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Diversity performance of Modulated Scattering Antenna Array with switched reflector

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Abstract: The previous researches on the modulated scattering antenna array (MSAA) have shown that the second-order intermodulation scattering signal is relatively low compared with the directly received signal. In this research, a switched reflector is used to solve this problem. The diversity performance of the MSAA with a switched reflector is investigated. It is shown that the diversity performance of the MSAA can be improved by mounting a switch on the reflector.

Keywords: array antenna, modulation, mobile handsets, Volterra series, MoM

Classification: Microwave and millimeter wave devices, circuits, and systems

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1 Introduction

Recently, a new concept of antenna arrays, which is called modulated scattering antenna array (MSAA), based on the modulated scattering technique (MST) has been proposed by Yuan et al [1], and it can be used as a receiving antenna array for the mobile handset. The MSAA consists of one ordinary antenna element and several modulated scattering elements (MSEs) without RF front-end circuits. Therefore, the MSAA is very remarkable when it is utilized for the mobile terminals in the multiple-input multiple-output (MIMO) systems where compactness and energy saving are of primary concerns. In the previous works [1, 2, 3, 4, 5], the performance of the MSAA for wireless communications has been extensively discussed by many experimental studies on the spatial diversity, the error vector magnitude (EVM) and the channel capacity etc. in the Rayleigh fading environment, it is found that the MSAA is suitable for mobile handset in the MIMO communication due to its simple configuration and low energy consumption.

In [6], a hybrid method based on the Volterra series method and the method of moments (MoM) has been presented to find optimum parameters of MSEs and to further improve the performance of the MSAA. Although the performance of the MSAA can be improved by that method, the second-order intermodulation scattering signal is still relatively low compared with the directly received signal. In this research, a thin-wire reflector is introduced to improve the performance of the MSAA. Moreover, the diversity performance of the MSAA with the reflector is analyzed in the first time through this approach to hybridization of the Volterra series method and MoM.

2 Configuration of the MSAA with a switched reflector

The configuration of the MSAA with a switched reflector is shown in Fig. 1, and a switched reflector is mounted near a modulated scattering element (MSE). V_d and V_{LO} are the DC bias and the local signal voltages, while internal resistance of the corresponding generators are represented by R_{id} and R_{io}, respectively. When the switch is changed from "Short" status to "Open" status, the received power of the MSAA versus different incident angle will be varied. Therefore, selection diversity can be realised.

3 Simulation and Results

In the simulation, the geometry of simulation model is similar to that shown in Fig. 1 and is created by FEKO from EM Software & Systems-S.A. (Pty) Ltd.. The entire structure is within the *yoz* plane, and array spacing d is 0.1λ (f=2.5 GHz). Distance s between MSE and reflector is also $0.1\,\lambda$. A vertically polarized plane wave is assumed as the excitation signal of the MSAA. The magnitude of the incident electric field is 0.09 V/m. The electrical length of reflector, MSE and receiving antenna is $0.6\,\lambda$, $0.5\,\lambda$ and $0.5\,\lambda$, respectively. Moreover, $V_{LO} = 0.5\,V_{P-P}$, $V_d = 0.2\,V$, and internal resistors R_{id}, R_{io} and the input impedance of the RF receiver are fixed as $50\,\Omega$. When the total

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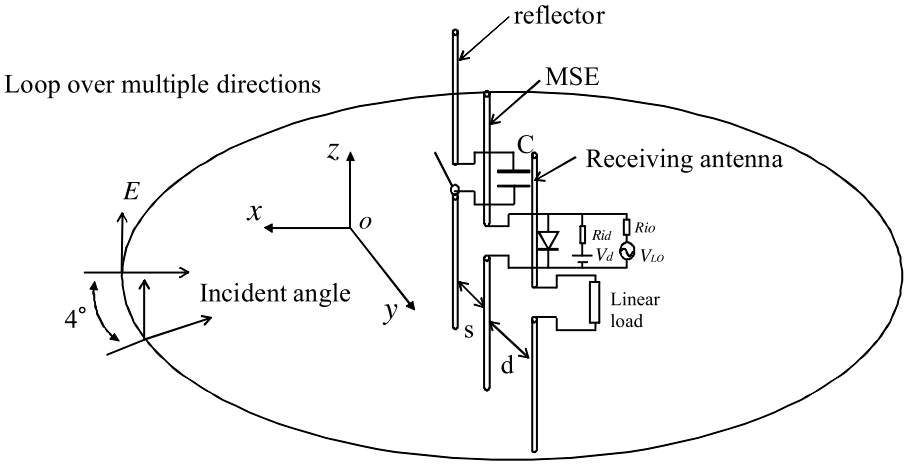

Fig. 1. Geometry of modulated scattering dipole antenna array with a switched reflector.

simulation model was built, 90 simulations were performed versus different incident angle with a step of 4° in the horizontal plane (xoy plane).

