

A study of MMSE adaptive array antennas for handsets in consideration of antenna configuration

Kazufumi Imamura and Hisashi Morishita

Department of Electrical Engineering, National Defense Academy

1-10-20 Hashirimizu, Yokosuka 239-8686 Japan

Tel: +81-468-41-3810 ext. 2261, Fax: +81-468-44-5911

e-mail: morisita@nda.ac.jp

Introduction

Channel capacities and data rates of mobile communications have been increasing to meet demands of modern communications. In order to achieve a low bit error rate (BER), we need high signal to interference plus noise ratio (SINR). To realize the high SINR, it is effective to use an adaptive array antenna [1]. The adaptive array antenna can reduce the influence of multipath rays.

On the other hand, the performance of an adaptive array antenna is strongly affected by the electromagnetic characteristics of the antenna array. An important electromagnetic characteristic of an antenna array is the mutual coupling between its elements. In the above work, mutual coupling between the antenna elements was, however, ignored. That is because the antenna elements were assumed to be isolated from each other. In practice, elements of an antenna array have mutual coupling which in turn affect the gain, beam width, etc., of the array [2]. But only little effort has been considered for developing adaptive antenna array receivers suitable for handsets. In fact, there are several difficulties with the implementation of such a solution at the handset level. First, the space on the handset device is limited, which does not allow us to implement an antenna array with enough elements for efficient spatial signal processing. The second problem is related to the movement of the mobile that provides an omnidirectional scenario. Third, the cost and the complexity of the implementation at every mobile is much greater than the implementation at each base station [3].

In this paper, MMSE adaptive array antennas for handsets in consideration of antenna configuration are studied when they are consisted of conventional antennas, such as a monopole and planar inverted-F antenna (PIFA) or newly proposed built-in folded monopole antenna (BFMA)[4] on a finite ground plane under simple propagation models.

Analytical models and simulation conditions

Figure 1 shows the antenna configurations. Three antenna combination models (A: PIFA+Monopole B: PIFA+PIFA C: BFMA+BFMA) are considered and each element is placed very close to the rectangular ground plane, which represents a shielding plate used in the handset unit. BFMA consists of a half of built-in folded dipole antenna (BFDA)[5] for handsets. The antenna has a structure, which folds a half-size of folded dipole antenna additionally so that small size and a low profile could be achieved. Furthermore, it is considered that the antenna has a self-balanced structure.

Antenna parameters are $a=30\text{mm}$ for monopole, $l=23\text{mm}$, $w=17\text{mm}$, $h=4\text{mm}$ for PIFA, $w_1=5\text{mm}$, $w_2=3\text{mm}$,

$w_3=4\text{mm}$, $d=0.5\text{mm}$, $w_t=1.5\text{mm}$, $h=7.5\text{mm}$, $s=13\text{mm}$ for BFMA. Antenna element and GP are made of copper plate with thickness of 0.2mm, 0.5mm respectively.

Figure 2 shows the propagation model. Broken line in this figure represents the place where elements are attached. As can be seen in the figure, we supposed 2 different propagation models. Condition α means the incident angle of desired and interference plane waves are different, while Condition β means the polarization angle of desired and interference plane waves are different. Desired wave incident angle is assumed 0° (It is x axis here). The signals are assumed plane wave and direction of arrival is assumed only horizontal plane (It is XY plane here). In order to emulate a plane wave, transmission dipole is placed to leave 3000mm (20λ) between the mobile terminal array and the dipole. Table 1 shows the simulation parameter. The electromagnetic simulator IE3D based on the method of moments (MoM) is applied to calculate mutual impedance and elements terminal voltage. This voltage is used as array starting vector to execute the minimum mean square error (MMSE) criterion algorithm processing.

Simulation results and conclusion

Figure 3 shows the spatial correlation ρ_{di} in condition α and condition β , respectively. Spatial correlation is a parameter that expresses the degree of orthogonal of the array response vector numerically. And the absolute value of spatial correlation influences the output SINR. In condition α , spatial correlation of B is low slightly. But remarkable difference about A-C is not seen. In condition β , the values of B and C are lower than that of A. Figure 4 shows the output SINR in condition α and condition β , respectively. In condition α , each output SINR is almost the same level. In condition β , C that has low spatial correlation value, high output SINR is shown.

