THE EFFECT OF ANTENNA DIRECTIVITY ON STATISTICAL CHARACTERISTICS OF A SIGNAL ON THE LINE-OF-SIGHT PATH

P.N.Dagurov, A.S.Zayakhanov, A.E.Tsybikov,

N.B.Chimitdorzhiyev

(Institute of Natural Sciences, Ulan-Ude, USSR)

Recently on line-of-sight paths useful are narrow beam aerials having the gain of 45-46 dB and directivity diagram width of $0.8° \div 0.9°$. When there are such values of diagram width, link stability begins to be effected on by variations of departure and arrival angles of radiowaves due to random changes of refraction conditions in troposphere /1-3/.

For example, when antenna gains of 39.5 dB and 45.5 dB are used, the results of investigating signal fluctuations show that link stability proved better in receiving a signal with a less directivity antenna /2/.

In multipath propagation, however, deeper fadings can be observed in using antennas having directivity diagrams of greater width.

Conditions of experiment

This paper gives the results of comparative investigation of signal fluctuations at the range of 3400-3900 MHz on a line-of-sight path in receiving a signal with a horn-parabolic antenna, having the gain G=39.5 dB, and in receiving a signal with a horn antenna, having the gain G=20 dB. The purpose of measurements was to find out the mechanism of fluctuations on paths having multipath propagation.
The 53 km path runs within 40 km over the Baikal lake. The frequency of 3405.5 MHz in horizontal polarization of a source was used for the measurements which were being made while receiving a signal in two channels at a time. The measurements were being made in July, and the total of recording at a time was 215 hours roughly regular distributed during day and night.

The results of measurements

As measurements showed, the character of a signal essentially depends on the directivity of antennas used. In most cases signal fadings have proved more substantial while using a weak beam receiving aerial. Very often there were observed the situations when a signal appreciably fluctuated on a weak beam aerial, where as the signal fluctuations of a second channel were small.
The most characteristic of the records for a weak beam aerial were not comparatively deep fadings /the depth of 10-20 dB/ with periods of several minutes. As usual, the period of a clear, windless weather corresponded to deep fluctuations. Practically, fluctuations were always marked when such weath-

er set in after the rain.
It is characteristic that deep fadings have been recorded not only in the morning, in the evening and at night, but also in the day time, when fluctuations are not observed, as a rule, on microwave radio links situated in a moderate climatic zone.

