Power Inversion Adaptive Array Antenna for High Power Interference Suppression in DS-CDMA System

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1 INTRODUCTION

DS-CDMA[1] is being investigated for the next generation mobile communication system. In DS-CDMA, to distinguish one user's transmission from another, each mobile terminal modulates the information data symbols by a pseudo-noise(PN) code and the strong point of this system is that it can easily realize the multi-rate transmission. On the other hand, the transmission power increases in proportion to bit rate, so the low bit rate signals such as voice data are greatly damaged from the high bit rate signal. Therefore, to cancel those high power interferences, it is effective to apply the adaptive array antenna to the base station in DS-CDMA system. Usually, MMSE(Minimum Mean Square Error)[2] using a replica of the desired signal has been used for the control algorithm and the beamforming has been carried out for every users. This algorithm can certainly capture the desired signal and it is not impossible to process in real time taking into account the rapid device improvement in recent years. However, the system scale becomes large in proportion to the number of channels and this increases the consumption power of the system. Also, the requirement for large number of antenna elements in adaptive array could be a cause of the implementation problem. Therefore, introducing the adaptive array antenna would greatly affect the base station. It is necessary to solve these problems in order to spread the use of adaptive array. In this paper, we propose an adaptive array antenna for high power interference suppression. Power Inversion (PI) algorithm [3] is adopted as the signal-processing algorithm. By using this algorithm, the interference having the power larger than the noise power could be cancelled. Power Inversion procedure should be carried out before despreading (matched filtering), so the amount of the calculation is reduced compared to that of the conventional adaptive array system. Small size antenna can also be used as the auxiliary antenna.

2 THE PROPOSED ADAPTIVE ARRAY

2.1 Configuration

The system configuration is shown in Fig.1. In the proposed adaptive array, we assume as follows. There is a high bit rate signal such as 2Mbps and there are several low bit rate ones such as voice data. For the low bit rate users, the proposed adaptive array performs to cancel the high power interference using the auxiliary antenna. For the high bit rate user, demodulation is done by the flow without PI procedure. The beamforming is carried out before despreading. The low bit rate users commonly use this beam for the interference suppression, so it can decrease the consumption power of the system.

We also propose a simple array antenna configuration with small auxiliary antenna.

2.2 Weights control method

The proposed adaptive array takes advantage of the low CNR (Carrier to Noise power Ratio) property of the spreading signal in DS-CDMA and performs the minimization of power (PI procedure). In DS-CDMA, the transmission signal is spread over wide-band and the desired signal is extracted by the processing gain by despreading. Therefore, before despreading, the low bit rate signal power is less than the thermal noise and only the high bit rate signal power such as 2Mbps would be larger than the thermal noise. Under this condition, the PI technique is useful to receive the low bit rate signal because the array would not form the null in the direction of the desired signal that has low power.

The weights of power inversion algorithm are given by

$$\mathbf{W}_{PI} = R_{xx}{}^{-1}\mathbf{T}$$
$$\mathbf{T} = [1, 0, \ldots, 0] \qquad (1)$$

where R_{xx} is the correlation matrix of the received signals and $\mathbf{T}$ is the constrained vector of the weights and ^{T} means transposition of the matrix.

Of course, the capturing property of the desired signal in the PI algorithm is not as good as that in MMSE but the PI algorithm is a blind process, which is a strong merit. We describe the features of the proposed system as follows.

[1] Beamforming done before despreading (decreasing the consumption power of the system)
[2] Simple algorithm using minimization of power (PI algorithm)
[3] Simple implementation using small auxiliary antenna

3 Numerical Results

Here, the performance evaluation of the proposed adaptive array has been accomplished in numerical calculation. The calculation parameters are shown in Table.1 and the model of the arrived signals is shown in Fig.5. In this case, the power of the interference that arrives from the direction of 30 degree is varied. The output CINR versus input CIR is shown in Fig.3. Usually, the PI adaptive array eliminates the signal having larger power. But as shown in Fig.3, the desired signal is not eliminated even when the input CIR is larger than 0dB because the input CNR is very low, in which case the desired signal is lower than the thermal noise. Furthermore, although the ability of the interference suppression declines as the auxiliary antenna becomes small, the desired signal can not be easily eliminated. By the way, although the output CINR is less than 0dB in Fig.3, SINR in demodulator can be improved by processing gain when despreading. (in ideal value, SINR of 18.1dB in case of spreading factor 64 and 21.1dB in case of spreading factor 128 can be achieved.)

4 CONCLUSION

We have proposed an adaptive array antenna for high power interference suppression in DS-CDMA system. In the proposed adaptive array, it is not necessary to derive the weights for each channel thus it can decrease the consumption power of the system. Simple algorithm of Power Inversion is used. In future, we will consider the proposed adaptive array in more details by the computer simulation and experiment.

