

Performance Study of W-CDMA Adaptive Array Antennas

Q. Yuan*¹, T. Suguro², Q. Chen², K. Sawaya², E. Kudoh², and F. Adachi²

¹ Intelligent Cosmos Research Institute, Japan, qwyuan@hotmail.com

² Tohoku University, Japan

1 Introduction

The benefits of using adaptive array antenna (AAA) technique in wireless mobile systems have been thoroughly studied in recent years, showing overcoming multipath fading of the desired signal and suppressing the interfering signals, as a consequence, an increase in the system capacity [1]-[2]. Although, most of the applications of AAA have been found in base stations, the application to mobile terminals has been paid more and more attention. In the case of mobile terminals, because of the space limitation for locating array antennas, the array spacing is small compared with the case of base station. Therefore, the mutual coupling between array elements should be considered carefully in adaptive array antenna systems [3, 4].

In this study, the effect of the antenna geometry and the adaptive algorithm on the performance of a W-CDMA adaptive array antenna for mobile terminals is investigated experimentally. A W-CDMA receiving system for a 4-element array antenna is developed. The adaptive algorithm and the array antenna configuration are changed according to the requirement of the investigation. The performance of the system including synthesized pattern, adaptive weight and BER characteristics are measured for the performance analysis.

2 System Configuration of W-CDMA Receiver

The configuration of the W-CDMA receiver is shown in Fig.1. There are 4 RF branches with SMA input ports to connect 4 receiving antennas. The system works at 2.452GHz. Each RF branch consists of a low noise amplifier and a mixer to convert RF signal at 2.452 GHz to IF signal at 15.36 MHz. In the baseband circuit, the IF signal is over-sampled at a clock of 61.44 MHz and converted into digital data by a 12-bit A-D converter (ADC). The baseband signal is received by a digital demodulator and a correlator.

3 Geometry of Array Antenna

In this research, a 4-element monopole array antenna(Fig.2a), and a 4-element monopole array antenna with a reflecting plane (Fig.2b) are used as the receiving array antennas, respectively. The array element pattern of these array antennas has been measured. It is found by the measurement that the monopole with a reflecting plane has a higher gain in the front direction than the monopole, while the array element pattern of the monopole is more homogeneous than that of the monopole with a reflecting plane.

4 Adaptive Algorithm - NLMS

Since the normalized least mean square (NLMS) algorithm requires few calculating operations and small memory size, it is applied to the developed W-CDMA receiver.

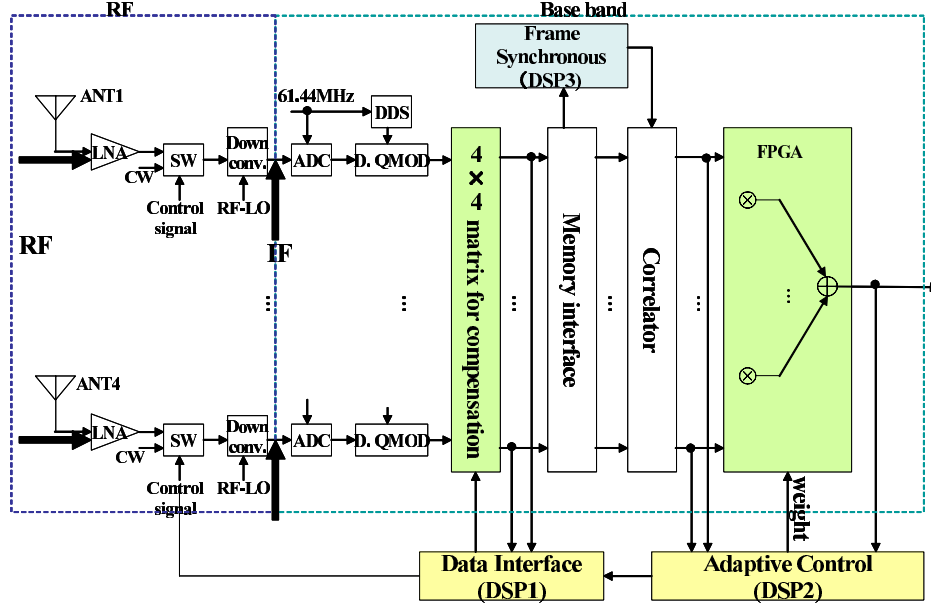


Figure 1: System configuration of W-CDMA receiver.

