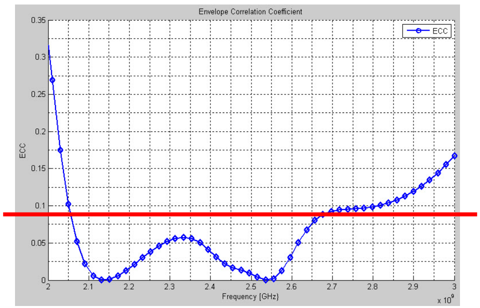


Fig. 4. ECC results

4. Conclusion

In this paper, practical H-shaped coupler was proposed and construct platform as MIMO using CMT. Consequently we can use platform as an MIMO system with booster which can excite targeted mode without any additional antenna. And demonstrated its MIMO performance with ECC also acceptable.

Acknowledgment

This research was supported by a grant to Bio-Mimetic Robot Research Center funded by Defense Acquisition Program Administration, and by Agency for Defense Development (UD130070ID).

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