Fig. 2 shows results of the received power of the MSAA versus various incident angles in the free space. P_{RF} and P_{IF} are received power of directly received signal and the second-order intermoudulation scattering signal by the MSAA, respectively. As been described before, when a state of the switch is changed, received power level of the MSAA has a remarkable difference with various incident angles. For instance, when the range of the incident angle is from 164° to 360°, P_{IF} of "Open" status is higher than that of "Short" status. However, P_{IF} of "Short" status is higher than that of "Open" status in the range of 16° to 164°. In other words, larger P_{IF} can be selected by changing the switch status. Therefore, for different incident angle, we can take the maximum P_{IF} as the optimal results. The optimized P_{RF} and

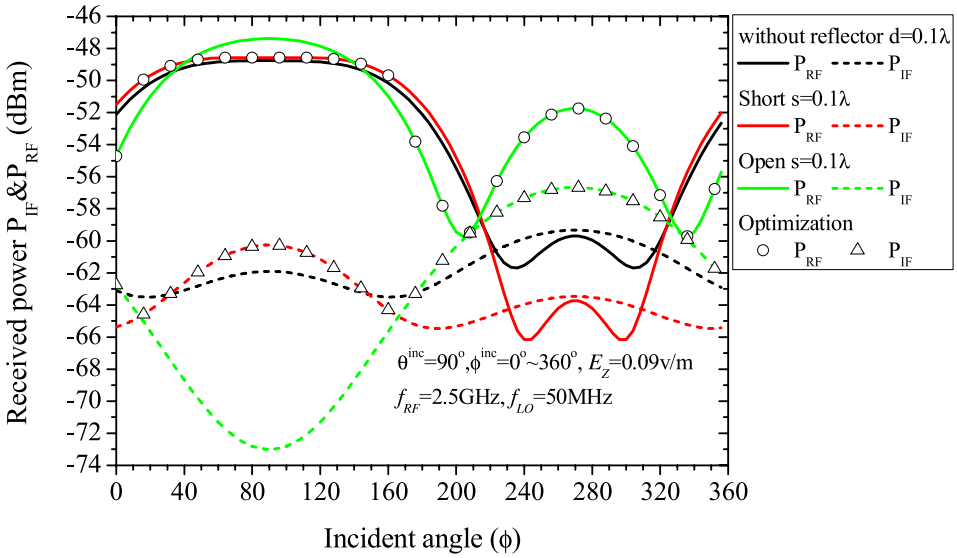

Fig. 2. Results of the received power of the MSAA versus various incident angles.

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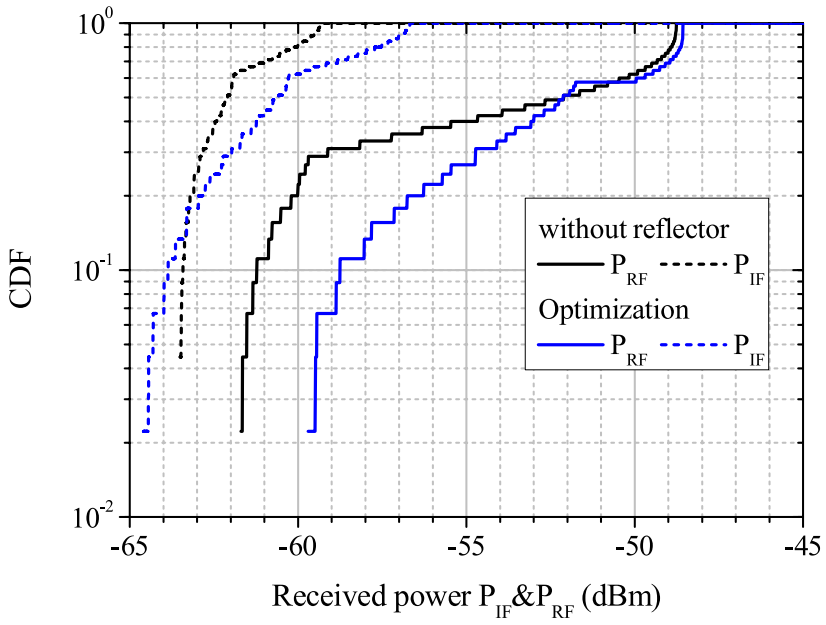

Fig. 3. CDF of the received power of the MSAA.

P_{IF} are denoted by circle and up triangle, respectively. The cumulative distribution function (CDF) of the received power of the MSAA is shown in Fig. 3. It is found that when the reflector is introduced, median result of P_{IF} is improved about 1.5 dB comparing with that of the MSAA without reflector. And when CDF is 0.3, P_{RF} is also improved about 4 dB. Therefore, the performance of the MSAA can be improved by introduction of the switch on the reflector.

4 Conclusions

The diversity performance of the MSAA has been analyzed in this research. It has been found that when the switched reflector is mounted near the MSAA, the selection diversity can be used to improve the performance of the MSAA.

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