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A TECHNIQUE FOR CURRENT DIAGNOSTICS OF THE HIGH-FREQUENCY RADIO CHANNEL

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INTRODUCTION

One of the efficient and economical methods of transmitting information to long distances is HF communication. In order to ensure the quality of communication, it is necessary to accomplish a prediction of radio wave propagation conditions for a selected time interval. Usually, radio wave propagation conditions are predicted on the basis of calculating radio signal characteristics with the use of the ionosphere model (long-term prediction). The determination of radio communication characteristics using long-term prediction is usually unsatisfactory for practical purposes, owing to the considerable differences of the real parameters of the medium from median values. The use of the various kinds of sounding (vertical-, oblique-incidence and backscatter sounding) for current diagnostics and prediction of the propagation conditions is able to improve significantly the quality of operation on high-frequency radio paths.

There exist two approaches to determine radio communication characteristics from radio measurements based on using results of soundings for correcting ionospheric parameters, followed by a calculation of propagation characteristics and on the basis of a direct diagnostics of the propagation conditions, when the sounding signal is used to determine the radio channel characteristics, by omitting a correction of ionospheric parameters.

In this paper we propose a direct diagnostic technique based on using frequency dependencies of group characteristics of the diagnostic signal. Within the framework of this method we have developed algorithms for calculating maximum usable frequencies (MUF) and distance-frequency characteristics (DFC) of the propagation modes for a given radio path from data of oblique-incidence sounding and backscatter sounding.

DESCRIPTION OF THE METHOD

The method is based on adiabatic relationships of the diagnostic signal characteristics and of the radio channel under investigation, with varying ionospheric parameters. These relationships were detected through model calculations of characteristics of signals of oblique-incidence sounding (OIS) and backscatter sounding (BS) and by analyzing experimental data. A numerical simulation of OIS and BS signals was carried out with the use of fast algorithms that were developed in terms of a waveguide approach [1]. Data of oblique-incidence and backscatter soundings obtained by means of an FMCW ionosonde [2] were used as the diagnostic signal when optimizing the techniques.

The main adiabatic relationships are:

- the difference of the group path P(f), corresponding to a maximum in the amplitude envelope of the backscatter sounding signal, and the range to the illuminated zone boundary D(f), on the relative grid of frequencies;
- the difference of the MUF mode for a given range D and frequency f, for which P(f) = D;
- the variation in distance-frequency characteristic of the propagation mode on the relative grid of frequencies (f/MUF);
- the ratio of the MUF modes of different radio paths.

On the basis of the determined adiabatic relationships we have solved the following questions of current diagnostics of the HF radio channel.

1. A current determination of the maximum usable frequency and the distance-frequency characteristic of OIS signals for a given range from the real ionograms of backscatter sounding in the azimuthal direction of the OIS path.

2. The reconstruction of the full DFC of BS signals from fragments of "traces" on the experimental ionogram. This technique is used whenever BS ionograms lack signals scattered from the ranges, for which radio communication characteristics must be determined, because of a strong absorption on the path or due to the sounding on a limited interval of frequencies.

3. The determination of the DFC of OIS signals of the mode of second multiplicity under conditions when the technical capabilities of the BS station or the ionospheric situation on the propagation path do not permit echoes to be obtained from the second-hop ranges. It is necessary to know the characteristics of this mode, for example, for determining the frequency interval of minimum multipathing.

4. The determination of the DFC of OIS signals on a given path from current recordings of oblique-incidence sounding ionograms from reference stations, whose location does not coincide with the transmit point in range or azimuth of the path.

5. The determination of the DFC of oblique-incidence sounding signals on a given path using data from the BS station, whose direction of sounding does not coincide with the azimuth of the OIS path.

ILLUSTRATIONS

Fig.1 gives the results of the modelling of the OIS DFC for a radio path of 3000 km length, with the azimuthal angle of 330 degrees (solid line) using data from a reference station of oblique-incidence sounding located at the distance of 1500 km from the emitter in the azimuthal direction of 270 degrees. The figure also presents the results of calculations of the OIS DFC from a longterm prediction (dotted line) and from real ionospheric data (dashed line) for a chosen radio path.