This time an adaptive characteristic is studied in consideration of antenna configuration with the ground plane in simple propagation models. Next subject is the examination of the antenna characteristics and adaptive performance of this model by the actually near radio propagation environment.

References

- [1] S.Tanaka, et al "Pilot Symbol-Assisted Decision-directed Coherent Adaptive Array Diversity for DS-CDMA Mobile Radio Reverse Link," IEICE Trans. FUND, vol.E80-A, NO.12 Dec, 1997
- [2] I.J.Gupta, et al "Effect mutual coupling on the performance of adaptive arrays," IEEE Trans. on Antenna and Propagation, vol.AP-31, No.5, Sept, 1983.
- [3] Tayeb A. Denidni, et al "Experimental Investigation of a New Adaptive Dual – Antenna Array for Handset Applications," IEEE Trans. on Vehicular Technology, vol.52, No.6, Nov, 2003.
- [4] S.Hayashida, et al "Characteristics of built-in folded monopole antenna for handsets," IEICE Technical Report, AP2003-269, Feb. 2004.
- [5] T.Tanaka, et al "Built-in folded dipole antenna for handsets," IEEE AP-S Proc., vol.1, pp.451-454, Jun. 2003.

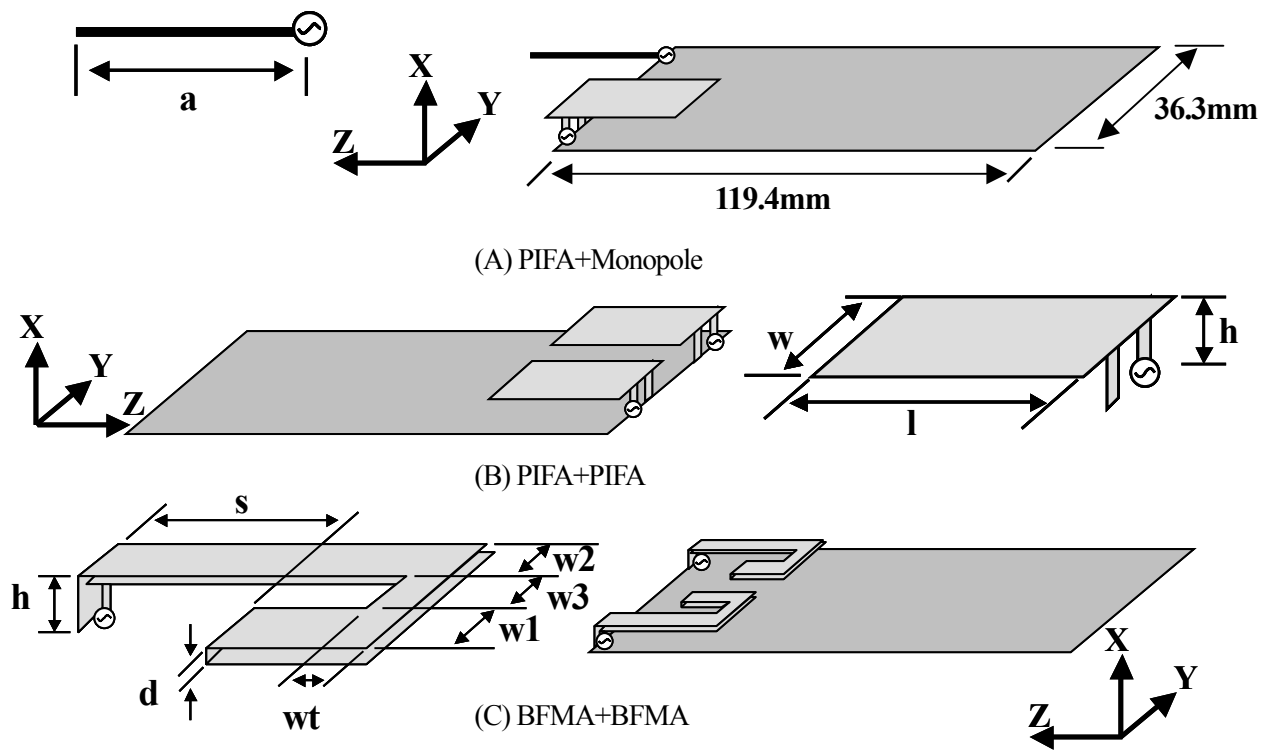


Fig. 1 Antenna configuration

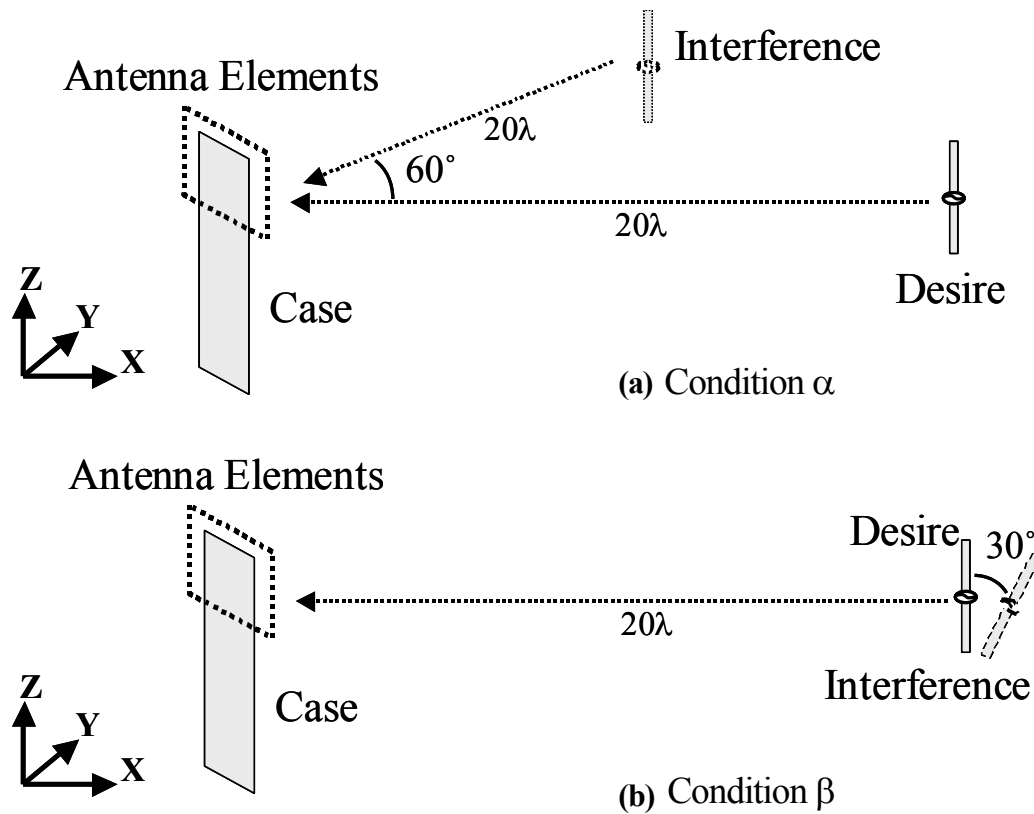


Fig. 2 Simulation model

Number of elements	2
Algorithm	SMI
Frequency	2 GHz
Condition α	Desire 0°, Interference wave incident angle change
Condition β	Desire 0°, Interference wave polarization angle change