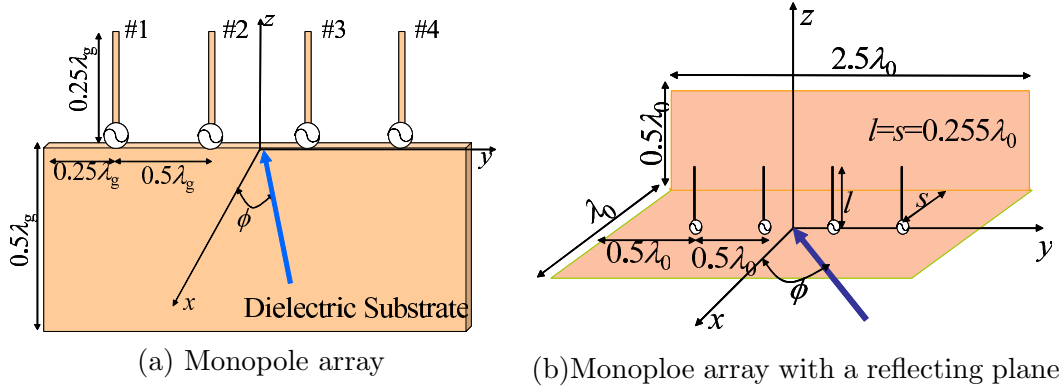


Figure 2: Configuration of receiving array antennas.

The optimum weight vector $[W(t)]$ for each slot is obtained by the following iteration

$$[W(t)] = [W(t - \Delta t)] + \mu e^*(t)[X(t)] / \| [X(t)] \|^2, \quad (1)$$

and further normalized as

$$w_i(t) = w_i(t) / \| [W(t)] \|^2. \quad (2)$$

In equation (2), $w_i(t)$ denotes the i^{th} element in the weight vector. In equation (1), $[X(t)]$ represents the pilot data in each slot. Δt is the time interval between two slots. μ is the step size which should be selected between 0 and 1. $e(t)$ is the error between the synthesized output and the known reference pilot signal $plt(t)$, and is obtained by

$$e(t) = plt(t) - [W(\Delta t)]^H [X(t)], \quad (3)$$

where the superscript H denotes the complex conjugate transpose, $[W(\Delta t)]^H [X(t)]$ represents the output signal synthesized by the weights and the input data $[X(t)]$.

5 BER Measurement

BER measurement is performed in a microwave anechoic chamber shown in Fig.3. The desired wave and the interference generated by vector signal generators are W-CDMA modulated signals whose data formats are shown in detail in Table 1. A logic analyzer used to collect the output data from the W-CDMA receiver in a required period of time. Every BER value is calculated at off-line mode from 100,000 bits of sample data which are collected by the logic analyzer.