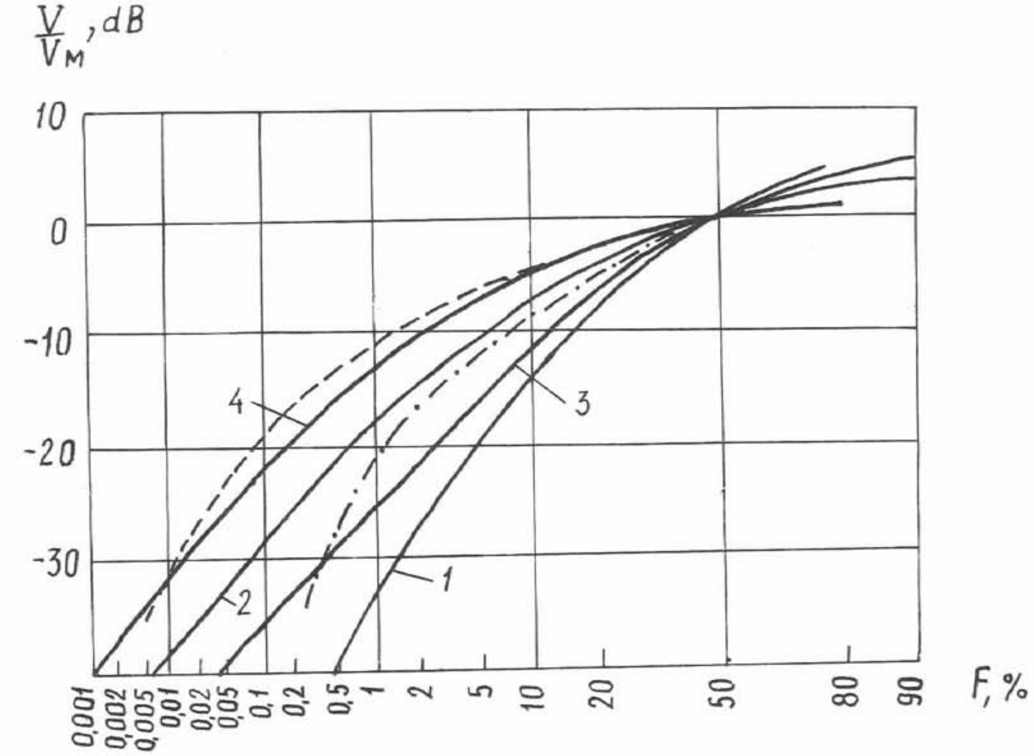

Fig. 1

Fig. 1 gives cumulative distribution of signal levels obtained while receiving on the antenna with G=39.5 dB /dotted curve/ and G=20 dB /line-dotted curve/. The distribution of a signal levels standardize to their median values and their difference was 19.5 dB that corresponds to the difference of antennas gains. The comparison of the curves on fig. I shows that a signal stability while receiving on a less directional antenna proved substantially worse than a signal stability on an antenna with greater directivity /39.5 dB /. So the difference of signal levels is 15 dB at 0.5% time of observation.
While receiving a signal on an antenna with a wider diagram of directivity great fluctuations can be explained only with multipath propagation, and arrival angles of additional waves, propagating besides a main wave, must be greater than a half-width of directivity diagram of a horn-parabolic antenna /θ_0=0.9 /.
Evaluation of difference of arrival angles of a main wave and a reflected one from land surface (screening of a wave reflected with an obstacle is ignoring) shows that this difference does not exceed θ_0 even at critical refraction.
Therefore, one may conclude that the existence of such waves is conditioned by the reflection from stratifield inhomogeneities of troposphere. Previously the measurements of refractive index of troposphere were made on this path. These mea-

surements showed the presence of intensive elevated inhomogeities in high-altitude distribution of refractive index of troposphere. They appear due to peculiarities of meteorological processes near a coast line.
It is necessary to mark that the existence of the reflections from stratified troposphere inhomogeneities, recorded in a channel with a weak beam aerial, is possible when these inhomogeneities are inclined, as evaluations show, relatively to a horizontal plane. Such inclination appears possible due to processes occuring on the boundary line "water-land".

Comparison of experimental statistical distributions

of a signal fluctuations with theoretical ones

Let us compare experimental statistical distributions of a signal fluctuations with theoretical ones, characterizing channels with fadings.
The paper /4/ suggests a new generalized function of fadings distribution on paths with multipath propagation and shows that it well approximates known theoretical distributions. The generalized cumulative distribution has the form

$$\mathcal{F}_\alpha(x) = \begin{cases} 0, & x < 0 \\ -\dfrac{fop_2(\alpha x)}{2fop_2(\alpha)}, & 0 \leqslant x < x_\alpha \\ 1 & x > x_\alpha \end{cases} \qquad (1)$$

where

$$fop_K(z) = \sum_{n=K}^{\infty}(-1)^n \frac{z^n}{n!} = e^{-z} - \sum_{n=0}^{K-1}(-1)^n\frac{z^n}{n!}$$

α - is distribution parameter, bound values of x_α are determined by the condition

$$\frac{fop_2(\alpha x_\alpha)}{2fop_2(\alpha)} = 1 \quad . \qquad (2)$$

From the expresion /2/ it follows that $\mathcal{F}_\alpha(1) = 0.5$ i.e. x -is the relation of meanings of a random value to its median value.
Fig.1 shows some functions of distribution constructed according to /1/ for values of $\alpha = \infty$ /curve 1/, α = 1.07 /curve 2/, α = 20 /curve 3/, α = -2.5 /curve 4/. Curves 1, 2 with graphic exactness approximate two path distribution and Rayleigh distribution according to /4/.
The given dependencies show that statistical distribution of fadings of a signal in a channel with a horn-parabolic aerial is satisfactory described with distribution /1/ when α=-2.5. For distributing the fluctuations obtained in a channel with a weak beam aerial it is difficult to select distribution with the definite value of α , which could approximate experimental distribution with all time periods of observation. Fig.1 shows that experimental distribution lies between Rayleigh and two path distributions. And within the range of small percentage of observation time the experimental distribution varies from the inclination, corresponding to Rayleigh law, to the inclination characteristic for two path distribu-

tion.

Conclusion

Thus, the results of experimental investigation of a signal fadings on the line-og-sight path show that in using a comparatively weak beam aerial the probability of deep fadings appreciably increased in comparison with the reception on the standard antenna of a microwave radio link with a weak correlation between fluctuations of a signal in both channels.
Formerly carried out investigations of fluctuations of a signal in using a narrow beam aerial /2/ also showed the worst stability of connection in comparison with a standard variaant.
Taking this into account one may make the conclusion about the existence of the optimum value of the width of directivity diagram of antennas.
This optimum value provides the best stability of a signal.

Literature

1. A.A.Kalinin Effect of width of directivity diagram of antennas and accuracy of their orientation on statistical characteristics of signals in intervals of microwave radio lines of sight. - Works of Radio Research Institute. 1981, No.I.

2. L.V.Nadenenko, V.V.Svyatogor, Y.A.Brickman Effect of width of directivity diagram of antennas on work stability of intervals of microwave radio lines of sight. - Electrosvyaz 1983, No.II.

3. The Hand Book on microwave radio link. - Moscow: Radio and svyaz, 1981.

4. O.P.Frolov, V.Y.Yampolski About a generalized function of a signal. - Radioengeneering and electronics, 1985, No.10.