IVth International Conference on

Antenna Theory and Techniques

Volume 1

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9 – 12 September 2003
Sevastopol, Ukraine

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We wish to thank the following for their contribution to the success of this Conference:

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Technical Support

IEEE AP-S
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Moscow Chapter IEEE

This material is based upon work suppoted by the Europen Office of Aerospace Research and development under grant FA8655-03-15060

2003 International Conference on Antenna Theory and Techniques

IEEE Catalog Number: 03EX699
ISBN: 0-7803-7881-4
Library of Congress: 2003103227

International Conference on Antenna Theory and Techniques, 9-12 September, 2003, Sevastopol, Ukraine pp. 374-375

CORRECTION OF SMART ANTENNAS RECEIVING CHANNELS CHARACTERISTICS FOR 4G MOBILE COMMUNICATIONS

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Abstract

The paper considers a way of correction of the reception channels characteristics for smart-antennas in 4G mobile communications.

Keywords: smart-antenna, mobile communications, digital beam formings, correction coefficients, digital antenna array, calibrating source, base station.

The key technology of 4G mobile communications systems is adaptive digital beam forming for smart antennas. Adaptive array technology provide for high gain systems, in turn optimizing handset size and power consumption, and at the same time reduce possible interference effects from other terminals in the same cell area. Software radio technology of smart antennas also enable multimode and multi band operation for base stations [1].

For errors minimization of digital beam formings communications systems with nonidentical channels of antenna arrays arises a problem of correction of the reception channels characteristics.

For the solution of the given problem it is proposed to operate by a special external submission of the pilot-signal. To minimize the hardware expenditures it is proposed to use as a the pilot-signal a signals from other base stations in the same cell area (Fig. 1).

When applied a pilot-signal from only one base station, as a correction procedures for square smart antennas is proposed to use a method [2]. In the general case the correction process is consisted in weighing the digital voltages in receiving channels by complex weight coefficients:

$$\begin{aligned}\dot{U}\cdot\dot{\alpha}_{cor} &= (U^c + j\cdot U^s)(\alpha^c_{cor} + j\cdot\alpha^s_{cor}) = \\ &= (U^c\alpha^c_{cor} - U^s\alpha^s_{cor}) + j(\alpha^s_{cor}U^c + U^s\alpha^c_{cor})\end{aligned}, \quad (1)$$

where α^c_{cor}, α^s_{cor} – quadratic components of correction coefficient, U^c, U^s – quadratic components of response of the primary digital antenna arrays (DAA) channels.

In the case of square smart antennas with $R \times Q$ elements the quadratic components of correction coefficient must been calculated for a set of N readings of pilot-signal from base station with number "m":

$$\alpha^c_{rqm} = \frac{\sum_{n=1}^{N}\left\{U^c_{rqn}\beta^c_{rqm,n} + U^s_{rqn}\beta^s_{rqm,n}\right\}}{\sum_{n=1}^{N}\left(U^{c^2}_{rqn} + U^{s^2}_{rqn}\right)},$$
$$\alpha^s_{rqm} = \frac{\sum_{n=1}^{N}\left\{U^c_{rqn}\beta^s_{rqm,n} - U^s_{rqn}\beta^c_{rqm,n}\right\}}{\sum_{n=1}^{N}\left(U^{c^2}_{rqn} + U^{s^2}_{rqn}\right)}, \quad (2)$$

where $\beta^s_{rqm,n}$, $\beta^c_{rqm,n}$ – quadratic components of a measurement standards response of the rq-th primary smart antennas channels in the n-th time interval, α^s_{rqm}, α^c_{rqm} – quadratic components of correction coefficient for rq-th primary smart antennas channels, which calculate for a pilot-signal from base station with number "m", U^s_{rqn}, U^c_{rqn} – quadratic compo-

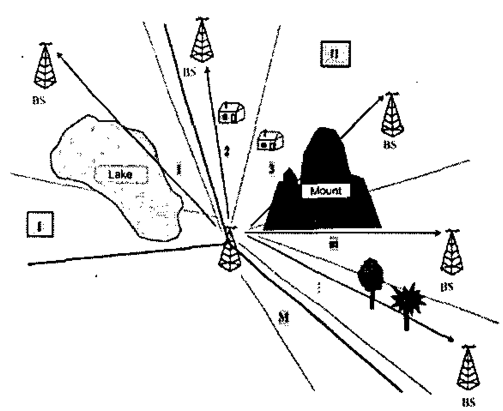

Fig. 1.

nents of response of the rq-th primary smart antennas channels in the n-th time interval,

$$\beta^{c}_{rqm,n} = a^{c}_{n}\cos(X) - a^{s}_{n}\sin(X),$$

$$\beta^{s}_{rqm,n} = a^{s}_{n}\cos(X) + a^{c}_{n}\sin(X),\ X = x_{rm} + x_{qm},$$

x_{rm}, x_{qm} – generalized coordinates of calibrating source (base station with number "m") with respect to DAA normal,

$$x_{rm} = \frac{2\pi}{\lambda} d_r \left(r - \frac{R+1}{2}\right)\sin\theta_m \cdot \cos\varepsilon_m,$$

$$x_{qm} = \frac{2\pi}{\lambda} d_q \left(q - \frac{Q+1}{2}\right)\sin\theta_m \cdot \sin\varepsilon_m,$$

λ – wavelength of calibrating source carrier, d_r, d_q – the distance between array's elements in a row and in a column correspondingly, R, Q – number of array's elements in a row and in a column, θ, ε – angle coordinates of the calibrating source with respect to DAA normal, $a^{c}_{n} = U^{c}_{ST_n}$, $a^{s}_{n} = U^{s}_{ST_n}$ – quadratic components of response of the standard primary smart antennas channel in the n-th time interval.