REFERENCES

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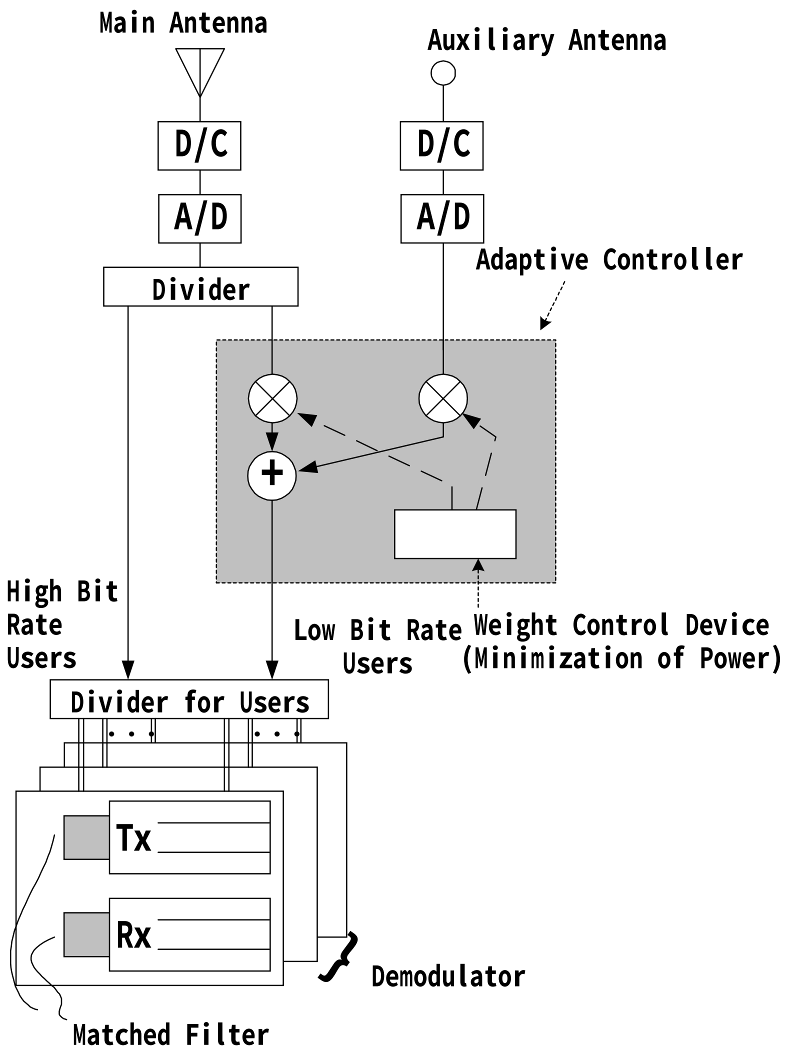

Fig. 1 Configuration of the proposed adaptive array antenna

Table. 1 Calculation parameters

Element pattern	gauss beam (beamwidth:60deg)
DOA of the desired signal	0 degree (boardside)
DOA of interferences (eleven interferences)	From 30 to 330 degrees with 30degree step
Input CNR	0 dB
Input CIR	From -40 to 10 dB
Element distance	0.5 λ

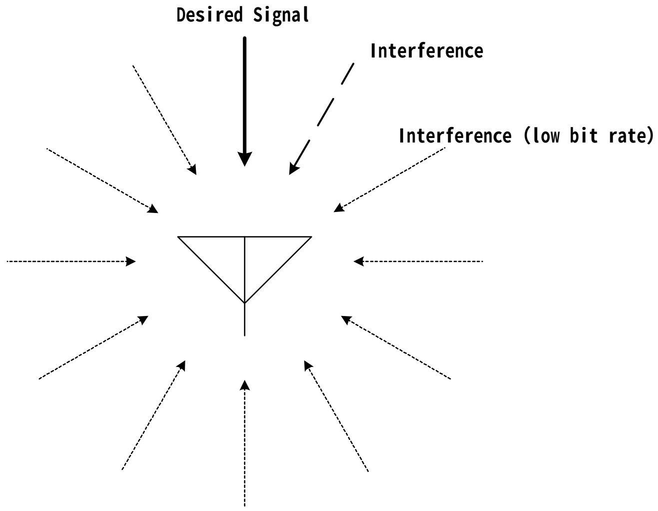

Fig. 2 Model of the arrived signals

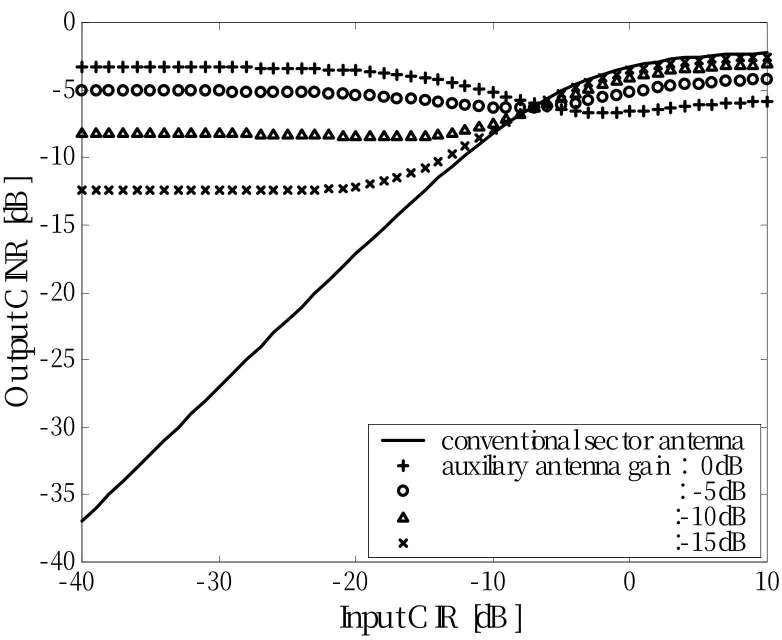

Fig. 3 Output CINR versus input CIR (one desired signal and eleven interferences)