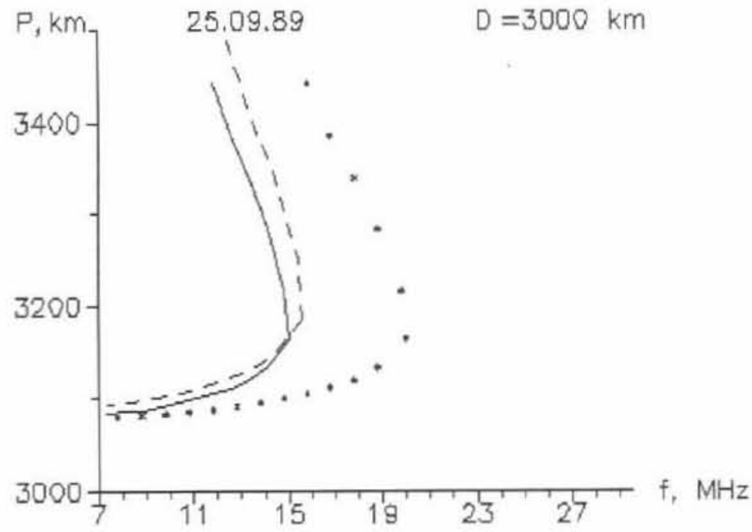

Fig. 1. The results of modelling of the OIS DFC in the azimuthal direction of 330 degrees and the range of 3000 km from current data from a reference station of oblique-incidence sounding.

Fig. 2a gives the results of calculation of the DFC of the OIS modes IF2 and 2F2 from a long-term prediction (dashed line) and from the BS ionogram (solid line) on a radio path of 3000 km length, superimposed on the real ionogram of oblique-incidence sounding. The experimental BS ionogram for the same period is presented in Fig. 2b. The DFC of the BS signal in maximum in the amplitude envelope is used as the diagnostic characteristic.

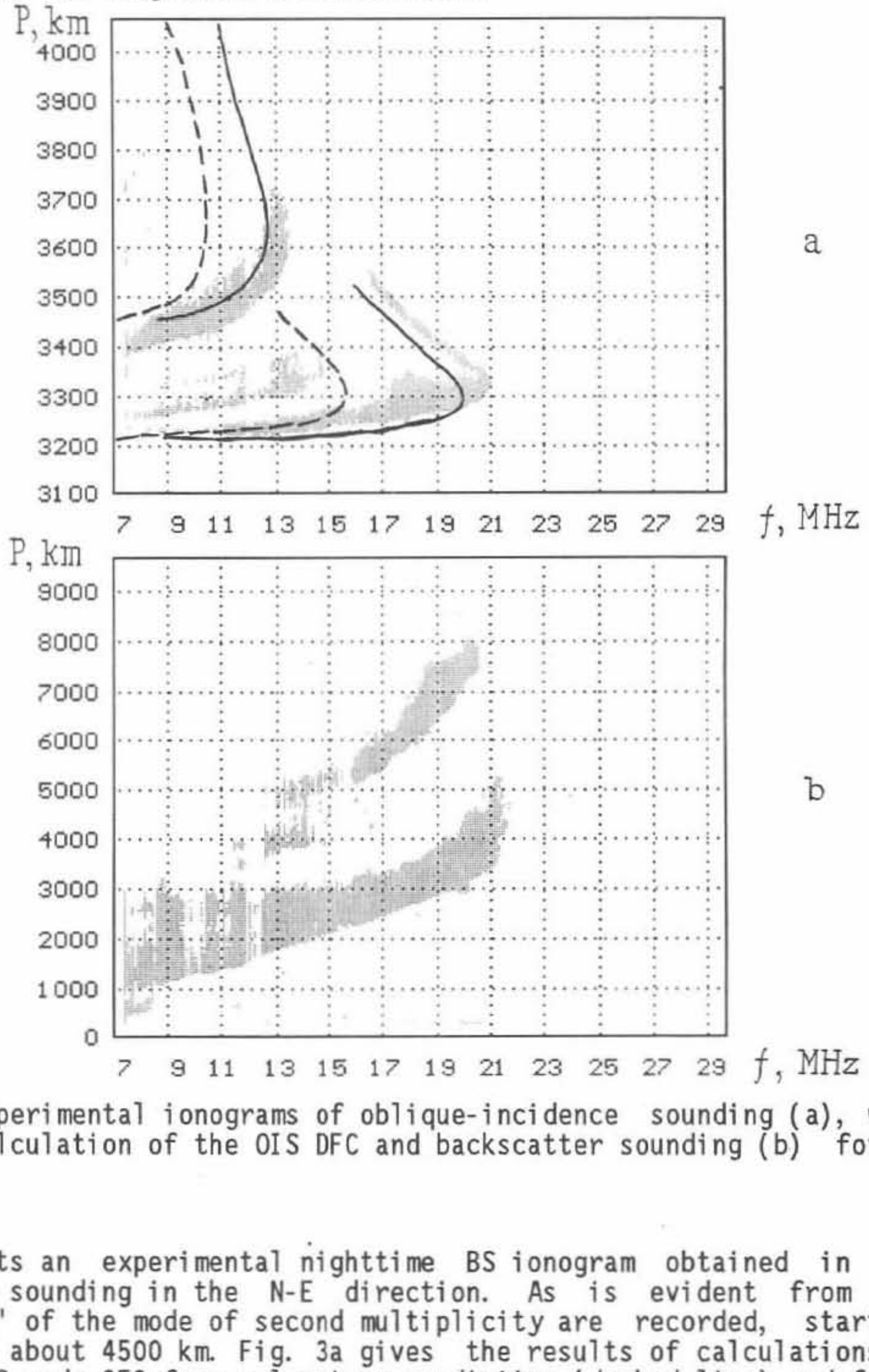

Fig. 2. The experimental ionograms of oblique-incidence sounding (a), with the results of calculation of the OIS DFC and backscatter sounding (b) for 26 June, 1989.