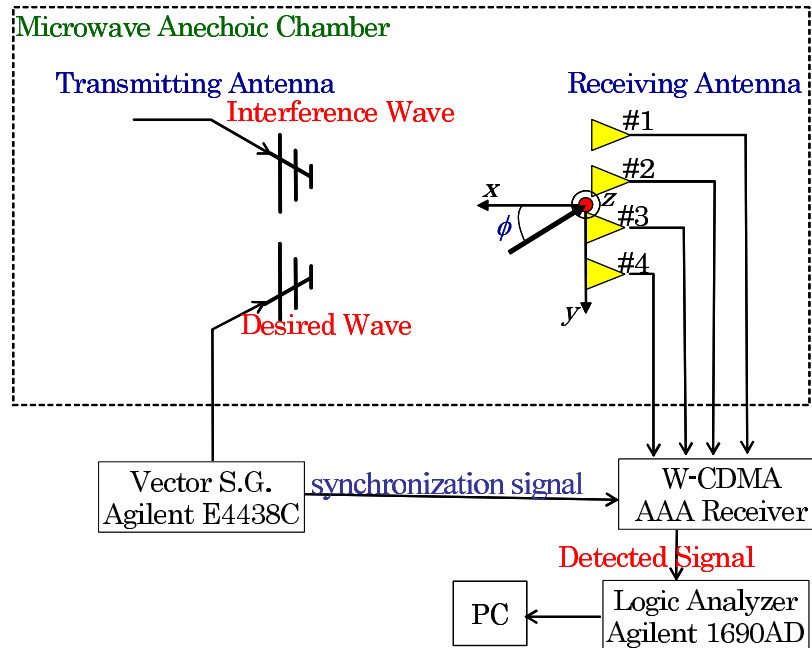


Figure 3: BER measurement system.

BER versus SIR (signal-to-interference ratio) for different types of antennas is shown in Fig.4 when spreading factor (SF) is 256. The incident direction ϕ_d of the desired wave is 0 and incident direction ϕ_i of interference is -40° . It is found that SIR of 4-element adaptive array is improved by 6-10 dB compared with that of a single antenna when BER is equal to 10^{-3} . BER of the single monopole with reflector is lower than that of the single monopole because the monopole with reflector has a higher gain in the direction of the desired wave. However, the SIR improvement of the monopole array is larger than that of the monopole array with reflector. It is because the array element gain of the monopole to the direction of the interference is larger. Therefore, the gain of array antenna elements in the direction of both the desired waves and the interference waves are important to the performance of adaptive array antennas. Since the incident of the desired waves and the interference waves should be in all directions in practice, array elements which have homogeneous radiation pattern and high radiation efficiency are suitable to the adaptive array antennas.

6 Conclusions

The W-CDMA receiver combined with AAA technique has been developed and used to measure the BER performances for different configuration of receiving array

Table 1: Specification of desired wave and interference

	Desired Wave	Interference
DOA	0	-40^0
Spread Factor	256	128
Symbol Rate	15 ksps	30 ksps
Spread Code	0	8
data	PN9	Random

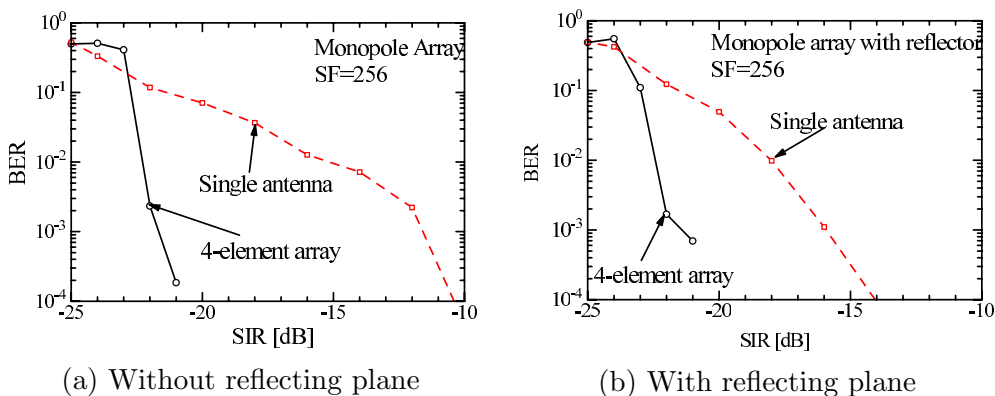


Figure 4: BER performance of W-CDMA receiver when SF=256.

antennas. The experimental results have demonstrated SIR can be greatly improved by 6-10 dB compared with the single antenna when BER is equal to 10^{-3} . BER of the single monopole with a reflector is lower than that of the single monopole because the monopole with reflector has a higher gain in the direction of the desired wave. However, the SIR improvement of the monopole array is larger than that of the monopole array with a reflector because the array element gain of the monopole to the direction of the interference is larger. It seems that array elements which have homogeneous radiation pattern and high radiation efficiency are suitable to the adaptive array antennas.

References

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