Table 1 Simulation conditions

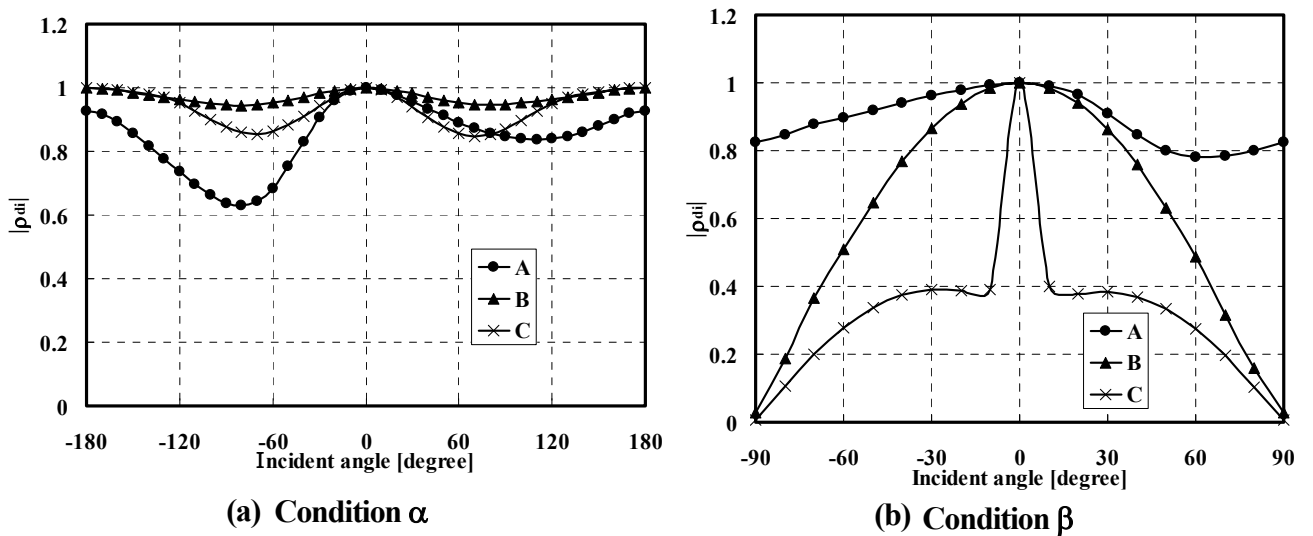


Fig. 3 Comparison of the $|\rho_{di}|$ between 3 models

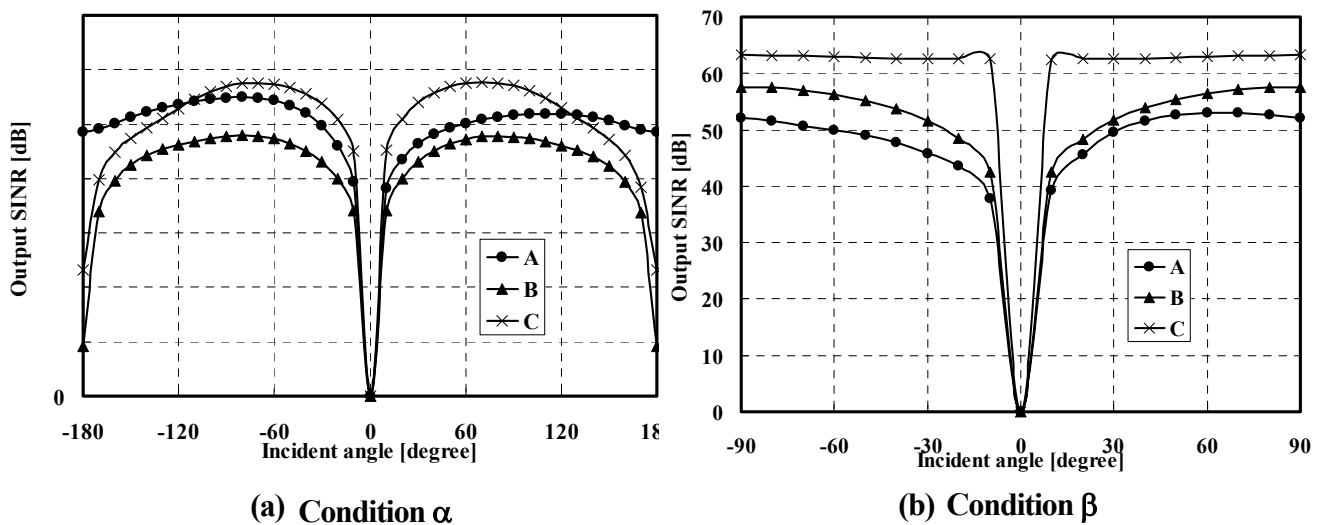


Fig. 4 Comparison of the Output SINR between 3 models