UHF TROPOSPHERIC SIGNALS OF THE SCANNING DIRECTIONAL ANTENNAS INVESTIGATION AT THE OKHOTSK RADIOPHYSICAL PROVING GROUND

G.S. SHARYGIN, A.A. MESCHERYAKOV, M.V. KRUTIKOV,
A.P. BOLDYREV, S.V. TYUFILIN
Tomsk State Academy of Control Systems and Radioelectronics
40, Lenin av., Tomsk, 634050, Russia.

1. Introduction

When the transmitting antenna maximum does not look along the polarization parameters of the signal at the receiving site change greatly. There could be two causes of this change.

First, real directed antennas has higher level of cross-polarization component in directions different from the main lobe maximum - see [1], as an example. It leads to the noticeable growth of the mean components rate (modulus of polarization index) and to the increase of the regular component of cross-polarization in comparison with the random one. All this takes place because the signal of the main polarization becomes smaller. The same causes lead to the growth of the main- and cross-components correlation, to the stable regular change of mutual correlation function phase (components mean phase difference).

Second, coherence of the main polarization signal greatly decrease when the side lobe illumination is received [2]. It also leads to the polarization index mean level and dispersion increase. Fig.1 give an example of typical "instant" diagrams of the transmitting antenna for the main- (vertical) and cross-polarization, measured beyond - the - horizon, as well as their phase difference.

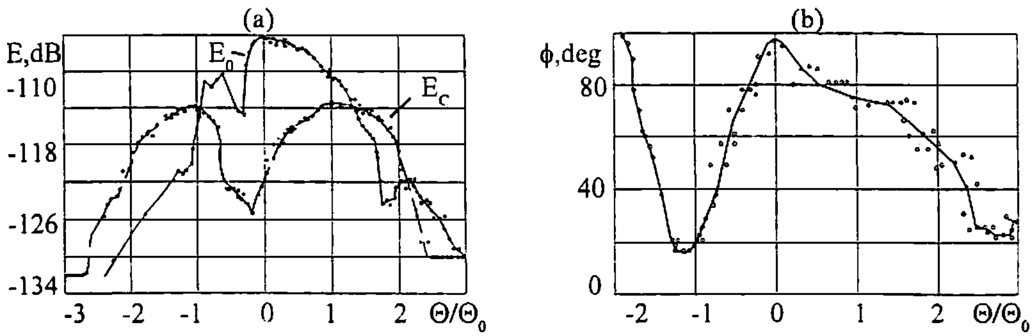

Fig.1 Example of the "instant" diagram over the terrestrial path 86 km long in 10 cm - band (transmitting antenna angle Θ, its half lobe angle in free-space at -3 dB level Θ_0): (a) - signal of the main (vertical) polarization E_0 and signal of cross-polarization E_C; (b) - phase difference (beginning of reading is conventional) .

Experimental investigation of the mentioned above phenomenon along different paths is necessary in order to build the statistical model of diagrams and to solve some important problems involved in design of radars, communication and navigation systems.

2. Methods of measurements and signals processing

Measurements of the polarization parameters were made in Summer (August, September) along the path Vsmorje - Kurilsk 495 km long at the Okhotsk Radiophysical Proving Ground.

Transmitter was in Vsmorje, it transmitted pulse signal, f=3 GHz and had scanning in horizontal plane antenna with vertical polarization. Speed of scanning 36 degrees/s, the main lobe width in horizontal plane 0.75 degree and in vertical plane 2 degrees. The level of transmitted horizontal polarization cross-component less than -30 dB in the main direction. Measurements were made by sessions in 15-20 minutes with registration of each pulse, received in Kurilsk by the parabolic symmetrical antenna 2.5 m diameter, having polarization splitter which spitter the signal polarization into vertical and horizontal. Discoupling between the channels was not less than 40 dB.

During each session 60 diagrams of the transmitting antenna were registered with recording signals of vertical and horizontal polarization and the phase difference between them. Recording was done in the digital form on the magnetic storage. There was an opportunity to align diagrams according to the transmitting antenna angle. In order to do that there was transmitted special mark when the antenna's ray passed the path direction.

The signal's processing includes calculation of histograms and amplitude's correlation analysis as well as calculation of non-energy parameters, such as polarization index, lobe width for the main- and cross-component and so on.

3. Depolarization

Modulus of polarization index (relative level of cross-component) in case, when the transmitting antenna maximum coincide with the path direction, changes in range -10...-40db with the r.m.s. deviation 5-6 db (fig. 2), the time of the both components fast fluctuations and their ratio is about (4-5) sec, which shows that there are many anisotropic inhomogeneities scattering the signal with polarization alike the linear one. Distribution

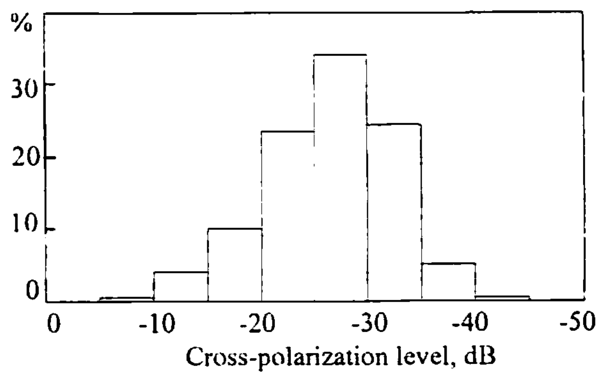

Fig.2 Histogram of the relative cross-polarization level. Measuring duration 30 hours in August-September.

of the phase difference, grouping around the zero says the same (fig.3). The signal depolarization becomes bigger when the path becomes longer (fig. 4). Index of mutual correlation at the diagrams maximum changes from - 0.2 to 0.7 with confidence probability 0.8.

