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ADAPTIVE METHOD OF FORMING WEIGHTS WITHOUT REFERENCE SIGNAL

Describes a method for the control pattern adaptive antenna array to improve the noise immunity of GPS systems in the absence of a reference signal in the user segment.

The above criteria forming weights suggest that the direction of the source is known, or known amplitude and phase distribution of signal channels antenna array, that is to implement these algorithms need a priori knowledge of the signal, or form in the receiving path reference signal. The reference signal can be formed with the adopted mixture signal obstacle.

Mathematically, the reference signal is given by (1.26) [1], [3] and weighting coefficients are determined from the expression (1.27) [1], [3]. From (1.27) [1] to ensure the sustainability of adaptive devices to match a value of $1/\gamma$ (Fig. 1.14) if this is not done growing weights lead to disruption of the system. Also for forming the reference signal [1, 3] proposed transfer service combinations, but in GNSS systems such impossible (GPS and Galileo did not involve the transfer of any additional information). Therefore, to ensure the sustainability of the adaptive antenna system is necessary to eliminate the dependence of weight vector of the reference signal, or remove the signal component from a mixture of signal/interference.

An important requirement for the optimization of weights - the need to eliminate the influence of the signal in the calculation of the inverse matrix interference $\mathbf{R}^{-1}_{сп}$. Also, to reduce the impact of nonidentity channels AAA (no identity frequency characteristics of receivers, constructive elements no identity AAA, scatter quadrature channels for gain and phase shift and other factors) to calculate weights to exclude signal component in the calculation of the correlation matrix interference. For it is recommended to remove the signal from the mixture signal/interference [2].

Functional scheme for calculating weights without reference signal shown in fig. 1.

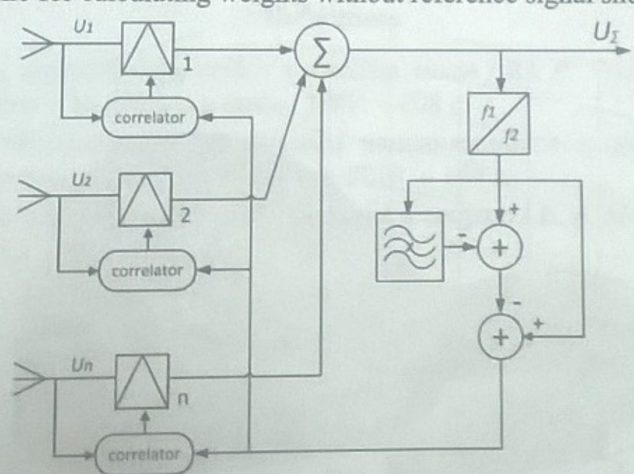

Figure 1

The transducer converts the signal of frequency f_1 in the signal with frequency f_2, which is kept constant. Notch filter cuts out the signal component and takes the stress interference with the opposite sign to the adder, the output of the adder is signal voltage. Voltage noise comes less from a mixture of "signal/interference" voltage signal. Double deduction in order not to alter the correlation matrix of the signal and noise.

The error signal is formed as the difference

$$\varepsilon = \mathbf{w}^{\mathrm{T}}\mathbf{u}_{сп} - S \quad (1)$$

Squared error
$$\varepsilon^2 = S^2 - 2S\mathbf{w}^T + \mathbf{w}^T\mathbf{u}^*_{cn}\mathbf{u}^T_{cn}\mathbf{w}$$

Finding the expectation of ε^2, we obtain an expression for the mean square error
$$E[\varepsilon^2] = S^2 + \mathbf{w}^T\mathbf{R}_{cn}\mathbf{w} - 2\mathbf{w}^T\mathbf{r}_{cn,c}\,, \qquad (2)$$

where $\mathbf{r}_{cn,c} = \overline{\mathbf{u}^*_{cn}S}$; E – average.

Correlation matrix $\mathbf{R}_{cn}$ is the sum of the correlation matrix $\mathbf{R}_{п}$ interference and signal $\mathbf{R}_c$, $\mathbf{R}_{cn}=\mathbf{R}_{п}+\mathbf{R}_c$. From fig. 1 shows that the formation of the error signal $\mathbf{R}_{cn}=\mathbf{R}_{п}+\mathbf{R}_c-\mathbf{R}_c=\mathbf{R}_{п}$.

Vector $\mathbf{r}_{cn,c}$ in the expression (2) is a correlation vector voltage U^*_{cni} і S (i=1,2, … , N), at $S^*_i=0$, ie the reference signal is missing
$$\mathbf{r}^T_{cn,c} = \left[\overline{\mathbf{u}^*_{cn1}}\ \overline{\mathbf{u}^*_{cn2}}\ \ldots\ \overline{\mathbf{u}^*_{cnN}}\right],$$

where $U^*_{cni}=U^*_{пi}$.

Otherwise
$$\mathbf{r}^T_{cn,c} = \mathbf{r}^T_{п}$$

Then the expression (2) takes the form
$$E[\varepsilon^2] = S^2 + \mathbf{w}^T\mathbf{R}_{п}\mathbf{w} - 2\mathbf{w}^T\mathbf{r}_{п}\,, \qquad (3)$$

Optimization of the expression (3) in its minimization by selecting weighting coefficients vector w. Since the mean square error (3) quadratic function of the vector w it has only minimum which can be found by differentiating (3) and equating to zero the derivative
$$dE[\varepsilon^2]/d\mathbf{w} = 0. \text{ Так як } dE[\varepsilon^2]/d\mathbf{w} = 2\mathbf{R}_{п}\mathbf{w} - 2\mathbf{r}_{п} \qquad (4)$$

vector weights will be determined by the expression
$$\mathbf{w} = \mathbf{R}_{п}^{-1}\mathbf{r}_{п}, \qquad (5)$$

Expression (5) corresponds to the expression Wiener-Hopf for calculating the weights in an adaptive antenna array.