Fig. 3b presents an experimental nighttime BS ionogram obtained in the summer of 1989 by sounding in the N-E direction. As is evident from the ionogram, "traces" of the mode of second multiplicity are recorded, starting from the range of about 4500 km. Fig. 3a gives the results of calculations of the DFC of the OIS mode 2F2 from a longterm prediction (dashed line) and from a current diagnostics using the DFC of the BS signal of first multiplicity (solid line) on a path of 3000 km length in the same direction.

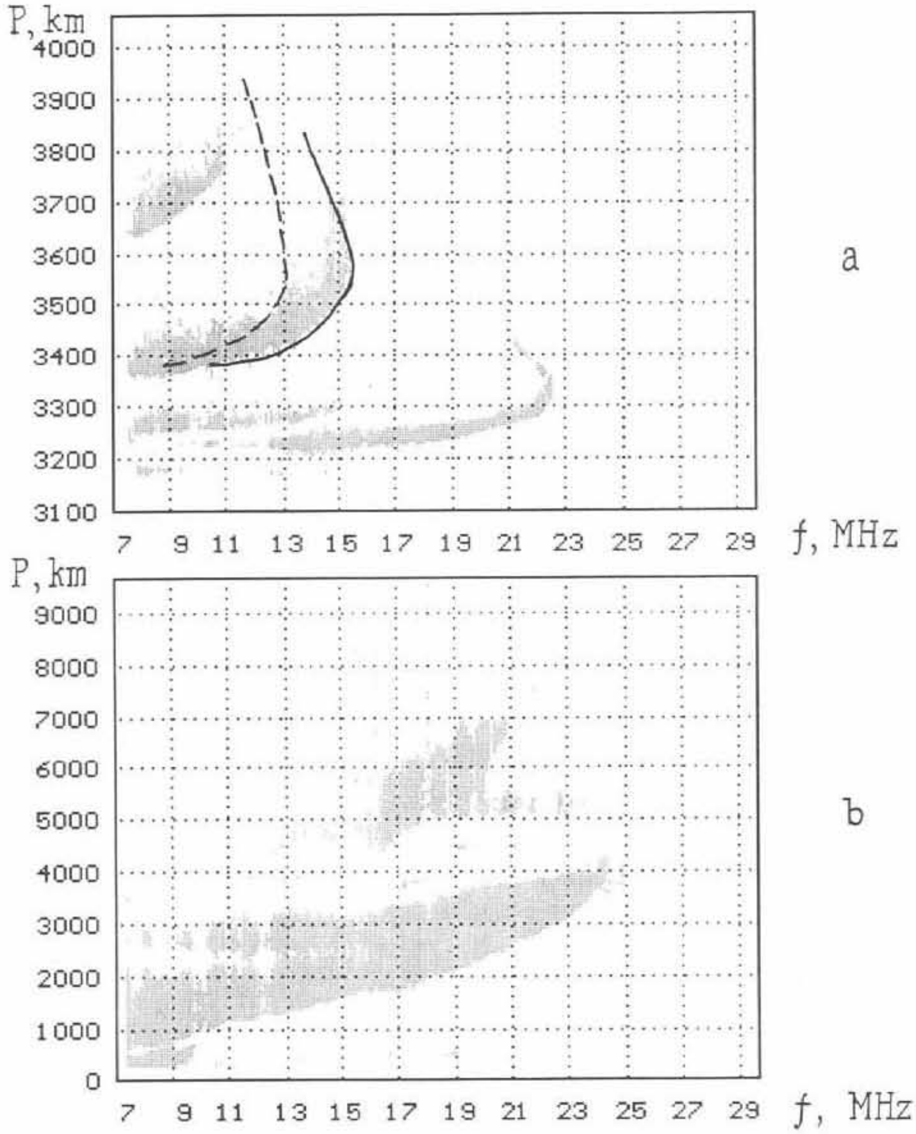

Fig. 3. The experimental ionograms of oblique-incidence sounding (a), with the results of calculation of the OIS DFC and backscatter sounding (b) for 25 June, 1989.

CONCLUSIONS

The techniques for current diagnostics of the HF radio channel described here have been realized in the form of programs on IBM PC AT. The algorithms, which we have developed, are compact and feature a high speed of response. At present the method of current diagnostics is being optimized on paths of a different length and orientation.

REFERENCES

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