In the case of linear digital antenna array use a correction coefficients only for one angle plane:

$$\alpha^{c}_{rm} = \frac{\sum\limits_{n=1}^{N}\left\{U^{c}_{rn}\beta^{c}_{rm,n} + U^{s}_{rn}\beta^{s}_{rm,n}\right\}}{\sum\limits_{n=1}^{N}\left(U^{c^2}_{r_n} + U^{s^2}_{r_n}\right)},$$
$$\alpha^{s}_{rm} = \frac{\sum\limits_{n=1}^{N}\left\{U^{c}_{rn}\beta^{s}_{rm,n} - U^{s}_{rn}\beta^{c}_{rm,n}\right\}}{\sum\limits_{n=1}^{N}\left(U^{c^2}_{r_n} + U^{s^2}_{r_n}\right)}, \quad (3)$$

where $\beta^{s}_{rm,n}$, $\beta^{c}_{rm,n}$ – quadratic components of a measurement standards response of the r-th primary smart antennas channels in the n-th time interval, α^{s}_{rm}, α^{c}_{rm} – quadratic components of correction coefficient for r-th primary smart antennas channels, which calculate for a pilot-signal from base station with number "m", U^{s}_{rn}, U^{c}_{rn} – quadratic components of response of the r-th primary smart antennas channels in the n-th time interval,

$$\beta^{c}_{rm,n} = a^{c}_{n}\cos(x_{rm}) - a^{s}_{n}\sin(x_{rm}),$$

$$\beta^{s}_{rm,n} = a^{s}_{n}\cos(x_{rm}) + a^{c}_{n}\sin(x_{rm}),$$

x_{rm} – generalized coordinate of calibrating source (base station with number "m") with respect to DAA normal,

$$x_{rm} = \frac{2\pi}{\lambda} d\left(r - \frac{R+1}{2}\right)\sin\theta_m,$$

λ – wavelength of calibrating source carrier, d – the distance between array's elements in a row and in a column correspondingly, R – number of array's elements, θ – angle coordinate of the calibrating source with respect to DAA normal.

When applied a pilot-signal from more base stations, for a correction procedures can be used a average correction coefficient:

$$\alpha^{c(s)}_{cor} = \frac{1}{M}\sum_{m=1}^{M}\alpha^{c(s)}_{rq_m}. \quad (4)$$

The most effective way of correction is use of a more pilot-signals from M base stations in the one time interval. In this case must be used a correction coefficients:

$$\alpha^{s}_{rq} = \frac{\sum\limits_{n=1}^{N}\left\{U^{c}_{rq_n}\sum\limits_{m=1}^{M}\beta^{s}_{rqm} - U^{s}_{rq_n}\sum\limits_{m=1}^{M}\beta^{c}_{rqm}\right\}}{\sum\limits_{n=1}^{N}\left(U^{c^2}_{rq_n} + U^{s^2}_{rq_n}\right)},$$
$$\alpha^{c}_{rq} = \frac{\sum\limits_{n=1}^{N}\left\{U^{c}_{rq_n}\sum\limits_{m=1}^{M}\beta^{c}_{rqm} + U^{s}_{rq_n}\sum\limits_{m=1}^{M}\beta^{s}_{rqm}\right\}}{\sum\limits_{n=1}^{N}\left(U^{c^2}_{rq_n} + U^{s^2}_{rq_n}\right)}, \quad (5)$$

where

$$\beta^{c}_{rqm} = a^{c}_{m}\cos(x_{rm} + x_{qm}) - a^{s}_{m}\sin(x_{rm} + x_{qm}),$$

$$\beta^{s}_{rqm} = a^{s}_{m}\cos(x_{rm} + x_{qm}) + a^{c}_{m}\sin(x_{rm} + x_{qm}),$$

$$a^{c}_{m} = \mathrm{Re}[A_m],\ a^{s}_{m} = \mathrm{Im}[A_m],$$

$$[A_m] = [P^{*}P]^{-1}P^{*}\dot{U},$$

$$P = \begin{bmatrix} f_1(\omega_1) & f_1(\omega_2) & \cdots & f_1(\omega_M) \\ f_2(\omega_1) & f_2(\omega_2) & \cdots & f_2(\omega_M) \\ \vdots & \vdots & \vdots & \vdots \\ f_N(\omega_1) & f_N(\omega_2) & \cdots & f_N(\omega_M) \end{bmatrix}$$ – matrix of amplitude-frequency characteristics meanings of N FFT-filters for a measurement standards reception channels;

$$f_n(\omega_m) = \frac{\sin N(\omega_m - \omega_n)}{\sin(\omega_m - \omega_n)},$$

ω_n – the central frequency of n-th FFT-filter, U – vector of voltages of the responses channels.

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