The scheme in fig. 1 to satisfy the minimum mean square error. Here are the results of mathematical modeling. The simulation results (fig. 2, fig. 3) for interference azimuth 241°, elevation 28°, matrix AAA 4×4, dx, dy = 0.25, variance of noise - 1, phase shift interference 0°.

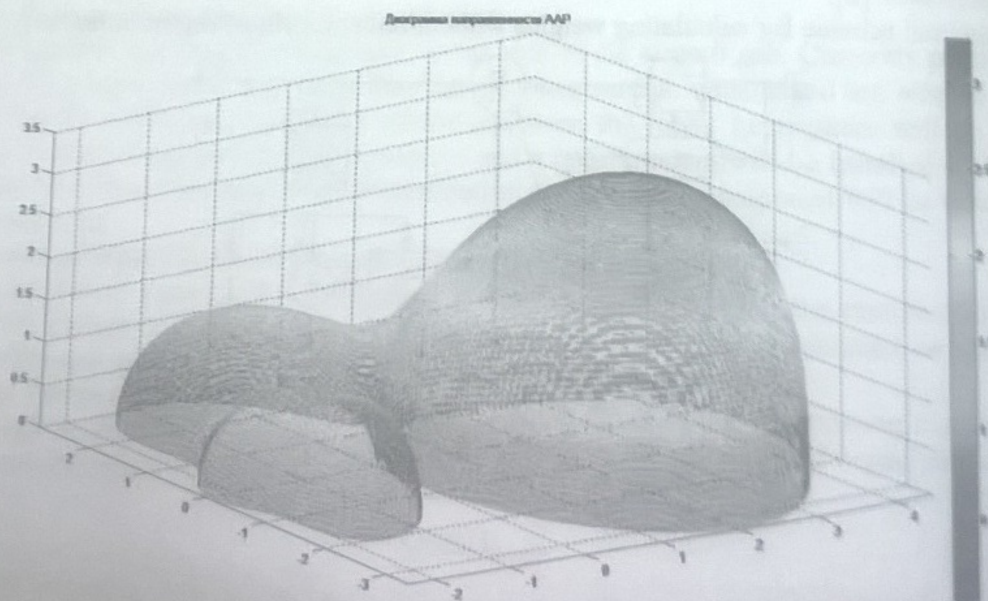

Figure 2

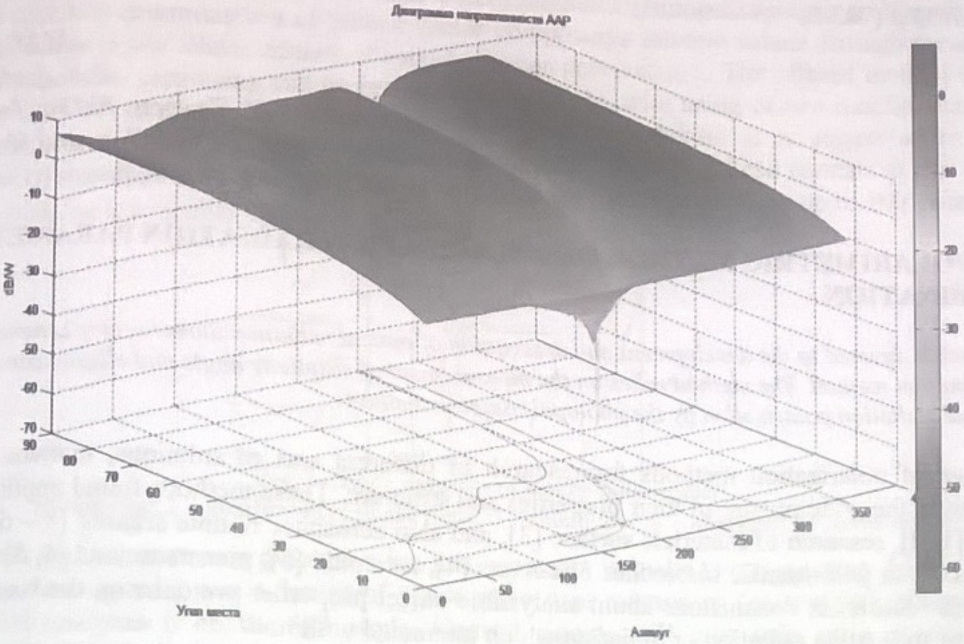

Figure 3

Conclusions

The proposed method allows to calculate the weights to control the pattern AAA GPS systems without knowing the useful signal. These results suggest that the quality of the noise reduction is not worse given in [3].

References

1. Адаптивная компенсация помех в каналах связи / *Ю. В. Лосев, А. Г. Бердников, Э. Ш Гойхман, Б. Д. Сизов* – М.: Радио и связь, 1988. – 208 с.
2. Цифровое формирование диаграммы направленности в фазированных антенних решетках / *Л. Н. Григорьев* – М.: Радиотехника, 2010. – 144 с.
3. Адаптивные антенные решетки: Введение в теорию / *Р. А. Монзинго, Т. У. Миллер* – М.: Радио и связь, 1988. – 448 с.