Transmitting antenna lobe for the main and cross-component measured at the receiving site widen differently. The lobe width for the main polarization is 0.83 degree, for the cross-component 1.43.

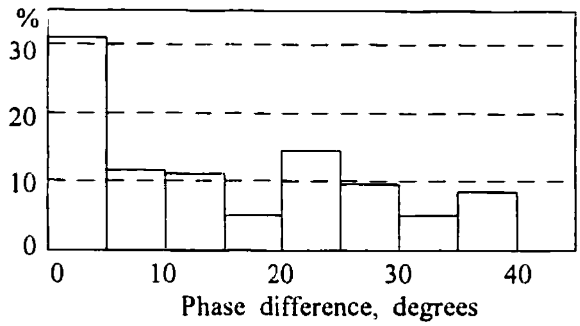

Fig.3 Histogram of the phase difference between the main and the cross-components.

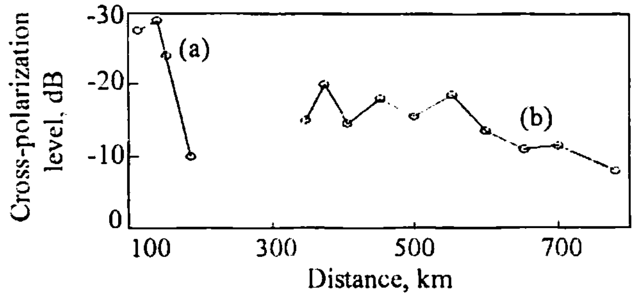

Fig.4 Variation of the relative cross-polarization level measured over the Sea of Japan in May-June of 1990 (a) - $\lambda = 3$ cm (b) - $\lambda = 10$ cm.

Fig.5 shows mean diagrams and m.r.s. level deviations at different points. Relative level of deviations in the limits of the doubled lobe width is about the same. It allows to suggest the statistical model of each component as logarithm of the signal level randomly dependent of the transmitting antenna orientation.

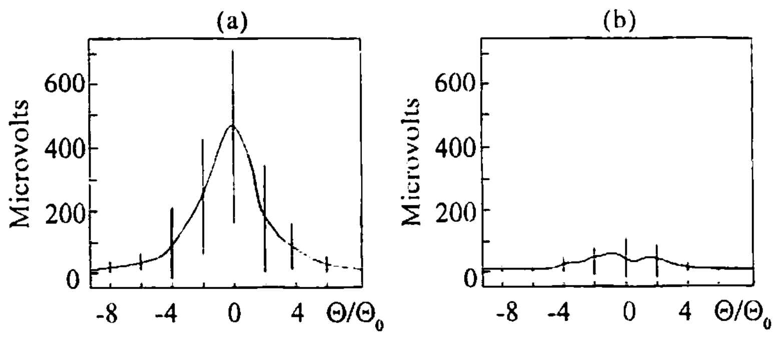

Fig.5 Mean signal level dependence from the transmitting antenna angle (linear scale). Day measurements in August 1990;
(a) - signal of the main (vertical) polarization and its mean square deviation;
(b) - the same for the cross-polarization.

This dependence can be interpreted as the mean diagram and the stationary by angle Gaussian addition with the zero mean value and the constant dispersion - see fig.6.

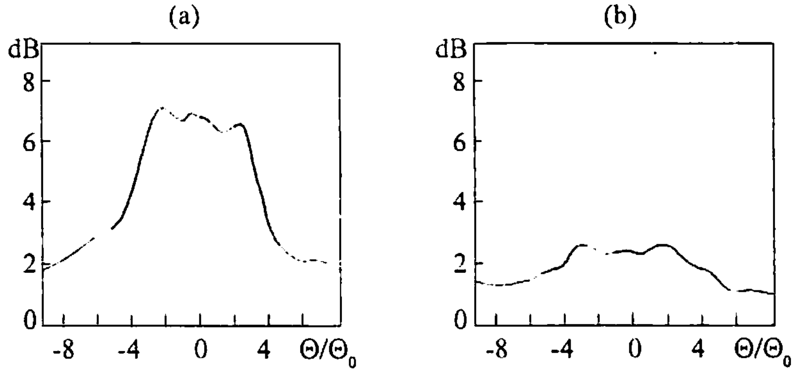

Fig.6 Mean square deviation of the main (a) and cross-component (b) in logarithmic scale.

Interval of angular correlation of this addition is about the same as the undistored transmitting antenna love width . In our case it is (0.7-0.8).

4. Conclusion

Results of the experiments carried out at the Russian Okhotsk Radiophysical Proving Ground allow to offer the statistical model of the scanning antennas vector field beyond- the - horizon and the calculate the main parameters of such model for sea paths.

References

1. Rusch W.V.T. Phase error and associate cross-polarization effects in Cassegrainien fead microwave antennas. - IEEE Trans., 1966, AP-14, No. 3.

2. Sharygin G.S., Mescheryakov A.A. Directional patterns of UHF-antennas under signal reception beyond the horizon. - EMC-94: Twelfth International Wroclaw Symposium. - Institute of Telecommunications, Wroclaw, Poland, 1994, pp.63-67.